Quality Assessment of REDD+ Carbon Credit Projects

Berkeley Public Policy
The Goldman School
Berkeley Carbon Trading Project

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Acknowledgments

The authors would like to thank Carbon Market Watch for funding for this research. The authors would also like to thank Moira Birss (Moira Birss Consulting), Kyle Hemes (Amazon), Sumi Hoshiko, Jessica F. Needham (LBNL), Tracey Osborne (University of California, Merced), and Loren Rodgers for thoughtful discussions and reviews of chapter drafts. We are also grateful to Jude Berman for help editing. The views and assumptions expressed in this report represent those of the authors and not necessarily those of the funder or reviewers.

Suggested citation

Haya, B. K., Alford-Jones, K., Anderegg, W. R. L., Beymer-Farris, B., Blanchard, L., Bomfim, B., Chin, D., Evans, S., Hogan, M., Holm, J. A., McAfee, K., So, I. S., West, T. A. P., & Withey, L. (2023, September 15). *Quality assessment of REDD+ carbon credit projects*. Berkeley Carbon Trading Project. https://gspp.berkeley.edu/research-and-impact/centers/cepp/projects/berkeley-carbon-trading-project/REDD+

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September 15, 2023

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Acronyms

AES	Applied Energy Services
AFOLU	agriculture, forestry, and other land use
AGB	aboveground biomass
AGC	aboveground carbon
AMOREMA	Association of Residents of the Mapuá Extractive Reserve
A/R	afforestation/reforestation
BGB	belowground biomass
BGC	belowground carbon
CAR	corrective action request
CCBS	Climate, Community, and Biodiversity Standard
CDM	Clean Development Mechanism
CGI	carbon green investments
CID	climatic impact driver
CO_2	carbon dioxide
CONAP	National Council of Protected Areas
CR	clarification requests
DBH	diameter at breast height
DFI	development finance institution
DOI	digital object identifier
ESA CCI	European Space Agency Climate Change Initiative
FAR	future action request
FSF	forest scarcity factor
FPIC	free prior and informed consent
FPP	Forest Peoples Programme
FSC	Forest Stewardship Council
GCS	geologic carbon storage

GER	gross emissions reductions
GHG	greenhouse gas
H	height
ha	hectare
HWP	harvested wood products
IACHR	Inter-American Commission on Human Rights
iLUC	indirect land use change
IFC	International Finance Corporation
ISO	International Organization for Standardization
IPCC	Intergovernmental Panel on Climate Change
LULUCF	land use, land-use change, and forestry
MAP	mean annual precipitation
MLP	multilayer perceptron
NCR	nonconformance requests
NER	emission reductions and/or removals
NFA	non-forest area
NPV	net present value
PA	project area
PP	project proponent
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RR	reference region
RRD	reference region for projecting rate of deforestation (used in VM0007)
RRL	reference region for projecting location of deforestation (used in VM0007)
SOC	soil organic carbon
SW	SimWeight
tCO_2e	metric tons of carbon dioxide-equivalent
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture
v	version
VCS	Verified Carbon Standard
VCU	verified carbon unit
VVB	validation/verification body
WD	wood density
WWC	Wildlife Works Carbon

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Executive Summary

Quality Assessment of REDD+ Carbon Credit Projects

Well over half of the world's largest public companies globally have taken on carbon emissions reduction goals and many expect to meet these targets, at least in part, by buying carbon credits to "offset" their continued emissions. These commitments are anticipated to direct significant investments from the private sector into external climate mitigation projects.

The voluntary carbon market generates credits, each nominally equivalent to one metric ton of carbon dioxide reduced or removed from the atmosphere, from a wide range of projects around the globe. Previous research has shown that these projects rarely represent their claimed climate benefit, and that it is not uncommon for programs to overestimate their impact manyfold (e.g., Badgley et al., 2022; Cames et al., 2015; Coffield et al., 2022; Gill-Wiehl et al., 2023; Haya, 2010, 2019; Stapp et al., in press).

Reducing Emissions from Deforestation and Forest Degradation (REDD+) is the project type that has the most credits on the voluntary carbon market—about a quarter of all credits to date. These projects pay governments, organizations, communities, and individuals in forest landscapes (primarily tropical ones in the Global South) for activities that preserve forests and avoid forest-related greenhouse gas (GHG) emissions.

Many see the private funds generated through REDD+ carbon crediting as critical to preserving tropical forests, home to a significant portion of the world's biodiversity, 40% of the world's vegetation carbon (over 180 billion metric tons of carbon), and innumerable forest communities. But despite more than US$3 billion in aid for REDD+ and close to a half billion carbon credits awarded over the last 20 years to most forested countries in the Global South, deforestation is still continuing at an alarming rate. A tremendous amount of trust and hope are being put into the voluntary carbon market and the small number of nonprofit organizations that create, manage, and self-regulate it.

In this report, we assess the effectiveness of REDD+ carbon crediting programs at reducing deforestation, generating high-quality carbon credits, and protecting forest communities. This analysis can inform the future direction of REDD+ crediting under both the voluntary carbon market and UN climate agreements. We focus on the four crediting methodologies that have generated almost all REDD+ carbon credits to date, all under Verra, the largest voluntary carbon market registry.

We found that current REDD+ methodologies generate credits that represent a small fraction of their claimed climate benefit. Estimates of emissions reductions were exaggerated across all quantification factors we reviewed when compared to the published literature and our independent quantitative assessment.

Almost all projects focus on changing the behavior of some of the world's poorest communities. REDD+ is not designed to address the most important commercial drivers of deforestation: politically and economically powerful large-scale agriculture, cattle ranching, logging, and mining. While many projects aim to better the lives of forest communities, some also restrict smallholder use of forest resources. These restrictions, when enforced, commonly fall hardest on more vulnerable households and communities, and in the worst cases, have resulted in displacement or dispossession. Safeguard policies, presented as ensuring "no net harm" to forest communities, in practice have been treated as voluntary guidance.

Companies buy these inflated carbon credits to sell "carbon neutral" flights and fuel, call themselves carbon neutral to investors, employees, and customers, and justify their own continued emissions. These credit purchases take funds and attention away from more effective climate mitigation and forest protection measures.

Our exploration of the underlying reasons REDD+ crediting projects deviate so dramatically from good practice in carbon accounting and safeguards found that Verra offers project developers significant flexibility in performing emissions reduction estimates and applying safeguards. Developers have used that flexibility to make methodological choices that lead to high estimates of project benefits, instead of conservative estimates as required. Project auditors, who are hired by the project developers and so have incentives to be lenient in order to be hired again, did not adequately enforce compliance with Verra's standards, including conservativeness in emissions reduction estimates.

Today, throughout the forests of the Global South, communities are being approached by REDD+ project developers to enroll new lands in carbon crediting projects. Rarely do project designs originate from the communities themselves. The power imbalances in these interactions are obvious. This is the opposite direction that REDD+ needs to go to successfully reign in deforestation and protect people.

When considering all evidence together, our overall conclusion is that REDD+ is ill-suited to the generation of carbon credits for use as offsets. The logic of the voluntary carbon market is to create a financial incentive for private actors to find the lowest-cost carbon emissions reductions and removals. But all decision-makers involved in the creation and use of carbon credits benefit financially from excess crediting. The methodologies used to estimate project benefits and credits awarded are developed by companies and organizations that go on to use them to develop projects and sell credits. Developers benefit from selling more credits for doing less, credit buyers seek inexpensive credits, and the auditors tasked with ensuring quality have conflicts of interest because they are hired directly by the project developers. Verra itself competes for market share with the other carbon credit registries. High levels of over-crediting come from the compounding of decisions made throughout the carbon credit lifecycle, all of which lean toward generating more credits.

This market system creates a race to the bottom that is hard to emerge from. Buyers seek the lowest-cost credits that are often the most over-credited, and the market values carbon over people by design.

In addition to the fundamental incentive structure, two other issues suggest that REDD+ credits should not be traded with, or treated as equivalent to, fossil fuel emissions. Programs that use reductions in forest carbon emissions to offset fossil fuel emissions effectively transfer carbon from permanent storage as unmined fossil fuels to the short-duration carbon cycle where it is at risk of release into the atmosphere. Furthermore, uncertainty in REDD+ baselines and leakage impacts are still too high for credits to be seen as offsetting a known amount of carbon emissions.

Research Questions and Methods

We reviewed the four most widely used REDD+ carbon crediting methodologies: Verra's VM0006 (Terra Global Capital, 2017), VM0007 (Avoided Deforestation Partners, 2020), VM0009 (Wildlife Works & ecoPartners, 2014), and VM0015 (Pedroni, 2012). Each methodology defines what projects are allowed to participate and generate credits and methods for monitoring and calculating the emissions reductions/removals from each project. Verra requires all projects and credit calculations to be audited by third-party auditors, and manages and oversees the auditing process.

In exploring the effectiveness of these methodologies, we focus on five quality factors:

- Baselines: deforestation that likely would have occurred in the absence of the project intervention that is reduced and credited by the project
- Leakage: the increase in carbon emissions outside project boundaries due to project activities, such as from conservation activities that displace rather than reduce production of a product, such as timber
- Forest carbon accounting: estimates of carbon per hectare in forests conserved
- Durability: the risk that forest carbon conserved by the project will be released into the atmosphere from natural disturbance, such as wildfire, or from human activities
- Safeguards: criteria and procedures for mitigating risks and minimizing harm to forest communities

For each factor, we assess the rules and procedures laid out in the methodologies and in Verra's overarching *Verified Carbon Standard* (VCS), their implementation by projects, and their enforcement by auditors. We compare the rules and their application by projects with published literature and perform our own project assessments.

Report Findings

Over-Crediting

We found evidence of widespread over-crediting across all four quantification factors covered in this report. Many REDD+ credits are created from unrealistically high baselines, unrealistically low estimates of leakage and durability risk, and high estimates of carbon stocks in forests. The carbon estimates used by projects to generate credits were significantly higher than results based on best-practice methods described in the literature and our own independent estimates.

Baselines

Verra's REDD+ methodologies estimate project impacts and credits as the difference between actual, monitored changes in forest carbon and the predicted loss of carbon stocks in a baseline scenario. The *baseline* should represent the deforestation and forest degradation rates that would likely have occurred without the REDD+ project. All methodologies forecast the baseline at the start of the project based on historical deforestation and degradation rates in the larger region.

Baselines that forecast higher rates of deforestation and forest degradation without the project intervention result in more credits when compared with monitored rates over time.

Previous research found that baselines used by projects are far higher than those constructed using best-practice baseline methods (Guizar-Coutiño et al., 2022; West et al., 2023; West et al, 2020). These studies use actual deforestation rates in well-matched control plots looking backwards in time over the reporting period rather than forecasting baselines at the start of the project. One study of 17 sample REDD+ projects in five countries (West et al., 2023) found that the credits issued to projects represented more than 13 times the study team's independent assessment of actual project impacts. The study also found more than half of the projects showed no reduction in deforestation, despite having generated credits. These findings are consistent with other studies of REDD+ projects that documented much lower impacts than credits issued or no impact at all (Seyller et al., 2016; Withey, 2021).

Leakage

When projects reduce the production of a traded commodity, such as timber or coffee, that production can shift to other non-protected areas—a process known as *leakage*. For example, if demand for timber remains the same, then reduced harvest in one forest may simply result in increased harvesting in another. All methodologies require developers to estimate and deduct the carbon impacts from leakage.

We identified a number of projects with substantial leakage risk that nevertheless applied zero leakage deductions. Verra's REDD+ methodologies include market leakage rates that reflect the academic literature—between 10% and 70%, depending on project conditions. However, in practice, more than half (59%) of Verra's REDD+ projects did not take any leakage deduction, and most of those that did applied total leakage rates under 25%. This suggests that the portfolio of projects is likely to over-credit by failing to deduct sufficient credits to cover leakage risk.

Forest Carbon Accounting

The carbon benefits of a project are calculated as the hectares of forest saved by the project multiplied by the carbon per hectare. Aboveground and belowground carbon in live trees are the largest carbon pools protected and credited by REDD+ projects.

Under Verra's REDD+ methodologies, most developers translate tree inventory data (e.g., tree height and diameter in sample plots) into carbon per hectare in live trees using equations published in scientific articles and reports. Our study sample of 11 projects found that developers chose allometric equations that, on average, resulted in credit generation 23% to 30% higher than our independent estimates.

Durability

All REDD+ projects must estimate the risk that the carbon they conserved and credited will be released into the atmosphere due to natural or human causes over a 100-year period (called a *reversal*) and put a corresponding quantity of verified reductions into an insurance buffer pool. Credits from this insurance pool can be used to cover a reversal, and so should be sufficient to ensure that all credits sold remain valid even if reversals occur in some projects.

For the 57 REDD+ projects for which we were able to find matching remote sensing data in the published literature, we found the mean 100-year risk of a stand-clearing natural disturbance to be 28%. In other words, if past disturbance rates continue unchanged, around 28% of preserved forest carbon will be released into the atmosphere by a major natural disturbance event over the next 100 years. This is likely an undercount of actual risk for two reasons: first, our estimate only took into account a portion of the disturbance (stand-clearing disturbance), and second, our calculated risks did not account for the expected increases in risk with climate change. Nonetheless, the average REDD+ project estimated its risk from all natural disturbance to be just 2% of credited carbon reductions, less than a tenth of our estimates. Furthermore, more than half of all projects contributed the minimum allowed deduction, 10%, into the buffer pool to cover both natural and human risks.

Flexibility

All four of Verra's methodologies grant project developers significant flexibility in defining project baselines, accounting for the carbon impacts from leakage, estimating the carbon in forests, estimating project reversal risk, and applying safeguard standards. We found that, despite Verra's requirement that they treat uncertainty with conservativeness, project developers often made use of the flexibility allowed by Verra to make choices that generated high rather than conservative quantities of credits.

Baselines

To explore the accuracy of Verra's methodologies, we chose one project from each methodology. For each, we recreated the baseline seven times, using all four methodologies, and applying three methodologies twice, using different options within them. Since credits under all methodologies are treated as equivalent, applying all allowed methods to the same project area should result in similar baseline predictions.

Instead, we found that baseline deforestation rates varied enormously when different REDD+ methodologies and options were applied to the same project area, and that developers consistently went with higher baselines. The average difference between the lowest and highest baselines values for the four sample projects was 1459%. In other words, on average, the highest of the seven baseline values we calculated for a project using the different Verra methodologies was more than 14 times the lowest value for that same project.

Unsurprisingly, we also found that the official baselines used by developers to generate offset credits were consistently on the high end of the range of the alternative baselines we constructed. The official baselines used by the developers were higher than 23 of our 28 reconstructed baselines.

Leakage

We used four case study projects to examine the reasons for the application of low leakage rates. We found that project developers were able to apply no leakage deduction through a number of paths, even for projects with substantial leakage risk. For example, one project developer performed two household surveys back-to-back and chose to apply the results from the smaller survey that showed no leakage risk even though doing so was not conservative.

Forest Carbon Accounting

All methodologies lay out guidance for choosing equations to translate forest inventory data into aboveground and belowground carbon. The guidance allows for significant flexibility. We found that the range of equations the methodologies allow for assessing carbon in live trees per hectare resulted in estimates that varied by 80% for the aboveground portion and 193% for the belowground portion on average across our sample projects. We also found that most developers chose equations that led to high rather than conservative estimates of carbon per hectare of forest.

Social Safeguards and Outcomes for Forest Communities

While Verra's safeguard standards are presented as assurance that projects will not cause harm to local communities, in practice they are commonly treated as a check-box activity by both developers and auditors. Verra's safeguard policies are less specific and less stringent than those considered to be best practice. As with the other quality standards we reviewed, VCS safeguard policies are flexible and permissive. Verra provides little guidance to developers on how to follow them or to auditors on how to verify them; we saw many instances where safeguard policies were overlooked, or only weakly carried out, yet projects were still positively verified. Stakeholder consultation practices, for example, were rarely described in detail; practices such as sending emails to affected community members were accepted by auditors, reflecting serious misunderstanding of what *consultation* means.

In the process of estimating reversal risk, VCS asks developers to quantify *external risks* to project permanence, which are calculated based on the extent of local consultation, among other factors. We found that 17 of 18 projects reviewed (94%) rated community engagement risk as zero in their first monitoring period. Ultimately, the only actors who can determine whether harm has occurred are impacted communities themselves, yet our review found project-level grievance mechanisms to be non-transparent and rarely utilized; audit reports included surprisingly little indication that these mechanisms had been verified as effective avenues for complaints. Our review suggests that safeguards are most likely to fail to protect the rights of Indigenous peoples and local communities precisely in the contexts in which risks are greatest and protections are most needed.

Verra's most recent update to its safeguards policy recognizes important protections left out of prior policies, such as international human rights standards and respect for Indigenous peoples' rights. However, our close review of how safeguards are implemented and verified in practice suggests these changes in the standard alone may do little to change outcomes for forest communities. Safeguards have inherent limitations. What constitutes proper implementation is context-dependent, and judging compliance can be subjective. For example, assessing whether stakeholder consultations created space for meaningful dialogue with affected communities—or were merely a one-sided presentation of project information to a non-representative group invited by the developer—may hinge on contextualized knowledge and time in the field to meet with a broad range of stakeholders. Auditors rarely have the time, nor the expertise, to determine whether social safeguards meet Verra's standard and relevant international rights standards. Auditors cannot force compliance or provide redress for harms; they can only withhold credits. That auditors are hired by developers exacerbates a natural bias toward approval.

Ultimately, safeguards are implemented within existing power structures and political realities. As a set of discretionary policies with weak oversight and no binding mechanisms for accountability, safeguards provide no guarantee that harm has been avoided. Binding, enforceable standards with truly independent oversight, project design led by or in partnership with forest communities, as well as fundamental changes to the underlying incentive structures of REDD+ in private carbon markets, are needed to improve safeguard compliance and outcomes for forest communities.

Validation and Verification Bodies

The voluntary carbon market relies on third-party auditors, called *validation and verification bodies (VVBs)*, to enforce compliance with the registry standards and methodologies. Our analysis shows that verifiers see their role as ensuring that the emissions calculations used are allowed, and not that they are accurate or conservative. We also saw many instances where requirements were not enforced, or when problems were found, the verifier accepted a simple answer by the developer rather than ensuring that the concern was adequately addressed.

The following instances illustrate ways VVBs failed to identify problems with projects or approved developer choices that were not conservative:

- One verifier approved a zero fire risk rating for a project in which that verifier had directly observed a fire during the site visit.
- One project noted that it used an equation for estimating aboveground carbon in live trees from a published article unrelated to forest carbon and actually about water nutrients.
- One project that restricted immigration into the area by coffee growers claimed a zero risk of leakage. In other words, the developer claimed that individuals who would have migrated into the project area to clear forest to grow coffee were assumed to not migrate elsewhere for that purpose, and that the reduction in coffee production because of project restrictions would not result in increased coffee production elsewhere to meet demand for this globally traded product.
- VVBs accepted communication via email or posting to a message board as sufficient fulfillment of stakeholder consultation requirements in regions with low levels of literacy and electrification.

Lack of Transparency

Our analysis was made more difficult due to lack of data availability. Offset registries do not require release of the data needed for independent analysts to fully reproduce credit calculations, yet the resulting credits are used to publicly claim a lower impact on one of the most important public goods: the stability of the Earth's climate system. Much of the data and assumptions used by developers to estimate project baselines, carbon in preserved forests, and total credits generated were not publicly available for independent evaluation. Project developers commonly stated that they met safeguard requirements but provided little or no description of how the requirements were met. Access to such data is critical to enable independent review of credit quality and project claims.

Verra's Proposed Program Updates

Verra was undertaking a major revision of its REDD+ program when the research for this report was conducted. Verra's August 2023 updates provide some important improvements. These include integrating future climate change impacts into natural risk assessments and buffer pool contributions (but with a vague 40% reduction for projects that include adaptive capacity), explicitly requiring respect for human rights and Indigenous peoples' rights, requiring benefit sharing when a project affects property rights or use, and improving transparency in emissions calculations. Verra's proposed consolidated REDD+ methodology, if adopted, would reduce flexibility in constructing project baselines. All of these important improvements remain vague and actual improvement will depend on additional guidelines and how they are implemented in practice.

Our analysis suggests that substantial additional changes are still necessary to prevent over-crediting. These include improving estimates of current natural risk, refining the process of choosing allometric and belowground biomass equations, applying deductions for international leakage and leakage from agricultural displacement, and requiring more rigorous assessment of safeguards compliance for all projects and especially those with greater risk.

In addition, Verra could make several more fundamental changes to prevent over-crediting and improve protections for forest communities. These include changing the auditing system to remove conflicts of interest by auditors who are hired directly by project developers, enforcing the application of conservative methods for estimating impacts, shifting from forecasted to dynamic ex post baselines, creating a truly independent body to verify safeguard compliance and address grievances, requiring more appropriate assessment of safeguards compliance, and changing the program so that forest communities lead or fully participate in the design of projects that affect them. These and other suggested changes are described in each report chapter and in the conclusions below.

Conclusions

REDD+ Is Ill-Suited to Carbon Crediting

A key finding of this research is how widespread and significant over-crediting is for REDD+ crediting methodologies across all quality factors. Previously published studies found that flawed baselines alone likely resulted in over-crediting of 92% (i.e., projects are issued 13 times more credits than their climate benefit). In addition, forest carbon accounting methods used by project developers resulted in estimates 23% to 30% higher than our independent estimates. We found that average deductions for natural risk were 2% when they should have been greater than 28%, which translates into additional over-crediting of more than 36% from this factor alone. Leakage deductions taken were much lower than those from the academic literature. Since over-crediting compounds across factors, only a very small fraction of credits likely represent real emissions reductions from Verra's REDD+ projects.

The findings presented in this report make it clear that the current design of the carbon credit market is not effective at reducing deforestation and protecting people. More than 20 years ago, scholars asked why the World Bank and other development finance institutions continued to fund projects with well-documented human rights abuses. The answer was incentives—a culture of approval that rewarded Bank staff for moving money and demonstrating success. As a result, some projects reported successes with little relation to what was actually happening on the ground, using safeguards that offered little actual protection (Rich, 1994, 2013, Wade, 1997).

Carbon markets have a similar incentive structure. All participants benefit financially from moving more projects forward and exaggerating success. By primarily valuing carbon, emissions reductions are prioritized over people. Safeguards are presented as a backstop to avoid harm but are limited in their effectiveness, especially in the contexts in which they are most needed. The carbon market, by creating a set of rules and letting the market find the least expensive reductions in the uncertain, complex, deeply unequal, and often contentious contexts of REDD+ interventions, creates the perfect conditions for generating poor-quality credits and imposing risk on vulnerable populations.

Already the world's carbon sink is full to overflowing. Offsets, even if they could work perfectly, would not reduce the concentration of greenhouse gasses in the atmosphere but would mainly move where the emissions occur (McAfee, 2012). As companies lay claim to the carbon sequestration services produced by distant landscapes to justify and offset their own ongoing emissions, the governments, landholders, or communities that receive offset payments cede their *own* emissions rights—their ability to use the territories designated as carbon sinks for their own subsistence and development.[1] Instead of the people who depend directly on the land, water, and forests, those with the ability to pay get to choose the use of "the greatest share of the earth's biomass and all that it contains" (McAfee, 1999, p. 138).

Therefore, we must direct our attention and actions to the underlying causes of deforestation and work to reverse the local, national, and international policies that promote them.

Another Way Forward

Support for the preservation of the Earth's dwindling climate sinks through forest and biodiversity conservation in the tropics is urgently needed. The findings of this report show that carbon markets create a set of incentives unable to protect forests and people. Another approach is urgently needed.

Here we list some of the measures that private actors can take or support that together can help to reduce tropical deforestation:

Curb the demand-side drivers of deforestation. To a great extent, the demand from industrialized and fast-growing economies for food (especially meat and animal feed), fibers, ores, and fuels impels deforestation and forest degradation. Legislation and regulatory action by governments at all levels can mandate nationally and globally sustainable trade. The European Union regulation on deforestation-free products offers one model for government action. Regardless of the regulatory environment, companies can proactively phase out all sourcing of supply chain inputs from tropical forests and other high conservation value areas.

Support forest plans designed by Indigenous and local communities. Many Indigenous Peoples and local communities have been and continue to be effective forest protectors, but often need additional resources to support their institutions in the face of mounting forest pressures. Indigenous Peoples networks have outlined how such contributions can prioritize local and indigenous communities in ways that recognize their human and territorial rights and support locally-determined sustainable development strategies.

Contributions approach. Funds can be provided to organizations, funds, programs, and projects that mitigate climate change, without counting any quantified benefits as offsets. Criteria and procedures for such contributions, how they can be guided by deep understanding of the root drivers in specific regions, and how additional finance for that purpose can be mobilized, have been proposed by civil society organizations and some governments, and are under discussion in

[1] Oxfam (2021) found the land area required for the offsetting plans of just the top four oil companies that have made net-zero pledges would be the size of the UK by 2030 and twice that by 2050.

UNFCCC negotiations on Article 6.8, Non-Market Mechanisms, for achieving the Paris Agreement goals.

Debt relief. Some governments condone forest-destroying activities because exports from them earn foreign-exchange income they need to finance their operations and pay interest on their foreign debts. Carbon credits are the latest in this series of low-priced tropical export commodities. These debts, accrued over a long history of unequal trade between the Global North and Global South, are again on the rise. Loans from the International Monetary Fund and multilateral banks have added to the debt burden, with requirements that loan recipient countries take steps to increase exports. The failure of these policies has prompted some wealthy governments to write off part of these debts as unpayable. Further write-offs by governments, banks, and companies could relieve some pressure driving tropical deforestation.

Fair share climate finance. Full funding is needed for the international finance facilities established to aid developing countries in carrying out their obligations under the Paris Agreement and the Convention on Biological Diversity and to compensate for the immense losses and damages to these countries from climate change. Countries could revive UN negotiations on establishing a global carbon budget and "fair share" distribution of reductions as a source of climate mitigation funding.

Focus on the largest driver of climate change—fossil fuel emissions. To effectively address climate change, the global community must take actions that focus on reducing fossil fuel emissions at their source. Reducing emissions at their source can, in turn, help relieve the biophysical stresses that forests face from climate change itself. Companies can invest funds they would have spent on carbon credits into directly reducing their own emissions.

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Chapter 1: Introduction

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Reducing Emissions from Deforestation and Forest Degradation (REDD+) is the project type with the most credits on the voluntary carbon market. As of the end of May 2023, 97 registered REDD+ projects (with another 109 under development), mostly in the biodiversity-rich tropics of the Amazon, Congo Basin, and Southeast Asia, had generated 445 million carbon credits, one quarter of the total credits on the voluntary carbon market (So et al., 2023). Verra, a nonprofit organization based in Washington, DC, that runs the largest voluntary carbon crediting program globally, called the *Verified Carbon Standard* (VCS), has issued almost all REDD+ credits to date.[2]

REDD+ first emerged in the context of international climate policy negotiations during the late 1990s as a strategy for reducing the cost of meeting climate targets while mitigating two global crises at once: climate change and biodiversity loss. Even before it became clear that the world's wealthy countries were unwilling to pay the costs of implementing the international treaties on biodiversity (UNCBD) and climate change (UNFCCC) in the Global South, World Bank economists and other climate policy analysts looked to the for-profit private sector as a funding source (McAfee, 2012; Wade, 1997). A leading idea was that emitters in industrialized countries could receive tradable carbon credits in return for paying governments, organizations, communities, and individuals in forest landscapes, primarily tropical ones in the Global South, for actions that preserve forests and reduce forest-related greenhouse gas (GHG) emissions (Tyndall Centre for Climate Change Research, 2007; World Bank, 2012). They could use these credits, each nominally equivalent to one metric ton of carbon dioxide (CO_2) emissions reduced or removed from the atmosphere, as "offsets" to meet emissions targets instead of reducing their own emissions directly.

Since then, more than US$3.5 billion has flowed to or been approved for disbursement in most forested countries of the Global South from multilateral organizations (such as the World Bank and UN agencies) and bilateral aid, with Norway and Germany as the largest funders (Climate Funds Update, 2023; Norwegian Agency for Development Cooperation, n.d.). As directed by UN climate agreements, these funds were provided in three phases: (1) REDD+ readiness for developing forest plans, monitoring systems, and safeguards; (2) implementation of policies and measures including pilot projects; and (3) results-based payments for monitored and verified emissions reductions.

Today, under the UN Paris Agreement, REDD+ credits from countries that reduce emissions below their targets at a jurisdictional level, including in the forest sector, may soon be traded between countries under subarticle 6.2. Whether REDD+ activities can be traded as offset projects under subarticle 6.4 was still under negotiation when this report was released.

In parallel, around half of the world's largest public companies globally have taken on carbon emissions reduction goals. Many expect to meet these targets, at least in part, by buying

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[2] Plan Vivo, a much smaller carbon credit registry, also credits REDD+ projects.

carbon credits from the voluntary carbon market to offset their continued emissions (estimated using data from Lang et al., 2023).

Private funds directed through expanding voluntary and UN carbon markets have been described as necessary for filling the large funding gap for tropical forest preservation. This requires tremendous faith and trust in carbon crediting and in REDD+, both of which have tenuous track records to date.

Previous research on project-based carbon crediting across multiple generations of programs and project types, overseen by both voluntary (e.g., Verra) and compliance (e.g., the UN and California) carbon credit registries, has found that projects rarely represent their claimed climate benefit and commonly generate many times more credits than reductions achieved (e.g., Badgley et al., 2022; Cames et al., 2015; Coffield et al., 2022; Gill-Wiehl et al., 2023; Haya, 2010, 2019; Stapp et al., in press).

A diverse and rich body of case studies from geographers, sociologists, anthropologists, and political ecologists, based on extensive field research, has documented with nuance the outcomes of REDD+ interventions on forests and forest communities. REDD+ projects funded by governments, multilateral institutions, and the voluntary carbon market overwhelmingly have focused on changing the behavior of smallholder farmers, Indigenous peoples, rural forest dwellers, migrants, and other lower-income forest users (Skutsch & Turnhout, 2020). They do this instead of addressing the larger but more politically and financially powerful direct drivers of tropical deforestation: commercial agriculture, cattle ranching, logging, and mining (de Sy et al., 2018). This mismatch is to be expected: by treating all credits as equivalent, the carbon market incentivizes private market participants to find the lowest-cost reductions and removals. Addressing the primary commercial drivers of deforestation is much more costly than changing the behavior of the poor. It is also unpopular with the elites who benefit from these drivers.

Published research finds that the impact of REDD+ on those affected by projects has been mixed. In the best cases, some members of forest communities have received short-term benefits from projects, often in the form of small payments for tree planting or forest guard duties, or community benefits such as fuel-efficient stoves or school or health clinic buildings (e.g., Duchelle et al., 2017; Kapos et al., 2022; Pandey et al., 2016; Poudel et al., 2015). In the worst cases, REDD+ has resulted in evictions, displacement, or dispossession of forest dwellers from land designated for forest conservation, including as part of REDD+ readiness, pilot programs, and projects (Beymer-Farris & Bassett, 2012; Chomba et al., 2016; Griffiths, 2008; Howson, 2017; Sarmiento Barletti & Larson, 2017).

Even as some community members may benefit, projects have also inadvertently imposed hardships on smallholders by restricting the use of forest resources (e.g., Asiyanbi, 2016; McElwee et al., 2017; Poudel, 2015). These restrictions typically fall hardest on those who are poorer, landless, and women, as these populations typically rely on common pool forest resources for a greater percentage of their income and livelihood (Duker et al., 2019; Griffiths, 2008; Kansanga & Luginaah, 2019; Mutabazi et al., 2014; Poudel et al., 2015; Ratsimbazafy et al., 2011; Satyal et al., 2020; To et al., 2017). Unfortunately, the funding generated by REDD+ that actually makes it back to participant communities has generally been insufficient or too delayed to make up for restrictions or to incentivize conservation (Duker et al., 2019; Milne et al., 2019; Nathan & Pasgaard 2017), and elites tend to capture any benefits and funding that projects do generate (Andersson et al., 2018; Chomba et al., 2016; Parrotta et al., 2022; Poudel et al., 2015; Poudyal et al., 2016). Some REDD+ interventions have also stoked tensions within and between communities (Alusiola et al., 2021;

Griffiths, 2008; Schmid, 2022), thus weakening community cohesion and local governance systems (Ece et al., 2017; Ezzine-de-Blas et al., 2019; Kemerink-Seyoum, 2018; Withey, 2021).

The rationale for carbon offsetting is that it should lead to more climate mitigation by allowing private actors to find the least expensive emissions reductions, reducing political opposition to mandatory carbon caps, and making it easier for companies to take on voluntary emissions targets. Even if credits accurately represent true emissions reductions, they can simply move emissions from one place to another instead of reducing total emissions. But if credits equal less than the amount they supposedly offset, which most do, they can undermine both climate mitigation and biodiversity protection by taking the place of direct emissions reductions and diverting attention and funds from more effective forest preservation and climate mitigation actions. Furthermore, preserving forests cannot offset fossil fuel emissions because this effectively moves carbon from permanent storage deep in the Earth as fossil fuels to the short-duration carbon cycle, where it is at risk of release into the atmosphere.

Of course, exaggerated credits are less expensive than accurately quantified credits since the cost of carrying out a project can be spread over more credits. This results in carbon prices below those needed to drive accurately estimated mitigation, locking in low prices, low-quality credits, and ongoing but seemingly guilt-free emissions. They justify and can even encourage continued emissions by creating the illusion that we can buy, fly, drive, and otherwise emit GHGs without harming the climate.

The purpose of this report is to assess the effectiveness of REDD+ carbon crediting programs at reducing deforestation, generating high-quality carbon credits, and protecting forest communities. This analysis of the performance to date, and why it falls short when it does, can inform the evolution of REDD+ programs in the voluntary market and under the UN system in this critical decade for both climate change and biodiversity.

Methods

We assessed the quality of Verra's four most-used REDD+ crediting methodologies: VM0006 (Terra Global Capital, 2017), VM0007 (Avoided Deforestation Partners, 2020), VM0009 (Wildlife Works & ecoPartners, 2014), and VM0015 (Pedroni, 2012). By *quality* we mean credits that represent their claimed climate benefits, treat uncertainty conservatively (i.e., choosing assumptions and methods that are more likely to under-credit than to over-credit when there is uncertainty), and are unlikely to cause harm to people and ecosystems with systems in place for remediation when they do. We compared the methods used to estimate emissions reductions and protect people—as well as how those were applied in practice in projects—with best practice in the published literature and with our own project analysis.

We focus on five critical quality elements:

- Baselines: deforestation that likely would have occurred in the absence of the project intervention that is reduced and credited by the project
- Leakage: the increase in carbon emissions outside project boundaries, due to project activities, such as from conservation activities that displace rather than reduce production of a product, such as timber
- Forest carbon accounting: estimates of carbon per hectare in forests conserved
- Durability: the risk that forest carbon conserved by the project will be released into the atmosphere from natural disturbance, such as wildfire, or from human activities

- Safeguards: criteria and procedures for mitigating risks and minimizing harm to forest communities

We conclude with two sets of recommendations. We provide specific recommendations for bringing Verra's standards and methodologies into alignment with current science. Our findings also point to the need for more fundamental changes from carbon crediting to other approaches for supporting REDD+.

The Making of a Carbon Credit Under Verra

Color legend: Actors, Documents, Steps

The voluntary carbon market is created, managed, and self-regulated by a small number of nonprofit credit registries. Verra,[3] a nonprofit organization based in Washington, DC, runs the largest voluntary carbon market program, the *Verified Carbon Standard* (VCS), with close to two-thirds of the market to date. Verra maintains rules, requirements, and procedures[4] for the whole system. These are documented in its overarching *Program Guide* and *VCS Standard*.[5] Previous versions of all program documents are archived on the Verra website.[6] Verra adopts methodologies,[7] mostly developed by project developers, and also called *protocols*, for a range of project types.

Each methodology defines project eligibility criteria and methods for estimating the climate impacts from participating projects, including reference to separate tools and modules, and monitoring and reporting requirements. Verra also created and manages a system of third-party auditing. Verra accredits auditors; issues credits (called Verified Carbon Units; VCUs); and maintains a registry[8] for keeping track of what credits are issued (each with its own serial number), who owns them, and who retires them (i.e., informs Verra they are using credits to meet a target). This is a private-sector model whereby Verra creates and oversees a set of market rules, and market players do the rest.

The project proponent (also called the project developer) is the entity to whom credits are issued. The developer can be the landowner, such as a forest community, government, or timber company; they can also be, and often are, a business or nonprofit organization dedicated in full or part to developing carbon credit projects. Because the methodologies are so complicated, unless the developer has significant expertise in carbon credit projects, they will likely bring on a consultant to do the paperwork, modeling, and calculations.

The project developer chooses an appropriate methodology. They develop a project description document, which describes the project and shows that it meets all the eligibility

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3 Verra website: https://verra.org/
4 VCS Program Details: https://verra.org/programs/verified-carbon-standard/vcs-program-details/
5 *The Program Guide* and *VCS Standard* are on the VCS Program Details page under VCS Requirements: https://verra.org/programs/verified-carbon-standard/vcs-program-details/#rules-and-requirements
6 VCS Program Previous Version: https://verra.org/programs/verified-carbon-standard/vcs-program-previous-versions/
7 VCS Methodologies: https://verra.org/programs/verified-carbon-standard/vcs-program-details/#methodologies
8 Verra Registry: https://registry.verra.org/

requirements of the methodology and submits it to Verra so Verra can list the project on the Verra Registry.

The developer hires a Verra-accredited third-party auditor, called a validation/verification body (VVB), most of which today are large long-established companies based in the Global North. The VVB is hired to validate the project design document, including with a site visit, to make sure the project meets all requirements. The VVB checks project eligibility, its monitoring process, and methods of calculating project emissions reductions or carbon removals. The VVB's validation report is sent to Verra.

If a project is positively validated, it is considered registered on the Verra Registry. The project is then allowed to generate credits, each nominally representing the equivalent of one metric ton of carbon dioxide (tCO_2e) reduced or removed from the atmosphere.

Periodically, the project developer prepares a monitoring report that reports on the results of their team's ongoing project monitoring, performed according to their approved monitoring plan. The monitoring report includes calculations of the total climate benefit since the end of the previous monitoring period, or the start of the project if it is the first one, in accordance with the methodology.

The developer hires a VVB to verify the monitoring report, including with a site visit, to make sure that the project still meets all eligibility requirements and that the carbon calculations follow methodology rules. If it is the first monitoring report, the developer can have the validation and the first verification audited at the same time by the same VVB. The verification report is sent to Verra.

With Verra's approval of the documents, the developer can request that Verra issue credits (paying a fee per credit). The developer can sell the credits to credit buyers, often through credit brokers. Buyers should retire credits if they use them toward a climate target, and are required to retire the credits if they use an official inventory system such as the Carbon Disclosure Project or The Climate Registry. They can retire credits by informing Verra of the credit serial numbers they are using. The credits cannot then be sold and used by someone else.

Verra's *Program Fee Schedule*[9] lists the fees it charges for opening an account, registering a project, issuing each credit, and developing a methodology.

All the project reports mentioned above should be available on the project's page on the Verra Registry, along with information about all credit issuances and retirements.

A Typical Verra REDD+ Carbon Project

Here we describe how a typical REDD+ project generating credits on the voluntary market describes itself, by summarizing the narratives in the project design documents of the 75 REDD+ projects that had been issued credits on the voluntary market as of March 2022.

A typical VCS-REDD+ project is created by a project developer (a non-governmental organization, a company devoted to REDD+ project development, a timber company, or sometimes the government itself). The project developer might also be the landowner or might work with the landowner to develop the project. The land area enrolled may be owned by a government (sometimes leased with a logging or other type of harvesting/producing concession to a

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[9] The Program Fee Schedule is on the VCS Program Details page under VCS Requirements: https://verra.org/programs/verified-carbon-standard/vcs-program-details/#rules-and-requirements

company), forest communities (who may or may not have property rights), or private actors (such as timber companies or private ranchers).

The majority of projects focus on reducing deforestation and forest degradation by changing the behavior of forest communities, Indigenous peoples, migrants, and other subsistence land users. Some are impoverished smallholders who practice selective (sometimes illegal) logging as a means of market access. Some practice swidden agriculture and collect fuelwood from the forest. Some are migrants without formal land rights who convert land to small-scale agriculture and pasture for their livelihoods.

Most project narratives describe smallholders, locals without land tenure, and migrants as primary drivers of deforestation, due to ineffective or inefficient agricultural practices, population growth, and selective logging. Interventions by these projects focus on changing community land use practices, sometimes in ways that restrict local livelihoods. Common interventions described in the project documents (but not always carried out in practice) include training and technical assistance on sustainable agricultural practices to improve crop production and intensify agriculture on existing farmland to relieve pressure on the forest. Support for alternative livelihoods (e.g., growing cocoa, coconut, acai, chestnuts; developing fisheries and aquaculture) to replace timber and other forest-related income is also common, either through education and training or funds for specific equipment. Some projects involve paying people directly to reduce deforestation activities; and some involve the conversion of communal or informally held lands to individual property titles. The majority of projects describe paying for patrols or monitoring of project areas with varying intensity. Occasionally, projects offer cookstoves for more efficient fuelwood burning to reduce the collection of firewood from the forests. Projects can involve other community benefits unrelated to deforestation, such as schools and health clinics. When the primary driver of deforestation is a single agent holding an economic concession plan to clear the land for a plantation or timber operation, the intervention may involve substituting carbon credits for lost business revenue.

How REDD+ Methodologies Work

Of the 97 REDD+ projects registered on the Verra registry through May 2023, 94 use four offset methodologies (Table 1.1). Each methodology defines the eligibility requirements projects should meet to participate, the activities credited under the methodology, methods for estimating emissions impacts, and methods for monitoring and reporting those impacts. Note that developers can deviate from the methodology as long as they provide justification, and that justification is accepted by the third-party auditor. Projects must also meet the requirements laid out in the *VCS Standard* (Verra, 2023b).

The leading developers of VM0006, VM0009, and VM0015 and several codevelopers of VM0007 were REDD+ project developers who went on to develop REDD+ projects using the methodology they developed (Table 1.2). Prior to adopting a new methodology, Verra invites public comment by posting the draft methodology on its website for at least 30 days. Verra also requires new methodologies to be assessed by a VVB, which is chosen by the developer from a pool selected by Verra (2023a). Methodologies are also periodically reviewed and updated.

The four VCS REDD+ methodologies differ somewhat in scope (e.g., ecosystems, types of deforestation drivers); the types of activities that may be monitored and credited; and their carbon calculation methods, including required or recommended modules and tools. All methodologies credit reductions in unplanned (unsanctioned) deforestation, and VM0007 and VM0009 also credit reductions in planned deforestation (designated and sanctioned; Table 1.2).

Table 1.1

Projects and Credits, by REDD+ Methodology

	Projects		
Methodology	**Registered**	**All**	**Credits issued**
VM0006 methodology for carbon accounting for mosaic and landscape-scale REDD projects	13	19	15,123,204
VM0007 REDD+ methodology framework (REDD+MF)	36	75	179,073,015
VM0009 methodology for avoided ecosystem conversion	11	18	129,970,656
VM0015 methodology for avoided unplanned deforestation	34	93	86,520,677
Sum of 4 methodologies	**94**	**205**	**410,687,552**
Sum of all REDD+ projects	**97**	**215**	**444,551,724**

Source. So, I., Haya, B. K., & Elias, M. (2023). *Voluntary Registry Offsets Database, v8*. Berkeley Carbon Trading Project, University of California, Berkeley. https://gspp.berkeley.edu/faculty-and-impact/centers/cepp/projects/berkeley-carbon-trading-project/offsets-database

REDD+ methodologies define how projects establish deforestation baselines; account for leakage; and measure, monitor, and report emissions reductions and removals over time. The climate benefits of REDD+ activities, meant to mitigate one or more of the drivers of deforestation and degradation, increase removals or otherwise reduce emissions on project lands, are calculated by a number of equations. These equations estimate the difference between the project scenario (actual changes in carbon stocks in the project area), and the baseline scenario (predicted changes that would likely have occurred without the project intervention). Broadly, the total number of credits generated is the difference between those two scenarios, minus estimated emissions from leakage, a discount factor for uncertainty, and a buffer pool deduction to cover the risk of reversal from natural and human causes.

Baseline emissions projections for deforestation rates are estimated based on historical trends in a reference region. A reference region is a comparison region whose historical deforestation and forest degradation rates and trends are used to predict future deforestation and degradation rates in the project area in the baseline scenario, almost always over the 10-year period just prior to the start of the project. Methodologies differ in how they estimate these rates, which we discuss in some detail in Chapter 2: Baselines. Baseline rates are multiplied with the carbon per hectare estimates in the project area (*forest carbon accounting*), based on inventories of sample plots and extrapolated to the whole project area, using remote sensing imagery. The sample plots are periodically reinventoried, and the baseline is adjusted over time to accommodate forest growth or degradation. Often this process is performed separately for different types of forests in the project area (called *stratum*).

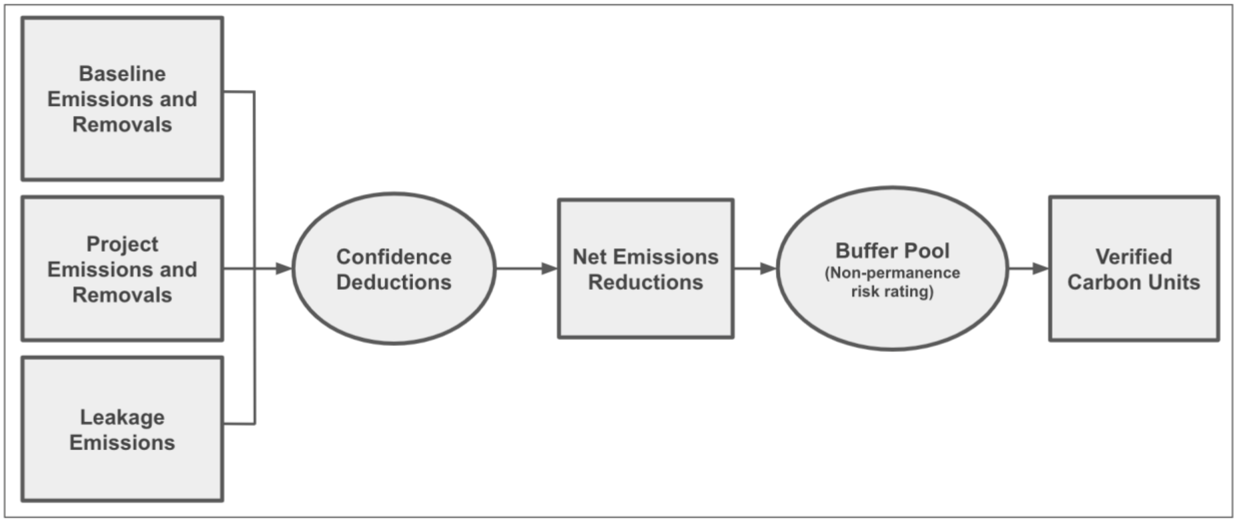
For the project area, actual changes in forest carbon stocks due to deforestation are monitored over time by remote sensing imagery. Methods for estimating project effects on degradation vary by activity (e.g., timber harvesting, improved cookstove deployment).

Forest carbon accounting always includes aboveground carbon in live trees. VM0006, VM0009, and VM0015 recommend the inclusion of belowground carbon in live trees but do not require it. Three of the methodologies—VM0006, VM0007, VM0015—require the use of the T-SIG tool (United Nations Framework Convention on Climate Change [UNFCCC], 2013), which provides the steps to determine which of the other pools are significant (greater than 5% of total project carbon benefits over the project lifetime) and, consequently, must be included in a REDD+ project. Dead wood, litter (VM0015 only), harvested and long-lived wood products (VM0006 and VM0015), and soil must be included when changes caused by the project activities are significant, if they are depleted by the project activities or if they are expected to have increased in the baseline. Otherwise, including the pools is optional, and excluding them is considered conservative since exclusion leads to fewer credits.

Credits are adjusted for *leakage*. Leakage occurs when reduced production, such as of timber or cattle, on project lands displaces production to other forested lands, causing deforestation or forest degradation elsewhere. Offset credits are reduced to account for uncertainty in carbon pool estimates. In addition, a proportion of credits is set aside into a buffer insurance pool in accordance with estimated natural and human-caused reversal risk, meant to fully cover the risk that credited emissions reductions will be reversed over a 100-year period (*durability*; Figure 1.1).

Figure 1.1

Simplified Flow Diagram for the Quantification of GHG Emissions Reductions and/or Removals and VCUs by REDD+ Methodologies



The methodologies differ in their list of other activities that must or may be included in the project's carbon accounting. Project activities can include legal logging operations, livestock grazing, charcoal production, improved cookstoves, tree planting, and assisted natural regeneration. For example, VM0006 allows for the crediting of changes in grazing and cropping systems, while VM0007 does not include those activities but includes wetland restoration. VM0009 includes the option of crediting reduction of conversion of native grasslands and shrublands to a non-native state (i.e., ecosystems with exotic species), including through activities such as legal logging, grazing, sustainable production of charcoal, and controlled burning. VM0015 is almost identical in scope and activities to VM0006, except that it also allows for the inclusion of forested wetlands that are not on peat soils. The methodologies also differ in how they estimate baselines, leakage, and emissions reductions. We describe these in detail in each of the respective chapters.

Safeguards are laid out in Verra's *VCS Standard*, which provides the requirements for developing projects and programs under any VCS methodology. The policies have evolved over time. In 2007, there was a general requirement for stakeholder consultation. In 2017, Verra created explicit safeguards, including the aim that projects have "no net harm" on communities and ecosystems.

Table 1.2
Overview of REDD+ Methodologies

	VM0006	VM0007	VM0009	VM0015
Overview	VM0006 credits reduced unplanned deforestation and forest degradation where deforestation follows a mosaic configuration, mainly by small-scale deforestation agents and drivers spread out across a forest landscape.	VM0007 is a modular REDD+ methodology that credits reduce planned and unplanned deforestation and degradation in forestlands, wetlands, peatlands, and tidal wetlands. Removing wood for fuel is the only cause of unplanned degradation included in the methodology.	VM0009 credits reduced planned and unplanned deforestation and reduced conversion of native grasslands and shrublands.	VM0015 credits reduced unplanned deforestation. Forested wetlands can be included except those on peat soils.
Developer	Terra Global Capital (REDD+ project developer)	Avoided Deforestation Partners (NGO) in partnership with several REDD+ project developers and consultants	Wildlife Works and ecoPartners (REDD+ project developers)	Carbon Decisions International (REDD+ consultants), Amazonas Sustainable Foundation (REDD+ project developer), BioCarbon Fund
Year first adopted	2010	2010	2010	2010–2011

This Report

The rest of this report assesses the rules and performance of Verra's REDD+ project-based carbon crediting program focused on the four most popular protocols and five essential quality elements:

In each chapter, we describe how Verra's standards and methodologies address offset credit quality. We also describe major differences between the methodologies. We summarize the scientific literature on the quality element and compare the methodologies, and how they are implemented and audited in practice, with that literature. We also report on our own analyses on samples of projects to further explore how well the crediting system accurately and conservatively estimates project emissions impacts and protects people, and why the methodologies fall short when they do.

Each chapter ends with specific recommendations for improving the quality of the methodologies and processes. We note where Verra's currently proposed updates make those improvements and where improvement are still needed. We also describe some inherent limitations of REDD+ carbon crediting, notably high levels of baseline and leakage uncertainty, the non-equivalence of fossil fuel carbon and carbon held in biomass, and an incentive structure at odds with protecting people and addressing the largest drivers of deforestation. Overarching discussion, conclusions, and recommendations are presented in the Executive Summary.

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Chapter 2: Baselines

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Executive Summary

Emissions reductions and removals from carbon market projects are estimated against a counterfactual scenario, the *baseline*, that represents what would likely have happened without the crediting program. For Reducing Emissions from Deforestation and Forest Degradation (REDD+) carbon crediting projects, the baseline is the most important factor in emissions reduction estimates. Because the total number of credits is generated based on the total area of forest *assumed* to be deforested or degraded in an alternative future without the crediting program, baseline estimates involve substantial uncertainty.

The four most-used *Verified Carbon Standard* (VCS) REDD+ methodologies—VM0006 (Terra Global Capital, 2017), VM0007 (Avoided Deforestation Partners, 2020), VM0009 (Wildlife Works & ecoPartners, 2014), and VM0015 (Pedroni, 2012)—forecast baseline deforestation rates at the start of the project. Project developers define a *reference region* larger than the project area and use historical deforestation rates in that region to construct the project baseline, either directly as a simple historical average or as a modeled trend. Two protocols (VM0007 and VM0015) have an additional step. They also use a risk-mapping exercise to apportion the projected deforestation across the reference region based on factors such as proximity to roads and to population centers. For each year, the portion of projected deforestation that falls inside the project area is the project baseline.

Recent literature points to serious problems with VCS-REDD+ baselines. The most rigorous evaluations of the impact of REDD+-type interventions construct baselines based on actual deforestation over time in one or several well-matched control areas unaffected by the intervention. Importantly, these methods assess baselines ex post, looking backward instead of forecasting forward. Ex post methods can capture changes unrelated to the REDD+ intervention that affect regional deforestation rates. Studies using these best practices report project baseline estimates that are much lower than the official baseline estimates used by VCS-REDD+ projects to generate credits (West et al., 2023; West, Börner, et al., 2020) and therefore report lower levels of impact than carbon credits issued to them, or even no impact at all (Delacote et al., 2022; Guizar-Coutiño et al., 2022; West et al., 2023). One study of 16 sample VCS-REDD+ projects across five countries found that the number of credits issued to them by VCS represented substantially more than their independent assessment of project impacts on deforestation using ex post control-plot methods (West et al., 2023). These quantitative findings comport with field-based case studies that found that three VCS-REDD+ projects generated large quantities of credits with little actual reduction in deforestation by choosing baselines with much higher historical deforestation rates (Seyller et al., 2016; Withey, 2021).

This chapter explores features of the four VCS-REDD+ methodologies that might explain the gaping differences between the baselines used by developers and the ex post baselines using control areas. We start by describing how each methodology constructs project baselines and the differences between them. We then examine the extent to which they offer developers flexibility in how they are applied, and whether the developers exploit that flexibility to earn more credits. This exploration includes an empirical exercise. We chose one project from each methodology in Brazil, Colombia, the Democratic Republic of Congo, and Peru. For each, we recreated the baseline seven times, using all four methodologies, and applying three methodologies twice, using different options within them. We made conservative methodological choices when choices were needed. Our analysis focuses on the unplanned deforestation component of the four projects, which tends to generate substantial volumes of credits and enables us to apply all four methodologies to all four projects, regardless of their eligibility criteria.

When we applied different VCS-REDD+ methodologies, and options within them, to the same project, the resulting deforestation baseline estimates varied enormously. The average difference across projects was 1459%. In other words, the highest of the seven values was more than 14 times the lowest value, on average, across the four projects (Figure 2.2). If a developer chose the most financially beneficial methodology over the least beneficial, they could receive in excess of 14 times the number of credits. All credits generated by the methodologies are treated as equivalent to one metric ton of CO_2-equivalent (tCO_2e) reduced. Large discrepancies between the alternative baselines of VCS-REDD+ methodologies raise concern about whether the credited reductions actually occurred, and consequently, about the environmental integrity of their carbon offsets, since those are derived from the project's performance relative to its baseline.

As anticipated, we also found that the official baselines used by the developers to generate offset credits were consistently on the high end of the range of alternative baselines we constructed. The official baselines were higher than 23 of our 28 alternative baselines. This suggests that developers are making methodological choices that lead to high, rather than conservative, estimates of project effects on emissions and credits issued.

All methodologies offer developers substantial flexibility in constructing baselines. VM0007 and VM0015 are the most manipulatable because of their reliance on deforestation risk maps. The choice of a risk-map modeling algorithm substantially affects the levels of baseline deforestation in the project area, thus affecting the volume of carbon offsets a project can issue. For example, for Project 1112 (Figure 2.2), our estimated baselines from VM0007 and VM0015, based on one allocation algorithm (multilayer perceptron; MLP), were orders of magnitude (off the chart) higher than the baselines from the second option (SimWeight; SW). Each risk map goes through a validation process that tests the percentage of map pixels that match reality. The original requirement was a validation score of 40% to 80%, depending on project conditions, but validation requirements have since been weakened so much they are almost meaningless. A review of the risk-map validation scores for nine voluntary REDD+ projects found the highest score (or accuracy) to be 12%. Three projects had scores lower than 1% but still passed the validation process (West, 2016). The lack of proper model validation creates a perverse incentive for developers to cherry-pick risk-map algorithms that financially benefit them.

All four methodologies allow flexibility to select the reference region, as long as minimum requirements are met. For example, Project 934 in the Democratic Republic of the Congo, using VM0009, defines its reference region 650 km away from the project. A field-based case study found that the far-away reference region was more heavily populated and closer to central commerce centers than the project area (Seyller et al., 2016). All methodologies also offer flexibility in the construction of the baseline equation, including whether a simple historical average or a trend line is used, and the factors used to construct the trend line if that option is chosen. A weakness of VM0009, beyond flexibility, is that it uses a logistic regression equation that can result in artificial spikes in baseline deforestation at year zero and steep growth curves in the early years of the project.

VCS is working on a new, consolidated REDD+ methodology for avoided unplanned deforestation projects that would replace all current REDD+ methodologies (Climate Focus, 2023). While their draft remains to be finalized, it significantly reduces the flexibility we observed. It would establish baseline deforestation rates that are based on 10-year historical averages, which is more conservative than regression models with upward-trending forecasts, such as the model prescribed by VM0009 and allowed by all methodologies. It would require the use of a deforestation risk map similar to those of VM0007 and VM0015, which involves the highly subjective choice of algorithm and underlying data, as demonstrated in this study. Risk maps likely will be developed at the jurisdictional level, using the whole jurisdiction as the reference region, thereby removing the flexibility individual developers have to choose their reference region. Furthermore, the consolidated methodology is expected to set out more clear and transparent guidelines that would avoid bias in deforestation risk-map development.

However, the draft consolidated methodology does not go far enough to avoid the risk of gaming and to accurately estimate baselines. The risk-map approach transfers the responsibility of the allocation analysis (and also room for baseline gaming) from developers to third-party contractors. Furthermore, gaming can still occur through the choice of project areas that would not have been deforested because of factors the developer may know about, but which the deforestation risk map does not capture. Similar adverse selection has been documented with improved forest management carbon projects in the United States (Badgley et al., 2021). Perhaps most importantly, the proposed consolidated methodology falls short of controlling for dynamic changes in deforestation drivers and rates, and thus would remain unable to rigorously demonstrate additionality and ensure the environmental integrity needed for offsetting.

To address the remaining potential inaccuracies in the proposed consolidated methodology, we suggest several fundamental changes. Ex post methods that monitor real deforestation in a well-matched control plot and use those rates as the project baseline have been found to be most accurate (Guizar-Coutiño et al., 2022; West et al., 2023; West, Börner, et al., 2020). We note two limitations with such methods. Good controls for the project areas may be difficult to find and can change over time. Also, dynamic baselines add risk to developers by creating uncertainty in the baseline and therefore in the number of credits generated by avoided deforestation projects, thus making it harder for truly additional projects to participate. Alternatively, potentially more accurate and less gameable methods for setting baselines may be available from the statistical modeling literature (Balmford et al., 2023). These methods have not been explored and tested in the REDD+ context, but efforts could be made to do so. Regardless of the method used, fully disclosing baseline calculations and assumptions so that independent parties can assess the credibility of baseline calculations is necessary for a quality market.

It is clear from our review and empirical analyses that the VCS-REDD+ methodologies represent complex ways of creating simplistic reference levels for the project sites, as opposed to constructing rigorous counterfactuals for proper impact evaluations. The extent to which methodological choices and choice of methodology can change the baseline scenario and the number of credits generated, sometimes with a 10-fold or greater difference, means that baseline setting under current methodologies is more akin to storytelling and assumption choosing than about real forest risk. While Verra's proposed consolidated REDD+ methodology addresses many of the sources of flexibility we find with the current pool of projects and credits, it does not address the more fundamental challenges of accurately assessing project baselines, specifically around confounding factors, risk map creation, and adverse selection. Inherently high uncertainty in true project baselines and room for manipulation with both existing and proposed methods justify a shift away from carbon crediting to a contributions- or donations-based approach for directing private funding into REDD+ initiatives.

Introduction

The effectiveness of voluntary REDD+ projects at reducing greenhouse gas (GHG) emissions from deforestation is measured against a baseline (or counterfactual) scenario representing the expected deforestation in the absence of REDD+ activities. The higher the baseline deforestation, the more carbon credits a project can claim. Because deforestation can be affected by a number of factors that change over time, ex post analyses (i.e., based on actual results rather than forecasts) using control units (i.e., similar areas that were not exposed to REDD+ activities) are considered the state of the art for creating credible counterfactuals and estimating the impact of REDD+ projects (Guizar-Coutiño et al., 2022; West et al., 2023; West, Börner, et al., 2020). Such ex post approaches control for potential bias from confounding factors that vary over time but affect both project and control units similarly (Ferraro & Hanauer, 2014).

In contrast, the REDD+ methodologies adopted by most existing voluntary REDD+ projects take a different approach. Those methodologies, approved under the *VCS Standard* for carbon credit certification, including the four that have generated almost all REDD+ carbon credits to date—VM0006, VM0007, VM0009, and VM0015—use ex ante baselines (i.e., based on forecasts). Baseline deforestation rates are based on simple extrapolations of historical trends (usually observed over a 10-year period prior to the project start date), ignoring contemporaneous changes in political or economic contexts known to influence deforestation (Assunção et al., 2015; Busch & Ferretti-Gallon, 2017; Lambin et al., 2014; West & Fearnside, 2021). As a result, simplistic ex ante baselines can easily become unrealistic.

In addition, the construction of ex ante deforestation baselines, according to the VCS-REDD+ methodologies, involves a critical spatial analysis. Because project sites are largely covered by forests (i.e., areas virtually without deforestation), the baseline deforestation is informed by the historical deforestation observed at a broader spatial scale, known as the *reference region*. Furthermore, while VM0006 and VM0009 tend to proportionally use the reference region's historical deforestation rates (i.e., annual averages or forecasts from statistical models) as the project baseline, the most popular methodologies, VM0007 and VM0015, adopt an approach based on spatial "pixel-level prioritization." Under this approach, the spatial allocation of baseline deforestation is distributed across the reference region based on regional deforestation-risk/suitability maps, produced based on relationships between historical deforestation patterns and observable spatial attributes within the reference region (e.g., distances to roads and rivers, presence of protected areas, elevation, slope, and soil type; Sloan & Pelletier, 2012; West et al., 2019). Instead of simply annually applying an average or forecasted deforestation rate to the project area, annual baseline deforestation rates are distributed across the reference region according to deforestation-risk maps, starting with the pixels with the highest risk. Only the deforestation allocated within project boundaries throughout the lifetime of the project is considered part of the project's baseline scenario. However, several algorithms can be employed for the construction of deforestation-risk maps (e.g., logistic regressions and artificial neural networks), resulting in "equally valid," and yet contradicting, spatial configurations (Lin et al., 2011; Soares-Filho et al., 2013; West, Monge, et al., 2020). As a result, VM0007 and VM0015 leave extra room for gaming, given that configurations that allocate more baseline deforestation inside the project areas—thus allowing the projects to claim more credits—are financially more attractive than others (e.g., Soares-Filho, 2012).

Recent literature points to serious problems with VCS-REDD+ baselines. Studies using best practice ex post control methods report project baseline estimates that are much lower than the official baseline estimates used by VCS-REDD+ projects to generate credits (West et al., 2023; West, Börner, et al., 2020) and therefore report lower levels of impact than carbon credits issued to them, or even no impact at all (Delacote et al., 2022; Guizar-Coutiño et al., 2022; West et al., 2023). For example, the number of verified credits for 16 VCS-REDD+ projects across five countries through 2021 (So et al., 2023) were more than 12 times West et al.'s (2023, Table S10) estimates of project impact using rigorously estimated project baselines based on control sites. West et al. (2023) also detected no positive effect on deforestation from nine of the 16 REDD+ projects.

These quantitative findings comport with field-based case studies. Withey (2021) found the VCS BIOREDD+ project (VCS 1392) in Colombia did not result in reductions in deforestation and degradation but still earned almost half a million credits. This happened primarily due to the choice of a reference region with greater historical levels of deforestation than the project area. Similarly, Seyller et al. (2016) found the developers of the Maï Ndombe REDD+ Project (VCS 934) in the Democratic Republic of the Congo and the CAZ REDD+ Project in Madagascar (VCS 1311) used reference regions with historical rates of deforestation almost double those of the project areas. The authors concluded that because projects can easily generate credits without anything changing on the ground, baselines "amount to untestable guesses" (p. 240).

In this chapter, we explore the methodological reasons the baselines adopted by voluntary REDD+ projects tended to result in unreliable counterfactual scenarios. First, we examine the key assumptions underlying the four most-adopted VCS-REDD+ methodologies. Second, we use the key methodological assumptions underlying those methodologies to create alternative ex ante deforestation baselines for four operational REDD+ projects in Brazil, Colombia, the Democratic Republic of Congo, and Peru. We compare our alternative baselines to the official project baselines used to claim carbon credits, as well as to ex post counterfactuals constructed based on observable control units from West, Börner, et al. (2020) and West et al. (2023).

VCS-REDD+ Methodologies

VM0006: Methodology for Carbon Accounting for Mosaic and Landscape-scale REDD Projects (v.2.2)

VM0006 is a VCS-REDD+ methodology for projects located in regions where deforestation follows a "mosaic" configuration (Terra Global Capital, 2017), where mainly small-scale deforestation agents and drivers "are spread out across the forest landscape" and "most areas of the forest landscape are accessible to human populations" (VCS, 2017, p. 22). In VM0006, baseline deforestation is based on a historical average or trend observed from the project's reference region and is proportionally applied to the REDD+ project area (Table 2.1). Thus, decisions about the spatial allocation of baseline deforestation are only required if the project is represented by more than one forest stratum (with different carbon stocks), and/or more than one post-deforestation land-use class is considered part of the baseline scenario (also associated with different carbon stocks).

The estimation of the baseline deforestation rate is based on "beta regressions," fitted to historical deforestation data.[10] These regressions are mainly a function of time (i.e., years prior to project start) but can include other covariates related to deforestation, such as protection status, distance to roads, etc. If a model can be constructed for which all covariates are significant (*p*-value ≤ 0.05), the lower limit of the 95% confidence interval of the regression model's forecast can be used as the deforestation baseline; otherwise, the baseline must be based on a historical average (Table 2.1). The baseline deforestation is further discounted by two "forest scarcity factors," rendering the baseline more conservative. The use of these factors is grounded on the forest transition theory (Köthke et al., 2013; Rudel et al., 2005), which postulates deforestation rates to decrease with socioeconomic development and associated shifts in the labor market.

While VM0006 is complex, the calculation of the baseline deforestation can be simplified to:

$$D_{PA,t} = d_{RR}(t) \times \frac{PA}{RR} \times \frac{1}{1 + e^{s_1\left(s_2 - \frac{NFA_t}{PA}\right)}} \qquad 1)$$

where $D_{PA,t}$ is the baseline deforestation in the REDD+ site in year t (ha), which is a function of $d_{RR}(t)$, representing either an annual deforestation average or a forecast from a linear (or "beta regression") model based on historical deforestation data from the project's reference region, adjusted by the proportional size of the project area (PA) in relation to its reference region (RR), and discounted by the forest scarcity factors s_1 and s_2. In turn, these factors are a function of the non-forest area (NFA_t) proportion within PA; s_1 represents the deforestation rate of decay, whereas s_2 is the relatively cleared area at which deforestation is expected to reach 50% of the initial deforestation rate in the project region.

VM0007: REDD+ Methodology Framework (v.1.6)

VM0007 is a VCS-REDD+ methodology composed of several modules (Avoided Deforestation Partners, 2020). The VMD0007 "Estimation of baseline carbon stock changes and greenhouse gas emissions from unplanned deforestation and unplanned wetland degradation (v.3.3)" is the module dedicated to the construction of unplanned deforestation baselines. This module provides two approaches to estimating baseline deforestation rates: simple historic and population driver (Table 2.1). Under the simple historic approach, baseline deforestation rates are based on the historical deforestation observed within the project's reference region for projecting rate of deforestation (RRD); similar to VM0006, rates are based on historical averages or forecasts from statistically significant regression models—linear, exponential, or logarithmical—that are a function of time (with *p*-values ≤ 0.05 and $R^2 \geq 0.75$). Under the population driver approach, rates are instead informed by the historical per capita deforestation observed within a geopolitical unit where the

[10] As defined in VM0006, beta regressions are "commonly used to model variables that assume values in the standard unit interval (0; 1)," where the dependent variable is beta-distributed with a mean related to a set of regressors through a linear predictor with unknown coefficients and a link function (Terra Global Capital, 2017, p. 48). However, such a definition of beta regressions is not compatible with the equations, steps, and examples provided throughout VM0006 on the calculation of baseline deforestation rates (Terra Global Capital, 2017, pp. 48–52). It is our understanding that, despite its definition, the term *beta regression* is in fact used in the methodology to describe a linear regression model (hence our use of the term in quotes).

REDD+ project site is located (e.g., municipality, census unit); this approach requires historical information about the local or regional population (e.g., from household surveys or census data), as well as a projection of population growth.

In VMD0007, baseline deforestation rates are estimated at the reference region level but are not proportionally allocated to the REDD+ project site, as in VM0006 (Table 2.1). Although exceptions may apply, the project's baseline deforestation is ultimately a function of the spatial allocation of the RRD rates across another reference region encompassing the project area (reference region for projecting location of deforestation; RRL). Only the baseline deforestation allocated within project boundaries is considered part of the project's baseline scenario. The spatial allocation of the baseline deforestation is informed by a deforestation-risk/suitability map, which can be constructed in a variety of ways. Generally, spatial algorithms establish relationships between historical deforestation patterns observed within the RRL (i.e., the dependent variable) and biophysical and socioeconomic factors observed across the landscape (e.g., soil type, slope, elevation, accessibility, tenure status—that is, independent variables), returning a raster map with estimated likelihoods of deforestation at the pixel level. Any international peer-reviewed algorithm is eligible for use under VMD0007. Once a deforestation-risk map is constructed, baseline deforestation rates are annually allocated to the pixels with the highest likelihood of deforestation, until the total expected area of baseline deforestation is reached. Because the number and type of independent variables included in the spatial algorithm can substantially alter the estimated pixel-level likelihood of deforestation, and thus the final deforestation baseline map itself, VMD0007 requires several risk maps (and deforestation baseline maps) be produced. In the end, the map associated with the highest accuracy, based on the outcome of model validation metrics, is adopted as the project's baseline scenario.

According to VMD0007, the validation of the deforestation baseline maps should be based on the Figure of Merit method (Pontius, 2018). This method is based on map comparisons, where the output from the allocation algorithm (i.e., simulated baseline map) for a specific historical period is compared to an observed map. The Figure of Merit can range from 0% (when no simulated pixel-level deforestation matches what was observed in the real world) to 100% (for a perfect match). According to VMD0007, the minimum Figure of Merit threshold for the spatial algorithm to pass validation is defined by the relative historical deforestation level in the RRL (but exceptions are allowed if supported by the literature).

VM0009: Methodology for Avoided Ecosystem Conversion (v.3.0)

The estimation of baseline deforestation rates in VM0009 is similar to that in VM0006: they are based on the historical deforestation observed across the project's reference region level and proportionally applied to the project area (Wildlife Works & ecoPartners, 2014). However, VM0009's estimates are based on the forecast of a logistic regression model fitted to random samples collected at the reference region level through time, prior to the start of the project (Table 2.1). The logistic regressions are a function of time but, similar to VM0006, can also include additional covariates related to deforestation (e.g., population density, road density). Yet, like VM0006, VM0009 provides little guidance on how these covariates should be constructed and employed; thus, these covariates tend to be ignored by project developers.[11] VM0009 does not apply

[11] As of March 2022, only two projects included one additional covariate (i.e., population density) other than "time."

discounts, such as the forest scarcity factors, nor require the lower limit of the 95% confidence interval of the forecast be adopted for conservativeness, resulting in less conservative baselines compared with VM0006. As in a standard logistic regression model, baseline deforestation in VM0009 can be generally defined as:

$$D_{PA,t} = \frac{1}{1 + e^{-\mu(t,\theta)}} \tag{2}$$

where $D_{PA,t}$ is the baseline deforestation in the REDD+ site in year t (%), which is a function of time t and, optionally, other covariates related to deforestation (θ).

Mathematically, the use of logistic regressions (as well as beta regressions) can lead to inflated baselines in two ways, particularly in the early years of the project. First, the exponential growth behavior of the logistic functional form before its inflection point (i.e., concave upward) potentially leads to a sharp increase in baseline deforestation within the first years of the project. Second, the intercept of the logistic regression can artificially lead to an assumed "spike" in baseline deforestation at year zero of the project. This is because the time variate in VM0009's logistic regressions is relative to the project start date (e.g., $t = -10, -9, \ldots, -1$; Wildlife Works & ecoPartners, 2014, pp. 76–78). Despite these functional issues, VM0009 claims to be grounded on the "economic theory of resource consumption (i.e., ecosystem conversion) within a discrete area over time" (p. 191).

VM0015: Methodology for Avoided Unplanned Deforestation (v.1.1)

The construction of unplanned deforestation baselines in VM0015 is rather similar to VM0007's "simple historic" approach; how the allocation of the baseline deforestation is conducted and validated is also similar (Pedroni, 2012). In addition to allowing the use of a historical deforestation average observed within the project's reference region and linear or nonlinear regression models to forecast the baseline deforestation, VM0015 explicitly allows the use of any other (simulation) modeling approach (e.g., Vitel et al., 2013; Table 2.1).

The main difference between VM0015 and VM0007 is that the former does not have an alternative population driver option. Furthermore, when baseline deforestation is based on a historical average rather than a model forecast, annual deforestation rates are proportionally applied only to the remaining forest area within the reference region over time. Thus, even though VM0015's average proportional rate of deforestation (% year^{-1}) remains constant, the absolute deforestation rate (ha year^{-1}) shrinks over time, as:

$$D_{RR,t} = \left(A_{RR} \times \frac{PA}{RR}\right) \times FA_t \tag{3}$$

where $D_{RR,t}$ is the baseline deforestation in the REDD+ project's reference area in year t (ha), which is a function of the historical annual deforestation rate average (%) in the project's reference region (A_{RR}), adjusted by the proportional size of the project area (PA) in relation to its reference region (RR), and discounted by the remaining forest area within the REDD+ site at time t (FA_t). Consequently, this formulation implies an exponential decay of the deforestation rate over time across the reference region, in line with the forest transition theory (Köthke et al., 2013; Rudel et al., 2005). Lastly, when baseline deforestation is forecasted with the use of a model, VM0015 requires time-varying discounts to be applied to the forecasts, which are a function of the remaining forest area "eligible" for deforestation within the reference region, based on biophysical factor constraints (Pedroni, 2012, pp. 44–47). As a result, baseline deforestation rates estimated based on VM0015 are, in theory, more conservative than those based on VM0007. Still, unlike VM0006 and VM0007, VM0015 does not have explicit requirements about the statistical robustness of regression or simulation models used to forecast baseline deforestation (Table 2.1).

Like VM0007, VM0015 requires spatial allocation of the baseline deforestation across the reference region and validation of the allocation algorithm, but it allows for the use of alternative model validation methods other than the Figure of Merit (although that is the only spatial validation method mentioned in VM0015). Again, only the baseline deforestation allocated within project boundaries is considered part of the project's baseline scenario.

Methods

We systematically scrutinized and empirically tested the key assumptions used in the construction of unplanned deforestation baselines underlying the four VCS-REDD+ methodologies discussed above and their implications. We selected four VCS-certified voluntary REDD+ projects from Brazil (Project 1112; VM0007), Colombia (Project 1396; VM0006), Democratic Republic of Congo (Project 934; VM0009), and Peru (Project 944; VM0015) and constructed alternative deforestation baselines based on the key methodological assumptions underlying those four methodologies.

Each of the selected projects adopted a different VCS-REDD+ methodology and had been rigorously evaluated in previous studies, in which ex post deforestation counterfactuals were constructed for these projects based on observable control units through time (West et al., 2023; West, Börner, et al., 2020). Project selection was based on the overall quality of those ex post deforestation counterfactuals, measured as the covariate balance (i.e., the similarity between the covariates used to match the project and control areas), including similar pre-project deforestation rates in the "to-be" project sites and buffer zones, as well as the outcome of proof-of-concept exercises involving the construction of the ex post counterfactuals (West et al., 2023; West, Börner, et al., 2020). We chose four projects from West et al. (2023) that were geographically diverse and for which reduced avoided deforestation was both the most significant component for credit generation and appropriate for baseline setting under all four methodologies.

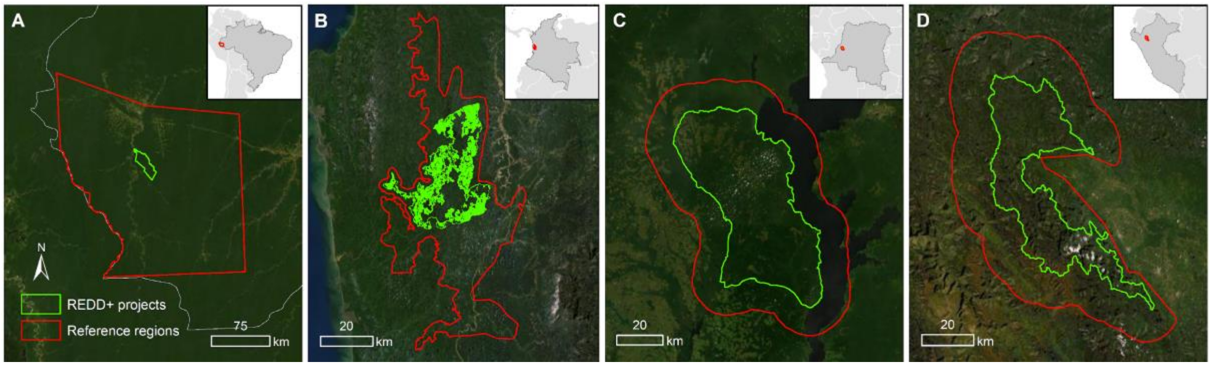
We compared our alternative baselines to the official project baselines and the projects' respective ex post counterfactuals. In particular, because Project 934 did not provide information on its baseline deforestation rates, we needed to estimate those based on the project's reported living biomass stock of 876.7 metric ton CO_2 ha^{-1}, obtained from the project's validation report (DNV Climate Change Services, 2012) and the project's reported ex ante annual baseline emission reductions (Wildlife Works, 2012). We created multiple alternative baselines from the same VCS-REDD+ methodology by adopting different approaches to estimate baseline deforestation rates and allocated those across the projects' reference regions, as allowed by the respective methodologies.

Voluntary REDD+ project areas (in the form of spatial polygons) were obtained from the VCS project database (Figure 2.1). We replicated the projects' reference regions with similar sizes and shapes, as reported in the official project descriptions (CarbonCo et al., 2014; Conservation International Peru, 2015; ecoPartners et al., 2014; Wildlife Works, 2012). We employed a buffering approach to create Project 934's reference region instead of replicating its actual reference area because the latter is located approximately 650 km from the project site and does not comply with the requirements from the other VCS-REDD+ methodologies. Additionally, the project's official reference region is apparently more heavily populated and closer to central commerce centers than the project area with different policy contexts and drivers of deforestation (Seyller et al., 2016).

We employed two algorithms to construct the deforestation risk maps for the projects' reference areas, both available from the Land Use Modeler, a land-use/cover change simulation model, part of the TerrSet software (v.18.2; Eastman, 2016) and often adopted by project developers: the MLP artificial neural network and SW, a similarity-weighted, instance-based machine-learning tool (see Eastman, 2016; Sangermano et al., 2010). Table 2.A1 describes the variables used to construct the deforestation-risk maps, matching the ones also considered by the project developers. To ensure the compatibility of our results with the projects' ex post counterfactuals from West, Börner, et al. (2020) and West et al. (2023), deforestation data for Projects 934, 944, and 1396 were obtained from the Global Forest Change dataset (Hansen et al., 2013) for the 2001–2021 period (West et al., 2023), whereas the data for Project 1112 were obtained from a reprocessed version of the MapBiomas land-use/cover dataset (Souza et al., 2020; see West, Börner, et al., 2020).

Figure 2.1

REDD+ Project Locations (Inner Borders)



Note. **(a)** Project 1112, Brazil; **(b)** Project 1396, Colombia; **(c)** Project 934, Democratic Republic of Congo; **(d)** Project 944, Peru. Reference regions (outer borders) were constructed based on the information available from the official project descriptions, with the exception of Project 934 for which we replaced the project's reference region located ~650 km from the project area with a ~15-km buffer around the project area.

To create alternative project baselines for each project in our study using the four VCS-REDD+ methodologies, additional assumptions needed to be adopted. For the baselines based on VM0006, two sets of values were adopted for parameters s_1 (i.e., 0.25 and 0.75) and s_2 (i.e., 0.25 and 0.75) in order to cover a wide range of deforestation contexts. Due to population data constraints, we restricted the construction of the alternative deforestation baselines based on VM0007 to the simple historic approach. Lastly, following the standard practices adopted by project developers, additional model covariates related to deforestation (represented by the θ parameter; Equation 3) were not included in the logistic regressions from VM0009.

The time parameter estimates from VM0006's, VM0007's, and VM0015's regression models were only significant for Project 944 (Tables 2.A3 and 2.A4). Thus, deforestation baseline rates were based on historical averages for Projects 934, 1112, and 1396, under VM0006, VM0007, and VM0015, and on forecasts for Project 944. As expected, all logistic regression models from VM0009 returned significant time parameter estimates (Table 2.A5).

Results

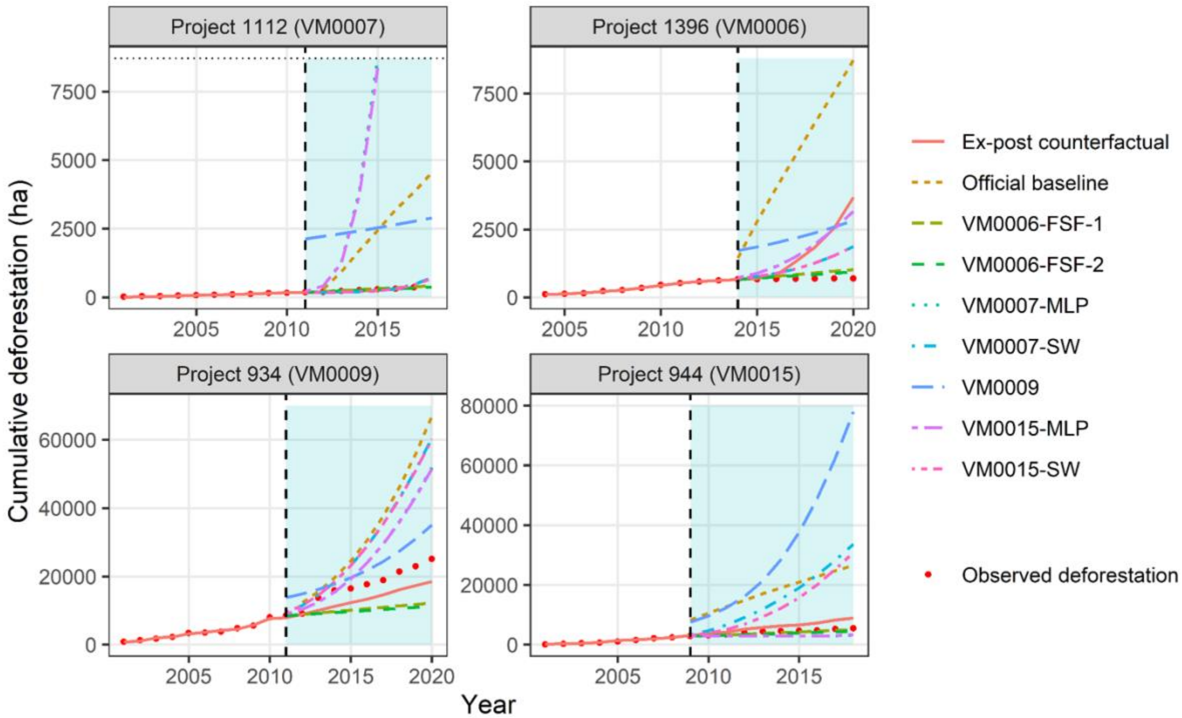
We found large discrepancies in deforestation baselines for voluntary REDD+ projects across the VCS-REDD+ methodologies and options within them, driven by the underlying methodological differences discussed above (Figure 2.2). In the most extreme case, Project 1112's alternative baselines varied by 2401%. This variation ranged 363–8713 ha of cumulative deforestation through 2018, with the official baseline for the project being 4547 ha for the same year. The variability in alternative baselines for Project 944 was also significant, varying by 2521%. The range of cumulative deforestation through 2017 was 3092–77,943 ha, with the official baseline for the project set as 26,528 ha for the same year. Project 934's alternative baselines varied by 537%, ranging 11,271–60,512 ha by 2020; the project's official baseline through 2020 was set at 66,896 hectares. Finally, Project 1396's alternative baselines varied by 340%, ranging from 931–3166 ha by 2020; the project's official baseline for 2020 was set at 8735 ha (see this chapter's appendix for details). Furthermore, most recalculated deforestation baselines from the VCS-REDD+ methodologies were substantially higher than the projects' estimated ex post counterfactuals from West, Börner, et al. (2020) and West et al. (2023).

Overall, VM0006 returned the most conservative baselines (likely because our calculations were based on forecasts from linear as opposed to actual beta regression models, as discussed above), whereas VM0007 and VM0015 resulted in the least conservative estimates. For these two methodologies, which rely on risk maps to spatially allocate baseline deforestation across the projects' reference regions, we found that the baseline deforestation allocated within project boundaries was substantially affected by the algorithm employed for the construction of the underlying deforestation risk maps (i.e., SimWeight or MLP; Figures 2.A1–2.A17), as best illustrated by the Project 1112 case (Figure 2.2). For that project, the baselines from VM0007 and VM0015, based on the MLP allocation algorithm, were orders of magnitude higher than the baselines from other VCS-REDD+ methodologies. In fact, we found small differences in baseline deforestation between VM0007 and VM0015 when the same allocation algorithm was adopted by each project (Figures 2.2 and 2.A2–2.A17).

Among all methodologies, VM0009 was the only one associated with artificial spikes in baseline deforestation at year zero of the REDD+ project, driven by the intercepts of the underlying logistic regressions, as discussed above. Project 944 best illustrates the potential for the initial exponential growth behavior of logistic regressions to substantially inflate baseline deforestation rates under VM0009. In contrast, we found that the range of different values adopted for the forest scarcity factors under VM0006 had relatively little impact on baseline deforestation, but it still contributed to slightly more conservative baselines, as intended. Overall, most of the alternative deforestation baselines constructed in this study (23 out of 28) were more conservative than the official project baselines in terms of cumulative deforestation at the end of the evaluation period of each project (Figure 2.2).

Figure 2.2

Variation in Baselines: Official Baselines Used by the Projects Versus Our Reconstructed Baselines Using Four VCS-REDD+ Methodologies, Ex Post Counterfactuals, and Observed Deforestation in the Project Sites



Note. Dashed black lines separate the historical period used to inform the construction of the baselines from the baseline periods (shaded blue areas). Official baselines were constructed by the project developers. For our reconstructed baselines, FSF-1 and FSF-2 refer to different ranges of the "forest scarcity factor" parameters of VM0006. MLP and SW are the algorithms employed for the spatial allocation of the baseline deforestation in VM0007 and VM0015. The horizontal dotted line in the Project 1112 panel is a cutoff to improve visualization. Ex post counterfactuals based on observable control units are from West et al. (2023).

Discussion and Recommendations

Our results highlight issues with key methodological assumptions underlying the construction of deforestation baselines for the four most-adopted methodologies for voluntary REDD+ projects worldwide. Overall, we found the VCS-REDD+ methodologies used to create project baselines to be unreliable and lack consistency, with the potential to harm meaningful efforts to fight climate change. Each methodology offers significant flexibility in establishing baselines, and our analysis indicates this flexibility is likely being exploited by project developers to generate more credits than would be generated with conservative baselines. It is clear from our review and empirical analyses that the VCS-REDD+ methodologies represent complex ways of creating simplistic reference levels for the project sites, as opposed to constructing rigorous counterfactuals for proper impact evaluations or performance assessments (Bos et al., 2017; Ferraro & Hanauer, 2014; Guizar-Coutiño et al., 2022). Yet, each carbon credit issued according to these methodologies is promoted and traded as equivalent to 1 metric ton CO_2 that has not been emitted to the atmosphere but would have been in the absence of the REDD+ intervention. More broadly, the current policy discussions to scale and integrate the offsets issued following faulty REDD+ methodologies into GHG emission reduction commitments and cap-and-trade markets (Blum & Lövbrand, 2019; Food and Agriculture Organization of the United Nations, 2019; Lee et al., 2018; Taskforce on Scaling Voluntary Carbon Markets, 2021; Verra, 2021) may negatively impact global efforts to mitigate climate change (McAfee, 2022; West et al., 2023; West, Börner, et al., 2020).

Discrepancies in the baselines from applying the four VCS-REDD+ methodologies average 1459% across our four sample projects. This raises concern about whether the credited reductions actually occurred and, consequently, the environmental integrity of their carbon credits, since those are derived from the project performance relative to its baseline. Furthermore, the official baselines used by the developers to generate credits were higher than most (23 of 28) of our reconstructed baselines.

Our findings identify possible methodological explanations for exaggerated baselines documented by ex post impact evaluations (West et al., 2023; West, Börner, et al., 2020). The differences between the projects' official baselines and our alternative baselines are at least partially driven by the differences in the underlying data. The differences also appear to be driven by developer decisions when methodological steps are flexible, lack clarity, or leave room for interpretation. Subjectiveness and flexibility present in the VCS-REDD+ methodologies we examined could be exploited by profiteers in the form of baseline gaming (Angelsen, 2017; Ehara et al., 2021; Mertz et al., 2018; Rifai et al., 2015). The bluntest example of flexibility is with the construction of the underlying deforestation risk maps in VM0007 and VM0015, which has a direct impact on deforestation baselines, and thus on the volume of carbon credits entitled to each project. These maps are highly sensitive to the method and data used in the analysis (e.g., Ehara et al., 2021; Sloan & Pelletier, 2012; Soares-Filho, 2012; West, Monge, et al., 2020), and yet, different risk maps of the same region could potentially be considered equally valid from a model validation perspective (e.g., Lin et al., 2011; Soares-Filho et al., 2013; West, Monge, et al., 2020). In fact, a review of the Figure of Merit validation scores associated with nine voluntary REDD+ projects found the highest score (or accuracy) to be just 11.7%, with three other projects with scores lower than 1%. Still, those project baselines passed the minimum Figure of Merit validation threshold set by VM0007 and VM0015 (West, 2016). The current, and seemingly arbitrary, low threshold for the Figure of Merit validation (see Table 2.1) becomes even more problematic if compared with the original requirements from both methodologies (v.1): 40%, 60%, and 80% for projects located in landscapes with frontier, transition, and mosaic deforestation configuration, respectively. The original version of VM0007's baseline module VMD0007 even stated that "where these minimum standards are not met the project proponent must demonstrate shall be considered ineligible." (Avoided Deforestation Partners, n.d., p. 19). While high Figure of Merit scores are not commonly found in the land-use/cover change modeling literature (Pontius et al., 2008; Sloan & Pelletier, 2012), extremely small values severely compromise the credibility of baseline scenarios intended to measure the performance of interventions.

Methodologies also allow ample flexibility for selecting reference regions, which is of critical importance for baseline setting, as long as minimum requirements are met. This is likely the main reason behind the null project impacts and location bias identified by Delacote et al. (2022) pertaining to several voluntary REDD+ projects in the Brazilian Amazon. Other factors used for baseline construction, such as the logistic regression's sampling in VM0009, the identification of biophysical deforestation constraints in VM0015, and even the forest scarcity factors from VM0006, also largely rely on the analysts' decisions and interpretations, which can be subjective or even deliberately biased, including cherry-picking of the literature (Seyller et al., 2016).

VCS is currently working on a new, consolidated REDD+ methodology for avoided unplanned deforestation projects that would replace all current REDD+ methodologies (Climate Focus, 2023). While the consolidated methodology remains to be finalized, its draft seems to significantly reduce the flexibility discussed above. It would establish baseline deforestation rates that are based on 10-year historical averages, which is more conservative than regression models with upward-trending forecasts, such as the model prescribed by VM0009 and allowed by all methodologies. It would require the use of a deforestation risk map similar to those of VM0007 and VM0015, which involve highly subjective algorithm construction and underlying data, as demonstrated in this study. Risk maps likely will be developed at the jurisdictional level, using the whole jurisdiction as the reference region, thereby removing the flexibility individual developers have to choose their reference region. Furthermore, the consolidated methodology is expected to set out more clear and transparent guidelines that would avoid bias in the development of deforestation risk maps.

However, the draft consolidated methodology does not go far enough to avoid the risk of gaming and to accurately estimate baselines. The risk-map approach transfers the responsibility of the allocation analysis (and also room for baseline gaming) from developers to third-party contractors. Furthermore, gaming can still occur through the choice of which lands to enroll in a REDD+ project. Developers can choose to enroll lands that would not have been deforested because of factors the developer knows about, but which the deforestation risk map may have failed to capture. Risk maps may also become outdated with changes in the landscape and local governance. Similar adverse selection has been documented with improved forest management carbon projects in the United States (Badgley et al., 2021). Perhaps most importantly, the proposed consolidated methodology falls short of controlling for dynamic changes in deforestation drivers and rates and thus would remain unable to rigorously demonstrate additionality and ensure the environmental integrity needed for offsetting (Balmford et al., 2023; Bos et al., 2017; West et al., 2020; West et al, 2023).

To address the remaining potential inaccuracies in the proposed consolidated methodology, we suggest several fundamental changes. Methodologies could use current best practices for baseline setting (Balmford et al., 2023). Ex post methods that monitor real deforestation in a well-matched control plot and use those rates as the project baseline have been found to be most accurate (Guizar-Coutiño et al., 2022; West et al., 2023; West, Börner, et al., 2020). We note two limitations with such methods. Good controls for the project areas may be difficult to find and can change over time. Also, dynamic baselines add risk to developers by creating uncertainty in the baseline and therefore in the number of credits generated by avoided deforestation projects, thus making it harder for truly additional projects to participate. Alternatively, potentially more accurate and less gameable methods for setting baselines may be available from the statistical modeling literature (Balmford et al., 2023). These methods have not been explored and tested in the REDD+ context, but efforts could be made to do so. Regardless of the method used, fully disclosing baseline calculations and assumptions, enabling independent parties to assess the credibility of baseline calculations, is necessary for a quality market.

The extent to which choice of methodology and methodological options within them can change the baseline scenario and the number of credits generated, sometimes with a 10-fold or greater difference, means that baseline setting under current methodologies is more akin to storytelling and assumption choosing than about real forest risk. While Verra's proposed consolidated REDD+ methodology addresses many sources of flexibility we find with the current pool of projects and credits, it does not address the more fundamental challenges of accurately assessing project baselines, specifically around confounding factors, risk map creation, and adverse selection. Inherently high uncertainty in true project baselines and room for manipulation with both existing and proposed methods justify a shift away from carbon crediting to a contributions- or donations-based approach for directing private funding into REDD+ initiatives.

Table 2.1
Overview of Verified Carbon Standard REDD+ Methodologies

Factor	VM0006	VM0007	VM0009	VM0015
Minimum size of the reference region	250,000 ha or the size of the project area (whichever is greater)	For RRD*: $7500 \times PA^{-0.7}$, where PA is the project area (ha); the area of forest in the RRL* must be ±25% of the area of the RRD*	Greater than or equal to the project size	Suggested: 5–7 times larger than >100,000-ha projects; 20–40 times larger than <100,000-ha projects
Reference region's forest cover at the project start	≥15%	100% for RRD*; ≥50% for RRL*	N/A	N/A
Shared characteristics between project area and reference region	Drivers of deforestation; landscape configuration (forest type, elevation, slope); and socio-economic and cultural conditions (land-tenure status, policies/regulations, degree of urbanization)	Agents of deforestation; landscape factors (forest class, soil type, slope, elevation); transportation networks and human infrastructure (roads, navigable rivers, settlements, etc.); social factor (presence of gangs or guerillas, the ethnic composition of local populations); policies and regulations	Drivers of deforestation; location and mobility of deforestation agents; landscape configuration (topography, land use/cover, soil type, infrastructure, market distance, land tenure)	Agents and drivers of deforestation; infrastructure drivers; any spatial drivers expected to influence the project area (resettlement programs, mining and oil concessions, etc.); landscape configuration and ecological conditions (forest/vegetation classes, elevation, slope, rainfall); socio-economic and cultural conditions (legal status of the land, land use); enforced policies and regulations
Estimation of baseline deforestation rate	Historical average or "beta regression" (as a function of time) fitted to historical deforestation data from the reference region. Annual baseline deforestation rates from the reference region are then proportionally applied to the project area and discounted by "forest scarcity factors"	Under the "simple historic" approach: based on historical average or linear/non-linear regression (as a function of time) fitted to historical deforestation data from the RRD* and proportionally applied to the RRL*. Under the "population driver" approach: based on per-capita historical deforestation, extrapolated from household survey or population census data. Under both approaches, the baseline deforestation rate at the project level is a function of the spatial allocation of the baseline deforestation estimated at the reference-region level across the reference region	Logistic regression (as a function of time) fitted to random samples observed throughout a historical period within the reference region. The relative deforestation forecast (%) is then annually applied to the project area	Historical average, linear/non-linear regression (as a function of time) fitted to historical deforestation data from the reference region, or other (simulation) modeling approaches. The baseline deforestation rate at the project level is a function of the spatial allocation of the baseline deforestation estimated at the reference-region level across the reference region

Statistical requirements for the estimation of baseline deforestation rate	Average historical deforestation is used if the estimated time parameter of the regression model is insignificant ($p \leq 0.05$). If not, the lower limit of the 95%-confidence interval of the forecast must be used when trending upwards	Under the "simple historic" approach: regression model must be significant ($p \leq 0.05$), with $r^2 \geq 0.75$, and unbiased (i.e., lowest possible residuals). Under the "population driver" approach: regression model must be significant ($p \leq 0.05$), with $r^2 \geq 0.50$, and unbiased (i.e., with a minimal trend in residuals)	N/A	N/A
Baseline deforestation allocation	Conducted at the project area level (only relevant if multiple forest strata and/or post-deforestation land-use classes are considered). Allocation is informed by a deforestation risk map based on the spatial driver of historical deforestation. Any suitable method can be used to construct the risk map	Conducted at the RRL* level. Allocation is informed by deforestation risk maps based (at minimum) on the landscape (e.g., soil type, slope, elevation), accessibility (e.g., distance to rivers, roads), anthropogenic (e.g., distance to sawmills, settlements, cleared land), and land tenure and management factors (e.g., protected areas, concessions). Internationally peer-reviewed algorithms are eligible to prepare the risk maps. Several risk maps should be prepared and the most accurate should be selected based on model validation outcomes. Only the deforestation allocated within project boundaries is part of the project's baseline scenario	N/A	Conducted at the reference region level. Allocation is informed by deforestation risk maps based on the spatial driver of historical deforestation. Risk maps must be constructed with a peer-reviewed model. Several risk maps should be prepared and the most accurate should be selected based on model validation outcomes. Only the deforestation allocated within project boundaries is part of the project's baseline scenario
Validation of baseline deforestation allocation	If a regression model is used, the full model and all covariates must be significant (p-value ≤ 0.05). One-third of the data must be exclusively used for the validation of the spatial allocation model. A goodness-of-fit score ≥85% is required	Based on the Figure of Merit method for the comparison between simulated and observed land-use/cover maps. The minimum threshold for the Figure of Merit is defined by the relative historical deforestation level in the RRL*. Exceptions are allowed if supported by the literature	N/A	Based on any appropriate method for the comparison between simulated and observed land-use/cover maps. If the Figure of Merit method is used, the minimum validation threshold is defined by the relative historical deforestation level in the reference region

* VM0007 adopts two reference regions: one for projecting the rate of baseline deforestation ("RRD") and the other for the allocation of baseline deforestation ("RRL")

References: Baselines

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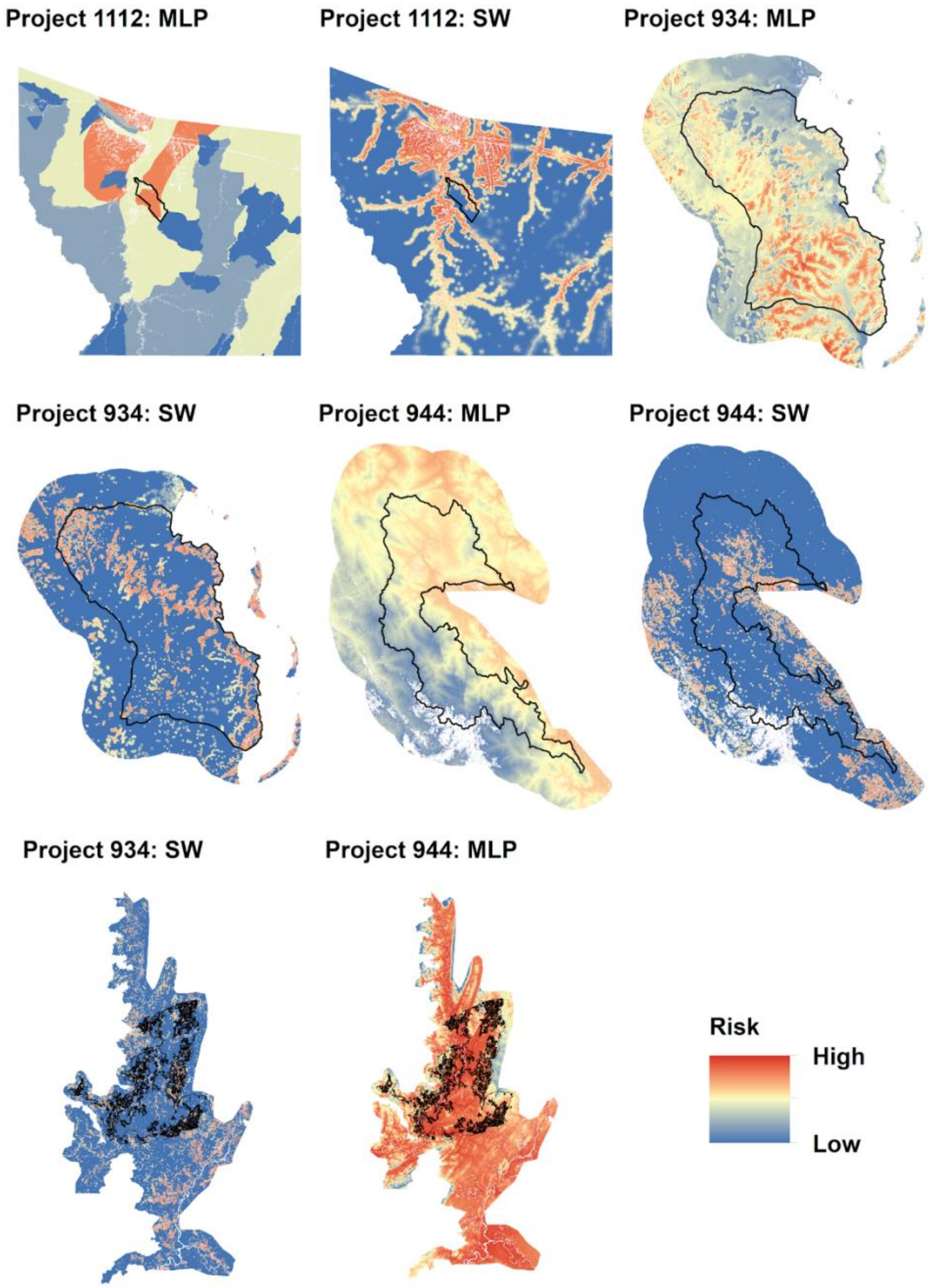
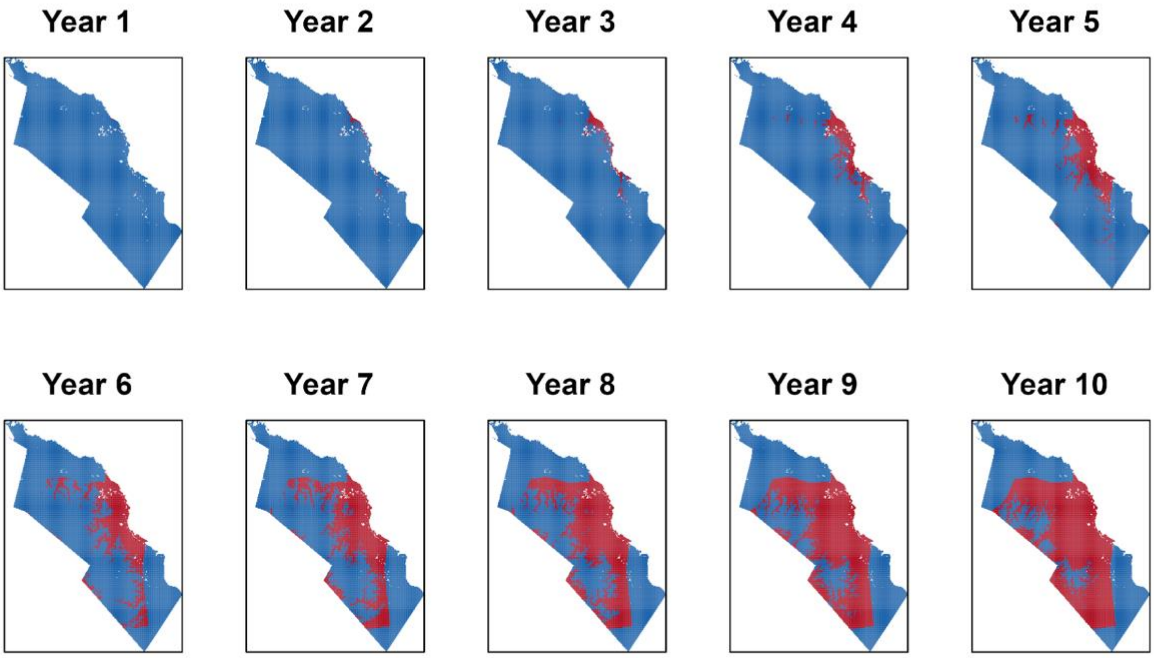
Appendices: Baselines

Figure 2.A1
Deforestation Risk Maps



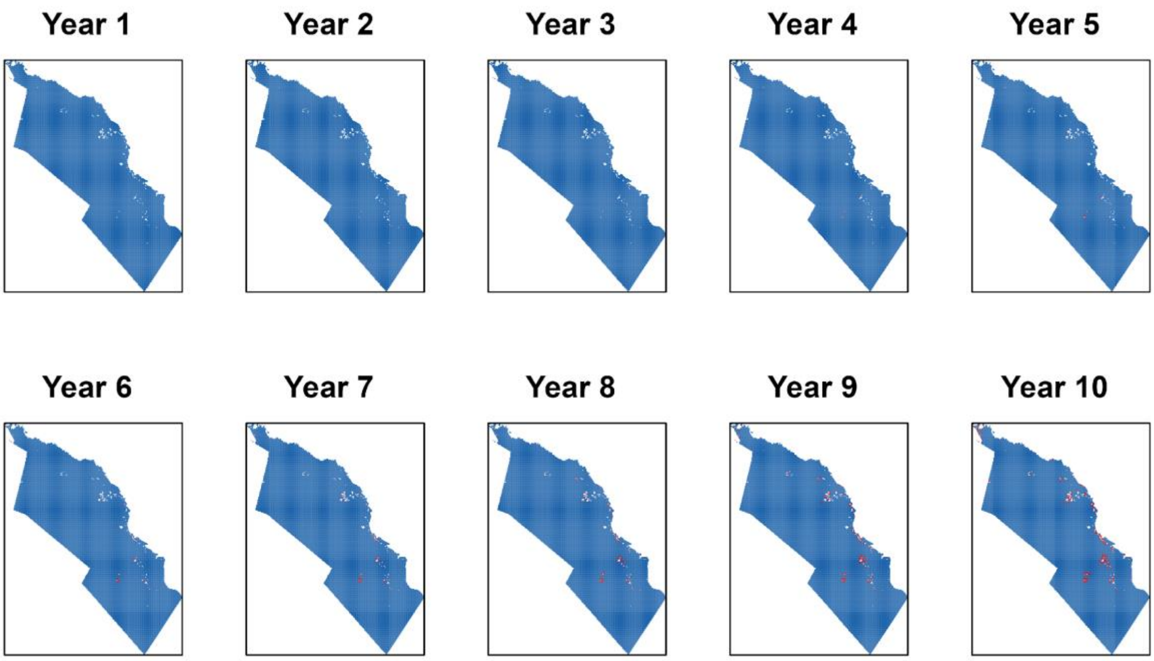
Note. Maps produced with the multilayer perceptron (MLP) and SimWeight (SW) algorithms for the selected REDD+ projects' reference regions. Project boundaries displayed in black.

Figure 2.A2
Spatial Allocation of VM0007's Baseline Deforestation for Project 1112 Produced with the Multilayer Perceptron Algorithm



Note. Red patches show baseline deforestation based on the risk map.

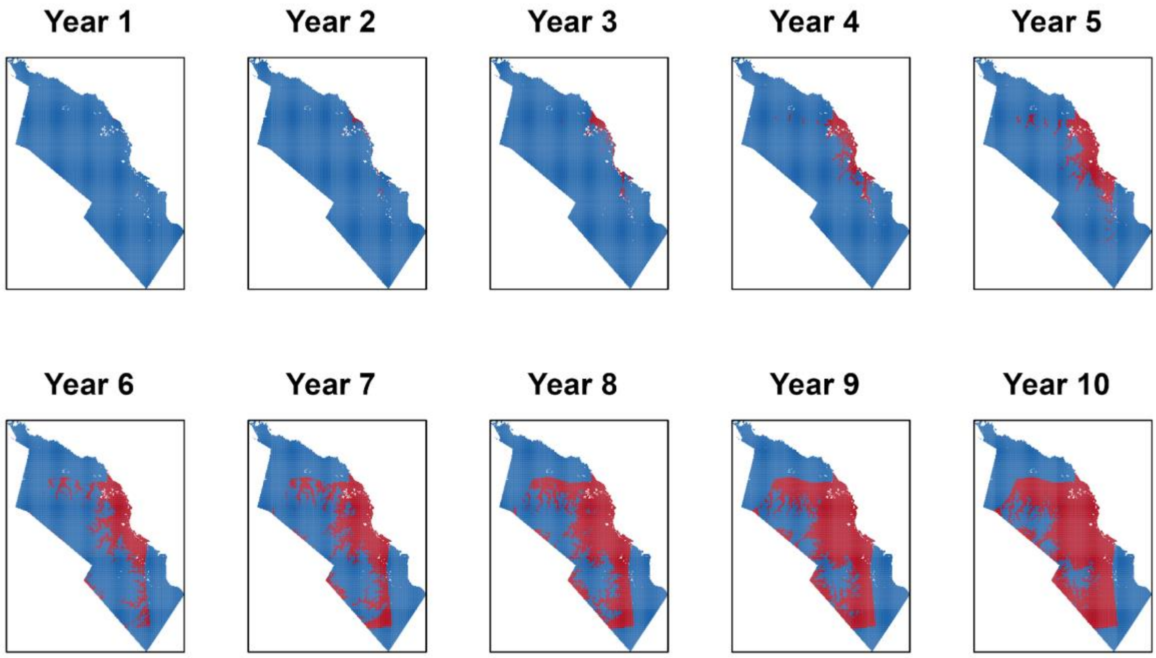
Figure 2.A3
Spatial Allocation of VM0007's Baseline Deforestation for Project 1112 Produced with the SimWeig



Note. Red patches show baseline deforestation based on the risk map.

Figure 2.A4

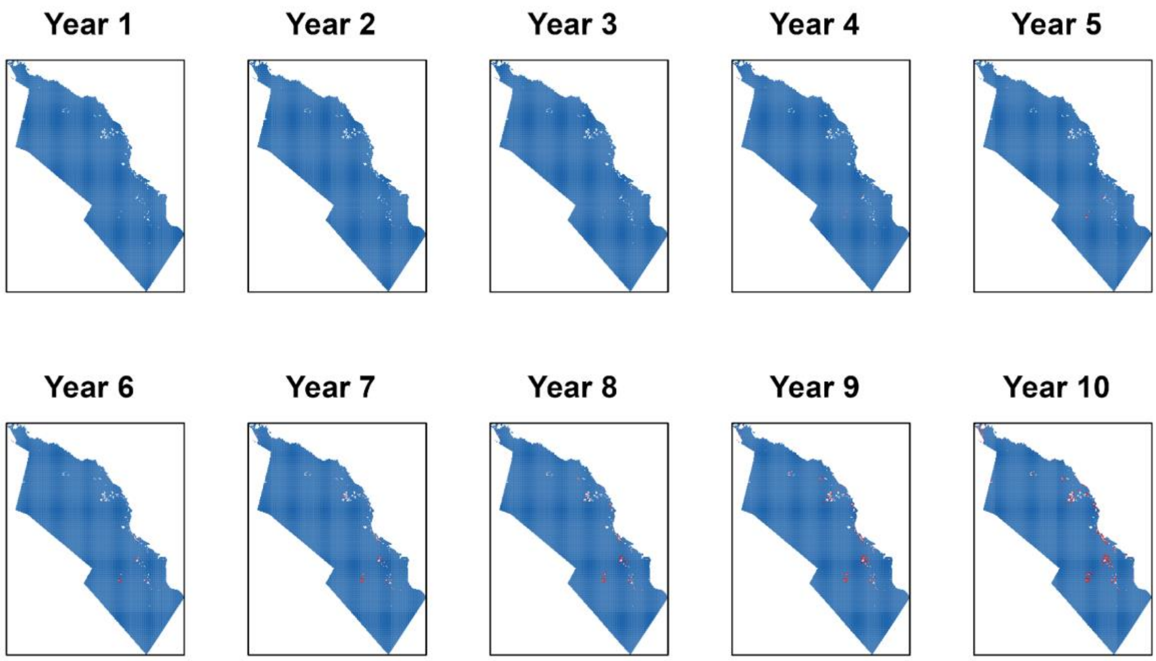
Spatial Allocation of VM0015's Baseline Deforestation for Project 1112 Produced with the Multilayer Perceptron Algorithm



Note. Red patches show baseline deforestation based on the risk map.

Figure 2.A5

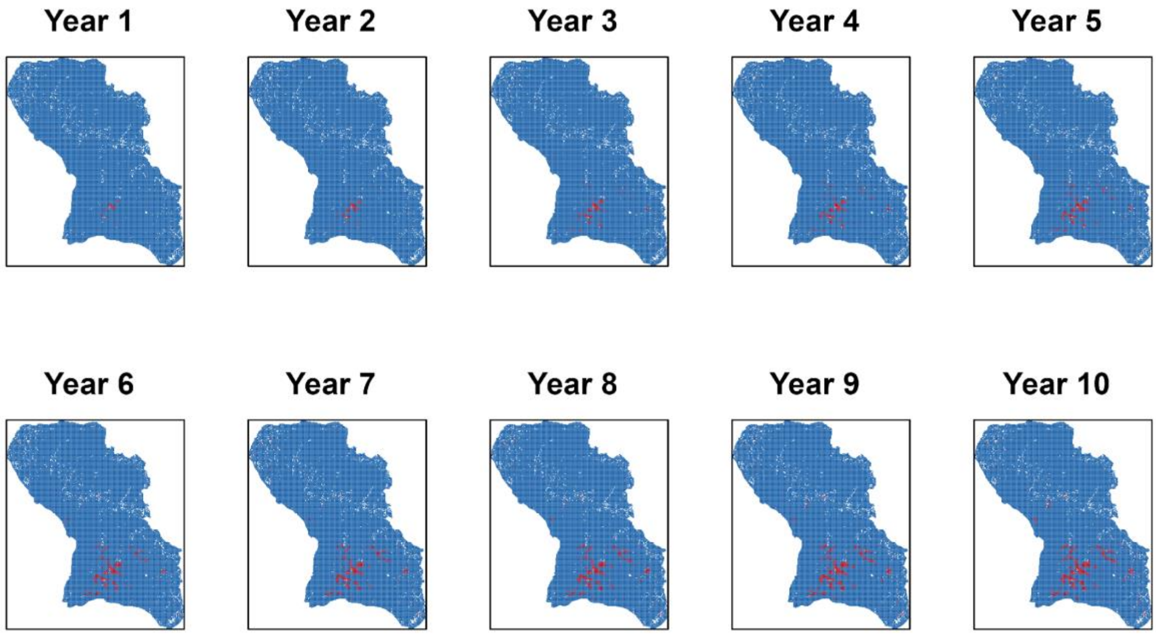
Spatial Allocation of VM0015's Baseline Deforestation for Project 1112 Produced with the SimWeight Algorithm



Note. Red patches show baseline deforestation based on the risk map.

Figure 2.A6

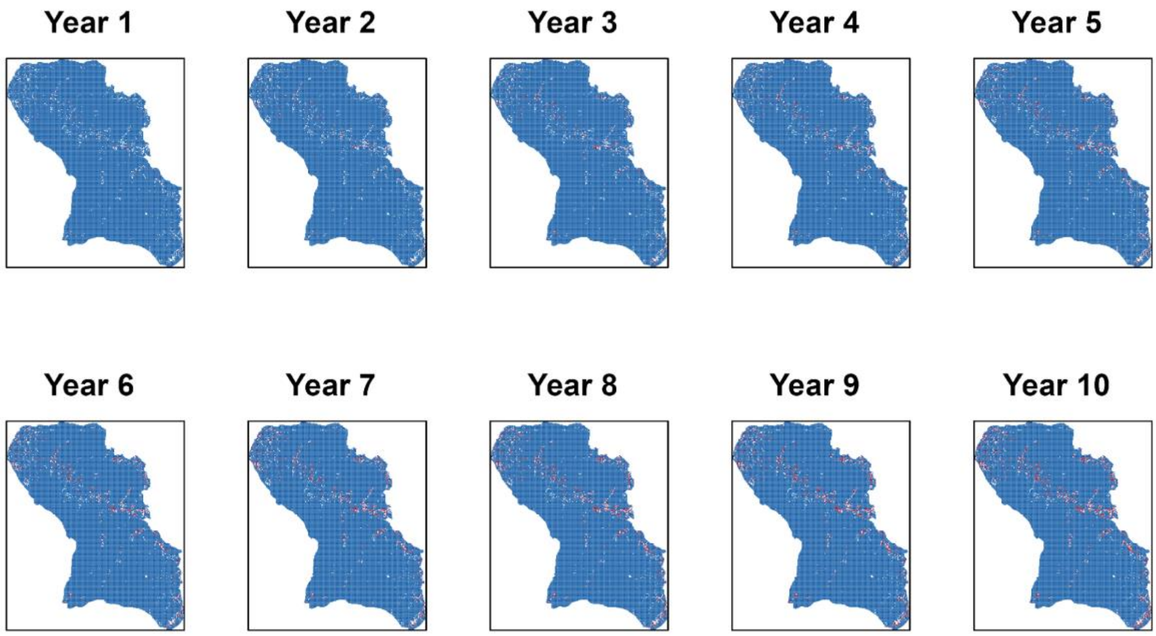
Spatial Allocation of VM0007's Baseline Deforestation for Project 934 Produced With the Multilayer Perceptron Algorithm



Note. Red patches show baseline deforestation based on the risk map.

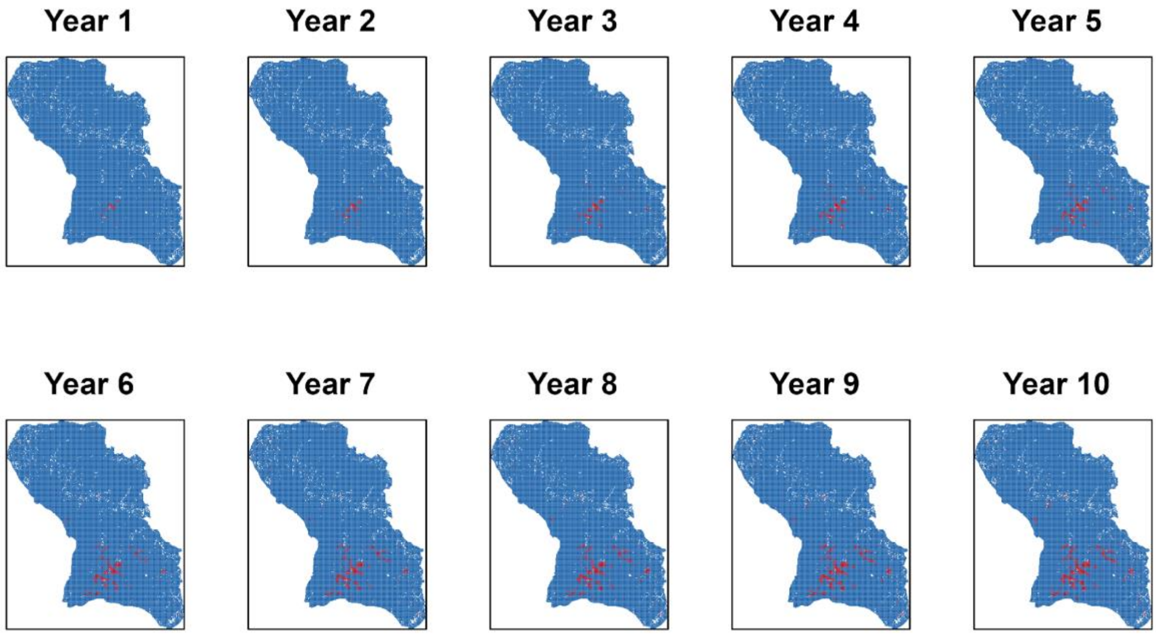
Figure 2.A7

Spatial Allocation of VM0007's Baseline Deforestation for Project 934 Produced with the SimWeight Algorithm



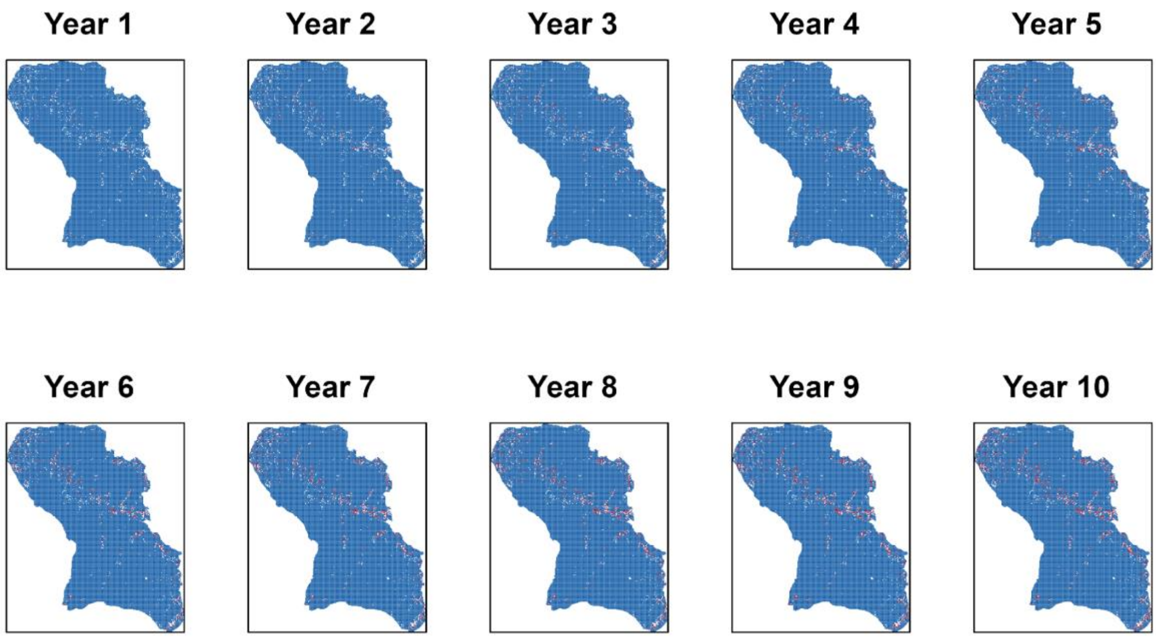
Note. Red patches show baseline deforestation based on the risk map.

Figure 2.A8
Spatial Allocation of VM0015's Baseline Deforestation for Project 934 Produced with the Multilayer Perceptron Algorithm



Note. Red patches show baseline deforestation based on the risk map.

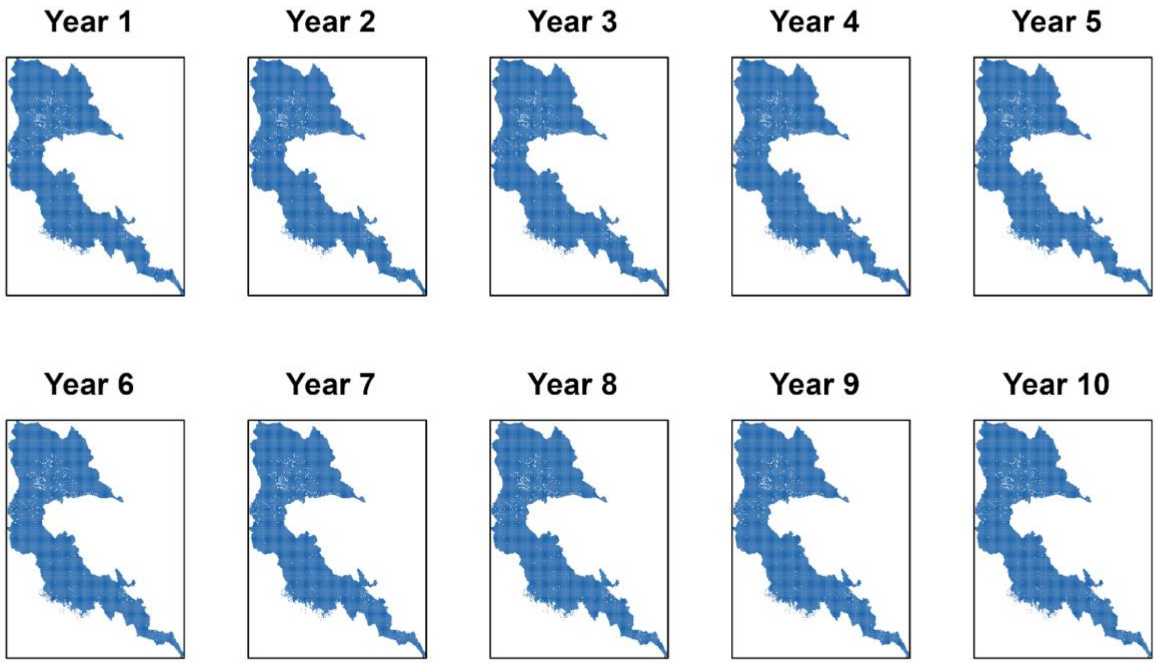
Figure 2.A9
Spatial Allocation of VM0015's Baseline Deforestation for Project 934 Produced with the SimWeight Algorithm



Note. Red patches show baseline deforestation based on the risk map.

Figure 2.A10

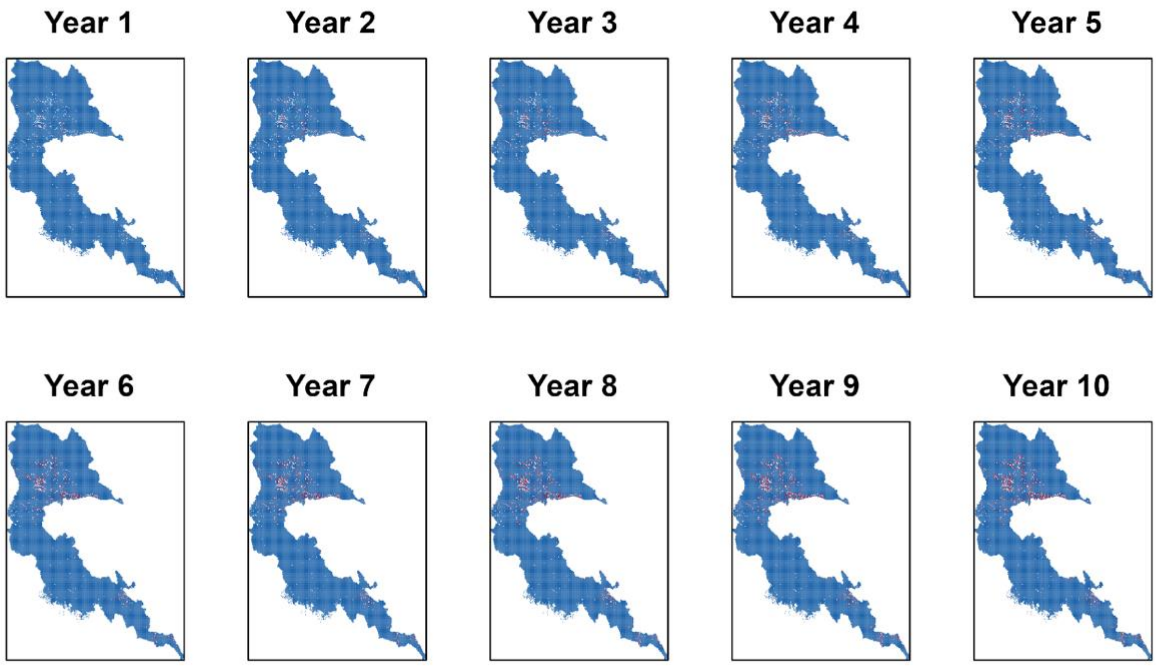
Spatial Allocation of VM0007's Baseline Deforestation for Project 944 Produced with the Multilayer Perceptron Algorithm



Note. Red patches show baseline deforestation based on the risk map.

Figure 2.A11

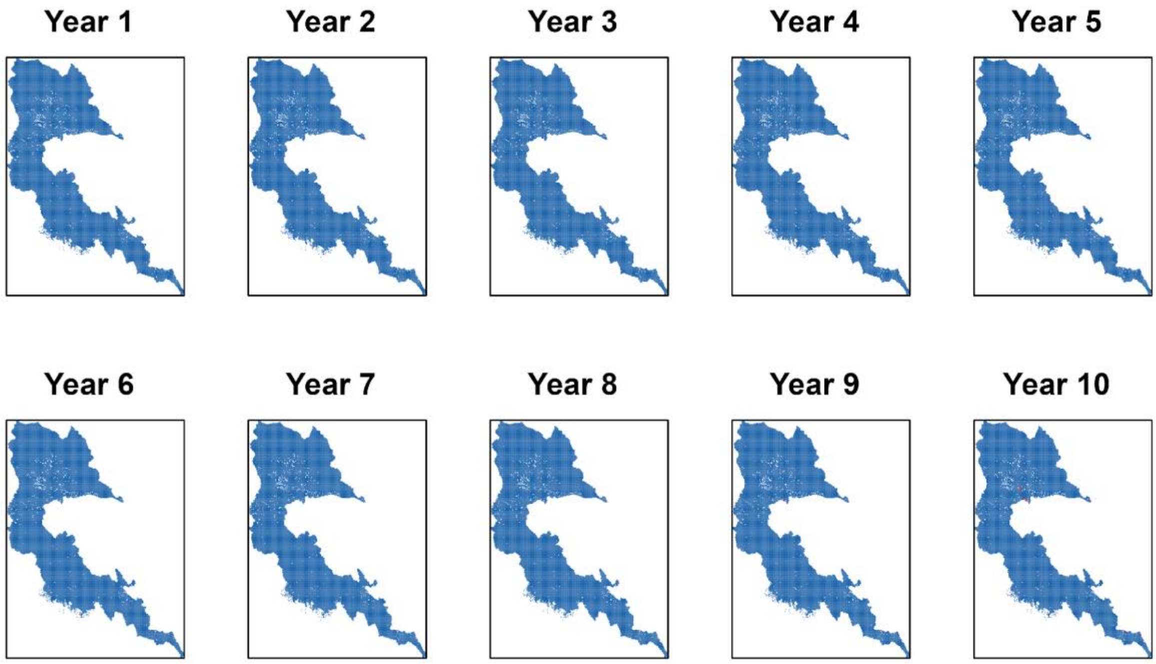
Spatial Allocation of VM0007's Baseline Deforestation for Project 944 Produced with the SimWeight Algorithm



Note. Red patches show baseline deforestation based on the risk map.

Figure 2.A12

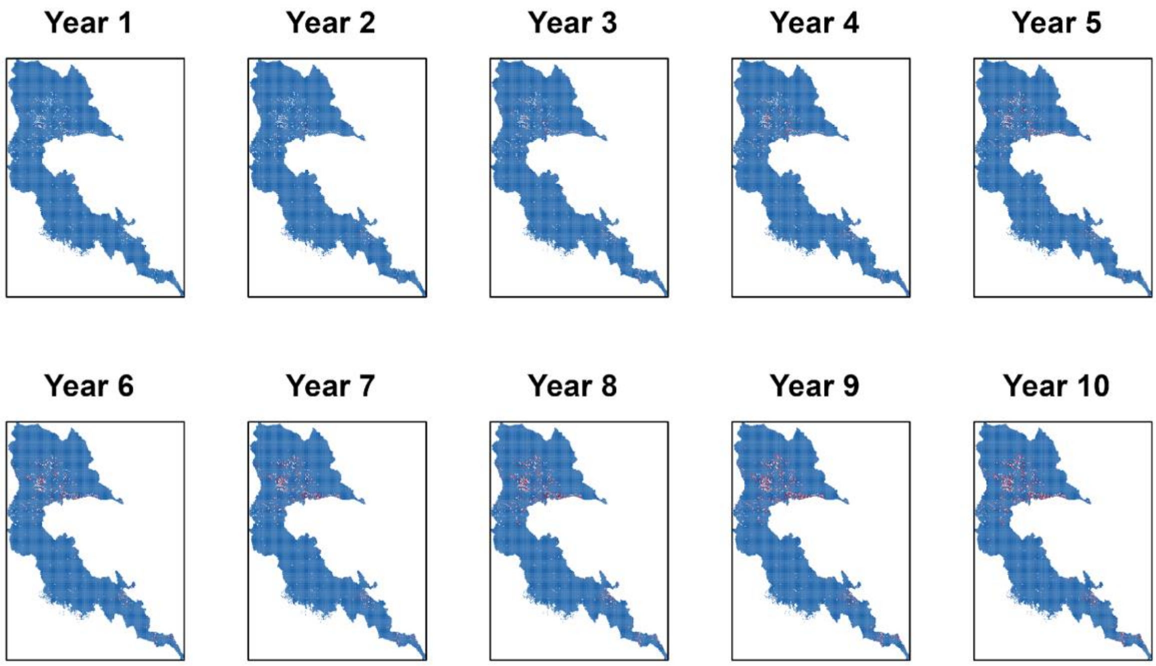
Spatial Allocation of VM0015's Baseline Deforestation for Project 944 Produced with the Multilayer Perceptron Algorithm



Note. Red patches show baseline deforestation based on the risk map.

Figure 2.A13

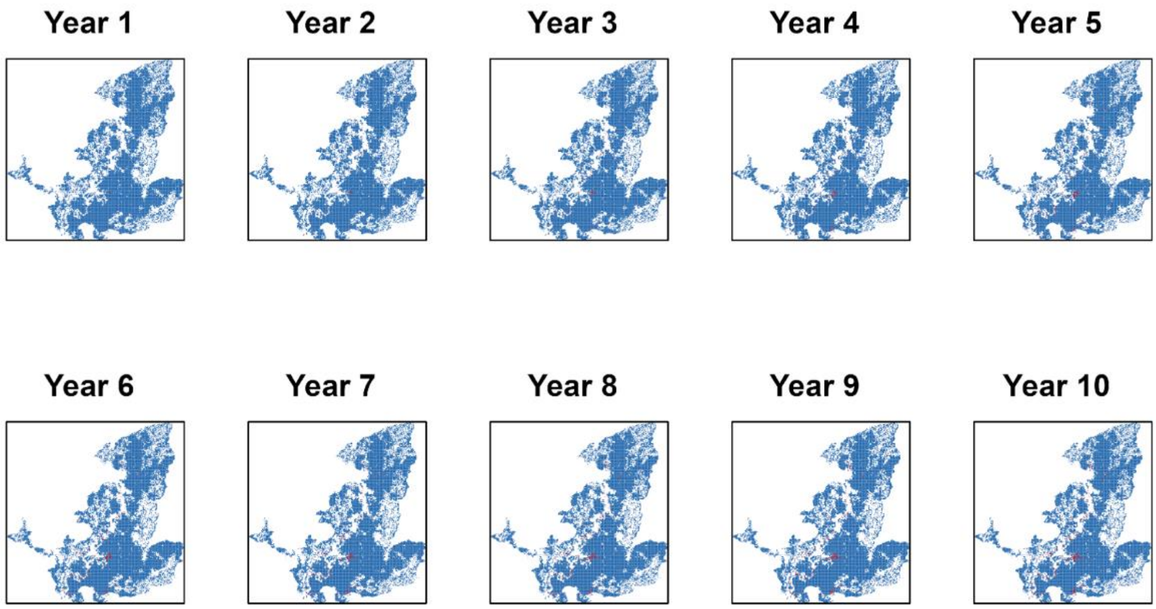
Spatial Allocation of VM0015's Baseline Deforestation for Project 944 Produced with the SimWeight Algorithm



Note. Red patches show baseline deforestation based on the risk map.

Figure 2.A14

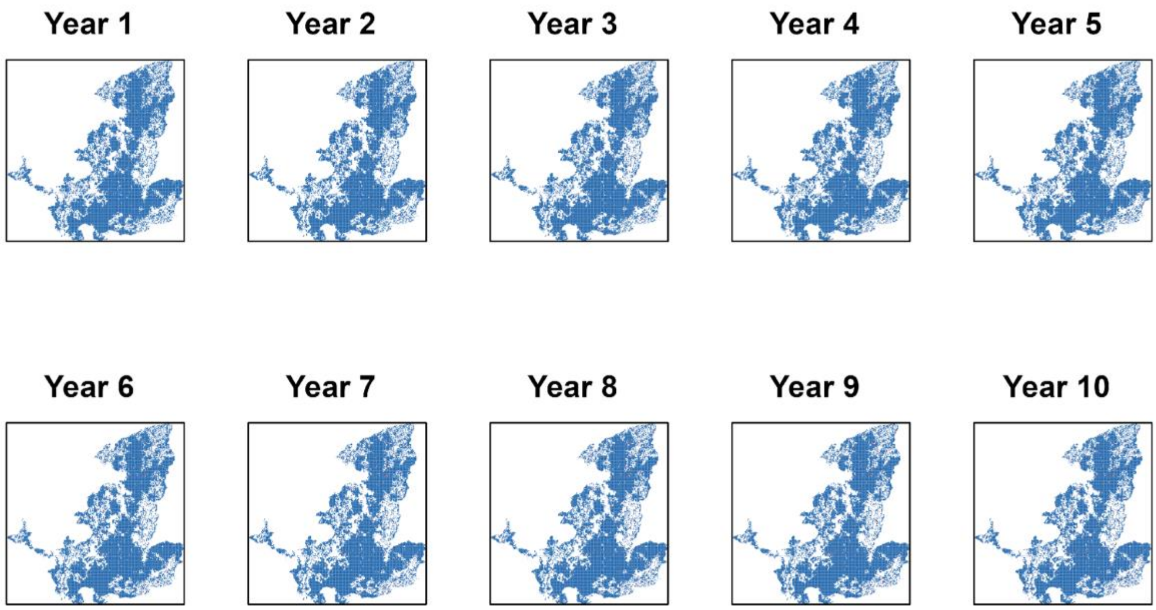
Spatial Allocation of VM0007's Baseline Deforestation for Project 1396 Produced with the Multilayer Perceptron Algorithm



Note. Red patches show baseline deforestation based on the risk map.

Figure 2.A15

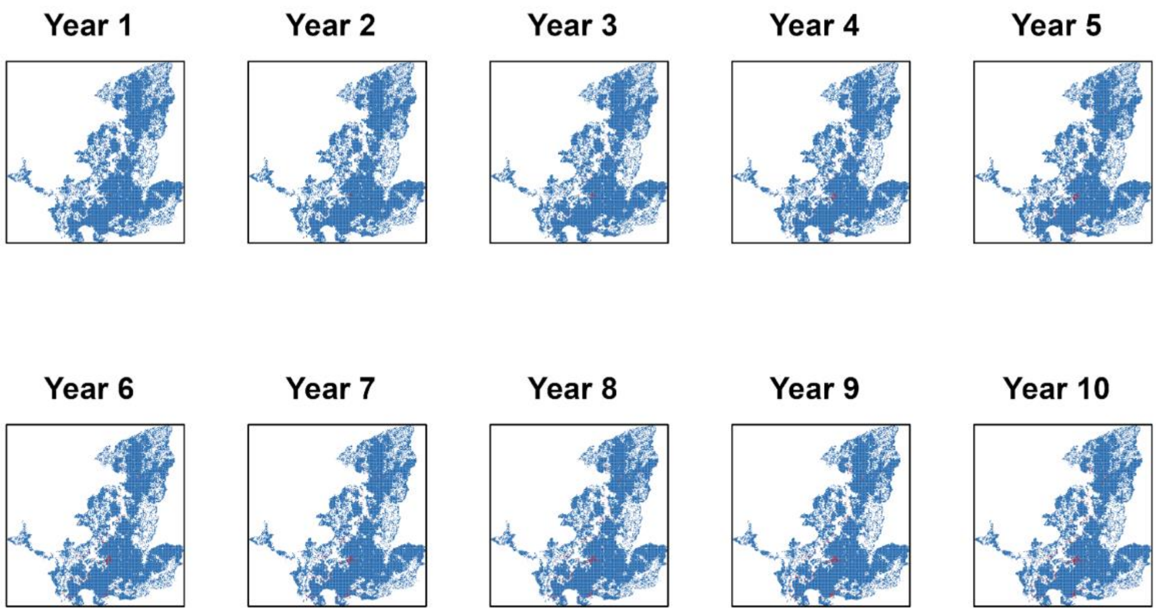
Spatial Allocation of VM0007's Baseline Deforestation for Project 1396 Produced with the SimWeight Algorithm



Note. Red patches show baseline deforestation based on the risk map.

Figure 2.A16

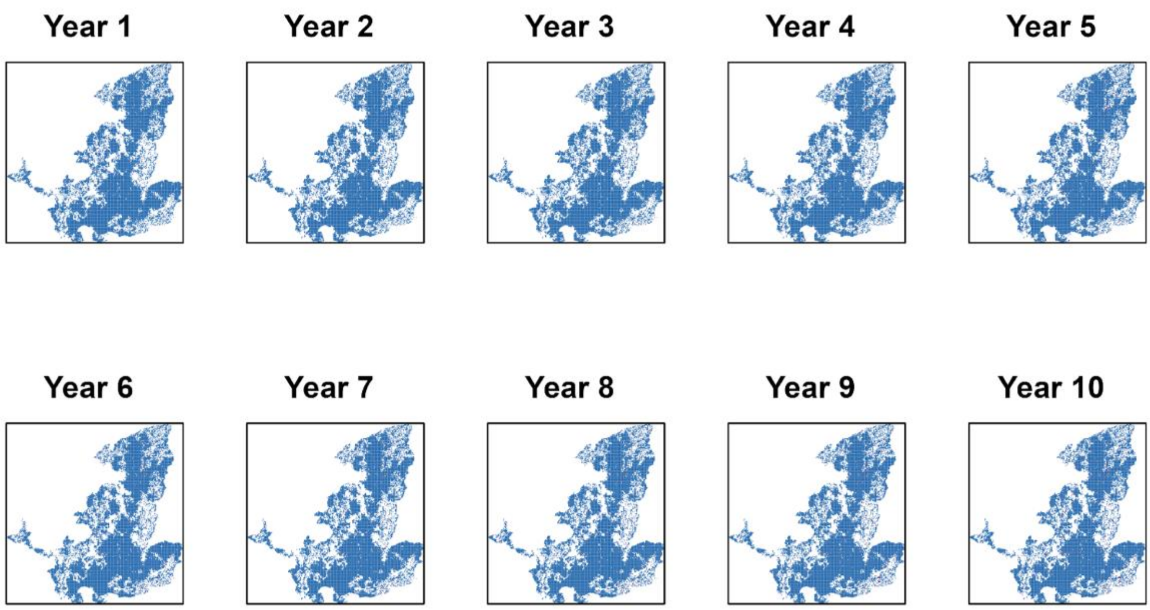
Spatial Allocation of VM0015's Baseline Deforestation for Project 1396 Produced with the Multilayer Perceptron Algorithm



Note. Red patches show baseline deforestation based on the risk map.

Figure 2.A17

Spatial Allocation of VM00015's Baseline Deforestation for Project 1396 Produced with the SimWeight Algorithm



Note. Red patches show baseline deforestation based on the risk map.

Table 2.A1
Selected REDD+ Projects Certified Under VCS

VCS-ID	Country	VCS methodology	Start year	Project reference region (ha)	Study reference region† (ha)	Minimum mapping unit	Maps used by the project to create the baseline deforestation risk map (for VM0007 and VM0015)	Maps used by the study to create the baseline deforestation risk map (for VM0007 and VM0015)
1396	Colombia	VM0006	2014	282,914	300,347	30 m	N/A	Elevation, slope, and distance to roads, rivers, built-up surface, and previous deforestation
1112	Brazil	VM0007	2011	4,552,510	4,564,979	1 ha	Elevation, slope, soil, and distance to roads, rivers, towns, previous deforestation, forest edges, vegetation, protected areas, and indigenous lands	Elevation, slope, protected areas and indigenous lands and distance to roads, rivers, built-up surface, and previous deforestation
934	Democratic Republic of Congo	VM0009	2011	648,965*	658,927	30 m	N/A	Elevation, slope, and distance to roads, rivers, built-up surface, and previous deforestation
944	Peru	VM0015	2009	580,616	564,397	2 ha	Elevation, slope, and distance to primary and secondary roads, primary and secondary rivers, and towns	Elevation, slope, and distance to roads, rivers, built-up surface, and previous deforestation

* Estimated based on the project description document.
† These sizes comply with the minimum area requirement from VM0007.

Table 2.A2
Data Description and Source

Variable	Description	Geographical coverage	Source
Deforestation and average tree cover in 2000	2000–2020 forest cover and change maps	Global	Global Forest Change dataset (Hansen et al., 2013)
Distance to urban centers	Euclidean distance maps to built-up surface	Global	Global Human Settlement Layer (https://ghsl.jrc.ec.europa.eu/download.php)
Elevation	Continuous maps based on a mosaic of the Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global (m)	Global	United States Geological Survey (http://earthexplorer.usgs.gov/)
Slope	Continuous slope map (degrees)	Global	Based on the elevation maps
Protected area cover	Location of protected areas	Brazil	Protected Planet (https://www.protectedplanet.net/)
Indigenous land cover	Location of indigenous lands	Brazil	Protected Planet (https://www.protectedplanet.net/)
Distance to roads	Euclidean distance maps to primary and secondary roads	Brazil	Brazilian Institute of Geography and Statistics (http://dados.gov.br/)
		Peru	The Humanitarian Data Exchange (https://data.humdata.org/)
		Colombia	
		DRC	World Food Programme (https://geonode.wfp.org/)
Distance to rivers	Euclidean distance maps to rivers	Peru	Geo GPS Peru (www.geogpsperu.com/)
		Brazil	Brazilian National Water Agency (http://hidroweb.ana.gov.br/)
		Colombia	The Humanitarian Data Exchange (https://data.humdata.org/)
		DRC	

Table 2.A3
Results From the Linear Regression Analyses for VM0006

	Deforestation in the reference region (ha)			
	Project 1112	**Project 934**	**Project 944**	**Project 1396**
Time (years)	164.483	2,183.248	1,980.893**	215.964
	(1,775.595)	(1,316.778)	(632.867)	(384.113)
Constant	83,556.970***	28,797.470***	22,279.140***	8,239.600***
	(9,991.834)	(8,170.393)	(3,195.822)	(2,383.361)
Observations	9	10	8	10
R^2	0.001	0.256	0.620	0.038
Adjusted R^2	-0.141	0.163	0.557	-0.082
Residual Std. Error	13,753.700 (df = 7)	11,960.230 (df = 8)	4,101.447 (df = 6)	3,488.883 (df = 8)
F Statistic	0.009 (df = 1; 7)	2.749 (df = 1; 8)	9.797** (df = 1; 6)	0.316 (df = 1; 8)

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

Table 2.A4

Results From the Regression Analyses for VM0007 and VM0015

	Deforestation in the reference region											
	Project 1112			**Project 934**			**Project 944**			**Project 1396**		
	ha		log(ha)	ha		log(ha)	ha		log(ha)	ha		log(ha)
Time (years)	164.483		0.002	2,183.248		0.087	1,980.893**		0.178**	215.964		0.057
	(1,775.595)		(0.023)	(1,316.778)		(0.076)	(632.867)		(0.050)	(384.113)		(0.069)
Log(time)		1,117.145			5,747.613			7,137.201**			1,242.034	
		(6,751.588)			(5,967.864)			(2,073.184)			(1,556.821)	
Constant	81,912.140***	81,145.500***	11.303***	4,781.733	8,108.168	9.025***	4,451.107	3,904.227	8.589***	5,864.000**	5,175.781*	8.405***
	(9,991.834)	(10,639.160)	(0.127)	(8,170.393)	(9,923.580)	(0.469)	(3,195.822)	(3,068.080)	(0.251)	(2,383.361)	(2,588.739)	(0.426)
Observations	9	9	9	10	10	10	8	8	8	10	10	10
R^2	0.001	0.004	0.001	0.256	0.104	0.142	0.620	0.664	0.680	0.038	0.074	0.080
Adjusted R^2	-0.141	-0.138	-0.142	0.163	-0.008	0.035	0.557	0.608	0.627	-0.082	-0.042	-0.035
Residual Std. Error	13,753.700 (df = 7)	13,735.300 (df = 7)	0.175 (df = 7)	11,960.230 (df = 8)	13,123.760 (df = 8)	0.686 (df = 8)	4,101.447 (df = 6)	3,858.211 (df = 6)	0.323 (df = 6)	3,488.883 (df = 8)	3,423.561 (df = 8)	0.623 (df = 8)
F Statistic	0.009 (df = 1; 7)	0.027 (df = 1; 7)	0.006 (df = 1; 7)	2.749 (df = 1; 8)	0.928 (df = 1; 8)	1.327 (df = 1; 8)	9.797** (df = 1; 6)	11.852** (df = 1; 6)	12.774** (df = 1; 6)	0.316 (df = 1; 8)	0.636 (df = 1; 8)	0.696 (df = 1; 8)

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table 2.A5

Results From the Logistic Regression Analyses for VM0009

	Deforestation in the reference region (state; dummy variable)			
	Project 1112	**Project 934**	**Project 944**	**Project 1396**
Time	0.045***	0.192***	0.364***	0.124***
	(0.006)	(0.010)	(0.022)	(0.007)
Constant	-3.044***	-3.532***	-3.627***	-3.794***
	(0.035)	(0.052)	(0.076)	(0.049)
Observations	100,000	110,000	80,000	140,000
Log Likelihood	-15,488.640	-6,391.269	-3,209.897	-7,639.847
Akaike Inf. Crit.	30,981.280	12,786.540	6,423.795	15,283.690

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Berkeley Public Policy
The Goldman School
Berkeley Carbon Trading Project

Chapter 3: Leakage

Samuel Evans, Marie Hogan, Barbara K. Haya

Executive Summary

This chapter analyzes the treatment of carbon leakage in Verra's four most-used Reducing Emissions from Deforestation and Forest Degradation (REDD+) carbon crediting methodologies—VM0006 (Terra Global Capital, 2017), VM0007 (Avoided Deforestation Partners, 2020), VM0009 (Wildlife Works & ecoPartners, 2014), and VM0015 (Pedroni, 2012). Carbon leakage occurs when a project's activities result in an increase in greenhouse gas (GHG) emissions outside its boundary. REDD+ projects can cause leakage for a number of reasons. Deforestation agents that were previously operating within the project's boundary, or would have migrated into the project area, can shift their activities to a new location outside the boundary (activity-shifting leakage). Projects that reduce the production of a traded commodity (e.g., timber, or commodity crops such as coffee or beef) can induce deforestation outside the project's boundary as a result of changing commodity and land prices (market leakage).

The chapter includes four parts. First, we describe how the four methodologies address activity-shifting and market leakage and the differences between them. Second, we summarize insights from the scientific literature on the presence and scale of leakage from conservation projects. Third, we calculate the leakage rates used by all REDD+ projects that had generated credits as of March 2022 and compare those rates with the scientific literature. Fourth, to explore some of the justifications developers used for low leakage rates, we qualitatively analyze four case study projects (one from each methodology). We conclude with specific recommendations for bringing REDD+ leakage assessments into better alignment with current science.

All four project-based *Verified Carbon Standard* (VCS) methodologies address leakage by encouraging measures that reduce leakage and by accounting for any remaining leakage. Project developers have incentives to undertake leakage-prevention activities (e.g., agricultural intensification) to reduce any leakage that could result in the issuance of fewer carbon credits if it were detected. All the methodologies estimate leakage from activity-shifting and market mechanisms, except for VM0015, which does not mention market leakage (as of March 2022, no VM0015 projects had taken a deduction for market leakage). Generally, the methodologies require projects to monitor and quantify activity leakage over time by analyzing changes in deforestation rates through satellite imagery in a leakage zone around the project area. The methodologies differ slightly with respect to how they establish leakage zones and baseline deforestation/degradation rates.

VM0006, VM0007, and VM0009 require an assessment of market leakage rates at the start of the project. The methodologies differ primarily in their criteria for triggering a market leakage deduction: when illegal logging that supplies national or international markets is a deforestation driver (VM0006); when timber, fuelwood, or charcoal production are identified as drivers (VM0007); and when any commodity is displaced (VM0009). If a market leakage deduction is required, it is applied to total emissions reductions (VM0006), to just the portion of reductions attributed to reductions in timber harvesting (VM0007), or to reductions from aboveground merchantable trees

(VM0009). All the methodologies allow for the use of a 0% market leakage rate, provided it is adequately justified. Only domestic leakage is assessed and deducted; international leakage is ignored by all the methodologies. This is the case even though international leakage is known to sometimes occur when the production of an internationally traded commodity is reduced in one country.

Our results show that the leakage deductions taken by VCS-REDD+ projects are quite low, at 2.6% for activity-shifting leakage and 4.4% for market leakage. For activity-shifting leakage, this rate is generally consistent with a small but important set of meta-analyses that found little evidence of deforestation agents shifting deforestation activities to nearby lands. However, the methods used to establish leakage baselines were similar in complexity and flexibility to those we found led to exaggerated baselines for the project area (see Chapter 3: Baselines). For market leakage, the rates prescribed by all the methodologies aligned well with the scientific literature, varying between 10% and 70%, depending on to where the deforestation was expected to shift. However, in practice, around half of projects do not take any deductions.

Our four case studies help us understand various ways that projects with risk of activity-shifting and/or market leakage are able to avoid taking leakage deductions through arguments for exceptions or lax requirements in their methodologies. The first case study is of a VM0006 project and one of eight nearly identical USAID/BIOREDD+ projects. A published field study of another BIOREDD+ projects found that it, like the case study project, changed its leakage belt area late in the registration process. The new area did not include the area where activity-shifting leakage was most likely to occur—the down-river mining area where forest dwellers restricted from wood harvesting by the project were likely to replace lost income. In the second case study, a VM0007 project in the Brazilian Amazon conducted two household surveys within the same year and chose to use the one that found no immigrant households, and therefore, according to the methodology, had zero risk of immigrant leakage. In the VM0009 case, the project's developer was the lead developer of the methodology itself. This methodology includes an exception that allows projects meeting a highly specific condition, which the case study project met, to avoid taking a market leakage deduction. The fourth case study uses VM0015, which does not require market leakage deductions. This project makes no leakage deduction despite risks of both activity-shifting and market leakage due to project activities. Strikingly, while we chose our four sample projects for reasons unrelated to leakage risk, each one applied no or low leakage rates using leakage rate justifications that were questionable and/or not conservative.

While the methodologies reflect the literature on leakage, they have led to problems during implementation. Developers commonly applied zero or low leakage deductions that were misaligned with the scientific literature. Additional research is needed to increase the scientific certainty about market leakage rates; however, based on our current understanding, VCS projects are likely over-crediting by underestimating market leakage deductions or by failing to take deductions at all. We recommend several changes to leakage accounting under VCS-REDD+ methodologies that can lead to more accurate leakage risk accounting:

Activity-Shifting Leakage

- Project developers should have less flexibility in defining the leakage zone and estimating baseline deforestation rates in it.
- Leakage mitigation activities, which are allowed in each of the methodologies, should be more rigorously quantified and should not necessarily be assumed to eliminate all leakage.

Market Leakage

- All methodologies should require leakage deduction when a project involves reduced production of a commodity, as per current VCS policy.
- Leakage deductions should be handled programmatically instead of by projects individually, eliminating the option for developers to justify exceptional zero leakage rates. With this approach, all projects would be required to apply the same market leakage rate, regardless of the individual project-level risk.
- International market leakage is well documented and should be accounted for by the methodologies.

Verra's draft consolidated REDD+ methodology (Climate Focus, 2023) requires that all REDD+ projects follow a single approach to calculating market leakage. However, the new methodology neither addresses international leakage nor market leakage from agricultural displacement. Also, the opportunity for projects to avoid a market leakage deduction by implementing mitigation measures remains in place, although methods for estimating these effects are still unclear.

Leakage is a complex quality criterion. It is difficult to both quantify and monitor, and quantifying it involves considerable uncertainty. However, for REDD+ programs, leakage poses a fairly high risk to carbon accounting integrity; thus it needs to be treated rigorously and conservatively to avoid over-crediting.

Introduction

Leakage is broadly defined by the Intergovernmental Panel on Climate Change (IPCC; Watson et al., 2000) as "the indirect impact that a targeted land use, land-use change, and forestry (LULUCF) activity in a certain place at a certain time has on carbon storage at another place or time" (section 2.3.5.2). Two primary types of leakage are relevant to activities that reduce emissions from deforestation and forest degradation (Aukland et al., 2003). *Activity-shifting* leakage (also referred to as direct, primary, or input leakage) occurs when a deforestation driver or agent is displaced from the project area and undertakes the deforestation activity in another area. *Market* leakage (also referred to as indirect or secondary leakage) occurs when a REDD+ activity changes market conditions, such as by reducing production of a traded good, and provides incentives for others to increase deforestation outside the project area. While leakage can theoretically be either negative (causing increased deforestation elsewhere) or positive (amplifying the carbon mitigation benefits of a REDD+ activity), we focus here on negative leakage.[12]

While there are other ways to conceptualize leakage, the distinction between activity-shifting and market leakage is the one used by project-based methodologies, with quantification handled separately for each type. For example, methodologies require that certain types of activity-shifting

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[12] The methodologies do not allow for positive carbon leakage crediting, which is an important source of conservativeness in leakage accounting. However, evidence of positive market leakage is rare in the academic literature; there is little evidence of large-scale positive leakage that could counter the known and observable pathways for negative carbon leakage.

leakage be monitored directly, while market leakage cannot be monitored at the project level and must be estimated using economic models.

Activity-shifting leakage occurs when the individuals or organizations responsible for deforestation-driven emissions in the project area are displaced due to project activities, and as a result, shift their deforestation activities outside the project's boundary. Any emissions arising from the displacement of these agents is activity-shifting leakage. Activity-shifting leakage can occur due to a variety of deforestation drivers. For example, if the primary driver is timber production, and the deforestation agent shifts their harvest from a REDD+ project zone to other concessions they own, any emissions associated with that increased harvest would be a direct result of the project activities. Other drivers of deforestation that could induce activity-shifting leakage include deforestation to make way for crop production, livestock grazing, and other non-forest activities. In theory, the direct displacement of specific deforestation agents makes monitoring activity-shifting leakage possible, although it can be quite challenging in practice.

The key distinction between activity-shifting and market leakage is the agent involved in the activity outside the project's boundary. With market leakage, REDD+ project or program activities change market incentives and therefore affect behavior of agents other than those directly involved in or displaced by the project. This can happen through multiple market-based channels. REDD+ conservation activities can affect land markets by reducing the supply of land available for agricultural activities. This increases the rental rate on non-forest land uses and incentivizes conversion of forest land outside the project's boundary to these alternative uses. REDD+ activities can also affect output markets. For example, by conserving an area that would have been deforested for timber production, the project decreases the supply of timber, causing an increase in price in timber markets. This higher timber price provides an incentive to harvest outside the project's boundary. Market leakage occurs when non-project agents respond to these changing incentives in a way that increases emissions. Measuring and monitoring market leakage is a challenge because it is impractical to identify which participants in a market are responding to changing incentives in a way that increases emissions. This can occur across large geographic areas (commodity markets tend to be regional, national, and even global in scale) and can involve numerous market participants. To address this challenge, market leakage is usually estimated at the project start, using economic models, and the resulting leakage rates then are applied uniformly across the REDD+ project.

How VCS-REDD+ Methodologies Address Leakage

VCS's *Methodology Requirements* specify that all methodologies must account for both market and activity-shifting leakage if applicable to the project type (Verra, 2023, p. 53). However, the four methodologies account for leakage differently, and a brief summary of those differences are included in this section. Depending on the agents and drivers of deforestation identified by project developers, methodologies allow projects to account for leakage by assuming ex-ante that it will not occur. Table 3.1 highlights differences in the broad categories of leakage that are accounted for in each methodology.

Table 3.1
Summary of Leakage Requirements in VCS-REDD+ Methodologies

Methodology	Activity-shifting leakage		Market leakage
	Local agents/ geographically constrained	Immigrant agents/ geographically unconstrained	
VM0006	Required	Required	Required
VM0007	Required	Required	Required
VM0009	Required	Not required	Required
VM0015	Required	Not required	Not required

Activity-Shifting Leakage

Activity-shifting leakage in project-based REDD+ methodologies is generally estimated differently based on the agent of deforestation. If the agent is a person or entity currently operating within the project boundary, activity-shifting leakage is monitored and measured in a designated leakage area, usually in the general proximity of the project's boundary. Some methodologies refer to this as *geographically constrained* leakage. However, if an agent is not currently operating within the project area but is expected to do so in the future (i.e., deforestation from future immigration into the project area), activity-shifting leakage is estimated based on assumptions regarding the immigration levels and emissions associated with deforestation activities. VM0006 refers to this as *geographically unconstrained* leakage.

Under all four methodologies, activity-shifting leakage from current deforestation agents is monitored after the project goes into effect by using satellite data to measure deforestation in a designated leakage area. Some methodologies refer to this leakage area as the *leakage belt*. The leakage monitoring area, or leakage belt, is defined differently for each methodology but generally means the areas where a displaced deforestation agent could plausibly shift their activities. The methodologies differ in details, such as the approach used to define the leakage area, the size of the leakage areas, and land classes that must be included (or can be excluded). We summarize major differences in Table 3.2.

VM0006, VM0007, and VM0015 use a similar approach, whereby a leakage belt is drawn around the project area using either a mobility or opportunity cost analysis. A mobility analysis captures how far a deforestation agent could reasonably travel (given predominant modes of transportation, road/waterway networks, etc.) to engage in deforestation activities. An opportunity cost analysis sets the leakage area based on where around the project's boundary deforestation activities are profitable. VM0009 relies on project developers to identify areas in the project region where leakage could occur; the process for delineating these areas varies by project.

Table 3.2
Determining Leakage Area for Monitoring

Methodology	Method	Leakage area size	Land area included
VM0006	Mobility analysis	Not specified	Forest, grassland
VM0007	Mobility analysis	>90% of the project area	Forest
VM0009	Not specified	Not specified	Forest or native grassland
VM0015	Opportunity cost or mobility analysis	Not specified	All

For each VCS monitoring report, the developer must conduct an analysis to determine whether more deforestation is occurring in the leakage area than would be expected in the project's absence. If it is, emissions from these deforestation activities are deducted from the emissions credits. Monitoring is done using remote sensing. A deduction for activity-shifting leakage is taken only if the deforestation levels during the monitoring period are above the baseline deforestation levels for that area. Methods to estimate baseline deforestation levels in the leakage areas are similar to those that are used to establish project baselines and that have led to exaggerated baselines (see Chapter 2: Baselines). If the leakage area has deforestation after the project, but it is below baseline deforestation, a zero leakage deduction is applied. In theory, if deforestation rates in a leakage area are below baseline rates, the project activity is inducing emission reductions outside the project area (i.e., positive leakage). However, because no positive leakage is allowed by the methodologies, setting leakage deductions to zero in such cases would be a conservative application of leakage rules.

Activity-shifting leakage from displaced migration into the project's boundary must be addressed by VM0006 and VM0007, and may be addressed by the other methodologies. This type of activity leakage occurs when agents of deforestation that can no longer immigrate into the project's boundary shift their deforestation activities elsewhere. Because identifying, monitoring, and measuring with reasonable accuracy who these displaced immigrants are, where they are displaced to, and what alternative activities they engage in is impractical, this form of leakage is estimated using a series of assumptions about immigrants' activities. It is left to the project developer, using guidance in the VM0006 methodology, to obtain the relevant data and assumptions to estimate this.

Market Leakage

Current VCS methodology requirements state that methodologies must account for market leakage when certain conditions are met. However, these conditions are interpreted differently by the four methodologies, resulting in considerable variation in how they approach, interpret, and apply market leakage accounting. The key issues related to market leakage in the REDD+ methodologies are: When must a market leakage deduction be taken? What is the size of the deduction? Are exceptions allowed?

Verra (2023) provides general guidance on the first two issues, while allowing methodologies to set additional rules. VCS methodology requirements note that "the methodology shall require projects to account for market leakage where the production of a commodity (e.g., timber, aquacultural products or agricultural products) is significantly affected by the project" (p. 53). However, *Voluntary Carbon Standard* (2008) and other earlier versions only required that market leakage be accounted for when timber production was significantly affected. The four methodologies appear to base their market leakage guidance on different interpretations and versions of the standard (Table 3.3). VM0006 requires market leakage rates only when illegal logging that supplies national or international markets is identified as a deforestation driver. VM0007 requires market leakage deductions when timber, fuelwood, or charcoal production are identified as drivers. VM0009 requires market leakage deductions when any commodity accounted for in the baseline scenario is displaced. VM0015 does not explicitly require the deduction of market leakage.

If leakage is due to avoided logging, guidance is provided on which leakage rates to use. The default leakage rates specified by VCS AFOLU guidance are 20%, 40%, and 70%, depending on the ratio of the project's merchantable biomass to total biomass, compared with that in the area to which the displacement occurs. However, the methodologies differ in how the leakage rates are applied (Table 3.3). VM0006 applies the leakage deduction to total gross emissions reductions (baseline emissions - project emissions + carbon in long-lived wood products), whereas VM0007 applies that leakage deduction just to the carbon emissions associated with the displaced timber harvest, and VM0009 similarly applies it to the portion of emissions reductions from aboveground merchantable trees.

VM0006 and VM0007 do not explicitly allow for exceptions to the VCS leakage rate defaults, whereas VM0009 notes that alternative rates can be found in the literature and applied if the developer provides a detailed justification. VM0009 also allows for a 10% leakage deduction if the developer can show that total harvested volume does not drop over the full-time horizon under consideration for a project. Zero leakage rates can also be applied in VM0009 if the developer can show that either new timber harvest concessions will not be given or substantial barriers prevent illegal timber harvest.

In theory, since market leakage occurs in response to changing market incentives, the geographic scope of these market effects is dependent on the geographic extent of the relevant land and output markets themselves. Project activities that displace commodities integrated into international markets could result in international leakage. However, both the VCS Standard and each methodology only requires the consideration of a national scope for market leakage, allowing projects to exclude any emissions associated with international leakage even when developers acknowledge that it may be occurring.[13]

[13] For example, VCS 832's project description document justified the exclusion of market leakage from future accounting, saying that "All sawnwood, processed on-site at CKBV's sawmill units located in RCC and Ananindeua, would be destined for the export market, and thus is not considered further in assessment of market leakage" (CKVB Florestal Ltda & TerraCarbon, 2012, p. 68).

Table 3.3
Market Leakage Deduction

Methodology	When is a deduction required?	How is the deduction applied?
VM0006	When illegal logging that supplies national or international markets is a deforestation driver	To total emissions reductions
VM0007	When timber, fuelwood, or charcoal production is identified as a driver	To just the portion of reductions attributed to reductions in timber harvesting
VM0009	When any commodity is displaced	To the portion of emissions reductions from aboveground merchantable trees
VM0015	Market leakage accounting is not explicitly required	

Leakage Mitigation

All four methodologies either allow for or require developers to undertake leakage prevention activities. These are activities within the project area meant to mitigate possible leakage from the conservation efforts. The specific leakage mitigation activity usually depends on the deforestation driver. For example, if a developer identifies agricultural use as an important driver of deforestation, a leakage mitigation measure could be to increase agricultural productivity (e.g., through intensification) on existing agricultural land in the project area. For projects where grazing is an important driver, increasing stocking rates on existing grazing land could mitigate leakage.

If any leakage prevention measure increases GHG emissions significantly, the developer is required to account for these increases. However, detailed accounting of leakage emissions avoided due to mitigation activities is generally not explicitly quantified. In addition to practices that directly address specific deforestation drivers, some methodologies allow for leakage prevention measures that increase the deforestation agents' economic activity and opportunity in the project area. These leakage mitigation measures are designed primarily to reduce activity-shifting leakage, although measures that increase the productivity of a displaced commodity would also decrease market leakage pressures.

Scientific Literature on Leakage

Considerable research has been conducted over the past several decades on the leakage effects of conservation-type programs. Improvements in data quality and availability and in empirical techniques have improved the quality of the assessments on forest-based carbon leakage. A comprehensive literature review of all studies quantifying forest-based leakage is beyond the scope of this report. Instead, we focus on two aspects of the literature that are most relevant for our research. First, we discuss the various methodological approaches to estimating leakage. Second, we review several recent forest-based leakage meta-analyses to gain some understanding of key findings from the literature.

Approaches to Leakage Estimation

Three general approaches are used in the academic literature to document and quantify forest-based leakage. The first uses partial or general equilibrium models, which are economic optimization models calibrated to real-world data that simulate how markets function based on economic theory. Important parameters, such as supply and demand responses in relevant markets, are usually taken from the economic literature. A benefit to these models is that they can capture complex interactions between economic sectors that often cannot be observed statistically. The strength of these models lies in their ability to generate estimates of market leakage.

A second approach is to statistically estimate leakage by analyzing deforestation around a protected area using satellite imagery. Ewers and Rodrigues (2008) referred to this as the "inside-outside" approach, where deforestation rates (or another relevant metric) within a project's boundary are compared to a nearby area outside the boundary. If deforestation rates increase outside the project's boundary after the project goes into effect, this is interpreted as project-induced leakage. Statistically, this is referred to as a "difference-in-difference" approach. VCS-REDD+ methodologies use a modified version of this approach to estimate activity-shifting leakage. The modeler must decide what constitutes an appropriate area outside the project's boundary to monitor, which can affect the results. This approach has evolved over time to better account for confounding factors between the protected area and the monitored control area (see Joppa & Pfaff, 2010; Schleicher et al., 2019).

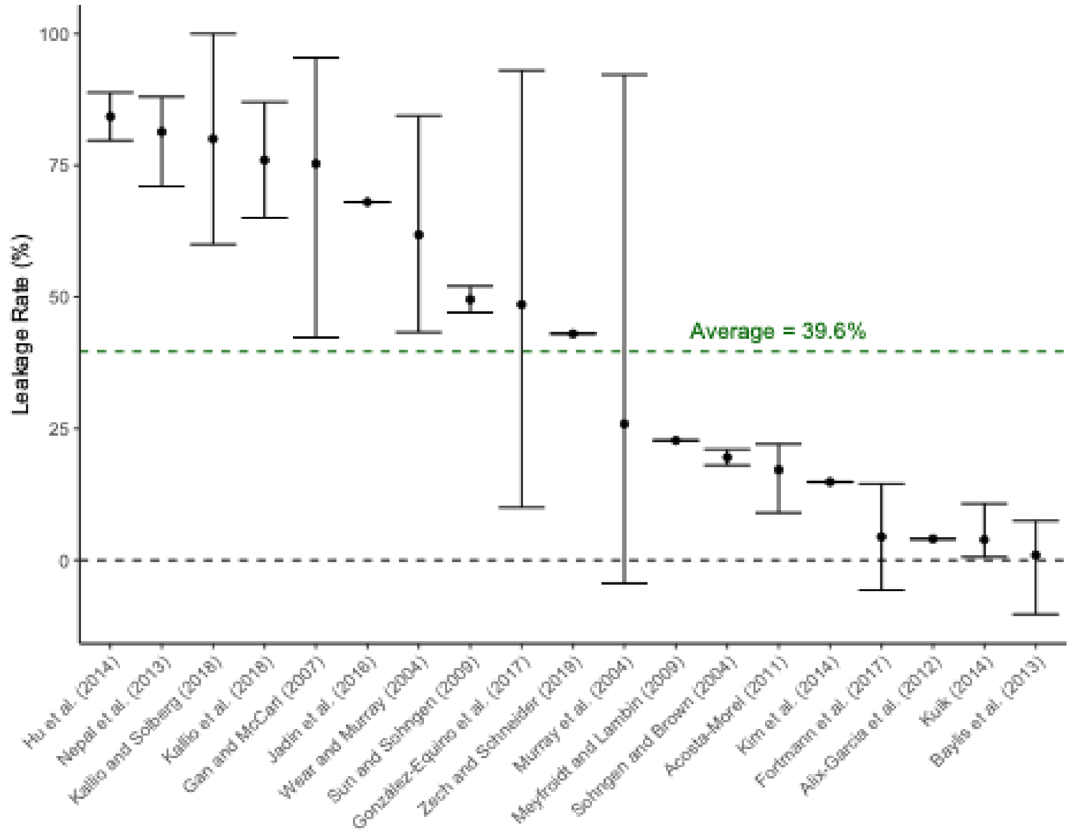
A third approach uses field research case studies to trace the movement of specific actors and shifts in markets from the project's area to other neighboring areas, regions, or countries. These studies use interviews corroborated by analyses of market trends.

Key Findings From the Literature

Several studies provide insights into the state of the science on leakage from forest conservation projects using the approaches described above. A recent meta-analysis by Pan et al. (2020) analyzed studies using the partial and general equilibrium models most relevant for market leakage. The studies included in this paper did not directly observe leakage using satellite data but instead relied on models of the economy wherein land decisions are linked with markets. The meta-analysis found 19 studies in the literature on forest-based carbon leakage, with the central estimate for each study showing (negative) leakage (Figure 3.1). The average leakage rate across all forest-based studies was 39.6%, larger than average rates found for studies of the energy sector considered in the same paper. However, there was significant variation, ranging from essentially zero leakage to estimates greater than 75%. One important caveat of this study is that it included estimates from outside the tropics, for different types of timber harvest reductions, and in countries with highly formal and globally integrated agricultural and timber markets. Also, the studies reviewed did not all measure leakage in the same way. Some measured carbon leakage, but others measured timber leakage or other economic metrics. The average leakage rate should therefore be interpreted with caution. However, a key finding from this literature is that total leakage is likely to be greater than zero and is likely to vary considerably based on context.

Figure 3.1

Empirical Estimates of Forest-Based Carbon Leakage from Pan et al. (2020)



Note. Ranges represent high and low estimates from studies if multiple estimates were made. Created from Pan et al. (2020).

To illustrate the variation in the literature on detecting leakage using satellite imagery, most relevant for activity leakage, we reviewed several recent statistically based meta studies of leakage from conservation activities in the tropics, as detected by satellites. Some site-specific or policy-specific case studies on leakage that we did not review in depth could be relevant for registries to assess leakage in specific jurisdictions (e.g., Gaveau et al., 2009; Heilmayr et al., 2020; Honey-Rosés et al., 2011; Leijten et al., 2021; Robalino et al., 2017). Results from just these few studies provide mixed evidence of leakage, with some showing evidence of positive leakage (Gaveau et al., 2009; Honey-Rosés et al., 2011), some showing negative leakage (Heilmayr et al., 2020; Leijten et al., 2021), and one with mixed results dependent on specific factors (Robalino et al., 2017).

Several studies used statistical techniques for analyzing satellite data on forest cover change to assess whether conservation interventions were causing leakage outside the protected area. Perhaps the most comprehensive of these studies was by Lui and Coomes (2016). Their study was notable for several reasons. First, they analyzed 60 conservation reserves, equally distributed across Africa, the Americas, and the Asia-Pacific region, making it the first study to have such a wide geographic coverage. Second, its method roughly corresponds to how VCS methodologies require project proponents to measure activity leakage. The authors created 10 km leakage belts around the conservation areas and examined deforestation rates in these belts. They also constructed baseline deforestation rates for the broader region, including outside the leakage belts. They then defined leakage as deforestation in the leakage belt that occurs at a higher rate than the baseline. While the baseline setting approach and the leakage belt size determination are slightly different in VCS, this is the general approach for monitoring. The study did not find evidence of large-scale leakage from these conservation projects, both at a global and continental scale. In fact, the analysis found evidence of modest positive leakage, which is consistent with project-level monitoring reports. One important limitation of the study is that it was not focused on VCS-REDD+ projects, which could be characteristically different from the conservation areas selected by the authors.

Another large-scale study on leakage using satellite data from 120 protected areas in tropical regions also found mixed evidence (Ford et al., 2020). These researchers found evidence of leakage in just under half (46%) of the protected areas analyzed. The protected areas showing leakage were evenly distributed across all tropical regions. One improvement of this study compared with that by Lui and Coomes (2016) was the use of more advanced statistical matching algorithms to establish better comparison groups.

The study by Guizar-Coutiño et al. (2022) is the only one, to our knowledge, that estimated activity leakage from multiple VCS-REDD+ projects using satellite data. Their study used a statistical matching approach to evaluate 40 VCS-REDD+ projects in nine countries. Their results showed very little statistical evidence of leakage within 10 km of the project's boundary. Only three of the 40 projects exhibited higher deforestation rates in the leakage belts, and two projects exhibited lower deforestation rates. The remaining 35 projects showed no evidence of leakage.

It is well accepted that international leakage can occur when there is a reduction in production in one country of an internationally traded commodity. A number of high-quality but dated modeling studies have estimated international carbon leakage from forest conservation programs, showing that timber harvest reductions often induce harvesting in other countries (Gan & McCarl, 2007; Lee et al., 2004; Sohngen & Sun, 2009). More recent studies on exploring bioenergy expansion policies in the United States and Europe have used similar economic equilibrium modeling to quantify the indirect land use change (iLUC) that occurs when agricultural land is reallocated to produce energy crops (for a review, see Tokgoz & Laborde, 2014). Many studies predict land-use conversion to agriculture in other countries as a response. While the policy context is quite different, the iLUC literature illustrates how land markets are internationally connected and can result in leakage risks when a production globally traded commodity is reduced.

Performance of the Methodologies

The four methodologies we studied each outline specific approaches to quantifying leakage deductions for individual projects. In this section, we explore the outcomes of the methodologies in comparison with what is known in the scientific literature about leakage in forest conservation projects. First, we calculate a methodology-wide leakage rate that pools the leakage deduction taken by each project in a given methodology. Then we select four case studies, one from each methodology, to explore how leakage requirements are being implemented in practice and to discuss deviations from the methodologies commonly adopted by projects.

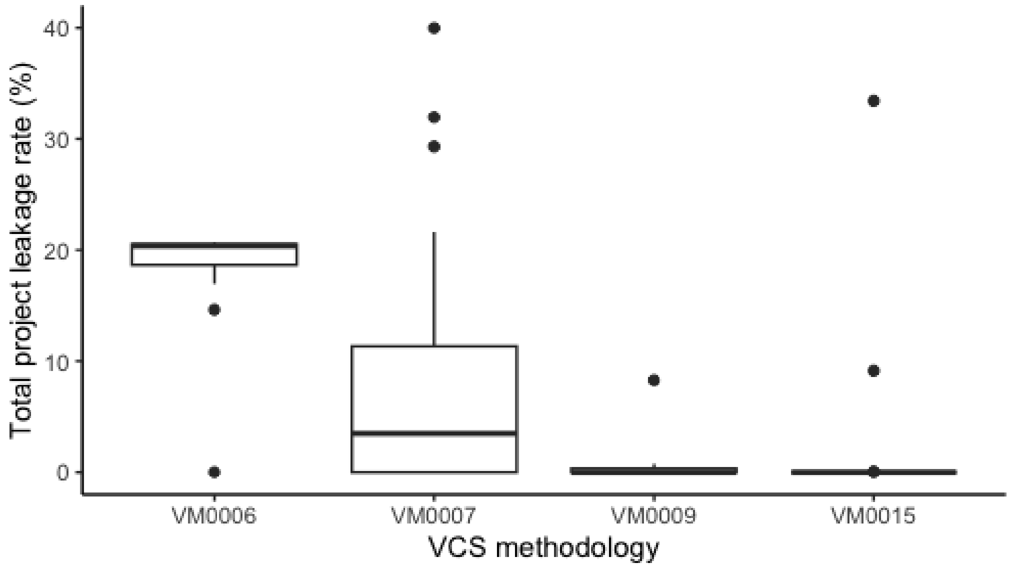
Leakage Quantification in Practice

We analyzed the most recent publicly available monitoring reports as of December 2022 from the 75 REDD+ projects that had been issued carbon credits as of March 2022, representing the four methodologies (Table 3.A1). Two REDD+ projects were excluded due to a lack of clarity in the leakage accounting in their monitoring reports. Because the methods and parameters used to determine leakage deductions were not consistent across monitoring reports, we standardize the assessment by defining the effective leakage rate as the total leakage deduction divided by net avoided emissions from the project, based on one or two of the most recent monitoring reports. Activity-shifting leakage rates (which represent a portion of the total rates) include monitored emissions in the leakage area as reported in individual monitoring reports, and any ex ante activity-shifting leakage deductions applied to the project (e.g., for unconstrained drivers like diverted immigration). VCS-REDD+ guidance requires project developers to provide complete ex ante leakage assessments in their project description documents, but since these estimates are not used to estimate credit issuances, we excluded these figures from our leakage analysis.

The leakage rate after summing together (pooling) all leakage deductions and net avoided emissions for all projects across four methodologies is 6.6%.[14] The pooled methodology-specific effective leakage rates for VM0006, VM0007, and VM0009, and VM0015 are 14.8%, 9.0%, 2.4%, and 3.5%, respectively. Figure 3.2 shows the distribution of project-level leakage rates across the four methodologies. VM0006 has the highest median leakage rate, presumably because it has the strictest market leakage rate requirements.

Figure 3.22

Distribution of Project-Level Leakage Rates Across the Four Project-Based REDD+ Methodologies

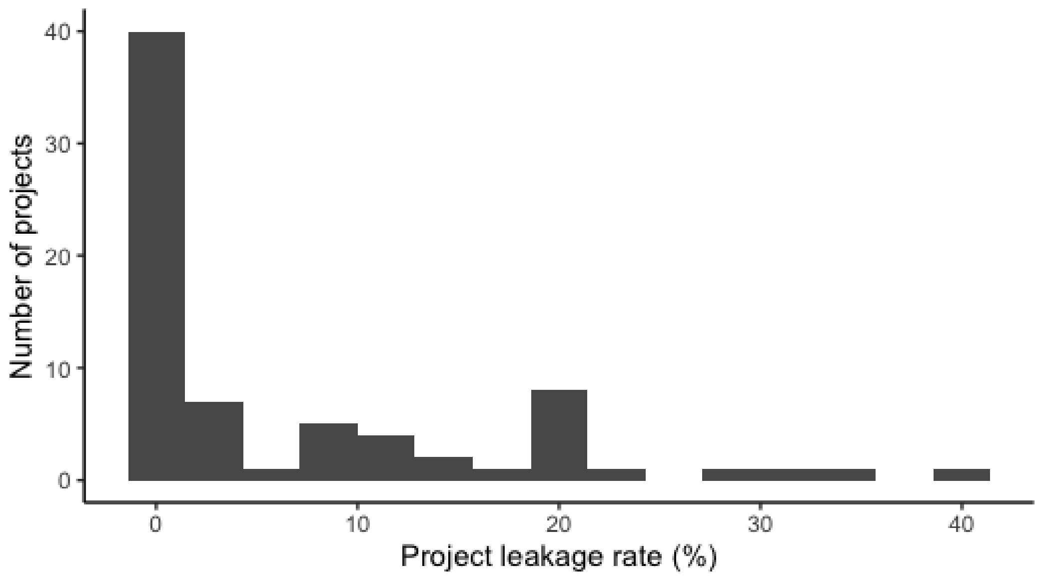


[14] Note that the pooled leakage rate calculated here is different than if one were to average the effective leakage rates of the individual projects. The pooling approach takes into account project size and is more appropriate for a methodology-wide estimate of leakage deductions.

A histogram of project-level leakage rates shows about half of VCS projects did not take a leakage deduction in their most recent monitoring reports as of 2022 (Figure 3.3). Around half of these projects (20) used the VM0015 methodology, nine used the VM0007 methodology, eight used the VM0009 methodology, and one used the VM0006 methodology. The other clusters of leakage rates were approximately 10% to 20%, reflecting the market leakage deductions used in several of the methodologies.

Figure 3.3

Distribution of Project-Level Leakage Rates Across All VCS-REDD+ Methodologies



Decomposition of total leakage rates into activity-shifting and market leakage reveals some interesting patterns (Table 3.4). In VM0006, the total leakage rate across all projects consists primarily of market leakage deductions. Many projects did not take any activity-shifting leakage deduction in their monitoring reports. Only one (of 11) VM0006 projects had activity-shifting leakage, 15 (of 29) VM0007 projects had activity-shifting leakage, one (of 11) VM0009 projects had activity-shifting leakage, and one (of 22) VM0015 projects detected activity-shifting leakage. We found similar patterns for market leakage. Most projects (54 of the 73 analyzed) do not take a market leakage deduction. Nine (of 11) VM0006 projects had market leakage, seven (of 29) VM0007 projects had market leakage deductions, two (of 11) VM0009 projects had a market leakage deduction, and one (of 22) VM0015 projects had a market leakage deduction.

Table 3.4

Pooled Leakage Rates and Component Elements for Each Methodology

Methodology (number of projects)	Market leakage rate	Activity-shifting leakage rate	Total leakage rate
VM0006 (*n* = 11)	12.3%	2.5%	14.8%
VM0007 (*n* = 29)	7.7%	4.4%	9.0%
VM0009 (*n* = 11)	0.3%	0.3%	2.4%
VM0015 (*n* = 22)	1.5%	1.5%	3.5%
All methodologies (*n* = 73)	4.4%	2.6%	6.6%

Note. Rates represent pooled leakage deductions and baseline/project emissions across all projects within a methodology.

Illustrative Case Studies

Our analysis of REDD+ projects revealed that most projects applied either very low or no leakage deduction in practice, despite the detailed accounting requirements contained in the methodologies. To better understand the justifications for these low leakage rates, we qualitatively analyze how projects apply leakage accounting in practice using four core case study projects (one from each methodology). These four projects are used throughout all sections of this report and were chosen because they had the data necessary to run the baseline analysis while representing a reasonable degree of regional heterogeneity. These projects are not necessarily representative of other REDD+ projects but rather are meant to highlight some important project-specific nuances missing from the quantitative analysis. Interestingly, each case study highlights one or more issues in the leakage estimations. In particular, these projects show that leakage deductions are often the result of argumentation based on expert knowledge.

Leakage rates, derived from project monitoring reports, for each project are reported in Table 3.5.

Table 3.5

Leakage Rates for Four Case Studies

Project	Methodology	Activity-shifting leakage	Market leakage	Total leakage deduction
VCS 1396	VM0006	0%	21%	21%
VCS 1112	VM0007	3%	0%	3%
VCS 934	VM0009	0%	0%	0%
VCS 944	VM0015	0%	0%	0%

VM0006 Case Study: The Rio Pepe y ACABA REDD+ Project (VCS 1396)

The Rio Pepe y ACABA REDD+ project, based in Chocó, Colombia, is one of eight USAID/BIOREDD+ projects. Project documentation and methodology application was nearly identical across BIOREDD+ projects, which are active on collectively-owned Afro-Colombian reserves. According to the project narrative, community members in the project area rely on timber harvesting and wood product sales to supplement their incomes. The project aimed to reduce that reliance by providing access to non-timber income streams. Project activities also included land titling and increased deforestation monitoring (ecoPartners et al., 2014). Rio Pepe y ACABA considered both locally displaced activity-shifting leakage, monitored in a leakage belt, and market leakage, which was calculated based on parameters chosen at the project's start. While the project applied a market leakage deduction equal to 21% of total emissions reductions in accordance with VM0006 guidelines, it found no activity-shifting leakage during monitoring events.

This project provides an interesting example of how leakage belt and baseline deforestation levels can change over the course of a project. After validators raised concerns that the leakage belt was too small and contradicted deforestation patterns in the area, project developers increased it considerably (Rainforest Alliance, 2015, p. 105). This did not necessarily change the quantification of activity-shifting leakage, because leakage is estimated as the change in deforestation rates in the leakage belt over time, compared with the baseline in the leakage belt. However, a study of Cajambre (VCS 1392), one of the other USAID/BIOREDD+ projects, discussed the validity of a similar late change in its leakage belt:

> Originally, in Los Cocos the leakage area had been designated to run along the riverbanks of the project. But members of the community who understood the process, a few months before the project was to be validated, argued that this would be problematic for them, as there was mining taking place in this area. As a result, the leakage area was moved to the outside of the project area, and the mining areas were taken out of the project altogether. This was a somewhat surprising outcome given that, according to interviews, the one activity that substituted for cutting wood was mining. It could easily have been argued, then, that as a result of the project, and in hopes of being paid via carbon credits in the future, woodcutters shifted over to mining to provide their income in the interim. (Withey, 2021, p. 76)

VM0007 Case Study: The Russas Project (VCS 1112)

According to the project narrative within publicly available project documents, the Russas project in the Brazilian Amazon reduces deforestation pressures from subsistence farmers with informal land tenure within the project area by granting land tenure, sharing carbon credits, monitoring the project area, and improving agricultural techniques. Immigration and population pressures were also identified as factors causing deforestation to rise. As a result, following VM0007 rules, Russas must account for possible leakage outside the leakage belt from immigrants who would have migrated to the area in the absence of project activities, in addition to accounting for leakage detected in the leakage belt itself.

To estimate the potential scale of immigration-induced leakage, Russas surveyed a sample of local households each crediting period to determine the percentage of households that immigrated into the project area. Under the leakage accounting module used by the project, this percentage is a key parameter used to calculate leakage outside the leakage belt. A higher percentage is assumed to mean a higher likelihood that immigrants were being displaced by the project and a higher activity-shifting leakage deduction, while a percentage value of zero leads to zero deduction for activity shifting leakage outside the leakage belt.

In its project description document, finalized in 2014, Russas found that one of the 19 communities surveyed was an immigrant community (CarbonCo et al., 2014, p. 77). That same year, Russas published its first monitoring report, which sought verification of carbon credits from avoided deforestation in 2012 and 2013. For that document, the project performed a separate survey of 15 households and found that none were recent migrants. The developer used this second survey to apply a leakage rate of zero (CarbonCo & TerraCarbon, 2014, p. 69). Although auditors raised concerns during the verification process about this inconsistency, they eventually accepted it because the second survey was more up-to-date, even though it was performed close to the same time as the other survey and was less conservative (Environmental Services, Inc., 2014, pp. 57–58). During subsequent verifications, Russas used new estimates of immigrant percentages, which did result in immigration-induced activity-shifting leakage deductions.

VM0009 Case Study: The Mai Ndombe Project (VCS 934)

The Mai Ndombe project is based in the Democratic Republic of Congo's Mai Ndombe forest, an area known for hardwood that is highly valued in international timber markets (Wildlife Works, 2012). Mai Ndombe was one of the first REDD projects to apply the VM0009 methodology. The project was developed by Wildlife Works Carbon, a REDD+ project development company that also helped develop the VM0009 methodology itself. According to the deforestation narrative in publicly available project documents, logging conglomerate SOFORMA would have held the logging concession for the project area had Wildlife Works Carbon not gained control. This concession would have given SOFORMA the right to selectively log the forested areas and, according to the project developers, would have kicked off a "cascade" of both legal and illegal deforestation by smaller logging groups and individuals. Under VM0009 v2.0 used by the project, if the developers identify a specific agent of planned deforestation in their baseline and can prove the specific agent would not be able to increase their planned deforestation elsewhere in the country, then market leakage may be considered zero. The justification presented by the methodology is that market leakage cannot happen if legal logging in the country cannot increase. However, in the project description document, the developer repeated the language in the methodology: "Market leakage does not apply when the primary agent is known, and the project proponent has demonstrated that there is no possibility for *that agent* to be awarded a further/replacement concession within the national boundary" (emphasis in the original; p. 97). In this case, SOFORMA could set a zero market leakage rate because its own concessions were already above the legal limit and the company was unable to increase them, even if market effects might cause other agents to increase logging if the government offered more concessions. Wildlife Works Carbon used this specific provision, from the methodology they helped draft, to claim zero market leakage.

Furthermore, Wildlife Works argued that because unplanned deforestation and degradation by secondary actors would not occur in the absence of access to roads and transportation networks the logging conglomerate would have built, the project was also able to exclude any activity-shifting leakage and was not required to define a leakage zone. However, to appease communities dependent on forest resources, Mai Ndombe's developers carved out buffer zones around each community in the concession boundaries so these communities could meet their forest resource needs. These areas were not included in the project area and appeared as circular carve outs in the project's accounting area map (Wildlife Works, 2012, p. 18). Despite appearing to play a role similar to a leakage belt, Mai

Ndombe's buffer zones were excluded from project accounting, and deforestation or degradation in these zones does not appear to have been included in the project's crediting calculations.

VM0015 Case Study: The Alto Mayo REDD+ Project (VCS 944)

The Alto Mayo REDD+ project, based in the Peruvian Amazon's Alto Mayo Protected Forest, shows how less restrictive leakage rules in VM0015 might attract projects where other methodologies would likely require large leakage deductions. According to the deforestation narrative described in publicly available project documents, a combination of global coffee prices, immigration, and unsustainable agricultural methods drives deforestation, while the Peruvian government lacks the resources to enforce the area's legal status as a protected natural area (Conservation International Peru, 2015). Migrants move to the project area, where they clear forest land for coffee plantations. Poor growing practices deplete the soil, and before long, the migrants must find new land to clear. The developers justified their baseline projections of accelerated deforestation based on these deforestation drivers and an increasing population.[15]

The project aimed to reduce deforestation through greater enforcement of the conservation area, combined with training and support for coffee growers to increase the sustainability and yield of their coffee production. Leakage could occur for a variety of reasons: coffee and other agricultural production could shift to other forested areas when new immigrants settle elsewhere (immigrant leakage), coffee growers could be voluntarily or involuntarily displaced from the project area due to increased enforcement in the conservation area (activity-shifting leakage), and the project could result in less overall coffee or other production (market leakage). An investigative news story documented involuntary displacement of forest dwellers from the Alto Mayo forest due to the project (Greenfield, 2023).

The developer monitored activity-shifting leakage in a leakage belt, as required by all four methodologies. Under a different methodology, however, the developer would also be required to account for immigrant leakage and market leakage. Under VM0015, the developer neither includes these sources nor has to justify their exclusion. A zero leakage risk deduction was applied despite the realistic risk of activity-shifting, immigrant, and market leakage due to project activities.

Discussion and Recommendations

VCS-REDD+ methodologies rules generally align with the scientific literature on leakage from forest conservation. However, in practice, developers consistently applied either no leakage deduction or low deduction for both activity-shifting and market leakage.

Several improvements could be made to the methodologies as they are currently structured. One key improvement would be to strengthen the baseline calculations of activity-shifting leakage in leakage monitoring zones. Another would be to include the potential for international leakage in market leakage rates. However, the main structural shortcoming of the methodologies appears to be how they are applied in practice, and specifically, the ability of developers to justify leakage

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[15] For example, describing baseline calculations in the project description document's methodological annex: "The AMPF is currently being impacted by the significant population of settlers within and around its boundaries that rely heavily on forest conversion to cropland to sustain their income generation activities" (Conservation International Peru, 2015, p. 44).

exemptions in a manner that deviates considerably from the standards written into most methodologies.

In the case of activity-shifting leakage, low leakage risks reported by projects comports with several recent studies of activity-shifting in tropical conservation-type projects that appear to support low levels of activity-shifting leakage (Ford et al., 2020; Guizar-Coutiño et al., 2022). This is an important empirical result even if the mechanisms for explaining it require further study. Conservativeness in carbon accounting also suggests that without a strong understanding of the mechanisms for this result, continued awareness of the evolving academic literature is warranted. Furthermore, there appears to be room for improvement in increasing the rigor with which baseline deforestation rates in leakage monitoring zones are calculated. As with establishing the baseline for the project area, overestimating baseline deforestation rates in the leakage monitoring zone can result in over-crediting. As we noted with the VCS 1396 and VCS 1112 case studies, developers have a strong incentive to undertake actions to minimize the possibility of detecting activity-shifting leakage during monitoring periods. This can be done through inflating baselines, carefully choosing leakage monitoring zones, and other project-level decisions. Updates to the VCS-REDD+ unplanned deforestation methodologies should focus on these topics for activity-shifting leakage.

The results from this chapter show that while the market leakage rates prescribed by the methodologies are supported by the academic literature, in practice, projects take very low or no market leakage deductions. This suggests a considerable opportunity for strengthening the methodologies' approach to market leakage. Perhaps the most straightforward solution is to revise the VCS requirements to improve the clarity about when market leakage deductions are required. Reductions in legal timber harvesting and agricultural commodity production can also trigger market leakage and should be accounted for in all VCS-REDD+ methodologies.

For market leakage, zero leakage claims by developers are common. The methodologies appear to allow developers substantial leniency in arguing for market leakage rate exemptions. The ability to apply these project-level exemptions should be assessed across all VCS-REDD+ methodologies. The VCS 934 and VCS 944 case studies exemplify how projects are able to claim zero market leakage deductions. One possible approach to addressing this issue is to treat market leakage risk as a program risk, rather than a project risk. With this approach, all projects would be required to apply the same market leakage rate, regardless of the individual project-level risk. This approach has drawbacks, such as unfairly penalizing projects that truly have a low market leakage risk or doing away with the incentive for developers to design projects in a way that minimizes leakage. However, given the application of market leakage rates in practice, which likely results in program-wide over-crediting, this risk may be warranted.

Verra has released a draft consolidated REDD+ methodology that, if adopted, would take the place of the four methodologies reviewed in this report (Climate Focus, 2023). The draft requires that all REDD+ projects follow a single approach to calculating market leakage. This is an improvement for methodologies that currently have weak market leakage provisions. The leakage rates in this new methodology are the same as current methodologies (20%, 40%, or 70%, depending on project features). However, the new methodology does not address international leakage and market leakage from agricultural displacement. There is also still opportunity for projects to avoid a market leakage deduction by implementing mitigation measures. While this is reasonable conceptually, given the historical tendency for many projects to claim zero market leakage deductions, it is important to track how it is applied in practice, to ensure the integrity of the market leakage module.

Leakage is a complex quality criterion for nature-based carbon reductions and removals. It is difficult to both quantify and monitor, and quantifying it currently involves considerable uncertainty.

For REDD+ programs, leakage poses a fairly high risk to carbon accounting integrity and thus needs to be treated rigorously. This chapter shows areas where the VCS methodologies are strong but low leakage rates result from leniency in their implementation. Program-wide improvements are necessary to reduce the risk of over-crediting.

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Appendix: Leakage

Table 3.A14

Projects Included in the Analysis and Project-Specific Leakage Rates

VCS project number	Methodology	Activity-shifting leakage rate	Market leakage rate	Total leakage rate
VCS562	VM0009	0%	0%	0%
VCS612	VM0009	0%	0%	0%
VCS647	VM0007	29%	0%	29%
VCS812	VM0007	0%	0%	0%
VCS818	VM0007	0%	0%	0%
VCS832	VM0007	1%	21%	22%
VCS844	VM0007	2%	0%	2%
VCS852	VM0007	32%	0%	32%
VCS856	VM0009	0%	0%	0%
VCS868	VM0007	3%	0%	3%
VCS875	VM0007	0%	3%	3%
VCS902	VM0009	0%	0%	0%
VCS904	VM0006	0%	15%	15%
VCS934	VM0009	0%	0%	0%
VCS944	VM0015	0%	0%	0%
VCS953	VM0007	40%	0%	40%
VCS958	VM0015	0%	0%	0%
VCS963	VM0007	9%	0%	9%
VCS985	VM0007	3%	0%	3%
VCS1067	VM0007	0%	0%	0%
VCS1094	VM0015	0%	0%	0%
VCS1112	VM0007	3%	0%	3%
VCS1113	VM0007	12%	0%	12%
VCS1115	VM0015	0%	0%	0%
VCS1118	VM0015	0%	0%	0%
VCS1133	VM0007	0%	3%	3%

VCS1168	VM0006	0%	0%	0%
VCS1175	VM0007	0%	0%	0%
VCS1201	VM0007	4%	1%	5%
VCS1202	VM0009	0%	0%	0%
VCS1215	VM0007	0%	0%	0%
VCS1218	VM0007	0%	0%	0%
VCS1311	VM0015	0%	0%	0%
VCS1325	VM0015	0%	0%	0%
VCS1326	VM0007	0%	12%	12%
VCS1329	VM0015	0%	0%	0%
VCS1340	VM0015	0%	0%	0%
VCS1359	VM0006	17%	0%	17%
VCS1360	VM0015	0%	0%	0%
VCS1382	VM0007	0%	14%	14%
VCS1389	VM0006	0%	21%	21%
VCS1390	VM0006	0%	21%	21%
VCS1391	VM0006	0%	20%	20%
VCS1392	VM0006	0%	21%	21%
VCS1395	VM0006	0%	20%	20%
VCS1396	VM0006	0%	21%	21%
VCS1399	VM0006	0%	20%	20%
VCS1400	VM0006	0%	20%	20%
VCS1403	VM0007	4%	0%	4%
VCS1408	VM0009	8%	0%	8%
VCS1477	VM0007	0%	0%	0%
VCS1503	VM0015	0%	0%	0%
VCS1532	VM0015	0%	0%	0%
VCS1541	VM0015	0%	0%	0%
VCS1566	VM0007	11%	0%	11%
VCS1571	VM0015	0%	0%	0%

VCS1622	VM0015	0%	9%	9%
VCS1650	VM0015	33%	0%	33%
VCS1654	VM0015	0%	0%	0%
VCS1686	VM0015	0%	0%	0%
VCS1689	VM0009	0%	1%	1%
VCS1748	VM0009	0%	1%	1%
VCS1775	VM0009	0%	0%	0%
VCS1811	VM0015	0%	0%	0%
VCS1882	VM0015	0%	0%	0%
VCS1897	VM0007	11%	0%	11%
VCS1899	VM0007	0%	0%	0%
VCS1900	VM0007	0%	10%	10%
VCS1953	VM0015	0%	0%	0%
VCS2252	VM0015	0%	0%	0%
VCS2290	VM0007	8%	0%	8%
VCS2293	VM0009	0%	0%	0%
VCS2324	VM0007	0%	0%	0%

Note. Leakage rates represent the total deduction reported in the most recent monitoring reports as a percentage of the total claimed emissions reductions in the most recent monitoring report.

Chapter 4: Forest Carbon Accounting

Barbara Bomfim, Thales A. P. West, Jennifer A. Holm, William R. L. Anderegg, Barbara K. Haya

Executive Summary

Most carbon credits generated under Reducing Emissions from Deforestation and Forest Degradation (REDD+) crediting methodologies come from the conservation of live trees. The quality of REDD+ credits therefore relies on the accuracy, or at least conservativeness, of estimates of the carbon per hectare in participating forests. If these estimates are exaggerated, the number of carbon credits generated from conserving forests will also be exaggerated. In this chapter, we share evidence that widely used methodologies leave the door open for over-crediting.

While studies of REDD+ projects have focused on the other quality factors discussed in this report (baselines, leakage, durability, and impact on forest communities), little has been published about the accuracy of the methods REDD+ projects use to estimate carbon per hectare of forest. The general perception is that these methods are reasonably rigorous. This chapter presents our analysis of the four most commonly used REDD+ crediting methodologies—VM0006 (Terra Global Capital, 2017), VM0007 (Avoided Deforestation Partners, 2020), VM0009 (Wildlife Works & ecoPartners, 2014), and VM0015 (Pedroni, 2012), all developed under Verra's *Verified Carbon Standard* (VCS)—focusing on their accuracy in measuring the two largest forest carbon pools: aboveground carbon (AGC) and belowground carbon (BGC) in live trees.

This chapter begins by describing how VCS-REDD+ methodologies quantify forest carbon. We then describe the results from our study of their accuracy and conservativeness in estimating both AGC and BGC in live trees. Our analysis focuses on flexibility. Flexibility in forest carbon accounting under these methodologies allows project developers to make choices that result in high, rather than conservative, estimates of forest carbon and carbon credits. We assess the flexibility allowed by these methodologies and how scientifically sound and conservative third-party verified developer choices have been to date. We conclude with a summary of our findings and specific recommendations for updating the methodologies to avoid over-crediting from the process of estimating the carbon in protected forests.

Since the only way to directly measure carbon in a forest is to cut down the trees, dry them, and weigh them—which would be counterproductive, to say the least—most projects rely on published models or equations. Project developers first inventory trees above a certain size in sample plots. Tree measurements always include diameter and may include height and wood density (i.e., the dry weight of wood per volume). These measurements are converted into estimates of aboveground biomass (AGB), using *allometric equations*. Belowground biomass (BGB) is typically estimated as AGB multiplied by a *root-to-shoot ratio*. Biomass is converted into metric tons of carbon using a *carbon fraction*. Developers typically choose allometric equations, root-to-shoot ratios, and carbon fractions from published literature. Carbon stock estimates are then applied to the entire project area for each forest category, or *stratum*, using remote sensing imagery. Project developers must assess the uncertainty in their estimates and apply an uncertainty deduction if uncertainty exceeds a threshold level.

The accuracy of physical measurements in forest inventories is crucial. One study found that if the diameter of the largest 5% of trees in a typical forest was exaggerated by as little as 10%, estimates of the carbon it stores—and the number of credits that would be generated by preserving it—could be inflated by more than 10% (Rifai et al., 2015). This suggests that small biases in the measurements of the largest trees can meaningfully inflate the number of carbon credits issued.

We found evidence of a significant risk of over-crediting due to the flexibility all four methodologies afford. In 12 sample projects (three from each methodology), we applied the guidance provided by each methodology to identify a range of allometric equations that developers are allowed to use to estimate AGC. We found that, on average, the maximum estimate of AGC was 80% higher than the minimum (Figure 4.3). This means that developers have significant latitude to choose allometric equations that maximize credit generation.

Our analysis suggests that most project developers choose high rather than conservative allometric equations, even though Verra requires developers to address uncertainty by choosing conservative values. Of the 11 sample projects that reported the allometric equation they used, five used equations that resulted in carbon estimates that were highest or second highest, compared with our range of allowed alternative equations (Figure 4.3). Using the best available science, we characterized each project's allometric equation choice into a quality class, ranging from highest quality (1, species-specific and locally developed) to lowest quality (7, general or local equation developed from fewer than 30 trees; Table 4.A2). The quality of the allometric equations projects used varied from 3 to 6. When we compared the developers' choices to the subset of alternative equations we ranked as an equal or better fit, we found that the projects' AGC estimates were, on average, 15.4% higher than the mean of those alternative estimates across all methodologies (Figure 4.4).

We performed a similar analysis on the BGB equations used by a random selection of four projects from our sample, one from each methodology. For each project, we identified three or four well-fit BGC estimation methods (root-to-shoot ratios or equations) from peer-reviewed literature that met the methodology requirements. We found that, on average, estimates of BGC using these methods varied by 193% across our sample projects. When we compared the average of these alternative estimates with the estimate using the project's root-to-shoot ratio or BGC equation, we observed substantial differences (Figure 4.5). In two of four projects, the project's own method yielded the highest estimates, while the other two had the second highest estimates. On average, the four BGC estimates were 37.1% higher than the mean of the alternative estimates. When we also took into account the developers' AGC estimates, the average estimate of BGC from the projects' methods were 61.3% greater than the averages of our alternative estimates.

Since the number of carbon credits issued for reducing deforestation is approximately proportional to estimates of AGC and BGC in live trees, our analysis suggests that the credits issued for the AGB portion from our sample could be over-credited by 15.4%, on average, and BGC by 61.3%. In combination, the project estimates are 23% to 30% higher than the average of the alternative estimates, implying that over-crediting from estimates of carbon in live trees is likely within a similar range.

Lack of transparency is another quality concern with forest carbon accounting under the four VCS methodologies. Verra does not require that forest data be publicly reported, and project developers keep substantial amounts of information related to forest carbon accounting confidential. This makes it hard for independent reviewers such as ourselves to assess a project's carbon calculations and impossible to fully replicate them. We learned from Verra that it plans to digitize its methodologies and data submission and make those data public, which could resolve the transparency issues described herein.

Project description documents often omit basic information about the allometric equations used, including study location, sampling design, statistics, and even the construction of allometric equations. Developers end up not transparently justifying their selection of allometric equation or root-to-shoot ratio. For example, the developer of one project we analyzed (VCS 1392) used an allometric equation from published research by Saldarriaga (2011) about water nutrients that is unrelated to tree allometry. Yet others, such as VCS 944 (VM0015) and VCS 985 (VM0007), performed sensitivity analyses on AGC using different allometric equations to defend the conservativeness of their choices. We contacted all 12 developers to request their forest inventory data so we could precisely assess their choice of allometric equation. As of the date of this report, none had shared their data.

In sum, our analysis found significant room for gaming (i.e., methodological choices that lead to high rather than conservative estimates of climate benefits and therefore credits issued) in methods to estimate AGC and BGC stocks. We also found evidence that developers use the flexibility allowed by these methodologies to choose equations that lead to high estimates of forest carbon and more credits, rather than make conservative choices, given uncertainty.

We highlight two recommendations that could help avoid over-crediting. First, VCS should require allometric equations be selected from an up-to-date, independently and scientifically curated set of equations (e.g., the GlobAllomeTree database) that reflect current science. If the curated list includes several well-fit equations, developers should be required to choose one that results in carbon estimates that are conservative (below the mean). We offer the same recommendations for BGB equations / root-to-shoot ratios, and for carbon fractions. Second, the full forest data used by VCS-REDD+ projects should be released in a public repository to allow independent analysts to understand, reproduce, and assess carbon calculations. Transparency is essential to credit quality because it allows for independent assessments of carbon calculations and serves as another accountability mechanism for developers. It can also lead to greater trust in the credibility of the carbon credits. Disclosed data should include forest inventories, the allometric and BGB equations, carbon fraction, and justifications for all of those choices. These data should always be shared using open-source programming languages (e.g., Python or R) and carbon analysis scripts.

Introduction

REDD+ projects on the voluntary carbon market have been criticized for their baselines, leakage, permanence, and effects on forest communities, but their methods for estimating carbon in forests have received little attention. Since projects are credited for the amount of deforestation and forest degradation they are estimated to have prevented, the number of credits generated is approximately proportional to the carbon per hectare in the forest. If that carbon is overestimated by 5%, the number of credits generated will also be inflated by approximately 5%.

While little has been written about carbon accounting in REDD+ voluntary carbon market projects, one study found that if the diameter of the largest 5% of trees in a typical forest was exaggerated by as little as 10%, the number of credits would be inflated by more than 10% (Rifai et al., 2015). Another study based on more than 10,000 field measurements found that the root-to-shoot ratios used to estimate root biomass in earlier published studies led to estimates 50% larger than in their own in tropical forests (Huang et al., 2021). REDD+ projects using Verra's *Verified Carbon Standard* (VCS) that choose root-to-shoot ratios that result in high root biomass estimates could also be issued inflated credits. It is clear that accurate and conservative methods for estimating the carbon in a forest have a large and direct impact on carbon credit quality.

In this chapter, we take a careful look at how the four most-used VCS-REDD+ methodologies—VM0006, VM0007, VM0009, and VM0015—estimate forest carbon stocks. We focus on the two largest carbon pools, whose preservation produces the large majority of REDD+ credits: AGC and BGC in living trees. We explore how aligned the methodologies are with the science of forest carbon accounting. We also explore the extent to which developers have flexibility in choosing carbon accounting methods, and whether that flexibility opens the door for gaming.

Background: Forest Carbon Pools

Forest carbon can be divided into seven major carbon pools, all of which can be affected by forest protection projects (Figure 4.1):

- Live aboveground (e.g., trees, shrubs)
- Live belowground (roots with diameter greater than 2 mm)
- Deadwood (standing dead trees and downed logs)
- Litter (dead leaves, twigs, seeds, fruits, etc. sitting on the forest floor)
- Soil organic matter
- Harvested wood products
- Non-woody biomass (e.g., palms, grasses)

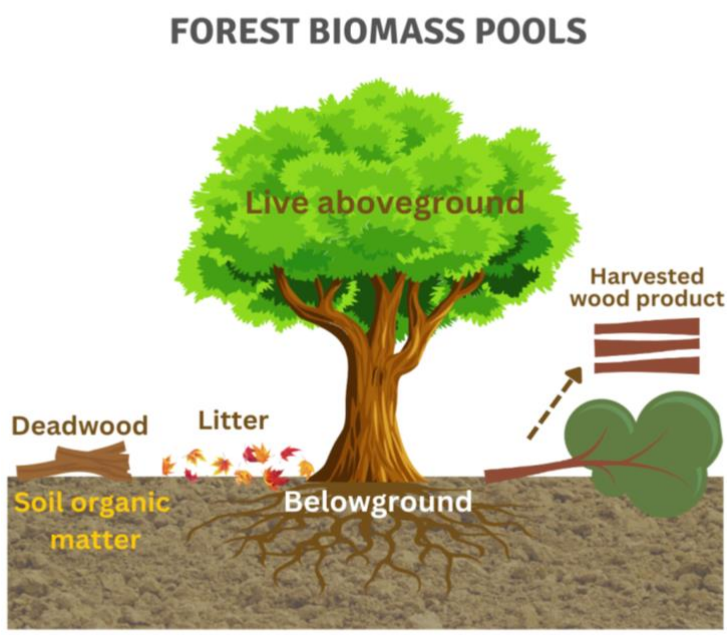


Figure 4.1
Six Forest Carbon Pools

Note. Non-woody carbon pools are not shown.

Tropical forests account for about 40% of the world's vegetation carbon (Erb et al., 2018). The AGC tropical tree pool (or woody pool) is the most studied (Castillo-Figueroa, 2021) and holds the greatest amount of carbon, with an approximate stock of 188 billion metric tons of carbon (Avitabile et al., 2016; Nogueira et al., 2008).

How VCS-REDD+ Methodologies Quantify Forest Carbon

Even though REDD+ methodologies differ in scope and permitted activities (see Chapter 1: Introduction), they all follow a similar basic method for estimating each carbon pool affected by the project and for monitoring emissions and removals by the project over time. Before we discuss estimates of carbon in live trees, we look more broadly at carbon accounting under VCS-REDD+ methodologies.

Under VCS-REDD+, net emissions reductions are estimated as the difference between baseline and project emissions/removals (considering all significant biomass pools). For deforestation, the amount (hectares) of deforestation forecasted per stratum (forest category) in the project area in the baseline scenario (see Chapter 3: Baselines), minus the rate that actually occurs in the project area, is multiplied by the amount of carbon per hectare in the forest. Over time, deforestation inside the project area is monitored using remote sensing, while degradation is estimated with remeasurements of the project's fixed area plots.

Activity-related changes are also monitored, and methods depend on the drivers of degradation and the type of activity. Changes in forest management, reforestation, and assisted natural regeneration are monitored with field measurements and remote sensing imagery. When a project includes harvesting, the ex post volume of timber extracted from within the project's boundary must be monitored and quantified using forest operation records (i.e., the log books kept as part of the forest management plan). Furthermore, any changes in activity emissions compared with the baseline (e.g., fertilizer application or tractor emissions) are also taken into account. In addition to the leakage deduction (see Chapter 4: Leakage), an uncertainty deduction may also be applied to accommodate uncertainty in forest carbon estimates.

If gaming occurs in any of the project's components, the carbon credits issued will exceed the actual project impact.

A Focus on Carbon per Hectare of Forest

Not all the forest carbon pools shown in Figure 4.1 matter equally to a REDD+ project. The pools included in the carbon accounting of a REDD+ project are determined by the T-SIG tool (United Nations Framework Convention on Climate Change [UNFCCC], 2013); one methodology (VM0009) makes the use of this tool optional. The T-SIG tool provides the steps to determine which pools are significant and, consequently, must be included in a REDD+ project. A pool is considered significant if it contributes more than 5% of the total project carbon benefits over the project's lifetime. In addition, regardless of significance, a pool can only be excluded from a project's accounting if doing so would result in fewer credits and therefore would be conservative. In other words, a pool can only be excluded if it is expected to increase due to the project or to decrease in the baseline scenario. (For a comparison of the carbon accounting approaches of all four methodologies, see Table 4.A1.)

Live Tree AGB Pool

AGB pools for live trees must always be quantified in REDD+ projects because most carbon stock changes occur in these pools. Across the 12 REDD+ projects included in our analysis, 100% reported tree AGB pools, whereas five out of 12 did not report non-tree (e.g., palms) AGB pools.

Typically, live tree AGB is estimated using field sampling (Réjou-Méchain et al., 2017) and extrapolated to the project area using remote sensing observations (Asner et al., 2013; Meyer et al., 2013). The sampling process involves recording key tree attributes, including tree species, diameter of the trunk at breast height (DBH), tree height, and wood density (dry weight of wood per volume). These tree data are then converted into quantities of dry biomass, using allometric equations. In forestry, *allometry* refers to the statistical relationships between tree size characteristics. Trees in a population develop similarly, within the normal limits of life-history-related variability. For all trees growing under the same conditions, regardless of size, the proportions of easy-to-measure tree attributes (e.g., DBH, height, and wood density) and more difficult-to-measure variables (e.g., volume and biomass) follow the same rules.

Generally, tree allometry can differ by species, climate, and soil type. Generating allometric equations requires felling a sample of trees, drying and weighing them, and documenting the weight with tree attributes. Forest managers and timber companies, for example, can use these equations to make timber harvesting decisions. Allometric equations are published in journal articles and technical and scientific reports, and some can be used to estimate biomass in forests other than where they originated. Four key criteria (e.g., Cifuentes Jara et al., 2015; Picard et al., 2012) can be used to rank the appropriateness of equations for sample plots in another forest:

1. **Sampling criteria.** The DBH range and number of trees sampled. The minimum cutoff DBH (e.g., DBH ≥ 5 or 10 cm) and the maximum DBH specified in the allometric equation should be reported. The sample size must be greater than 30 trees and ideally greater than 100 trees (Picard et al., 2012).
2. **Target population.** Equations can be species-, genus-, or family-specific, or general (i.e., tree data from multiple species in a given forest stand).
3. **Geography.** Equations can be generated with tree data at a local, regional (i.e., multiple sites within the same climate province), or pantropical scale (i.e., multiple sites across tropical regions). Geography matters because trees in similar functional groups but in different geographic areas can differ greatly in their growth forms.
4. **Climate.** Category levels are based on mean annual precipitation, where dry is < 2000 mm, moist is ≥ 2000 m and < 3000 mm, and wet is ≥ 3000 mm (Holdridge, 1947).

While allometric equations that are specific to individual species or groups of species are preferable, most equations generated for tropical forests are developed with trees from multiple sites and thus are generic. These are commonly pantropical equations that consider several species within a forest, and can be forest- type-, climate-, or geography-specific (e.g., Brown et al., 1997; Chave et al., 2005).

All REDD+ methodologies allow project developers to generate their own allometric equations or to use existing equations from different sources (e.g., local, regional, or pantropical peer-reviewed; non-peer reviewed) or the Intergovernmental Panel on Climate Change (IPCC, 2003) default equations. Specifically, the methodologies have a suggested rank order, ranging from site- and species-specific to region- and forest-type-specific. The best equation is locally developed and specific to each species included in the project; the worst is a general equation from IPCC (tier 1), government, or peer-reviewed literature that can be applied in any tropical forest.

VM0009 seems to be the most flexible of the four methodologies, as it allows the use of allometric equations, whenever available, from existing IPCC, government, or peer-reviewed literature. VM0006 is also flexible but includes recommendations for the use of local allometric equations from groups other than the developer, and forest types similar to the ones in the project. VM0015 is the most prescriptive, preferring locally derived and forest-type-specific equations but allowing generic equations if they are conservative. VM0007 recommends the use of VCS's VMD0001 module, which recommends a validated equation for each species group in the inventory.

REDD+ project developers can generate their own allometric equations or calibrate existing equations by collecting wood samples from fallen trees or destructively felling new trees in the field to measure their oven-dry weight in kilograms (Temesgen et al., 2015). They largely rely on existing allometric equations (Asner et al., 2009; Brown, 1997; Chave et al., 2014; Goetz et al., 2009; Pan et al., 2011; Xu et al., 2021), because the destructive felling approach is not preferred in the context of REDD+. Due to the flexibility allowed by REDD+ methodologies, pantropical equations (e.g., Brown et al., 1997) are widely used. Developers must show that their allometric equation is conservative.

Wood density is a common parameter used in allometric equations (Chave et al., 2009; Flores & Coomes, 2011). Although methodologies vary, all are flexible about how density should be measured or retrieved from existing databases. VM0006 instructs developers to retrieve wood density data from any database; VM0007 does not specify how these data can be acquired. VM0009 uses Williamson and Wiemann (2010) as a source for wood density values, whereas VM0015 specifies that the mean wood density of a given tree species should be measured or estimated from the literature.

After allometric equations have been applied to tree-level data obtained from ground forest inventories in the project area, the resulting AGB estimates are converted to carbon values, using the carbon fraction of dry matter (i.e., the mass of carbon per unit dry mass). Methodologies differ in their guidelines for choosing carbon fractions. VM0006 uses the default carbon fraction of 0.5, and VM0007 uses 0.47 when literature values are not available. VM0009 and VM0015 recommend a species-specific carbon fraction based on literature data.

Live Tree BGB Pool

BGB, or the entire biomass of all live roots whose diameter is greater than 2 mm, must be included under VM0006, VM0007, and VM0009, and inclusion is recommended by VM0015. All 12 REDD+ projects in our analysis reported tree BGB pools. Numerous studies have indicated that root-to-shoot ratios vary with tree species (Sanford & Cuevas, 1996), stand and tree age (Gerhardt & Fredriksson, 1995), and tree size and climate (Ledo et al., 2018). Unlike AGB, BGB can only be measured using very difficult, time-consuming methods. In fact, estimates of root biomass based on standard methods are scarce (Cairns et al., 1997; Mokany et al., 2006). Consequently, it is more efficient and effective to apply a model to determine the BGB from the AGB. BGB is also often estimated based on a root-to-shoot ratio, defined as the root biomass divided by the shoot biomass (i.e., the biomass above the ground surface). All VCS-REDD+ methodologies permit the use of root-to-shoot ratios; appropriate values can be retrieved from any database (e.g., literature, IPCC default values).

Other Biomass Pools

Deadwood pools, both lying and standing, serve as crucial carbon reservoirs (Malhi et al., 2009; Pan et al., 2011) but are classified as nonessential and can be conservatively excluded from REDD+ carbon accounting. Deadwood pools were not reported by six out of 12 projects, but one distinguished between standing and lying deadwood pools and reported only the former.

In REDD+ projects, tree harvesting is allowed, depending on the methodology used. Tree harvesting results in harvested wood products (HWPs), which are part of the forest's carbon cycle. HWPs, a renewable material that can be used in place of GHG-intensive materials (Geng et al., 2017), constitute a major carbon pool affected by REDD+ project activities. The carbon expected to remain in long lived HWPs for more than 100 years after a tree's harvest is treated as permanently sequestered carbon and can be included. The HWP pool was not reported in seven out of 12 projects.

Soil organic carbon (SOC) is a major pool (Sanderman et al., 2017) that is usually considered optional and thus conservatively excluded, especially because it is expected to decrease (at least in the top soil layers) under the baseline scenario. VM0009 projects developed in drier climates (Figure 5.2) tend to report this pool. Five out of the 12 REDD+ projects included in our analysis reported the SOC pool including all three VM0009 projects.

Performance of the Methodologies

We explored the accuracy of VCS-REDD+ carbon accounting methods through a focused investigation of how they estimate the carbon in live trees. We explored whether flexibility allows project developers to choose allometric equations and root-to-shoot ratios that are not conservative. We hypothesized that if landowners or project developers could choose between a range of allometric equations and root-to-shoot ratios, they would choose values that generate larger estimates of forest carbon (and therefore more carbon credits from protecting it).

AGB

Methods

Project selection. To evaluate whether the choices of allometric equations made by REDD+ project developers likely lead to exaggerated carbon stocks, we selected three representative projects from each of the four methodologies in Brazil, Colombia, the Democratic Republic of Congo, Peru, Zambia, Zimbabwe, and Guatemala. We chose projects with

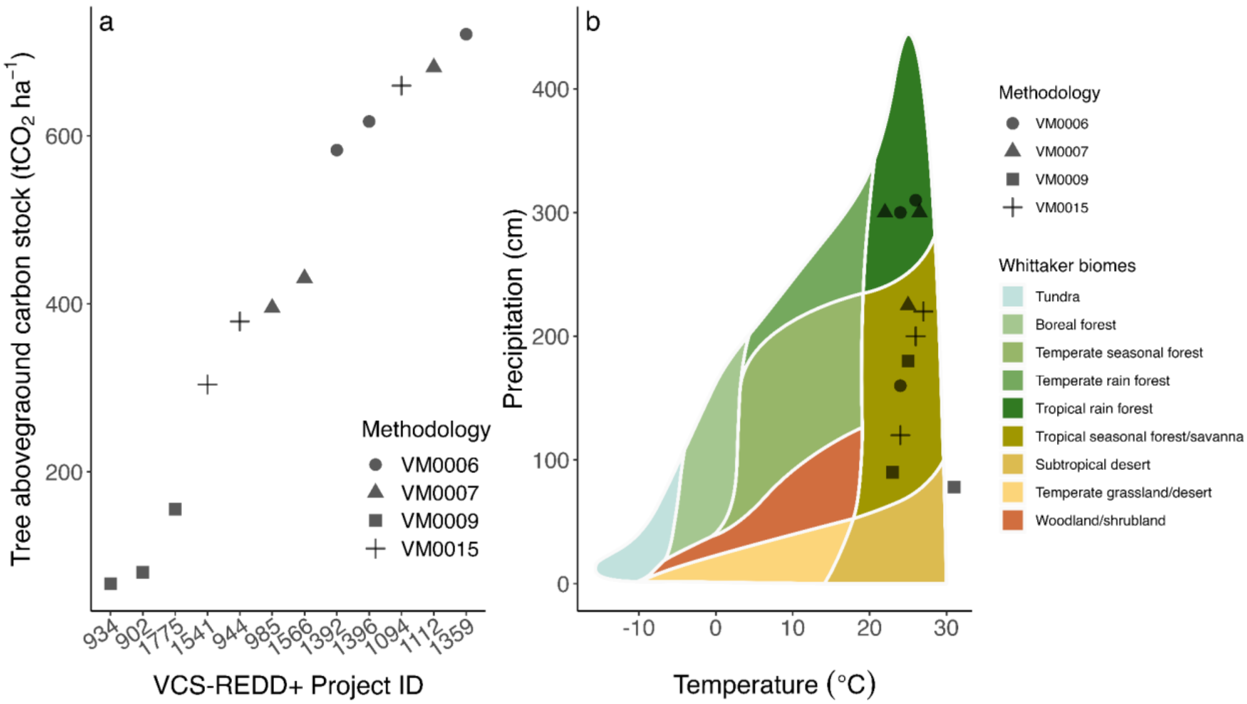
a. publicly available Keyhole Markup Language (KML) files, a format used to display geographic data in an Earth browser, such as Google Earth;
b. issued credits; and
c. diversity of tropical regions and countries.

The country diversity requirement did not always apply. For instance, within VM0006, only a few projects met the three criteria. If multiple projects met the criteria, we randomly selected a project. Among our chosen projects were the four projects (VCS 1112, VCS 1396, VCS 934, and VCS 944) from our baseline analysis.

The selected projects reported live-tree AGC stocks, ranging between 67 metric tons of carbon dioxide-equivalent per hectare (tCO_2e/ha; VCS 934) and 721 tCO_2e/ha, for the main forest type (i.e., covering the largest area within the project's forest are; VCS 1359; Figure 4.2a). Most of the selected forests fall within the tropical seasonal forest and savanna category, followed by the tropical rainforest category, according to Whittaker biomes (Figure 4.2b).

Figure 4.25

Aboveground Live Tree Carbon per Hectare and Climate of the REDD+ Projects Studied



Note. **(a)** REDD+ project-reported values for live tree AGC stocks for the main forest type (i.e., covering the largest area within the project's forest area), **(b)** Mean annual temperature and mean annual precipitation of the 12 REDD+ projects. Each dot represents mean climatic conditions retrieved from each project description document. Dot shape indicates the REDD+ methodology of the projects and are superimposed on Whittaker biomes (i.e., indicating potential vegetation; Whittaker, 1975). The plot was created using the R package *plotbiomes* (R Project, 2023; Stefan & Levin, 2021).

Allometric equation rank-order categories. We used the project design, verification and validation, and monitoring reports obtained from the VCS project database to retrieve information on each project's total forest area; tree AGC stock (tCO_2e/ha); main forest type (i.e., woodland, or dry, moist, and wet forest classification, following Holdridge, 1947); geographic coordinates; mean annual precipitation and temperature; allometric equation(s) used for live tree biomass estimation, and the source of the equation(s); and whether the project's AGC estimates were validated against project field biomass observations, as well as the root-to-shoot ratio(s) used and their sources.

VM0015 and VM0007 recommend using species-specific and local (if available) allometric equations first, followed by generic equations, such as Brown et al. (1997), while VM0006 and VM0009 are flexible in their approaches to choosing allometric equations. Similar to VM0015 and VM0007, but in much more detail, we assessed the allometric equation choice for each project by ranking each equation according to the following rank-order categories (Table 4.A2), where rank 1 is the most appropriate and rank 7 the least appropriate equation:

1. Species-specific, locally developed less than 100 km from the project for the same forest type (e.g., dry, moist, wet), using more than 30 trees covering a wide range of DBH (minimum to maximum DBH in the sample size)
2. Species-specific, developed in other regions or forest types, using at least 30 trees covering a wide range of DBH (minimum to maximum DBH in the sample size)
3. General (i.e., includes several species in a given forest stand), locally developed for a given forest type (e.g., dry, moist, wet forest type, based on mean annual precipitation), using at least 100 trees covering a wide range of DBH (minimum to maximum DBH in the sample size)
4. General, regionally developed within the same climate province and, ideally, < 500 km from the original forest data location for a given forest type (e.g., dry, moist, wet forest), using at least 100 trees covering a wide range of DBH (minimum to maximum DBH in the sample size)
5. General, pantropically developed (i.e., trees from multiple stands across different tropical regions) for a given forest type (e.g., dry, moist, wet forest), using at least 100 trees covering a wide range of DBH (minimum to maximum DBH in the sample size)
6. General, pantropically developed for any tropical forest (i.e., not forest type specific), using at least 100 trees covering a wide range of DBH (minimum to maximum DBH in the sample size)
7. Species-specific or general equation developed using fewer than 30 trees

This rank ordering provides a means to compare the fit of allometric equations for projecting forest carbon stocks. The choice of an allometric equation can involve tradeoffs in accuracy between a larger sample and the specificity of the location, geography, and climate of the forest to which it is being applied. As long as a minimal set of destructive tree measurements is used to generate an allometric equation (over 30, or even better, 100), for a given number of sampled trees, generally it can be assumed that specificity is more important than sample size. For example, Chave et al. (2014) pantropically developed an allometric equation, which is widely used for any tropical forest type, that would receive a 6 based on these rank-order categories. This low rank was assigned even though it was developed based on a global database of directly harvested trees at 58 sites, spanning a wide range of climatic conditions and vegetation types (4004 trees ≥ 5 cm trunk diameter).

For each project, we compared the carbon stocks generated using allometric equations that (a) are permitted by each methodology to show the full range of carbon that could be claimed by a given set of inventory plots and (b) have a rank equal to or higher than the equation selected by the project. A robust, data-driven, and transparent scientific method was used to select and apply the allometric equations using our rank-order approach (Table 4.A3).

Consulting the GlobAllomeTree platform (Henry et al., 2013), we used the latitude and longitude of each project as inputs to obtain the alternative equations. Several allometric equations were generated for each latitude/longitude search. Using Google Scholar and the Web of Science, we confirmed each equation and its original peer-reviewed study. To refine our selection of alternative equations, we retrieved information about sampling criteria, target population, geographic location, and climatic province. With this method, we were able to rank each alternative equation and determine which was most suitable for each project and methodology.

Project VCS 902's allometric equation was kept confidential in the publicly available documents on Verra's website, and we were unable to obtain it from the developer. Therefore, for this project, we only evaluated the range of carbon stock possibilities by using equations permitted by the REDD+ methodology and suitable for the project, based on the four criteria listed above.

Forest inventory data. Although we conducted carbon stock calculations for the 12 REDD+ projects based on the documents available on the projects' webpages, none of the projects' forest inventory data were publicly available on Verra's website. We contacted the 12 project developers, using names and email addresses from their project description documents, but were not successful in obtaining inventory data from any. Because we did not have the original inventory data, we were unable to use the same information as the developers; therefore, we could not fully reproduce their analyses. Instead, we found similar forest inventory data for each project according to the following criteria:

1. The dataset was publicly available (e.g., dos-Santos et al., 2022) to allow for a fully reproducible workflow.
2. The dataset represented similar forest types (e.g., we used moist forest plot-level data for the project's moist forest) and climatic zones (i.e., similar mean annual precipitation between the project's forest and forest data used in the analysis), and geography in most cases (Figures 4.2b and 4.A1).
3. The dataset included genus, species, and diameter data for each tree.
4. The dataset for each project covered at least four 1-ha plots.
5. The dataset showed similar AGB values, as reported by the project. See Table 4.A4 for additional information regarding the forest data used for each project.

To analyze the carbon stock consequences of different allometric equations used by VCS-REDD+ projects and determine the difference between the project's chosen allometric equation (Table 4.A2) and the alternative equations whose ranks are equal to or higher than the project's equation rank (Table 4.A3), we used the Biomass package (Réjou-Méchain et al., 2017) in R v.4.2.2 (R Core Team, 2023), designed by highly cited allometric equation researchers (e.g., Chave et al., 2014). Our analysis used forest plot data files (Table 4.A4), including variables such as tree taxonomy at the species level, DBH (in cm), height (in m, from the forest inventory file or retrieved using the *retrieveH* function in the Biomass package), and wood density (i.e., the oven dry weight divided by the green volume of wood). In our allometric equation analysis, we assigned a wood density value to each taxon included in each tree inventory data using the *getWoodDensity* function in the R Biomass package.

Carbon fraction. Carbon fractions are used to convert biomass into carbon. A carbon fraction is the percentage of total dry AGB that is carbon and is applied to the estimates of AGB and BGB derived from the allometric equations. For tropical non-woodland trees (i.e., trees growing in forest ecosystems), 0.456 is the most appropriate carbon fraction value, as suggested by Martin et al. (2018), who conducted a global synthesis of over 2,000 wood carbon concentration observations across all forested biomes and presented the most updated values for each forest type. For tropical woodland trees (i.e., trees going in areas with sparse, 10% to 30% tree cover), 0.47 is the most appropriate value, as empirically determined by Ryan et al. (2011). In contrast, VM0006's default value of 0.50 is likely to lead to over-crediting. Following suit, of the nine projects in our sample that disclosed their values, the average non-woodland carbon fraction value was 0.485 (range from 0.47 to 0.5), which is 6% higher than the 0.456 from Martin et al. (2018). The one tropical woodland project used a value of 0.47, which is the same as Ryan et al.'s (2011) value.

Some projects, such as VCS 1392, chose to use a value (0.485) below the methodology default of 0.5. Their choice, while lower than the project's default value, is still higher than the mean value for tropical forests provided by Martin et al. (2018) of 0.456. Martin et al. emphasized that the ubiquitous 0.5 generic wood carbon fraction introduces a systematic error in forest carbon accounting that can lead to as much as an 8.9% overestimate in tropical forests. Martin and Thomas (2011) showed that assuming generic carbon fractions in tropical wood alone overestimates forest carbon stocks by 3.3 to 5.3%, leading to overestimates of 4.1 to 6.8 Mg C/ha in tropical forest.

VM0009 and VM0015 recommend carbon fractions be measured or estimated from literature per species, but this is not what we saw in practice. Projects developed with these methodologies used a single value for their credited forest types.

We used values from the literature for our alternative AGB estimates. For the project allometric equation analysis, we used the project's carbon fraction (Table 4.A2). When the project's carbon fraction was not publicly available, we used the 0.47 value for woodland trees and 0.456 for non-woodland trees. See Table 4.A2 for the full list of the project equations and Table 4.A3 for the alternative equations.

Results

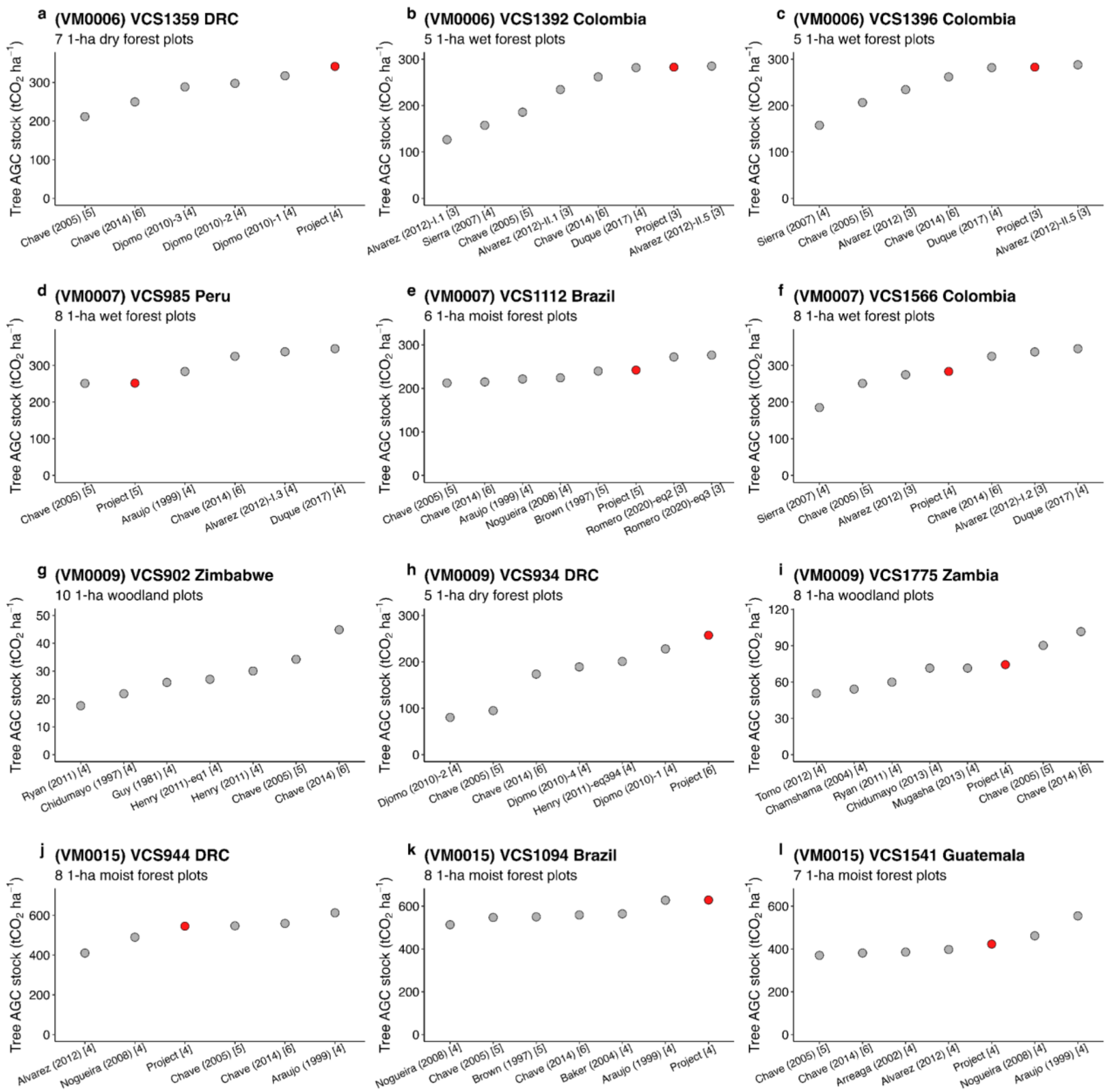
We applied the four methodologies to assess the carbon stock consequences of the choice of allometric equations across the proxy forest inventories for the 12 REDD+ projects. Figure 4.3 shows the variation in tree AGC stocks in tCO_2e per hectare across projects and methodologies. The percentage difference between the highest and the lowest AGC estimates, calculated as the difference between the maximum and the minimum divided by the minimum, varied between 50% and 125% across VM0006 projects, 30% and 87% across VM0007, 100% and 184% across VM0009, and 22% and 50% across VM0015 projects. On average, we found an 80% relative difference between the highest and the lowest AGC estimates across REDD+ projects representing the four methodologies.

We observed a variety of allometric equation choices across the 12 REDD+ projects. Of the 12 projects analyzed, one did not show which allometric equation was used or its source, one used a non-peer-reviewed equation, one developed its own allometric equation, another used a locally developed equation, one used Brown et al.'s (1997) pantropical moist forest equation, two used two of Chave et al.'s (2005) pantropical equations, and five used regional peer-reviewed allometric equations (see Table 4.A2 for the full list of equations used in each project). Of the 11 projects that disclosed their allometric equations or sources, five used equations that resulted in carbon estimates that were highest or second highest, compared with our range of allowed alternative equations; nine used equations that were higher than the average of our estimates; and two used equations that were lower than the average of our estimates.

Based on our rank-order categories, the project equations ranged from 3 to 6. Two out of the 11 projects used a rank 3 equation, six out of 11 used a rank 4 equation, two out of 11 used a rank 5 equation, and one used a rank 6 equation.

Figure 4.3

Range of AGC Stock Values from the Application of Permitted Allometric Equations for the 12 Study Projects

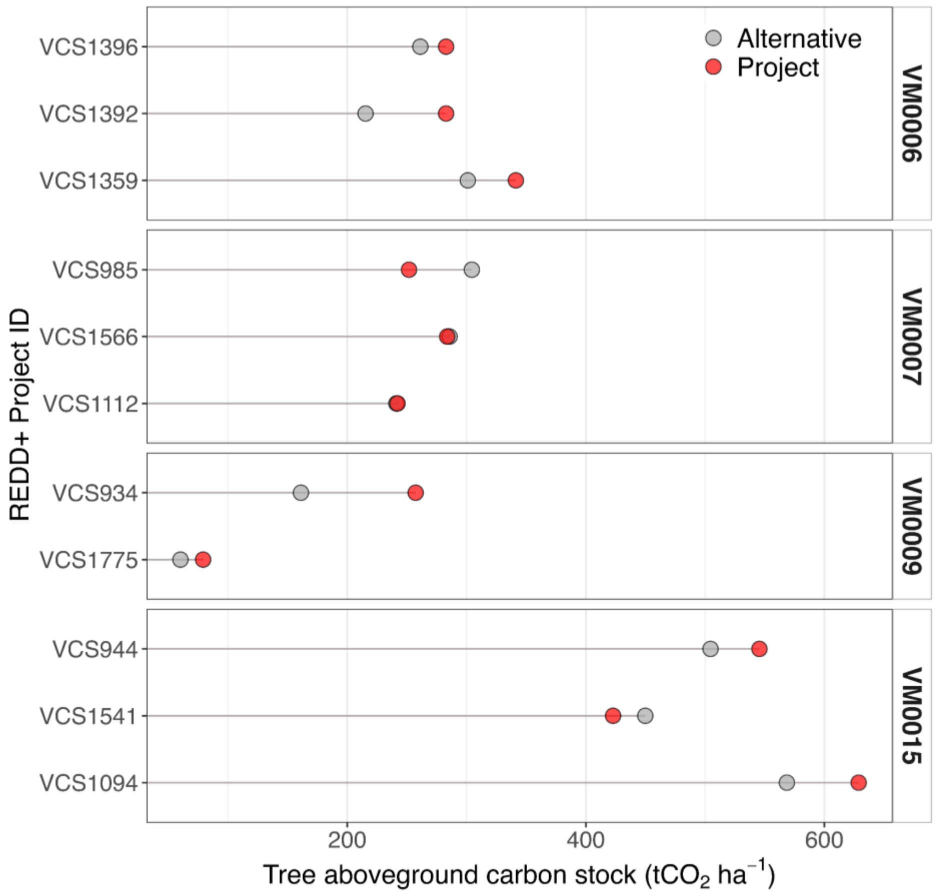


Note. The numbers in brackets indicate the rank category of each equation in the x axis. Red dots represent the estimated AGC, based on the project's allometric equation and our alternative inventory data.

The AGC stock estimates using the project's choice of allometric equation were greater than the equally or better-ranked alternative peer-reviewed equations for seven of the 11 projects, two were just about equal, and two were lower (Figure 4.4). Across all four REDD+ methodologies, the project's choice led to AGC estimates that were, on average, 15.4% higher than the mean of the alternative carbon estimates. By methodology, the project's AGC estimate was higher than equally or better ranked alternative estimates by 45.7% in two VM0009 projects, 17.7% in VM0006 projects, and 4.2% in VM0015 projects, and was lower than the alternative estimates by 5.9% in VM0007.

Figure 4.4

Comparison of AGC Stocks Estimated From the Project Allometric Equation Versus the Mean of Equally or Better Ranked Alternative Equations



Note. For project VCS 1112, the project and alternative AGB estimates are the same.

Three projects (see Table 4.A2) used general pantropical equations (Brown et al., 1997; Chave et al., 2005), although better-ranked regional equations were available for these forest types. For instance, project VCS 934 used the general equation of Chave et al. (2005), which is not forest-type-specific. Unsurprisingly, we found a 60% difference between the project's AGC estimate and the mean of the six better alternative estimates for that project. We also found issues related to how the allometric equations are used. VCS 985 used the same allometric equation for live trees across all credited forest types, and a single wood density value of 0.62 g/cm^3, based on Baker et al. (2004), for all trees.

BGB

Methods

We used project design, validation, monitoring, and verification reports from the VCS database to obtain information on each project's choice of root-to-shoot ratio or the equation used to estimate BGB (Table 4.1). We noticed that projects VCS 1396 and VCS 1094 used different root-to-shoot ratios, depending on the project document reviewed; we included all values from the project description document, monitoring report, and verification/validation reports in Table 4.1 and assume the verification/validation report value is the one used to generate credits. Due in part to the significant effort required to measure the mass and carbon stock of tree roots, research on BGB is limited, resulting in fewer alternatives to estimate BGB compared with AGB.

We randomly chose four projects from our sample of 12 to use as case studies, one from each methodology. We searched for alternative root-to-shoot ratios or methods to estimate BGB that are appropriate for the project's forest type, following the same criteria used in the AGB analysis. Using the project and alternative AGB estimates from our analysis, we estimated the BGB using the project's choice of equation and alternative methods.

Results

We observed various methods for obtaining BGB across projects (Table 4.1). Some projects do not clearly specify which root-to-shoot ratio or equation was used. For instance, VCS 1359 stated that the BGB was estimated based on the root-to-shoot ratio for tropical forests (Table 4.4 in *Aalde et al.*, 2006), which includes mean values ranging between 0.20 and 0.56. VCS 1094 used different methods across reports: although the project documents did not include an explicit reference to root-to-shoot ratios, a ratio of 0.2055 was used based on the ratio between AGB and BGB estimates in the project description document, whereas a ratio of 0.24 was used in the monitoring report (for tropical rainforest with AGB values above 125 Mg/ha).

Table 4.15

Root-to-Shoot Ratios (BGB/AGB) and BGB Equations Used to Estimate BGB

Methodology	Project ID	Project name	Project's BGB method	BGB method source
VM0006	VCS 1392	Cajambre	BGB = 0.489 * (AGB^0.89)	Saatchi et al. (2011)
VM0006	VCS 1359	Isangi	BGB/AGB = 0.20 - 0.56 (0.37 based on AGB/BGB in Table 23 of PD)[A]	Table 4.4 (*Aalde* et al., 2006)
VM0006	VCS 1396	Rio Pepe y ACABA	BGB/AGB = 0.20 - 0.56 (PD); BGB/AGB = 0.489 (Monitoring); BGB = 0.489 * (AGB^0.89) (Validation)	Saatchi et al. (2011)
VM0007	VCS 1112	The Russas Project	BGB = exp(-1.085 + 0.9256 * ln(AGB))	Cairns et al. (1997)
VM0007	VCS 1566	REDD+ Project Resguardo Indigena Unificado Selva de Mataven	BGB/AGB = 0.24	Table 4.4 (*Aalde* et al., 2006)
VM0007	VCS 985	Cordillera Azul National Park	BGB = exp(-1.085 + 0.925 * ln(AGB))	Cairns et al. (1997)

VM0009	VCS 1775	Luangwa Community Forests Project	BGB/AGB = 0.54	Chidumayo (2014)
VM0009	VCS 902	Kariba	BGB/AGB = 0.42	Ryan et al. (2011)
VM0009	VCS 934	The Mai Ndombe	BGB/AGB = 0.37	Table 4.4 (*Aalde* et al., 2006)
VM0015	VCS 1094	Ecomapua Amazon	BGB/AGB = 0.2055 (PD); BGB/AGB = 0.24 (Monitoring); BGB/AGB = 0.2055 (Verification)	VM0015 v1.1
VM0015	VCS 1541	Lacandón - Forest for life	BGB/AGB = 0.24	Mokany et al. (2006)
VM0015	VCS 944	Alto Mayo Conservation Initiative	BGB = exp(-1.0587 + 0.8836 * ln(AGB))	Cairns et al. (1997)

Note. PD refers to project description document. BGB and AGB are in metric tons per hectare.
[A] The project did not specify which root-to-shoot ratio was used but stated it used a value within the 0.20-0.56 range. But the proportion between the AGB and BGB in Table 23 of the project description document is 0.37.

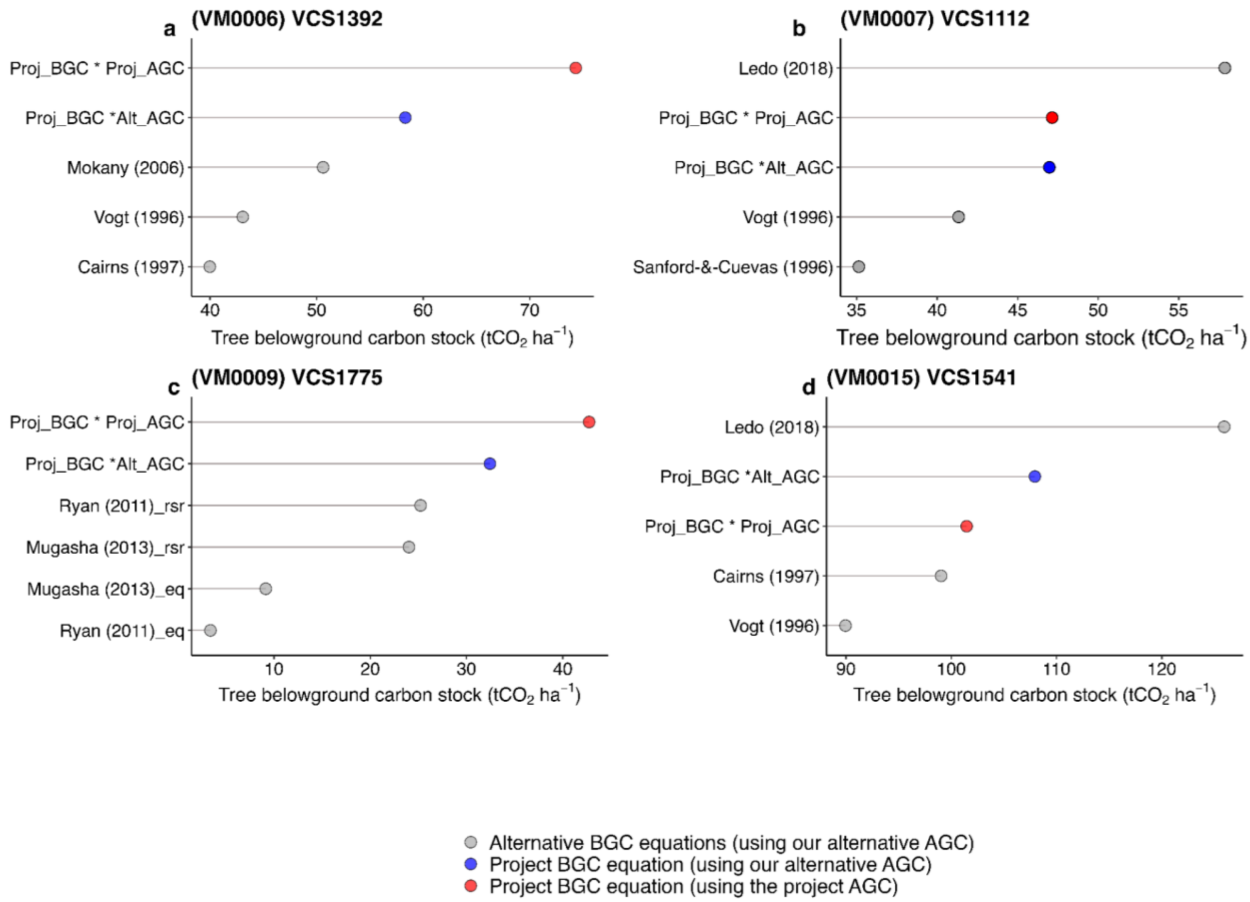
Using four randomly selected projects as case studies, we compared the project's choice of root-to-shoot ratio or BGB equation with alternative peer-reviewed methods (gray dots in Figure 4.5). Across methodologies, the minimum and maximum BGC estimates differ by, on average, 193%.

By comparing the alternative methods with each project's chosen equation (blue dots in Figure 4.5), we found that, on average, the projects' choices of BGC method resulted in BGC estimates that were 37.1% higher than the mean of the alternatives. In two of the four projects, the project's method yielded the highest estimates, while the other two had estimates that were second highest among the alternatives. Since all root-to-shoot ratios or BGC equations extrapolate BGC from AGC estimates, we also calculated BGC using both the project's BGC method and its AGC estimate (red dots in Figure 4.5). These BGC values are, on average, 61.3% above the mean of our alternative estimates, also taking into account differences between the projects' and our AGC estimates.

We found specific choices of BGC estimation methods that were not conservative. For instance, BGC estimates from projects VCS 1392 and VCS 1775 were much higher than the alternative estimates. While both projects used methods from peer-reviewed literature, they were not contrasted with other possible peer-reviewed methods to show that their choices were conservative.

Figure 4.5

Range of Belowground Carbon (BGC) Estimates From Alternative Equations and the Project's Equation



Note. The estimates were obtained using the project's methods (root-to-shoot ratio or BGB equation) and alternative peer-reviewed methods (Table 4.A5). We calculate BGC with the project's chosen BGC equation (Table 4.1) using the project's AGC estimate (red dots), and the mean of the well-fit alternative AGC estimates from our aboveground pool analysis (blue dots). The gray dots are the alternative BGC estimates obtained by applying the alternative methods (ratios or equations) listed in Table 4.A5 and the mean of the well-fit alternative AGC estimates from our aboveground pool analysis.

Uncertainty Deductions

Estimating the uncertainty in carbon emissions and emission reductions is challenging (Yanai et al., 2020) but possible. Four main types of uncertainty should be considered when estimating live tree AGC: (a) error due to tree measurement (e.g., the standard error associated with the measurement of tree diameter, height, or wood density), (b) error due to the choice of an allometric equation relating AGB to other tree dimensions, (c) sampling uncertainty related to the size of the sample plot, and (d) representativeness of a network of small plots across a vast forest stratum. Proper uncertainty analysis for the live tree AGB pool would consider how the uncertainties propagate (compound) as tree measurements (with some amount of error) are used in the choice of allometric equation (with more error), on a set of sample plots that are then extrapolated to the whole forest (more uncertainty). In contrast, while each methodology uses a different method to estimate uncertainty and apply an uncertainty deduction, they all use a simple method that does not align with good practice. For example, none of the methodologies require error propagation (see Chave et al., 2004 for details on error propagation for forest biomass estimates), likely resulting in underestimates of uncertainty.

Discussion and Recommendations

Our analysis of a sample of twelve projects, three from each methodology, found that the range of allometric equations allowed to be used by the methodologies resulted in AGC estimates that varied by an average of 80%. A similar analysis of four of those projects, one from each methodology, found that the range of allowed BGB equations resulted in carbon estimates that varied 193% on average.

If project developers had made choices that were conservative, as VCS requires, we would expect their estimates to be consistently below the middle of our alternative good-fit estimates. However, this is not what we found. Across our sample projects, the allometric equations chosen by the developers were 15.4% higher than the average of our set of best-fit equations, and the project's BGC estimates were, on average, 61.3% higher than the mean of the alternative estimates. This suggests that that project developers are likely taking advantage of the REDD+ methodologies' flexibility to choose carbon accounting methods that lead to high estimates of forest carbon and more credits generated. Combining both AGC and BGC estimates, we found that the project estimates are 23% to 30% above the mean of our estimates using good-fit equations.

Allometric Equations

Owing to the varied quality of the allometric equations available in the literature, it is necessary to constrain carbon stock calculations to reduce the likelihood of gaming and over-crediting. Allometric equations considered and chosen should reflect up-to-date scientific publications and should be selected based on scientific rigor, from a curated database. We specifically recommend using the GlobAllomeTree allometric equation database (Henry et al., 2013). Ideally the process of selecting allometric equations, and methods for estimating forest carbon more broadly, would be performed by an independent party.

The use of a common database to choose equations makes it possible to follow the rank-order method used in this chapter. Our suggested rank-order category is an improvement on REDD+'s methodology recommendations and provides a means to compare stock estimates from different equations. Because the IPCC-suggested equations, such as those proposed by Brown et al. (1997), are not updated frequently, we recommend using current scientific literature included in dedicated databases instead.

We recommend that developers use the step-by-step process we used on our analysis in this chapter:

- Allometric equations for each forest type should be searched for using the forest's climatic zone and latitude and longitude coordinates in the GlobAllomeTree database. As many allometric equations ranked 4 or better should be found as possible.
- The original papers should be consulted to determine the rank and appropriateness of each equation.

- If three equations are not identified, additional lower-ranked (5 and 6) equations or equations from other papers can be used; rank 7 equations should be avoided.
- Each equation should be applied to the forest data to estimate AGC.
- A final allometric equation should be chosen that results in AGC estimates that are both below the mean of the full set of equations and below the mean of all equations equal to or better ranked than the equation chosen for the project.

Furthermore, previous research (Rifai et al., 2015) found that errors in the physical measurements of the largest trees in a forest have a disproportionate impact on total forest carbon estimates. Therefore, we recommend that auditors focus on large trees when reviewing tree measurements.

REDD+ methodologies do not provide sufficiently strong recommendations on how to conservatively estimate wood density. Therefore, if wood density values are needed, we recommend developers use a clear, transparent process to retrieve them for each species included in forest inventory data. We found the *get WoodDensity* function in the R Biomass package adequate for this purpose because it references the global wood density database (Chave et al., 2009; Zanne et al., 2009) in a transparent and reproducible way. Developers can include a similar step in their carbon calculations.

We recommend project developers show that their BGB estimation choices are suitable for their forest type. This is necessary because developers will continue to rely on methods to estimate BGC as long as reliable ground observations of root biomass are difficult to obtain (Poorter et al., 2011; Robinson, 2004).

Project developers should also transparently show that their choice of BGC estimation method is conservative. They can show this by reporting comparisons of estimates using different root-to-shoot ratios and BGB equations. Constraining the methods used for allometric equation and root-to-shoot ratio or BGB-equation selection by REDD+ projects must be prioritized.

VCS methodologies should require developers to use carbon fraction values appropriate for each credited forest type, as reported in Martin et al. (2018), and use the values reported by Ryan et al. (2011) for woodland trees. Their choice of carbon fraction needs to be clearly stated in all publicly available documents.

For estimating uncertainty in forest carbon estimates, VCS methodologies should require error propagation, as is common practice in the uncertainty assessment associated with AGB estimates. Verra's draft consolidated methodology suggests that uncertainty should be reduced and indicates that developers must include protocols for assessing data for outliers, transcription errors, and consistency across measurement periods. However, clear guidance on error propagation requirements seems to still be lacking.

Similar assessments of other methodological elements are needed to compare methodologies, and how they are implemented in practice, with current best practices in forest carbon accounting. For example, we recommend a full review of uncertainty estimation methods and how they are implemented by projects and the validation of allometric equations (i.e., the process of adjusting them to the forest to which they are being applied).

Transparency

Currently, project developers fail to disclose considerable information about forest carbon accounting in their project documents. For instance, the raw tree data collected by developers are not disclosed on the project's webpage. When we requested such data to replicate their carbon accounting methods from each of the 12 project developers, none responded positively to our request. Three projects did not show which carbon fraction value they used, and another project did not disclose their choice of allometric equation. To ensure that tradable credits are of high quality, based on transparent and robust calculations, we provide the following recommendations:

- Full forest data should be made public to allow independent analysts to understand and reproduce carbon calculations. Disclosed data should include forest inventories, the allometric and BGB equations, carbon fraction, and justification for all of those choices.
- Transparency should be maintained through forest-data sharing and reproducible workflows, including organizing and documenting ABG and BGB and carbon data analysis procedures so they can be easily replicated or repeated. Carbon analysts can do this by writing carbon analysis scripts in open-source programming languages (e.g., Python and R).
- Data repositories offer the possibility of standardizing metadata and data formats, as well as assigning a citable digital object identifier (DOI) to ease citation tracking. Developers can share data and metadata in the public GitHub repository (https://github.com/bdbomfim/REDD_Forest_Carbon). Developers are also encouraged to contribute raw data to repositories such as Dryad (http://datadryad.org/) or DataONE (http://www.dataone.org/) to facilitate future research.
- A clear, transparent validation of biomass and carbon estimates through comparisons with estimates obtained from other models should be fully described.

This level of transparency is necessary to allow for independent assessments of the choice of allometric equation. We learned from Verra that it plans to digitize its methodologies and data submission and make that data public, which could resolve the transparency issues described herein (N. Swickard, personal communication, July 6, 2023).

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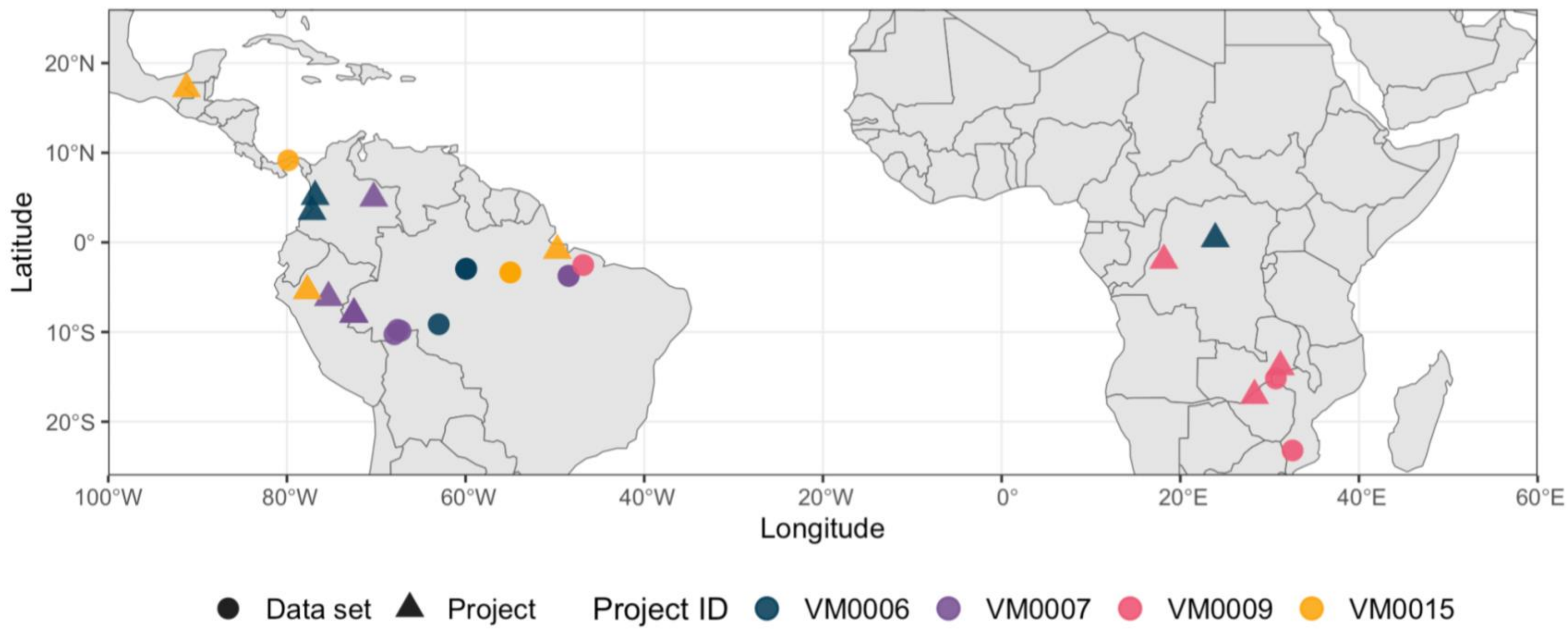
Appendices: Forest Carbon Accounting

Figure 4.A1

Location of REDD+ Projects and Data Sets Used in Our Study



Note. Projects colored by methodology (VM0006 to VM0015). Publicly available forest inventory datasets used for each project analysis are listed in Table 4A4. Map was prepared using R packages *rnaturalearth* and *sf*.

Table 4.A16
Overview of VCS-REDD+ Methodologies

	VM0006	VM0007	VM0009	VM0015
1. How are the procedures for quantifying net emission reductions and/or removals (NERs) from project activities explained in the methodology?				
	Explained in EB31 Appendix 16 and listed in Table 1 of VM0006. The activities considered for NER calculations include ANR, harvesting, intensifying grazing, and cropping systems. Does not differentiate among carbon pools.	Given in specific modules for REDD, ARR, WRC or WRCalt, CIW or CIW-REDD RWE or RWE-ARR both for baseline and project emissions. Does not differentiate among carbon pools.	NERs are current gross emissions reductions (GERs) minus a confidence deduction (if any) and buffer pool allocation. NERs are determined for each project accounting area and if the project area contains multiple project accounting areas, summed across project accounting areas. VM0009 uniquely differentiates among carbon pools. It is different from VM0006 and VM0007 in that the accounting for the various sources of emissions from biomass is simplified by rolling all sources of potential emissions into a single model and parameterizing the model based on baseline types. Project emissions are accounted for separately from the models to determine gross credit generation. Net credit generation is determined by subtracting deductions for contributions to the AFOLU Pooled Buffer Account.	Nine steps for the calculation of ex ante net anthropogenic GHG emission reductions are shown in VM0015 Figure 3. Step 7 includes Ex ante estimation of actual carbon stock changes and non-CO_2 emissions under the project scenario. Step 9 (final) is the ex-ante calculation of net anthropogenic GHG emission reductions. Any decrease in carbon stock or increase in GHG emissions attributed to the project activity must be accounted for when it is significant, otherwise it can be neglected. Significance in this methodology is assessed using the most recent CDM-approved and VCS-endorsed version of the "Tool for testing significance of GHG emissions in A/R CDM project activities."

Can project developers omit certain carbon pools from the carbon accounting? If so, why?				
	Yes. The belowground, deadwood, and soil organic carbon pools can be omitted. The T-SIG tool is suggested to test for pool significance, as well as the CDM A/R Methodological Tool 06 Procedure to determine when accounting of the SOC pool may be conservatively neglected. Carbon pools must not be double-counted and significant pools should not be excluded.	Yes. The pools that can be omitted vary by activity. In general, any significant decreases in carbon stock in the project scenario and any significant increases in carbon stock in the baseline scenario must be accounted for. The T-SIG tool must be used to justify the omission of carbon pools and emission sources. Insignificant carbon pools can always be ignored.	Yes. The reasons for omission vary by pool. Project proponents may first select carbon pools to include in the project boundary. Long-lived wood pool is included if there is logging, and merchantable trees are included. If soil organic carbon is a selected pool, and the default value from section 6.19.2 is selected, then the project must be in a tropical ecosystem. T-SIG tool is not cited. Project developer needs to provide evidence for the conservative exclusion of any optional pools.	Yes. Non-tree and BGB pools are optional. BGB is recommended as it usually represents between 15% and 30% of the AGB. Deadwood and litter recommended only when significant. Harvested wood products (HWP) included when significant. SOC to be decided by the proponent and recommended when forests are converted to cropland. Not to be measured in conversions to pasture grasses and perennial crop according to VCS Program Update of May 24, 2010. In most cases the exclusion of a carbon pool will be conservative, except when the carbon stock in the pool is higher in the baseline compared to the project scenario. T-SIG shall be used. Approach to conservativeness: Carbon pools that are expected to decrease their carbon stocks in the project scenario compared to the baseline case must be included if the exclusion would lead to a significant overestimation of the net anthropogenic GHG emission reductions generated during the fixed baseline period.

2. Data sources: On non-forest land, can project developers use default values from the literature to calculate carbon stocks?				
	Yes. IPCC default values by following the CDM Tool Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities	Not applicable.	Allometric equations or destructive sampling may be used for estimating non-tree carbon stocks.	Carbon stock estimations for the non-tree vegetation components are usually based on destructive harvesting, drying and weighing. These methods are described in the Sourcebook for LULUCF projects (Pearson et al., 2005).
Can project developers use secondary data in project activities? If so, are they free to choose datasets?				
	Yes. Project developers are free to use secondary data and to choose data sources.	Yes. Project developers are free to use secondary data and to choose data sources supported by the literature in a conservative way.	Yes. When monitoring data is not yet available, literature estimates for carbon stocks in selected carbon pools may be used. During subsequent monitoring events, direct measurements must be used.	Yes. Existing data could be used to quantify the carbon stocks of one or more land use classes. These data could be derived from a forest inventory or perhaps from scientific studies. Criteria for data selection are listed.
Can the belowground pool be estimated from the aboveground pool with a root-to-shoot ratio? If so, how is this ratio constrained?				
	Yes. It can be measured through destructive sampling, obtained in the literature or using standard ratios in Table 4.4 of the IPCC GPG-LULUCF 2003.	Yes. VCS Module VMD0001 gives fixed ratios depending on ecological zone and AGB thresholds (IPCC GPG-LULUCF).	Yes. Ratio can be obtained from reviewed literature (e.g., equation from Cairns et al 1997), allometry, or IPCC default values (Table 4.4 of the IPCC Guidelines for Greenhouse Gas Inventories).	Yes. If the vegetation strata correspond with tropical or subtropical types, then roots are included, and root-to-shoot ratio obtained from standard ratios in Table 4.4 of the IPCC GPG-LULUCF 2003.

3. AGB: Are project developers free to choose allometric equations?				
	Yes. Allometric equations can be developed by the project proponent, locally by groups other than the project proponents, or for forest types that are similar to the ones in the project as found in Tables 4.A.1. and 4.A.2. of the GPG LULUCF.	Yes. It must follow guidelines given in VCS Module VMD0001. It is acceptable practice to use equations developed for regional or pantropical forest types.	Yes. When available, allometric equations from existing IPCC, government, or peer reviewed literature may be used.	Yes. Allometric equations preferably local-derived and forest type-specific. Generic allometric equations can be used, if it can be proven that they are conservative.
Is wood density measured or obtained from databases?				
	Project developers can acquire data from any database. When no species-specific or species-group specific densities are available, an average representative density may be used for all species or species groups.	Not specified.	When wood density measurements are required, the guidance provided by Williamson & Wiemann (2010) should be followed in data collection.	For the biomass expansion method of estimating AGB and carbon stocks, methodology refers to IPCC GPG-LULUCF, 2003 table 3A.1.9 or United States Department of Agriculture (USDA) wood density table. In the appendix, it is stated that the mean wood density of species should be measured or estimated from literature.
What carbon fraction is used?				
	Default (unitless) = 0.5.	Follows the VCS Module VMD0001, which states that values from the literature (e.g., Aalde et al., 2006 Chapter 4 Table 4.3) shall be used if available, otherwise default value of 0.47 can be used.	Measured or estimated from literature per species.	Measured or estimated from literature per species.

Are palm-specific allometric equations used? How is non-tree biomass estimated?				
	The above ground non-tree vegetation must be measured by destructive harvesting techniques. Alternatively, the aboveground organic matter can also be estimated using default values IPCC default values by following appropriate tools such as the latest version of *CDM Tool Estimation of carbon stocks and change in carbon stocks of trees and shrubs in AR CDM project activities*.	Methodology suggests following VMD0001 Estimation of carbon stocks in the AGB and BGB in live tree and non-tree pools (CP-AB).	The allometric equation based methods described for trees can be applied to estimating above-ground biomass of palms as well. Table 4.A.2 of the IPCC Good Practice Guidance for LULUCF provides a source of allometric equations relevant to palms. Non-tree biomass (includes grasses, sedges, herbaceous plants, woody shrubs and any trees smaller than the minimum diameter specified for using the methods described for tree biomass) can be estimated using either destructive sampling in a clipped plot, allometric equations, or a combination of the two approaches.	No mention of palm-specific equations. Includes information to measure it: Carbon stock estimations for the non-tree vegetation components are usually based on destructive harvesting, drying and weighing. These methods are described in the Sourcebook for LULUCF projects (Pearson et al., 2005). Unless non-tree biomass form a significant component of the ecosystem, they should not be measured, which is conservative. If significant, the carbon stock in the above-ground non-tree biomass per hectare is calculated by multiplying the dry mass by an expansion factor calculated from the sample-frame or plot size and then by multiplying by the carbon fraction and CO_2/C ratio.

4. Uncertainty: How is uncertainty handled? Do specific sources of uncertainty need to be reported separately?				
	Uncertainty is dealt with through discounting factors in equations. If uncertainty is below 15%, then there is no deduction. Carbon pool errors are summed when calculating the combined error per land use class or stratum i.	The project must identify key parameters that would significantly influence the accuracy of estimates. Where this precision level is met then no deduction should result for uncertainty. Where uncertainty exceeds 15% of REDD+ at the 95% confidence level then the deduction shall be equal to the amount that the uncertainty exceeds the allowable level. Local values that are specific to the project circumstances must then be obtained for these key parameters, whenever possible. Carbon pools are summed following VMD0017 Estimation of uncertainty for REDD project activities (Module X-UNC). Uncertainty calculated across combined strata.	Methodology mentions standard error for each major carbon pool and for stratified samples. Standard error of the total carbon stock is explained on page 199. The standard error of such a sum can be estimated from the individual standard errors using equation [B.34]. Carbon stocks in pools per stratum are summed. Equations [B.8] and [B.10] to estimate the standard error of the total carbon stock in above-ground trees.	No, just the allowable sampling error which is 10% calculated from the mean. No mention of combined error.
How is total uncertainty for each project activity calculated?				
	<u>No mention of Module X-UNC.</u> Stratification: Because emission reductions are discounted based on the uncertainty of the biomass inventory, stratifying forest may	<u>Project must use Module X-UNC</u> to combine uncertainty information and conservative estimates and produce an overall uncertainty estimate of the total net GHG emission reductions.	<u>No mention of Module X-UNC</u>. The methodology discounts credit generation based on the magnitude of sampling error that results from an inventory.	<u>No mention of Module X-UNC.</u> Methodology mentions discounts for uncertainties but details on each activity are poorly described.

	lead to increased emission reductions. Uncertainty in ANR activity: related to the calculation of carbon uptake by biomass in ANR areas. Uncertainty discounting factor: The larger of the two combined errors of the carbon stock density at time t1 and t2 must be used for uncertainty assessment in ANR areas. If the combined error in estimated biomass stock density at time period t is lower than 0.15, then the uncertainty discounting factor is null. Emissions reductions: Discounting factors for all emission reductions are based on the uncertainty of biomass inventory related to transition i.	The estimated cumulative net anthropogenic GHG emission reductions must be adjusted at each point in time to account for uncertainty as indicated in Module X-UNC. Total uncertainty for REDD project activity considers uncertainty in baseline and in project scenario (eq 7, pg 8) Module X-UNC. The allowable uncertainty under this methodology is +/- 15% of NER-REDD+ at the 95% confidence level. REDD+ include REDD and WRC activities	It shows how to calculate a confidence deduction based on uncertainty in emissions models, carbon stock estimates in the project accounting area and carbon stock estimates in the proxy area. A 90% confidence level is considered in this confidence deduction calculation. Uncertainties in major carbon pools are expressed as standard error (SE, measured by tCO_2e). For example, *U*mp is used to indicate the uncertainty in estimated total carbon stocks for selected carbon pools in the project accounting area at monitoring period.	Carbon stock uncertainty: If the uncertainty of the total average carbon stock of a forest class is less than 10% of the average value, the average carbon stock value can be used. If the uncertainty is higher than 10%, the lower boundary of the 90% confidence interval must be considered in the calculations if the class is an initial forest class in the project area or a final non-forest class in the leakage belt, and the higher boundary of the 90% confidence interval if the class is an initial forest class in the leakage belt or a final non-forest class in the project area.
Variable measurements: Are the variable measurements for each carbon pool detailed? Does the methodology mention outliers in forest data and how /if remove them?				
	Carbon stocks calculated by pool separately (AGB live, AGB dead, BGB, soil, litter) following IPCC GPG LULUCF 2003 and CDM methodology AR-AM0002. No mention to outliers in tree or inventory data.	Expert opinion to assist with data selection is allowed. Project proponents must use the guidance provided in Chapter 2 (Approaches to Data Collection) in Section 2.2 and Annex 2A.1 of the IPCC 2006 good practice guidance. If uncertainty is significant, the project must choose data such that it indisputably tends to underestimate, rather than over-	Stratification is recommended (but not strictly required) as a tool for minimizing sampling error. Project proponents may use different-sized plots for different carbon pools. The procedures appropriate for estimating the carbon stock in each pool to be monitored are detailed in Appendix B. They provide a means of estimating the total carbon stock in selected pools	The carbon stock of trees can be estimated using: (a) Existing forest inventory data See the most recent version of the GOFC-GOLD sourcebook for REDD for more details); or (b) Direct field measurements. The Inventory method (a) can be through stand tables (stem density by mid-point DBH class). The mid-point diameter of a diameter class should be used in combination with an allometric biomass regression equation. It is preferable to use allometric equations, if

		estimate, net GHG project benefits. Project must establish and document clear standard operating procedures and procedures for ensuring data quality, including protocols for assessing data for outliers, transcription errors, and consistency across measurement periods. VCS Module VMD0001 used for above and belowground tree and non-tree woody biomass.	within the project accounting area and the uncertainty of that estimate at a given point in time. Project proponents may deviate from the procedures detailed in Appendix B per current VCS requirement, including a description of the deviation and justification for the deviation.	the equations are available, and as a second-best solution, to use age dependent or stand density-dependent BEFs. Methodology shows equations to calculate the average carbon stock per hectare in the above-ground biomass pool per land use/land cover class.
5. Are the size of the study sample area and the sampling design details required? Are the same plots revisited during recurring measurements?				
	Methodology explains how to do sampling design (number, location, layout of plots). Yes, the same plots are revisited during recurring measurements.	Based on VCS Module VMD0001 random or systematic sampling. Fixed Area Plots and Point Sampling with Prisms, both using Allometric Equations method to estimate biomass from measured tree dimensions. Flexibility to allow project developers to choose the best sampling approach.	If an inventory does not achieve a desired degree of precision ex post, project proponents may choose to install additional plots to decrease uncertainty and reduce confidence deductions, regardless of the sample sizes suggested by the equations provided in this section. While stratification is not mandatory, this methodology mentions that stratum must contain at least two sample plots.	Yes. Sampling design should follow the guidance of appendix 3 (see also chapter 4.3 of GPG LULUCF and in the sourcebook for LULUCF by Pearson et al., 2005). Where carbon stocks are monitored, the methods on sampling and measuring carbon stocks described in appendix 3 must be used.

6. Does the methodology establish recurring sampling methods for C stock estimation and monitoring?				
	Yes. IPCC GPG LULUCF 2003; CDM methodology AR-AM0002.	Project developers need to report a standard operating procedure (SOP) and follow procedures during the monitoring period.	Yes. The methodology includes procedures appropriate for estimating the carbon stock in each pool to be monitored in Appendix B. Carbon stocks must be estimated for the first monitoring period by sampling all plots in all strata in the project, activity-shifting leakage, and proxy areas. After the first monitoring period, all plots and all strata in the project and the activity-shifting leakage areas must be re-measured at least every five years, a process which may be accomplished on an intermittently rotating basis.	If the project activity generates a significant decrease in carbon stocks during the fixed baseline period, the carbon stock change must be estimated ex ante and measured ex post. If the decrease is not significant, it must not be accounted for, and ex post monitoring will not be required. If the project proponent wishes to be credited for carbon stock increases on areas projected to be deforested in the baseline case, ex post monitoring of the carbon stock increase is mandatory. If activities related to leakage prevention lead to significant decrease in carbon stock or increase in GHG emission, it must be accounted for and monitoring will be required.

Table 4.A2

Allometric Equations Used in the Most Representative Forest Type

Methodology	Project ID	Country	Forest type	MAP (mm)	Mean tree AGC (tCO_2e/ha)	Carbon fraction	Allometric equation used by the project	Allometric equation source	Rank category[B]
VM0006	VCS1392	Colombia	Primary tierra firme forest (wet forest)	3000	583	0.485	AGB = exp(-2.130 + 2.015 * ln(DBH) + 0.724 * ln(H) + 1.002 * ln(WD))	Locally developed by the project by harvesting 296 trees across 3 forest types	3
VM0006	VCS1359	DRC	Primary forest (dry forest)	1600	721	0.50	AGB = 0.11 * (DBH)^2.58	Djomo et al. (2010)	4
VM0006	VCS1396	Colombia	Tierra firme forest (wet forest)	3100	617	0.485	AGB = exp(-2.130 + 2.015 * ln(DBH) + 0.724 * ln(H) + 1.002 * ln(WD))	Developed by VCS1392	3
VM0007	VCS1112	Brazil	Dense and open alluvial forest (moist forest)	2250	656.3–706.9	0.47	AGB = 42.69 – 12.8 * DBH + 1.242 * (DBH)^2	Brown (1997) moist forest equation	5
VM0007	VCS1566	Colombia	Floodplain forest with and without underwood (wet forest)	3000	377.3–484	0.47	AGB = exp(-1.544 + 2.37 * ln(DBH))	Yepes et al. (2011) bh-T equation	4
VM0007	VCS985	Peru	Alluvial forest (wet forest)	3000	282.7–508.9	0.47	AGB = WD * exp(-1.239 +1.980 *ln(DBH) + 0.207*ln(DBH)^2 – 0.0281 * ln(DBH)^3)	Chave et al (2005) wet forest	5
VM0009	VCS1775	Zambia	Miombo, Mopane, Munga Woodlands	900	156	"Same as methodology" (undefined)	(5) for DBH < 65 cm: AGB = 0.0446 * (DBH)^2.765 (ii) for DBH > 65 cm: AGB = 0.1027 * (DBH)^2.4798	(i) Chidumayo (2014), and (ii) Mugasha et al (2013)	4
VM0009	VCS902 [A]	Zimbabwe	Woodland	780	81	0.47	Not publicly available, but project documents state that a list of allometric equations has been provided separately to the auditor at validation stage. Ryan et al 2011 cited as source of root-to-shoot biomass.	**Not disclosed in public documents [a]**	**NA**
VM0009	VCS934	DRC	Primary forest (dry forest)	1800	67	"Same as methodology" (undefined)	AGB = exp(−1.602 + (2.266 * ln(DBH)) + (0.136 * ln(DBH)^2)+ (-0.0206 * ln(DBH)^3)+ (0.809 * ln(WD))	Chave et al (2005) general equation II.2 (All types)	6
VM0015	VCS1094	Brazil	Riparian dense tropical rainforest (moist forest)	2200	660	0.50	AGB = ΣWD/0.67 * (exp(0.33 * (lnDBH) + 0.933* (ln(DBH)^2) – 0.122 *(ln(DBH)^3) – 0.37))	Baker et al. (2004) equation 2.1	4

VM0015	VCS1541	Guatemala	Broadleaf forest medium-high statured humid (moist forest)	2000	264–344	0.50	AGB = 10^(-4.09992 + 2.57782 * $\log_{10}$DBH)	Arreaga Gramajo (2002) – eq. 21 – a non-peer reviewed source	4
VM0015	VCS944	Peru	Pre-montane forest (500 – 1000 m elevation) (moist forest)	1200	379.1	Undefined	AGB = exp(1.96 – 1.098 * ln(DBH)+ 1.169 * (ln(DBH))^2 – 0.122 * (ln(DBH))^3 + 1.061 * ln(WD))	Alvarez et al. (2012) equation type II.1 pre-montane moist	4

Note. AGB is AGB of trees (in kg or mg), MAP is mean annual precipitation, AGC is the mean AGC stock as reported for the forest type in each project, DBH is diameter at breast height (in cm), H is total height (in m), and WD is wood density (in g/cm^3)

A This project did not specify the allometric equation used to estimate live tree AGB in the forests within the project area. However, Eregae et al. (2017) adopted the wildlife works allometric model, where AGB was calculated by the tree species specific allometric equation as AGB = $\alpha * (DBH)^{\beta}$, where AGB is above-ground weight of the tree in kilogram (kg), DBH is diameter at breast height in cm and α and β are the model coefficients (Korchinsky et al., 2011). Korchinsky et al. (2011) reported that genus-level allometric equations were developed using all trees for each of 5 dominant genuses in the ecosystem, and these curves were used when species-level equations were not available. In the absence of genus-level curves, the all-species curve was used by default, for those rare trees for which no destructive harvest data was available. **B 1:** Species-specific, locally developed (i.e., does not have to be developed by the project proponent, but by a third party in a location (lat/long) less than 100 km from the project) for the same forest type (e.g., dry, moist, wet) using more than 30 trees covering a wide range of DBH (minimum to maximum DBH in the sample size); **2:** Species-specific, developed in other regions or forest types using at least 30 trees covering a wide range of DBH (minimum to maximum DBH in the sample size); **3:** General (i.e., includes several species in a given forest stand), locally developed for a given forest type (e.g., dry, moist, wet forest type based on mean annual precipitation) using at least 100 trees covering a wide range of DBH (minimum to maximum DBH in the sample size); **4:** General, regionally developed (within the same climate province and < 500 km from the original forest data location) for a given forest type (e.g., dry, moist, wet forest) using at least 100 trees covering a wide range of DBH (minimum to maximum DBH in the sample size); **5:** General, pantropically developed (i.e., trees from multiple stands across different tropical regions) for a given forest type (e.g., dry, moist, wet forest) using at least 100 trees covering a wide range of DBH (minimum to maximum DBH in the sample size); **6:** General, pantropically developed for any tropical forest (i.e., not forest type specific) using at least 100 trees covering a wide range of DBH (minimum to maximum DBH in the sample size); **7:** Species-specific or general equation (all species in a given forest) developed using fewer than 30 trees. Project 1775 included trees with stem diameter at breast height (DBH) ≤ 65 cm only due to the project's approach to selecting allometric equations.

Table 4.A3

Alternative Allometric Equations Used to Compare AGC Tree Stocks

Project ID	Country	Alternative Eq1	Source	Rank[A] Eq. 1	Alternative Eq2	Source	Rank Eq. 2	Alternative Eq3	Source	Rank Eq. 3	Alternative Eq 4	Source	Rank Eq. 4
VCS1392	Colombia	AGB = 0.089 * ((DBH)^2 * H * WD)^0.951	Duque et al. (2017)	4	AGB = exp(-1.482 + (2.499* ln(DBH)) + ln(WD))	Alvarez (2012) – Eq. wet II.5	¾	AGB = exp(1.662 – (1.114 * ln(DBH)) + (1.169 * ln(DBH)^2) – (0.122 * ln(DBH)^3) + (0.331 * ln(WD)))	Alvarez (2012) – Eq. wet forest II.1	¾	AGB = exp(-2.286 + (2.471 * ln(DBH)))	Sierra et al. (2007)	4
VCS1359	DRC	AGB = exp(-2.2057 + 2.5841 * ln(DBH))	Djomo et al. (2010) – Eq. 1	4	AGB = exp(-2.1801+ 2.5624 * ln(DBH))	Djomo et al. (2010) – Eq. 2	4	AGB = exp(-3.2249 + 0.9885 * ln(DBH)^2 * H))	Djomo et al. (2010) - Eq. 3	4	AGB = exp(-1.9644 + 2.3382 * ln(DBH) + 0.3579 * ln(WD))	Djomo et al. (2010)	4
VCS1396	Colombia	AGB = 0.089 * ((DBH)^2 * H * WD)^0.951	Duque et al. (2017)	4	AGB = exp(-1.482 + (2.499* ln(DBH)) + ln(WD))	Alvarez (2012) – Eq. wet II.5	¾	AGB = exp(1.662 – (1.114 * ln(DBH)) + (1.169 * ln(DBH)^2) – (0.122 * ln(DBH)^3) + (0.331 * ln(WD)))	Alvarez (2012) wet equation II.1	¾	AGB = exp(-2.286 + (2.471 * ln(DBH)))	Sierra et al. (2007)	4
VCS1112	Brazil	AGB = exp(−8.26306 + (0.87461 * ln(DBH)^2 * H) + (0.97690 * ln(WD))	Romero et al. (2020) – Eq. MB2	3	AGB = 0.6 * 4.06 * (DBH)^1.76	Araújo et al. (1999)	4	AGB = exp(−8.26077 + (1.73728 * ln(DBH)) + (0.89154 * ln(H)) + (0.96957 * ln(WD)))	Romero et al. (2020) – Eq. MB3	3	AGB = exp(-1.716 + (2.413 * ln(DBH)))	Nogueira et al. (2008)	4
VCS1566	Colombia	AGB = 0.089 * ((DBH)^2 * H * WD)^0.951	Duque et al. (2017)	4	AGB = exp(-2.289 + 0.937 * ln(DBH)^2 * H * WD))	Alvarez (2012) – Eq. I.2 tropical wet	¾	AGB = exp(1.662 – (1.114 * ln(DBH)) + (1.169 * ln(DBH)^2) – (0.122 * ln(DBH)^3) + (0.331 * ln(WD)))	Alvarez (2012) – Eq. wet II.1	¾	AGB = exp(-2.286 + (2.471 * ln(DBH)))	Sierra et al. (2007)	4
VCS985	Peru	AGB = 0.6 * 4.06 * (DBH)^1.76	Araújo et al. (1999)	4	AGB = exp(-2.289 + 0.937 * ln(DBH)^2 * H * WD))	Alvarez (2012) – Eq. type I.2 tropical wet	4	AGB = 0.089 * (DBH^2 * H * WD)^0.951	Duque et al. (2017)	4	AGB = 0.0776 * (WD * DBH^2 * H)^0.940	Chave et al. (2005) – Eq. Wet forest	5
VCS1775	Zambia	AGB = 0.0625 * (DBH)^2.553	Chamshama et al. (2004)	4	AGB = exp (2.601 * ln(DBH) – 3.629)	Ryan et al. (2011)	4	AGB = 0.056 * (DBH)^2.549	Tomo (2012) in Mate et al. (2014)	4	AGB = exp(-1.083 + (2.266 * ln(DBH)) + ln(WD))	Chave et al. (2005) – Eq. Dry forest	5
VCS902	Zimbabwe	AGB = -0.089 + 0.000634 * (0.78539 * (DBH)^2)	Henry et al. (2011)	4	AGB = 20.02 * DBH – 203.37	Chidumayo (1997) in	4	AGB = -41.077 + 2.816554 * DBH + 0.35657 * (DBH)^2	Henry et al. (2011)	4	AGB = exp(2.601 * ln(DBH) – 3.629)	Ryan et al. (2011)	4

						Henry et al. (2011)									
VCS934	DRC	AGB = exp(-1.083 + (2.266 * ln(DBH)) + ln(WD))	Chave et al. (2005) – Eq. Dry forest II.5	5	AGB = exp(-2.2057 + 2.5841 * ln(DBH))	Djomo et al. (2010)	4	AGB = exp(-3.2249 + 0.9885 * ln(DBH)^2 * H))	Djomo et al. (2010)	4	AGB = -0.089 + 0.000634 * (0.78539 * DBH^2) * exp((0.5^2)/2)	Henry et al. (2011) – Eq. 394	4
VCS1094	Brazil	AGB = 0.6 *(4.06 * (DBH^1.76))	Araújo et al. (1999)	4	AGB = exp(-1.716 + (2.413 * ln(DBH)))	Nogueira et al. (2008)	¾	AGB = exp(0.33 * log(DBH) + 0.933 * (ln(DBH)^2) – 0.122 * (ln(DBH)^3) – 0.37)	Baker (2004)	4	AGB = exp(-2.134 + 2.530 * ln(DBH))	Brown et al. (1997) – Eq. moist forest	5
VCS1541	Guatemala	AGB = exp(-1.716 + (2.413 * ln(DBH)))	Nogueira et al. (2008)	4	AGB = exp(-9.44041 + (2.57782 * ln(DBH)))	Arreaga Gramajo (2002) Eq. 22	4	AGB = exp(-2.919 + (2.081 * ln(DBH)) + (0.587 * ln(H)) + (0.391 * ln(WD)))	Alvarez (2012) – Eq. type I tropical moist	4	AGB = exp(-1.716 + (2.413 * ln(DBH)))	Nogueira et al. (2008)	¾
VCS944	Peru	AGB = exp(-2.221 + 2.081 * ln(DBH) + 0.587 * ln(H) + 1.089 * lm(WD))	Alvarez et al. (2012) – Eq. type I.1 Premontane moist	4	AGB = exp(-1.716 + (2.413 * ln(DBH)))	Nogueira et al. (2008)	4	AGB = 0.6 *(4.06 * (DBH^1.76))	Araújo et al. (1999)	4	AGB = 0.0509 * (WD * DBH^2 * H)	Chave et al. (2005) – Eq. moist forest	5

Table 4.A4

Description of the Forest Type and Data Used to Calculate the AGC Tree Stocks

Project ID	Country	Dataset name used in the analysis	Dataset source	Link to dataset	Identification of the forest plots used in the analysis	Number of plots and area covered
VCS1359	DRC	Forest Inventory and Biophysical Measurements, Brazilian Amazon, 2009–2018	dos-Santos et al. (2022)	https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=2007	JAM_A02_2013 and JAM_A03_2013dry forest plots from Rondonia State	28 0.25-ha plots combined into 7 1-ha dry forest plots
VCS1392	Colombia	Forest Inventory and Biophysical Measurements, Brazilian Amazon, 2009–2018	dos-Santos et al. (2022)	https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=2007	DUC_A01_2016 wet forest plots	17 0.25-ha wet forest plots combined into 4 1-ha plots
VCS1396	Colombia	Forest Inventory and Biophysical Measurements, Brazilian Amazon, 2009–2018	dos-Santos et al. (2022)	https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=2007	DUC_A01_2016 wet forest plots	17 0.25-ha wet forest plots combined into 4 1-ha plots
VCS1112	Brazil	Forest Inventory and Biophysical Measurements, Brazilian Amazon, 2009–2018	dos-Santos et al. (2022)	https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=2007	BON_A01_2014, HUM_A01_2014, TAL_A01_2014 moist forest plots in Acre State, Brazil	6 1-ha moist forest plots
VCS1566	Colombia	Forest Inventory and Biophysical Measurements, Brazilian Amazon, 2009–2018	dos-Santos et al. (2022)	https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=2007	CAU_A01_2014 wet forest plots from Pará State	32 0.25-ha plots combined into 8 1-ha plots
VCS985	Peru	Forest Inventory and Biophysical Measurements, Brazilian Amazon, 2009–2018	dos-Santos et al. (2022)	https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=2007	CAU_A01_2014 wet forest plots from Pará State	32 0.25-ha plots combined into 8 1-ha plots
VCS1775	Zambia	Structure and composition of woodlands across Mozambique	Woolen et al. (2017)	https://doi.org/10.5285/70b5cdda-72df-4007-b10e-d75b4046e603	"1" = "HCN_CF10", "HCN_CF17", "HCN_CF22", "HCN_CF27", "HCN_CF41", "HCN_OF13", "HCN_OF18", "HCN_OF35", "2" = "HCN_OF4", "HCN_OF5", "HCN_SS17", "HCN_SS27", "HCN_SS3", "HCN_SS32","HCN_SS33", "HCN_SS42", "3" = "HCN_SS49", "HCN_SS61", "HCN_SS65", "HCN_SS77", "HCN_SS87", "HCN_SS89", "HCN_SS92", "MPS_CF248"),"4" = "MPS_CF249", "MPS_CF250", "MPS_CF251", "MPS_CF256", "MPS_OF605", "MPS_OF609", "MPS_OF615",	64 0.126-ha plots combined into 8 1-ha plots

					"MPS_OF625", "5" = "MPS_OF627", "MPS_OF631", "MPS_OF642", "MPS_OF643", "MPS_OF648", "MPS_OF649", "MPS_OF657", "MPS_OF662","6" = "MTB_CF123", "MTB_CF124", "MTB_CF125", "MTB_OF153", "MTB_OF185", "MTB_OF208", "MTB_OF212", "MTB_OF222"), "7" = "MTB_SS219", "MTB_SS220", "MTB_SS231", "MTB_SS232", "MTB_SS236", "MTB_SS244", "MTB_SS246", "MTB_SS249", "8" = "MTC_OF135", "MTC_OF137", "MTC_OF62", "MTC_OF64", "MTC_OF73", "MTC_OF74", "MTC_OF79", "MTC_OF81"	
VCS902	Zimbabwe	Structure and composition of woodlands across Mozambique	Woolen et al. (2017)	https://doi.org/10.5285/70b5cdda-72df-4007-b10e-d75b4046e603	"1" = "MHO_0b"", ""MHO_10b"", ""MHO_12a"", ""MHO_12b"", "MHO_14a"", ""MHO_14b"", ""MHO_15a"", ""MHO_15b", "2" = ""MHO_19b"", ""MHR_19a"", ""MHR_19b"", ""MHR_22b"", ""MHR_4b", ""MHR_8b"",""MHO_19a"", ""MQT_16""), "3" = ""MQT_24a"", ""MQT_27"", ""MQT_2b"", ""MQT_32a"", ""MQT_40b"", ""MQT_42b"", ""MQT_43a"", ""NCN_17a",""4"" = ""NCN_18a"", ""NCN_18b"", ""NCN_1a"", ""NCN_1b"", ""NCN_23a"", ""NCN_2a"", ""NCN_3a"", ""NCN_3b",""5"" = c(""NCP_11a"", ""NCP_20a"", ""NCP_20b"", ""NCP_3a"", ""NCP_3b"", ""NCP_8a"", ""NCP_8b"", ""NMP_10b",""6"" = ""NMP_14a"", ""NMP_19b"", "NMP_20a"", ""NMP_20b"", ""NMP_22b"", ""NMP_23a"", ""NMP_23b"", ""NMP_4a", ""7"" = ""NSE_1a"", ""NSE_20a"", ""NSE_22a"", ""NSE_22b"", ""NSE_5a"", ""NSE_5b"", ""NTX_0a"", ""NTX_14a", "8" = "NTX_14b"", ""NTX_18b"", ""NTX_20a"", ""NTX_20b"", ""NTX_23b"", ""NTX_6a"", ""NTX_6b"",	80 0.126-ha plots combined into 10 1-ha plots

					""NTX_7a""), ""9"" = c(""PLK_14a"", ""PLK_14b"", ""PLK_15a"", ""PLK_15b"", ""PLK_23a"", ""PLK_4a"", ""PLK_4b"", ""PLK_5a""), ""10"" = c(""SRA_11a"", ""SRA_11b"", ""SRA_12a"", ""SRA_12b"", ""SRA_13a"", ""SRA_16a"", ""SRA_4a"", ""SRA_4b"")))"	
VCS934	DRC	Forest Inventory and Biophysical Measurements, Brazilian Amazon, 2009–2018	dos-Santos et al. (2022)	https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=2007	AND_A01_2013_2018 dry forest plots from Para State	20 0.25-ha plots combined into 5 1-ha dry forest plots
VCS1094	Brazil	Forest Inventory and Biophysical Measurements, Brazilian Amazon, 2009–2018	dos-Santos et al. (2022)	https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=2007	ANA_BR_FI_2015 moist forest plots from Para State	32 0.25-ha plots combined for a total of 8 1-ha plots
VCS1541	Guatemala	Complete data from the Barro Colorado 50-ha plot: 423617 trees, 35 years, Dryad, Dataset	Condit et al. (2019	https://doi.org/10.15146/5xcp-0d46	BCI data	250 0.04-ha plots combined for a total of 10 1-ha moist forest plots
VCS944	Peru	Forest Inventory and Biophysical Measurements, Brazilian Amazon, 2009–2018	dos-Santos et al. (2022)	https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=2007	ANA_BR_FI_2015 moist forest plots from Para State, Brazil	32 0.25-ha plots combined into 8 1-ha plots

Note. Brazilian Amazon Forest Inventory Data (dos-Santos et al., 2022) from 50 m x 50 m plots. In each plot, all trees included in the inventory have a stem diameter (DBH) equal or higher than 10 cm. For project VCS1775 only, we used trees with DBH lower than 65 cm as the project used an equation specific for trees with DBH lower than 65 cm. We used woodland inventory data from Woolen et al. (2017) for VM0009 project VCS1775 in African woodlands, as Miombo woodlands can be found in southeastern and central Africa and form a dominant vegetation type in Angola, Zambia, Tanzania, Malawi, Mozambique and Zimbabwe (Malmer, 2007).

Table 4.A5

Alternative Methods to Estimate BGB

Methodology	Project ID	Alternative method 1	Source alternative method 1	Alternative method 2	Source alternative method 2	Alternative method 3	Source alternative method 3
VM0006	VCS1392	BGB = exp(-1.0587 + 0.8836 * ln(AGB)	Cairns et al. (1997)	BGB = 0.235 * AGB	Mokany et al. (2006)	BGB = 0.2 * AGB	Vogt et al. (1995)
VM0007	VCS1112	BGB = 0.2 * AGB	Vogt et al. (1995)	BGB = 0.28 * AGB	Ledo et al. (2018)	BGB = 0.28 * AGB	Sanford and Cuevas (1996)
VM0009	VCS1775	BGB = 0.40 * AGB	Mugasha et al. (2013)	BGB = 0.2113 * DBH^1.9838	Mugasha et al. (2013)	BGB = exp(2.262 * ln(DBH) - 3.370)	Ryan et al. (2011)
VM0015	VCS1541	BGB = exp(-1.0587 + 0.8836 * ln(AGB)	Cairns et al. (1997)	BGB = 0.28 * AGB	Ledo et al. (2018)	BGB = 0.2 * AGB	Vogt et al. (1995)

Note. Methods include root-to-shoot ratios or equations obtained from the literature. BGB and AGB are in Mg/ha. DBH is the diameter at breast height.

Berkeley Public Policy
The Goldman School
Berkeley Carbon Trading Project

Chapter 5: Durability

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Executive Summary

Forest carbon durability (also called *permanence*) refers to the ability of forests to maintain their carbon stocks over time and is critical to the quality and effectiveness of Reducing Emissions from Deforestation and Forest Degradation (REDD+) projects. Carbon dioxide (CO_2) that is being rapidly released from burning fossil fuels can persist in the atmosphere for hundreds to thousands of years, causing continued warming of the planet. The climate benefits from avoiding the release of carbon into the atmosphere from deforestation and forest degradation can be partially or even completely reversed if the forest is protected for only a short period of time.

While even short-term carbon storage in nature can delay the impact of climate change (Leifeld, 2023), carbon needs to be stored in forests for long periods to effectively counteract the climate impacts of burning fossil fuels. It is important to note that even if forest carbon is reasonably durable, preserving forests is not equivalent to reducing fossil fuel emissions. Programs that use reductions in forest carbon emissions as offsets for fossil fuel emissions effectively move carbon from the long-duration carbon pool to a short-term carbon cycle, where it is at risk of re-release. Although forest protection is essential for climate mitigation as well as for numerous co-benefits (e.g., biodiversity protection), the risk of reversal means these projects cannot truly offset industrial emissions.

Forest carbon can be released through natural mortality processes when older or diseased trees die and decompose, and through disturbance events such as wildfire, pests, storms, heat stress, and droughts, which can damage or kill many trees at once. The frequency and severity of these disturbances are increasing with climate change and are a major concern, particularly in drier tropical forests (Brando et al., 2019). Verra's *Verified Carbon Standard* (VCS) addresses the risk of reversal within forest carbon crediting projects by setting a percentage of verified reductions aside into what is known as an insurance *buffer pool*. A project's buffer pool should fully cover the risk of reversal of the credited emissions reductions over a period of 100 years. In the event of a reversal during the project's lifetime (up to 100 years and typically spanning 30 years), credits equal to the amount reversed are retired from the buffer pool, and the project must replenish them. At the end of the project's last crediting period, all remaining buffer pool credits are retired to cover any future risk of reversal. All REDD+ projects must follow the latest version of VCS's agriculture, forestry, and other land use (AFOLU) Non-Permanence Risk Tool v.4.1, which prescribes how project developers should assess project risk and their contributions to the buffer pool (Verra, 2023a). Risk factors are classified into three categories: natural risks (fire, pests, extreme weather, geological risks, other natural risks), external risks (related to the human context of the project, including land tenure, stakeholder engagement, political risks), and internal risks (internal to the project, such as management, finances, project length).

This chapter examines whether VCS-REDD+ projects' contributions to their buffer pool are sufficient to cover the risk of reversal over 100 years. Our analysis focuses on the methods prescribed by VCS for assessing risk as well as the application of those methods by VCS-REDD+ projects. We analyzed all REDD+ projects that had been issued carbon credits as of March 2022 under the four most-used VCS-REDD+ methodologies, which at the time used v4.0 of the AFOLU Non-Permanence Risk Tool (Verra, 2019), focusing on the most recent risk assessments (total risk and risk for each subcategory). We reviewed the projects' risk ratings and justifications for these ratings and contextualized and compared the risk assessments with relevant scientific literature, where possible. In this chapter, we report on our findings with respect to natural risks, external risks, and internal risks.

Natural risks. Project developers rated natural risk as very low for all projects, with a mean rating of 2% for all natural risks combined, with 12% of projects reporting no natural risk projected over a 100-year period from the time of credit issuance (Figure 5.1a). A risk rating of 2% indicates a 2% chance that the forest carbon conserved and credited by the project will be released to the atmosphere over a 100-year period. Of the five natural risk subcategories, fire was reported to have the highest impact (but only 53% of the projects reported fire as a risk). The majority of projects reported no risk for the four remaining natural risk subcategories.

We performed a basic validation by comparing the project reports to observational, remote-sensing data from 2002–2014. For the 57 projects for which we had matching spatial coordinates, we found the mean 100-year risk of a stand-clearing disturbance (all natural risks combined) to be 28% (Figure 5.1e), or more than 10 times the average natural risk reported by the projects. This risk estimate was conservative because we only included stand-clearing disturbances and ignored other forms of disturbance. In addition, climate change is expected to increase risk due to natural disturbances over time. For these two reasons, risk of reversal is likely to be higher than the 28% reported here.

External risks. The majority of projects (72%) reported external risks to be zero. The remainder reported a very low external risk, with a mean rating of 2%, which is likely too low and inaccurate, given that external political risk and land tenure issues are common concerns in countries where REDD+ projects are located. In addition, the risk from low community engagement (in the form of communication with households reliant on the project) was zero or negative in 94% of the projects (see Chapter 7: Safeguards), despite some using consultation approaches that would normally not be considered appropriate, such as sending emails in regions with low levels of literacy and electrification.

Internal risks. A third of the projects reported no risk or mitigating ratings (negative ratings) for internal risk. The remaining projects that reported some sort of internal risk had a mean risk of 9%.

After summing the natural, external, and internal risks, more than half of the projects (57%) had a total risk value at or below the minimum required threshold of 10% (Verra, 2019), indicating an exceptionally low risk of carbon reversal at their sites. The mean total risk rating was 15%. (If a total risk rating is below 10%, the project is automatically assigned a 10% risk).

We raise one more concern with the low risk ratings. A contradiction exists between the low risk of reversal reported by the projects in their buffer pool calculations and their reported deforestation baselines, which indicate a high risk that projects will experience deforestation *unless* REDD+ project action occurs. In other words, if the project documents are accurate in stating that projects are durable over time and have very little risk of reversal, there is arguably also very little risk of deforestation, and hence credited avoided forest conversion is unlikely to be credible (or additional). *Additionality* is defined as the reduction of greenhouse gas (GHG) emissions from a

REDD+ activity that would not have occurred without the revenue from sales of carbon credits. Many projects reported substantial deforestation rates in the baseline as well as a low risk of reversal; thus, it is unlikely both are accurate for all of these projects.

With respect to transparency and reporting, we found that project documents differed in how consistently—and thoroughly—they described risk ratings. Moreover, although projects are expected to update their risk assessments with every monitoring period, in the majority of cases they simply reused the previous periods' figures, evidence, and rationale.

The most recent release of Verra's Non-Permanence Risk Tool (v4.1; 2023a) requires that projects take into account projected future climate change impacts in their risk assessments, extends the minimum crediting period to 40 years, and increases the minimum threshold for the total risk rating to 12%—all of which are meaningful improvements. These changes, however, do not appear to remedy the low assessments of current risk.

Our main recommendations are as follows:

- The minimum threshold for the total risk rating should be increased to greater than 12% (the current minimum threshold) to allow for more conservative estimates and to encourage project developers to use greater scrutiny when evaluating risk.
- Natural risks should be estimated using the latest science for taking impacts from climate change into account. For example, (a) high-resolution satellite data can provide details about past rates of change of forest coverage, including impacts from disturbance such as wildfire, and (b) ecologically based dynamic vegetation demographic models can be used to more realistically quantify forest carbon storage and change in carbon over time as a result of disturbances and resulting forest growth trajectories, and survival or mortality. These demographic models can also be coupled with climate change models to help us understand the impact of climatic stress on forest disturbance and growth. We also recommend providing project developers with citations and examples of science-backed research and predictions of natural risks via an online scientific reference repository. The citations discussed in this chapter are a good starting point.
- Social science databases, governmental reports, and other community-based surveys should be used to update external risk categories.
- Projects should not be allowed to claim both substantial deforestation in the baseline and low risk reversal, or these should only be allowed in unusual circumstances.
- The lifetime of carbon storage in forests is not equivalent to the lifetime of CO_2 emitted into the atmosphere; thus, it should not be used as an *equivalent* offset for fossil fuel emissions.

Introduction

Forest carbon durability (also called *permanence*) refers to the ability of forests to maintain their carbon stocks over time and is critical to the quality and effectiveness of REDD+ projects. Durability is crucial for reducing GHG emissions, as forests pull and hold carbon out of the atmosphere and also act as important carbon sinks (i.e., absorb CO_2 from the atmosphere), thus helping to mitigate climate change. If a REDD+ project only protects forest carbon for a short period of time and if the carbon is released into the atmosphere through deforestation, forest degradation, or natural disturbances, most or all of the climate benefits of the project are reversed. Without durability, any reduction in emissions achieved through forest conservation efforts may be short lived and ultimately ineffective in addressing climate change.

CO_2 that is rapidly released from burning fossil fuels can persist in the atmosphere for hundreds to thousands of years, causing continued warming of the planet (Archer et al., 2003; Solomon et al., 2009). The carbon stored in forests (even if for only 100 years) can be a helpful means for mitigating climate change by preventing deforestation-based CO_2 from being released into the atmosphere and by drawing down atmospheric CO_2, which has been rising due to human activities. Forest protection from deforestation for even short periods has been shown to have a quantitative near-term impact on climate mitigation by displacing emissions (Leifled, 2023) and can provide climate benefits by delaying and lowering peak warming potential and by reducing the cumulative impact of atmospheric warming (Intergovernmental Panel on Climate Change [IPCC], 2021). While the longer forest-based carbon remains in natural carbon storage pools, the greater the climate benefits are, it should also be noted that carbon storage in nature is inherently short term, compared with fossil-based carbon, and is therefore not equivalent to the reduction of fossil fuel CO_2 emissions (i.e., it does not offset fossil fuel emissions). When carbon sequestration in forests is used to offset fossil fuel emissions, the effect is, at best, to move carbon from long-term storage as a fossil fuel into a short-term carbon cycle, where it is at increasing risk of reversal with climate change. Longer duration carbon storage in forests tends to occur primarily in the trunks of large trees and in slow-turnover soil carbon pools (Bossio et al., 2020).

Natural ecosystems, especially tropical forests, can provide this ecosystem service as long as they are not affected by either natural or human disturbances. Carbon stored in forests can be lost through slower processes, such as tree mortality, or more rapid disturbances, such as wildfire, pests, disease, storms, heat stress, and droughts. These are often termed *natural* disturbances. However, human-caused climate change is increasing the frequency and severity of many of these climate-sensitive disturbances, especially drought and wildfire, which can have many negative consequences on forest health and carbon storage (Abatzoglou & Williams, 2016; Anderegg et al., 2020, IPCC, 2021; Seidl et al., 2017). Increases in climate-sensitive disturbances are crucial to climate policy because they have a negative impact on carbon storage on a landscape scale, and it can take a long time to reverse negative impacts. Human-caused drivers of forest loss (e.g., logging, road building, and land-use conversion) are also substantial risks to impermanence. Additionally, it is important to engage with local communities and Indigenous peoples in the codesign and implementation of REDD+ projects and monitoring and reporting systems, to ensure they are aligned with local values and priorities and to build long-term support for REDD+ activities.

How VCS-REDD+ Methodologies Address Non-Permanence Risk

REDD+ projects reduce and manage risk of reversal in two ways. One is through what is known as an insurance *buffer pool*. Project developers must estimate the risk that forest carbon that has been preserved and credited will be released into the atmosphere over a period of 100 years after issuance. Those credits act like an insurance system. All VCS AFOLU projects pay into the pool with a share of their credits; the integrity of credits generated by VCS forest projects that experience a reversal, whether natural or human caused, is insured by the buffer pool. Second, developers have a financial incentive to take actions that lower the risk of reversal, because doing so means fewer credits must be deposited into the buffer pool.

Buffer Pool

Projects should use the guidelines laid out in the VCS AFOLU's Non-Permanence Risk Tool to determine the natural and human risk factors and their contributions to the buffer pool. Reversals are defined as either catastrophic (not under the control of the developer) or non-catastrophic (caused by or under the control of the developer). A reversal is considered to have occurred in a reporting period if actual total losses in the project are larger than the losses predicted in the baseline. A catastrophic reversal is first covered by credits the project previously deposited into the buffer pool, and then if needed, with future verified reductions eligible for issuance, until the reversal is fully covered (Verra, 2023b, section 5.3.3). Non-catastrophic reversals, which are caused by or can be prevented by the developer, should be fully replaced by the developer and not covered by the buffer pool. Replacement credits can include future verified reductions eligible for issuance by the project. If a project is terminated or becomes inactive, then reversals of either type are covered by other credits in the pooled buffer account.

Upon request and after each 5-year period, if a project does not undergo a reversal and maintains or reduces risk over time, VCS can release 15% of the project credits in the buffer pool to the developer as salable credit issuances (Verra, 2023b, section 5.2.3). At the end of the project life (which can range from 30 to 100 years), all remaining buffer pool credits from the project are removed from the pool and retired to cover any future risk of reversal. Verra (2022b) is developing a long-term monitoring system that would use remote monitoring to detect loss events during the post-crediting period. This will help Verra monitor the sufficiency of the buffer pool over time.

Non-Permanence Risk Analysis

Because we only analyzed REDD+ projects that had generated credits by March 2022, we used the VCS criteria required for the projects, which were from v4.0 of the Non-Permanence Risk Tool (Verra, 2019) for our analysis. To assess the risk of a potential loss in carbon stocks in a project over a period of 100 years, the Non-Permanence Risk Tool classifies risk factors into three categories (natural risks, external risks, and internal risks), "based on the conditions present and the information available at the time of the risk analysis" (p. 2). This assessment determines the number of credits to be deposited in a project's pooled buffer account. The *VCS Standard* defines how the verified carbon units (VCUs) issued are considered permanent:

> All VCUs issued to AFOLU and Geologic Carbon Storage (GCS) projects (as with all projects) are permanent. The VCS approach provides environmental integrity because the AFOLU and GCS pooled buffer accounts will always maintain an adequate surplus to cover unanticipated losses from individual project failures, and the net GHG benefits across the entire pool of AFOLU and GCS projects will be greater than the total number of VCUs issued. (Verra, 2023c, section 2.4.1)

VCS uses the following criteria to determine current project risk ratings:

- Where a risk factor does not apply to the project, the rating is zero.
- The Non-Permanence Risk Tool divides natural, external, and internal risks into subcategories. For example, external risk has a subcategory of land tenure and resource access/impacts. Subcategories are further divided into criteria bins, and projects assign predetermined risk values based on which bin is applicable to the project. For example,

under land tenure and resource access/impacts, a project is assigned a risk rating of 10% if disputes over land tenure occur in more than 5% of the project area.

- If the project demonstrates that mitigation activities (i.e., project actions that lessen the effect of risk) are being applied, then the risk rating for a subcategory can be reduced. A subcategory can have a risk value lower than zero (i.e., a mitigating rating).
- The total risk rating for each category (natural, external, or internal) is determined by summing the ratings for each subcategory. A few subcategories may have negative values; however, the total rating for any of the three categories may not be less than zero. If a project passes a threshold as "fail" for any risk factor category, then the project fails the entire risk analysis (see Table 5.1 for risk-rating thresholds in each category).
- If the overall risk rating is greater than 60% (i.e., the forest carbon storage of the project has a >60% chance of being reversed over 100 years), the project's risk is deemed unacceptably high, and the project fails the entire risk analysis.
- When a project fails the risk assessment, it is not eligible for crediting until it has adequately addressed the risk so it will no longer be assessed as a failure.
- The *minimum total* risk rating should be 10%, regardless of the risk rating calculated using the VCS AFOLU Non-Permanence Risk Tool.

The overall non-permanence risk rating is the sum of natural, external, and internal risks, with each category individually having the potential to qualify for mitigating factors. Again, an individual category can have a negative rating, but the overall total summed rating cannot be negative and must have a minimum rating of 10%. As described in the AFOLU's Non-Permanence Risk Tool v4.0 (Verra, 2019), to determine the number of buffer credits that should be deposited in the AFOLU pooled buffer account, the overall risk rating is converted to a percentage (e.g., an overall risk rating of 35 converts to 35%). This percentage is multiplied by the net change in the project's carbon stocks.

Table 5.1
VCS Risk Analysis Factors Used to Evaluate REDD+ Projects

Type of risk	Risk factors related to	Number of subcategories
Natural	Fire	Risk = 5; Mitigation = 1
	Pest and disease outbreaks	Risk = 5; Mitigation = 1
	Extreme weather	Risk = 5; Mitigation = 1
	Geological risk	Risk = 5; Mitigation = 1
	Other natural risk	Risk = 5; Mitigation = 1
	Threshold risk rating for project ineligibility = 35%	
External	Land tenure and resource access/impacts	Risk = 4; Mitigation = 2

	Community engagement*	Risk = 2; Mitigation = 1
	Political risk	Risk = 1; Mitigation = 1
	Threshold risk rating for project ineligibility = 20%	
Internal	Project management*	Risk = 4; Mitigation = 2
	Financial viability	Risk = 2; Mitigation = 1
	Opportunity costs*	Risk = 1; Mitigation = 1
	Project longevity	Risk = 1
	Threshold risk rating for project ineligibility = 35%	

* Total may be less than zero for this subcategory.

Natural Risks Description

VCS natural risk assessments are based on quantitative assessments that take into account both the likelihood of a natural event occurring and the significance (i.e., severity) of the damage when it does occur. Likelihood considers the frequency or occurrence of each natural risk and is measured as the historical average number of times the event has occurred in the project area over the last 100 years. Significance is the percentage of carbon stocks lost in those historic events. Using a matrix format, likelihood and significance determine which criteria bin the project falls in. The bin assigns the project a risk value that reflects the risk that credited reductions will be reversed for each natural risk factor. These values are then added across all five natural risks (fire, pest and disease, extreme weather, geological risk, and "others" subcategory). As defined in the AFOLU Non-Permanence Risk Tool v4.0 (Verra, 2019) for natural risk, the "frequency and significance of events shall be estimated based on historical records, probabilities, remote sensing data, peer-reviewed scientific literature and/or documented local knowledge, such as survey data in project areas" (p. 14). Losses in carbon stocks should be "based on the conditions present and the information available at the time of the risk analysis" and "*may* include projected climate change impacts" (p. 14, emphasis added). When data are not available for a project area, then likelihood and significance should be determined based on conservative estimates (i.e., err on the side of caution that natural risk will impact credits). Using conservative estimates is intended to allow project developers to account for higher than expected risk of reversal. However, how project developers should conclude this conservative estimate is not well defined by the VCS Non-Permanence Risk Tool, and in reality, is a difficult metric that could be very subjective.

Within weeks of when this report was written, new guidance on risk assessment (Verra, 2023a) was issued that, for the first time, requires risk be based not only on current conditions but on an understanding of the impacts of climate change, including sea-level rise, based on the concept of climatic impact drivers (CIDs) under the Working Group I of the IPCC (2020) *Sixth Assessment Report* (AR6). The updated tool has a new section that defines criteria for evaluating a project's adaptive capacity to future climate change (Table 12, p. 21); projects that demonstrate adaptive capacity can reduce their estimates of risk from projected future climate change impacts by 40%. How a project proves its adaptive capacity to climate change is in fact implemented is vague, thus allowing project developers more leeway to mistakenly reduce overall natural risk scores. This is in addition to the natural risk mitigation factors held over from the previous risk assessment tool. For public consultation and precursor drafts for taking into account climate change impacts, see Verra (2022a, 2022c).

The likelihood and significance of damage to a project can be reduced by mitigation ratings. A mitigation rating can be given based on whether a project can provide evidence that risk prevention measures are in place, the project has a proven history of effectively containing natural risk, or both. When reviewing the Non-Permanence Risk Tool, we did not find guidance or explanations about whether the prevention measures stop risk entirely or only limit risk. Substantial room remains for improvement in defining how much the mitigation practice should reduce damage. Furthermore, scientific literature on the extent to which management practices and mitigation approaches are successful in tropical locations, compared with in temperate forests, is lacking (Moreau et al., 2022).

External and Internal Risks Description

VCS classifies external risks into three categories: land tenure and resource access/impact, community engagement risk, and political risk. Land tenure and resource access/impact has seven criteria, including the existence of disputes over land tenure on more than 5% of the project area and disputes over access/use rights. Community engagement risk is measured by whether 50% of households in the project area and 20% of households within 20 km of the project boundary and reliant on the project area have been consulted. Political risk is measured by the country's governance score according to World Bank indicators.

VCS classifies the internal risk of non-permanence into four categories: project management, financial viability, opportunity costs, and project longevity. Project management risk is assigned if (a) the species planted (if applicable) are non-native or adapted to the same agro-ecological zone where the project is located, (b) ongoing enforcement is needed to protect more than 50% of the carbon stocks from outside actors (e.g., illegal logging), (c) the management team does not include individuals with significant experience, and (d) the management team does not maintain a presence in the country or is located more than one travel day from the project site. Mitigation ratings can be given to project management if (a) management team members include individuals with significant experience in AFOLU project design and approved GHG programs and/or (b) adaptive management plans are in place.

Financial viability risk is assigned based on (a) the number of years until the cash flow break-even point is reached and the cumulative cash flow is positive (between 4 and 10 years) and (b) the percentage of funding that has already been secured relative to what is needed to implement and operate the project until reaching the cash flow breakeven (between 15% and 80% of secured funding). A mitigation rating can be given if the project has available as "callable financial resources" at least 50% of total cash out before the project reaches breakeven.

Opportunity costs risk is assigned based on the alternative profitable land uses identified in the project's additionality assessment.

> The opportunity costs analysis shall include a net present value (NPV) analysis, covering the project crediting period, of such profitable alternatives as compared to the project, taking into consideration a conservative estimate of revenue from GHG credit sales and other project revenue streams, and potential price fluctuations of commodities impacted by the project. (Verra, 2019, p. 6)

This also considers whether the majority of a project's baseline is subsistence driven and whether the project is led by a nonprofit organization that would protect the project from outside opportunity costs.

Project longevity is the number of years, beginning at the project start date, that project activities will be maintained. For all AFOLU project types, the entire period of project longevity should be covered by management and financial plans, as submitted to local governmental or financial institutions, or otherwise made public. Project longevity risk scores vary, depending on whether the project has a legal agreement or requirement to continue the management practice over the length of the project.

Performance of Non-Permanence Standards and Methodologies

Permanence Quantification in Practice

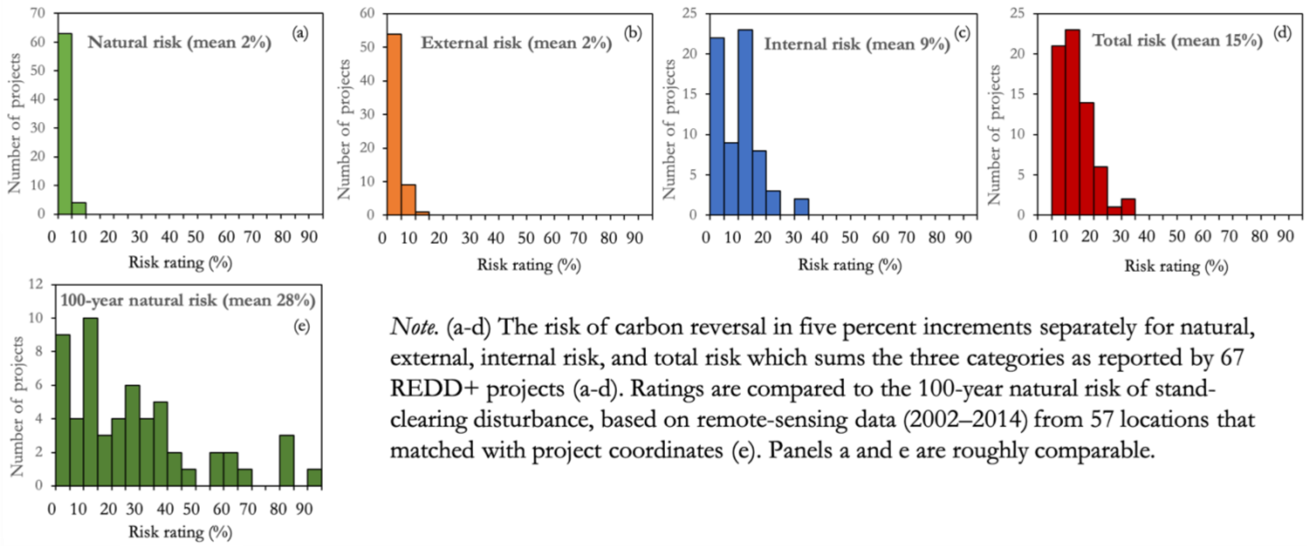
We analyzed all REDD+ projects that had been issued offset credits as of March 2022, using the latest documentation from either the project's description document, verification report, monitoring report, or risk-rating report, and using the most recent complete assessment. In general, we found that document types differed in how consistently—and thoroughly—they described risk ratings. Projects are supposed to update their risk assessments with every monitoring period, but the majority reused their previous period's evidence and rationale in subsequent reporting periods.

Natural Risk

Natural risk was rated very low by all projects, with a mean rating of 2% (out of a 35% total threshold for project ineligibility) for all natural risks combined (Figure 5.1a), representing a 2% chance that the forest carbon conserved and credited by the project would be released to the atmosphere over a 100-year period. Further confirming that natural risk was rated low, 82% of the projects claimed their risk for carbon reversal was between only 1% and 5%. Twelve percent of the projects reported no natural risk at all to carbon stocks over a 100-year period (Figure 5.2a). In the recently released Non-Permanence Risk Tool v4.1 (Verra, 2023a) the classification that allows projects to apply zero natural risk scores was changed from "no loss" to "not applicable."

The maximum natural risk rating from a single project was 6.5%. Out of the five natural risk categories, fire was reported to have the highest impact (but only 53% of the projects reported fire as a risk at all; Figure 5.3). Notably, the majority of projects reported no risk (i.e., green bars in Figure 5.3) for the four remaining natural risk categories. The second-largest natural risk subcategory was extreme weather (reported by 40% of the projects). Between 8% and 32% of the projects did not include any rate for some of the subcategories (i.e., blue bars in Figure 5.3). Although the majority of other natural risk categories were either left blank or given a zero rating, examples of other natural risks included reversal events from landslides, torrential flows (VCS 944, VCS 958), drought (VCS 977), salinization, sea-level rise, coastal erosion (VCS 2290), and flooding (VCS 1748).

Figure 5.1
Risk Ratings for Carbon Reversal



Note. (a-d) The risk of carbon reversal in five percent increments separately for natural, external, internal risk, and total risk which sums the three categories as reported by 67 REDD+ projects (a-d). Ratings are compared to the 100-year natural risk of stand-clearing disturbance, based on remote-sensing data (2002–2014) from 57 locations that matched with project coordinates (e). Panels a and e are roughly comparable.

Figure 5.2
Breakdown of Risk Ratings, by Risk Categories

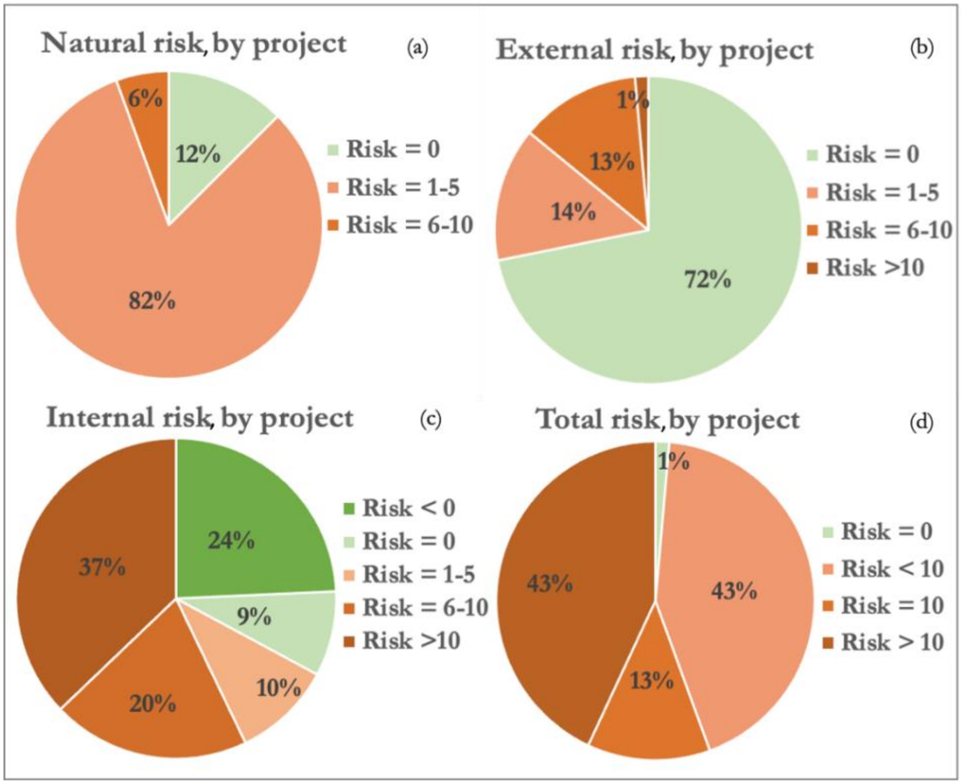
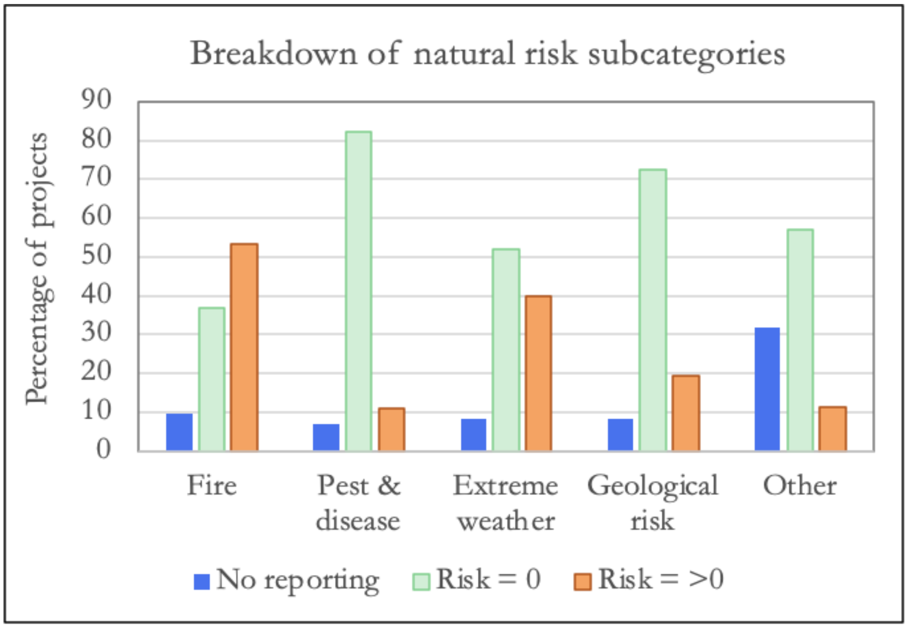


Figure 5.32
Risk Ratings for Five Natural Risk Subcategories



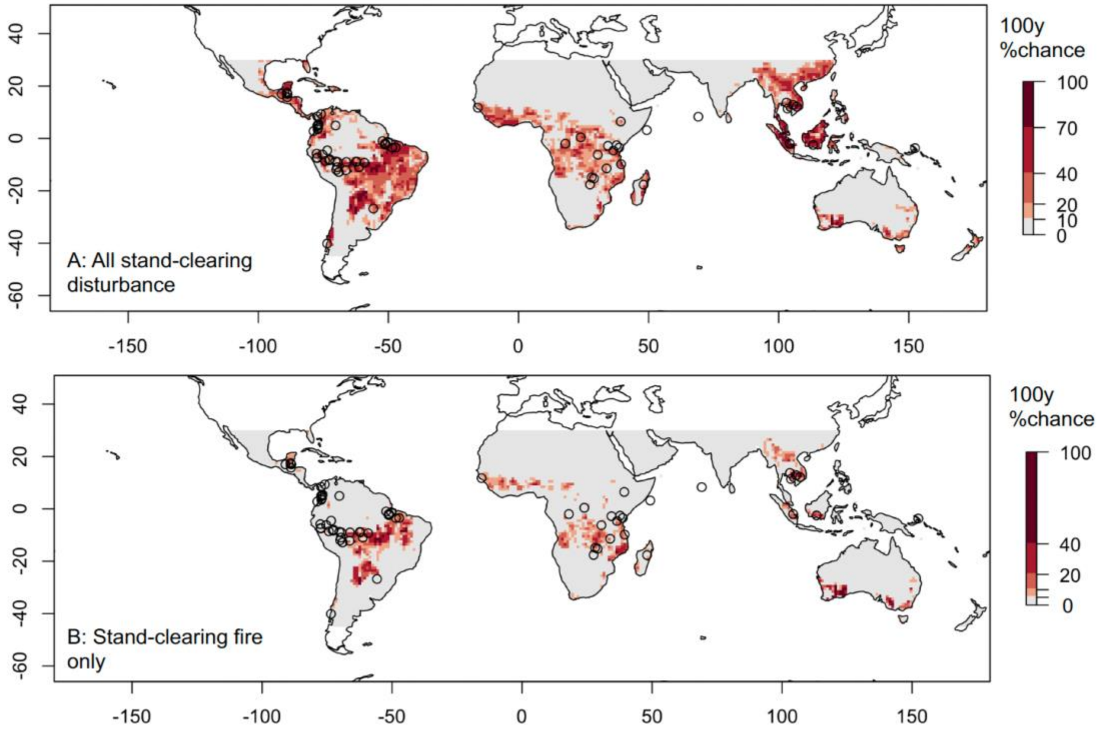
To evaluate and predict the likelihood of future natural risks, project developers were asked to determine any natural risk that affected more than 5% of the project area and that had occurred over the past 100 years. These events were then applied to the rating of non-permanence due to natural risk. Developers were allowed to use historical records, probabilities, remote-sensing data, peer-reviewed scientific literature, and/or documented local knowledge (e.g., survey data in project areas). However, collecting such information for a whole project area over the last 100 years is challenging. Thus, we provided an example of evaluating the likelihood that a natural disturbance event occurred in the past using remote-sensing observational data, and then compared those data with project documents' estimations of disturbance risk.

We used satellite-based estimates of stand-clearing disturbances estimated by Hansen et al. (2013) using Landsat time-series at 30 m resolution. The annual probability of a stand-clearing disturbance was calculated at a 0.5 degree resolution over the 2002–2014 harmonized Landsat record, to calculate an annual probability of stand-clearing disturbance. After we had determined the annual probability, we used a simple function to estimate the probability of this disturbance happening at least once in a 100-year period. This assumed that a 12-year average annual probability would remain constant over 100 years, which is probably a conservative assumption because disturbance most likely would increase over time. To account only for natural forest disturbances, we excluded human-driven forest conversion / forest loss from this calculation, using European Space Agency Climate Change Initiative (ESA CCI) land-cover-type data. We calculated the 100-year probability of a stand-clearing disturbance for all disturbances and for fire disturbances only (Acil et al., 2021) by scaling the average 2002–2014 annual value over 100 years, which did not account for climate-driven trends in disturbance impacts and is thus likely conservative (for detailed information on methods, data processing and caveats/limitations, see Acil et al., 2021; Anderegg et al., 2022; Pugh et al., 2019).

Using the latitude and longitude coordinates of each project, we then compared the project's risk rating to the value estimated by remote-sensing observations for those locations. We were only able to confidently get coordinates from 67 project documents for this analysis, and then only *match* coordinates from 57 projects to the remote-sensing data used by Acil et al. (2021). The variability in probability of stand-clearing disturbances across a geographical gradient is shown in Figure 5.4a, and for fires-only in Figure 5.4b, with the higher probabilities found around the edge of the Amazon forest and in Southeast Asia, where many REDD+ projects are located. We created a histogram to show the range of observed natural disturbance for each of the projects using the ESA CCI land-cover data (Figure 5.1e). We found that the mean 100-year risk of a stand-clearing disturbance (all natural risks combined) was 28% risk for the 57 projects analyzed. This percentage is more than 10 times the average natural risk used by the projects; however, it is still lower than it would be with climate change factored in. Moreover, it only considered stand-clearing disturbances and not partial natural disturbances, and thus is likely conservative.

Figure 5.4

Hundred-Year Chance of a Stand-Clearing Disturbance Estimated from Satellite Observations



Note. (a) stand-clearing disturbances from all natural causes including from fire; (b) stand-clearing disturbances from only fire. Circles indicate the locations of projects reported in project documentation.

External Risk

A striking finding is that a large majority of projects (72%) reported external risks to be zero (Figure 5.2b). These projects reported no risk at all from land tenure issues and resource access, poor community engagement, or political risk. The remainder of the projects reported very low external risk, with a mean rating of only a 2% risk, out of a 20% total threshold for project ineligibility (Figure 5.1b). The maximum external risk rating from a single project was 12%. We would expect to see high levels of risk for many if not most of the projects, due to both their country context and challenges with processes such as community engagement. Many of the projects were implemented in countries that were going through a post-conflict transitional period, had high levels of corruption or a weak institutional capacity, or had a history of political violence. In addition, the risk from low community engagement in the form of consultation with households reliant on the project was zero or negative in 94% of the projects (see Chapter 6: Safeguards), despite some using consultation approaches that would normally not be considered appropriate, such as sending an email in regions with low levels of literacy and electrification. (For additional detail on risks that should be considered related to land tenure, land grabbing, effective community engagement, and forest subsistence needs, see Chapter 6: Safeguards).

Internal Risk

We found that a third (33%) of projects reported internal risk to be at or below zero (i.e., no risk at all from project management, financial viability, opportunity costs, project longevity; Figure 5.2c). The remaining projects that reported some sort of internal risk had a mean risk rating of 9% (out of a 35% total threshold for project ineligibility; Figure 5.1c). The maximum internal risk rating from a single project was 32% (VCS 1133), out of 35% (see also Chapter 6: Safeguards).

We took a deeper look into the projects that reported mitigation activities, which have the potential to reduce risk. A mitigation activity will result in a negative rating for the risk subcategory. When summing across the four subcategories in the internal risk category, we found that 24% of projects had negative ratings (Figure 5.2c), meaning these projects claimed they could also mitigate against any potential internal risk.

Total Risk

A final conclusion is that the majority of projects (57%) had a total risk rating either at or below 10% (Figure 5.2d). The minimum allowable threshold and required rating must be 10 for total risk. When we evaluated individual project documents, we discovered that 44% of projects had a rating less than 10, and thus had to be increased to the minimum allowable threshold. The average total risk rating across all projects was 15% (i.e., a 15% chance of permanent reversal of credits over a 100-year period). A low durability risk rating contradicts the assertion that these projects also have a high chance of experiencing deforestation/degradation. In other words, if project documents claim little risk of reversal, suggesting a low risk of deforestation, the project is unlikely to provide additionality in limiting CO_2 emissions reductions. In the recently released Non-Permanence Risk Tool v4.1, Verra (2023a) completely removed negative scoring, which had the potential to be abused, and increased the minimum allowable total risk rating to 12%, a modest increase.

Case Studies

A few projects had a total rating of zero for all natural risks (i.e., fire, pests, extreme weather, geological risk, and other). However, in our observational analysis using remote-sensing data for 100-year stand-clearing disturbances (i.e., all natural disturbances, including fires), these same projects had a greater than 10% risk (the minimum threshold for all risk types).[16] Projects VCS 1094, VCS 1622, VCS 1503, VCS 844, and VCS 818 reported no natural risk but had stand-clearing probabilities of 11%, 37%, 11%, 23%, and 23%, respectively. Four of these projects are located in the Amazon, and one is in a Guatemalan coastal forest.

With regard to wildfire risk specifically, we found a notable example of misreporting of fire risk. In the VCS 1897 project, located in Tanzania, a corrective action request (CAR) was issued in the 2021 verification report about the fire natural-risk rating, because the audit team saw numerous fires throughout the project area during their site visit, but no village member responded. The auditors noted that the description for the use of mitigation credits for natural risk did not align with the active fires observed. The CAR was ultimately resolved without any change to the risk rating, and the wildfire risk rating was reported as N/A.

Scientific Literature of Natural Risk to Durability

The long-term storage of carbon in forests has many additional benefits, such as helping to maintain the ecosystem services that forests provide (e.g., regulating local and regional climate, protecting biodiversity, and supporting human livelihoods). Any set of processes that drives declines in forest carbon storage can be considered a risk to durability and has been studied in thorough detail by the ecological/biological community outside the carbon market arena (e.g., Allen et al., 2010; Anderegg et al., 2020; Cox et al., 2000; Franklin et al., 1987; Hurteau et al., 2009; Seidl et al., 2017). Slower ecological dynamics (e.g., declines in growth rates, gradual increases in mortality rates, community compositional changes, and invasive species) can be important and pervasive drivers of long-term carbon storage (Friend et al., 2014; van Mantgem et al., 2009). These slower dynamics are crucial for modeling and predicting carbon storage on timescales ranging from multiple decades to centuries.

The vast majority of the permanence-risk literature, however, focuses on rapid carbon loss driven by forest disturbances (Anderegg et al., 2020; Hurteau et al., 2009). Climate-driven increases in disturbances have been documented for wildfires, climate stress, droughts, biotic agents, and wind disturbances, although with important differences across ecosystems and regions. Increases in wildfire frequency and severity are a major concern, particularly in drier tropical forests (Brando et al., 2019). Droughts and climate stress broadly to forests have been a major concern for forest permanence, as droughts have been documented to have a major impact on Amazonian carbon uptake and storage in recent decades (Brienen et al., 2015; Gatti et al., 2021; Phillips et al., 2009), although African forests may be more resilient to droughts and direct climate stress (Lewis et al., 2009). Future projections of drought impact indicate severe risks in drier regions of tropical forest biomes (del Rosario Uribe et al., 2023; Duffy et al. 2019). In the Amazon, large wind events that result in uprooting trees and forest mortality are likely to increase with increasing storm frequency under global warming (Feng et al., 2023). This is important because forest mortality caused by storms is a major disturbance in the Amazon and an increasing driver of carbon loss. Feng et al. (2023) projected a 51 ± 20% increase in the area favorable to extreme storms, and a 43 ± 17% increase in windthrow density within the Amazon by the end of this century under the high-emission scenario (SSP 585).

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[16] We did not interview project developers about any reporting mistakes that might have occurred, which presents a potential limitation to this study.

Efforts have been made to improve statistical analyses of global fire data products to increase understanding of fire regimes and the complex links with wildfire emissions—all toward informing project assessments of environmental change and guiding future REDD+ fire-risk quantifications (Krawchuk & Moritz, 2014). The MODIS sensor on board NASA satellites provides data on active fires, based on thermal anomalies of fire hotspots as well as a burned-area dataset based on a hybrid analysis of the active 1-km fire data and a 500-m reflectance product. Additionally, the Global Fire Emissions Data (GFED, 2020) dataset provides the longest duration of global burned-area estimates (1996 to present) by integrating MODIS with other sensors (Giglio et al., 2013) and is routinely used by the scientific community to assess biomass burned area.

Several global analyses of climate risks to Earth's forests have been undertaken. Scholze et al. (2006) quantified the probability of forest loss in a single mechanistic vegetation model across a range of climate model outputs and found a high risk of forest loss in Eurasia, Canada, Central America, and the Amazon Basin. More recently, Anderegg et al. (2022) conducted a synthesis of three broad and widely used approaches to capturing forest risk (i.e., dynamic vegetation models, climate niche models, and satellite-based disturbance models) and compared patterns of risk across methods. The authors found that the different approaches showed little spatial agreement and that uncertainty was incredibly high in most regions, but a few regions did show consistent patterns of higher or lower risk. In particular, swaths of the southern and eastern Amazon and parts of Asian tropical forests were at consistently higher risk, while the northwestern Amazon and northern parts of African tropical forests were at consistently lower risk. Carbon dioxide fertilization is likely benefiting tropical forests now, but this stimulation of biomass increase appears to be reaching saturation in the Amazon and will eventually saturate all tropical forests (Brienen et al., 2015; Koch & Kaplan, 2022).

To achieve durability in REDD+ projects, it is necessary to develop effective monitoring systems and implement sustainable mitigation practices to meet anticipated risk. However, the complexity of forest ecosystems can make it hard to monitor losses in long-term carbon storage. Forests are dynamic systems, and accurately measuring carbon stocks and changes over time requires sophisticated techniques, technologies, and understanding of potential changes in future natural risk in a region. Risks such as droughts, wildfires, pests, and illegal logging can vary widely in different forest types and regions, making it difficult to develop standardized approaches to risk reporting. In addition, quantifying changes in forest carbon stocks over time requires long-term historical monitoring and documentation efforts, which can be challenging to sustain over extended periods (both from the past and into the future). Accurately measurement of forest carbon stocks on a large scale can be logistically complex and costly.

Finally, human disturbances and risks to permanence are often large and thus are beyond the scope of this analysis. We note, however, that interactions between the impact of human land use/management and the vulnerability of forests to natural disturbances are likely important. For example, forest edges often experience higher rates of tree mortality, invasive species, and wildfires, and thus any human impact that creates more forest edges (e.g., clearing, roads) is likely to decrease resilience and increase the risks of climate stress, wildfires, and biotic agents in the remaining forests.

Discussion and Recommendations

Almost all REDD+ projects report high durability, or a very low risk rating, especially regarding risks from natural disturbances (only 2%). In comparison with observational (remote-sensing) data from 2002–2014, we found that the mean 100-year risk of a stand-clearing disturbance (all natural risks combined) was 28%, or more than 10 times the average natural risk used by the projects. Actual risk of reversal is likely higher for two reasons: (a) our 28% risk estimate only included stand-clearing disturbances and ignored other forms of disturbance and (b) climate change is expected to increase disturbance risk over time. In addition, implementing effective adaptation measures in tropical forests that are already vulnerable to climate change has many challenges.

We also found serious contradictions between the low risk of reversal reported by projects and the high chance those projects would experience deforestation *unless* REDD+ project action occurred. In other words, if project documents accurately state that a project will be durable over time and has very little risk of reversal, there is arguably also very little risk of deforestation, and hence the credited emission reductions are unlikely to be additional (i.e., the risk of forest conversion was lower than claimed and credited by the project). It is unlikely that low risk of reversal and substantial deforestation in the baseline are both accurate, and project documentation should be improved to reflect higher risk to forest conversion and higher buffer pool, and/or more accurate baselines.

Another conclusion is that while carbon stored in forests has climate benefits—the longer the durability, the greater the climate benefits—carbon storage in nature is inherently short term, compared with the storage of fossil-based carbon, and is increasingly at risk with climate change. Therefore, avoiding forest deforestation or degradation is not equivalent to reducing fossil fuel CO_2 emissions and does not fully offset fossil fuel emissions. However, existing forest protection measures can be bolstered by a contributions model that helps companies, individuals, and others support climate mitigation through well-designed programs, rather than in exchange for offset credits that can be used to make a net emission claim. In the recently released Non-Permanence Risk Tool v4.1 Verra (2023a) increased the project longevity period from 30 to 40 years, which is a good step and helpful for longer durability, but we recommend that Verra extend the period further.

We offer the following recommendations for improved durability reporting:

- The minimum threshold for the total risk rating should be increased to greater than 12% to allow for more conservative estimates and to encourage project developers to use greater scrutiny when evaluating risk. More constraints, definitions, and resources should be given to project developers to aid in determining natural risk, so that when data are not available for a project area, the best conservative estimates of the likelihood and significance of risk/disturbance can be truly conservative and buffer against reversal.
- Past natural risks should be estimated using the latest remote-sensing datasets and published science, which should be standardized. One option is for projects to use freely available high-resolution satellite data that can provide more details about forest structure and forest change that have not been captured in the past. The high resolution of the open-source ESA World Cover land cover data (30 m) is very useful for REDD+ projects in determining durability and is accessible via Google Earth Engine. Lower-resolution data, such as that from Dynamic World v1 at 500 m, is still helpful. The approach we used in this report to generate the natural risk in Figure 5.1e (e.g., the project's latitude and longitude coordinates, with the stand-clearing disturbance remote-sensing product generated by Acil et al. [2021]) was useful to quantify the likelihood of natural risks at that location. This tool could be used by all developers.
- To predict changing risk into the future, state-of-the-art dynamic vegetation demographic models should be used to predict and simulate forest residence times, disturbance and forest competition, and survival or mortality. These demographic models should be coupled with climate change models to help us understand the impact of climatic stress on forest

processes. Current forest models that do not take into account changes in climate variables (e.g., temperature, precipitation, and humidity) will not be able to assign risk quantification to *future* growth, mortality, biomass, and the carbon storage permanence of forests.

- Social science databases, governmental reports, and other community-based surveys should be used to update external risk categories.
- Projects should not be allowed to claim both substantial deforestation in the baseline and low risk reversal, or it should only be allowed in unusual circumstances.
- The lifetime of carbon storage in forests is not equivalent to the lifetime of CO_2 emitted into the atmosphere; thus, it should not be used as an equivalent offset for fossil fuel emissions.

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Chapter 6: Safeguards

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Executive Summary

Reducing Emissions from Deforestation and Forest Degradation (REDD+) safeguard policies are a set of social and environmental standards meant to ensure that actions taken in projects do not cause harm to local and Indigenous communities or the local ecosystem. Safeguards have been a feature of project-based REDD+ in some form for more than a decade.

Research has shown that REDD+ projects globally, while seeking to improve the well-being of forest communities by providing new revenue streams and support for alternative sustainable livelihoods, also pose significant risks. REDD+ projects tend to focus on changing the behavior of smallholders because of the greater political and economic costs of trying to control the larger commercial drivers of deforestation. Many projects do this through restricting smallholders' use of forest resources, with impacts that often fall hardest on vulnerable and marginalized populations since they are often more reliant on the forest for their subsistence. In the worst cases, REDD+ has led to evictions from forests and human rights abuses. Moreover, in many tropical forest regions land tenure is contested and Indigenous customary land rights are not recognized or upheld. When REDD+ projects unfold in context of past displacement and land grabs, they can reinforce and perpetuate dispossession and inequity.

In this chapter, we explore how safeguards are defined under Verra's *Verified Carbon Standard* (VCS); how they are implemented by project developers; how they are audited by third-party auditors; and why they often fail to prevent, mitigate, and redress harm. We closely examine the VCS requirements, reviewing their evolution from the 2007 requirement for basic consultation through the expanded and more detailed safeguards required under VCS v4.3, the latest standard applied to the projects we evaluated.

Verra's safeguards policy includes substantive criteria that all projects must meet, such as avoiding harm to local communities and the natural environment and showing respect for local property rights. They also include procedural requirements that all project developers must perform, such as community consultation and the establishment of a grievance mechanism. These criteria expanded again with the adoption of VCS v.4.5, released in August 2023.

To evaluate how VCS's safeguard standards have been applied, we reviewed project descriptions, monitoring reports, validation and verification documents, journal articles, and news reports for a sample of 18 REDD+ offset projects around the world. These projects include the original 16 projects chosen for Chapter 4: Forest Carbon Accounting because of their data availability and diversity across region and methodology. We added two more projects with known safeguards issues so we could see how those issues were handled under the VCS system.

We found that VCS's safeguard policies are vague and lag behind international best practice. Our analysis of safeguard implementation suggests that developers frequently demonstrate both substantive and procedural nonconformance with safeguards. Project descriptions and monitoring reports included incomplete, outdated, or incorrect information. Developers treated requirements such as consultations as a check-box activity—in some cases, reflecting a profound lack of understanding about what a consultation process should entail.

The role of independent auditors is critical, as they are the main mechanism to ensure project developers follow safeguard policies and are accountable to their commitments. However, we found that auditors repeatedly failed to ensure developers clearly and accurately documented how they met basic safeguard requirements, failed to ensure developers meaningfully addressed procedural or substantive harms during the project's execution, and failed to withhold certification of projects with safeguard violations that remained unaddressed. Moreover, our review of verification reports over time found no evidence that auditors were holding developers to a higher standard with expanded safeguard policies. Therefore, while safeguard compliance is described as a requirement for project registration and issuance of carbon credits, this review found that auditors—as well as Verra—saw them as voluntary policies.

Here are only some examples of poor implementation and enforcement of safeguards in audited project documents from our sample projects:

- Actions, such as sending emails, were accepted as forms of consultation, even in projects spanning large geographical areas and in regions with low levels of literacy and household electrification. In one project in Zimbabwe, communities were "informed through a newsletter."
- Despite the projects reviewed covering large or remote areas, with affected communities reaching, in some cases, into the hundreds of thousands, 17 of 18 projects (94%) were verified as having zero community engagement risks.
- The developers of one project in Brazil claimed to have consulted 100% of communities in the project area, but the number of households changed from document to document: 35 communities, 35 households, no communities, 85 households; one verifier referred to "about 20 families."
- In another project in Brazil, a project was positively verified by Verra during a period when the developer was under active government investigation for illegal timber harvesting and community rights violations.
- In Guatemala, the violent eviction of a community from within the project area was never mentioned in project reports or audits.

The effectiveness of REDD+ safeguards should be measured by their ability to consistently protect the most vulnerable communities, and ideally to promote positive impacts. Current safeguards are failing to protect Indigenous peoples and local communities precisely in the contexts in which risks are greatest and external protections are most needed.

Verra's August 2023 update to its safeguards standards made some important substantive improvements, including more explicit recognition of customary land rights, a requirement for benefit sharing under certain conditions, and the adoption of more explicit human rights standards in line with international law.

Still, underlying patterns of poor safeguards implementation, which we documented with our 18 sample projects, will require more fundamental changes to the Verra program. The incentive structure of private carbon markets, and its "independent" third-party verification system, impedes effective implementation. Perversely, the incentives of independent auditors align not with the protection of communities but with external project developers and even the registry who financially benefit from more projects and credits. Since auditing companies are hired directly by the project developers and compete with one another, their incentive is to judge leniently to be hired again. We did find a few examples in which auditors demonstrated a concerted effort to do the time-consuming and extensive research on the ground that is needed to assess safeguard compliance, but this was the exception rather than the norm.

Finally, safeguards have no enforcement mechanism other than withholding validation or verification; once a project is running, even the most proactive validation bodies have limited ability to ensure compliance, and no power to sanction violators or ensure remedy for affected communities.

Ultimately, while safeguard policies are important for lowering the risk of harm, they cannot guarantee that harm will be avoided. There is no evidence to suggest that a corporate safeguards regime, with ingrained conflicts of interests and auditors with no authority to ensure substantive enforcement, can overcome or avoid the contextual challenges. Indeed, even safeguards that are considered current best practice, such as the International Finance Corporation (IFC) Performance Standards have struggled to avoid harm.

We conclude with recommendations for improving Verra's safeguard policies and guidance for auditors. While written standards are important, far more urgent are broader reforms to the current program structure. These reforms must place the respect for rights and the prevention of harms at the center of the policy. They must correct for the perverse incentives auditors have to judge in favor of the developer who hires them, rather than to protect forest communities. An independent accountability mechanism that is accessible, predictable, transparent, and compatible with rights should be available to affected communities. Importantly, any project affecting forest communities should be designed by those communities, or in partnership with them, respecting their right to self-determination and ensuring they have control over decision-making in projects affecting them.

Introduction

Social and environmental safeguard policies are viewed as assurance that actions taken by REDD+ projects do not cause harm to local and Indigenous communities or to local ecosystems. In this chapter, we closely examine VCS safeguards and other safeguard-relevant elements of the VCS policy, focusing on risk assessment, requirements for stakeholder consultation, respect for land tenure, and grievance mechanisms, to understand how VCS seeks to protect vulnerable communities, how the practices compare with best practice, and how those practices are implemented and audited in specific projects.

We start by explaining why REDD+ projects are high risk to people affected by them, and therefore why safeguards are so important, by synthesizing the case study literature on the outcomes of REDD+ interventions (grant-funded and VCS). We then describe the VCS safeguard policies. To better understand how these safeguards are working in practice, we evaluated 18 REDD+ offset projects around the world, including four from each of the protocols that have generated most REDD+ credits to date. Sixteen of the projects were the original projects chosen for Chapter 4: Forest Carbon Accounting because of data availability and diversity across regions and methodologies; we added two more projects with known safeguard issues (Jari/Pará [VCS 1811] and GuateCarbon [VCS 1384]) to understand how VCS addresses them. Focusing specifically on social protections, we assessed whether the safeguards, and the process of validating and verifying compliance with those safeguards, (a) identified or addressed key risks to communities before the project began, (b) identified safeguard violations as projects evolved, and (c) ensured conflicts or harms were resolved and grievances were redressed, or otherwise withheld validation or verification when a high risk of rights violations was linked to the project. We discuss the challenges of preventing harm through voluntary safeguard policies, and why systemic changes are needed. We conclude with several suggestions for fundamental changes that can make the *VCS Standard* more meaningful, including ways in which its implementation and oversight can be improved, but caution that corporate safeguards will never adequately protect against harm.

REDD+ Poses a High Risk to Vulnerable Populations

Safeguards are necessary for REDD+ projects because of the risks they pose to vulnerable communities. Well before REDD+, it was clear that programs that pay for avoided deforestation pose risks to forest people (Barnett, 1992; Fearnside, 1996). Even those intimately involved in those early projects voiced concerns about how they would affect vulnerable forest communities. For example, Mark Trexler (1991), the designer of the first forest carbon offset project, in 1989, in which US coal-based electricity supplier Applied Energy Services (AES) invested in reforestation in Guatemala, warned of risks of future forestry offsets:

> Projects could reduce the funding available for critically needed economic development. Projects could displace large numbers of people from their lands, and indeed buttress inequitable systems of land tenure. Projects could result in the loss of critically needed agricultural land. Projects could be constraining to the development opportunities of developing country populations.… These lands are rarely, if ever, abandoned regardless of the degree of degradation, and the people on them face far more important concerns than sacrificing their meager livelihoods to offset pollution emitted in developing countries. (p. 105)

The conflictual context surrounding the projects Trexler highlighted in 1990 still affects REDD+ projects and programs today (Alusiola et al., 2021). While forests and forest users around the world are very diverse, the dynamic forest landscapes in which REDD+ takes place also share commonalities. For example, land and resource tenure arrangements are still frequently overlapping or actively contested, with legal land and resource rights not matching the reality on the ground (Leach & Scoones, 2013; Sunderlin et al., 2009). Communities in these spaces have often experienced exclusion and marginalization historically, including at the hands of the state, development aid organizations, nongovernmental organizations (NGOs), and private economic actors (Larson & Ribot, 2007; Ribot & Larson, 2012; Sikor et al., 2010). Many people living in these communities subsist primarily on the natural resources around them, with few safety nets to catch them if they cannot make a livelihood from these resources (Angelsen et al., 2014). Forests are spaces in which those who have power are often not those who rely most heavily upon the forests to sustain themselves, and where elites are able to capture greater benefits from forest resources, as well as from development and conservation projects (Howson, 2017; Iversen et al., 2006; Jumbe & Angelsen, 2006; Larson, 2011; Poudyal et al., 2016).

REDD+ also takes place amidst complex and often competing governance and institutional contexts. Indigenous, common property resource, and traditional forms of governance often exist in these forests. As these institutions are frequently unrecognized under the law or by outside actors, they may be ignored, replaced, or threatened by top-down management, immigration and emigration, and new pressures on resources (Katz, 2000; Ostrom, 1994a, 1994b; Robson & Klooster, 2018). State rule of law is often weak or unequal, with few enforcement resources and elite capture. National or provincial laws may restrict large-scale deforestation on the books but are typically poorly enforced (Burgess et al., 2012). Local politicians may benefit personally from allowing deforestation, including through support for their campaigns (Burgess et al., 2012; Morpurgo et al., 2023; Ruggiero et al., 2021).

Violence against forest defenders frequently goes unpunished (United Nations Environment Programme, 2019). Conflicts in these spaces have multiplied under growing competition for these lands and resources (Searchinger et al., 2023). Many REDD+ projects have been placed along the world's commodity frontiers, where agricultural and mineral extraction has intensified as a result of economic growth and globalization; some have been portrayed as helping to compensate for the damage caused by these forest-destroying industries (Bruno, 2022; Werner, 2022). REDD+ therefore takes place on a highly "uneven playing field" (Ribot & Larson, 2012), often within violent contexts (Grant & Le Billon, 2019; Hines, 2022), where inequality, historical marginalization, and justifiable distrust of forest conservation interventions must be actively countered.

Over the past 20 years, geographers, sociologists, anthropologists, political ecologists, and other social scientists have spent months or years as field researchers living in and around the communities participating in REDD+ projects and readiness efforts and their predecessors. These researchers have sought to understand what REDD+ has meant on the ground for forests and people within these environments of high levels of vulnerability and inequality, and often violence. This body of literature and the findings in this chapter reinforce that safeguards are necessary but hard to enforce and often insufficient to avoid harm in the challenging contexts of REDD+ projects (Lofts et al., 2021).

Among the conclusions of this body of research is that REDD+ projects and programs have focused primarily on changing the behavior of smallholder farmers, Indigenous peoples, rural forest dwellers, migrants, and other lower-income forest users (Skutsch & Turnhout, 2020). Our review of the 75 REDD+ projects that had generated carbon credits for the voluntary carbon market as of March 2022 found that they, too, largely focus on smallholders. REDD+ projects and programs do this instead of focusing on the largest drivers of deforestation globally: commercial agriculture, cattle ranching, logging, and mining (de Sy et al., 2018).

This mismatch between deforestation drivers and target activities is unsurprising. The primary economic motivation for REDD+ is the promise that it can mitigate climate change cheaply because of the low opportunity cost of paying poor people to change their behavior. Replacing profits from the primary drivers of deforestation globally is much more expensive. It can also be politically costly. Many local and national elites benefit from land speculation, export-crop markets, logging, and mines, and influence regional and national politics to keep these benefits flowing. These industries are also important sources of revenue for governments, including as a key source of foreign currency needed to pay the external debts that burden many formerly colonized countries (Culas, 2006; Shandra et al., 2008). Deforestation-driving industries are often subsidized by national policies and by bilateral and multilateral banks (Ding et al., 2021).

The impacts of REDD+ on those affected by projects have been variable, context dependent, and at times unequal (Parrotta et al., 2021). In the worst cases, REDD+ has resulted in evictions or displacement of forest dwellers from land for forest conservation, including as part of REDD+ readiness programs and projects (Beymer-Farris & Bassett, 2012; Chomba et al., 2016; Griffiths, 2008; Howson, 2017; Sarmiento Barletti & Larson, 2017).

REDD+ project restrictions on use of community land or forest resources by smallholders commonly fall hardest on the most vulnerable within these communities, including the poor, landless, and women (Duker et al., 2019; Griffiths, 2008; Kansanga & Luginaah, 2019; Mutabazi et al., 2014; Poudel et al., 2015; Ratsimbazafy et al., 2011; Satyal et al., 2020; To et al., 2017). This is a recurring result because the poorest and most vulnerable members of a community often rely on common pool resources, including forests, for a greater percentage of their basic needs and livelihoods (Angelsen et al., 2014). When REDD+ comes in, often with the approval of those who are less directly dependent on the forest for their livelihoods, these vulnerable individuals may be told they are no longer permitted to access forest resources (Kansanga & Luginaah, 2019).

Those most affected by REDD+ projects frequently have not received adequate compensation from REDD+, while community elites are often better positioned to capture the benefits from these projects (Andersson et al., 2018; Chomba et al., 2016; Parrotta et al., 2022; Poudel et al. 2015; Poudyal et al., 2016). Even where communities may plan to use carbon credit sales from REDD+ primarily to pay back those who have had to give up or change their livelihood strategies, the funding generated by REDD+ that participant communities receive has been less than promised, and insufficient or too delayed in some cases to incentivize conservation (Duker et al., 2019; Milne et al., 2019; Nathan & Pasgaard, 2017).

The mismatch between who benefits and who is harmed in REDD+ projects is among the factors shown to generate conflicts that often result within and between communities from these projects (Alusiola et al., 2021; Griffiths, 2008; Schmid, 2022). The weakening of community governance resulting from this conflict may also be exacerbated when projects impose new governance institutions within these communities (Ece et al., 2017; Kemerink-Seyoum, 2018). When REDD+, with its significant technical demands, dominates existing community institutions, this can backfire by turning these institutions into agents primarily for foreign conservation goals, generating local distrust in the very governance bodies best suited to sustainably manage common pool forest resources (Withey, 2021). Long-term increases in deforestation can also result from the "crowding out" (Neuteleers & Engelen, 2015; Rode et al., 2015) of motivations and institutions for sustainable resource management by the financial motivations of REDD+. People come to expect payments for conservation, and thus allow other community institutions to atrophy and are more inclined to deforest when these payments fail to materialize or stop coming (Ezzine-de-Blas et al., 2019; McAfee, 2016).

REDD+ has shown mixed results in solidifying the customary or contested tenure regimes that define many forests around the world (Larson et al., 2013). One study of various projects showed that some REDD+ participants perceived their tenure security had increased, while others felt it has declined, though concluded that REDD+ has thus far had little transformative impact in securing legal recognition of customary tenure (Sunderlin et al., 2018). However, in some reported instances, tenure reforms associated with REDD+ projects and national readiness programs have weakened local resource rights and the customary tenure of some forest users (Leach & Scoones, 2013; Milne et al. 2019; Scheba, 2015) and increased conflict over land (Alusiola et al., 2021). Even collective titling that supports the recognition of customary rights has been found to be ineffective without state help to defend these rights (Larson et al., 2019).

The conclusions from published research that outcomes for communities are mixed at best, with the most vulnerable members of communities losing out more often, have been unsurprising, given the risky context in which these projects occur. This body of research shows how projects can do serious harm to some or all members of forest communities, and this may become more common when project developers are driven by the profit motives of the voluntary carbon market. Safeguards and due diligence by credit buyers that go beyond trust in the verification process are the minimum needed to try to prevent harm and provide widespread benefits to forest communities. Given the complexity of these forest contexts, however, even these efforts may be insufficient for ensuring that REDD+ projects offer meaningful and lasting benefits for all members of forest communities.

REDD+ Safeguards

Social and environmental safeguards aim to identify, prevent, and address possible harm to stakeholders and other affected communities. Safeguards arose in the context of international development projects, such as large hydropower dams (Bugalski, 2016; Fox, 1998; Rich, 1994) and conservation programs (Arhin, 2014), as a response to widespread documented harms to Indigenous communities and other vulnerable groups that occurred as a result of many of these initiatives (Arhin, 2014). Safeguards are meant to hold all developers—whether public institutions or private businesses—accountable to a set of social and environmental standards, independently of where they operate. The World Bank was the first institution to develop a set of social safeguard policies in the 1980s. Since then, safeguards have been used by development finance institutions (DFIs), with different standards evolving at the World Bank, regional development banks, bilateral aid agencies, and the Green Climate Fund.

REDD+ safeguards were first introduced in 2010 at the 16th Conference of the Parties to the UN Framework Convention on Climate Change (COP 16) in Cancun, Mexico, as a set of principles to guide jurisdictional (government-run) REDD+ programs. The Cancun safeguards provide an overarching framework of social and environmental standards for countries seeking results-based payments. Private carbon credit registries, such as Verra, developed their own safeguard policies for project-based REDD+, informed in part by international expectations about safeguard standards from Cancun and other processes. Developers of projects in private carbon markets hire auditors to verify results.

As a multitude of public and private entities have developed their own standards, referred to broadly as "REDD+ safeguards," have come to include a diverse set of flexible, sometimes overlapping, and often nebulous requirements across dozens of standards.[17] The potential for harmonization across standards, as well as coordination across national and subnational jurisdictions and across public and private spheres, are key challenges highlighted in the academic literature (Jagger et al., 2014; Parrotta et al., 2022; Roe et al., 2013; Sarmiento Barletti et al., 2021; Zelli et al., 2014).

Generally speaking, however, REDD+ social safeguards typically include *substantive* standards that projects must meet, such as avoiding or mitigating negative impacts and respecting land tenure rights, and *procedural* requirements to be carried out by developers, such as stakeholder consultations and engaging with affected communities over the course of a project's implementation. Some standards also include explicit policies about respecting Indigenous rights under international law, including free prior and informed consent (FPIC),[18] establishment of a grievance mechanism, and development of a benefit-sharing policy. The distinction between

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[17] A number of academic papers provide comparative analyses of these systems, including helpful tables to assess specific themes or requirements across systems. For example, Roe et al. (2013) reviewed more than 30 standards from multilateral, bilateral, and private entities; Sarmiento Barletti et al. (2021) compared 11 standards from multilateral lending institutions and independent, voluntary initiatives; Arhin (2014) assessed eight jurisdictional and project-based safeguard systems; and McDermott et al. (2012) compared five standards across multilateral, project-level, and public-private initiatives.

[18] FPIC is a basic tenet of the UN's Declaration on the Rights of Indigenous Peoples and the International Labour Organization Convention 169. FPIC has been incorporated into the legal framework of many countries; some regions also have specific legal jurisprudence for FPIC requirements, such as from the Inter-American Court of Human Rights in Latin America and the African Court on Human and Peoples' Rights.

substantive criteria and procedural requirements is blurry because, in many cases, the failure to follow procedural safeguard requirements (e.g., not consulting people about projects that affect their lives or not allowing recourse when harm occurs, independent of actual project outcomes) is itself a rights violation.

Most policies, including Verra's, focus on carbon values and the use of social safeguards to avoid net harm; others, such as the Climate, Community, and Biodiversity Standard (CCBS), prioritize non-carbon values and emphasize generating positive co-benefits, such as poverty reduction and promotion of improved tenure rights (McDermott et al., 2012; Roe et al., 2013).

The ever-growing body of research documenting the harms occurring in REDD+ projects suggests that safeguards have not been sufficient protection for vulnerable communities. Decades of similar safeguard failures in DFI-funded projects have given rise to many lessons learned. Advocates have argued that these frameworks can become more effective if, among other attributes, they reflect international human rights standards; are specific and communicated effectively to affected communities; and are binding requirements, with sanctions for noncompliance. Moreover, experiences with safeguard failures have shown the importance of an independent accountability mechanism that can receive complaints, conduct project audits, and ideally have the power to provide redress for harms (Bugalski, 2016; Fox, 2000; Ribot & Larson, 2012).

Rather than building on these lessons learned, however, REDD+ safeguard policies, including those from both Cancun and VCS, replicate or even amplify many of the weaknesses of their DFI counterparts: their written standards tend to be more vague and flexible; their enforcement often depends on auditors, who have clear incentives to approve projects; and they fail to provide affected communities with a clear, transparent avenue for accountability and remedy. The fragmented nature of REDD+ frameworks means that community complaints and grievances are not compiled in a transparent and standardized manner. It is often unclear whether the standard setters themselves have data on safeguard compliance from which to defend their success.

VCS Safeguards

Verra requires project developers (called *project proponents,* or *PPs,* in VCS documents) to identify and take steps to address social risks and report on their compliance. Compliance with safeguard requirements is audited by independent validators and verifiers to determine initial project eligibility and ongoing compliance with program requirements. Verra's most specific language regarding consultation and land tenure is found in its Non-Permanence Risk Tool, wherein lack of community engagement and land conflicts are framed as risks to the success of the project instead of to forest communities.

Safeguards in the VCS Standard

Safeguards are outlined in the *VCS Standard*, which provides the requirements for developing projects and programs under any VCS methodology. The policies have evolved over time, starting as brief and general social criteria and expanding to include a more detailed set of explicit safeguard policies. In 2007, the first *VCS Standard* (version [v] 2007; Voluntary Carbon Standard, 2007) required only that the project documents include "relevant outcomes from stakeholder consultations and mechanisms for ongoing communication" (p. 14)—a requirement carried over from the International Organization for Standardization's (ISO) standards for monitoring and reporting on greenhouse gas (GHG) emission reductions. In 2008, additional requirements were added for agriculture, forestry, and other land use (AFOLU) projects, including that projects "shall identify potential negative environmental and socio-economic impacts and shall take steps to mitigate them prior to generating verified carbon units" (VCUs; v2007.1; Voluntary Carbon Standard, 2008b, p. 9).

In 2017, VCS v3.7 included the term *safeguards* for the first time, framing the requirements as a way to ensure no net harm, adding a public comment period, and expanding language around stakeholder consultation (Verra, 2017b). In 2019, VCS v4.0 further expanded the requirements for AFOLU projects (Verra, 2019c); by January 2022 (v4.2; Verra, 2022d), this included more explicit criteria regarding stakeholder identification, tenure/access rights, identifying risks to stakeholders, the presence of a project manager with experience in community engagement, respect for stakeholder resources (helping secure rights, reducing damage to ecosystems), communication and consultation with stakeholders, and a grievance procedure. The latest version (v4.3) used in the projects reviewed here is almost identical to both v4.2 and v4.4 (see Box 6.1). Finally, Verra itself has a complaint and appeals policy that is available to the public (Verra, 2022i).

In August 2023, Verra updated its safeguards with expanded requirements. For example, it explicitly required that project implementation respect human rights and Indigenous peoples' rights, added more detailed language on what constitutes adequate stakeholder consultation (i.e., that it be "inclusive, culturally appropriate, and respectable [sic] of local knowledge" [p. 42]), and added a requirement for benefit sharing when a project affects property rights or use.

Safeguards in the AFOLU Non-Permanence Risk Report

Until 2019 and the release of VCS v4.0, Verra had no explicit safeguard policies for AFOLU projects in the *VCS Standard*. Nevertheless, from 2008 onward, issues that comprise the key pillars of current social safeguards have also been reflected in the AFOLU Non-Permanence Risk Report (Verra, 2019a; Voluntary Carbon Standard, 2008a). Verra labels land tenure conflicts and community engagement practices as "external risks." The Non-Permanence Risk Tool contains specific criteria on which to assess risks to the project that are related to these social issues and assigns specific point values to each risk (or negative values for actions that mitigate risk). If risk scores sum to greater than the risk threshold, the project is not able to register or generate carbon credits. A higher risk score means that a higher proportion of the verified emissions reductions achieved by the project will be set aside in the buffer insurance pool to cover the higher risk of reversal.

To quantify external risk related to land tenure and resource access/impacts, developers assess seven subcategories, including the existence of disputes over land tenure on more than 5% of the project area and disputes over access/use rights. To quantify risk related to community engagement, developers report whether 50% of households in the project area and 20% of households within 20 km of the project boundary that are reliant on the project area have been consulted. Percentages lower than these consultation levels are considered a risk to the project and result in a higher risk score and increased contribution into the buffer pool. External risk also includes a third category, political risk, measured by the country's governance score according to World Bank indicators.

Box 6.1

Safeguards in the VCS Standard v4.3 (Verra, 2022e)

Verra's intentions for social safeguards are clear: Project activities shall not negatively impact the natural environment or local communities. Project proponents shall identify and address any negative environmental and socioeconomic impacts of project activities, and shall engage with local stakeholders during the project development and implementation processes (Verra, 2022e, p. 39).

In developing and implementing any project under the VCS standard, developers must (Verra, 2022e, pp. 40–41):

- identify and take steps to mitigate potential negative impacts (3.17.2);
- conduct stakeholder consultation prior to validation and establish mechanisms for ongoing communication and incorporate feedback into project design (3.17.3–.5); and
- submit projects to a 30-day public comment period (3.17.7–.9).

For AFOLU projects specifically including VM0006, VM0007, VM0009, and VM0015, Verra requires project proponents to:

- identify and assess the situation of local stakeholders who will be impacted by the project, including their location, land tenure status, cultural diversity, and expected changes in well-being (3.17.11);
- assess possible risks from natural processes such as fire and extreme weather, human-induced activity, or participation in the project;
- design and implement the project to avoid trade-offs, such as with food security, land loss and loss of yields (3.17.12–13);
- respect local property rights (help secure property rights when feasible); and
- not exacerbate any existing land or resource conflicts; however, the "project may affect property rights if free, prior and informed consent is obtained from those concerned and a transparent agreement is reached that includes provisions for just and fair compensation" (3.17.16).

Moreover, project developers "shall take all appropriate measures" to consult with stakeholders over the life of the project related to risks, costs and benefits, labor laws, and VCS validation and verification processes (3.17.17). They shall develop a grievance redress procedure to address any disputes, and documentation of disputes resolved through the procedure should be available to the public (3.17.18).

Developers are expected to have personnel with experience in community engagement as part of management teams involved in project implementation (3.17.15) and to report on the process used to conduct their stakeholder analysis and engagement process (3.17.11). Moreover, they must justify to Verra either how project designs take into account concerns from stakeholders and public comments or why updates were not appropriate or relevant (3.17.5, 3.17.9).

For many projects, including those initiated after the addition of AFOLU-specific safeguards, these risk reports provide important insights into how developers engage with safeguard-relevant issues, such as how they understand the risk of community harm, the actions they have taken to conduct consultation, and how they plan to address potential land conflicts. While they often provide evidence to show VCS standards have not been met, they are not incorporated into analyses of safeguard compliance.

VCS Guidance on Safeguard Implementation and the Role of Validation / Verification Bodies

Verra provided little detail on how developers are expected to implement these policies and how validation/verification bodies (VVBs) should audit safeguard compliance. Version 4.1 of the templates for the program description and monitoring reports have a safeguards section with basic prompts and examples for developers (e.g., "Describe…the procedures or methods used for engaging local stakeholders…[and] the mechanism for on-going communication with local stakeholders" [Verra, 2022a, p. 10]). Notably, however, other important guidance documents reviewed in 2022 omitted mention of safeguards entirely, including the VCS Program Guide (which explains the overall requirements governing the VCS Program), the AFOLU Risk-Assessment Tool, and the VCS definitions document. In fact, Verified Carbon Standard Program Definitions (v4.3; Verra, 2022b) did not include *any* of the key terms or concepts used in the safeguard section, including *safeguard*; *stakeholder*; *tenure* or [*non-intellectual*] *property rights; community engagement*; *participation*; *grievance mechanism; free, prior, and informed consent* (FPIC).

Despite enhancements over time, Verra's safeguard policies provide significant flexibility for developers. Verra requires developers to conduct consultation and encourages stakeholders' participation, yet only *VCS Standard* v.4.5, released in August 2023 provides, guidance on who should be included as a stakeholder or what is expected with respect to the process used to identify or consult with local stakeholders. Similarly, although the policy mentions FPIC—a process defined under international law and having specific procedural requirements in many jurisdictions—the lack of specific guidance has left the door open for developers and VVBs to reinvent this process according to their convenience.

Given the *VCS Standard*'s vague policy language, with undefined terms and flexible criteria for developers, the role of independent auditors becomes critical, as they have a mandate to determine whether developers have fulfilled their safeguard obligations. VVBs review written records, conduct interviews with project personnel and stakeholders, and conduct a short site visit.

VVBs have a collection of tools they can use in their official communication with developers to document and address safeguard issues. Specifically, they can use clarification requests (CLs) to gather further information from developers; corrective action requests (CARs) to ask developers to take further action before validation or verification; and if a certain aspect of a project is not in line with safeguards, nonconformance requests (NCR), which require developers to provide further justification or take corrective action before the project can be verified. If the auditor decides sufficient information has been provided by the developer, the issue is considered resolved. If the auditor believes the issue should be reviewed in a future audit, the issue can be moved to a future action request (FAR).

Although VVBs play a pivotal role for a functioning safeguards regime, Verra's guidance document for VVBs does not mention safeguards or provide any specific criteria with which to assess compliance (Verra, 2016). VCS v4.1 templates for validation and verification reports include prompts such as "discuss whether reasonable steps have been taken to mitigate [negative socio-economic] impacts"; "summarize any stakeholder input received during the local stakeholder consultation"; and "for AFOLU projects, identify, discuss and justify a conclusion regarding whether the project communicated information about the project design and implementation, risks, costs and benefits" (Verra, 2022h, p. 7). Verra does consider safeguard violations to constitute a material nonconformance and grounds to reject a project (A. Mortimer, personal communication, February 22, 2023).[19] However, the lack of clarity in the requirements needed to comply with safeguards suggests that VVBs have significant flexibility in deciding what constitutes safeguards compliance. As we discuss in our project review, VVBs have certified projects with significantly divergent, and sometimes shockingly weak, practices, indicating that safeguards requirements may be close to meaningless.

VCS and Co-Benefits

Verra is explicit in its promotional material that VCS and AFOLU projects are focused on emissions reductions and not on providing other co-benefits. The new VCS v.4.5 only requires benefit sharing under certain conditions and does not explicitly seek to improve local livelihoods. Earlier versions of the Standard had no benefit-sharing requirement. Verra projects can, however, be linked to co-benefit programs, such as the CCBS (Verra, 2022j). In fact, when Verra took over management of CCBS in 2014, 70% of its forest carbon offset projects were already seeking certification under CCBS (Goldstein, 2014). Now, project documents, including monitoring and verification reports, are often completed simultaneously for VCS and CCBS and submitted as a single report. Therefore, although this analysis does not specifically review CCBS policies, our findings may extend to CCBS as well.

Project Review: How Safeguards Are Implemented in Practice

We reviewed 18 projects in Brazil (4), Cambodia (1), Colombia (4), Democratic Republic of Congo (2), Guatemala (2), Kenya (1), Peru (2), Zambia (1), and Zimbabwe (1). The projects were validated in different years under different standards, with the earliest in 2011 and the latest in 2019 (Table 6.1). For each project, we reviewed the project description, monitoring reports, AFOLU non-permanence risk reports, and validation and verification documents. Although Verra did produce project review reports to address gaps in the verification reports for some projects, we did not review these for this report. The projects were also evaluated in relation to the broader context in which they take place, through a review of external sources, including academic research, NGO reports, and the media.

[19] The formal guidance on materiality refers only to "the aggregate of errors, omissions and misrepresentations *relative to the total reported GHG emission reductions and/or removals*" (*VCS Standard* v4.3, p. 53, emphasis added; Verra, 2022e).

Table 6.1
VCS Projects Reviewed

Project ID	Project name (in brief)	Country	Metho-dology	Additional certifications*	Valida-tion year	Standard used for valida-tion	Number of VCS verifica-tions	Standard (year) of last published verification reviewed**
VCS612	Kasigau	Kenya	VM0009	CCBS Verified	2011	2007.1	8	3.7 (2018)
VCS934	Mai Ndombe	DRC	VM0009	CCBS Verified	2012	3.2	3	4.2 (2022)
VCS944	Alto Mayo	Peru	VM0015	CCBS Verified	2012	3.2	5	4.0 (2020)
VCS1094	Ecomapuá	Brazil	VM0015	SocialCarbon	2013	3.3	2	4.0 (2020)
VCS985	Cordillera Azul	Peru	VM0007	CCBS Verified	2013	3.3	6	3.7 (2018)
VCS902	Kariba	Zimbabwe	VM0009	CCBS Verified	2013	3.3	5	4.2 (2022)
VCS1113	Valparaiso	Brazil	VM0007	CCBS Verified	2014	3.4	3	3.7 (2019)
VCS1112	Russas	Brazil	VM0007	CCBS Verified	2014	3.4	3	3.7 (2019)
VCS1650	Keo Seima	Cambodia	VM0015	CCBS Verified	2014	3	4	3.7 (2018)*
VCS1392	Cajambre	Colombia	VM0006	CCBS Verified	2014	3.4	1	3.7 (2019)
VCS1359	Isangi	DRC	VM0006	Seeking CCBS	2014	3.4	1	3.4 (2014)
VCS1396	Rio Pepe/Acaba	Colombia	VM0006	Seeking CCBS	2015	3.4	1	3.7 (2019)
VCS1384	GuateCarbon	Guatemala	VM0015	CCBS Verified	2015	3.5	1	**3.6** (2017)
VCS1541	Lacandon	Guatemala	VM0015	CCBS Verified	2016	3.5	2	4.0 (2021)
VCS1566	RIU SM	Colombia	VM0007	CCBS Verified	2017	3.4	3	4.0 (2020)
VCS1399	Mutatá	Colombia	VM0006	Seeking CCBS	2017	3.4	1	3.7 (2019)
VCS1811	Jari/Pará	Brazil	VM0015	Seeking CCBS	2019	3.7	1	3.7 (2019)
VCS1775	Luangwa	Zambia	VM0009	Seeking CCBS	2019	3.7	4	4.3 (2022)

Key:

- Consultation; mitigate negative effects prior to generating carbon credits
- No net harm; conduct consultation prior to validation…mechanism for ongoing communication to allow stakeholders to raise concerns
- Expanded AFOLU requirements, including for consultation, participation, tenure rights

* From Verra website, status as of November 30, 2022
** In some cases, the project was approved under the *VCS Standard* noted here, but all the reporting was done on the CCBS template.

In a system based on flexible standards and conducted by actors with inherent incentives to move the project forward, analysis of safeguard effectiveness requires understanding how actors interpret requirements and how risks, complaints, grievances, and possible safeguard violations are addressed and resolved. Our assessment focused on procedural elements of the safeguard process traced through project reports. We sought to understand (a) how developers identify and address social risks before projects start, (b) if and how developers or VVBs identify and address safeguard violations that arise after a project begins, and (c) whether high-risk projects where safeguards have not been met are denied verification. We focused on consultation and community engagement, land tenure assessments, and grievance processes—three elements of VCS safeguards that have been shown to be essential to REDD+ (Larson, et al., 2013; Roe et al., 2013). In addition, this review starts with a close look at the non-permanence risk assessment process. Our detailed review of 18 projects highlights issues that occurred repeatedly in our sample.

Non-Permanence Risk Assessments

While the Non-Permanence Risk Assessment is meant to identify risk of reversal and is not an official part of VCS safeguards policies, we found that in many cases, risk reports provided as much or more safeguard-relevant information than the safeguards section of monitoring or verification reports. Risk assessment plays an important role in any risk-management-based safeguards regime. In the context of Verra's changing safeguard requirements, the Non-Permanence Risk Tool also provides a consistent metric to assess key social issues.

Nevertheless, high risk ratings do not appear to trigger greater VVB scrutiny over the course of a project, and the information provided in the risk assessments does not appear to be considered in VVBs' determinations of conformance with safeguards. Here, we analyze risk assessments to better understand how developers and VVBs approach key safeguards issues, such as community engagement.

We expected to see high assessments of risk in many if not most of the projects reviewed. Some of the projects are in countries with poorly maintained land registries, histories of land grabbing and forced displacement, or ongoing disputes related to customary or ancestral land rights. Most if not all countries have struggled to implement effective community consultation practices. Finally, some projects are implemented in regions with high levels of violence or repression that limit communities' ability to freely express concerns. For REDD+ projects, these contextual risks are exacerbated when a large number of households are affected, often across remote or inaccessible terrain and linguistic variation.

The risk reports varied dramatically in terms of the level of detail and justification provided by the developers. Perhaps the most striking finding is the overall low level of external risk claimed by the developers, as well as the corresponding acceptance of these ratings by auditors (Figure 6.1). Our review found that 13 of 18 projects (72%) claimed zero land tenure/access risks in their first monitoring period or first available AFOLU report.[20] We also found that 17 of 18 projects (94%)

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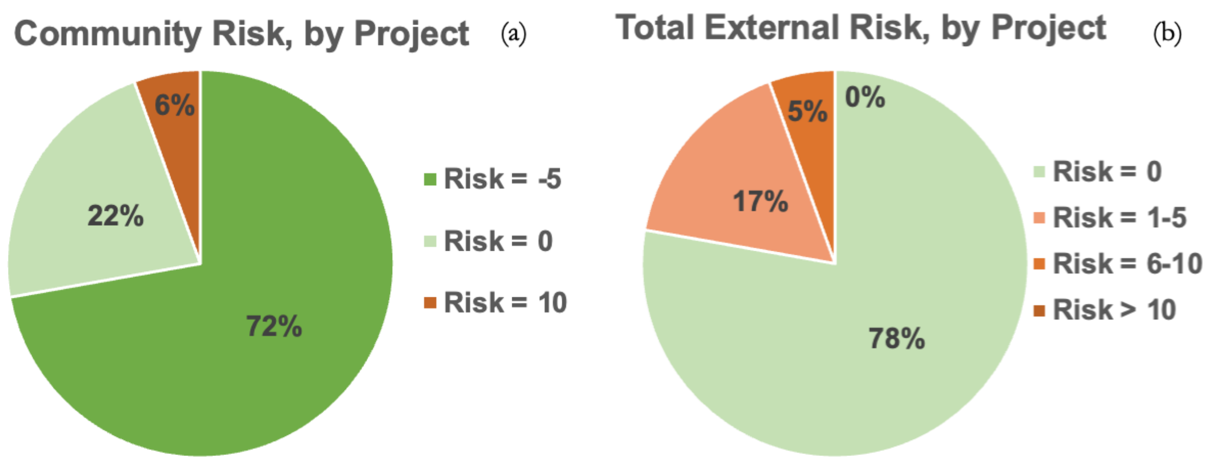
[20] For two projects, the AFOLU risk rating at first monitoring/verification was not available, so the second monitoring report was used.

rated community engagement risk as zero in their first monitoring period or first available AFOLU report. Zero risk is given when (a) more than 50% of households living within the project area, who are reliant on the project area, were consulted and (b) more than 20% of households living within 20 km of the project boundary outside the project area, and who are reliant on the project area, were consulted.

Figure 6.1

Risk Ratings for 18 Projects at First Verification



Note. When data were not available at first verification, we used the first publicly available AFOLU report.

The confusing logic of developers' risk determinations is exacerbated by the fact that a risk related to community engagement can be offset by a positive indicator, such as the fact that the project is seeking validation from CCBS or SocialCarbon, or vague claims by the developer that the project provides "net positive" benefits. This is done without the developer justifying the specific linkage between the risk factor and the mitigating action (i.e., they need not show that they met CCBS requirements—generally, or specifically on consultation) or that the proposed net benefits would address potential community concerns arising during consultation. Of the 18 projects reviewed, 14 reduced the level of risk by 5 points due to these vague mitigation measures. Because of this, 72% of projects claimed a *negative risk* for community engagement (Figure 6.1).

Risk ratings were accepted at first verification in all 18 projects, with rare requests for clarification (Table 6.A1 provides further detail on risk ratings for community engagement). However, our review of project documents shows that claims about consultation were frequently made by developers, without specific evidence that the 50%/20% benchmark had been met, and in some cases, reflect a profound lack of understanding about the process of community consultation. Three projects illustrate the trends we observed.

Kariba, Zimbabwe (VCS 902). The Kariba Project is an example of community consultation being justified through pure conjecture. The Kariba Project includes communities in four districts across different provinces in rural Northwestern Zimbabwe, an area home to more than 330,000 people (VCS 902, 2013, *Project Description,* p. 94). The developer, Carbon Green Investments (CGI), located in the United Kingdom, alleged zero engagement risk, claiming that "locals have been informed about project details through the newsletter published by CGI. Therefore *it can be assumed* that more than 50% of households living within the project area who are reliant on the project area have been consulted" (VCS 902, 2014, *AFOLU Non-Permanence Risk Assessment*, p. 9, emphasis added). Project documents prepared by Switzerland-based South Pole Carbon provided no evidence to demonstrate households had received the newsletter, that people could read and understand information about the project, or that the newsletter provided any avenue for concerns to be voiced. The verifier raised two nonconformance requests, but ultimately accepted this approach to consultation, along with the developer's assumptions (VCS 902, 2012, *Validation Report*, p. 138).

Valparaiso, Brazil (VCS 1113). The Valparaiso Project provides a clear example of poorly justified risk assessments that are inconsistent across reports, and of VVBs failing to follow up on risks identified in prior verifications (Table 6.2). The developer's risk report claimed that "100% of local communities have been consulted" and the auditor agreed (VCS 1113, 2014, *Verification Report*, p. 28). The project description document identified *35 communities* (in later documents referred to as "households") living on the project property but provided little information about how or when consultation was carried out (VCS 1113, 2014, *Project Description*, p. 4). The developer later clarified and the auditor positively validated that "no communities live within the project area, rather they live within the boundaries of the land ownership" (VCS 1113, 2014, *Validation Report*, pp. 82–83).

At the second verification, Rainforest Alliance found evidence of *85 households* in the project area (and 35 more in the leakage belt), far more than the developer had listed. This increased the community engagement risk to 10, which was offset by 5 points due to the fact that the project had been previously validated and verified under CCBS (VCS 1113, 2017, *Verification Report*, p. 63). That CCBS was used to offset risk is questionable because, for the monitoring period in question, VCS and CCB verifications were conducted simultaneously, using the same data, and were reported together on the CCB template. In other words, the vague and contradictory information about the number of affected households and consultations was the same information submitted for review under CCBS. Instead of the additional certification raising standards (and theoretically offsetting risk), it simply accepted the same low standard. Had this "risk offsetting" not occurred, the combined risk would have exceeded the accepted threshold for external risk (20%), and the project would not have been eligible for verification.

We would expect that, by the third verification, the higher community engagement risk in the 2017 verification, the extensive issues raised in FARs, and the sloppy or misleading information provided by the developer would provoke a close assessment by the next auditor. However, the 2019 verification, conducted again by EnviroServices, Inc., seemed to ignore new evidence of a larger number of affected families. The auditor accepted the developer's claim (repeated from the first monitoring period) that "100% of the local communities have been consulted," (VCS 1113, 2019, *Verification Report*, p. 36). Despite evidence to the contrary from both the previous audit and the developer's own monitoring report, EnviroServices referred to "about 20 families in the Valparaiso communities" and commented "this indicator was adequately addressed in the [2014] project description document and does not need to be re-examined during this verification process. Item closed" (p. 71). The auditor approved a community engagement risk of -5, again citing CCBS.

Table 6.23
Changing Community Engagement Risk Ratings Over Time in the Valparaiso Project in Acre Brazil (VCS 1113)

2014	Project description/1st monitoring report (CarbonCo and TerraCarbon, 2014)	Risk rating	Validation/1st verification (Environmental Services, 2014)	Notes
	35 communities on the project property; 100% have been consulted. Developer later clarifies that "No communities actually live within the project area, rather they live within the boundaries of the land ownership" (pp. 82–83).[21]	0	Risk rating approved. "Validation team confirmed that 100% of the local communities have been consulted and are involved in the project, thus a default risk value of zero is applicable."	Ilderlei Souza Rodrigues Cordeiro, vice mayor of Cruzeiro do Sul, and later federal congressperson for Acre (and landowner of the nearby Russas project), along with landowner Batista Lopes, are responsible for all social aspects of the project.
2014-2016	Second monitoring report (CarbonCo and TerraCarbon, 2018[22])	Risk rating	Second verification (Rainforest Alliance, 2017)	Notes
	35 communities on project property (p. 7) "To the best of the Project Proponents' knowledge as a result of a local census conducted by Ilderlei Cordeiro in May-June 2013, there were **35 households** living on the Valparaiso Project and all such households were consulted. However, a high-level survey by the Ministry of Health for the Municipality of Cruzeiro do Sul suggests **there may be more households than originally thought**" (p. 7).	5	Approved. "To the best of the Project Proponents' knowledge, all households living on the Valparaiso property directly adjacent to the project area have been consulted. However, a high-level survey by the Ministry of Health for the Municipality of Cruzeiro do Sul suggests there may be more households than previously thought" (**risk = 10**). As a mitigation measure, the Valparaiso Project has been validated and previously verified to the CCBS (**risk = -5**).	Verification Report also finds that most social aspects of the project have not occurred or have only just begun; planned patrols are not occurring; families are not located where described; project proponent has not proven the community benefits it claimed nor distributed any benefits to communities; and communities expressed concerns about negative impacts from proposed land titling initiative (see Verification Report section 4.3.1, Implementation Status). *Not mentioned* in the report was that, in 2016, **Ilderlei Cordeiro**, in charge of social engagement, was named in an investigation related to mis-use of public funds

[21] It is unclear from the documents reviewed what the project developer meant by project area, as opposed to land ownership.
[22] It is unclear why the monitoring report is dated after the associated verification.

				(MPF denuncia, 2016); he was also convicted of abuse of political and economic power in the 2016 elections (Juiz mantém sentença, 2019).
2017	Third monitoring report (CarbonCo & TerraCarbon, 2019)	Risk rating	Third verification (Environmental Services, 2019)	Notes
	85 communities living on the project property (p. 5) "It is now estimated that approximately **123 families** live on the Valparaiso Project. Of the 123 families, approximately **85 families live in the Project** and the remaining 38 families live in the leakage belt" (p. 5). **100% of local communities consulted.** [No information is provided by the project developer about any specific outreach to the newly identified communities (or families) or how or when they were consulted.]	-5	Rating approved. "Given that 100% of the local communities have been consulted* and are involved in the project ...the default risk value of zero is applicable." Verifier refers to "**about 20 families** in the Valparaiso communities" (p. 71). "A mitigation score of -5 was applied as the Valparaiso Project has been **previously verified to the CCBS**." [The verification report repeatedly cites the 2014 *project* description rather than the 2019 monitoring report. It makes no mention of the additional families, nor requests further information about consultation.]	That this project was also verified by CCBS, which allegedly has a higher standard for community engagement, calls into question the integrity of CCBS and its to offset community engagement risk in both 2017 and 2019.

Stakeholder Identification and Consultation

Since 2008, Verra has required stakeholder consultation, and for AFOLU projects, required the developer to "identify potential negative environmental and socio-economic impacts and shall take steps to mitigate them prior to generating voluntary carbon units." (Voluntary Carbon Standard, 2008b, p. 9). To do this, it logically follows that developers must, at a minimum, clearly identify the communities, organizations, and other entities they consider to be stakeholders and then report on specific measures they have undertaken to conduct consultation. The AFOLU risk metrics for community engagement further imply that developers should identify stakeholders down to the *household* level. By 2019, Verra's guidance to VVBs for consultation in AFOLU projects, while still minimal, asked auditors to report on specific criteria, including to "identify, discuss and justify a conclusion regarding whether the project communicated information about the project design and implementation, risks, costs and benefits, relevant laws and regulations and the process of VCS Program validation" (VCS Validation Report Template v4.0; Verified Carbon Standard, n.d.).

Developers repeatedly justified, and auditors repeatedly accepted, compliance with consultation requirements through activities such as sending emails, sending meeting invitations, posting on a message board, and holding an information session. Developers rarely provided any detail about the material discussed in a consultation.

The process used by VVBs to verify consultation practices differed substantially between projects. Some VVBs reported meeting with numerous community members across different communities; others met with stakeholders selected by the developer. Some VVBs did issue requests for clarification or corrective actions due to insufficient consultation; others approved the developer's practices even while noting their problematic nature (e.g., the Valparaiso Project, where verifiers noted written material was provided to target communities with high levels of illiteracy).[23] No VVB report we reviewed clearly discussed the full list of criteria laid out in Verra's guidance document; the majority of VVB reports appear to have simply rewritten the information provided by the developer.

The following three projects illustrate other issues we observed with stakeholder identification and consultation.

Mai Ndombe, Democratic Republic of Congo (VCS 934). The Mai Ndombe is an example of a verification that failed to take into account publicly available information that provided clear cause for concern about consultation practices. Reports from NGOs and community-based organizations highlighted very low levels of understanding of REDD+ and problems with consultation practices. One report highlighted a "botched awareness campaign" by developer Wildlife Works Carbon (WWC), noting,

> Confusion around the creation of an "air market" and "air sequestration" has made communities believe that they would be deprived of the air they breathe. The lack of information available in a community-friendly format is a major obstacle to the free and prior informed participation of communities in a process directly impacting their lands and livelihoods. (Gauthier, 2018, p. 58)

Another report found the following:

> Although WWC claims that project activities were "selected in consultation with the local communities," 47 Bolukiluki observers found that 70 percent of respondents had never heard of REDD+. Of the remaining 30 percent that had, only 8 people responded they felt their community had the opportunity to provide their opinion on the project's establishment.... In some cases, it appears WWC failed to consult entire villages in its concession. (Berk & Lungungu, 2020, p. 17)

Although reports such as these were readily available when auditors conducted verification, the project was approved for verification under VCS v4.2, which requires the developer to "take all appropriate measures to communicate and consult with local stakeholders in an ongoing process for the life of the project" (Verra, 2022d, p. 42). It appears the verifier did not review this available external information, nor did they request additional evidence from the developer to justify their consultation claims.

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[23] One verification report noted, "The handouts that were provided to community members with the project's summary was provided to the verification team on site, although many members of the community appeared to be illiterate" (VCS 1113, 2019, *Verification Report*, p. 26).

The verifier, SCS Global (VCS 934, 2022, *Verification Report*),[24] only briefly described the developer's compliance with VCS's consultation requirements:

> The verification team interviewed both project personnel and local community members regarding their understanding of potential costs, risks and benefits to communities…. The verification team agrees that in all cases stakeholders were aware of the projects [sic] effect on the communities and all decisions are made after consultation with stakeholders. (p. 18)

According to the report, the 172 "local community members" who were interviewed over the course of one week were individuals the auditor claimed were "not associated with the project proponent" (p. 7). However, all 172 were affiliated with ERA Congo (p. 7), the entity that owns the land concession and is listed as a joint project proponent alongside WWC (VCS 934, 2012, *Project Description*; 2012, *Monitoring Report*), until it became a direct subsidiary of WWC in 2013 (VCS 934, 2022, *Monitoring Report*, p. 30).

Cordillera Azul National Park, Peru (VCS 985). The Cordillera Azul National Park Project is an example of a project that, although verified as compliant with VCS requirements, nonetheless gave rise to community allegations of lack of prior consultation. The estimated 321,000 community members living outside the park but described as having access to the park for subsistence hunting and fishing were defined as secondary stakeholders by the developer and not consulted prior to validation; instead, the developer described an intention to have monthly visits "to communities" to provide information and get feedback (VCS 985, 2012, *Project Description*, p. 190; 2013, *Validation Report*, p. 25). This is permissible under the standard, as the developer is responsible for defining who project stakeholders are. However, affected Kichwa communities—whose land claims were never referenced explicitly in any project documents—have filed suit against the government and the National Park for lack of FPIC and for blocking access to ancestral lands (Forest Peoples Programme [FPP], 2021). They also denounced the developer for exclusionary and nontransparent practices (FPP, 2023). Even so, Verra issued credits to the project in April 2023, following a positive verification by VVB Aster Global in July 2022 (VCS 985, 2022, *Verification Report*).

Jari/Pará, Brazil (VCS 1811). Even when auditors have noted issues with consultations in CARs, consultation practices rarely improve. One example is the Jari/Pará project, validated under VCS v3.7, which explicitly requires stakeholder consultation prior to project validation. The developers identified 98 communities in the project zone and described "interviews and meetings [and] participatory workshops" (VCS 1811, 2019, *Project Description*, p. 35) but had "consulted" with only six communities (VCS 1811, 2019, *Validation Report*, p. 97). Validation was carried out simultaneously for VCS and CCB by VVB RINA Services S.p.A (RINA), and the auditors noted issues with stakeholder consultation from the outset, flagging consultation in CARs. RINA explained the requirement for all relevant stakeholders to be consulted, defined for the developer what "full and effective participation" means, and reminded the developer of the need to carry out FPIC for validation under CCBS (p. 96). In response, the developers did a new round of outreach, inviting representatives of 53 communities to a meeting, but RINA's review found that only 13 of the 53 were located in the project area, and only five new communities attended the event (pp. 96–97). Nevertheless, the auditor was ultimately conciliatory and supportive, concluding it was "satisfied

[24] The audit was conducted for VCS and CCBS simultaneously on the CCBS template.

that the developer is committed to expand even further the participation to institutions recognised by all communities identified in the Project Zone" and noting that,

> Even considering that the PPs did not conduct a consultation with 100% of the traditional communities in the area, it is evidenced that there is no kind of restraint, impediment or conflict over access to resources between the Jari Group and the communities. (pp. 97–98)

The VCS verification report, conducted simultaneously with validation, included no further comments regarding stakeholder consultation and only noted concerns in a forward action request, claiming that "effective communities [sic] consultation…is not in the VCS standard and therefore is to be resolved by the first verification of the CCB Standard" (VCS 1811, 2019, *Verification Report*, p. 14). RINA's trust in the developers is striking, given that during the years covered by the first audit (2014–2017), the landowner and one of the proponents (Jari Group) were under active investigation by the Brazilian government, and subsequently by the Forest Stewardship Council (FSC), for a series of illegal actions, including the violation of traditional and human rights in forestry operations.[25] These findings prompted the FSC to suspend Jari Group's certification in September 2017, and in March 2019, the FSC board of directors decided to disassociate from Jari Group. These serious allegations of illegal actions were never mentioned by the developers or RINA and did not affect Verra certification. The project was registered in 2020 and issued credits from 2019 to 2021. (No further VCS monitoring or verification reports have been published, however, and as of August 1, 2023, the project is on hold while it undergoes a quality control review by Verra.[26])

The Jari/Pará REDD+ Project is one of many we reviewed in which developers cited outdated or incorrect information about local communities, consulted with only a small (and unspecified) number of households, and provided superficial and self-referential justifications in response to CARs. Nevertheless, these issues were largely overlooked by VVBs. In other words, the *VCS Standard* was insufficient to ensure developers conducted effective household consultation, and when independent audits documented substandard practices and sought corrective action, this did not lead to substantive change. In fact, auditors uniformly accepted the developers' responses and approved projects despite the absence of clear evidence the safeguard standard had been met.

Land Tenure

Verra requires some "qualitative discrepancies such as a discrepancy with respect to ownership," to be noted as a material non-conformance that must be resolved prior to issuing a positive validation or verification (Validation and Verification Manual v3.2; Verra, 2016, p. 7). Later versions of VCS safeguards require developers to "respect…local property rights" and "undertake no activity that could exacerbate the conflict or influence the outcome of [existing land or resource

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[25] Whereas Jari identified 98 communities, the Brazilian public prosecutor identified 150 and was investigating the company's use of violence against community members claiming land tenure rights (FSC, 2019). This investigation prompted the FSC to conduct its own inquiry into the Jari group. The FSC found that the first stakeholder allegations were brought against the company in 2012 and increased starting in 2015. The FSC concluded that evidence existed beyond a reasonable doubt that Jari Group had violated community rights within its forest management area, as well as conducted illegal logging and timber laundering.
[26] To date, the project has not been verified under CCB but has published a monitoring report draft for 2017–2023 (https://registry.verra.org/app/projectDetail/VCS/1811).

conflicts]" (Verified Carbon Standard v4.3; Verra, 2022b, p. 46). The AFOLU risk tool considers projects to be higher risk if more than 5% of the project area has disputed land tenure or ownership.

It follows logically that to comply with these policies requires a clear understanding of local property rights regimes and related conflicts. We found, however, that official project descriptions did not always provide sufficient analysis of the project region to evaluate discrepancies in ownership, while historical analyses of forced evictions or allegations of past land rights violations were rarely mentioned. Moreover, the information that was provided was sometimes conflicting, noting tenure disputes in one section, and claiming no land conflicts in another.[27] Multiple projects we reviewed were approved despite clear discrepancies in ownership or titling legality.[28]

Of the numerous issues identified in our review, we highlight two examples of tenure-related safeguard failures.

Ecomapuá, Brazil (VCS 1094). A clear example of legal discrepancies in land ownership is the Ecomapuá Project. The 2013 project description and validation report noted that the owner, Lap Chan,[29] had legal title over all project lands. However the next year, the project's risk assessment noted that, in 2005, the government had issued a decree to acquire two of the five properties for extractive reserves; Mr. Chan justified his ownership by stating that he was never paid, and therefore the government's land claim had expired (VCS 1094, 2014, *Non-Permanence Risk Assessment*, p. 7). It is unclear whether the auditors flagged this in the first round of verification, but their report makes no mention of the issue (VCS 1094, 2015, *Verification Report*). The 2020 report, however, raised land ownership as a possible concern, citing federal law from 2000 that established an extractive reserve overlapping approximately 74% of the project area (VCS 1094, 2020, *Verification Report*, p. 39).[30] The VVB consulted the institution responsible for managing the reserves, which responded that it had "already denied support to the project, because of legal conditions," and the auditor found that five project properties were listed as pending in the Pará state rural land cadaster (p. 39). With legal rights to the project area unclear, the VVB issued a CAR, which was resolved and converted to a forward

27 This was the case with the Russas Project Verification (2019), for example. The AFOLU risk report notes that the project "has begun the CAR [rural land registration] process and is working with the adjacent landowner to resolve the overlapping [property] claim" (p. 36), whereas in justifying compliance with the CCBS (Indicator G1.6), the VVB cites the project description document and the monitoring report to conclude that there are "no land tenure disputes" (p. 60).

28 For example, in the Russas and Valparaíso projects, both developers claimed to have full ownership over project areas, although later audits revealed they did not have proper rural land titles, and some areas of land were actively contested. Moreover, one member of developer Grupo Jari, Jari Florestal, also had questionable land ownership. Jari Florestal was a developer of the Jari/Amapa Project (VCS 1115) until 2018, and is also linked to the Jari/Pará Project, assessed here. An investigation in 2017 related to its FSC certification found that Jari Florestal's forestland titles had been blocked for more than 10 years due to questions regarding the registration process (ASI, 2017); however, this did not appear to prompt increased due diligence into Grupo Jari's operations in the Pará project. Despite the implications for affected communities (not to mention carbon accounting and permanence), these projects have also been actively selling carbon credits on land where ownership rights are legally unclear.

29 Lap Chan, the founder of the developer Bio Assets, is a businessperson involved in helping secure Chinese energy investments in Latin America and has also been involved in the aluminum and banking industries (Bio Assets, 2023.)

30 On the same page, the VVB states again (although with different statistics) that "it's worth mentioning for legal purposes (land ownership, land management and VCUs titularity) that around 60% of the Project area is overlapping two Federal conservation unities (RESEX)" (VCS 1094, 2020, *Verification Report*, p. 39).

action request. The project was verified, and the VVB simply noted, "This issue must be re-evaluated in the next monitoring period" (p. 79). In April 2022, The Association of Residents of the Mapuá Extractive Reserve (AMOREMA) took legal action against the project developers, alleging the companies are selling credits for private gain on land in the public domain, and for false claims about using the sale of credits to contribute to traditional populations. AMOREMA is calling the credits to be nullified, and for both civil and criminal action to be taken again the developers (Publica, 2022; Quantum Commodity Intelligence, 2022). The developer continued to actively sell credits on the voluntary market, and as of August 1, 2023, a third verification had not occurred. From a safeguards perspective, the VVB did not ensure that "discrepancies with regard to land ownership" were resolved prior to verification, as the policy requires. Moreover, the auditor did not assess the implications of this overlap in relation to the risks for affected communities.

GuateCarbon, Guatemala (VCS 1384). A second land tenure issue relates to the ways in which communities that are within project boundaries and are designated by developers as "illegal" or "squatters" can be excluded from safeguard protections—and project analyses more generally. Our review suggests that, more often than not, developers choose to forgo engagement with households they deem to have no legal claim to the land and deny any responsibility for the project's effects on their livelihoods. These communities are typically noted in the project design as one of the drivers of deforestation, and perhaps in risk reports as a threat to permanence.[31]

The GuateCarbon Project exemplifies how this approach can allow REDD+ projects to exist alongside serious harms, without any effect on compliance with safeguards. The project is located within the Mayan Biosphere Reserve and managed by Rainforest Alliance on behalf of the National Council of Protected Areas (CONAP). The reserve is a protected area, created before the signing of Guatemala's Peace Accords, at a time when an estimated 1 million people had been displaced, including in the Petén, where the reserve was created. Today, dozens of communities have unclear land titles in this region; tenure disputes are prevalent; and the government (including CONAP) has repeatedly used evictions, often with violent force, to "manage" the reserve (Inter-American Commission on Human Rights [IACHR], 2017).[32] The VCS project has multiple goals, including to increase enforcement of the protected area (VCS 1384, 2017, *Project Description*, pp. 2, 8). The AFOLU risk report, validated in 2015 and cited again in the June 2017 verification report, noted,

> The Candelaria area has also been identified as an area with potentially illegal occupation, however this area is estimated to be less than 5% of the project area…Technically there are no disputes over the legal recognition of land ownership….because any known areas of land use disputes are largely illegal in

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[31] One counterexample is in the Alto Mayo project in Peru, where communities without formal land tenure are described in some project documents as project stakeholders. This did not prevent forced evictions, however (Greenfield, 2023).

[32] Specifically, human rights bodies describe

> A pattern of human rights violations in the execution of evictions, including the violation of the right to consultation and the failure to provide advance notice, which is usually carried out in summary fashion and with violence by members of the National Civilian Police, the Army and the National Council of Protected Areas (CONAP), and involve burning and destruction of homes, food, animals, without any arrangement for return or relocation or any real chance for due process or access to justice. (IACHR, 2017, p. 115)

> nature…[and] have either been excluded from the project area or they are less than 5% of the project area. (VCS 1384, 2015, *AFOLU Non-permanence Risk Assessment,* pp. 7–8)

Labeled as "occupiers" rather than affected communities, these families in the Candelaria were never referenced in any reporting on safeguards. No clarification requests or CARs were requested by VVBs to better understand the history of land claims in the Candelaria region or to assess the potential risks the project could pose to families in the area. On June 2, a few weeks before the verification report was published (June 23, 2017), 111 families (about 450 people, mostly children) comprising the community of Laguna Larga in the Candelaria region were violently evicted from their homes (Morales et al., 2017). Approximately 1,800 police and military, along with representatives of the state agency for protected areas, oversaw the eviction in violation of international standards. The families' belongings were destroyed, along with at least 77 homes; the local school was reappropriated as a military base. The trauma of the eviction caused many to relive experiences of wartime persecution. The IACHR (2017) reviewed the case and granted precautionary measures to the community, but the government has since done little to comply, and the families continue to live in tenuous conditions at the Guatemala-Mexico border. The eviction made national news and was denounced by international human rights bodies, yet the updated project description produced in October 2017 made no mention of the Candelaria region or the community of Laguna Larga.

As of August 2023, no further verification reports had been posted, although the Verra website noted the project was registered in 2020 and was validated and verified under CCBS. As of June 2023, this project had not issued any credits. Mention of this eviction may never appear within project reporting, yet the affected families continue to experience negative impacts. Here, the "do no harm" protections of VCS policy excluded from consideration, at the outset, some of the most vulnerable communities in the project area.

Grievance Mechanisms

VCS requires developers to have a grievance procedure to address disputes. This vague requirement is rarely mentioned with any detail in project documents. VVBs did flag issues with grievance procedures in multiple projects; however, the verification process provided minimal oversight, and we saw no evidence that VVBs asked affected communities about this issue during their on-site visits. As with consultation and land tenure requirements, VVBs repeatedly considered issues to have been resolved without any documented evidence of compliance. This is not an indication of lack of community concerns—which abound, as detailed herein. Instead, it likely suggests that these mechanisms are not communicated clearly to affected communities, or that communities do not view them as an adequate pathway to resolve conflicts.

Mai Ndombe, Democratic Republic of Congo (VCS 934). One example from the projects reviewed is the Mai Ndombe Project, located in a post-conflict country with a history of rights violations against Indigenous peoples, with a land-rights regime that is not well understood by rural communities (Gauthier, 2018), and generalized governance challenges. The project suffers from a design that does not address drivers of deforestation, a lack of engagement with marginalized populations, and inadequate analysis of the potential negative impacts of the initiative (Gauthier, 2018). At validation, only CCBS required a grievance process, which the developer had failed to describe. After a CAR, Wildlife Works claimed the project grievance mechanism was regulated by a national decree, passed in Kinshasa in 2009, that designated a committee composed of local public officials.[33] However, the documents provide no indication of whether a local committee was ever established or whether it was equipped to resolve REDD+ disputes. Repeating the VCS requirement almost verbatim, the project's monitoring report (2022) for 2017–2020 reiterated that a grievance procedure had been established at validation and stated that the "procedure provides an accessible, fair and efficient mechanism for resolving complaints and grievances, and ensuring that the process is transparent and comprehensive" (p. 36). No further detail was provided in the document. An independent investigation found an abundance of community concerns, including lack of information, consultation, or FPIC; restrictions on land use and the ability to attain legal land tenure; inequitable distribution of benefits; and a series of failed promises by the developer (Berk & Lungungu, 2020). The investigation also found that communities were unaware how to raise formal complaints.

Discussion and Recommendations

This analysis of VCS safeguards focused on both the quality and clarity of the written standard, as well as how they were implemented by developers and audited by VVBs. VCS's safeguards regime failed to ensure that (a) developers accurately document community risks in project documents, (b) developers or VVBs address safeguard violations that arise after a project begins, and (c) VVBs do not validate projects with a high risk of harm and withhold crediting from projects where procedural or substantive harms have occurred.

We found that VCS safeguards are not clearly defined and Verra does not provide clear guidance to developers and auditors on how they should be implemented. The standards for community engagement, consultation, participation, and grievance procedures improved over time but continue to fall short of international human rights norms and best-practice standards. Moreover, Verra has accepted a flexible process for safeguard implementation and compliance review, in which developers are given considerable leeway and auditors do little to correct practices that do not meet the VCS Standard.

Our review of 18 projects, using publicly available project reports and VVB audits, found written reports by both developers and VVBs to be inconsistent and often at odds with safeguard standards. The quality and specificity of project documents and monitoring reports varied widely across projects, and in some cases, were rife with inconsistencies, outdated information, and poorly justified findings. Moreover, comparison of project documents with external sources brought to light repeated examples where relevant safeguard risks or potential safeguard violations were overlooked or left unaddressed. Time and again, projects received positive verifications despite woefully inadequate consultation, evidence of contested land claims, and even violent evictions. Therefore, while safeguard compliance is described as a requirement in the *VCS Standard*, it is not treated as such in practice.

We found that risk assessment via non-permanence risk reporting uses a framework that is incoherent and disconnected from project realities. Despite the complex contexts in which these projects were carried out, often with longstanding land tenure conflicts or cases of land grabbing, our review found that 13 of 18 projects (72%) claimed zero land tenure/access risks to the project in its first monitoring period (or first available risk report). Similarly, despite the complexity of consulting with affected communities—sometimes as many as hundreds of thousands of affected

[33] Decree 103/CAB/MIN/ECN-T/15/JEB/09, which regulated disputes related to forest concessions.

households—we found that 17 of 18 projects (94%) considered there to be zero risk to the project, due to lack of community engagement.

Verra's risk reporting framework allows developers to reduce their risk rating when undertaking actions with a perceived benefit; this resulted in both a consistent underreporting of external risks (including consultation and land tenure) as well as false equivalences (i.e., offsetting an identified risk with vague actions that did not directly mitigate the risk). In some cases, VVBs requested further justification of a risk rating; however, in the documents we reviewed, developers were always able to justify their risk-level choice, even for projects in regions with widespread and well-documented risks in terms of governance, land conflict, criminal activity, or ongoing rights violations. When projects did report higher risks, or previous verifiers questioned a risk rating, we found no evidence this prompted increased due diligence on the part of VVBs. Verra's August 2023 update eliminates the ability to offset stakeholder engagement risks with supposed community benefits, but it maintains the practice of reducing risk ratings through mitigation activities in other areas of its framework.

For projects assessed under VCS 3.7 and later, we also assessed the safeguard section of project documents. Stakeholder consultation is the longest-standing VCS requirement to engage affected peoples, yet we found that it was common for developers to justify compliance with consultation requirements through similarly vague, passive, and inappropriate actions, such as sending emails, sending meeting invitations, posting on a message board, or simply holding an "information session." VVBs frequently accepted these practices while doing minimal due diligence. In some cases, VVBs did not apply basic common sense, accepting, for example, "sending emails" as a form of consultation in regions with low levels of literacy and household electrification. CARs were used in some cases but did not appear to lead to substantive improvements. In sum, VVB reports did not comply with even the minimal guidance provided by Verra for verifying consultation practices.

Similarly, although Verra requires discrepancies related to land ownership to be resolved prior to validation or verification, our evaluation of land tenure requirements found examples of projects that had been approved even though the proposed project area was not properly registered or had outstanding legal challenges related to land tenure claims. Historical or customary land claims were rarely described or investigated; in multiple projects, developers used the term *squatters* to refer to those present in the project area without formal title. This designation apparently allowed them to omit analyses about possible negative impacts and other safeguards protections. Our review of these projects was insufficient to judge whether the developers were justified in their description, but it is clear these practices can allow developers to disregard negative impacts on vulnerable communities and allow safeguard compliance to coexist with practices such as violent, forced evictions.

At the same time, evidence suggests the formal avenue available to communities to address concerns about negative impacts and reject projects in the form of a project grievance mechanism has not been effective. In many cases, the process for making a complaint is not described in any detail and lacks minimal elements of transparency, raising concerns about whether affected communities know they exist or can easily access them—or if the mechanisms exists beyond its written description. During our research, we located few examples of a publicly documented grievance redress process, a requirement of the VCS Standard since 2017. VVBs in turn use the lack of grievances filed as evidence of no community concerns. While information from NGO reports, investigative journalism, and academic literature suggests communities frequently have concerns or feel they are adversely impacted, we find these mechanisms are one of the most overlooked elements of VCS safeguards by both developers and VVBs.

Our findings emphasize the key role of auditors in voluntary safeguard regimes, and the myriad ways VVBs are failing to uphold and enforce even the most basic elements of the VCS safeguards standards. Project reviews, conducted by auditors with incentives to verify projects, are subjective and vary widely from one auditor to another. Most VVBs appear to seek out limited, if any, external information from NGO reports, the media, and international human rights bodies to inform their analysis of risks to the project and affected communities; where a developer has acknowledged high risk, VVBs do not appear to conduct an increased level of due diligence. The tools available to auditors to correct safeguard issues (and protect communities), such as corrective action requests and nonconformances, were used inconsistently; issues raised by auditors were often "resolved" through communication with the developer, even when no substantive action had been taken. Instead, developers are uniformly given the benefit of the doubt, even in cases where they have been under criminal investigation (e.g., the Jari Project) or where prominent project personnel have been convicted of crimes (e.g., the Russas and Valparaiso Projects). Safeguard compliance, it appears, is systematically rubber-stamped despite evidence of noncompliance.

Finally, our review of projects validated over time under different versions of the *VCS Standard* found little evidence that stronger standards led to more stringent safeguarding by developers or expanded due diligence by auditors. We found no consistent evidence of improved consultation practices, for example, or more detailed documentation that would demonstrate compliance with the requirement to "not negatively impact … local communities" (*VCS Standard* v4.3, p. 39). Although not the focus of this analysis, many of these findings hold for CCB as well in shared VCS/CCBS reports.

Here we recommend several important changes to the current safeguards system.

- Safeguards should be treated as mandatory. Meaningful (not just performative) compliance should be required before project registration and each credit issuance. Resolution of safeguard violations should not be postponed to future monitoring periods, and projects that do not meet the standard should not be verified.
- Verra should further expand its policy and guidance to reflect the expanded requirements of its new safeguard standards. As a point of comparison, the Green Climate Fund has a 23-page Indigenous Peoples Policy and a 37-page document with operational guidelines for the policy to guide projects in understanding and implementing activities in line with Indigenous rights.
- "External risks" in AFOLU Non-Permanence Risk Assessments should not be a standardized check-box activity but a place-based assessment, and auditors should use more scrutiny when assessing them. Where risks are higher, auditors should undertake increased due diligence when assessing safeguard compliance, particularly where risks relate to the rights of vulnerable populations.
- While reporting has improved over time, it continues to vary widely between projects and auditors. Both developers and verifiers should publicly report in detail on how each requirement was met, with up-to-date information; verifiers should look to a variety of sources, including local organizations and human rights bodies, to assess developer's reports. While reporting has improved over time, it continues to vary widely between projects and auditors.
- Developers should be required to identify risks to all affected communities, whether or not they are identified as stakeholders or have recognized claims to property or resource rights. While this is implicit in the policy's recognition of human rights, it should be made explicit in all guidance to developers and auditors.

- Verra should decertify auditors who consistently fail to conduct thorough assessments of developers' activities.

In addition, the following two subsections discuss several fundamental changes we find are needed to improve protections for forest communities affected by REDD+ projects.

Why a Systemic Change Is Needed to Avoid Harm in REDD+

Logistical challenges, subjective criteria, incentives built into private carbon markets, and challenging political and land tenure environments all impede the functioning of a system that safeguards the most vulnerable.

Complying with social safeguards is context dependent and time consuming. REDD+ carbon projects involve multiple levels of translation, both linguistic and cultural, between forest communities and carbon credit market actors. Ensuring effective communication—and especially free, prior, and informed consent—is an iterative and multidimensional process. When projects are developed by outsiders and presented to forest communities, stakeholders need time to take in information; discuss it with their family or community; perhaps engage in an internal community consultation or seek external advice from advisors or lawyers; return to the developer with questions and recommendations, including the ability to reject a project; and discuss updated versions to understand how their feedback was incorporated. In other words, ensuring effective consultation takes time, careful planning, and expertise in community engagement. Judging from the projects we reviewed, few external developers conduct such a process.

Verifying compliance with social safeguards is similarly complex. Those hired to verify and validate safeguards often do not have expertise in the local context, history, language, or socio-political dynamics, nor do they allocate sufficient time to talk to a broad and representative number of affected households to know who the stakeholders are and how resources are used, controlled, and managed. For example, for projects designed by external developers, verifying consultation requires determining whether the project meets a detailed set of criteria that includes whether project information provided to community members was complete and well-understood, whether community members' questions were adequately answered and their concerns discussed, whether sufficient time was given for stakeholders to deliberate and make an informed decision, and whether concerns were meaningfully addressed. The stringency of this process should increase further for safeguards that relate to rights regulated by domestic legal frameworks and jurisprudence, such as land tenure claims or FPIC. The Green Climate Fund's operational guidelines for its Indigenous Peoples Policy, for example, includes 18 detailed questions to assess whether FPIC has been carried out appropriately. Instead of conducting such a rigorous process, many VVBs glean much of the information for their assessment from the developers themselves.

More broadly, the very structure and incentives of REDD+ in private carbon markets impede adequate safeguarding. REDD+ carbon crediting as a market in carbon emissions reductions prioritizes forest carbon over people. Research has shown that the incentives for auditors reviewing REDD+ projects align not with the protection of communities but rather with the developer who hires them. Auditors have incentives to charge less, and therefore do less, in order to compete with other verifiers. They also benefit directly from positively validating and verifying projects in order to be hired again (Bulkan, 2016; Seyller et al., 2016). These incentives run directly counter to the meaningful implementation and oversight of a social safeguards, such as consultation and the internationally recognized right to FPIC, which are likely to slow a project's preparation and approval, may alter a project's design, and could prevent the project from going forward.

Finally, to be effective, a safeguards regime must function as a protective mechanism across political and historical contexts; voluntary corporate standards fail to do so. As we described at the beginning of this chapter, projects are often initiated in regions with widespread corruption and a history of violation of customary land rights, displacement, and land grabbing that obfuscates legal land tenure (Chhatre et al., 2012; Jagger et al., 2014; Roe et al., 2013; Zelli et al., 2014). Efforts by the international community to develop safeguards in related contexts map onto and reinforce inequality and past injustices (Chomba et al., 2016; Sarmiento Barletti & Larson, 2017). The failure to ensure Indigenous peoples' right to FPIC has been a particular concern (Crippa & Gordon, 2012; Jagger et al., 2014; Ribot & Larson, 2012; Sarmiento Barletti & Larson, 2017). Many governments are reluctant to fully enforce respect for the right of Indigenous peoples to self-determination, and substantial gaps remain with regard to rights for non-Indigenous local communities (Baker, 2013; Diergarten, 2019; Tomlinson, 2017). As a result, forest communities rarely have the agency required to meet their expectations of a deliberative process to voice real critique and reject REDD+ projects if they choose, or the power to create a bottom-up, alternative vision.

There is no evidence to suggest that a corporate safeguards regime, with ingrained conflicts of interests and auditors with no authority to ensure substantive enforcement, can overcome or avoid the contextual challenges. Indeed, even safeguards considered current best practice, such as the IFC Performance Standards (with clearer requirements, more binding constraints, and an independent complaint mechanism) have struggled to avoid harm.[34]

Recommendations for an Alternative Preventive Approach, Guided by Local Communities

Safeguards can be best understood as a tool rather than a guarantee that rights abuses will not happen. When carried out by good faith actors, they can help raise awareness about social issues among REDD+ actors, promote respect for the rights of affected communities, and support the standardization of basic protections for vulnerable communities. In some contexts, safeguard standards can raise the bar for developers, encouraging them to take steps that may go beyond what is common practice in their local jurisdiction. At their best, safeguards not only prevent harm but also promote positive outcomes for people and the environment.

Safeguards, however, should not be judged by whether they can address community concerns in *some* projects; rather, the effectiveness of REDD+ safeguards should be measured by their ability to consistently protect the *most vulnerable* communities in the *most high-risk* environments.

Verra's safeguard regime cannot guarantee social protection. As a set of discretionary policies that rely heavily on the project developer's own analysis, with weak mechanisms for

[34] The IFC's Performance Standards, considered "best in class," have been used as the basis for the Equator Principles, the Green Climate Fund, and the ICVCM, among others. However, hundreds of complaints by affected peoples have been filed using the IFC's independent complaint mechanism. These formal grievances make evident that IFC operations continue to result in negative impacts; research shows, moreover, that these formal complaints have not resulted in adequate IFC audits or sufficient remedies for impacted communities (Altholz & Sullivan, 2017; Daniel et al., 2016).

oversight and accountability and strong incentives to approve projects, the current VCS safeguard regime is not oriented toward the protection of forest peoples. The explicit recognition of international human rights standards in VCS v4.5 is a welcome addition. But it still fails to address the underlying reasons safeguards have been poorly implemented, as we described above.

Our recommendations below lay out a fundamental shift in the program structure that centers on international human rights law and the prevention of harm, fixes the incentive problems embedded in the current auditing processes, provides independent avenues for accountability when auditing processes fall short, and respects the right of forest communities to have control over decision-making about the project from start to finish.

Rights-based rather than risk mitigation approach. Verra's updated *VCS Standard* (v4.5, Verra, 2023c) includes, for the first time, a section on respect for human rights. This is an important step to bring Verra's policy in line with existing international human rights law and related norms protecting Indigenous peoples and other communities negatively impacted by REDD+. Indigenous and tribal peoples are among the most marginalized populations globally, and international law enshrines a specific set of rights that they hold; fully respecting those rights requires additional due diligence. However, acknowledging rights in a written policy is not the same as ensuring they are respected. In some cases, paying lip service to a right, such as FPIC, can serve to legitimize processes as being rights compliant even when they have been poorly implemented and undermined local self-determination. The shift to recognize rights in the past has provided limited opportunities to communities to resist or oppose REDD+ (Dehm, 2016). To ensure full respect for rights, other aspects of the VCS program will need to shift from a risk-mitigation framework to a rights-based one. In the current framework, the project developer is the principal actor, responsible for identifying risks and deciding how to mitigate them. In a rights-based framework, the rights holders (i.e., communities) are at the center of the policy, which should have clear, enforceable protections that ensure communities have the information needed to participate, and a mechanism to hold actors accountable and ensure avenues for justice. A rights-based approach emphasizes private entities' responsibility to respect rights and to conduct due diligence with a focus on preventing harm, rather than simply mitigating it. No entity should be able to buy credits that were generated in a context of rights violations. Verra should look to experts in the field of international human rights to update its policies and provide guidance to developers and auditors. The following recommendations are key elements of a rights-based approach.

Auditor independence with appropriate expertise. Auditors should be chosen and hired by an independent party rather than directly by developers. The party choosing the verifier should not have financial interest in the credit market. Those who audit safeguards should have the necessary knowledge and expertise and be oriented toward the protection of communities. These individuals should have a detailed understanding of local law and regulations, as well as relevant international human rights norms. Auditing should involve information gathering from actors other than the developer, including independent human rights bodies, Indigenous peoples' organizations in the region, and independent and detailed interviews with local communities that are not organized by the developer. They should be empowered to withhold verification should safeguards standards not be met.

Independent accountability mechanism. Project-level grievance mechanisms are not functioning and are not sufficient. Moreover, a recent analysis found Verra's own complaint process to be inadequate, in part because it, too, is non-transparent, is inaccessible to many, and lacks predictability, among other shortcomings (Carbon Market Watch, 2023). Ultimately, however, a carbon crediting standard-setter is not the appropriate entity to decide if a REDD+ project is linked to rights violations or other harms.

A new, independent mechanism should be created in line with those outlined by the UN Guiding Principles on Business and Human Rights (2011). The guiding principles define basic standards for grievance mechanisms to include legitimacy, accessibility, predictability, fairness, rights compatibility, transparency, and capability. Such a mechanism should be empowered to review allegations of any harms or suspected harms (i.e., human rights violations) directly from affected communities. This approach has been integral to the strengthening of other safeguard systems, (e.g., the IFC and other development finance institutions). The mechanism should provide a public registry of complaints and have staff with the power to request information and action from the developers, and to prevent verification in cases of documented violations. Furthermore, the mechanisms should have the power to flag VVBs who consistently approve projects with serious safeguard violations, and make recommendations to Verra about improvements to the safeguard policy.

Proposed REDD+ projects that affect forest communities should be designed by or in partnership with those communities. The UN Human Right to Self-Determination is a fundamental principle enshrined in international law. It recognizes the right of peoples to determine their own political status and their economic, social, and cultural development, without external interference. Indigenous peoples' inherent right to self-determination and sovereignty, including to determining what happens on their lands, is clearly spelled out in international law. Moreover, the right to information, participation, and justice is enshrined in regional treaties, such as the Aarhus Convention and the Escazu Agreement, in addition to numerous other environmental treaties.

Indigenous and forest communities have been the most important protectors of tropical forests. REDD+ must follow these key principles so forest-dependent communities, whether or not they have legal rights to the forests targeted for REDD+, can enact their right to self-determination, with the ability to oppose a project, or should they decide to engage, have active participation and control over project benefits.

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Appendix: Safeguards

Table 6.A1

Project Risk Ratings for Community Engagement

Project ID	Project	# affected households or communities in project area	Community engagement risk
VCS1113	Valparaiso	35 "communities" (2014 PDD) or 35 "households" (2017 Monitoring Report) or "more households than previously thought" (2017 Monitoring Report) or "123 families"; 85 within the project area and 38 in the leakage belt (2019 Monitoring Report" or "about 20 families" (2019 Verification Report).	0
VCS1112	Russas	20 communities w/in project area	0
VCS1094	Ecomapuá	99 families living within project area, est. 187 families living in reference area.	-5
VCS1811	Jari/Para	98 communities (a Brazilian public prosecutor separately identified 150)	10
VCS1650	Keo Seima Wildlife Sanctuary	20 villages participating, 17 of whom live within the project area. An estimated 67% of population is Indigenous. Possible future relocation, with FPIC.	0
VCS1566	Resguardo Indigena Unificado Selva de Mataven (RIU SM)	17 communities, all Indigenous	-5
VCS1399	Mutata	13 communities located within multiple Indigenous reserves	-5
VCS1396	Rio Pepe y ACABA	Afro-Colombian population of about 18,395 inhabitants, made up of 2,571 families.	-5
VCS1392	Cajambre	13 villages or communities	-5
VCS934	Mai Ndombe	50,000 people within project area	-5
VCS1359	Isangi	At least 100-150k people in project area; project claims to directly engage about 50 thousand (in 24 villages)	-5
VCS1541	Lacandon Forest for Life	28 "human settlements" in project area, population in and around project area about 25% Indigenous	-5
VCS1384	GuateCarbon	No specific number of households or affected communities inside project area located in project documents. 27,690 families within 20 km of the project area.	-5

VCS612	The Kasigau Corridor Project - Phase II	13 private, group-owned ranches as well as the Marungu Hills; also affected: Taita community, Durumba tribe (no specific number of affected households or communities mentioned)	-5
VCS985	Cordillera Azul National Park	No communities in project area; one non-contacted Indigenous community within park but outside of project area, in separate protected zone. 181 communities in Huallaga Valley, only one of which has recognized land tenure rights as Indigenous; 51 communities in Ucayali area of buffer zone, most are Indigenous.	-5
VCS944	Alto Mayo Conservation Initiative	14 settlements and 9 rural sectors (less formal than settlements) within project area (3-4 thousand families), 55 settlements in buffer zone as of 2008, number Indigenous not given. Recent large influxes of settlers/in migration and population growth.	-5
VCS1775	Luangwa Community Forests Project	165 955 community stakeholders registered with the project, living in 28, 268 households, in 12 chiefdoms.	-5
VCS902	Kariba	4 rural districts with total population of 334,528	0