



Improved Forest Management: Progress, Challenges, and Opportunities

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Acronyms and Abbreviations

- BAU: business as usual
- CAR: Climate Action Reserve
- FIA: Forest Inventory and Analysis (United States Forest Service)
- FMP: Forest Management Plan
- FPIC: free, prior, and informed consent
- FSC: Forest Stewardship Council
- GTM: Global Timber Model
- IFM: improved forest management
- NPV: net present value
- tCO₂e: tonnes of carbon dioxide equivalent
- US: United States
- VCM: voluntary carbon market

Executive Summary

Improved forest management (IFM), is one of the most promising interventions for delivering tens of millions of tonnes of carbon dioxide removal in the next 5–10 years. IFM can include deferred timber harvest, reduced-impact harvesting, and related practices. It is one of the largest project categories by volume in the voluntary carbon market (VCM), accounting for 29% of all forestry and land use-based credits on voluntary registries globally. Scrutiny of IFM's climate integrity remains high. However, recent methodological advances are currently being applied to industrial forestlands in the United States (US) and have the potential to scale globally. This is an exciting inflection point for IFM's potential to deliver credible monitoring and accounting at an effective scale and cost.

Climate-smart forest management is not only possible, but essential to meeting global climate goals. Relae examined the challenges facing IFM as a climate solution. Specifically, we assessed current approaches for constructing baselines, demonstrating additionality, deducting for leakage, and ensuring positive social impacts. Here, we offer practical frameworks for buyers and developers to unlock methodological advancements and realize credible, high-quality climate impacts as well as meaningful social outcomes from IFM projects.

Key Takeaways

- **Baselines:** Credible baselines must reflect what would likely have happened in the absence of the project. This requires a quantitative assessment of carbon stock trends in comparable non-project forests that considers land ownership type, tree species mix, and age class. The baseline scenario should not project carbon stocks lower than those observed or plausibly modeled in comparable forests, and should be updated every few years. The most credible baselines reflect landowner decision-making processes, are externally verifiable, and incorporate dynamic adjustment mechanisms.
- **Additionality:** Additionality claims must be justified against the project's financial, operational, and regulatory context with documentation that fully supports these claims. Project additionality becomes clearer the more that project activities and climate impacts exceed what can plausibly be explained from business-as-usual fluctuations.
- **Leakage:** Market leakage remains one of the most uncertain risks in IFM projects, with current methodologies relying on a variety of approaches to deductions that may not reflect, and are believed to undercount,

project-specific conditions. While advanced models used for estimating leakage are improving and becoming more widely accessible, a practical interim approach to assessing leakage risk is to compare the size of the “leakable carbon” pool (i.e., carbon associated with reduced harvest) to total project benefits and evaluate the likelihood of supply substitution (i.e., leakage rate) using heuristic indicators such as market integration, supply responsiveness, product substitutability, project scale, and forest growth rates. Projects may have to consider taking a greater leakage deduction than is currently required by registries to ensure project accounting is conservative.

- **Social impact:** Industrial IFM projects, or projects owned and managed by industrial landowners, are embedded in working forest landscapes and rural economies. To date, social co-benefits from IFM projects have been limited. Stakeholder engagement, harm mitigation, and community benefit sharing must be appropriate to the magnitude of a project’s impacts and the vulnerability of affected communities. Buyers can play a meaningful role by signaling through offtake decisions that they expect projects to implement robust stakeholder engagement and harm mitigation.

Introduction

Forests play a critical role in regulating the Earth's climate with potential to sequester and store vast amounts of carbon. Forest-based natural climate solutions generally fall into three broad categories: conserving existing forests; increasing forest extent through reforestation, afforestation, and agroforestry; and IFM, an approach that changes how existing forests are managed to increase carbon stored in forests and forest products. Together, the protection, restoration, and improved management of forest ecosystems represent some of the most effective and economically viable strategies for facilitating large-scale climate mitigation, with over seven gigatonnes of cost-effective mitigation potential annually.^{3, 4}

The scale of IFM's contribution to the VCM reflects this potential. In the last decade, 58% of the 326 million carbon credits issued in the US have come from forestry projects, with IFM as the most common forest carbon project type.⁵ Since the first IFM credits were issued in 2008, 1,056 IFM projects have been listed on voluntary registries and have issued over 274 million credits globally. This represents approximately 29% of all forestry and land use-based credits, and roughly 10.7% of all carbon credits listed on voluntary registries since 2025.⁶ Globally, IFM is estimated

³ Intergovernmental Panel on Climate Change (IPCC). 2023. Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press. [accessed 2026 Sep 21]. <https://www.cambridge.org/core/books/climate-change-2022-impacts-adaptation-and-vulnerability/161F238F406D530891AAAE1FC76651BD>.

⁴ Griscom BW et al. 2017. Natural climate solutions. Proceedings of the National Academy of Sciences. 114(44):11645–11650. <https://doi.org/10.1073/pnas.1710465114>

⁵ Baral S, Lamichhane S, and Koirala A. 2025. Current status of improved forest management carbon offset projects in the US voluntary market. Forest Policy and Economics. 178. <https://doi.org/10.1016/j.forpol.2025.103567>

⁶ Haya B, Quartson P, Bernard T, Abayo A, Rong X, So I, Elias M. 2025. Voluntary Registry Offsets Database v2025-12. Berkeley Carbon Trading Project, University of California, Berkeley. [accessed 2026 Mar 20]. <https://gspp.berkeley.edu/berkeley-carbon-trading-project/offsets-database>

to increase carbon stocks by 0.2–2.1 gigatonnes per year.^{7,8,9} From 2023 to 2025, IFM credit retirements increased approximately 118%, signaling growing buyer demand for these credits.

Forest managers are under pressure to simultaneously produce more wood products and biomass while increasing their contribution to conservation and climate mitigation. Decarbonization scenarios consistently project that a transition away from fossil-based energy and materials will require substantial increases in sustainably produced biomass. The United Nations Food and Agriculture Organization projects an increase in roundwood demand growth to 2050 and beyond as the bioeconomy expands.¹⁰ Rising demand for wood products is already placing increasing pressure on both natural and plantation forests. Meeting that demand will require choices among expanding the amount of forest area under production, drawing on land that may be better conserved, intensifying management within forests already in use, and improving the sustainable management of existing forests.¹¹ Climate-smart IFM focuses on the last. Yet, under current market conditions, forest managers face little structural incentive to prioritize climate-smart practices. Without a meaningful price signal for carbon, business-as-usual (BAU) harvest regimes remain the economically rational choice. Analysis using the Global Timber Model (GTM) finds that achieving even 10% of the forest-sector mitigation needed to limit warming would require carbon prices well above those observed in today's voluntary markets to justify the transition to IFM practices.¹² Therefore, it is imperative to get IFM right on three fronts: supplying the biomass a sustainable economy increasingly requires, continuing to provide the wood products that society relies on, and contributing meaningfully to limiting temperature rise.

⁷ Griscom BW et al. 2017. Natural climate solutions. *Proceedings of the National Academy of Sciences*. 114(44):11645–11650. <https://doi.org/10.1073/pnas.1710465114>

⁸ Roe S et al. 2019. Contribution of the land sector to a 1.5 °C world. *Nat Clim Chang*. 9(11):817–828. <https://doi.org/10.1038/s41558-019-0591-9>

⁹ Haya BK, Evans S, Brown L, Bukowski J, Butsic V, Cabiyo B, Jacobson R, Kerr A, Potts M and Sanchez DL. 2023. Comprehensive review of carbon quantification by improved forest management offset protocols. *Frontiers in Forests and Global Change*. 6:958879. <https://doi.org/10.3389/ffgc.2023.958879>

¹⁰ Food and Agriculture Organization of the United Nations. 2024. Global forest sector outlook 2050: Assessing future demand and sources of timber for a sustainable economy. [accessed 2026 Jul 6]. <https://www.fao.org/3/cd1211en/online/src/html/projections-increases-wood-demand.html>

¹¹ Intergovernmental Panel on Climate Change. 2022. Chapter 7: Agriculture, Forestry, and Other Land Uses (AFOLU) in: IPCC Sixth Assessment Report. [accessed 2026 July 6]. <https://www.ipcc.ch/report/ar6/wg3/chapter/chapter-7/>

¹² Austin KG et al. 2020. The economic costs of planting, preserving, and managing the world's forests to mitigate climate change. *Nat Commun*. 11(1):5946. <https://doi.org/10.1038/s41467-020-19578-z>

IFM operates within existing working forests and prioritizes the optimization of climate benefits, through increased carbon sequestration and reduced operating emissions, while continuing to produce wood products and biomass. This includes a broad range of practices, including deferred timber harvest, reduced-impact harvesting, ecological forest management (e.g., uneven-aged silviculture), and the protection of sensitive areas like riparian buffers.¹³ IFM projects sequester carbon and generate carbon credits through two distinct pathways: carbon removals and carbon reductions. In this paper, we focus on removal credits, which are grounded in physical carbon stocks that accrue in the forest as a result of an IFM project. Reduction credits are earned by retaining carbon that would have been lost under the BAU regime. Both types of credits can be high quality with the appropriate implementation approaches and safeguards, and many of the challenges described here are common to both types of credits. Beyond direct climate benefits, IFM practices can deliver meaningful co-benefits including improved forest health, enhanced habitat and biodiversity, greater ecosystem resilience, and, in select cases, social uplift. IFM can also reduce forests' vulnerability to future carbon reversals from wildfire, pests, pathogens, and drought. Collectively, these changes can maintain higher standing carbon stocks over time and increase net carbon removals relative to the baseline scenario.

In the past, many IFM projects have been criticized for overestimating their climate impacts due to the use of inappropriately low baselines that reflect unrealistically high harvest or because they benefited from methodological gaps that encouraged overestimates.^{14, 15} Methodologies have traditionally been oriented to support additionality claims in industrial forestry settings. They allowed projects to set the baseline by modeling profit maximizing logging, based on the trees existing within the project area at the project start.¹⁶ However, if landowners never intended to manage at this level of intensity, the modeled baseline scenario showing maximized profits results in significant overcrediting. Some methodologies also award substantial credits when projects exceed regional stocking averages. When these regional averages are not representative of the lands projects elect to enroll, this also leads to

¹³ Kaarakka L et al. 2021. Improved forest management as a natural climate solution: A review. *Ecological Solutions and Evidence*. 2(3):e12090. <https://doi.org/10.1002/2688-8319.12090>

¹⁴ Haya BK, Evans S, Brown L, Bukowski J, Butsic V, Cabiyo B, Jacobson R, Kerr A, Potts M and Sanchez DL. 2023. Comprehensive review of carbon quantification by improved forest management offset protocols. *Frontiers in Forests and Global Change*. 6:958879. <https://doi.org/10.3389/ffgc.2023.958879>

¹⁵ Badgley G et al. 2022. Systematic over-crediting in California's forest carbon offsets program. *Global Change Biology*. 28(4):1433–1445. <https://doi.org/10.1111/gcb.15943>

¹⁶ Subject to limits on the ability of nearby log buyers to process logs, and some other factors.

overcrediting. Both of these issues contribute to skepticism around IFM’s impacts and serve to limit meaningful climate ambition through IFM.

Currently, we are at an inflection point for IFM’s credibility and continued growth. Recent methodological innovations, particularly the shift to dynamic baselines, combined with greater supplier sophistication create new opportunities to deliver high-quality credits at effective cost and scale. These advances are gaining institutional recognition. In 2025, the Integrity Council for the Voluntary Carbon Market approved several IFM methodologies for its Core Carbon Principles label, including ACR IFM on Non-Federal U.S. Forestlands (version 2.1) and Verra VM0045 (version 1.1)—both of which incorporate dynamic baselines.¹⁷ The Climate Action Reserve (CAR) Mexico Forest Protocol (version 3) is also approved, pending fulfillment of certain remedial actions. The transition to more dynamic, adaptive approaches represents meaningful progress, but unresolved challenges in baseline construction, additionality demonstration, and leakage accounting require further actions (e.g., standards updates, third-party analysis and ratings, additional buyer due diligence) to confirm a project achieves its stated climate benefits.

In the sections that follow, we examine both the climate integrity and social dimensions of US industrial IFM projects. On the climate side, Relae presents frameworks for baseline construction, additionality demonstration, and leakage accounting—identifying challenges and areas where methodologies have improved, where critical gaps remain, and what buyers and developers can do to assess and improve quality. On the social side, we examine how industrial IFM projects interact with the communities and workers embedded in forest-dependent economies, and propose a framework for right-sizing social design to project context and impact. Taken together, climate integrity and social dimensions define what high-quality IFM looks like and what the field must do to achieve it consistently.

In this paper, we focus on industrial ownership of forest lands because their technical capacity, access to capital, clear historical management records, and institutional sophistication make them well positioned to navigate complex

¹⁷ The Integrity Council for the Voluntary Carbon Market. 2025. Integrity Council approves Biochar & Improved Forest Management methodologies. [accessed 2026 Mar 18]. <https://icvcm.org/integrity-council-approves-biochar-amp-improved-forest-management-methodologies/>

carbon markets and methodologies.^{18,19} This focus also reflects the geographic aperture of the methodologies themselves, which are bounded to specific forest regions within the US where industrial ownership and the data infrastructure supporting these methodological advancements are most developed. Promising signals exist for family forest applications, but the techniques discussed here are most mature in the industrial context. Smaller and non-industrial landowners face a different set of structural challenges: intermittent harvest activity complicates baseline construction, and additionality may be more difficult to demonstrate where historic management was not harvest oriented. While many of the diligence principles we discuss here apply to other IFM contexts, buyers and developers working outside of industrial IFM projects in the US should expect material differences in baseline construction, additionality demonstration, leakage dynamics, and community engagement considerations.

Demonstrating Net Climate Impact in IFM Projects

Ensuring that IFM projects deliver a net additional climate impact is integral to credit quality. Recent methodological advances have meaningfully raised the bar, requiring more robust approaches to measuring carbon stocks, quantifying counterfactual baselines, demonstrating additionality, and mitigating leakage. However, methodologies are intentionally accommodating to a wide variety of project contexts, and challenges still remain for transparently demonstrating high quality across these areas in ways that consistently instill buyer confidence. Quantifying counterfactual baselines and conservatively addressing leakage continue to pose significant challenges to transparent, credible demonstration of high-quality IFM projects. These remain critical areas where improvements to methodological approaches and available data are required to increase confidence that IFM projects result in positive net climate impacts. As a result, buyers can find it difficult to determine whether a methodology's quality guardrails are sufficient to ensure that credits represent genuine impact or whether compliance with protocol requirements is a reliable proxy for integrity.

¹⁸ Thompson A et al. 2025. Effects of Carbon Policies on Disadvantaged Forest Communities in the United States. Agricultural and Resource Economics Review. 2025:1–29. <https://doi.org/10.1017/age.2025.10012>

¹⁹ Because the methodological advancements we assessed for this paper are not yet widespread for these use cases, we do not consider smallholder or family forest IFM, projects outside the US, or adjacent forest carbon pathways such as reforestation, afforestation, REDD+, or avoided conversion. Ecological uplift, while incredibly important, is not an area of focus for this paper and is discussed only in the context of additionality, while durability is addressed only briefly; these topics warrant dedicated treatment beyond the scope of this analysis.

Below, we examine three related dimensions of IFM carbon credit integrity: additionality, baselines, and leakage. For each, we describe general methodological approaches, discuss the key challenges and tensions, and present pathways toward robust, credible quantification that developers can pursue. Because they are interdependent, additionality and baselines are discussed together.

Additionality and Baselines

To have credible climate impact, a project must be able to demonstrate additionality and construct a plausible baseline. Additionality considers whether carbon finance—rather than market conditions or regulatory requirements—is required to carry out project activities and depart from BAU, as represented by the project baseline. A project’s baseline describes the carbon trajectory the forest would have followed in the absence of the project. Every IFM removal credit must represent a physically real metric tonne of carbon sequestered as a result of project activities, beyond a BAU scenario (i.e. the baseline). Together, additionality and baseline largely determine a project’s climate impact. Both depend on comparing forest management and harvest plan data under an unobservable BAU scenario, or counterfactual, to the changed management plan under the project scenario. The credibility, precision, and accuracy of these data are key to developing high-quality projects. IFM projects often focus on shifting timber harvest to longer rotations in order to store more carbon in live forest biomass.²⁰ Industrial owners often operate under clear institutional incentives and logic, maintain robust records and data, and manage forests predictably enough to support credible baseline construction and demonstrate additionality.

Ideally, data used to support baseline and additionality claims would be project-specific and externally verifiable, but buyers usually face a tradeoff where the most project-specific data (e.g., developer-provided management plans) is proprietary to the developer, and the most externally verifiable data (e.g., average regional harvest intensity; **table 1**) may not always capture project-specific management nuances. Landowners will always have more information about

²⁰ Kaarakka L, Cornett M, Domke G, Ontl T, Dee LE. 2021. Improved forest management as a natural climate solution: a review. *Ecol Solut Evid*. 2(3):e12090. <https://doi.org/10.1002/2688-8319.12090>

their harvest plans and the conditions that shape them than registries and buyers do.^{21, 22} Methodologies are built to accommodate a diversity of landowners and often favor flexible approaches that introduce variation in baseline credibility (e.g., developers select among several approaches, methods, and data for baseline development). Further, this information asymmetry exists within a structural conflict of interest, where landowners are incentivized to maximize crediting under the protocol's rules. To mitigate this conflict, buyers should seek credits that are generated under methodologies that incorporate independent, externally-specified data to quantify baselines and that contextualize project-specific counterfactuals. Theoretically, independent data is valuable because it allows registries, buyers, and their diligence partners to externally validate a developer's claims about how a forest would be managed in the absence of carbon finance. External data may not be an appropriate benchmark for every project, but it can ideally be used to identify when project-specific counterfactuals deviate from common practice, which can signal that additional scrutiny and project justification is required. Along these lines, methodologies that incorporate dynamic baselines hold promise for producing more accurate and credible crediting. We have noted below where it is prudent to introduce additional guardrails to improve or enhance baselines, and how we have observed these being implemented in some projects.

²¹ This challenge can lead to the problem that has been characterized as “adverse selection” throughout literature (see Haya et al., 2023). Landowners with a low likelihood of harvesting timber might be more likely to enroll in a forest carbon project. If the project's baseline is constructed based on the assumption of timber harvest that is actually unlikely, this leads to overcrediting.

²² Haya BK, Evans S, Brown L, Bukowski J, Butsic V, Cabiyo B, Jacobson R, Kerr A, Potts M and Sanchez DL. 2023. Comprehensive review of carbon quantification by improved forest management offset protocols. *Frontiers in Forests and Global Change*. 6:958879. <https://doi.org/10.3389/ffgc.2023.958879>

Table 1. Project-independent data used to establish and evaluate baselines

External data	Example data sets/methods	Primary use case
Common-practice stocking levels	Climate Action Reserve US Forest Protocol common-practice carbon stock estimates for the United States Forest Service Forest Inventory and Analysis Assessment Areas; ^a remote sensing analysis	Applying a conservative common-practice baseline constraint
Historical trends of comparable properties	Control parcel stock trends (selected under ACR IFM 2.1 Comparable Properties Analysis, <i>when management of control parcels is independent of the influence of the project owner and any affiliates</i>) ^b	Anchoring baseline harvest intensity to credible, external, independent observation
Operational and regulatory constraints	GIS data (e.g., slope, wetlands, roads, access); forest regulations; professional forester attestations	Confirming baseline feasibility
Market capacity	United States Forest Service Timber Products Output Interactive Reporting Tool; ^c commercial timber market research (e.g., Forisk Online Mill Capacity Database) ^d	Confirming baseline feasibility
Observed carbon performance	United States Forest Service Forest Inventory and Analysis (FIA) data	Benchmarking project performance relative to matched baseline/controls
Land use/harvest activity	Landscape Change Monitoring System; ^e Global Forest Watch data ^f	Independently verifying historic harvesting intensity

a. CAR. n.d. Assessment Area Data. <https://climateactionreserve.org/how/protocols/ncs/forest/assessment-area-data/>

b. Under ACR’s Tool for Comparable Properties Analysis, ACR. 2025. Tool for Comparable Properties Analysis. https://acrcarbon.org/program_resources/acr-improved-forest-management-methodologies-tool-for-comparable-properties-analysis/

c. United States Forest Service. 2025. Timber Products Output (TPO) Interactive Reporting Tool. <https://research.fs.usda.gov/products/dataandtools/timber-products-output-tpo-interactive-reporting-tool>

d. Forisk. 2026. North American Mill Capacity Database. <https://forisk.com/product/north-american-forest-industry-capacity-database/>

e. Housman IW et al. 2026. Coincident maps of changing land cover, land use, and forest condition in the United States, 1985-present. Sci Data. 13(1):575. <https://doi.org/10.1038/s41597-026-06743-0>

f. Global Forest Watch. 2014. World Resources Institute. <https://www.globalforestwatch.org/>

Challenges and Opportunities in Demonstrating Additionality

Beyond constructing a credible baseline, projects must demonstrate additionality. While a baseline describes forest biomass stocks, additionality reflects whether a project's expected climate impacts can be reliably attributed to proposed project activities or to other factors. The challenge of demonstrating additionality can be more pronounced in IFM than in afforestation, reforestation, and agroforestry projects (where demonstrating additionality requires confirming that the decision to plant trees in primarily non-forested areas is dependent on carbon finance). IFM projects are situated in already forested, managed landscapes, and buyers must be confident that the project's proposed management changes are dependent on receiving carbon finance. Foregone profits from counterfactual harvest scenarios are inherently more challenging to validate, which introduces uncertainty that project activities are motivated by carbon finance.

Registries address this through a set of formal additionality tests that require projects to demonstrate that activities are not legally mandated, exceed common practice in the region, and would not be financially viable without carbon revenue. These tests provide additionality assurance, but are still subject to the project specificity versus verifiability tradeoff described above. Common practice thresholds may be set too broadly to be meaningful for specific forests, financial additionality tests rely on projections that developers prepare and are therefore subject to the same conflict of interest and uncertainties as baseline construction, and regulatory additionality does not necessarily account for future regulatory requirements.

Buyer confidence in a project's additionality improves when project activities result in climate impacts that exceed what could plausibly be explained by market fluctuations, coincidental management shifts, or typical variation in harvest intensities from year to year. Practice changes can be measured in terms of carbon outcomes (e.g., changes in average rotation age or rotation age of selected stands) and strengthened by associated co-benefits (e.g., ecological or environmental uplift demonstrated through observable, specific, measurable shifts in management). For example, a rotation extension of one to two years across part of an industrial forestland is potentially explainable due to soft market conditions, but an extension of several or more years across most of that forestland, or more extreme and spatially-focused extensions (e.g., establishing permanent, no-harvest riparian buffers), becomes harder to rationalize under the economic logic of BAU. An important nuance is that the magnitude of the management change required to demonstrate additionality is dependent on baseline quality. A well-validated,

dynamic baseline that is built from the developer's own planning tools and is transparently presented provides a credible counterfactual from which to measure a project's carbon outcomes. By measuring carbon outcomes from a high-quality baseline, even a moderate practice change is a compelling demonstration of additionality. The magnitude of the management change (e.g. harvest reductions) also directly interacts with leakage risks, as we explore later in this report.

A landowner's management profile and history provide context for reinforcing additionality claims. Additionality is clearest where a project proposes new practices that diverge from the landowner's established practices and where the resulting carbon sequestration can plausibly be attributed to project activities. Landowners that have a history of managing forests to maximize net present value (NPV)²³ under BAU conditions (which decidedly does not optimize for carbon benefits) provide a more reliable context for an additionality assessment.²⁴ Their behavior is more predictable, their harvest decisions are more directly tied to financial conditions, and it is more plausible to attribute departures from BAU behavior aimed at improving carbon outcomes to carbon finance. Even where landowners do not explicitly manage for NPV, consistent and well-documented forest management behavior, particularly where that behavior is institutionalized in corporate structure, incentives, or long-term planning systems, can provide important evidence that IFM project activities satisfy additionality claims.

Projects that result in ecological uplift can further reinforce additionality claims by providing observable, corroborating evidence that project activities diverge from BAU management. Industrial forestlands managed to maximize NPV typically optimize for stand uniformity, rotation efficiency, and commercial species composition, which are conditions that constrain a forest's structural complexity, age-class diversity, and habitat value. Active ecological uplift can take two complementary forms: (1) integrating ecological structure directly into managed stands to accelerate structural development (e.g., through practices such as variable density thinning, retention forestry, and uneven-aged silviculture); and (2) setting aside higher-value areas from active management (e.g. through expanded riparian buffers, larger aggregated leave-tree patches, and deferred harvest focused on stands with high conservation value).

²³ NPV is the sum of all future cash flows from a managed forest, discounted to today's dollars.

²⁴ Actual behavior often reflects factors that may not be included in NPV modeling, such as harvest deviations to optimize cash flow or to manage labor and equipment constraints. The closer observed landowner behavior hews to an idealized model, the more that model will reliably inform a project's baseline.

When these approaches deliver measurable improvements relative to a baseline (e.g. increased structural heterogeneity, enhanced habitat for regionally threatened or declining species, improved ecosystem connectivity, recruitment of late-successional characteristics) the outcomes demonstrate a clear departure from BAU industrial forest management. Unlike financial additionality tests, which rely on developer-prepared projections, ecological uplift is externally observable through field inventories, remote sensing, and applicable third-party certification frameworks, such as the Forest Stewardship Council (FSC) Ecosystem Services Procedure,^{25, 26} and can be monitored over the crediting period.

Challenges and Tensions in Constructing Baselines

Credible baselines must resolve key issues related to their uncertainty and applicability over time, and the potential for exaggerating counterfactual harvests. Because methodologies quantify credits based on carbon stock changes from a project’s baseline, defining and building an accurate, project-specific baseline scenario is critical. Methodologies do this in a variety of ways. For most IFM projects on private industrial land in the US, methodological approaches to baselines mainly differ in their temporal mechanics (e.g., how they adapt over time in response to changing conditions; see **figures 1a-d**) and how they model the intensity of baseline timber harvests (**table 2**).

²⁵ The FSC Ecosystem Services Procedure is a voluntary framework where landowners can opt to demonstrate positive impacts from forest management on ecosystem services. The procedure can be used to demonstrate impacts from biodiversity conservation, carbon sequestration and storage, water services, soil conservation, recreational services, cultural practices and values, and air quality.

²⁶ Document | FSC Connect. [accessed 2026 July 6]. <https://connect.fsc.org/document-centre/documents/resource/316>

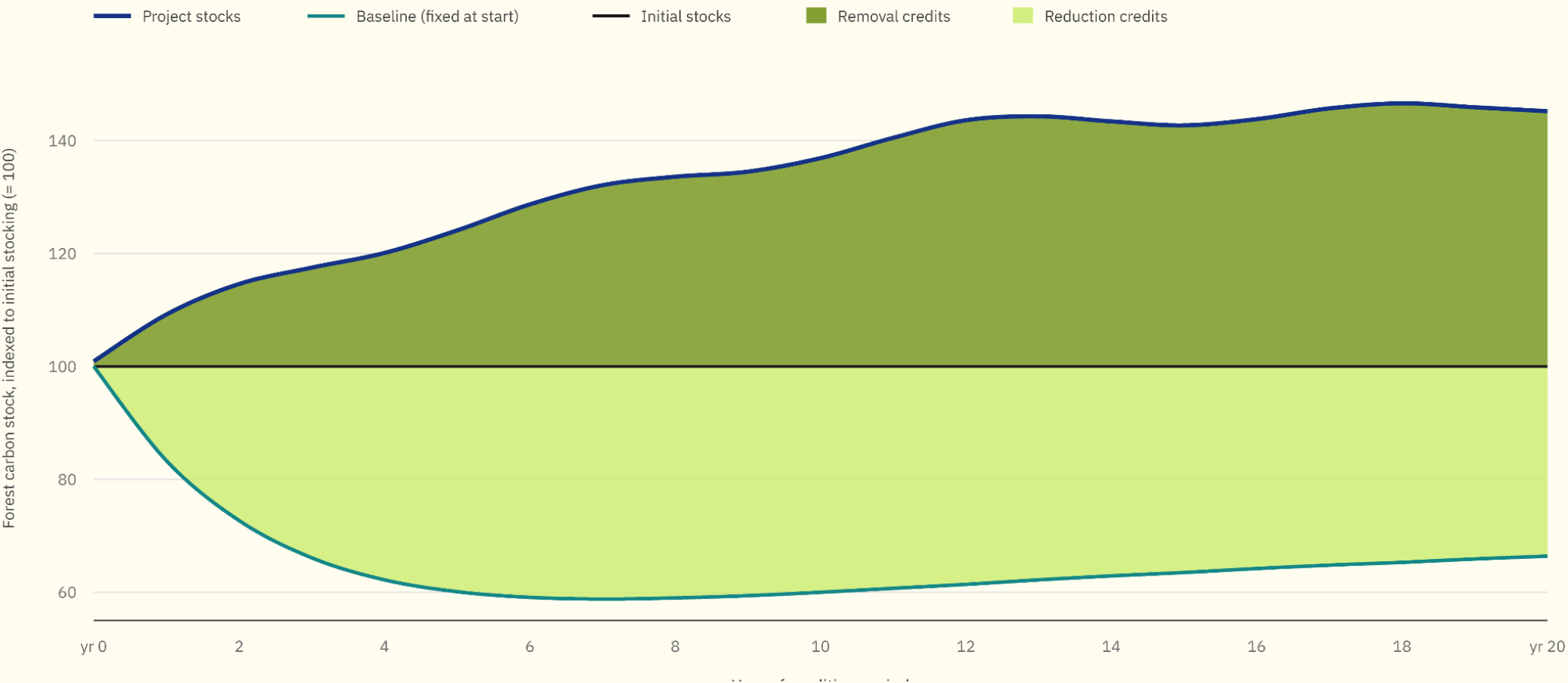


Figure 1a. Conceptual illustration of a modeled baseline (light blue line) that is fixed at project initiation. This represents an improved forest management (IFM) project that issues credits with no periodic reevaluation of the baseline. In this non-dynamically assessed baseline example, modeled baseline harvesting is front-loaded into the first few years, generating a combination of reduction credits (light green shading, between the baseline and initial stocks) and removal credits (dark green shading, for carbon sequestered above initial stocks). Historically, this type of baseline's precipitous early drop in carbon stocks, and the resulting front-loaded issuance of reduction credits, proved problematic, because it often reflected unrealistic harvest assumptions that were not observed across the broader landscape and risked overcrediting. Note: Forest carbon stocks are indexed to initial stocking (= 100). Source: Relae.

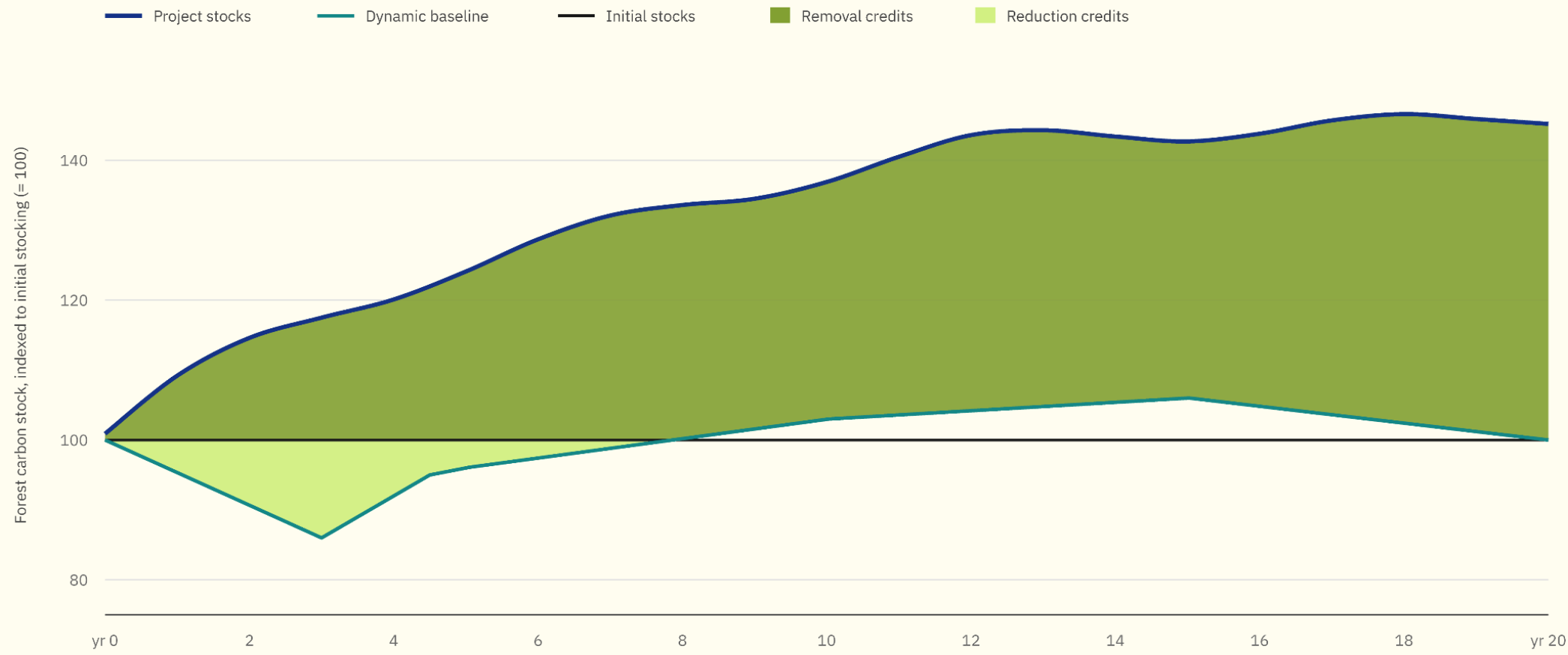


Figure 1b. Conceptual illustration of a dynamic baseline (light blue line) that adjusts over the crediting period. In this scenario, a planned forest stock drawdown (years 0-3) is interrupted by a mill closure that depresses timber demand, causing the baseline carbon stocks to rise. Dynamic re-evaluation over the crediting period limits overcrediting that may have occurred using a fixed baseline. Credited removals (dark green shading) represent the carbon stored above the adjusted baseline. Credited reductions (light green shading) represent avoided emissions from planned harvests. The dynamic baseline (light blue line) represents the ex post baseline at the end of the crediting period. Note: Forest carbon stocks are indexed to initial stocking (= 100). Source: Relae.

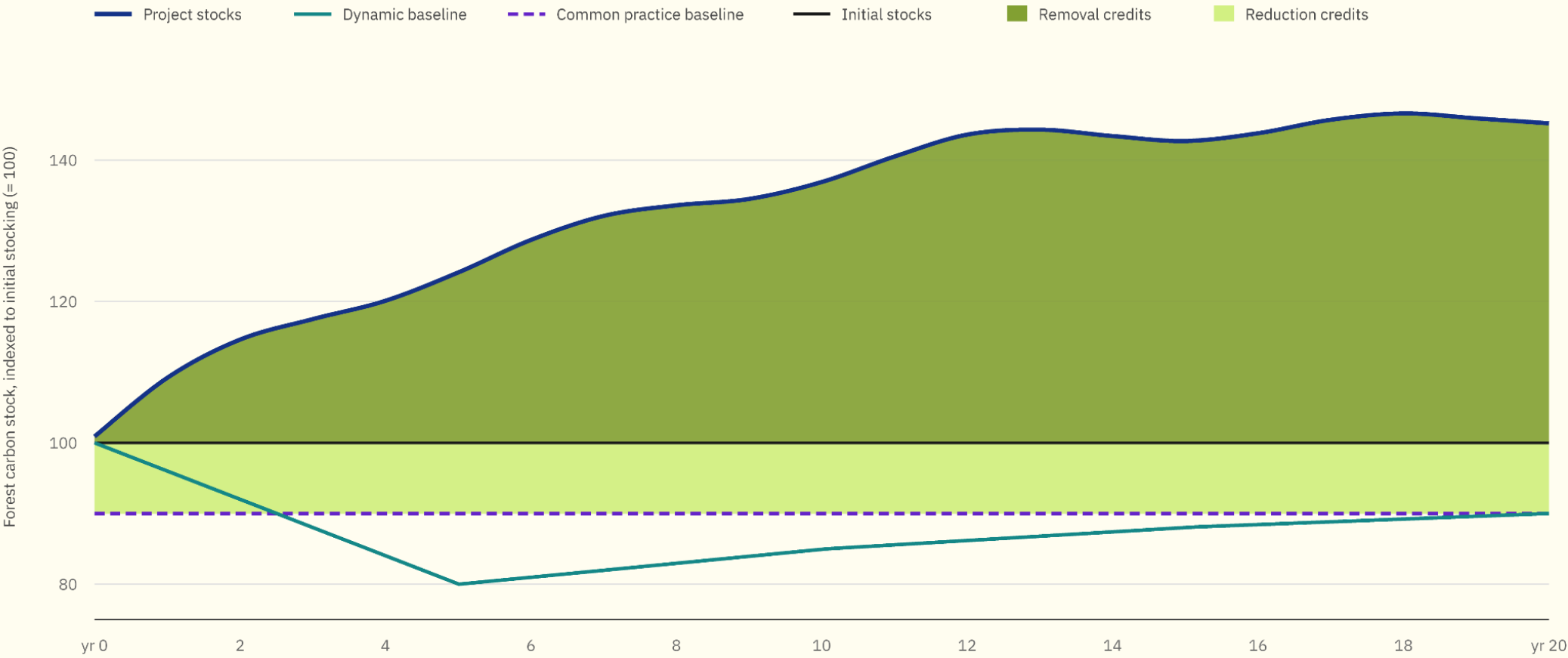


Figure 1c. Conceptual illustration of a dynamic baseline (light blue line) that is subject to a common-practice constraint (dashed line). Here, proxies for harvest intensity (e.g., mill capacity, legal constraints) lead to an updated baseline at periodic intervals (light blue line). The common-practice constraint acts as a conservative floor: reduction is credited only for stocks above the common-practice baseline, not for the additional gap down to the deeper dynamic baseline. Removal credits (dark green shading) continue to accrue for stocks above starting levels, while reduction credits (light green shading) are only credited for reductions above the common-practice floor. Note: Forest carbon stocks are indexed to initial stocking (= 100). Source: Relae.

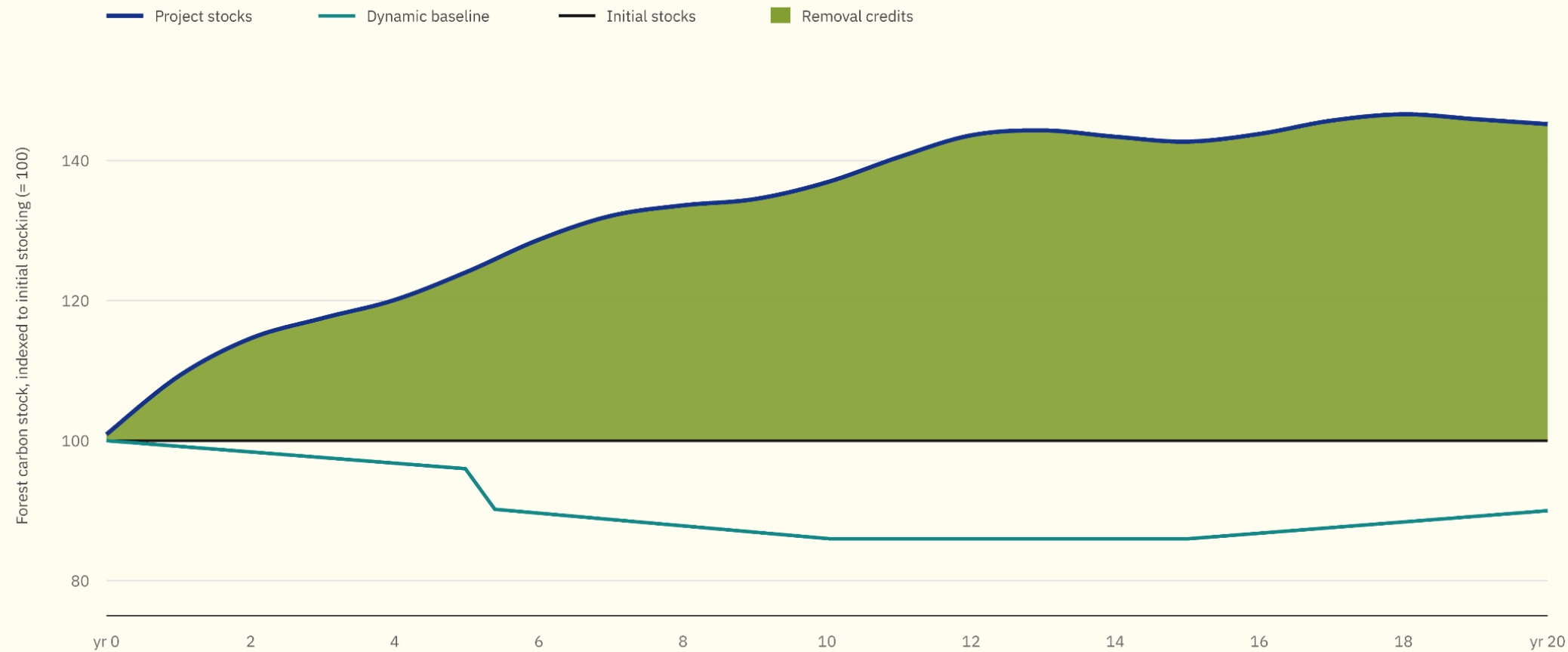


Figure 1d. Conceptual illustration of a dynamic baseline (light blue line) with a removals-only crediting approach. In this case, only removals above initial stocks are credited (dark green shading), despite observed increases in harvest intensity across control parcels that lower the dynamic baseline below initial stocks. Even where the dynamic baseline falls below the initial stock (black line) this conservative approach does not issue reduction credits. Note: Forest carbon stocks are indexed to initial stocking (= 100). Source: Relae.

Table 2. Improved forest management (IFM) baseline approaches

Baseline approach	Temporal mechanics	How the baseline is determined	Example methodologies and protocols
Baseline fixed for entire crediting period, barring major shifts in constraints	Fixed for crediting period	Baseline are determined at project initiation through modeling or estimates of business-as-usual carbon stocks, informed by some combination of harvest schedules that maximize net present value, initial carbon stocks, historic practices, Forest Management Plan harvest schedules, common practice and reference forest statistics, and applicable legal* and financial constraints. Baselines are generally not updated regularly (e.g. other than on decadal timescales) after project registration.	ACR IFM v2.0, ^a Climate Action Reserve Mexico Forest Protocol, ^b Climate Action Reserve US Forest Protocol, ^c Verra VM0003, ^d Verra VM0005, ^e Verra VM0010, ^f Verra VM0012 ^g
Periodic reassessment of key external conditions	Dynamic	Baselines are informed and justified with a combination of the above factors. Baseline assumptions are periodically re-assessed based on observed conditions (e.g., every reporting period at each verification before issuance).	ACR IFM v2.1 ^h
Dynamically matched baseline	Dynamic	Baselines are informed and justified with a combination of the above factors. Credit issuance is adjusted based on the relative carbon trajectory of matched control plots.	Verra VM0045, ⁱ Isometric IFM ^j

* Under some methodologies, the baseline must be recalculated if new legal constraints restrict modeled baseline harvests during the crediting period.

a. ACR. 2022. Improved Forest Management in Non-Federal US Forestlands, Version 2.0. [accessed 2026 Mar 31]. <https://acrcarbon.org/wp-content/uploads/2023/10/ACR-IFM-Non-Federal-v2.0.pdf>

b. Climate Action Reserve. 2022. Mexico Forest Protocol, Version 3.0. [accessed 2026 Mar 31]. <https://climateactionreserve.org/how/protocols/ncs/mexico-forest/>

c. Climate Action Reserve. 2023. US Forest Protocol, Version 5.1. [accessed 2026 Mar 31]. <https://climateactionreserve.org/how/protocols/ncs/forest/>

d. Verra. 2023. VM0003 Methodology for Improved Forest Management through Extension of Rotation Age, v1.3. [accessed 2026 Mar 31]. <https://verra.org/methodologies/vm0003-methodology-for-improved-forest-management-through-extension-of-rotation-age-v1-3/>

e. Verra. 2013. VM0005 Methodology for Conversion of Low-Productive Forest to High-Productive Forest, v1.2. [accessed 2026 Mar 31]. <https://verra.org/methodologies/vm0005-methodology-for-conversion-of-low-productive-forest-to-high-productive-forest-v1-2/>

f. Verra. 2024. VM0010 Methodology for Improved Forest Management: Conversion from Logged to Protected Forest, v1.4. [accessed 2026 Mar 31]. <https://verra.org/methodologies/vm0010-methodology-for-improved-forest-management-conversion-from-logged-to-protected-forest-v1-4/>

g. Verra. 2013. VM0012 Improved Forest Management in Temperate and Boreal Forests (LtpF), v1.2. [accessed 2026 Mar 31]. <https://verra.org/methodologies/vm0012-improved-forest-management-in-temperate-and-boreal-forests-ltpf-v1-2/>

h. ACR. 2024. Improved Forest Management on Non-Federal U.S. Forestlands, Version 2.1. [accessed 2026 Mar 31]. <https://acrcarbon.org/methodology/improved-forest-management-ifm-on-non-federal-u-s-forestlands/>

i. Verra. 2025. VM0045 Improved Forest Management Using Dynamic Matched Baselines from National Forest Inventories, v1.2. [accessed 2026 Mar 31]. <https://verra.org/methodologies/methodology-for-improved-forest-management/>

j. Isometric. 2026. Improved Forest Management, Version 1.0.1. [accessed 2026 Mar 31]. https://registry.isometric.com/protocol/improved-forest-management/1.0/ctn_1K5CR38P21S05DD7

Pathways to Credible Baseline Construction and Evaluation

To reconcile the tension between independent validation and project-specific realism, a hybrid approach to baseline construction and evaluation may support credibility. The following recommendations are tractable for buyers to request and for developers to implement, and are discussed further below:

1. **Developers must establish baselines that reflect institutional decision-making**, using consistent, integrated growth-and-yield and economic models (when applicable) in order to clearly demonstrate baseline credibility and additionality.
2. **Developers must model baselines using plausible and verifiable assumptions**, which may include robust historic harvest data, land-use planning records, initial carbon stocks, and land-use models or mapping.
3. **Where applicable, developers, buyers, and their diligence partners should benchmark modeled baselines against remotely sensed and other regional data** to assess whether they fall within a plausible range of observed practices, with any deviations requiring clear, evidence-based justification. To reduce overcrediting risk, developers can impose a common-practice baseline constraint that limits crediting to only carbon sequestered above average stocking levels found on similar properties.
4. **Registries and methodologies must require dynamically adjusted baselines** to ensure appropriate crediting and additionality across changing conditions.

1. Developers Must Establish Baselines That Reflect Institutional Decision-Making

One way to improve baseline credibility is through establishing project-specific modeled baselines that reflect the process through which the landowner actually makes management decisions. This can be combined with long-term data for enhanced inference, with a dynamic baseline that changes over time. In industrial timberland settings, many companies already rely on integrated economic and growth-and-yield models (e.g., United States Forest Service Forest Vegetation Simulator,²⁷ Woodstock²⁸) to develop long-range management plans. These models are used to optimize harvest timing, silvicultural treatments, and financial returns under BAU conditions. When these same models are used to define a baseline that excludes carbon revenue, they can provide a credible representation of

²⁷ United States Forest Service. n.d. Forest Vegetation Simulator. [accessed 2026 May 21].

<https://www.fs.usda.gov/managing-land/forest-management/fvs>

²⁸ Remsoft. 2026. Woodstock Optimization Studio. [accessed 2026 Jul 6]. <https://remsoft.com/woodstock-optimization-studio/>

what the landowner would have done in the absence of the project, particularly when historical data support consistent BAU management approaches. Critically, this approach is only valid if the modeling framework is demonstrably consistent with the tools and processes the company used prior to project implementation, rather than a bespoke model introduced solely for carbon accounting purposes. A consistent modeling framework can be used to simulate a project scenario by introducing a carbon constraint (e.g., requiring carbon stocks to increase by adjusting harvest rotation length to optimize for carbon stocking). This allows for a consistent comparison between BAU and carbon-optimized management. If both scenarios are generated using the same underlying model, data, and assumptions, the differences between them may be more plausibly attributed to carbon incentives, which could strengthen confidence in both the project's baseline and its additionality.

However, modeled baselines introduce their own challenges that leading methodologies strive to mitigate. Key assumptions must be transparent, rigorously validated (e.g., both plausible and likely given past management and corporate incentives), and regularly updated to reflect changing market and legal conditions (e.g., timber prices, operational costs, environmental regulations), as is already required under some existing methodologies. Recent methodologies are making progress toward ensuring this happens via more frequent recalculation of baselines and through observing conditions on other forest lands to better calibrate project baselines (e.g., ACR IFM 2.1 Periodic Modeling Assessment and Observed Conditions Assessment, as outlined in ACR IFM Methodologies Tool for Dynamic Evaluation of Baselines; ACR Comparable Properties Analysis). A supplementary external check on modeled baselines could include statistical evaluation of baseline assumptions (including harvest intensity) against benchmark forestlands at points where historic, project-specific data has diminished relevance (e.g., 5–10 years into the project cycle).

2. Developers Must Model Baselines Using Plausible and Verifiable Assumptions

For established industrial landowners with consistent historic management approaches, developers can initially anchor credible baselines in specific, project-relevant data. Developers can utilize recent Forest Management Plans (FMPs), created prior to carbon project development. FMPs are decision-support and forest policy tools²⁹ that describe stand-level silvicultural prescriptions over project-relevant timeframes (10–30 years) and are based on

²⁹ Brukas V, Sallnäs O. 2012. Forest management plan as a policy instrument: Carrot, stick or sermon? *Land Use Policy*. 29(3):605–613. <https://doi.org/10.1016/j.landusepol.2011.10.003>

landowner objectives. These may serve as a strong proxy for landowner intent to harvest under the macroeconomic and legal conditions present at the time the FMP was drafted, prior to implementing a carbon project. Weaknesses of relying on FMPs are that they are not always fully implemented (e.g., they do not necessarily serve as a perfect proxy for landowner intent and/or capacity to harvest),³⁰ they are not available for all landholdings (e.g. many industrial ownerships do not operate under consolidated FMPs, instead using a more flexible harvest allocation model), and they represent only a snapshot of a landowner’s intent, as they are typically not dynamically adjusted on the same timeframe as harvests might occur.

Developers can prioritize recent historic management, typically documented through harvest records and statistics. This constitutes strong evidence of historic intent and capacity to harvest. In some cases (e.g., clearcut harvests) and where reliable records are absent (see **box 1**), harvests can be externally verified through remote sensing analysis. In general, historical forest management is one of the best indicators of future management practices within landownerships.

Box 1. Baseline approach when relevant historic data is unavailable

Setting an accurate baseline when lands are newly acquired by a project, and a history of management by the current owner has not yet been established, is challenging because the ideal project-specific data may not be available. In these cases, developers must present a baseline that represents the likely counterfactual (e.g., if previously industrial lands were recently purchased, what would have most likely occurred in the absence of the acquisition). Buyers and their diligence partners must also place a greater focus on testing the plausibility of a project’s baseline against external, independent data, even if it is not project-specific.

Developers can evaluate initial carbon stocks on project lands and use them to verify that proposed baseline harvests are reasonable and realistic under prevailing regional management practices. Initial stocking helps inform the plausibility and expected quantity of near-term reduction credits (e.g., if starting stocks are very high relative to neighboring lands and common practice, this suggests that near-term harvests are potentially realistic to expect). Accurate measurement of initial carbon stocks also ensures that removals are correctly quantified. Any strong

³⁰ Estimating Management Plan Implementation in Northeast Wisconsin | Northern Journal of Applied Forestry | Oxford Academic. [accessed 2026 July 6]. <https://academic.oup.com/njaf/article-abstract/17/4/135/4788472>

deviation from starting stocks in the proposed baseline (e.g., immediate, large-magnitude harvests, or any baseline that significantly drops below common practice) must be supported with a compelling explanation (e.g., timber stocks are of a realistic age-class distribution for harvest; the parcel was recently purchased and now could plausibly fall under a more intense harvest regime to defray acquisition costs).

Check baselines against land-use models or operability and constraints mapping. Models using historical data can project and validate baseline harvest intensities,^{31, 32} and standard geographic layers can support baseline validation (e.g., layers demonstrating access, operational constraints like slope, and features tied to regulatory and environmental constraints such as wetlands or high conservation value habitat areas). Further, project data should confirm that project parcels are statistically representative of broader holdings and guard against gerrymandering (e.g., when project developers select sites for rotation extension that already have a low potential for or likelihood of harvest due to environmental and operational constraints).

3. Where Applicable, Developers, Buyers, and Their Diligence Partners Should Benchmark Modeled Baselines Against Remotely Sensed and Other Regional Data

Developers can use data on neighboring parcels' carbon stocks to constrain crediting and improve baseline credibility. Buyers and their diligence partners can independently evaluate the plausibility of modeled baselines using external data. Verifying the plausibility of modeled baseline harvest intensity is relatively straightforward for many large landowners (especially for timberland investment management organizations and real estate investment trusts) when they continue harvesting under BAU practices on nearby non-project lands. Methodologies are moving in this direction. ACR's recently developed Comparable Properties Analysis is an approach that requires projects to evaluate harvest intensity in neighboring forestland and, based on this, apply a ceiling to project baseline harvest intensity. Developers not using this specific methodology can justify the plausibility of modeled baselines by comparing them with actual, observed harvest intensities on non-project lands owned by the same landowner. Comparisons should be limited to similar forests under similar management objectives to ensure representativeness

³¹ Radeloff VC et al. Economic-based Projections Of Future Land Use In The Conterminous United States Under Alternative Policy Scenarios. (Faculty Scholarship. University of Puget Sound). [accessed 2026 July 6]. <https://jstor.org/stable/community.36602594>

³² Lewis DJ. 2010. An economic framework for forecasting land-use and ecosystem change. *Resource and Energy Economics*. 32(2):98–116 (Spatial Natural Resource and Environmental Economics). <https://doi.org/10.1016/j.reseneeco.2009.11.00>

using features such as proximity, ecoregion, age-class distribution, species composition, market factors, and intended products (**box 2**).

Box 2. Toward a common-practice baseline constraint

Moving toward a common-practice baseline constraint offers one way to improve baseline conservativeness by limiting credit issuance to reductions achieved above the average stocking found on comparable forest lands. To date, developers have pursued at least two concrete approaches in this direction. One is conceptually based on Climate Action Reserve’s US Forest Protocol default approach, under which developers can voluntarily impose a common-practice baseline constraint even if it is not specifically included in the project’s methodology. Another approach is to use remote sensing data and analysis to establish average stocking levels on comparable properties. Under either approach, it is essential that the data informing regional or comparable average stocking are representative of the project forests. An analysis of California’s offset program indicates that IFM projects can face significant overcrediting risks when project forests are non-representative or ecologically distinct from the regional forests used to determine baselines.³³ A common-practice constraint can help improve baseline conservativeness and reduce the risk of issuing unrealistic reduction credits that have historically affected the credibility of IFM projects.

Remote sensing can be helpful for independent verification of the project’s baseline management scenario. Landscape Change Monitoring System³⁴ and Global Forest Watch data³⁵ are useful for spatially explicit quantification and verification of clearcut harvest intensity in the US. In particular, remotely sensed spatial data is useful for confirming that the historical physical reality aligns with a project’s harvest records and other proxies for the claimed baseline harvest intensity. An advantage of this type of remote sensing data is that it can illuminate specific areas of a project’s holdings where harvest intensity has been significantly lower than the proponent’s historical average. This can uncover potential attempts at gerrymandering project activities to have them occur on the least operable locations (e.g., steep slopes or areas of poor drainage) or locations that are already at low risk of harvest

³³ Badgley G et al. 2022. Systematic over-crediting in California’s forest carbon offsets program. *Global Change Biology*. 28(4):1433–1445. <https://doi.org/10.1111/gcb.15943>

³⁴ Housman IW et al. 2026. Coincident maps of changing land cover, land use, and forest condition in the United States, 1985-present. *Sci Data*. 13(1):575. <https://doi.org/10.1038/s41597-026-06743-0>

³⁵ Global Forest Watch. 2014. World Resources Institute. <https://www.globalforestwatch.org/>

(e.g. ecologically sensitive). Unfortunately, the most accessible remote sensing data, 10-meter optical imagery, is not suitable for detecting and verifying some silvicultural treatments or lower-intensity harvest treatments that comprise part of many project's baseline scenario (e.g., historical thinning, single-tree selection, shelterwood harvest). These treatments require higher-resolution data products to reliably detect.

Current methodologies do not consistently allow or specifically define how remote sensing can be used in dynamic baselining, which can pose a barrier to its adoption.^{36, 37} At the same time, uncertainty in remotely sensed estimates of forest structure, combined with limited standardization in how that uncertainty is quantified and reported, continues to affect trust and adoption, although efforts are underway to build consensus on best practices.³⁸ Higher-quality datasets are often costly or inaccessible at scale and generally still have more uncertainty associated with them than the forest inventory data that large, industrial forestry companies already have on hand.

Emerging high-resolution datasets, such as sub-meter canopy height models,³⁹ may offer a pathway to remotely observe fine-scale management activities like selective harvesting and thinning. These tools also show promise for detecting more subtle forms of forest degradation and early structural changes that have historically been invisible to coarser datasets. As these technologies become more accessible and are available at higher temporal resolution, they could improve the transparency of baseline construction while reducing reliance on sparse field data.

In the longer term, advances in open data and remote sensing-based data modeling may help democratize access to IFM by enabling smaller landowners to participate at a lower cost globally. However, in the near term, effective deployment will likely remain concentrated among larger, data-rich industrial operators with the technical capacity to implement and validate these approaches against their more extensive, internal field inventories.

³⁶ In a notable exception, ACR recently published a framework for the remotely sensed quantification of forest carbon.

³⁷ ACR. 2026. Framework For Remotely Sensed Quantification of Forest Carbon. https://acrcarbon.org/program_resources/framework-for-remotely-sensed-quantification-of-forest-carbon/

³⁸ SHIFT-CM. 2026. SHIFT-CM: Advancing Scientific Integrity for Carbon Markets. <https://nature4climate.org/shift-cm/#:~:text=Q3%202025%20Update-,HUB%20MEMBERS,-Subscribe%20to%20our>

³⁹ Tolan J et al. 2024. Very high resolution canopy height maps from RGB imagery using self-supervised vision transformer and convolutional decoder trained on aerial lidar. Remote Sensing of Environment. 300:113888. <https://doi.org/10.1016/j.rse.2023.113888>

4. Registries and Methodologies Must Require Dynamically Adjusted Baselines

Dynamic baselines can ensure that changing conditions continue to inform future harvest trajectories and credit issuance. The introduction of dynamic approaches that update project baselines with external data is the most significant methodological advancement enabling baseline credibility. Project-specific historical data can credibly establish an initial baseline, especially when the baseline is independently evaluated by a qualified validation and verification body, but a fixed baseline cannot account for how changing conditions influence future harvest trajectories. Methodologies have begun to address the limitations of fixed baselines with dynamic approaches. For example, softening market conditions for harvested wood products could cause industrial forestland managers to reduce harvest under an evolving BAU scenario, even as a fixed baseline scenario would continue to assume historic harvest rates; this would lead to overcrediting.^{40, 41} How much confidence a dynamic baseline warrants depends on the approach used, the quality of the data behind it, and how it balances project-relevance with verifiable, independent data (**box 3**).

Box 3. Buyer checklist for dynamic baseline evaluation

Dynamic baselines use internal modeling, assumptions, and/or external data as a proxy for how the project would have behaved under business-as-usual conditions. In order to vet the quality of a project’s dynamic baseline, buyers can:

- **Identify the approach:** Identify the mechanism by which the baseline updates: (1) a project-produced model, re-run with updated assumptions, or (2) matched, comparable control forestlands, where crediting is adjusted against the carbon trajectory of the control. The first mechanism is project-specific and relevant but must be externally verified, whereas the second mechanism is more empirical and independent, but may lack project relevance.
- **Evaluate project relevance:** A model’s updated assumptions, and the data that underpins it, must reflect the drivers of project decision-making about forest harvest. Similarly, control areas in comparable forestlands must be well-matched in terms of proximity to mills and markets, species mix, age-class distribution, and ownership objectives. The choice of matching variables is therefore more important than the specific matching calculation or

⁴⁰ Independent monitoring of IFM projects (i.e., under Verra AR-CM-003-V01 and AR-AM001/version 02 methodologies) finds evidence of low additionality and overcrediting from unreasonably low, static baselines.

⁴¹ Yu R, Zhu Z, Qin S, Zhang D. 2026. Dynamic Ex-Post Baselines for Enhancing the Credibility of Improved Forest Management Carbon Offsets. Environ Sci Technol. 60(9):6885–6898. <https://doi.org/10.1021/acs.est.5c11387>

threshold, since statistical similarity alone cannot establish comparability if key drivers of management are omitted. Where those drivers are adequately represented, an absolute standardized mean difference of ≤ 0.25 provides a reasonable guideline for acceptable balance, consistent with the threshold used in VM0047.

- **Confirm independence:** Confirm that key data inputs come from independent, verifiable, unbiased sources, and that the protocol constrains which data and assumptions are allowed. Where developers choose (e.g., ACR Comparable Properties Analysis; updated modeling assumptions), look for transparent justification against public data.

Standards bodies and registries face the challenging task of designing methodologies that are both practical for landowners to implement and robust enough to ensure credible, reliable accounting for climate mitigation outcomes. Recent methodological innovations focus on two approaches that use updated assumptions and data to adapt baselines to external conditions:

- **Periodic reassessment of project baseline:** Methodologies that dynamically adjust baselines (e.g., ACR IFM v2.1) attempt to address the problem of outdated baselines. When conditions change from the initial baseline scenario (e.g., stumpage prices, laws and regulations, or market capacity for specific wood products), under this approach, developers can adjust ex post accounting and/or update baselines for future issuances. The approach has notable limitations. Data independence remains a concern, as methodologies allow developers to select the updated assumptions, reintroducing the same conflict of interest present in initial baseline construction. Unpredictable credit deliveries, should baseline assumptions change, complicate commercial planning for developers and buyers. This approach is only as reliable as the assumptions developers make about factors driving harvest decisions (e.g., market capacity, wood prices). If updated conditions do not reflect the actual factors influencing a specific landowner's behavior, updated baseline models may not be accurate or improve baseline credibility. Developers can improve the credibility of these periodic reassessments by justifying their selection of updated assumptions using publicly available data. Future iterations of methodologies could better limit conflict of interest by imposing more stringent guardrails around the types and sources of data used to inform and constrain baselines, particularly as robust third-party data becomes more available.
- **Dynamic adjustment of credits through matching statistics on comparable control forestlands:** Distinct from periodic reassessment of the baseline itself, some methodologies and protocols (e.g., Isometric IFM

Protocol, Verra VM0045) may dynamically adjust crediting based on carbon performance in matched, control forestlands. In theory, control forests face similar external conditions, and their observed, real-world, management responses to these conditions serve as an ongoing proxy for BAU behavior. This is conceptually similar to how researchers establish synthetic controls to evaluate carbon project performance.⁴² If matching is robust, dynamic baselines could extend credibility to project baselines where landowners historically did not manage for NPV, or in cases where ownership recently transitioned and a developer does not have relevant or extensive historic harvest records. However, this approach does have some weaknesses. The complexity of socio-ecological and economic systems, the inherent uncertainty of robust causal inference,⁴³ industrial IFM landowners that exhibit spatially-dependent objectives (e.g., influenced by proximity to specific mills and markets) can all present challenges under this approach. Control forestlands must be very well-matched to project forests to illustrate subtle divergences between project and control. External data, such as differences in the age-class distribution of trees within project lands versus on control sites, and US Forest Service Forest Inventory and Analysis (FIA) data (used for Verra VM0045 control data), is temporally misaligned with project activities and crediting,^{44, 45} which limits the value of adjusting ex post credits on more immediate timeframes (**box 4**).

⁴² West TAP, Börner J, Sills EO, Kontoleon A. 2020. Overstated carbon emission reductions from voluntary REDD+ projects in the Brazilian Amazon. *Proceedings of the National Academy of Sciences*. 117(39):24188–24194. <https://doi.org/10.1073/pnas.2004334117>

⁴³ Rana P, Fleischman F, Sharma A. 2026. Why carbon offsets may fail in complex systems: A causal inference perspective. *Environmental Science & Policy*. 176:104325. <https://doi.org/10.1016/j.envsci.2026.104325>

⁴⁴ FIA data is resampled on cycles of 5-7 years in the eastern US and 10 years in the western US. Most FIA estimates use a “temporally indifferent method” of combining observations over the resampling cycles, where estimates are not produced for a single year and there is a lag in observing trends.

⁴⁵ Westfall J, Coulston JW, Moisen G, Andersen H. 2022. Sampling and estimation documentation for the Enhanced Forest Inventory and Analysis Program: 2022. Gen Tech Rep NRS-GTR-207 Madison, WI: US Department of Agriculture, Forest Service, Northern Research Station 129 p. 207:1–129. <https://doi.org/10.2737/NRS-GTR-207>

Box 4. Opportunities and challenges with data independence and project-relevant dynamic baselines

US Forest Inventory and Analysis (FIA) data is an independent, external data source that can be used to benchmark a project's performance; it is systematically sampled, peer-reviewed, and publicly documented.⁴⁶ As the longest-running national forest inventory of its kind, FIA offers developers something no proprietary dataset can: a consistent, transparent, and freely accessible record of forest conditions and trends that allows baseline claims to be validated against data no project participant controls. Nevertheless, FIA data aggregates across a highly heterogeneous set of landowners, which can limit its use as a relevant project-specific baseline. In some regions (e.g., US Northeast), FIA plots may disproportionately reflect small, non-industrial landowners who are not managing forests to maximize net present value, making them a poor proxy for industrial timberland management. Critically, FIA data does not, by default, allow users to distinguish between industrial and non-industrial ownership types, even though recent literature reports that harvest intensities on commercially focused ownerships are higher than family ownerships across almost all regions of the US.⁴⁷ Even within industrial ownership, management objectives vary between companies, further complicating efforts to define a representative regional baseline. FIA data also do not, by default, include other key variables that strongly influence harvest rates such as operability (i.e., how physically or economically feasible it is to harvest a given area), property size, and the age-class distribution of trees. Less operable stands that are on steep slopes or in areas of poor drainage will have systematically lower harvest rates. Harvest rates are also highly dependent on the age structure of a forest, with older, merchantable stands driving higher harvest levels and younger, recently planted stands leading to lower harvest rates regardless of carbon project participation. Taken together, these limitations mean that, in some cases, FIA data may not adequately represent a project's business-as-usual baseline. These limitations call for using FIA thoughtfully, with appropriate filtering and complementary project-specific data, rather than not using it at all.

⁴⁶ Such as with Verra's VM0045 methodology.

⁴⁷ A Comparative Analysis of Forest Harvesting, Timber Supply, and Tree Planting across Regions of the United States. Resources for the Future; [accessed 2026 July 6].
<https://www.rff.org/publications/working-papers/a-comparative-analysis-of-forest-harvesting-timber-supply-and-tree-planting-across-regions-of-the-united-states/>

A third methodological approach, where project baseline modeling and crediting responds to external data, is the ACR IFM Tool for Comparable Properties Analysis.⁴⁸ Harvest intensity is a key constraint for modeling the baseline and issuing credits under this methodology.⁴⁹ Developers can opt to perform a Comparable Properties Analysis⁵⁰ to determine the appropriate harvest intensity from a selected nearby property with similar characteristics to the project area. This approach does not index on potentially non-representative regional data (a potential flaw with common-practice baselines), though it remains critical that the selected comparable property is a suitable match (i.e., harvest intensities on both properties respond similarly to external drivers) and that the selected property’s management and ownership is independent of the project itself (not a requirement of the tool). When the comparable property is conservatively selected, indexing on an observed rate of harvest can reduce the risk of using a baseline that predicts implausibly fast harvesting. Despite its utility, the Comparable Properties Analysis relies on a single data source that is selected at the project developer’s discretion, with only minor statistical guardrails and verifier review. The approach has an embedded conflict of interest because developers can select the most favorable property for comparison (i.e., the property with the most aggressive harvest intensity). Developers using this approach should transparently show and justify their parcel selection and select a property that is managed completely independent of the project landowner and any of its affiliates, with a comparable or lower historic harvest intensity to avoid overcrediting.

Key Takeaways for Buyers

- **Scrutinize additionality claims against the project's financial, operational, and regulatory context.**
Ask developers to show why the project’s proposed IFM practices would not have occurred absent carbon finance, and to include documentation of the counterfactual harvest scenario. If the baseline significantly drops below starting stocks the developer needs to provide compelling evidence to justify such a dramatic departure.

⁴⁸ ACR. 2025. ACR Improved Forest Management Methodologies: Tool For Comparable Properties Analysis. [accessed 2026 Jul 6]. <https://acrcarbon.org/wp-content/uploads/2024/07/ACR-IFM-Tool-for-Comparable-Properties-Analysis-v1.1-2025.09.29.pdf>

⁴⁹ For projects utilizing the Comparable Properties Analysis, harvest intensity is determined and the baseline is remodeled so that the baseline harvest intensity does not exceed observed harvest on the comparable non-project property.

⁵⁰ Other options to determine harvest intensity for modeled baselines under ACR IFM v2.1 include using a Forest Management Plan and adopting a removals-only baseline. Neither of these options dynamically adjusts harvest intensity in response to external observations of performance.

- **Prioritize projects with dynamic, regionally calibrated baselines.** Static or overly broad baselines remain the single biggest driver of overcrediting risk; look for projects using updated ACR IFM v2.1 approaches, or equivalent.

Key Takeaways for Developers

- **Build and preserve a defensible additionality case.** Document the counterfactual harvest scenario alongside the financial, regulatory, and operational context that makes the project's proposed IFM practices a departure from BAU. Treat this documentation as a living record throughout the project lifetime.
- **Model baselines using defensible, project-specific data, and benchmark against reliable external data.** The strongest baselines are defensible because they represent what a specific landowner was likely to do, but are also plausible when compared against what comparable landowners actually choose to do.
- **Impose a common-practice baseline constraint.** To limit unrealistic, near-term, reduction credits (overcrediting is historically a cause for concern), impose a common-practice baseline constraint that limits crediting to carbon sequestered above average stocking on comparable properties.
- **Invest in dynamic, regionally calibrated baselines from the outset.** Static or overly broad baselines are the leading source of buyer skepticism; using updated ACR IFM v2.1 approaches, or equivalent, positions a project to withstand diligence and command stronger credit pricing.

Leakage

Assessing the climate integrity of IFM projects includes quantifying a project's potential leakage impact and determining whether deductions taken for leakage are adequate. This can be challenging because market leakage depends on largely unobservable harvesting decisions of many third-party suppliers responding to project-induced price signals across integrated global timber markets. Scientific advancements and current methodological approaches are making progress toward capturing and understanding leakage as a complex, system-wide phenomenon. Leakage is generally divided into two forms: activity-shifting leakage, where landowners increase harvest elsewhere on their own lands to compensate for project activities that reduce harvest; and market leakage, where reduced harvest and wood product supply in one location leads to increased harvesting elsewhere through

price-mediated market responses. While activity-shifting leakage is theoretically more traceable through project-level safeguards, market leakage is systemic and more challenging to address. We discuss these two leakage types in more detail in the sections below. Methodologies deduct credits to account for the reality that IFM projects may cause leakage by displacing harvest activity outside of the project area, thereby offsetting some portion of the project’s climate benefits. Although leakage cannot be fully mitigated by individual projects, conservative estimations and deductions can increase buyer confidence in project quality.

Recent scientific literature emphasizes the need to move beyond harvest-based proxies toward more holistic carbon accounting frameworks that capture the full socio-ecological system response to IFM interventions. In particular, Daigneault et al. (2025)⁵¹ demonstrate that carbon leakage is fundamentally a market mediated carbon outcome, not simply a displacement of timber volume, and that narrowly scoped, harvest-based approaches can misrepresent both the magnitude and direction of leakage effects. Carbon leakage is not static over the life of a project. In the years immediately following a harvest reduction, leakage is typically high as market participants replace foregone supply; over longer periods, future harvests within the project area can offset some of that early displacement, and leakage measured on a cumulative basis can fall. In this paper, we generally assess leakage as a cumulative quantity averaged over a project's crediting period (typically 20 years), because this is the time period over which buyers and developers make climate mitigation claims. **Box 5** provides key definitions for use in forest carbon leakage accounting with a supporting diagram and brief discussion.

Box 5. Defining leakage rates, deductions, and deduction factors in forest carbon accounting

A clear understanding of leakage accounting is challenged by the lack of conceptual and methodological consistency across protocols, particularly in how leakage is defined, measured, and translated into crediting adjustments. In this paper, we use the following definitions (also see the diagram included in this box):

- **Carbon leakage:** Following Daigneault et al. (2025) we, by default, mean “carbon leakage” when we refer to “leakage rate,” which is defined as the percent of a project’s carbon benefits that are reduced or enhanced by activities on non-project lands that occur in response to reduced harvesting on project lands.

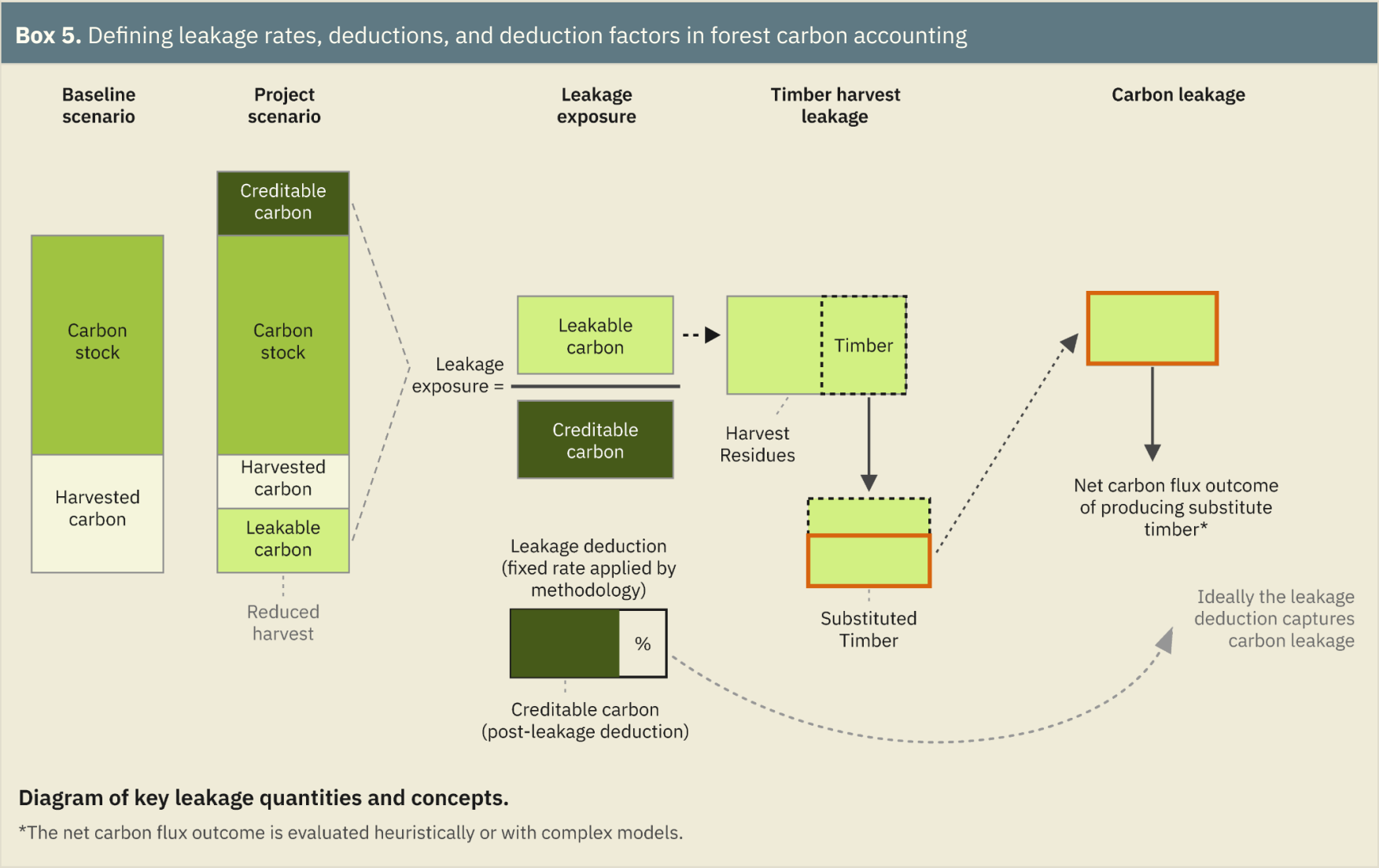
⁵¹ Daigneault A, Sohngen B, Belair E, Ellis PW. 2025. A globally relevant data-driven assessment of carbon leakage from forestry. Environ Res Lett. 20(11):114022. <https://doi.org/10.1088/1748-9326/ae0ce2>

Box 5. Defining leakage rates, deductions, and deduction factors in forest carbon accounting

- **Leakable carbon:** The pool of carbon that is no longer being emitted from project lands due to harvest reductions, and that could be emitted elsewhere because of the project.
- **Leakage deduction:** A multiplier applied to creditable carbon to reduce issued credits for some projects (e.g., the 30% leakage deduction used by ACR IFM v2.1).
- **Leakage exposure:** The size of the leakable carbon pool relative to the creditable climate benefit.
- **Leakage liability:** The number of credits deducted from the creditable carbon pool.
- **Timber harvest leakage:** Following Daignault et al. (2025), we define this as “a shift [i.e., substitution] in harvested wood volume.”

Several distinctions are critical: (1) a substitution in reduced timber harvest is not the same as carbon leakage, which is mediated by a complex socio-ecological response to project activities that is likely impossible to definitively track, (2) crediting adjustments (e.g., leakage deductions), on the other hand, define a methodology’s approach to project-level crediting, (3) conflating these concepts or applying simplified relationships between them can lead to both under- and over-estimation of leakage liability.

For example, a project may reduce timber harvest by 100 units, which could be substituted by 80 units from another supplier. This should theoretically translate to a leakage deduction of 80% (80/100). However, if the project generates 300 units of carbon credits over the same time period, the leakage deduction would be 27% (80/300). Importantly, a methodology’s leakage deduction attempts to capture the true carbon leakage rate, but is not necessarily the same as real-world leakage because a variety of factors (e.g., carbon intensity of substituted timber, ecological factors) could result in differences.



Activity-Shifting Leakage: Challenges and Potential Pathways

Current methodologies employ a range of safeguards, including certification requirements, monitoring of unenrolled lands, and attestation-based approaches to guard against activity-shifting leakage. These mechanisms seek to attribute increased harvesting on unenrolled land to project activities with the goal of monitoring and curtailing activity-shifting leakage through time.

An IFM program should hold boundary polygon data for all properties held by a participating entity, so that harvest intensity can be tracked through time on the project proponent's holdings. However, tracking harvest rates alone is insufficient to detect leakage, as variations may reflect normal forest management dynamics rather than project-induced behavior. Harvesting decisions are influenced by a wide range of factors, including timber prices, inventory, and age-class distribution. Although sustainability certifications (e.g., Sustainable Forestry Initiative, FSC) can minimize the environmental degradation associated with industrial forestry, they are an insufficient safeguard against activity-shifting leakage because they are generally not the limiting factor on harvest intensity for most developers.

A more robust approach would be data-driven monitoring frameworks that contextualize harvesting behavior relative to key drivers, such as price signals and inventory conditions. This would involve requiring developers to use historical data to establish relationships between harvest intensity and its key drivers, such as timber prices, inventory levels, and age-class distribution, and then test whether those relationships remain stable after project implementation. For example, developers would explore building a simple quantitative model (e.g., regression) linking harvest rates to these variables, periodically re-estimate model parameters post-project, and flag any systematic shifts that would suggest higher-than-expected harvesting under similar conditions. This analysis would be complemented by comparing actual harvesting against pre-project management plans (e.g., long-range plans) on non-project lands, and require explanation of any deviations. These assessments would be conducted at regular intervals (e.g., every three to five years) to balance statistical robustness with timely detection of potential leakage.

Market Leakage: Current Challenges

Market leakage presents a challenge for assessing the climate integrity of IFM projects, but ongoing work in the scientific literature and methodology development is making progress toward addressing three key difficulties: observation and attribution, making conservative deductions, and conceptual inconsistencies in market leakage definitions.

Market leakage is hard to observe and attribute but economic modeling may help. A central challenge in quantifying market leakage is that it cannot be directly observed or measured. Market leakage arises from distributed behavioral responses across global timber markets, making it difficult to isolate causal effects at the project level. Causal inference approaches face significant limitations, including difficulty in defining counterfactual harvesting behavior and isolating project effects in a system influenced by many external variables, such as commodity prices and macroeconomic conditions.

As a result, market leakage rates are fundamentally model-dependent estimates, rather than empirically observed quantities. Models such as the Global Timber Model (GTM) represent an important step forward in being able to quantify market leakage by incorporating dynamic market and ecological processes. Their core logic is based on fundamental forest market principles, but these tools are still in incipient stages of application to IFM credit quality and risk assessment. The way they are applied to IFM projects requires further validation and investigation of their decision relevance for buyers interested in quality.⁵² Buyers face the conundrum that leakage must be accounted for, but the methods used to estimate it are diverse, complex, and evolving.

Methodologies are evolving toward more conservative leakage deductions, but approaches need to capture more context and complexity. Methodologies commonly need to rely on simplified leakage deductions that are not well aligned with the complexity of the underlying system. Methodology-level market leakage deductions are frequently prescribed as fixed percentages or derived from empirically-derived averages that are not sensitive to project-specific conditions. For example, CAR Mexico Forest Protocol applies a default 20% market leakage rate to

⁵² Daigneault A, Sohngen B, Belair E, Ellis PW. 2025. A globally relevant data-driven assessment of carbon leakage from forestry. *Environ Res Lett.* 20(11):114022. <https://doi.org/10.1088/1748-9326/ae0ce2>

harvest reductions from a pre-project baseline,⁵³ while ACR IFM v2.1 and Verra VM0045 link leakage deductions to the magnitude of harvest reductions and the ratio of merchantable stocking to total stocking. These approaches may capture some aspects of leakage risk but do not reflect the full range of socioeconomic and ecological drivers identified in the literature. In a move toward a more comprehensive market leakage accounting framework Isometric IFM is using the updated version of the GTM from Daignault et al. (2025), and we anticipate that Verra may also move in this direction as they develop a new leakage accounting tool.^{54, 55}

The scientific literature itself presents a wide range of leakage estimates, highlighting methodological variability and context-dependence of leakage outcomes. Studies in the US have found leakage rates (typically conceptualized as timber harvest leakage) of over 80%,^{56, 57} while in other contexts, such as Bolivia, studies show much lower rates of 2–38%.⁵⁸ These differences are driven by factors such as market integration, supply elasticity, and forest type, suggesting that a single default leakage factor is unlikely to be appropriate across all projects and regions.

For buyers, this creates a critical tension. While methodologies provide standardized leakage deductions, due to the need to create broad enough applications of methodologies with limited real-world quantification tools, their adequacy is uncertain, and their relationship to real-world leakage risk is unclear. Buyers purchase from a single project, not from a registry average. That means project-level leakage realism, not the registry deduction, is what determines whether a buyer's projected tonnes are conservative, and there may be projects where the buyer needs

⁵³ CAR Mexico Forest Protocol uses a default market leakage rate of 20%, but projects may opt to calculate a higher, project-specific leakage rate by comparing cumulative project harvest volume with cumulative baseline harvest volume.

⁵⁴ Verra Outlines Steps to Strengthen Improved Forest Management Methodologies. 2023. Verra; [accessed 2026 July 6]. <https://verra.org/verra-outlines-steps-to-strengthen-improved-forest-management-methodologies/>

⁵⁵ The Integrity Council for the Voluntary Carbon Market. 2025. Observations in Relation to Category Assessment. [accessed 2026 July 6]. https://icvcm.org/wp-content/uploads/2025/08/Board-Observations_IFM.pdf

⁵⁶ Wear D, Murray BC. 2004. Federal timber restrictions, interregional spillovers, and the impact on US softwood markets. *Journal of Environmental Economics and Management*. 47(2):307–330. [https://doi.org/10.1016/S0095-0696\(03\)00081-0](https://doi.org/10.1016/S0095-0696(03)00081-0)

⁵⁷ Gan J, McCarl BA. 2007. Measuring transnational leakage of forest conservation. *Ecological Economics*. 64(2):423–432 (Special Section - Ecosystem Services and Agriculture). <https://doi.org/10.1016/j.ecolecon.2007.02.032>

⁵⁸ Sohngen B, Brown S. Measuring leakage from carbon projects in open economies: a stop timber harvesting project in Bolivia as a case study. *Canadian Journal of Forest Research*. 2004 [accessed 2026 June 17];34(4):829–839. <https://doi.org/10.1139/x03-249>

to request a larger leakage deduction than the registry requires. Current approaches may result in both overcrediting and undercrediting, depending on the project.⁵⁹

Conceptual inconsistencies in defining leakage can and should be addressed. A third challenge is the lack of consistent definitions and units for leakage across methodologies and the literature. Leakage is sometimes defined in terms of harvested wood volume, sometimes in terms of carbon, and sometimes as a percentage of project benefits. These differences complicate comparisons across studies and make it difficult to translate leakage estimates into crediting decisions.

Recent literature has emphasized the importance of focusing on carbon leakage, rather than timber harvest leakage, because changes in harvest volumes do not map cleanly onto atmospheric carbon outcomes. However, given the complex modeling infrastructure and expertise required to quantify carbon leakage outcomes in GTM and other models, methodologies must still largely rely on harvest reductions in calculations, which may misrepresent the true climate impacts of a leakage scenario. This disconnect between conceptual definitions and methodological implementation remains a key barrier to widespread, consistent, and credible leakage accounting.

Pathways to More Accessible Risk Evaluation for Market Leakage

We hypothesize that framing project-specific leakage risk as: (1) exposure to leakage, or the ratio of the project's leakable carbon pool to its total creditable carbon, and (2) qualitative leakage risk factors as determined via a heuristic assessment (**table 3**) will help move buyers toward a more structured, interim, decision-relevant screening approach (**box 6**). We recommended using this approach until more complex leakage modeling (e.g., the GTM) is more project-specific, widely available, and tested.

⁵⁹ Haya B. 2019. POLICY BRIEF: The California Air Resources Board's U.S. Forest offset protocol underestimates leakage. [accessed 2026 Jul 6]. https://gspp.berkeley.edu/archived/files/research/pdf/Policy_Brief-US_Forest_Projects-Leakage-Haya_4.pdf

Box 6. Important questions for buyers to consider when evaluating market leakage risk

Is the leakable carbon pool (i.e., the harvest reduction) large relative to the project's total creditable carbon pool? Do the project and the affected timber markets exhibit characteristics associated with high leakage risk (**table 3**)? If the answer to both of these questions is yes, then the project likely has higher market leakage risk and a higher market leakage deduction may be warranted.

1. Bounding Leakable Carbon and Heuristically Assessing Market Leakage Risk Rate

While complex socioeconomic-ecological modeling offers the most sophisticated framework for holistically quantifying leakage, its complexity and limited accessibility for quality screening mean that buyers and project evaluators need more practical, decision-oriented tools to assess market leakage risk in the near term. We propose an approach that first evaluates how large the pool of leakable carbon is in proportion to the project's total climate benefit, and then determines the likelihood of harvest substitution using a more holistic set of economic, heuristic indicators of leakage risk (**table 3**).⁶⁰ Together, these steps could provide a structured way to assess leakage risk early in the project evaluation process without requiring complex modeling, until more sophisticated frameworks become more widely accessible.

A guiding principle in defining leakable carbon is that leakage does not apply to all project carbon gains, but only to the portion of the project that reduces timber supply.⁶¹ Only the carbon associated with reduced harvest can plausibly be replaced by other producers and is therefore the only portion that can contribute to market leakage. By contrast, additional carbon stored through continued tree growth represents a broader climate benefit that is not directly subject to substitution. This distinction enables a more precise framing of market leakage risk and provides a natural, upper, conservative bound on potential market leakage impacts.

Identifying the leakable carbon pool enables an early and informative comparison between the size of the project's leakable carbon pool and the project's total carbon benefits. Projects where the pool of carbon in the reduced

⁶⁰ Leakage accounting in any IFM project is ultimately governed by the registry methodology under which the project is registered (e.g., ACR IFM 2.1, CAR Mexico Forest Protocol, Verra VM0045). The heuristic framework we present in this section, and demonstrate in [Appendix A](#), is intended to be compatible with these methodology-specific requirements rather than a replacement for them.

⁶¹ This logic is embedded in the market leakage deduction equations of some registries (e.g., Verra VM0045 and CAR Mexico Forest Protocol).

harvest is proportionally large compared to the total creditable carbon (e.g, 78% as shown in [Appendix A](#), Scenario 1) carry greater exposure to market leakage risk. In such cases, a conservative leakage deduction will be very high and buyers and developers should reconsider the commercial viability of the project. Projects with higher market leakage risk tend to be those with slower growing forests, where incremental carbon accumulation is limited relative to the reduction in harvest. Conversely, projects where the harvest reductions are proportionally small compared to the growth of the remaining timber (e.g., 29% as shown in [Appendix A](#), Scenario 2), are less exposed to market leakage risk (**box 7**).

Box 7. Project siting considerations for developers

Considering how large the leakable carbon pool is relative to total project carbon benefits could help developers determine if they have meaningful levers to reduce leakage at the project design stage. Siting projects in regions with higher forest growth rates should generally lower the ratio of leakable carbon to the total project climate benefit. Calibrating harvest reductions to be large enough to demonstrate a quantifiable deviation from the business-as-usual scenario, but still small enough to limit market-replacement pressure helps keep both the additionality case and the leakage risk within defensible bounds.

These siting levers can interact with durability risk, which this paper does not treat in depth: depending on the ecological and management context, maintaining higher carbon stocks over multi-decade crediting periods can increase exposure to reversal from wildfire, pests, pathogens, and drought, and regions attractive for low leakage exposure will not always be those with lower reversal risk. Developers should weigh reversal exposure alongside leakage when screening candidate sites, and buyers should expect projects to address both.

2. Heuristic-Based Assessment of Market Leakage Rates

The literature identifies several key drivers that can be used to develop a qualitative, heuristic-based assessment of immediate market leakage impacts (**table 3**).⁶² Highly commoditized, integrated timber markets in areas of active trade are often associated with higher market leakage risk, because non-project timber supply can be more

⁶² Here we focus on short-term market leakage effects. However, over decadal timescales, there is the potential for positive spillover effects to ameliorate market leakage risk (e.g., land use change as a response to increased carbon prices resulting in increased forest area).

responsive to price increases and timber products can be readily substituted across regions and suppliers.⁶³ Conversely, in less efficient systems and markets, market leakage risk is likely lower because supply is less responsive, less substitutable,^{64, 65} and more likely to shift to production systems that are less carbon intensive.⁶⁶ Some of these risk factors will likely vary systematically across regions and project types, which could further simplify a heuristic scoring framework that categorizes projects as having higher or lower market leakage risk (e.g., faster-growing forests having lower risk and slower-growing forests having higher risk). However, the scientific community's understanding of the complex interactions that ultimately affect market leakage rates for IFM projects is still nascent. The field requires more ex post empirical studies that can plausibly attribute shifting management behavior to IFM-induced market leakage. These studies will be important in evaluating specific, model-based, market leakage estimates (e.g., from the GTM).⁶⁷ It is, therefore, premature to classify entire regions as having uniformly high or low market leakage risk based on our current understanding. Instead, we believe these heuristics are best applied at the project level, where local conditions, product types, and market dynamics can be more carefully considered.

Market leakage risk can be understood as a function of various factors: the magnitude of the market shock, forest growth rates, merchantability, and market context. **Table 3** summarizes key indicators of relative market leakage risk.

⁶³ Murray BC, McCarl BA, Lee H-C. 2004. Estimating Leakage from Forest Carbon Sequestration Programs. *Land Economics*. 80(1):109–124. <https://doi.org/10.2307/3147147>

⁶⁴ Pan W, Kim M-K, Ning Z, Yang H. 2020. Carbon leakage in energy/forest sectors and climate policy implications using meta-analysis. *Forest Policy and Economics*. 115:102161. <https://doi.org/10.1016/j.forpol.2020.102161>

⁶⁵ Haya BK et al. 2023. Comprehensive review of carbon quantification by improved forest management offset protocols. *Front For Glob Change*. 6 [accessed 2026 July 6]. <https://doi.org/10.3389/ffgc.2023.958879>

⁶⁶ Daigneault A, Sohngen B, Belair E, Ellis PW. 2025. A globally relevant data-driven assessment of carbon leakage from forestry. *Environ Res Lett*. 20(11):114022. <https://doi.org/10.1088/1748-9326/ae0ce2>

⁶⁷ Daigneault A, Sohngen B, Belair E, Ellis PW. 2025. A globally relevant data-driven assessment of carbon leakage from forestry. *Environ Res Lett*. 20(11):114022. <https://doi.org/10.1088/1748-9326/ae0ce2>

Table 3. Project factors associated with high and low market leakage risk

Factor	Higher market leakage risk	Lower market leakage risk
Implementation rate/market shock*	Areas with large implementation rates;** large reductions in timber harvest	Areas with small project implementation rates; limited reductions in timber harvest
Ratio of total forest biomass to merchantable biomass	Harvest likely to shift to areas with a higher ratio of total biomass to merchantable biomass, raising emissions per unit of wood harvested	Harvest likely to shift to areas with a lower ratio of total biomass to merchantable biomass, lowering emissions per unit of wood harvested
Market context	Highly connected global markets; shifts to less efficient production systems	Isolated or localized markets; shifts to more efficient production systems
Product substitutability	Commoditized products; highly substitutable across suppliers	More differentiated or less substitutable products
Forest production (growth rates)	Slower growth; smaller total carbon gains relative to harvest reductions	Faster growth; larger total carbon gains relative to harvest reductions

* Market shock can affect leakage in opposing directions: the price rise from withdrawn project supply both suppresses demand (lowering leakage, in proportion to demand elasticity) and can induce additional harvest elsewhere (raising leakage, in proportion to non-project supply elasticity), with the net outcome determined by the relative elasticities. We believe it is more conservative for project-specific leakage accounting to assume the supply is more elastic. ** Implementation rate is the IFM enrollment concentration (i.e., the land area held in carbon projects) within the procurement basin.

Areas for Further Development

While the approach described above (and further illustrated in [Appendix A](#)) provides a practical, conservative, and transparent way to qualitatively assess market leakage risk, we exclude further consideration of several important dynamics that are expected to ameliorate leakage risk over decadal timescales. In particular, this framework does not explicitly account for the fact that leakage emissions are expected to be offset over time through accelerated regrowth, nor does it capture the potential for positive spillover, where market responses lead to net increases in global carbon stocks. Land use change, as a response to increased carbon prices, can result in increased forest area; and a recent modeling study of leakage found that negative leakage occurs when market and ecological responses to reduced harvest, such as increased investment in forest management, cause a shift to more efficient production systems.⁶⁸ Collectively, these responses could more than offset emissions from displaced harvesting. In these cases,

⁶⁸ Daigneault A, Sohngen B, Belair E, Ellis PW. 2025. A globally relevant data-driven assessment of carbon leakage from forestry. *Environ Res Lett.* 20(11):114022. <https://doi.org/10.1088/1748-9326/ae0ce2>

higher timber prices incentivize behaviors that increase forest carbon stocks outside the project area, including afforestation, intensification, and longer-term productivity gains. Modeling results indicate that, as these effects accumulate over time, managed forests store more carbon than they would have without the project, resulting in a net climate benefit beyond the project boundary. A limited number of modeling studies indicate that these factors could be important for net climate impacts in the long term.^{69, 70, 71} However, they are currently difficult to integrate into a conservative, project-specific, risk-based heuristic framework for evaluating market leakage, because they rely on assumptions about the future of a complex, global, socio-ecological system.

Key Takeaways for Buyers

- **Screen for market leakage exposure before evaluating the more challenging aspects of leakage risk.** Start by asking how large the leakable carbon pool is (i.e., carbon tied to reduced harvest) relative to the project's total climate benefit. Projects where this ratio is high (e.g., slower-growing forests with larger harvest reductions) will often carry greater market leakage exposure regardless of the registry default rate.
- **Consider key qualitative indicators of market leakage risk (table 3).** Include the degree of timber market integration, the substitutability of the project's wood products across suppliers and regions, and the carbon project implementation rate. Additional considerations include forest productivity characteristics, such as the ratio of total biomass to merchantable biomass, which governs emissions per unit of displaced harvest.
- **Require additional leakage deductions when methodology defaults are inadequate for the project.** Registry defaults are improving, but they still rely on flat percentages or limited heuristics. Where project conditions point to higher real-world market leakage, buyers can negotiate a larger project-specific deduction or purchase additional credits to cover the potential gap.

⁶⁹ Daigneault A, Sohngen B, Belair E, Ellis PW. 2025. A globally relevant data-driven assessment of carbon leakage from forestry. *Environ Res Lett.* 20(11):114022. <https://doi.org/10.1088/1748-9326/ae0ce2>

⁷⁰ Favero A, Daigneault A, Sohngen B. 2020. Forests: Carbon sequestration, biomass energy, or both? | *Science Advances*. [accessed 2026 July 6]. <https://www.science.org/doi/10.1126/sciadv.aay6792>

⁷¹ García JH, Orlov A, Aaheim A. Negative leakage: The key role of forest management regimes. *Journal of Forest Economics*. 2018 [accessed 2026 Apr 2];33:8–13. <https://doi.org/10.1016/j.jfe.2018.09.001>

Key Takeaways for Developers

- **Calibrate leakage deductions to project type and market context.** Transparently apply the leakage heuristic framework outlined above (and in [Appendix A](#)), showing how deductions reflect the project's harvest reduction, regional timber market dynamics, and substitution risk rather than relying on flat protocol defaults.
- **Build robust activity-shifting safeguards beyond attestation.** Implement quantitative monitoring on unenrolled lands that benchmarks harvest behavior against its drivers (e.g., price, inventory, age-class distribution) and re-tests these relationships periodically. This gives buyers and verifiers a more defensible basis for ruling out project-induced harvest displacement on owner-controlled lands.
- **Where possible, site projects in forests with faster growth rates.** This may lower the ratio of leakable carbon to total creditable carbon. Developers can also calibrate planned harvest reductions to balance additionality against market shock; harvest reductions should be large enough to demonstrate quantifiable practice change, but small enough to limit substitution pressure.

The Path Forward for Carbon Quantification

Additionality, baselines, and leakage are quality dimensions where methodological stringency, developer choices, and buyer diligence have significant and direct influence on project outcomes. For the private industrial forestland owners in the US that are the focus of this paper, the latest methodologies offer foundations from which to construct credible baselines and robust additionality claims. Baselines can be further improved through implementing practical guardrails, benchmarking against external data, and incorporating updates as conditions change. Leakage risk is best addressed through project design and site screening, and leakage accounting and risk estimation can leverage the best available literature and data. For landowners, developers, registries, and buyers committed to IFM climate impact, the methodological approaches and practical tools outlined here provide a credible basis for ensuring credit quality. Yet carbon quantification is only one dimension of IFM project quality. In the next section, we turn to the social outcomes of industrial IFM projects, which have received less methodological attention.

Driving Social Outcomes

IFM projects on industrial forestland in the US interact with communities and workers that are embedded in forest-dependent economies. They require a framework for right-sizing social design to project context and impact. These projects operate within working forest landscapes and often rural economies where timber production has historically supported community livelihoods, local supply chains, and municipal tax bases. When a large industrial landowner enrolls a timber tract in an IFM project and significantly reduces harvesting over a multi-decade crediting period, the effects may extend well beyond the project boundary to logging contractors, mill operators, hauling crews, and rural and Indigenous communities that depend on timber-related employment and revenues to support local socioeconomic well-being. These downstream impacts are understudied and poorly understood. Current IFM protocols generally do not require stakeholder engagement or community consultation for projects on private industrial lands.

This gap is becoming harder to justify as IFM project enrollment expands in scale and geographic reach. The distributional structure of these projects is consequential because carbon revenues primarily accrue to landowners and project developers (often the same entity for industrial forestland owners), while the economic costs of reduced harvesting may fall disproportionately on workers, local businesses, and communities—entities that typically have little influence over enrollment decisions. Addressing this asymmetry calls for a right-sizing framework that is context, stakeholder, and community specific. In this section, we outline the socioeconomic context of industrial IFM projects in the US, identify key dimensions of social risk, and propose a framework for advancing social outcomes: one that moves beyond harm avoidance and mitigation toward durable community benefit and resilience.

The Socioeconomic Context of Industrial IFM Projects in the US

The US forest products industry generates an estimated US\$288 billion annually and supports roughly 950,000 jobs, many concentrated in rural regions where forestry and wood products historically served as a primary economic driver and a defining feature of community identity.⁷² Proximate and timber-dependent communities in the US rely on forests not only for employment and income, but also for tourism, cultural value, recreation, and broader community

⁷² Forest Products | US Forest Service Research and Development. 2022. [accessed 2026 July 6]. <https://research.fs.usda.gov/forestproducts>

well-being.^{73,74} Like many forms of industrial development, industrial IFM projects are embedded within interconnected social and economic systems. Project design and implementation can reshape the fabric of communities that rely on forest products in ways that are rarely fully anticipated or addressed.

Timber investment management organizations and real estate investment trusts, which collectively manage an estimated 40 million acres of private forestland in the US, are increasingly evaluating IFM carbon project enrollment as a means to diversify revenue beyond traditional timber production.^{75,76} Under BAU management, these lands typically operate as working forests that are optimized for NPV, based on commercial timber production, with harvest regimes designed to sustain continuous flows of wood, paper, and pulp products.^{77,78,79} Enrollment in an IFM forest carbon project can substantially alter this operating model, with far-reaching effects. For example, enrolling an 80,000-acre, intensively managed, working forest into an IFM project that significantly reduces timber harvests by 20–70% may decrease log availability for sawmills, reduce contracts for logging crews, lower demand for hauling services, and diminish timber-related tax revenues for local governments.^{80,81} Not all industrial IFM projects follow this pattern. Practices such as extended rotations, increased retention, and improved silviculture can raise carbon stocks while sustaining timber volumes closer to baseline levels, with correspondingly smaller effects on local supply

⁷³ Poudel K. 2024. Private and public forestland policies and well-being of rural forest-based communities in the United States. [accessed 2026 July 6]. https://ir.library.oregonstate.edu/concern/graduate_thesis_or_dissertations/pg15bq34b

⁷⁴ Frey GE, Kallayanamitra C, Wilkens P, James NA. 2022. Defining and Measuring Forest Dependence in the United States: Operationalization and Sensitivity Analysis. *Forests*. 13(4):577. <https://doi.org/10.3390/f13040577>

⁷⁵ Sass EM et al. 2021. Dynamics of Large Corporate Forestland Ownerships in the United States. *J For*. 119(4):363–375. <https://doi.org/10.1093/jofore/fvab013>

⁷⁶ Schwartzman G. 2022. Climate rentierism after coal: forests, carbon offsets, and post-coal politics in the Appalachian coalfields. *The Journal of Peasant Studies*. 49(5):924–944. <https://doi.org/10.1080/03066150.2022.2078710>

⁷⁷ Thompson A, Wear D, Boyd J. 2025. Effects of carbon policies on disadvantaged forest communities in the United States. *Agricultural and Resource Economics Review*. 54(3):635–663. <https://doi.org/10.1017/age.2025.10012>

⁷⁸ Sustainable Forestry. Washington Forest Protection Association; [accessed 2026 July 6]. <https://www.wfpa.org/forest-management-2/sustainable-forestry/>

⁷⁹ Schwartzman G. 2022. Climate rentierism after coal: forests, carbon offsets, and post-coal politics in the Appalachian coalfields. *The Journal of Peasant Studies*. 49(5):924–944. <https://doi.org/10.1080/03066150.2022.2078710>

⁸⁰ Bubser D, Fernholz K, Meyer E., 2023. Exploring the Potential Effects of an Expanding Forest Carbon Market on Working Forests and Communities in the United States. Dovetail Partners; [accessed 2026 Jul 6]. <https://www.dovetailinc.org/upload/tmp/1703195421.pdf>

⁸¹ Kitch M. 2024 Feb 8. Carbon credits put timber industry at risk. *NH Business Review*; [accessed 2026 July 6]. <https://www.nhbr.com/carbon-credits-put-timber-industry-at-risk/>

chains. The magnitude of social impact is therefore a function of the specific management change, not of IFM enrollment as such.

Industrial IFM projects can also have positive effects when they proactively integrate social design into project development by supporting local and regional industry, sustaining livelihoods and cultural connections to working forests, and promoting resilient, sustainable forestry practices over the long term. There are many plausible benefits from industrial IFM projects depending on their design, structure, and how the developer ultimately directs carbon revenue to benefit forest-dependent communities. For example, industrial timberland in the US faces persistent pressure from parcelization, conversion to development, and ownership turnover, particularly where timber returns alone cannot compete with alternative land values. An IFM project that establishes a durable, contractually secured revenue stream can reduce the financial pressure to liquidate timber or divest land, keeping working forests intact and in single ownership over multi-decade horizons. For communities whose long-term risk relates to the disappearance of the forest land base altogether, carbon revenue could represent a material benefit.

Social Risks, Opportunities, and the Case for Proactive Social Design

Industrial IFM projects in the US operate largely outside formal social accountability requirements because most industrial timberlands are privately owned. As a result, project developers are generally not subject to the stakeholder engagement obligations, environmental impact review processes, or community consultation requirements that apply to publicly regulated land uses or other forest carbon projects that operate under different registry or protocol requirements (**box 8**). In practice, this means that industrial IFM projects often conduct minimal external stakeholder mapping, rely on the floor set by voluntary registry requirements, and make enrollment and design decisions without systematic input from the workers, communities, or local governments that stand to be most affected. The central, and still largely unresolved, question is: What obligations should industrial IFM landowners and project developers bear toward those communities, and how should those obligations be structured?

Box 8. Registry call to action

Registries and their methodologies are among the most potent and scalable means to improve social outcomes of IFM projects on industrial forestlands in the US. Yet, for many project contexts, methodologies prescribe virtually no social design elements. ACR’s current standard (Standard 8.0), for example, requires projects to identify, disclose, and mitigate potential social and environmental harms through its Environmental and Social Impact Assessment template. The framework requires project proponents to assess risks across six domains: biodiversity, pollution, labor rights, land acquisition, human rights, and gender equality. However, requirements for meaningful stakeholder engagement; community consultation; free, prior, and informed consent (FPIC); and benefit-sharing apply only to community-based projects and do not extend to private lands. As a result, many industrial IFM projects proceed with limited formal social design, and in some cases none at all.

Moving forward, registries have clear opportunities to expand social design expectations for private industrial IFM projects where appropriate, particularly for projects with substantial harvest reductions (i.e., implying significant disruption to local labor and economies), or elevated community vulnerability, regardless of land ownership status.

Early signals suggest this tension is beginning to attract regulatory attention. For example, in July 2024, New Hampshire became the first state in the US to enact legislation that established a forest carbon project public registry and conducted an assessment on how carbon project enrollment affects municipal timber yield tax revenues.⁸² This legislation was enacted in response to a large-scale forestland acquisition for an IFM project that planned to reduce timber harvest by more than 50%, raising concerns about job losses in the logging sector and declining revenue streams for forest-dependent municipalities.^{83, 84} Similarly, beginning in 2023 in West Virginia, concern about the

⁸² NH Department of Revenue Administration. 2025. Final report concerning the impact of carbon offset credit programs on timber tax revenue. [accessed 2026 Jul 6]. <https://www.revenue.nh.gov/sites/g/files/ehbemt736/files/documents/final-report-impact-carbon-offset-credit-program-timber-tax-revenue.pdf>

⁸³ Dario K. 2024. A new NH law will investigate the impact of carbon offset sites on tax revenue. New Hampshire Public Radio; [accessed 2026 July 6]. <https://www.nhpr.org/nh-news/2024-07-26/a-new-nh-law-will-investigate-the-impact-of-carbon-offset-sites-on-tax-revenue>

⁸⁴ When a Large Timberland Owner Decides to Sell Carbon Instead of Cutting Timber: Controversy in Northern New Hampshire. Northeastern Loggers Association; [accessed 2026 July 6]. <https://www.northernlogger.com/northern-logger-magazine/selling-carbon-instead-of-cutting-timber-controversy-in-northern-nh/>

expansion of large-scale industrial IFM projects prompted multiple legislative attempts to respond. The West Virginia Legislature introduced multiple bills aimed at taxing or restricting forest carbon agreements—including proposals that would have imposed excise taxes of up to 50% on agreements that restricted timber harvesting, and a bill that would have made a state-administered exchange the exclusive platform for all carbon credit transactions involving West Virginia land and timber.⁸⁵ While these bills did not pass, they reflect a tangible and growing tension between carbon project expansion and the economic and political interests of timber-dependent communities.

As industrial IFM project enrollment expands, distributional asymmetry (i.e., revenues for landowners versus negative impacts to workers and communities) raises questions about IFM’s role in a sustainable and equitable bioeconomy transition. However, not all industrial IFM projects carry the same social risks, and not all affected communities have the same degree of economic dependence on timber production. What is needed is a framework for right-sizing social design in IFM projects on industrial forestlands in the US: one that scales engagement, harm mitigation, and benefit distribution to a project’s impacts; is appropriate to a community’s level of vulnerability; and encourages positive socioeconomic outcomes.

Addressing Social Outcomes: Right-Sizing IFM Project Design

Not all industrial IFM projects carry the same social risks, and not all require the same level of social intervention. A contiguous 200,000-acre tract in a rural, timber-dependent community will require a fundamentally different social design approach than a 10,000-acre discontinuous tract near a metropolitan area. The principle of right-sizing—scaling stakeholder engagement, harm mitigation, and benefit-sharing commitments to the magnitude of project impacts and the vulnerability of affected communities—offers a practical framework for navigating this variability. Projects that materially reduce harvest, affect active local timber supply chains, or generate substantial carbon revenue in economically fragile communities should face a higher threshold of obligation than projects making marginal management adjustments in contexts with limited social exposure.

⁸⁵ Tony M. 2024 Feb 28. A new NH law will investigate the impact of carbon offset sites on tax revenue. Charleston Gazette-Mail; [accessed 2026 July 6]. https://www.wvgazettemail.com/news/legislative_session/wv-senate-passes-carbon-offset-bill-estimated-to-cost-state-millions/article_b10ba733-a51f-5751-9359-21f7cb7d79c1.html

Project developers and buyers should not ask whether or not social design is required, but what form and scale of social design is appropriate to the project at hand. In addition to a project's physical scale (i.e., amount of forestland affected), three contextual factors can help project developers evaluate this. Considered together, these factors can help distinguish between those projects where a primary focus on harm avoidance may be sufficient from projects where there may be meaningful opportunities to support workforce resilience, community investment, or broader social benefits. While not required under most current protocols, high-quality IFM projects can use these considerations to better align project outcomes with local socioeconomic contexts.

- 1. Timber dependency:** Communities vary substantially in their economic reliance on timber production, and project developers can consider these differences when evaluating potential project impacts. Developers should assess the extent to which local communities and workers depend on project forestlands for employment, broader economic activity, and cultural activities. Evaluation could include assessing whether surrounding rural economies are experiencing structural changes such as mill closures, declining timber supply, or workforce decline. Research using environmental, economic, and social criteria identified 524 (16.7%) counties across the US as forest-dependent, with the largest concentration in the Pacific Northwest and Southeast, though such communities exist across all major timber-producing regions.^{86, 87} Importantly, these communities do not respond uniformly to changes in timber markets. Some demonstrate economic resilience, while others experience prolonged decline following harvest reductions or policy shifts.⁸⁸ Communities with higher vulnerability tend to share certain characteristics such as geographic isolation, dependence on a single industry, aging workforces, and limited institutional capacity for economic

⁸⁶ Frey GE, Kallayanamitra C, Wilkens P, James NA. 2022. Defining and Measuring Forest Dependence in the United States: Operationalization and Sensitivity Analysis. *Forests*. 13(4):577. <https://doi.org/10.3390/f13040577>

⁸⁷ Bubser D, Fernholz K, Meyer E., 2023. Exploring the Potential Effects of an Expanding Forest Carbon Market on Working Forests and Communities in the United States. Dovetail Partners; [accessed 2026 Jul 6]. <https://www.dovetailinc.org/upload/tmp/1703195421.pdf>

⁸⁸ Rasker R. 2021. The Transition from Western Timber Dependence: Lessons for Counties. Headwaters Economics; [accessed 2026 Jul 6]. https://headwaterseconomics.org/wp-content/uploads/Lessons_Timber_Transition.pdf

diversification.^{89, 90, 91} In these contexts, project design should include an assessment of the project's potential social impacts and determine if there are meaningful opportunities to advance and uplift community socioeconomic conditions with carbon revenue.

- 2. Historical harvesting levels:** Projects that substantially alter existing harvesting patterns may disrupt established economic relationships across timber supply chains and should account for these effects in project design. Project developers should evaluate how significantly a project will alter existing harvesting patterns, workforce demand, contractor relationships, and downstream timber supply. Projects involving small management changes are likely to have materially different social and economic impacts than those implementing substantial harvest reductions, particularly in landscapes with long-standing and active timber supply chains. Critically, developers should consider not only the volume of harvested wood products the project will generate relative to baseline management, but also how project interventions may disrupt existing economic relationships within the timber value chain.
- 3. Community vulnerability:** Broader structural inequalities can amplify the social costs of harvest reductions. Developers should assess these inequalities alongside timber dependency when designing projects. Assessment should include identifying unresolved Indigenous land claims, environmental justice concerns, and historical patterns of dispossession that may influence how project benefits and burdens are distributed. In many cases, timber dependency overlaps with structural inequities such as concentrated poverty, racial disparities, limited economic alternatives, and lower educational attainment.⁹² Without careful design, project activities in these contexts risk reinforcing existing inequalities. Standard screening tools (e.g., US Environmental Protection Agency EJSCREEN,⁹³ or analogous tools in other jurisdictions) can help identify

⁸⁹ Frey GE, Kallayanamitra C, Wilkens P, James NA. 2022. Defining and Measuring Forest Dependence in the United States: Operationalization and Sensitivity Analysis. *Forests*. 13(4):577. <https://doi.org/10.3390/f13040577>

⁹⁰ Bubser D, Fernholz K, Meyer E., 2023. Exploring the Potential Effects of an Expanding Forest Carbon Market on Working Forests and Communities in the United States. Dovetail Partners; [accessed 2026 Jul 6]. <https://www.dovetailinc.org/upload/tmp/1703195421.pdf>

⁹¹ Rasker R. 2021. The Transition from Western Timber Dependence: Lessons for Counties. Headwaters Economics; [accessed 2026 Jul 6]. https://headwaterseconomics.org/wp-content/uploads/Lessons_Timber_Transition.pdf

⁹² Schwartzman G. 2022. Climate rentierism after coal: forests, carbon offsets, and post-coal politics in the Appalachian coalfields. *The Journal of Peasant Studies*. 49(5):924–944. <https://doi.org/10.1080/03066150.2022.2078710>

⁹³ United States Environmental Protection Agency. 2021. EJScreen: Environmental Justice Screening and Mapping Tool. [accessed 2026 Jul 6]. [EJSCREEN: Environmental Justice Screening and Mapping Tool | US EPA](https://www.epa.gov/ejscreen); also found at: <https://pedp-ejscreen.azurewebsites.net/>

communities that are facing elevated pollution exposure, reduced access to environmental amenities, heightened climate vulnerability, or socioeconomic disadvantage. Integrating such tools into project design can support more equitable and context-sensitive outcomes.

Taken together, and in the context of a project’s physical scale, these three factors define where a project sits on the spectrum of social obligation (**table 4**). A project with high timber dependency, substantial harvest reductions, and a vulnerable surrounding community calls for a robust and proactive social design, one that goes well beyond harm avoidance to include meaningful engagement, distributional equity measures, and active uplift. A project with limited harvest disruption, low community economic dependence, and no significant vulnerability indicators may adequately address social obligations through transparent communication and accessible grievance mechanisms. In the sections that follow, we outline what each level of response should be implemented in practice.

Table 4. Project and community characteristics indicating the level of social intervention required for IFM projects on industrial forestlands in the US

Factor	Lower intervention threshold	Higher intervention threshold
Timber dependency	Communities with diversified economies; limited reliance on forest-based employment	Rural communities with concentrated economic dependence on timber production and processing
Historical harvesting levels	Project proposes modest management adjustments with limited disruption to existing supply chains	Project proposes substantial harvest reductions (>20%) and active, long-standing timber supply chains affected
Community vulnerability	Limited structural inequities; strong institutional capacity for adaptation	Concentrated poverty, racial disparities, limited economic alternatives, unresolved Indigenous land claims

Note: These factors should be assessed in combination. Projects where multiple factors indicate elevated social risk warrant the most robust social design frameworks.

From Harm Minimization to Active Social Uplift

Avoiding harm is the baseline obligation of social design. However, leading industrial IFM projects could go further by actively creating durable social benefits for affected workers and communities. Currently, a project that does not worsen existing economic and social conditions meets the minimum quality floor. The distinctions between harm minimization and active social uplift occur along a spectrum, and where a project sits on that spectrum should be determined by the right-sizing framework we have outlined above. Advancing meaningful social outcomes may

include conducting analytical assessments of project-community relationships, minimizing socioeconomic disruption, and incorporating workforce transition within project design.

Engagement Process Foundations

Robust stakeholder engagement is the process foundation on which all other social design elements depend. The following principles apply across the spectrum of industrial IFM projects, with the depth and intensity of each scaled to the magnitude of project impacts:

- **Conduct comprehensive stakeholder mapping that extends beyond the legal landowner and the project boundary.** The relevant stakeholder universe for industrial IFM projects in the US includes forest workers, logging contractors, hauling crews, mill operators, adjacent communities, local governments, and Tribal Nations where relevant. Identifying this full range of affected parties early is essential to meaningful engagement.
- **Create genuine opportunities for influence early in the project life cycle.** Engagement that occurs after key design parameters are set provides little opportunity for affected parties to shape outcomes and builds limited legitimacy. Substantive consultation should occur before enrollment decisions are finalized and should allow for the possibility of modifying project design in response to community input.
- **Communicate transparently and specifically about management changes, project duration, expected local effects, and the realistic scope of stakeholder decision-making authority.** Vague commitments to community benefit are more likely to generate distrust than to build it. Clarity about what will change, when, and for how long is a prerequisite for informed engagement.
- **Establish accessible and durable grievance mechanisms.** Industrial IFM projects operate on multi-decade timelines, and the capacity for conflict and community concern to emerge years after enrollment is significant. Projects should commit resources to ongoing responsiveness, not only during the enrollment and early implementation phases.

Social Investment Opportunities

Beyond good process, industrial IFM projects have meaningful opportunities to invest in social outcomes that offset economic disruption and generate durable community benefits. Analytical assessment of project-community relationships is a foundational investment that remains surprisingly rare. Projects should routinely commission

studies of local economic dependencies on forest-based industries, model the downstream effects of harvest reductions on employment and supply chains, and map community vulnerabilities that project activities could exacerbate or address. In the same way that carbon accounting models sequestration outcomes under different management scenarios, projects should extend those modeling capabilities to forecast labor demand, employment type shifts, and expected income effects that together create a social impact baseline.

Minimizing socioeconomic disruptions requires particular attention to workforce continuity. Where project activities reduce the volume of harvesting operations, developers should assess whether workers currently engaged in those operations can remain meaningfully employed in modified forest management activities such as thinning, restoration, carbon monitoring, and inventory work. This requires proactive workforce planning. Research suggests that the new roles created by carbon and conservation-oriented forest management tend to require more technical skills and formal education than traditional harvesting and logging work.⁹⁴ This means that workforce transition is not automatic and cannot be assumed without deliberate investment in training and reskilling. Workforce transition support is perhaps one of the most consequential social investments available to projects operating in timber-dependent communities, and it deserves to be treated as a design element rather than a philanthropic add-on. This may include:

- **Prioritizing local hiring** for new roles in carbon monitoring, forest management, and restoration activities
- **Supporting retraining and workforce development programs** in partnership with local institutions
- **Establishing community-benefit funds** tied to project revenues
- **Designing placed-based interventions** aligned with local economic conditions and needs

The Role of Buyers in Shaping Social Outcomes

Buyers have more leverage over the social dimensions of IFM projects than is commonly recognized, and translating that influence into purchase decisions is one of the most direct levers available to improve market outcomes. In practice, industrial IFM projects are unlikely to invest in robust stakeholder engagement, workforce transition

⁹⁴ Schwartzman G. 2022. Climate rentierism after coal: forests, carbon offsets, and post-coal politics in the Appalachian coalfields. *The Journal of Peasant Studies*. 49(5):924–944. <https://doi.org/10.1080/03066150.2022.2078710>

support, or community benefit-sharing at meaningful scale without a market signal that those investments are valued by buyers.

Buyers seeking projects with meaningful social outcomes can ask structured questions during due diligence: Has the project conducted comprehensive stakeholder mapping, including workers and communities beyond the project boundary? Was engagement conducted before major design decisions were finalized? Does the project have a credible assessment of downstream economic impacts on timber-dependent workers and communities? Are there concrete commitments to workforce transition support or community benefit-sharing that are proportionate to the scale of harvest reduction? Are these commitments embedded in project design and funded from project revenues, or are they simply aspirational language appended to a project prospectus?

High-quality IFM projects provide credible answers to these questions on social dimensions. Buyers send a clear market signal when they buy from projects that factor community impact into their project design, which drives higher standards across the entire industry. In doing so, they shape whether industrial IFM projects generate net benefit or net risk for the rural communities embedded within them.

Key Takeaways for Buyers

- **Screen a project area's social risk profile to inform proactive social design.** Start by assessing the project across three dimensions: timber dependency of surrounding communities, magnitude of harvest reduction relative to historical levels, and community vulnerability indicators (e.g. concentrated poverty, racial disparities, Indigenous land claims, limited economic alternatives). Projects scoring high across multiple dimensions carry greater social risk regardless of registry requirements.
- **Evaluate key qualitative indicators of social design quality during diligence.** These indicators include whether stakeholder mapping extends beyond the project boundary, if engagement occurred before major design decisions were finalized, if the project has a credible assessment of downstream economic impacts on workers and timber supply chains, whether workforce transition and benefit-sharing commitments are proportionate to harvest reduction, and whether they are funded from project revenues rather than treated as ancillary commitments without dedicated funding or accountability structures.
- **Prepare to require social commitments beyond registry minimums when a project's context warrants it.** Current registry standards typically apply meaningful stakeholder engagement and benefit-sharing

requirements only to community-based projects, leaving most industrial IFM projects outside of formal social accountability. Where project conditions point to elevated social risk, buyers can require project-specific social design commitments and for projects that credibly deliver them.

Key Takeaways for Developers

- **Right-size social design to the scale of the project interventions and community impact instead of applying a uniform standard.** Use three contextual factors to calibrate the level of intervention required: timber dependency of surrounding communities, magnitude of harvest reduction relative to historical levels, and community vulnerability indicators (e.g. concentrated poverty, racial disparities, Indigenous land claims, limited economic alternatives). When multiple factors indicate elevated risk, the social design obligation rises accordingly.
- **Map stakeholders beyond the property line and engage them during the design process.** Relevant groups include logging contractors, hauling crews, mill operators, adjacent communities, local governments, and Tribal Nations where relevant—not just the legal landowner. Substantive consultation should occur before enrollment decisions are finalized and should allow for the possibility of modifying project design in response to community input.
- **Treat workforce transition and community benefits as design elements funded from project revenues, not philanthropic add-ons.** Carbon-oriented forestry roles (e.g. monitoring, inventory, restoration) require more technical skills than traditional logging roles, so transition is not automatic. Concrete commitments, including local hiring priorities, retraining partnerships, community-benefit funds, and durable grievance mechanisms should be embedded in project design and scaled to the magnitude of harvest reduction and community dependence.

Conclusions

IFM is one of the most scalable, cost-effective, and immediately deployable natural climate solutions available, yet its credibility as a carbon market instrument depends on resolving persistent challenges in both climate impact quantification and social design. In this paper, we focus on private industrial IFM in the US, and examine those challenges across three interconnected dimensions: baselines and additionality, leakage, and socioeconomic outcomes. We recommend practical pathways forward for project developers, registries, and buyers.

The current moment, which is marked by growing IFM credit demand, methodological innovation, and early regulatory interest in social dimensions, provides an opportunity to refine definitions of high-quality IFM projects, and make achieving them tractable and cost effective. Seizing this opportunity requires moving beyond minimum compliance toward a shared standard of rigor that is transparent, defensible, and durable across changing market and ecological conditions.

On the climate impact quantification side, recent methodological innovations have meaningfully advanced the field. Dynamic baselines, periodic reassessment mechanisms, and improved carbon accounting frameworks represent genuine progress over the static approaches that characterized early IFM projects and are prone to overcrediting. Yet significant challenges remain. The fundamental tension between the credibility of project-specific counterfactuals and independent verifiability is not fully resolved by any existing methodology. The absence of a universally applicable, transparent baseline construction standard continues to complicate buyer confidence. Similarly, leakage—particularly market leakage—remains a systemic and largely unobservable phenomenon that current methodologies can only partially address. We have proposed a practical, two-step heuristic framework that involves identifying leakable carbon and assessing substitution likelihood. This can be used as an interim tool for buyers to screen leakage risk in the absence of robust project-level economic modeling. While not a permanent solution, this framework represents actionable steps toward more structured and consistent quality assessment.

Related to social outcomes, the field is at an earlier stage of development. Industrial IFM projects have largely operated without formal requirements for stakeholder engagement, community consultation, or benefit-sharing. This is a gap that is becoming harder to justify as project scale expands and downstream economic impacts on timber-dependent communities become more visible. The principle of right-sizing social design to the magnitude of

project impacts offers a practical and proportionate framework. Not every project requires the same intervention, but every project should ask the same structured questions about timber dependency, historical harvesting patterns, and community vulnerability before design decisions are finalized. Leading projects should aspire beyond harm minimization to active social uplift, including workforce transition support, local hiring commitments, and community benefit-sharing mechanisms that keep project revenue circulating locally.

Ultimately, while meaningful advancements have been made, the credibility of IFM depends on whether the field can close the gap between what methodologies require and what high-quality outcomes actually demand. Buyers, developers, and registries each have a role to play. Buyers who prioritize transparent baselines, conservative leakage accounting, and meaningful social design, and who price those qualities into credit value, create the demand signal that drives quality improvement across the market. Developers who invest in robust data, independent verification, and proactive community engagement build the trust that sustains long-term project viability. Registries that continue to raise methodological standards to align with high-quality outcomes, require greater data transparency, and develop clearer guidance on social requirements provide the governance infrastructure the market needs to scale with integrity.

Appendix A: Illustrative Case Studies of Leakage Risks

In this appendix, we present three hypothetical IFM carbon project scenarios with varying leakage risk profiles. We expand on the two-part leakage heuristic framework introduced in the main body of the paper. It is intended as a supplementary screening tool for developers and buyers, not a replacement for the leakage accounting requirements of the registry methodology under which a project is registered. Developers must continue to follow the leakage accounting rules of their chosen methodology (e.g., ACR IFM 2.1, CAR Mexico Forest Protocol, Verra VM0045) in calculating and reporting the leakage deduction applied to issued credits.

The framework presented here goes beyond what these methodologies currently require. It draws on the latest scientific literature to characterize the broader range of socioeconomic and ecological factors that drive real-world leakage rates. However, this is only one way of approaching market leakage risk assessment for IFM projects; it likely errs on the side of being conservative, because it doesn't fully account for longer-term leakage phenomena (e.g., increased future harvest rates) that may ameliorate carbon leakage over time. We acknowledge that buyers are still early on in their journey of discovering decision-relevant, repeatable, and robust frameworks for analyzing IFM market leakage risk. We hope that this can serve as a starting point for subsequent iteration between academia and industry to continue to refine how developers, buyers, and methodologies can democratize risk assessments for this complex topic.

We conduct this assessment in two steps, integrating the quantitative and qualitative approaches described in the [Leakage](#) section. First, we evaluate leakage exposure, which is the size of the leakable carbon pool proportional to the magnitude of harvest reductions (see **box 5** for definitions) and relative to the creditable climate benefit generated through forest growth and carbon accumulation. Next, we perform a heuristic leakage-risk assessment to evaluate how much of the leakable carbon pool is likely to actually leak, based on qualitative factors such as market shock, market context, and product substitutability.

Scenario 1: Pacific Northwest Industrial IFM Project with High Leakage Risk

Scenario 1 is an industrial IFM project located in the Pacific Northwest with a high leakage risk profile. It combines high leakage exposure with high-risk qualitative risk factors (**figure A1**). The hypothetical project area is located in the Pacific Northwest and is dominated by Douglas-fir (*Pseudotsuga menziesii*). It is owned and managed by a large industrial landowner that historically operated a tree farm under an intensive timber production model characterized by even-aged management with clearcut harvesting at a 30–50+ years, due to slow growth rates compared to other areas of the US and Global South. Under the project scenario, harvesting declines substantially over the crediting period, with annual timber removals reduced by approximately 60% relative to the baseline scenario. The mean creditable carbon gain per year is 400,000 tonnes of carbon dioxide equivalent (tCO₂e) per year and the mean harvest reduction (i.e., leakable carbon pool) is 310,000 tCO₂e per year. **Therefore, leakage exposure, the fraction of leakable carbon to total creditable carbon is 78%. Conservatively assuming that all of the leakable carbon actually leaks, the leakage rate would also be 78%, which would require a leakage deduction factor much larger than the 30% used by ACR.** This is because the project generates relatively low creditable carbon gains, driven by slow forest growth rates, in proportion to the high harvest reductions under the project scenario. A critical next question is how much carbon will actually leak.

In this scenario, the heuristic leakage risk assessment also indicates high leakage risk, suggesting that a high proportion of the leakable carbon will actually leak and that a default 30% leakage deduction factor may not be conservative. Leakage risk is high because the project creates a substantial market shock by reducing timber supply by approximately 60% relative to baseline harvesting. Because the project operates within highly integrated regional and global forest product markets, reduced supply from the project area is likely to increase local stumpage prices and incentivize other landowners to harvest sooner or more intensively. Lastly, Douglas-fir lumber and pulpwood have a high degree of product substitutability and displaced supply is readily met by other producing regions. We note that this assessment does not account for possible longer-term market and ecological responses that could reduce or even reverse leakage, including accelerated forest regrowth, afforestation, more intensive forest management, and productivity gains induced by higher timber prices. Over time, these responses may increase forest carbon stocks outside the project area and partially or fully offset emissions from displaced harvesting. Nevertheless, on shorter timescales and in the context of a conservative project-specific assessment.

Scenario 2: US Southeast Industrial IFM Project with Low Leakage Risk

Scenario two is an industrial IFM project located in the US Southeast with an overall low leakage risk profile driven by low leakage exposure. Methodology market leakage deductions (30%) are likely conservative given the project's low leakage exposure, despite a high likelihood of leakage based on the heuristic leakage rate assessment (**figure A1**).

The project is located in the US Southeast and is primarily composed of loblolly pine (*Pinus taeda*) plantations.

Management in this region is characterized by fast growing, intensive industrial harvest rotations of 25–30 years, involving large clearcuts followed by site preparation, planting, thinning, fertilization, and growth to final harvest.

Project activities extend harvest rotations by an average of two years, reducing timber supply by less than 10% relative to the baseline scenario. The mean creditable carbon gain per year is 120,000 tCO₂e per year and the mean harvest reduction (i.e., leakage carbon pool) is 35,000 tCO₂e per year. **Therefore, across the crediting period, leakage exposure, or the fraction of leakable carbon to total creditable carbon, is 29%. Conservatively assuming that all of the leakable carbon actually leaks, the leakage rate would still be within the range of the 30% leakage deduction factor used by ACR.**

Similar to Scenario 1, the heuristic leakage rate assessment indicates a high leakage risk, suggesting that a high proportion of the leakable carbon will actually leak but overall leakage exposure is low. The project operates within a competitive regional timber market and loblolly pine softwood products are highly substitutable. However, project activities reduce wood supply by less than 10% (which reduces the pool of leakable carbon), involve only short-term harvest deferrals, and the pool of credible carbon is relatively large (partly due to faster growth rates). These qualitative factors indicate that we should conservatively assume a 100% harvest substitution rate, but the methodology's existing 30% leakage deduction is still sufficient because of the low leakage exposure.

Scenario 3: Amazon Frontier Hardwood Logging Operation⁹⁵

Scenario 3 is a hardwood logging operation located on the Amazon frontier with a low leakage risk profile, primarily because of the market context (**figure A1**). The project is located on the Amazon frontier and is composed of native tropical hardwood species. The project is implemented by a landowner with hardwood plantations, with management characterized by single-tree selection for high-quality wood products and opportunistic harvesting. Project activities reduce timber harvesting within the project area by 55% annually. **The project’s growth rates and harvest reduction magnitude generate a mid-range leakage exposure score that falls in between Scenarios 1 and 2 (approximately 45%).**

However, the heuristic leakage rate assessment indicates that a relatively low fraction of this leakage carbon will actually leak, driven primarily by market context. In this scenario, the tropical hardwood markets are less integrated and more geographically constrained due to underdeveloped road infrastructure. Wood products are also highly specialized and less substitutable, further decreasing the likelihood of displaced supply being replaced by competing regions.

Although most factors that inform the qualitative assessment of leakage risk are market and region-specific rather than project-specific, there are some specific data points that developers could be well-positioned to provide that would increase confidence in this type of assessment. First, developers could identify the project's contribution to regional timber supply and the magnitude of the harvest reduction relative to the broader market, helping buyers assess the likely size of the market shock. Developers could also characterize the end uses and substitutability of affected timber products, including whether harvest reductions involve highly commoditized products that can be readily sourced from alternative suppliers. Historical relationships between timber prices and regional harvest activity, as well as information on available timber inventories and processing capacity, could further help contextualize how responsive non-project supply may be to reduced harvests.

⁹⁵Although we focus on US-based IFM in this paper, Scenario 3 is an archetypical example of a project with low qualitative risk factors that we use for demonstrative purposes. US-based projects with a similar risk profile could include hardwood management in Hawaii, where endemic species like koa (*Acacia koa*) are essentially non-substitutable in domestic and global markets and grown in a geographically isolated, poorly integrated timber market.

FORESTRY • LEAKAGE ASSESSMENT

Estimating leakage risk in two steps

Leakage exposure sets the maximum amount of carbon at risk (Step 1); substitution risk determines how much of that exposure actually leaks (Step 2).

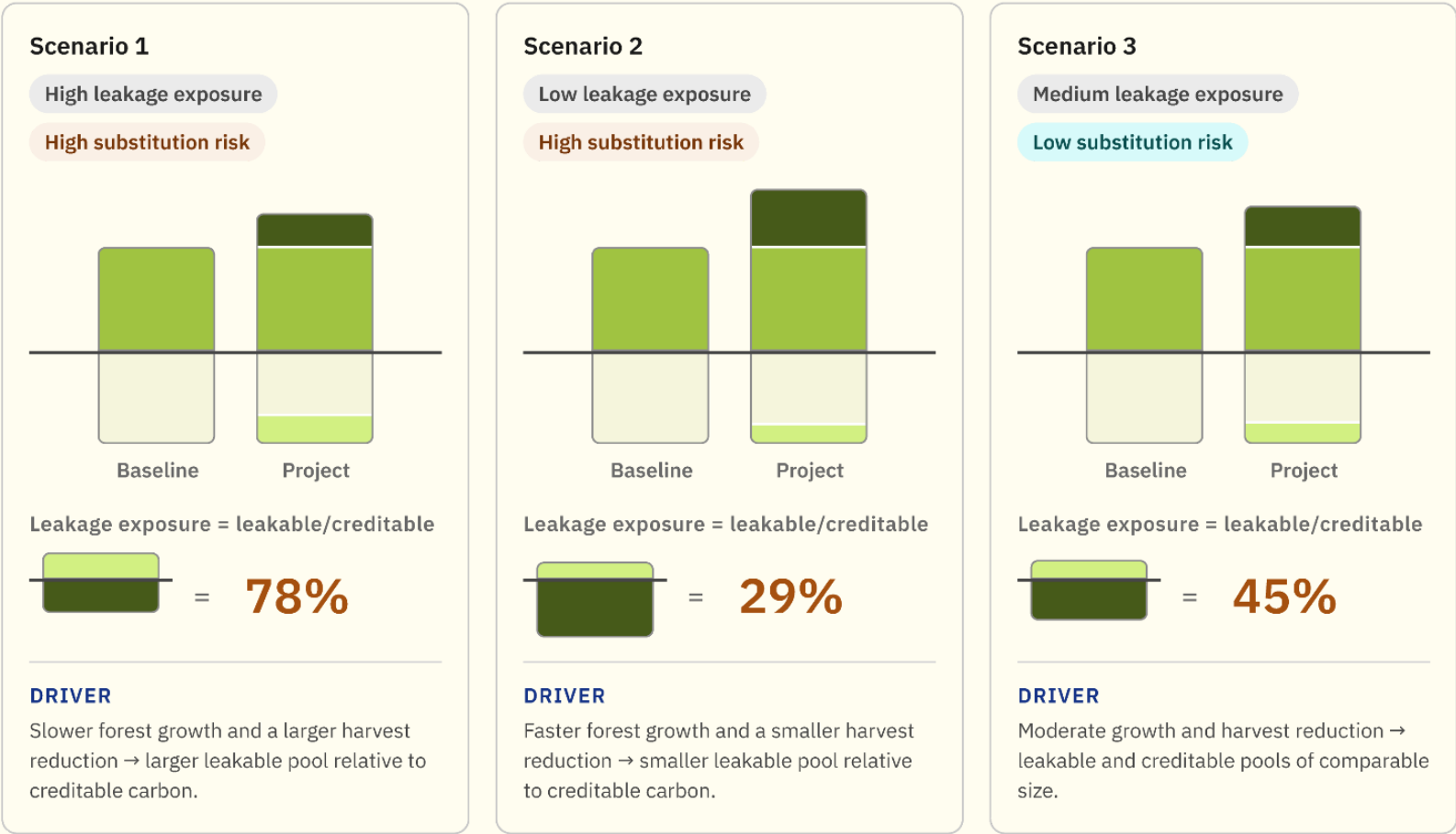
Creditable carbon

Harvested carbon

Carbon stock

Leakable carbon

STEP 1 Leakage exposure: How much carbon is at risk?



Appendix B: High-Quality Social Design Framework

The following hypothetical case studies illustrate how a project developer can apply the right-sizing framework—drawing on timber dependency, harvest disruption, and community vulnerability—to determine an appropriate level of stakeholder engagement and social risk mitigation within the project design and ongoing project management. We present two scenarios that reflect a range of contexts in which industrial IFM projects operate. Both are grounded in real-world project types, with the level of engagement and investment calibrated to each project’s magnitude of impact and the socioeconomic context of affected communities. They are illustrative only; developers should not treat them as the only way to implement high-quality social design.

Case Study 1: High Social Exposure, Elevated Project Obligation

Together, these conditions (**table B1**) present a situation where carbon project activities will likely contribute to social harms absent proactive design and interventions. The responsibility of the project developer to invest in harm mitigation and active social uplift is relatively high. As a result, such a developer should follow the best practice criteria for social design in industrial IFM projects laid out in **table B3**, which apply across all design verticals for this project.

Table B1. Project context for Case Study 1

Project profile	Large-scale, intensive: A vertically-integrated industrial landowner has enrolled a 100,000+ acre contiguous working forest in an IFM project with a multi-decade crediting period.
Timber dependency	High: The project is located in a rural, timber-dependent region where forest products industries represent a primary source of local employment and economic identity. Roughly half of local wage employment is concentrated in logging, hauling, milling, and related forest-products supply chains. Limited alternative economic opportunities are available.
Harvest reduction	Substantial: Planned harvest reductions of approximately 70% are expected to materially reduce log availability and disrupt established timber supply chains serving local mills, haulers, and contractors over the crediting period.
Community vulnerability	High: EJSscreen analysis indicates above-average poverty rates and geographic isolation limiting labor mobility. Nearby stakeholders include Indigenous Peoples who customarily, and recently, accessed project lands to hunt, raising considerations of cultural access and historical context that warrant proactive engagement.

Case Study 2: Moderate Social Exposure, Modest Project Obligation

In this case (**table B2**), potential impacts are distributed across a broad region and do not represent a severe risk to any single community, mill, or workforce. The project’s responsibility to invest beyond harm avoidance is real, but modest. As a result, the minimum acceptable criteria listed in **table B3** are generally sufficient for this project. However, specific site circumstances, such as a culturally sensitive area, concentrated employment, or supply chain impacts in a local area, may warrant targeted applications of best practice criteria.

Table B2. Project context for Case Study 2

Project profile	Medium-scale: An established industrial landowner has enrolled a 40,000+ acre, intensively managed, working forest, distributed among dozens of parcels across several US states, with a multi-decade crediting period.
Timber dependency	Moderate and highly variable by location: The regional economy is anchored in the forest sector but is diversifying, and timber demand is volatile. The forest sector is culturally important, though forest sector jobs tend to pay less than other sectors.
Harvest reduction	Moderate: The project proposes a cumulative 50% decrease in harvested wood products over the crediting period. The project’s timber impacts are distributed across over a dozen mills and processing centers, supplied by broad, multi-county procurement areas. Because project acreage is distributed widely, impacts on any individual mill, contractor, or community are limited in scope, and will likely include minor local job loss and disruption as loggers and foresters transition to project-relevant roles.
Community vulnerability	Moderate: EJScreen analysis indicates lower rates of educational attainment and household income than state and national averages, though results are variable across the project’s region. No local presence of Indigenous Peoples’ claims or project lands with insecure tenure.

Social Design Verticals: Minimal Acceptable and Best Practice Criteria

Table B3 shows minimal acceptable and best practice criteria for social design in IFM projects. Minimum acceptable criteria are the minimum standards expected, regardless of project scale or context. Best practice criteria build cumulatively on all good practice criteria and are expected of projects with large-scale, concentrated impacts in economically fragile or vulnerable communities (e.g., Case Study 1). Not all projects are expected to satisfy best practice criteria across every design vertical. The appropriate level of investment should reflect the right-sizing framework we described in the body of this report. Projects where multiple factors indicate elevated social risk likely warrant following best practice criteria across most or all verticals.

Table B3. Minimum acceptable and best practice criteria for social design in industrial IFM projects

Design vertical	Minimal acceptable criteria <i>Social design elements expected of all projects; adequate for projects like Case Study 2, with diffuse or limited impacts</i>	Best practice criteria <i>Social design elements expected of projects like Case Study 1 with large-scale, concentrated impacts in high-vulnerability communities</i>
Stakeholder engagement	Map and inform • Conduct stakeholder mapping that extends beyond the legal landowner to include affected workers, contractors, communities, local governments, and Tribal Nations where relevant. • Communicate project goals, management changes, and expected effects to all identified stakeholders in accessible formats. • Maintain accessible, up-to-date project information throughout the crediting period.	Engage early and sustain All minimal acceptable criteria, plus: • Begin engagement before key design decisions are finalized, providing genuine opportunities for stakeholders to influence project design. • Create and document multiple structured opportunities for stakeholder input across the project life cycle. • Develop a long-term engagement strategy spanning pre-enrollment through the end of the crediting period. • Establish ongoing, institutionalized mechanisms for stakeholder feedback, not limited to enrollment or early implementation phases.
Grievance mechanisms	Establish • Create accessible grievance channels and communicate them to all identified stakeholders via multiple formats (e.g., website, direct correspondence, postings). • Ensure all submissions receive written acknowledgment within a defined timeframe. • Designate responsible staff for grievance handling and maintain basic documentation of concerns received.	Formalize and strengthen All good practice criteria, plus: • Implement documented grievance procedures with defined response timelines, staff responsibilities, and clear escalation pathways. • Maintain multiple access points (e.g., hotline, web form, written submission, in-person sessions) and hold regular opportunities for concerns to surface before they become formal disputes. • Operate a transparent tracking system that is published and updated periodically showing volume, category, status, and resolution outcomes of grievances. • Build in independent escalation options and continuous improvement mechanisms driven by stakeholder feedback.
Benefit-sharing and community impacts	Evaluate • Conduct a socioeconomic impact assessment documenting how project changes may affect workers, contractors, supply chains, and communities.	Design and embed All good practice criteria, plus: • Co-develop benefit-sharing mechanisms with affected stakeholders including workforce development programs, community investment funds, or contractor retention policies based on community-identified priorities.

Design vertical	Minimal acceptable criteria <i>Social design elements expected of all projects; adequate for projects like Case Study 2, with diffuse or limited impacts</i>	Best practice criteria <i>Social design elements expected of projects like Case Study 1 with large-scale, concentrated impacts in high-vulnerability communities</i>
	• Share findings with affected stakeholders and assess whether project scale, harvest reduction, and community vulnerability warrant benefit-sharing or workforce transition support. • Determine appropriate form and level of social investment proportionate to project context.	• Establish formal, long-term benefit-sharing arrangements funded through project revenues, with meaningful community input on governance and distribution. • Embed workforce transition support into project design: prioritize local hiring for new project-related roles; support retraining and workforce development programs in partnership with local institutions. • Report benefit-sharing outcomes publicly on a regular basis.
Indigenous and Tribal rights and access	Identify and respect • Identify Tribal governments and Indigenous Peoples with customary, historical, or cultural connections to project lands, including those whose access may not be formally documented and specifically identify where multiple Indigenous communities have overlapping or adjacent connections to the project lands. • Ensure project activities do not impede established customary access to forest resources for hunting, gathering, or cultural practices. • Map and document known cultural sites, traditional use areas, and access routes within the project footprint.	Consult and co-design All good practice criteria, plus: • Where Indigenous Peoples’ formal or customary rights intersect with the project footprint, conduct meaningful consultation with Tribal Nations consistent with free, prior and informed consent (FPIC) principles before key project decisions are finalized. • Where traditional ecological knowledge is relevant to forest management, create formal mechanisms to incorporate it with Tribal consent and appropriate cultural protocols. • Negotiate formal agreements with Tribal governments covering access rights, benefit-sharing, and any co-management arrangements for culturally significant areas. • Ensure Tribal Nations share equitably in project revenues where Tribal interests are materially affected by harvest changes or land use decisions.

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