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# Confronting deep uncertainty in the forest carbon industry

Value of Information, resilience-based and service-focused approaches from other sectors could reduce contentions, costs and injustices in the sector.

Forest carbon offsetting is a billion-dollar industry attracting considerable criticism. This criticism stems in part from doubts about methods used to measure and causally attribute changes in tree cover and biomass (and thus in tree carbon) (*1*). The industry is thus pursuing increasingly detailed measurement and monitoring of carbon outcomes and risks, based on the assumption that this will improve accuracy and offset integrity (*2*). However, recent scientific advances (*3*) imply that many forest landscapes are subject to 'deep uncertainty'. Claims of high accuracy in assessing carbon change are thus likely to remain inherently contestable—regardless of the technology or methodology deployed. Further, demands for such accuracy are likely to perpetuate inefficiencies and injustices amongst carbon suppliers (*2*, *4*). 'Value of Information' (*5*) and resilience-based approaches (*6*) from other sectors (e.g. health, finance, conservation, and telecommunications), may offer alternative solutions. More radically, service-focused models could negate the need for highly accurate measurements of outcomes at all (*7*).

**Deep uncertainty in forest systems**

Markets thrive on good information. Buyers and regulators in the forest carbon market thus demand this from carbon suppliers, certification standards, monitoring services and rating agencies. In turn, these 'supply-side' actors are incentivized to differentiate their offerings through competing claims of superiority in certainty, transparency, and even 'truth' (*8*). Supply-side actors survive on their ability to convincingly quantify and causally attribute carbon change.

But the science is far from settled on how (or even if) it is possible to do this in a robust way. Commodification of forest carbon relies on the principles of additionality, leakage and permanence. Additionality requires that changes in carbon sequestration or stocks would not have occurred in the counterfactual (e.g. business as usual) scenario (a.k.a. the baseline); controlling for leakage requires that interventions do not increase emissions elsewhere (e.g. through direct displacement within the project area, or by increasing timber and agricultural commodity prices and production in other locations). Permanence requires that carbon stocks remain sequestered on decadal or centennial timescales.

To assess these principles, the market relies on estimated changes in tree cover and biomass, and assessments of their causality and risk. Such analytics and monitoring can consume most of a forest carbon project's revenues (*9*), and investments in new commercial analytical services reach into the tens of millions of dollars (*8*). Such analyses also underpin perennial disagreements about the effectiveness of many projects (*1*).

Yet science tells us that these analyses—and thus the commodity of forest carbon—are likely to remain uncertain. Forest landscapes are complex and dynamic systems where tree cover and biomass fluctuate in response to diverse interactions between natural (e.g. tree mortality, competition, pests, herbivory and natural fires) and anthropogenic drivers (e.g. land clearing, wood harvesting). Critically, the relative influence of these drivers varies greatly even across small areas, and are usually only partially understood, and only partially observable (*3*).

In ecology, this evidence has seen a shift away from theories of climax communities and single stable states (e.g. where undisturbed forests were assumed to continually increase in biomass before reaching a predictable and stable maximum), towards more dynamic understandings of non-linearity and hysteresis—and even of alternative (or the absence of) stable states. Strong evidence now exists that tree cover and biomass fluctuate in ways that are hard (and sometimes impossible) to precisely understand, predict and control (*10*).

These advances sit uncomfortably with claims of high certitude about forest carbon change. Certainty in additionality and leakage would imply that it is possible to reliably measure current biomass states at relatively fine scales, and that one can robustly attribute its causality (e.g. through objective counterfactual scenarios and baselines). Permanence would imply that forest biomass can be made to reach something akin to a climax community with stable levels of carbon. But a conservative interpretation of the current science (*3*) indicates that, no matter the technologies deployed, causal attributions of forest change and expectations of quasi-stable biomass would remain contestable (even where claims are retrospective, e.g. in *ex-post* crediting models). That is, many forest carbon interventions operate in something akin to 'deep uncertainty'—a world of unknown unknowns (*11*).

Deep-type uncertainty subsequently points to a more fundamental tension between dominant forest carbon offset methodologies and advances in the understanding of complexity in social-ecological systems. Even if it were possible to robustly assess changes in a singular system state variable (e.g. tonnes of forest carbon sequestered), complexity science suggests that doing so would (on its own) provide little insight about whether a system has undergone a sustained (e.g. 'permanent') regime change (or transformation) to a new (e.g. higher carbon) state (*12*). Such changes are instead more closely associated with the broader stability landscape of the system (e.g. the enduring environmental, social and economic factors that encourage or discourage changes in tree biomass) and the ability of an intervention to manoeuvre (i.e. their adaptive capacity) to retain a desired state in the face of (unanticipated) shocks and stresses (i.e. its general resilience).

Many carbon schemes do assess 'risks' to additionally, leakage and permanence from specific environmental, social and economic factors. However, by definition these risk assessments can only address 'known knowns' that can be anticipated, and about which one can estimate probabilities and impacts (*11*). They therefore can say little about the likelihood an intervention will prevail in the face of unanticipated (and sometimes incomputable) shocks and stresses (i.e. deep uncertainty). Thus, not only are quantifications of forest carbon outcomes and associated (specific) risks likely to remain contestable, but subsequent claims of permanence are also likely to be inherently precarious.

## The costs and injustices of claims to accuracy

Supply-side actors have tended to respond to these challenges by investing in ever more detailed technical measures for assessing carbon outcomes and risk (e.g. conservative estimates of carbon removals; new modelling and monitoring technologies; offset insurance products; blockchain-enabled transparency measures; automated risk assessments) (*2*, *8*, *13*). Yet evidence of deep uncertainty in forest landscapes suggests that scepticism about measurement accuracy will remain a stubborn burden on the sector.

This burden currently manifests in different ways. For one, it continues to cause disputes about the worth of different carbon schemes (*1*). Such disputes not only threaten the reputations (and so survival) of these individual projects, but also diminish market confidence more widely. Persistent uncertainty drives volatility in prices and revenues, and has led to an arms race in the sophistication and thus cost of competing (and still contested) verification methodologies (*2*). Volatile prices and growing compliance costs subsequently become the main barriers to entry for suppliers, rendering unviable up to 80% of potential projects in the tropics (*9*).

Overburdensome compliance demands can also fuel unfair and inefficient outcomes. In the tropics, many carbon suppliers are local organisations, communities or smallholders from poor areas. Often these suppliers have little capacity to negotiate on the rules to which they are subjected(*4*), and can be pressured to redirect already-scarce resources towards questionably complex and costly compliance measures (*14*). Flawed rules can also cause suppliers to be held to external standards of certainty and performance that are virtually unachievable (*15*). Such unfair, costly and restrictive conditions can subsequently combine to hinder efficiency and innovation (*16*). Ultimately, none of this is good for buyers, suppliers or the climate.

**Ideas from other sectors**

For the above reasons, and others, some deeply transformative proposals advocate discarding market-based approaches to forest conservation entirely (e.g. conservation basic income)(*17*). Here we point to existing practices from other sectors that may inspire improvements in the already (economically and politically entrenched) market-based model.

For one, health, financial, conservation and other sectors sometimes deploy 'Value of Information' (VOI) approaches to assess when generating more detailed data and information is worth the cost, relative to marginal changes in certitude, useability and user-perceived legitimacy(*5*). Certification organisations, regulators and other rule-makers in the forest carbon industry could explore similar approaches to more objectively assess what level of complexity is actually warranted in measurement and monitoring. More broadly, the industry could explore introducing a fundamental principle of parsimony in methodologies, rules and assessments—where approaches should be no more complicated than they need to be(*18*).

Another opportunity stems from a potential shift from risk- to resilience-based approaches to assessing and managing uncertainty. Energy, telecommunications and other sectors approach deep uncertainty by investing in (and assessing) their technical, organisational, social and economic readiness to persist in the face of unknown shocks and stresses—i.e. their adaptive capacity and general resilience(*6*). The forest carbon industry could explore ways to emulate these sectors by moderating its emphasis on the precision of (in any case uncertain) estimated outcomes, and instead more closely relating offset quality to the adaptive capacity (and subsequent general resilience) of the underlying intervention—e.g. the depth and breadth of skills, knowledge, labour and resources available, and the strength of institutional governance, inclusivity and learning(*6*, *12*). Higher adaptive capacity also usually engenders higher levels of stakeholder consultation and participation, thus also enhancing social equity and legitimacy(*16*). Some dimensions of adaptive capacity are already considered in various offset risk assessments and ratings—but they are often relegated in importance relative to (likely contestable) outcome-focused metrics, and focus only on 'known knowns'(*8*, *13*). Complexity science(*11*) and approaches from other sectors(*6*) suggest broader adaptive capacity and general resilience could be made more central indicators of offset quality.

Somewhat more radically, some operators in these sectors address uncertainty by adopting service-focused models that allow trading to proceed in the near-total absence of accurate measurements of outcomes. By employing 'efforts standards' from contract law, buyers pay suppliers to maximise delivery of a service, even if there is uncertainty about the precise level of final delivery possible(*7*). For example, internet service providers agree to undertake specific measures within their control (i.e. 'best efforts') to maximise the speed and stability of a service up to a maximum potential level—even if the actual level may be only approximately known, and may fluctuate due to events outside of their control (e.g. internet traffic; weather damage to infrastructure).

For carbon suppliers, systems theory provides a basis for assuming that while the precise level of a desired system function (e.g. forest carbon sequestration) may not be knowable, it can be assumed to be maximised over time when actors (e.g. forest stewards) use their adaptive capacity (e.g. their rights and available capital) to maximise the general resilience of a desired system state (e.g. a landscape with more trees) to (often unanticipated) shocks and stresses (e.g. political and economic drivers of deforestation)(*12*) (Biggs et al. 2012). Thus, from a complexity perspective, rewarding carbon suppliers based upon their adaptive capacity and related activities (rather than inherently uncertain outcomes) may be sufficient to guarantee that they are maximising carbon sequestration. Indeed, such adaptive capacity and resilience (and ultimately system transformation) is increasingly argued to be what really matters for a sustainable biosphere in face of unpredictable global change(*19*, *20*). Such an approach might be similar to activity-based models that already exist in the sector (*21*), but would be more clearly underpinned by complexity theory and resilience-thinking. Crucially, payments to providers could still be ‘conditional’—a defining feature of carbon offsets, as opposed to non-conditional transfers (e.g. ‘contribution approaches’ in conservation) (*21*).

The exact modalities of how such an experimental approach could apply in practice would need to be explored, along with how it links to the currently-entrenched, commodity focused (payments-by-tonnes-of-carbon) market infrastructure. But where there is a buyer there is a way, and judging by other sectors, a service-focused model may be sufficient for some.

Whatever the models that might emerge, service focused approaches would likely entail a change in the value proposition to, and the expectations of, buyers and policy makers towards something akin to making ‘conditional investments in sustainable and just future landscapes’—rather than purchasing specific amounts of (in any case contestable) offsets. Such an approach might also align with the emerging ‘carbon contribution’ approach, where retired credits in any case do not compensate for actual emissions (*22*), thus potentially reducing the need for precise quantification.

Overall, we suggest that by exploring VOI, resilience-based, and service-focused approaches the forest carbon industry may empower supply-side actors to be more realistic about what they can actually predict, measure and control. Generally, we propose that, by better confronting deep uncertainty in forest systems, the forest carbon industry (and potentially other ecological markets) may find fruitful new pathways for addressing many of the current contentions, costs and injustices in the sector.

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