CORE Carbon Removal Framework

Community-Informed • Open Access • Reviewed • Evaluated

Carbon180

April 2026

About Carbon180

Carbon180 is a climate NGO with a vision to remove legacy carbon emissions from the atmosphere and create a livable climate in which current and future generations can thrive. Based in Washington, DC, we design and champion equitable, science-based policies that bring carbon removal solutions to gigaton scale.

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Section One:

Executive Summary

Carbon removal is moving rapidly from theory to implementation.

Governments and companies are investing billions, and interventions are happening across landscapes and oceans. The decisions made in this early phase will shape the rules, infrastructure, and expectations of the field for decades. At the same time, carbon removal faces a central challenge: public trust. If interventions exclude communities from decisions that affect them, fail to deliver real climate benefits, or create environmental harms, the field risks losing the social license needed to scale.

The Community-Informed, Open Access, Reviewed, and Evaluated (CORE) Carbon Removal Framework was developed to help guide the field as it matures. It establishes shared expectations for how carbon removal should be designed, implemented, and evaluated. The goal is to ensure that climate outcomes are credible, environmental impacts are understood, and communities have meaningful influence over decisions that shape their lands, waters, and livelihoods. CORE recognizes that carbon removal will only succeed if it delivers both real climate benefits and equitable outcomes for people and ecosystems.

CORE centers around three groups whose wellbeing determines whether carbon removal is successful:

Communities

Climate

Environmental Outcomes

Communities need access to information, resources, and decision-making power. Climate outcomes must represent measurable and verifiable removal of carbon dioxide from the atmosphere. Environmental systems, including ecosystems, biodiversity, and natural resources, must be protected and, where possible, strengthened.

The framework also addresses several systemic challenges shaping the field today, including structural inequities that limit community participation, governance failures that weaken accountability, environmental and health risks that can fall disproportionately on already burdened communities, and weaknesses in climate accounting that undermine confidence in carbon removal claims. CORE addresses these risks by establishing clear expectations.

The framework is built around two components. CORE Principles define the values and technical foundations that must guide carbon removal. These are justice, equity, transparency, accountability, enforcement, inclusion, additionality, and net negativity. CORE Practices translate those principles into concrete actions that shape community engagement, project and program design, governance, monitoring, and verification. Together, they provide a practical structure for evaluating whether carbon removal efforts are delivering meaningful outcomes.

Four challenges that shape carbon removal today:

1.

Structural inequities that limit community participation

2.

Governance failures that weaken accountability

3.

Environmental and health risks that can fall disproportionately on already burdened communities

4.

Weaknesses in climate accounting that undermine confidence in carbon removal claims

CORE Principles

Justice

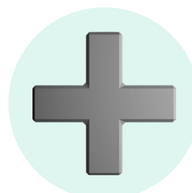
Equity

Transparency

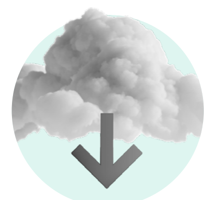
Accountability

Enforcement

Inclusion



Additionality



Net Negativity

Because carbon removal takes many forms — from local projects to large-scale programs — the framework is designed to be adaptable while maintaining consistent standards for carbon removal. Some interventions, particularly early research or demonstration efforts, may not yet meet every CORE principle or practice in full. In these cases, the framework serves as a design guide and long-term benchmark, helping interventions strengthen integrity as they mature.

Ultimately, CORE provides a shared language and set of expectations for anyone working to scale carbon removal responsibly. By embedding justice, transparency, and rigorous climate accounting from the start, the framework helps ensure that carbon removal contributes meaningfully to climate goals while strengthening the communities and ecosystems where it occurs.

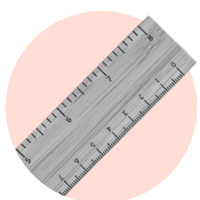
CORE Practices

Knowledge Building

Dignified Workforce Development

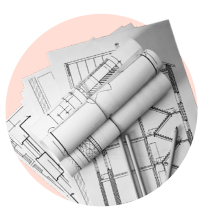
Community Agency Mechanisms

Community Benefit Mechanisms



Monitoring of Carbon Storage

Full System Carbon



Design for Additional Impact

Independently Verified

Environmental Health

Human Health & Safety

Enforcement Mechanisms

Section Two:

Introduction

Purpose

Carbon removal is essential to confronting climate change — and it's moving fast. Billions in funding are being deployed, policies are taking shape, and projects are being planned and built. The sector is shifting from theory to implementation — meaning early choices are becoming infrastructure, contracts, and precedents that will define this field for decades.

The single greatest risk to carbon removal's success is the loss of public trust. If carbon removal does not deliver real climate impact, overpromises on benefits, or causes harm to people and the environment, it will quickly lose support from communities, policymakers, and investors alike. Once trust is broken, it's incredibly difficult to rebuild. Without confidence that climate, environmental, or social benefits are real, without a social license to operate, carbon removal will not scale.

> "The single greatest risk to carbon removal's success is the loss of public trust."

This framework, the Community-Informed, Open Access, Reviewed, and Evaluated (CORE) Carbon Removal Framework, offers clear expectations for how carbon removal should be designed and carried out. It focuses on making impacts measurable, responsibilities clear, and protections enforceable. CORE treats justice, equity, and accountability as inseparable because long-term success of carbon removal depends on both social license and atmospheric impact, which is why decision-makers must embed these commitments now, while the field is still taking shape.

The framework is built on two layers: principles that define what CORE-aligned carbon removal must be, and practices that bring those principles to life.

Each practice includes:

1. **Key characteristics** to guide strong decision-making and meaningful engagement.
2. **A case study** that illustrates what the CORE framework looks like in action.

And because every carbon removal intervention unfolds in a specific place, with its own communities, histories, landscapes, and constraints, we emphasize context-responsive application of the framework, adapting how these principles are met, not whether they are met.

> "Our goal is to give communities, implementers, and decision-makers a shared foundation of language, expectations, and best practices."

If low standards are locked in today, it will be far harder to course-correct later. The recommendations we offer reflect today's standard for CORE carbon removal. Our goal is to give communities, implementers, and decision-makers a shared foundation of language, expectations, and best practices. They are aspirational in the sense that no pathway, program, or project will meet every expectation on day one. They are also intentionally specific, because clarity about the standard is what allows the field to mature responsibly. This foundation will evolve as the field advances — through new science, improved governance models, and stronger community-centered practice. This is how credible standards work: they got stronger, not weaker. That evolution depends on centering multiple knowledge systems, honoring community perspectives, and recognizing the histories of people and places.

Scope and how to use this framework

This framework is intended for climate-relevant carbon removal, that is, carbon removal outcomes that are claimed, credited, or counted toward climate goals, including in policy, program design, corporate strategy, and public accountability contexts. Carbon removal does not need to be the original intent of a program, funding stream, or intervention for CORE to be relevant. However, when carbon removal outcomes are claimed as a benefit, whether as a primary objective or a co-benefit, those outcomes must be supported by the integrity requirements in this framework.

Many interventions, particularly early-stage research, development, and demonstration efforts, may not yet be able to meet every CORE practice in full. In those cases, the framework should serve as a north star and design lens: a clear standard that guides how interventions mature over time, how tradeoffs are made explicit, and how integrity is strengthened as the field scales.

This includes work that enables future carbon removal, such as governance capacity-building, inclusive program design, and protections for land and ocean stewards, even when those programs do not center carbon removal as their primary objective.

In these contexts, the CORE framework clarifies both:

1. **What enabling conditions** make CORE-aligned carbon removal more possible over time
2. **When it is and is not appropriate** to claim carbon removal outcomes.

What this framework serves

The CORE framework centers the three beneficiaries whose wellbeing and integrity determine whether carbon removal is just and effective:

Communities: People and places directly affected by or responsible for implementing carbon removal interventions, including disadvantaged communities and historically underserved land and ocean stewards. The framework prioritizes their rights, wellbeing, and ability to participate meaningfully in decisions that impact them.

Climate Impact: The framework centers real climate outcomes, grounded in a need for net carbon removal – not just good intentions or financial transactions. It prioritizes credible, durable impact that contributes meaningfully to global climate goals.

Environmental Outcomes: Carbon removal unfolds in specific landscapes and seascapes, shaping ecosystem health, biodiversity, and the resilience of land and ocean ecosystems. The framework prioritizes environmental outcomes by preventing degradation, supporting ecological function, and where possible, actively restoring ecosystem health alongside carbon outcomes.

Who are "disadvantaged communities" and "historically underserved land and ocean stewards"?

These terms appear throughout the framework. Full definitions are available in the Glossary of Terms and the supplementary online glossary.

We refer to ***disadvantaged communities*** as communities that experience overlapping social, economic, environmental, and public health burdens, including poverty, disproportionate incarceration, pollution exposure, proximity to hazardous wastes, climate vulnerability, and elevated rates of chronic illness. These communities are disproportionately composed of people of color, women, LGBTQ+ people, people with low incomes, currently and formerly incarcerated people, people with disabilities, and veterans.

Historically underserved land and ocean stewards are people who tend and manage land or marine environments, regardless of ownership, and who have been systematically discriminated against, underserved, and subject to the violence of colonialism. These stewards, who are disproportionately people of color, women, veterans, and people with limited economic resources, hold dual roles as both carbon removal implementers and community members affected by landscape- or seascape-level decisions.[1–3] They face barriers to land ownership, federal assistance, and equitable access to ocean resources, while enduring the compounding impacts of market volatility and the climate crisis.[4] They also possess deep place-based knowledge that is often underrecognized or excluded from federal and state programs.

Section Three:

Issues at the Intersection of CORE and Carbon Removal

Issues at the intersection of CORE and Carbon Removal

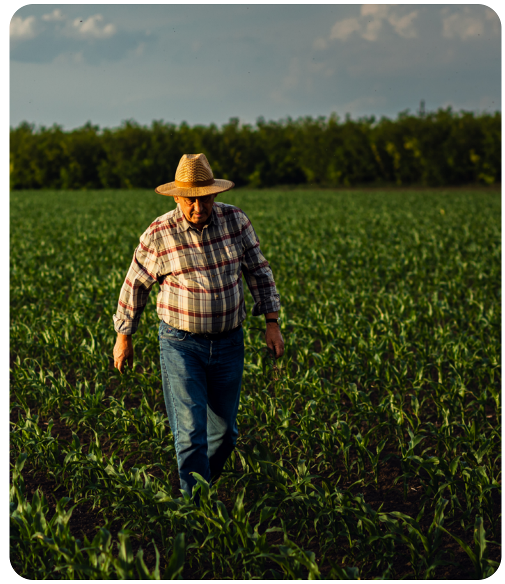
A framework that guides carbon removal has to name challenges clearly. This section identifies the systemic barriers, historic harms, and design failures that carbon removal must confront. These are the root causes of mistrust and misalignment that the CORE principles and practices are designed to address.

Structural Inequities and Capacity Gaps

Carbon removal can enter communities already burdened by structural inequities: historic underinvestment, exclusion, and barriers to resources. These limits shape access to funding, information, and decision-making, ultimately determining who can benefit from interventions or absorb risks. If unaddressed, they undermine trust and create conditions for governance failures.

Structural inequities show up most immediately as limits on capacity: who has time, resources, technical support, or institutional backing to engage. Some of the communities where carbon removal is being proposed - including Tribal lands, rural and coastal towns, and historically industrial regions - face long-standing financial strain, infrastructure gaps, and compounding burdens that reduce their ability to organize, evaluate risk, articulate priorities, and negotiate terms. Although these challenges vary by place, their cumulative effects shape who can meaningfully engage with carbon removal.



Funding opportunities are often narrowly restrictive, short-term, highly competitive, and administratively burdensome, effectively excluding communities with limited staff or grant-writing infrastructure.[5,6] Many land stewards are financially stretched to their limits, as farm management costs and land prices have risen while profit per acre and subsidies have stagnated.[7,8] Most farmers are older, unable to take large financial risks, and may not have sole authority over the management of rented land or livestock.[9,10] Traditional Ecological Knowledge remains under-recognized or excluded in many federal and state programs, further marginalizing communities whose expertise it represents.[11–13] Ocean stewards often experience inequitable access to ocean benefits and resources, and coastal development that displaces long-standing coastal communities.

Even when some resources are available, inequities persist through uneven access to information and the ability to influence it. Intervention timelines often move faster than shared knowledge-building can occur, leaving communities to respond to proposals they have not had the time or support to fully understand, much less to contribute their lived experiences and regional expertise. This is compounded by the fact that carbon removal itself is still new with low public familiarity, meaning communities are often responding to proposals they're encountering for the first time.[14,15] Moreover, the language used across media, agencies, and implementers is often overly technical, non-standardized, and rarely available in non-English languages.[14,16–18] Training systems and certifications for emerging carbon removal pathways are still in development and can be prohibitively expensive. These barriers limit who can build expertise, evaluate proposals, or participate in workforce development.

Inequities in how knowledge is generated, shared, and used further compound these gaps. Many of the data-collection efforts that guide carbon removal are designed without meaningful involvement from the people most affected. These processes often exclude Traditional Ecological Knowledge, disregard lived experience, and undervalue regional expertise. In some cases, they extract local insights without compensation or shared benefit. When the information used to justify or shape interventions is developed without communities, it undermines the relevance, legitimacy, and accountability of carbon removal.

"When the information used to justify or shape interventions is developed without communities, it undermines the relevance, legitimacy, and accountability of carbon removal."

Governance, Power, and Accountability Failures

When communities begin from an uneven playing field, decision-making structures often reinforce those disparities — leaving people without access to necessary information, enforceable protections, or real power over outcomes. Although these challenges manifest differently across communities, they often operate in connected ways: early exclusion limits access to information; limited information dilutes accountability; and diluted accountability diminishes delivery and enforcement of outcomes.

Exclusionary implementation processes are often the first point where power imbalances become visible. Many communities view carbon removal as moving forward without their say or involvement. Community engagement activities tend to be opaque, one-way, inconsistent, and timed to justify decisions already made. When communities are brought in only after locations are chosen, approaches and compensation are locked in, or permits are underway, participation becomes performative rather than influential. These dynamics leave local expertise undervalued, concerns unaddressed, and pathways for shared decision-making structurally closed.

These exclusionary processes then shape access to information. When communities are not included early, or are treated as consultees rather than partners, critical information about risk, benefits, monitoring, mitigation, results, planning, and decision rationales is often incomplete, inaccessible, or withheld entirely. Data is labeled proprietary, key documents require non-disclosure agreements (NDAs), and technical materials are presented in formats that are difficult to interpret or unavailable in local languages. Without transparent, timely, and accessible information, communities cannot meaningfully evaluate proposals, challenge assumptions, or make informed decisions about what they are being asked.

Both exclusionary processes and information gaps lead to weakened accountability where responsibility is diffused across actors and no single entity is clearly answerable. Carbon removal interventions typically involve multiple actors (developers, landowners, land and ocean stewards, technology providers, technical assistance providers, funders, registries, policymakers, regulators) yet few systems define who is responsible for what over time. Legal roles can be unclear, liability for reversal may be undefined, and long-term monitoring obligations often rest with entities that may not exist decades later. When oversight is weak, fragmented, or dependent on developer-funded verifiers, risks go unmanaged, harms fall through jurisdictional cracks, and communities have little ability to seek recourse. Most critically, accountability mechanisms rarely flow to communities themselves, leaving them without clear pathways to trigger corrective action, enforce commitments, or obtain remedies when harm occurs.

> "Accountability mechanisms rarely flow to communities themselves, leaving them without clear pathways to trigger corrective action, enforce commitments, or obtain remedies when harm occurs."

This weakened accountability then shapes whether promised benefits are delivered or enforceable, especially when those benefits were not co-created with communities from the outset. Community benefits agreements are often treated as aspirational documents rather than binding commitments. They may be drafted before meaningful engagement, misaligned with community needs, or lack any enforcement mechanism. Disadvantaged communities face significant barriers to negotiating or enforcing benefits. Even where benefits are offered, they tend to be narrow (e.g., job creation, infrastructure improvements), without addressing deeper, locally relevant priorities. In practice, benefits often flow elsewhere entirely - to non-local workforces, to outside contractors, or to entities with greater bargaining power. Without enforceable mechanisms, communities have limited ability to ensure that promised benefits materialize and persist.

Environmental, Health, and Safety Risks

Without strong governance that enables community power, environmental and public health burdens often fall hardest on the same communities and ecosystems that have historically borne the pollution and health costs of industrial development. Power imbalances shape not only how interventions move forward - including the assessment, monitoring, and mitigation of potential outcomes - but also where consequences land when protections fall short. Although these risks vary by pathway and place, they share a common root: when communities are denied shared power and enforceable safeguards, harm follows.

Environmental risks arise when carbon removal interventions contaminate air, water, or soil systems, deplete freshwater resources, degrade habitats, or contribute to habitat loss and fragmentation through land use change or monocultures. Each pathway carries distinct risks — land-based approaches may alter soil biodiversity or habitats, ocean-based approaches interact with sensitive marine food webs and biogeochemical processes, and technological approaches that rely on chemicals, energy, and underground CO_2 storage.[4,19,20] Yet, these environmental harms are frequently undermeasured in narrowly carbon-focused measurement, monitoring, reporting, and verification (MMRV) systems, resulting in gaps communities are left to navigate.

Health and safety risks emerge from the same power and accountability gaps. Communities already hosting energy, agricultural, coastal, or industrial infrastructure often experience elevated health burdens — impacts carbon removal can worsen without strong protections. Weak labor standards, unsafe operations, and inadequate emergency preparedness expose workers and residents to preventable harm, with undocumented workers facing heightened risks. When oversight is limited and emergency plans are unclear, leaks, equipment failures, or chemical exposures become more likely. Without enforceable safeguards and community-driven safety planning, these risks accumulate in ways that deepen mistrust and disproportionately affect those with the least capacity to respond.

> "Co-benefits are often assumed rather than collaboratively designed with attention to local ecosystems and community needs."

Governance failures also threaten the co-benefits that carbon removal can deliver, improvements to ecosystem health, biodiversity, soil quality, air and water quality, which are often more tangible to communities than carbon removal itself. Yet, co-benefits are often assumed rather than collaboratively designed with attention to local ecosystems and community needs. When interventions narrowly focus on maximizing tons of carbon removal, outcomes for environmental quality, biodiversity, and public health can suffer. When harm outpace benefits, co-benefits become meaningless, leaving communities and ecosystems worse off than before the intervention.

These risks rarely occur in isolation. Environmental and health burdens accumulate across industries, pathways, and time. Communities already facing pollution, economic precarity, or climate impacts experience the combined effects of multiple stresses, or cumulative burden. While every industry carries risks that cannot be fully eliminated, without strong protections and community-driven safeguards, carbon removal can add yet another layer of harm.

Integrity and Climate-Accounting Failures

When the systems meant to ensure fairness, safety, and accountability break down, communities are left carrying the risks of weak safeguards, opaque decisions, and unfulfilled commitments, while the climate benefits carbon removal is supposed to deliver become harder to trust. The same power imbalances that determine who participates and who is protected also shape whose data is believed and what counts as 'climate benefit.'

Misaligned incentives often push carbon removal toward what is easiest to measure, finance, or market rather than what provides real climate benefit. Narrow system boundaries can exclude major sources of emissions, such as supply-chain impacts or land use changes, allowing interventions to appear net-negative even when a full accounting would show otherwise. Verification systems shaped by financial ties, proprietary methods, or inconsistent independence further reinforce these distortions, weakening both scientific integrity and public trust.

> "Misaligned incentives often push carbon removal toward what is easiest to measure, finance, or market rather than what provides real climate benefit."

Weak standards for demonstrating real climate benefits deepen these vulnerabilities. Baselines may be unrealistic or incomplete, additionality may be inconsistently defined, and durability treated as a threshold rather than a probability of reversal that must be continuously assessed and reported over time. Uncertainty in the amount of carbon removed (which is often substantial) is rarely disclosed, enabling climate claims to appear precise while resting on compounding assumptions. These gaps make it difficult for host communities, policymakers, and the general public to understand the true impact of interventions or compare approaches transparently.

Together, these failures demonstrate that climate integrity cannot be separated from the CORE framework. Every principle (justice, equity, transparency, accountability, enforcement, inclusion, additionality, and net negativity) exists because of what can go wrong when it's absent. If systems do not protect communities or reflect real atmospheric change, the field risks producing harms with little to no climate benefit — undermining its legitimacy and its reason for existing.

Section Four:

CORE Principles

The CORE Principles define the core values and technical foundations that guide responsible carbon removal.

They directly address the problems outlined in the previous section, anchoring the framework by clarifying what integrity looks like in both process and outcome. Each principle reflects a necessary condition for carbon removal that benefits people and the planet: justice and equity as the moral basis, transparency, inclusion, accountability, and enforcement as the operational backbone, and additionality and net negativity as the standard for environmental and climate performance. Together, these principles guide how decisions are made, how impacts are measured, and how responsibility is shared across every stage of carbon removal.

Justice

Existing systems and structures are changed to balance power, address past harms, and create systems to prevent those harms from recurring.

Justice is achieved when all people have access to the same freedoms (freedom from poor air and water quality) and processes (planning and management) without additional support or accommodations because the systemic barriers impeding justice have been removed.

This may be achieved by **procedural justice** (requiring fairness in the decision-making); **distributive justic**e (equitably sharing resources, risks, and benefits); **restorative justice** (repairing previous harms); and **transformative justice** (changing the systems and structures that enabled those harms).[21]

Equity

Equity addresses and alleviates existing unfair treatment and outcomes. Equity is achieved when a person's life conditions (locally unwanted land use proximity, poor air quality, incarceration) are not predicted by their characteristics (e.g., race, ethnicity, sex, and gender).

Work centering equity acknowledges that some people and groups require more support than others, and creates conditions that close those inequitable gaps without relying on continued external assistance.[22]

Transparency

Parties exchange a robust accounting of all information essential to equitable and informed decision-making. Transparency applies both to how people are engaged and to how information and data are shared. It means that information is not only disclosed but made understandable and accessible to everyone affected.[23] Transparency allows all parties to see how decisions are made, who is responsible, and what impacts occur.

Accountability

Accountability invites examination. This means both maintaining open agendas and decision-making processes, and prioritizing openness when things go wrong. In practice, accountability means acting on criticisms, owning mistakes, and sharing the power over an intervention's purpose and scope.[24]

Accountability only works if someone is clearly responsible. For each part of this framework, there must be a clearly named actor who has the authority, resources, and systems in place to follow through, including fixing things if they go wrong. Commitments should be made public and binding, and it should always be clear who is accountable for what.

Enforcement

Enforcement means actors comply with laws, policies, directives, and missions while prioritizing and minimizing harms to vulnerable and disadvantaged people. Commitments are not only made but upheld through clear consequences for noncompliance, transparent oversight, and accessible avenues for remedy. In practice, enforcement includes regulations, polluter-pays models, legal aid, and capacity-building partnerships.

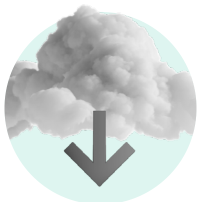
Inclusion

Inclusion means authentically involving traditionally excluded people and groups in processes, activities, and decision-making in ways that share power.[24] Truly inclusive work bridges the divide between community and intervention governance through efforts like community-driven planning and participatory action research. It must go beyond public comments, fact sheets, and surveys.[25]

Additionality

In carbon removal, climate additionality is the primary test of atmospheric integrity — proof that an intervention genuinely changes CO_2 levels beyond what would have occurred under a well-defined baseline scenario that reflects realistic estimates or inferences of carbon fluxes in the absence of the intervention.[26] For interventions that involve crediting, establishing additionality prevents over-crediting and ensures that every ton claimed reflects a genuine climate benefit.

Other forms of additionality help explain how climate benefit becomes possible. Financial additionality asks whether an intervention would have occurred without carbon finance.[27,28] Regulatory additionality asks whether it goes beyond existing legal requirements[28] Technological additionality asks whether innovation is expanding what's achievable.[27,29] Social additionality highlights the human and institutional shifts that make climate outcomes lasting and just.[30] Taken together, these lenses provide a fuller picture of integrity.



Net Negativity

Net negativity means that a carbon removal approach removes more greenhouse gases from the atmosphere than it emits across its full lifecycle.[31] Here, full lifecycle refers to the complete chain of activities and emissions from initiation through the end of the storage period, including ongoing management and monitoring where needed to maintain stored carbon.

True net negativity reflects both the physical outcome, a measurable drawdown of CO_2, and the confidence that this result holds up after counting every stage of the process, from energy and materials to transport and long-term storage. Without it, carbon removal claims have no credible basis.

Section Five:

CORE Practices

Practices are the actions that operationalize the CORE principles.

By implementing these practices, carbon removal efforts strengthen their own impact and build the public trust needed to scale.

Practices are not a box to tick. Rather, they are processes to embed into the lifecycle of an intervention that can be tailored to meet the needs and interests of implementers, impacted communities, and land and ocean stewards. To support that process, we offer guiding metrics that can be used to assess whether a practice has been meaningfully implemented.

Creating carbon removal by the project versus at the programmatic-scale

While some interventions are designed and assessed as discrete, site-specific projects, many others, especially nature-based, community-driven, or policy-enabled efforts, function at a broader programmatic scale. A CORE-aligned framework must accommodate both, without compromising on rigor, transparency, or quality.

Projects operate at a specific site with a defined set of actors and impacts. Because their boundaries are clear, projects are expected to build two-way partnerships with directly affected groups and report results through precise, bottom-up accounting.

Programs operate across a wider sphere of influence, often not defined by a single location but by a shared intervention model, governance structure, or target impact. They function through a coordinating institution (often a third party) that sets standards, provides guidance, and supports distributed implementers, such as farmers, ranchers, fishermen, or community groups, who carry out actions under a shared framework. Because program data may involve personal or sensitive information, success is typically reported through aggregated, top-down accounting that protects privacy while maintaining transparency and integrity.

Program-scale efforts often struggle to meet criteria designed for single-site projects. Smaller or more distributed implementers can face prohibitive measurement and verification requirements, even when their collective actions are essential for durable carbon storage, ecological resilience, or community wellbeing. Evaluation frameworks must recognize the legitimacy of programmatic interventions that deliver measurable, climate-relevant carbon removal, even when they do not cleanly fit crediting protocols, and must clarify how the CORE principles apply at this broader scale.

Knowledge Building & Management

Is the knowledge needed to evaluate and implement a carbon removal intervention accessible to communities, land and ocean stewards, and implementers — and is it informed by the multiple knowledge systems they hold?

Definition:

A collaborative approach where communities, land and ocean stewards, and implementers actively and reciprocally share, create, and apply knowledge to design and implement carbon removal. Knowledge encompasses expertise, lived experiences, practices, and beliefs held by individuals and groups.

At the project level, implementers partner with communities and land and ocean stewards to build shared knowledge for a project's design, implementation, and benefits delivery — centering multiple knowledge systems, including Traditional Ecological Knowledge and lived experiential knowledge.

At the program level, implementers embed these same commitments into program design and ensure that information about outcomes, co-benefits, and risks is transparent and accessible. At both levels, co-generated knowledge is maintained long-term in accessible formats, contributing parties retain the ability to use and interpret data collected through their participation, and culturally or personally sensitive information is protected from general circulation.

What needs to be true?

- Knowledge building is reciprocal, shared, respectful, and inclusive. It centers knowledge systems including lived experience, regional expertise, and Traditional Ecological Knowledge. Key carbon removal content, including its distinction from other interventions, local impacts, potential co-benefits, and resource requirements is shared in jargon-free, multilingual, and ADA-accessible formats across media types (audio, video, print).

- Appropriate protections are in place to ensure communities and land and ocean stewards retain ownership and control over knowledge they share including the translation, interpretation, and communication of knowledge.
- Local knowledge is centered in identifying sensitivities (social inequities, economic burdens, disrupted ecological activities, degraded natural habitats, and strained natural resources) and opportunities (interests in activities that restore forests, access to cultural spaces, air and water quality) relevant to an intervention.

- Knowledge is co-created and iteratively updated. Barriers to participate in knowledge-building activities are lowered through providing food, childcare, transportation, stipends, and any other identified support needs.
- Knowledge is managed accessibly, made publicly available where possible, attributed to its sources, readily obtainable, understandable, and usable by all parties. Data and text are machine-readable translated or translatable, and available both online and physically with provisions for public access through resources such as libraries or community centers.
  - A developer's intellectual property (e.g., trade secrets and patented processes) is protected unless it relates to or impacts the assessment

of human health and safety, environmental health and safety, or emergency preparedness.

- Cultural or personal knowledge contributed by land and ocean stewards and communities is protected and only made publicly available through expressed consent.
- Changes made to shared knowledge should be accompanied by an annotated record of any changes. Information that is no longer relevant is archived on the public site. Information is frequently updated, so that the public has access to information within 30 days of any other party receiving the information, the standard used for most data breach reporting.[32]

- Implementer-led research is equitably designed and, where relevant, findings are co-produced with communities. Opportunities to co-produce findings include: scientific publications, especially multi-author syntheses; participation in exchange platforms for data and knowledge sharing; participation in international technology transfer undertakings; participation in public forums for knowledge sharing such as conference attendance.

Mukurtu CMS

Restoring ownership and understanding through digital repatriation

Type: Project
Location: Australia

Mukurtu CMS is a free, open-source digital archive, creating shared access for Indigenous communities to their cultural materials, traditional knowledge, and language.[33] Created in 2007 for the Warumungu Aboriginal people of Central Australia to host repatriated photographs, the platform evolved into a digital safe harbor for Indigenous communities to protect their cultural, linguistic, and historical knowledge.[33]

In launching Mukurtu, digital archivists and members of the Warumungu community have co-authored standards for a practice called **digital repatriation**, the restorative process of:

1. Recognizing and recording the harms done to Indigenous communities in collecting information;
2. Deciding how to remake and undo colonial classifications and categories;
3. Expanding, replacing, and updating Indigenous metadata;
4. Updating or outright replacing copyrights and IP rights that bar Indigenous ownership of cultural materials; and
5. Developing ongoing relationships of stewardship.[34]

Many Indigenous communities distrust cultural heritage materials received from collecting institutions, whose cataloguing practices were shaped by colonialism, racism, and dehumanization — lenses that skew the accuracy of what images, songs, and documents are understood to represent.[34] Through Mukurtu, Indigenous users can opt-in to a feature called 'round-trip' that facilitates sharing recontextualized information like updated maps and song lyrics with the original collecting institutions.[33] Through the restorative process of return and recontextualization, Mukurtu users have created a bidirectional flow of materials and metadata from collecting institutions to Indigenous communities, and added and enhanced context and information back to collecting institutions.[34]

It's important to note that although collecting institutions can benefit from Indigenous community's use of Murkurtu, the platform's objective is to acknowledge and undo centuries of colonization done by the forced collection and misclassification of Indigenous cultural materials, not to help collecting institutions update their catalogues. Mukurtu aims to help communities find justice and resolution in the return of lost cultural materials, traditional knowledge, and languages.

Dignified Workforce Development

Does the intervention create durable, desirable, and livable opportunities for employment and income generation that strengthen local economies?

Definition:

Mutually reinforcing opportunities for workforce development and income generation that support workers and stewards in long-term career advancement, sustaining their families, and building wealth. Dignified work means trainees, workers, and stewards of all identities are respected and valued, and have access to resources in support of a fulfilling life.

At the project level, workforce development ensures that opportunities directly created by the carbon removal project pay family-sustaining wages, support upwards mobility, ensure respect and value for all workers and stewards, and are prioritized for workforces local to and most directly impacted by the intervention.

At the program level, workforce development embeds requirements for programmatic investment that builds resilient workforces across communities, provides dignity to all workers and stewards, and improves economic health over time across the impacted regions.

What needs to be true?

- Implementers are specific and forthcoming about potential employment opportunities, which, whenever possible, span entry-level through executive leadership positions. All workers and forms of labor, regardless of position, are valued and respected.
- Employment and income generation opportunities include family-sustaining wages with annual adjustments, comprehensive benefits

including health insurance, paid leave and retirement options, strong physical and psychological safety protections, and clear anti-discrimination and anti-harassment policies. Federal and state workers' rights and protections are communicated consistently in written and digital formats. Neutrality towards union organizing is upheld, and existing or newly formed unions are partnered with for job opportunities. Where dignified employment requirements cannot always be fully enforced for undocumented workers, employers must understand and communicate all federal and state protections that do apply so undocumented workers know their rights.

- Outreach for job opportunities is prioritized locally, including workforce development boards, city or county official websites, job fairs, community newspapers, bulletin boards, schools and colleges, social media page, and is available in regional languages. Local hire commitments are clearly stated and regularly reported, and included in workforce agreements. Barriers to job access are reduced through support like childcare, flexible scheduling for interviews/training, and fair-chance hiring.
- Workers and stewards from local industries (e.g., oil and gas, bioenergy, agriculture) with transferable skills are identified, prioritized for workforce development, and connected to employment opportunities.
- Implementers partner with local workforce development boards, unions, vocational and trade schools, colleges and universities, and other institutions to provide co-created skills training, reskilling, and upskilling related to carbon removal (e.g., machinery installation, soil sampling), as well as certification opportunities.

BlocPower

Growing a workforce through intentional investments

Type: Program
Location: Brooklyn, New York

BlocPower is a Brooklyn-based climate technology company focused on making smarter, greener, and healthier buildings in communities of color and low-income.[35] The company develops and implements clean energy solutions, including building electrification, energy efficiency retrofits, heat pump installations, and electric vehicle charging infrastructure.[36–38] Since its founding in 2014, BlocPower has retrofitted more than 1,000 buildings in disadvantaged communities in New York City, with projects underway in 24 cities across the state.[35]

A core part of BlocPower's approach is equitable workforce development and good job creation in clean energy technologies. Through their Climate Tech Workforce Program and Civilian Climate Corps, the company partners with communities and other companies to train a new workforce of people who can perform green building construction methods, such as installation of solar panels and replacement of fossil fuel equipment with all-electric heating systems.[36,37,39]

BlocPower's programs specifically focus on recruiting, training, and hiring people of color and people from low-income communities, including formerly incarcerated individuals and people at risk of gun violence.[36,39] Participants are recruited through a network of local community partner organizations. Trainees are paid $20 an hour to learn on actual job sites and receive certifications.[36] Many trainees become employees of BlocPower, working on BlocPower projects, or go on to work with an employer pool, partly created by BlocPower, that hires locally.

As of December 2023, BlocPower reports over 4,000 trained participants, over 700 job placements, over 2,795 certifications earned, and 5,100 city blocks impacted by their workforce development efforts.[40] BlocPower illustrates how a climate-tech company can reduce barriers to employment, build job-ready talent, and support economic mobility in disadvantaged communities.

Community Agency Mechanisms

How does the carbon removal intervention promote community power through who makes decisions and how decisions are made?

Definition:

The ability of communities to organize, express their collective voice, participate actively, and wield power in the decision-making and outcomes of interventions that impact their livelihoods.

At the project level, decision-making mechanisms promote community agency over design, implementation, and outcomes.

At the program level, community agency operates in two dimensions: communities have power over the program's design, funding, and regulation, and individual projects supported by the program must demonstrate community-driven decision-making structures.

What needs to be true?

- Impacted communities have agency over the design and implementation of a carbon removal intervention, including the type and potential site of an intervention, expansion plans, community benefits, monitoring and reporting on impacts, and contingency planning and emergency preparedness.
- Decision-making mechanisms balance power across community groups and implementers through inclusive representation of community identities. Community representatives are nominated to some extent by community members, and selections are transparent and timely.

- Community representation can take multiple forms throughout an intervention:
    - Voting seats on governing or executive boards with clear legal, fiduciary, and decision-making responsibilities.
    - Advisory boards that provide guidance and oversight, with defined responsibilities, oversight mandates, and enforcement mechanisms. Members may have specific expertise in areas such as ethics or community engagement.
- Formal agreements, like memorandums of understanding (MOUs), are used to ensure clarity, accountability, and enforceability across community groups and implementers.
- In addition to community representation on formal intervention bodies (e.g., boards, committees), communities can wield power through community-wide decision processes, such as participatory budgeting.
- Processes used to make intervention decisions are adapted to the impact of the decision and the needs of communities.
    - Consensus decision-making is appropriate for high-stakes decisions that require support from all groups. Content-based decision making is appropriate for moderate-impact decisions where the goal is a solution without strong objection. Both require neutral facilitation, sufficient time, and alignment on shared values.
    - Where community well-being is directly and significantly affected, community advisory boards or equivalent structures should hold a collaboratively defined veto power over decisions that fail to develop community well-being.

- Structural barriers to community involvement are identified and removed through community needs assessments, adequate time for review, compensation for participation, culturally appropriate scheduling, language and accessibility support, childcare, transportation, and minimized administrative burden.

Maine Lobster Fisheries

Co-management over top-down management

Type: Program
Location: Maine

Increasing demand for protein to feed a growing population, paired with a warming ocean, threatens fisheries with overharvesting and collapse.[41] In the early nineties, both the lobstering and groundfish fisheries of the Gulf of Maine had experienced decline. Top-down governmental mandates on fishing practices and catch limits had failed, as disgruntled fishermen resisted limits politically and through poaching.[41,42] Counterlobbies sunk multiple policy strategies and pushes before the government could set limitations on either fishery. But in 1995, Maine pioneered one of the first co-management governance structures, partnering directly with fishery partners to set management regimes.

In 1995, Maine established local zones for lobster fisheries, administered cooperatively between.[41,42] Zone councils had the power to set trap limits, fishing windows, and entry caps — with proposals requiring majority approval from license holders and sign-off from the Department of Marine Resources commissioner before becoming regulation. This gave fishers agency over the rules they were expected to follow. Within three years, all zones had passed trap limits with overwhelming support — a measure that had failed 17 times over the previous forty years. By 2001, most zones had also capped the number of fishers, a measure that had failed three times at the state level.

With that agency, zone councils responded to local conditions with nuance, setting trap limits that reflected local demand, adopting innovative approaches like ratio license limits to balance large- and small-scale operations, and creating zone buffers for seasonal migration patterns. Compliance has been extremely high, enforced not only by wardens but by self-regulation.

The contrast with the Gulf of Maine's groundfish fishery is stark.[41,42] Managed through slow-moving federal regulations with no local agency, groundfishermen resisted limits through political lobbying and widespread poaching. Populations have collapsed — where cods were once so numerous it was said one could walk across the water on their backs, their stock has dwindled to almost nothing.

External factors also played a role in these differences. Lobster fisheries experienced a major boom around the time this legislation was passed, driven partially by new guidelines but also by environmental factors.[41,42] This boom seems to have reinforced the emerging conservation ethos for lobstermen, encouraging them to take the risk of self-limitation. Additionally, lobstermen are highly local in their routes and are often selective about their harvest, whereas groundfishermen are generally wide-ranging and each haul takes fish regardless of size class or reproductive status However, there is general agreement that without local co-management much of the lobster fishery protections and subsequent economic and ecological benefits we see today would not have been possible.

Community Benefit Mechanisms

Does the carbon removal intervention offer benefits that address the wants and needs of communities, land and ocean stewards, and ecosystems?

Definition:

Any benefit delivered to a community, land and ocean steward, or ecosystem in exchange for a community's or steward's support of or participation in the implementation of a carbon removal intervention.

For a carbon removal project, benefits are co-identified by implementers with communities and land and ocean stewards. For some groups, relevant benefits are already clearly defined. For others, support may be required to identify needs and potential non-climate co-benefits, sensitive communities and areas, and risks associated with deploying a project nearby.

For a carbon removal program, benefits are co-identified by implementers with communities and land and ocean stewards. For programs, benefits can be tailored to meet individual needs, or can be broad enough to appeal to residents and implementers across regions. Designing programs that meet climate goals and the needs of communities and land and ocean stewards will require iterative, targeted conversations about the social, economic, and environmental needs of program participants and their local ecosystems.

What needs to be true?

- Benefits are co-identified through iterative, transparent conversations, including community listening and vision sessions, focus groups and interviews, negotiations with community engagement councils, and asynchronous input tools like surveys and public comments.

- Conversations should center the perspectives of disadvantaged groups and accommodate the capacity of impacted communities and participants.
- Community Needs Assessments (CNA) can be used to guide outreach practices. Residents and implementers who lend their time and expertise to outlining benefits should be compensated and accommodated (e.g., legal aid funds).
- Communities and implementers are represented at all stages of benefits delivery (e.g., outlining, negotiating, monitoring, and mitigating).

- Benefits meet the needs of impacted people and ecosystems.
  - Community benefits can target historical inequities in job availability, housing, transportation, healthcare, and green space access, including but not limited to job creation, pathways to homeownership, affordable housing, cultural and environmental preservation, community trusts, and unionized workforces.
  - Non-climate co-benefits should complement existing ecological activities and be designed to deliver measurable improvements for communities, stewards, and ecosystems and their resident populations. Co-benefits can include increased crop yields and biodiversity, higher returns on investment for participating stewards, wildlife habitat restoration, improved water, air, and soil quality, and access to recreation spaces.

- Community benefits, uniquely, can be delivered/secured through:
    - Community benefits plans (CBPs): implementer-led non-binding descriptions of expected benefits, which can provide initial expectations and information to communities and land and ocean stewards.
    - Community benefits agreements (CBAs): legally enforceable guarantees of benefits negotiated through an inclusive bargaining process. Guarantees should include delivery timelines, specific deliverables, and points of contact for each benefit.
    - Community benefits ordinances (CBOs): municipally enacted laws that require certain types of development, as triggered by community-decided metrics, to negotiate, disclose, and fulfill community benefits as a condition of approval. Local residents have influence over a city's CBO triggers like investment value, tax incentives received, or the value of city-owned land being purchased for the development.
    - Community benefits are made enforceable, where possible, through (1) defining consequences for undelivered commitments, (2) including successor's clauses for land that's purchased for an intervention, (3) laying out timelines, definitions, points of contact, and expectations for each benefit promised. Any changes to how, if, or when a benefit is delivered are made through a dispute resolution process that all parties agree to (e.g., arbitration, mediation).

Staples Center CBA

Leveraging community support to secure long-term benefits

Type: Project
Location: California

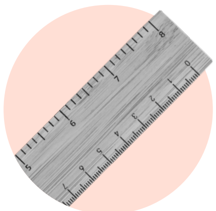
The Staples Center in Los Angeles, with a physical footprint spanning multiple city blocks and an economic impact in the tens of billions of dollars, became a proving ground for community benefits commitments.[43,44] The project was completed in two phases. In the first, a parking lot was built under oral agreements on union organizing, resulting in substantial displacement of low-income residents and a drawn-out labor conflict.[45]

To ensure that phase two would both promise and provide benefits to the community, a diverse coalition of grassroots organizers pioneered the US's first community benefits agreement (CBA). The developer, facing political fallout and potential stonewalling of permits and expected public financial support, agreed to negotiate with the coalition. Project development was put on hold until community consultation and a legally binding agreement could be negotiated.[43,45,46]

As a result, the final agreement addressed community concerns with explicitly outlined projects.[47,48] Affordable housing was addressed not only with housing requirements but with funding for a residential parking program and seed money for additional affordable housing projects.[43] Job creation was explicitly tied to a fair wage commitment and a first source hiring program targeting low-income individuals. A commitment to build green space included not only a dollar commitment but completion of a park and recreation needs assessment to steer that investment.

Benefits were not just promised but guaranteed through the legally binding agreement, oversight by an advisory committee, and provisions to ensure commitments would bind any successors or transferees of the undertaking.[47] Consultation was sustained not only throughout the five-year project commitment but voluntarily for several years after.

In contrast with the first phase of the project, direct negotiation between the community coalition and developer produced clear benefits suitably tailored to local needs, with the developer benefiting from speedy approvals for zoning and substantial public funding.[44,49] The Staples Center was credited with revitalizing the downtown and contributing over $32 billion in economic growth to the city.[49]



Monitoring of Carbon Storage

How will storage be monitored and transparently reported so that reversals are detected, quantified, and addressed?

Definition:

Monitoring of carbon storage involves (1) continuous evaluation of how securely carbon is kept out of the atmosphere, and (2) the transparent and publicly accessible reporting of any changes over time. It includes measuring the durability of storage, estimating the probability of reversal, and establishing systems for ongoing detection, disclosure, and remediation.

At the project level, monitoring must directly measure carbon inputs and outputs with sufficient precision to detect, quantify, and transparently report any reversals of stored carbon over time. Monitoring must define project-specific details such as storage mechanism, expected duration of storage, reversal probabilities, and liabilities for losses. These systems should include both direct measurements and modeled estimates appropriate to the storage type, with publicly accessible data and periodic verification by an independent reviewer.

Program-level carbon monitoring must evaluate the durability and reversal risk across all supported activities when assessed collectively. Programs should employ consistent probabilistic methodologies, harmonized data reporting, and statistically valid sampling to assess aggregate performance across diverse storage mechanisms or locations. Program-level monitoring must transparently disclose reversal risk assumptions, uncertainty ranges, and reversal events, ensuring that administrators are accountable for system-wide performance and that results remain comparable and verifiable across the program jurisdiction.

What needs to be true?

- Monitoring should occur over timeframes appropriate to the storage mechanism and risk profile, enabling transparency, accountability, and corrective action.
- Implementers must quantify and disclose the:
    - Expected storage duration (e.g., median or range of lifetimes).
    - Primary mechanisms of storage (biological, geological, mineral, chemical, oceanic, etc).
    - Key drivers of stability and risk (e.g., drought, equipment failure, political instability)
- Assess risk comprehensively in each category and cumulatively across categories, using both quantitative estimates and qualitative analysis appropriate to the storage mechanism and context, including:

    - Natural disturbance risks: For example, wildfire, drought, disease, pests, permafrost thaw, ocean circulation changes.
    - Human activities:
      For example, land use change, extraction, infrastructure failure, institutional failure.
    - Technological and operational risks: For example, equipment failures, loss of containment, maintenance lapses.
    - Climatic trends: For example, future climate-driven risks to durability.
    - Governance and institutional risks: For example, failure of monitoring

protocols, lack of enforcement, political or regulatory reversals.

- Estimate reversal probability and risk and report as time horizons with probabilistic error ranges (e.g., 100 +/- 10 years) rather than binary labels.
- Establish monitoring systems capable of detecting both gradual and catastrophic reversals, and update methods as technologies evolve.
- Transparency and public accountability for reversals should include:
    - Public disclosures of any reversals detected during monitoring.
    - Documentation of the extent, timing, and cause of reversal.
    - Ability to trace reversals to the original removal activity (intervention-specific traceability).
    - A clear process for informing any affected parties and regulators.
    - Formal roles for locally trusted community organizations to participate in verification and oversight
- Assign liability for reversals and outline clear remedies (e.g., remediation, re-crediting, over-buffering, or third-party response mechanisms). Liability must rest with the entity that caused or controls the intervention (e.g., the developer, operator, or administering agency), not with residents, Tribes, farmers, or landowners.
- Entities financially responsible for the intervention must cover all costs associated with reversal, harm, monitoring, and long-term stewardship. No financial risk or cost associated with carbon storage failure or reversal should be shifted onto the public or landowners.
- Long-term monitoring responsibility must be clearly assigned and fully funded, without shifting costs onto communities.

Illinois Basin-Decatur Project (IBDP)

Demonstrating safe and effective carbon storage systems

Type: Project
Location: Illinois

South of Decatur, Illinois in the Illinois Basin, the Midwest Geological Sequestration Consortium (MGSC) built a carbon storage facility that captured CO_2 from Archer-Daniels-Midland's (ADM) ethanol plant and stored it deep in the Mount Simon sandstone.

The project was developed before the Environmental Protection Agency's (EPA) Class VI regulations for geologic carbon storage took effect.[50] Permitted as a Class I non-hazardous injection well for research and development (R&D), it was not required to convert to Class VI, but nonetheless held to aligned monitoring expectations.[51,52]

The site was selected for its geology of deep saline formation and caprock integrity, which provided conditions for stable, long-term storage. Initial characterization included test wells and 3D seismic modeling.[53] Over November 2011 to November 2014, the project captured and stored roughly 1 million tons of CO_2 more than 2km underground.

During injection, the project employed multiple redundant monitoring systems, including downhole pressure and temperature logging, CO_2 saturation tracking, surface flux chambers, 17 groundwater monitoring wells, and real-time safeguards for catastrophic events such as wellhead pressure alarms and microseismic arrays.[54] This layered approach enabled detection of both gradual changes and acute risks, with operational data fed back into models to improve projections over time.

After injection stopped, monitoring continued at reduced intensity to verify secure storage. The EPA approved a shift from high-frequency operational monitoring to periodic verification (of groundwater sampling, pressure tracking, soil-gas testing, and targeted seismic checks), justified by site-specific indicators of stabilization rather than a fixed timetable.

From a liability perspective, ADM retained responsibility for demonstrating long-term non-endangerment, including detecting, reporting, and remediating any well integrity failure or loss of containment both during injection and throughout post-injection monitoring. ISGS and DOE committed to maintaining records and stewardship over the monitoring period. This created an unusual regulatory pathway: a research-demonstration well that pre-dated the Class VI program, but was nonetheless held to Class VI–aligned monitoring expectations to ensure continuity, transparency, and public protection.

Complete datasets are publicly available through DOE's EDX[55] and and CO_2DataShare[56] in machine-readable format, supplemented by peer-reviewed publications interpreting monitoring data and lessons learned.

An area for improvement relates to the visibility of decision-making documents. IBDP published much of the technical data, yet regulatory materials (permits, PISC plans, monitoring requirements, and closure documentation) were not easy to find or consolidated in a publicly accessible location. For communities and independent reviewers, access to these materials is essential for understanding risk, monitoring obligations, and liability. Strengthening this transparency would better align future projects with CORE principles of accountability and public accessibility.

Image courtesy of National Energy Technology Laboratory

Full System Carbon Accounting

Does the complete, end-to-end carbon removal approach result in a verifiable and confidently measured net removal of CO_2 from the atmosphere?

Definition:

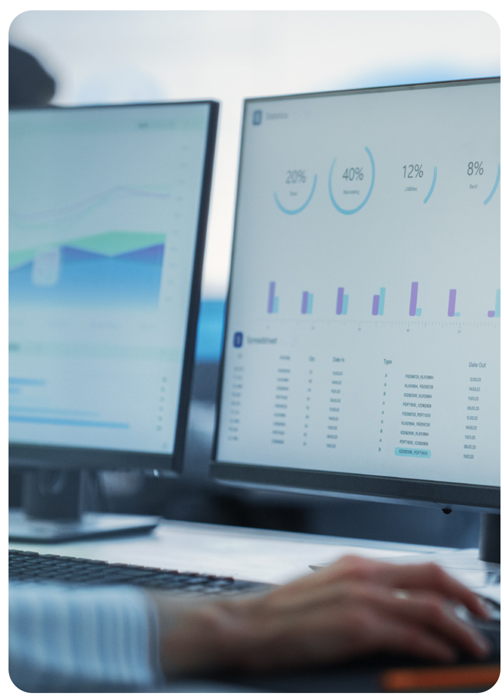
Full-system carbon accounting ensures that all emissions connected to a carbon removal activity are measured, disclosed, and updated over time. This includes upstream and downstream impacts, co-pollutant emissions, and quantified uncertainty.

Project-level carbon accounting must quantify the full lifecycle greenhouse gas balance through bottom-up accounting of direct emissions from operating the project (Scope 1 and 2) and indirect emissions from the materials and activities the project depends on (Scope 3). Direct operational emissions must be measured wherever feasible, while indirect emissions may rely on modeled or estimated values, with uncertainty transparently disclosed and appropriate to the source. Project-level reporting should provide clear reporting of system boundaries and uncertainty for all individual measurements and estimates within those bounds.

Program-level carbon accounting must demonstrate net negativity across all supported activities assessed collectively. Program-level reporting may take place through top-down or bottom-up accounting and must use statistically valid sampling, representative jurisdictional data, or system-level modeling that includes upstream and downstream impacts. Program-level reporting must be designed to capture aggregate uncertainty.

What needs to be true?

- The intervention must show that, with all inputs and outputs accounted for, it delivers a new flux of CO_2 out of the atmosphere.
    - Net result must be unambiguously negative on an atmospheric basis. If the uncertainty around the estimate overlaps with zero, meaning that it is not possible to confidently determine whether the intervention is net negative, the implementer must openly disclose this and publicly justify why the intervention remains climate relevant, using normative criteria such as its role in enabling system transformation or long-term potential.
    - Net negativity must be maintained throughout the intervention's life, with no shifting of emissions into the future. In this context, if emissions are generated prior to the intervention's operation (but in support of it), those emissions must be fully offset before any net negativity can be claimed.
    - Non-CO_2 greenhouse gases (like methane and nitrous oxide) must be included in the assessment using appropriate and clearly stated metrics for CO_2-equivalency.
- Direct measurements should be used where possible. Where direct measurements are not possible, implementers should use the best available data or modeling approaches, transparently disclose any exclusions, and clearly report any uncertainty or limitations in those estimates.
    - Where quantification is infeasible because the impacts cannot be reliably measured or modeled (such as induced demand or rebound effects), the intervention must include a qualitative risk assessment and scenario modeling to bound potential impacts and transparently disclose the associated uncertainty.



- System boundaries must include all direct and indirect emissions (Scope 1, 2, and 3).
    - Indirect emissions are modeled or estimated using best-available data, including feedstock sourcing, energy production and use, equipment and infrastructure, transportation, construction and operations, land use change (direct and indirect) and end-of-life impacts. .
    - Some existing methodologies allow the exclusion of small emission sources (for example, anything under 1%), but even small exclusions can add up when considered together. If these omitted sources collectively become significant, they can meaningfully affect whether an intervention is truly net-negative. Conservative estimates should be used in lieu of exemptions.
- All activities must transparently quantify and report the uncertainty in estimates.
    - Quantitative uncertainty analysis must accompany all removal estimates, explicitly reporting confidence intervals, probability distributions, and sensitivity analyses for sampling, measurement, and modeling choices.
    - Underlying data, assumptions, and models must be made publicly available in machine-readable form.

Washington State Department of Transportation (WSDOT)

Full lifecycle accounting in roadworks

Type: Series of Projects
Location: Washington

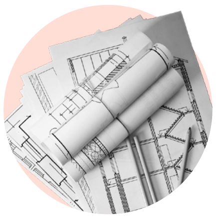
Building roadways generates emissions through the immediate construction work (Scope 1), but also by consuming energy (Scope 2) and materials (Scope 3). However, typically only Scope 1 and 2 have been included when studying climate impact. In 2023, the Washington State Department of Transportation set out to quantify all emissions through a full life cycle greenhouse gas inventory of its roadways construction and maintenance from 2017 - 2021.[57] The report quantifies Scopes 1, 2, and 3 emissions for the agency's roads by accounting for all stages: material extraction and production, transportation to site, construction and installation, maintenance, and end-of-life disposal of pavements and structures.

The report found that upstream Scope 3 emissions (embodied carbon in construction materials) makes up ~310,000 tCO_2e per year, roughly equal to WSDOT's total direct (Scope 1 / 2) emissions. That is, without this comprehensive approach, emissions would have been underestimated by roughly half.

The methodology and data are fully public. The report includes all detailed life cycle emission factors, inventory data (including 609 contracts, which are publicly available), and justification for any excluded processes.[57] Not all values could be directly measured for this study — where modeling was necessary, the study provided detailed information about where the model was sourced from and how the analysis was conducted.

Uncertainty is explicitly quantified. The report includes Monte Carlo simulations to model how variation of inputs produces a range of possible outcomes.

One area for improvement: continuing to transparently update this assessment over time as models and measurements evolve.



Design for Additional Impact

Would this removal still have happened without this intervention?

Definition:

Designing for additional impact means planning and evaluating carbon removal activities so they deliver measurable outcomes beyond what would have occurred without them. This requires clear, evidence-based baselines (also called counterfactuals) that reflect real-world conditions, local context, and change over time.

At the project level, additionality is demonstrated through direct comparison between project outcomes and a defined counterfactual, a baseline scenario representing what would likely happen in the absence of intervention. Carbon removal claims are compared directly to this baseline using measured or modeled data.

At the program level, not every supported activity must be individually additional, the program as a whole must demonstrate additional impact through transparent evaluation, representative sampling, or aggregate modeling.

What needs to be true?

- There must be an explicitly defined baseline counterfactual. This counterfactual may be evaluated by the following tests:
    - Counterfactual accounts for natural carbon fluxes (and changes to carbon fluxes)
    - Counterfactual accounts for human actions, including historical land use and management practices, market trends and business-as-usual adoption rates, financial incentives, and policy or regulatory drivers

    - Assumptions are demonstrably ‘conservative’, and direct, local measurements are always prioritized where available.

- The comparison between actual carbon removal may be evaluated by the following tests:
    - The method of comparison is clearly documented.
    - Preferred methods of comparison are quantitative, dynamically updated in response to real-world conditions, and use randomization and ‘blind’ construction to prevent selection bias or gaming of the system.

Family Forest Carbon Program (FFCP)

Protecting forests for additive climate impacts

Type: Program
Location: United States

The Family Forest Carbon Program (FFCP) is led by the American Forest Foundation and The Nature Conservancy.[58] Aimed at small private woodland owners (30+ acres), the FFCP pays landholders to adopt new climate-friendly forest practices that go beyond business-as-usual management.[59] This requirement for new actions (such as extended harvest rotations or enhanced forest stewardship) means the credited carbon sequestration is above what would have happened anyway, satisfying the fundamental test of additionality. By early 2023, the program had enrolled over 43,000 acres and signed 280 landowner contracts across several US states, storing a projected ~964,000 tons of CO_2 above baseline over the contract lifetimes.[60]

A key aspect of FFCP's approach is its explicit, evidence-based baseline (counterfactual) against which all carbon gains are measured. Rather than using a speculative 100-year harvest model (which relies on assumptions about what might happen), FFCP implemented a dynamic baseline methodology that directly observes what is happening on similar forests outside the program.[58,61] In essence, each participating property is statistically matched with a set of comparable control forests using independent data (such as the US Forest Service's extensive FIA inventory) to ensure that unpredictable events like fire and insect damage do not fuel over-crediting.[61,62]

These comparison forests are matched on key characteristics, such as region, tree types, management history, and access to mills, creating a real-time baseline that accounts for natural carbon fluxes and human factors like regional harvest pressures. The program measures the forests' carbon stock changes over time and compares them to the simultaneous changes in their unenrolled, matched counterparts. Any excess carbon sequestered beyond what comparison forests achieved is attributable to the FFCP intervention.

If a landowner was already practicing good forestry and ends up sequestering no more carbon than their peers outside the program, no credits are issued. No company can claim a removal that doesn't exceed the counterfactual.[62] Results show this leads to lower harvesting, and therefore, additionally saved carbon, which is a victory for conservative crediting. In some regions, this has led to low program uptake, but in others it has garnered greater financial incentives and lower regulatory disincentives.[63,64]

The FFCP shows that well-defined, conservative baselines can deliver real climate benefits while opening carbon markets to small landowners. Its use of real-world comparisons improves credibility, but this rigor brings complexity since accurate baseline matching requires ongoing refinement, and unmatched forests are excluded.[65] As FFCP expands to new regions, its methods will need continual review and strong data infrastructure. Dynamic baselines are a major advance — but transparency and ongoing investment remain essential.

Independently Verified

Have key claims been independently reviewed by qualified third parties with no conflict of interest?

Definition:

Independent verification means that critical aspects of a carbon removal intervention are reviewed, audited, or validated by third parties who are organizationally and financially separate from the entity making the claims. These reviewers must be qualified in relevant technical and regulatory expertise, free from conflicts of interest, and trusted by and accountable to impacted parties. Verification findings must be made public in accessible formats and must include full methodologies, documentation of uncertainty, and corrective actions taken where discrepancies or reversals are identified.

At the project-level, independent verification must review direct evidence for all major claims both before claims are issued and periodically throughout the project lifecycle, with publicly accessible reports that clearly disclose assumptions, data sources, and findings. Quantitative conclusions must be reachable through bottom-up accounting of all inputs and outputs.

At the program-level, independent verifiers review both system-level claims and aggregate performance, as well as a representative sample of individual projects. Program-level verification will also assess the consistency and credibility of methodologies, sampling, and reporting frameworks used across participating projects. Quantitative conclusions are reached through aggregate, top-down accounting, with uncertainty and variability across sites transparently reported.

What needs to be true?

- Reviewers are impartial and independent review is planned and executed to ensure objectivity, freedom from bias, and real or apparent conflicts of interest.
    - Reviewers must be impartial, with no vested interest, prior involvement, or personal connection to the intervention or its executors.
    - A management process must exist for declaring, reviewing, and resolving potential conflicts, and an appeals process must be in place for complaints or suggestions of ethical breach.
    - Reviewers are recorded by a public registry or accredited by an independent body against any real or apparent misconduct or error.
- Reviews will be conducted systematically, with clearly declared boundaries defined before the start of review. These shall include the intervention extent, sites, metrics, and time period.
- Reviews shall be comprehensive to the entire intervention scope and sufficient to ensure no leakage of carbon due to overly narrow boundaries.
    - Independent review must be performed on key aspects of the carbon removal intervention, including: net negativity claims; baseline and additionality modeling; plans for monitoring carbon storage; uncertainty quantification and assumptions; environmental health impact assessments; human health and safety impact assessment; legal and ownership assertions; monitoring, reporting, and crediting process.
- Reviews shall be conducted by qualified or accredited persons with all needed competencies to understand and evaluate the intervention.
    - The reviewer must have relevant technical, scientific,

    and regulatory expertise.

    - They must also adhere to defined quality standards and ideally be accredited (or held to the same rigor) by an independent accreditation body.

- Verification reports must be publicly available, understandable to non-specialists, and linked to specific intervention data.
- Reviews shall be conducted using publicly available methodologies that represent the best currently available evidence-based guidance. Where clarifications or corrections must be given, these must be resolved promptly and recorded publicly, along with a plain language explanation as to the reasons for the significance of the change.
- The reviewer must be independent from the entity claiming removals. This includes:
    - Verifiers having no financial stake in the outcome, with contract and payment structures designed to ensure independence and prevent capture.
- Verification must occur before the carbon removal is credited or claims are made (i.e., ex ante) and periodically throughout the intervention lifecycle (i.e., ex post). For long-duration interventions, periodic re-evaluation should be required, especially when conditions change or new risks emerge.
    - Resources and funding for long-term verification, shall be secured upfront so obligations do not fall on communities.
    - The timing and frequency of the periodic re-evaluation process shall be agreed upon by all parties and be based on best-in-class scientific assessment of risk over time.
- Verifications must be based on sufficient, appropriate, objective evidence, with direct measurements preferred over modeled data. Data should have external validity through instrumentation or records kept by public entities, not solely internal record-keeping.

California's Low Carbon Fuel Standard (LCFS)

Using third party verification to build trust and real impact

Type: Program
Location: California

The California Low Carbon Fuel Standard (LCFS) was established in 2009 by the California Air Resources Board (CARB). It is a performance-based regulation that aims to reduce the carbon intensity of transportation fuels. The LCFS assigns carbon intensities (CI) to fuels based on a full lifecycle analysis and allows regulated entities to purchase credits based on how their fuel compares to annual CI benchmarks.[66]

Since 2018, all carbon intensity calculations and fuel volumes reported under LCFS must be verified by independent third-party reviewers.[67,68] In 2020, CARB began maintaining a list of certified verifiers.[69,70] CARB verifiers must be approved and trained by CARB, and must meet education and experience standards, disclose any conflicts of interest, and remain financially independent of the regulated party.[71,72]

Although fuel producers pay for verification, CARB sets the terms of the verifier's contracts to ensure independence.[72] Verification includes a review of the lifecycle emissions calculations, data inputs, energy use, feedstock origin, and co-product treatment. Reports must be filed both at the fuel pathway application stage and annually for ongoing compliance. CARB publishes verifier names, status, and findings publicly, alongside detailed program guidance and audit records. However, it does not make the reviews themselves public. Nor do impacted communities have a role in selecting or overseeing reviewers.

California's adoption of third party verification led the way for other clean fuel standards in Oregon and British Columbia to follow.[70] Publicly reported data from the LCFS program shows a successful 10% reduction over the program's first ten years.[73] California's share of alternative fuels in the regulated transportation fuels pool increased by 30% from 2011 to 2015, and the reported average lifecycle fuel intensity of all alternative fuels declined 21%.

Environmental Health

Does the carbon removal intervention safeguard ecosystems, natural resources, and ecological resilience, and where possible, actively enhance them?

Definition:

Environmental health in carbon removal refers to the protection, restoration, and stewardship of ecosystems and biophysical systems across the full lifecycle of the intervention. It ensures that climate action does not come at the expense of biodiversity, water, land integrity, or other physical or resource limitations, and where possible, actively supports the resilience, integrity, and functioning of ecosystems, species, and biophysical processes.

At the project level, environmental risks and opportunities are specific to the operation and location, requiring direct assessment, mitigation, monitoring, and transparent disclosure, with local groups engaged through co-developed or community-based monitoring.

At the program level, risks and opportunities are assessed as cumulative ecosystem impacts across all supported activities, with standardized criteria embedded into monitoring requirements and aggregated data informing adaptive management toward long-term ecological resilience.

What needs to be true?

- Environmental risks must be anticipated and minimized according to a precautionary principle.
- Environmental co-benefits are intentionally designed, where possible, to maximize opportunities for improved resilience and enhancements to local ecosystems and their residents.

- Assessments of environmental risks, whether determined to be high risk or negligible, will be transparently reported to regulators and the public through standard governmental channels and to the public through electronically available, accessible, and user-friendly formats. Processes are clearly documented and subject to public feedback, with experts available to respond to media and community questions.
- Assessments of potential environmental co-benefits are done in collaboration with communities, integrating regional expertise, lived experience, and Traditional Ecological Knowledge.
- Systems must be in place to collaboratively manage, monitor, and adapt to ecological impacts over time. Activities that enforce this are:
    - Public disclosure of anticipated impacts on people, their health, and their lived environments. Often, these impacts are disclosed in required National Environmental Protection Act (NEPA) Environmental Impact Assessments, but can also be included in Health Impact Assessments and Environmental and Social Impact Assessments.

    - Mechanisms for community input, feedback, and grievance
    - Knowledge-building alongside community partners to better understand and predict environmental risks and opportunities. A step further than community feedback and grievance is making a council of community members a part of the development or submission of an environmental report.
    - Community-based monitoring, where community partners decide monitoring goals and environmental indicators for monitoring,

establish a monitoring protocol, help to collect data, and analyze and disseminate data findings to the broader community.[74]

- o Dynamic updating of practices as risks evolve, benefits accrue, or new information emerges. Approaches (e.g., models, technologies, statistical design) should be peer reviewed and best in class.

- The intervention should routinely and transparently assess environmental impacts, including those stemming from adjacent systems, such as energy generation, water use, land occupation, and waste management.[75,76] Interventions should evaluate their ability to preserve,sustain, and enhance ecosystem services.[77]
- Where tradeoffs arise, such as between land use and energy infrastructure, they must be addressed through negotiations among all affected parties including implementers, communities, and stewards. To assist with transparent discussion these should be explicitly documented, justified through transparent criteria, and minimized through alternative design, mitigation, or adaptive management.
- Assessment and reporting of environmental outcomes should address not only individual interventions but the cumulative impact across the broader region and across all categories of benefits and harms. For example, cumulative regional impacts across a watershed.
- Transparent incident reporting systems and corrective action, including publicly available aggregated data on incidents, trends, and corrective actions, shared with communities and regulators.

Gemini Solar

Building big solar while protecting endangered species

Type: Project
Location: Nevada

Nevada's Gemini Solar project, one of the largest co-located solar plus storage projects in the US, has provided about 10% of Nevada's peak power demand, 1,300 union and prevailing wage jobs, contributed ~$463M to the state's economy, and was located on several thousand acres of desert habitat used by hikers, Tribe members, and endangered species alike.[78,79]

The project raised environmental concerns, particularly around habitat for the endangered desert tortoise and the threecorner milkvetch, and the area's value as a natural viewshed. To address these, the developer engaged with the Department of Interior, local Tribes, and other parties through public comment processes, beginning scoping two years before the permitting proposal and four years before financing.[79–81] Recent research has suggested that mitigation measures were effective, and recent reporting has generally praised the project's middle-ground between protecting wildlife and building big on renewable energy.[82]

They reduced overall land footprint by 20% to accommodate community concerns even prior to NEPA review.[79,83] They also proposed a novel as-needed mowing adaptation that reduced the acreage of tortoise habitat expected to be impacted from 7,000 to 176 acres. Additionally, they invested in tortoise capture and relocation.

The Gemini project would likely not have been possible without a backdrop of prior engagement with Tribal members and environmental interests. In 2017, the nearby Moapa Southern Paiute Solar Project became the first successful solar project on Tribal lands.[84] As part of that process, the developer completed an Environmental Impact Statement and received a Biological Opinion, with support from the US Bureau of Land Management. These findings resulted in $1.6 million of mitigation fees for protection of desert tortoise populations.[85] Thanks to this trust-building and prior experience, the Moapa Band of Paiutes engaged as partners in accommodating the solar project on their ancestral lands.[86]

Image courtesy of Primergy

Human Health and Safety

Does the intervention protect public health, community wellbeing, and worker safety throughout its lifecycle?

Definition:

Human health and safety in carbon removal refers to the identification, prevention, and mitigation of physical, chemical, and social risks to individuals and communities, including both residents and workers involved in carbon removal operations.

At the project level, health and safety risks are specific to the operation and location, requiring direct assessment, mitigation, and monitoring through site-level emergency preparedness plans, worker protections, and co-developed monitoring systems.

At the program level, risks are evaluated as cumulative and systemic impacts, with baseline safety standards embedded in program guidance, consistent implementation across sites, and aggregated incident data used to identify patterns and improve protections over time.

What needs to be true?

- The monitoring and accountability systems described in Environmental Health apply here, with attention to public health indicators rather than ecological indicators. In addition, informed consent must be secured where appropriate, especially for siting decisions.
- The intervention must assess, disclose, and mitigate risks to human health throughout its lifecycle. This includes, but is not limited to:
    - **Air quality:** Air pollution (e.g., $PM_{2.5}$ and PM_{10}, NO_x, VOCs), ground-level ozonex

- **Water quality:** Ground and drinking water contamination (e.g., chemical leaching, brine migration, CO_2 migration from transportation and storage, heavy metal accumulation), and exposure to harmful chemicals (e.g., harmful sorbents and solvents).

- **Food safety:** Does not introduce chemicals or contaminants that impact either short-term food safety, as with unmanaged pesticides or fertilizers, or long-term food security, such as through cumulative impacts to soil health. Both acute incidents, such as ground-level ozone, and accumulation of toxic compounds, such as heavy metals, PCBs, or PFAS, are examined.
- **Occupational safety:** Does not expose workers to harmful or dangerous environments. Safety is actively managed in accordance with the highest current standard of regulation.
- **Noise, light, and proximity hazards (also known as adverse impact mitigation measures):** These risks should be identified and addressed together with affected communities and implementers to protect health and wellbeing throughout the intervention's lifecycle. Even non-emergency risks must be identified, reduced, and prevented where possible. This includes efforts to (1) limit noise and light pollution during construction and operations, (2) avoid disrupting culturally or economically sensitive areas, and (3) minimize daily impacts on transportation, traffic, and parking.

- The intervention must implement robust occupational health and safety protocols. Implementation must be consistent with local laws and regulations, including relevant standards from the Occupational Safety and Health Administration (OSHA).[87] At minimum, this includes:

hazard identification and risk assessment, multilingual worker training and communication, exposure controls aligned with OSHA Permissible Exposure Limits, transparent incident reporting and investigation, site-specific emergency preparedness plans co-developed with local communities and first responders, and occupational health surveillance for higher-risk interventions. Detailed implementation guidance for each protocol is provided in the supplementary resources.

Project XL

Going beyond compliance for community health and safety

Type: Project
Location: Georgia

The US Environmental Protection Agency (EPA) protects human health from air pollution, hazardous waste, and drinking water contamination; however, its approaches come from a command and control paradigm. In 1995, a new program was designed to combine recent environmental justice mandates[88] with an opportunity for innovative environmental management.[89] Project eXcellence and Leadership, or Project XL, allowed participants with a track record of good compliance to propose alternative pollution controls — they were required to go above and beyond current guidelines and to demonstrate community support and oversight of changes.[88,89]

One such project was a Georgia pulp mill owned by Weyerhaeuser.[90,91] The company proposed reducing air and water pollution through a series of upstream interventions that drastically cut hazardous waste production, water use, bleach effluent, and kept air pollution below facility caps.[91,92] In turn, Weyerhaeuser would gain exemptions from the standard "end of the pipe" pollution control devices, reducing their compliance costs while achieving the same health and safety goals.

To earn community support, the company spent nine months engaging public parties. They hosted three public consultations, publicized through county courthouses and local news.[93] They also personally contacted community leaders to offer meetings and raise awareness. They held additional discussions with DC-based NGOs to address specific technical concerns. They received extensive feedback from members of the public, government officials, academics, NGOs, and key institutions such as the county's Emergency Planning Committee.

These groups asked tough questions about how water and air quality would be maintained. Pulp mills have the potential to release some truly dangerous substances, from hydrogen sulfide to chlorine to sulfur dioxide. With EPA willing to relax controls, all parties needed assurance as to how public safety would be maintained.[88]

Accordingly, Weyerhaeuser made the results of their feasibility study fully available to all impacted parties and developed monitoring criteria with both federal and state environmental agencies.[91,93] This included monitoring of water use, effluent, and solid waste production by Georgia's Environmental Protection Division. It also effectively created a safety brake — Weyerhaeuser's permit exemptions were wholly dependent on the state's assessment of compliance, and could be revoked without challenge if monitoring showed that the changes were allowing more pollution. Finally, they agreed to hold annual meetings during the 15-year contract in order to present project updates and address public questions or concerns.

Overall, support from impacted parties was high, before, during, and after the consultation.[91,94] Many reported that the company made technical concepts clear and transparent, and followed up with any requested information in a timely manner. No failures of the pollution reduction system were reported during the 15-year contract or after the plant was eventually sold.[95,96]

Enforcement Mechanisms

How are carbon removal commitments (technical, social, and legal) backed by binding, transparent, and enforceable mechanisms?

Definition:

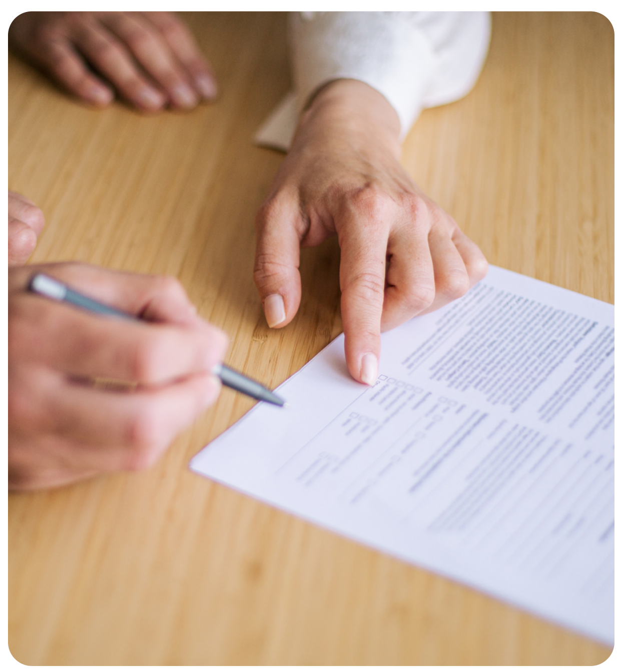
Enforcement mechanisms are the systems, structures, and processes that ensure carbon removal interventions deliver on their full set of commitments — from net carbon removal and long-term storage to community benefits and public safety. These mechanisms include legal enforceability, ongoing accountability throughout all intervention phases, consequences for non-compliance, and mechanisms that give communities and implementers the ability to trigger and / or participate in enforcement processes. While enforcement appears across multiple CORE practices, this section defines the dedicated mechanisms that make those commitments binding, durable, and actionable.

At the project level, enforcement mechanisms formalize all core commitments through binding contracts, permits, or legal instruments, and assigning clear responsibility, establishing remedies for non-compliance, and remaining enforceable through ownership transfers or project changes.

At the program level, enforcement embeds clear authority, independent oversight, and transparent dispute resolution and corrective action pathways into all program rules, requirements, and incentives, with mechanisms for communities and implementers to raise concerns and trigger enforcement reviews across jurisdictions, participants, and funding cycles.

What needs to be true?

- Commitments must be binding. All major commitments (such as storage duration, monitoring plans, community benefit agreements (CBAs), or environmental safeguards) must be documented in legally enforceable contracts, permits, or agreements.
- Consequences must be real and proportionate. When an entity fails to deliver on a promised outcome or requirement, there must be predefined, proportionate consequences (e.g., revocation of credits, financial penalties, legal liability, community redress). Consequences must be designed to meaningfully deter non-compliance and cannot be shifted onto communities, Tribes, or landowners. Public documentation must exist for penalties, corrective processes, and responsibilities for remediation.
- Accountability applies across the lifecycle. Enforcement mechanisms remain intact through scope changes, ownership transfers, or aggregation. Successor clauses, long-term stewardship plans, and clearly defined post-closure responsibilities ensure continuity and prevent accountability gaps. All post-closure obligations, monitoring responsibilities, and liability assignments must be transparent, continuous, and fully funded.
- Enforcement cannot solely rely on agencies or developers. Communities and implementers must have clear, accessible pathways to initiate or trigger enforcement processes, including around CBAs, health protections, and environmental risks, or safety concerns. Accessible, clear, multilingual procedures must exist for filing grievances, triggering investigations, and tracking outcomes. Communities must be supported with the resources needed to participate (e.g., legal aid funds, translation, process guidance).



- Oversight must be independent. Enforcement should be carried out by entities with no financial, political, or organizational interest in the intervention's success (whether a public regulator or third-party monitor) with power to investigate and impose remedies. Oversight structures and funding mechanisms must demonstrate independence from developers or beneficiaries.
- Public transparency is non-negotiable. Enforcement rules, procedures, and outcomes must be accessible to the public in plain language, published formats, and where appropriate, publicly searchable in registries. Transparency must include timelines for corrective action and documentation of how enforcement decisions were reached.

Clean Air Act (CAA) Title V

Actualizing technical and social commitments through enforcement mechanisms

Type: Program
Location: United States

The US Clean Air Act is a useful though imperfect example of how enforceable mechanisms can turn technical and social commitments into binding obligations. Under the Act's Title V operating permit program, major sources of air pollution must obtain a permit that consolidates all applicable emissions limits and monitoring requirements into a single, legally enforceable document.[97] These permits spell out specific emission limits, monitoring and reporting duties, and operating conditions that facilities must follow to continue operating.

Enforcement under the Clean Air Act combines multiple tools. The EPA and state or Tribal agencies can bring administrative, civil, or criminal actions against facilities that violate permit terms or fail to meet statutory requirements, including per-day penalties for ongoing non-compliance. At the same time, the Clean Air Act's citizen suit provision (Section 304, 42 U.S.C. 7604) allows 'any person' to file a civil action against polluters alleged to be in violation of an emissions standard or limitation, or against the EPA for failing to perform a non-discretionary duty.[98] This creates multiple, overlapping avenues to trigger enforcement.

The Clean Air Act also builds in continuity and independent oversight. Permits are tied to a physical facility and its operations, so they remain in force across ownership changes and can be modified, renewed, or revoked by regulators if conditions are violated.[99] States run most day-to-day permitting and enforcement, but the EPA retains backstop authority: it can object to state permits, overfile when state enforcement is inadequate, and issue federal orders to bring a source back into compliance.[100]

Additionally, the Clean Air Act attempts to promote public transparency and participation. Draft Title V permits must be noticed for public comment, and final permits can be challenged in administrative or judicial review.[101] Many permits, violation notices, and enforcement settlements are made publicly available, allowing individuals to track facility performance over time. Citizen suits further reinforce transparency by giving communities the legal standing to demand information, contest violations, and press for corrective action when agencies or operators fail to act.

While the Clean Air Act provides a strong example of binding, enforceable mechanisms, it also illustrates critical limitations that CORE-aligned carbon removal must avoid. The Act regulates pollution source-by-source, leaving cumulative impacts unaddressed and enabling "hot spots" in communities facing multiple emitters.[102,103] Even where transparency exists, the technical and legal complexity of Title V makes participation difficult for non-technical residents, resulting in uneven access to enforcement tools. State-by-state implementation introduces further inconsistency — monitoring requirements, documentation standards, and enforcement practices vary widely across jurisdictions, creating confusion and weakening accountability. Finally, shifts in the legal landscape, most notably West Virginia v. EPA (2022), have narrowed federal authority and demonstrated how statutory tools can erode over time, reducing enforcement durability and exposing communities to regulatory and political vulnerability.[104]

Section Six:

Conclusion & What's Next

Carbon removal is necessary, and how we build it will determine whether it serves both people and the planet.

Its benefits extend far beyond any single intervention, meaning its success depends on collective trust and the public permission that trust earns.

Our approach emphasizes whole-system thinking because the climate crisis can't be solved through carbon accounting alone. The reality is, impact cannot be achieved with a checklist mindset. This framework pairs principles with actionable practices: values strong enough to guide the field, and tools clear enough to act on.

The principles establish that justice and equity are preconditions for durable progress. Transparency and enforcement are how trust is maintained, and that additionality and net negativity ground ever claim in rigorous science.

This framework is the foundation, not the final word. Carbon removal continues to evolve quickly and there are still major questions and opportunities to explore. We invite everyone, whether deeply embedded or encountering carbon removal for the first time, to join us in shaping the standards that will guide carbon removal for decades to come.

CORE is foundational to how carbon removal should grow — shaping how solutions are funded, evaluated, and governed across pathways, sectors, and geographies. It offers a common base for aligning incentives with real climate impact and for ensuring that the benefits and burdens of carbon removal are shared equitably.

We commit to treat the CORE framework as a living document, ensuring that the ambition and applicability grow alongside the field. We hope this framework, rooted equally in deep scientific rigor and years of community wisdom, offers a foundation strong enough for industry and grounded enough for the people and places who will shape carbon removal's future.

Glossary of Terms

The following glossary defines key terms used throughout this framework to ensure a shared understanding. The terms presented here are foundational to the CORE principles and practices. Additional or extended definitions can be found in the supplementary online glossary.

Advisory Boards: Organizations will sometimes convene specialized groups of stakeholders and advisors to a commission or board with a prescribed role. Examples include a board of ethics or a community advisory board. These gatherings generally do not have decision-making power over or a legal responsibility to the institution they serve.

Accessibility (of data): Data that is readily obtainable, understandable, and usable by community stakeholders, including being machine readable, archived, annotated, frequently updated, translated or translatable, and available both online and physically.

Accountability: A second step to transparency, accountability invites examination. This invitation is extended by not only creating clear sightlines through an open agenda and decision-making process, but by prioritizing openness after the unforeseen occurs. Accountability looks like actors operationalizing collected criticisms, owning up to mistakes, and sharing the power to shape purpose and scope.

Atmosphere: The gaseous envelope surrounding the Earth, divided into five layers: the troposphere which contains half of the Earth's atmosphere, the stratosphere, the mesosphere, the thermosphere, and the exosphere, which is the outer limit of the atmosphere. The dry atmosphere consists almost entirely of nitrogen (78.1% volume mixing ratio) and oxygen (20.9% volume mixing ratio), together with a number of trace gases, such as argon (0.93 % volume mixing ratio), helium and radiatively active greenhouse gases (GHGs) such as carbon dioxide (CO_2) (0.04% volume mixing ratio) and ozone (O_3). In addition, the atmosphere contains the GHG water vapour (H_2O), whose amounts are highly variable but typically around 1% volume mixing ratio. The atmosphere also contains clouds and aerosols.

Baseline: The baseline (or reference) is any datum against which change is measured. It might be a ***current baseline***, in which case it represents observable, present-day conditions. It might also be a ***future baseline***, which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines.

Biodiversity: Biodiversity (or biological diversity) means the variability among living organisms from all sources, including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems.

Community Capacity Gap: Limitations in time, resources, staffing, technical expertise, or institutional support that prevent communities or land stewards from fully understanding, evaluating, or participating in a carbon removal intervention. Capacity gaps often stem from historic underinvestment and structural inequities, and can restrict meaningful engagement, informed decision-making, and the ability to negotiate or oversee outcomes.

Carbon Accounting: The process of quantifying carbon dioxide and other greenhouse gas emissions throughout a system or product's lifecycle.

Carbon Capture and Storage (CCS): A process in which a relatively pure stream of carbon dioxide (CO_2) from industrial and energy-related sources is separated (captured), conditioned, compressed, and transported to a storage location for long-term isolation from the atmosphere.

Carbon Dioxide (CO_2): A naturally occurring gas, CO_2 is also a byproduct of burning fossil fuels (such as oil, gas, and coal), of burning biomass, of land-use changes (LUC), and of industrial processes (e.g., cement production). It is the principal anthropogenic greenhouse gas (GHG) that affects the Earth's radiative balance. It is the reference gas against which other GHGs are measured and therefore has a global warming potential (GWP) of 1.

Carbon Dioxide Equivalency (CO_2e): Standardized measure converting various greenhouse gases to equivalent CO_2 based on global warming potential.

Carbon Dioxide Removal (CDR): Human activities that net remove CO_2 from the atmosphere and store it in land, ocean, geological reservoirs, or in products. This includes methods like enhancing natural carbon sinks or using technologies such as direct air capture, but excludes natural carbon uptake that happens without human intervention.

Carbon Removal Approach: The general category or method used to remove carbon dioxide from the atmosphere. For example, afforestation, biochar, direct air capture (DAC), enhanced weathering, and ocean alkalinity enhancement.

Carbon Removal Intervention: A specific implementation of a carbon removal approach in a real-world context. Note: Interventions are where design choices, monitoring, stakeholder engagement, and accountability measures are applied. For example, forest restoration in California or a direct air capture facility in Iceland.

Carbon Storage: The process of storing carbon in a carbon pool.

Climate Additionality: The removal is beyond what would have occurred under a well-defined baseline scenario that reflects realistic estimates or inferences of carbon fluxes in the absence of the intervention.

Climate Relevant Carbon Removal: An intervention that produces carbon removal counted towards climate goals (e.g., corporate, sub-national, national, global).

Community-Based Monitoring: Monitoring that involves local communities in defining monitoring goals, deciding monitoring indicators, establishing monitoring protocols, collecting and analyzing data, and disseminating results to the broader community.

Co-Benefit: A positive outcome that occurs alongside the primary goal of removing or storing carbon, as a result of an intervention. For example, improvements in air or water quality, job creation, ecological restoration, energy or infrastructure upgrades, or strengthened community resilience. Co-benefits are context-specific and can contribute to broader social, economic, environmental, and cultural well-being beyond climate impact.

Co-Development: The collaborative design, implementation, and management of an intervention by stakeholders who are impacted by the intervention and who hold multiple types of knowledge and skills.

Co-Pollutants: Air contaminants released alongside a primary pollutant or greenhouse gas during industrial, transportation, agricultural, or energy-related activities. Common co-pollutants include particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen oxides (NO_x), sulfur dioxide, and volatile organic compounds (VOCs).

Community: Community can be an expansive term that incorporates groups of individuals who share a common identity, which can include geographic location, government representation, labor occupation, cultural and ethnic backgrounds, values, and/or common interests. Communities often have their own definitions of themselves, and are comprised of many stakeholder groups with historical dynamics and power differentials.

Community Advisory Board (CAB): A collective group of community leaders, advocates, and residents convened to contribute community voice by providing guidance and participating in decision-making regarding the design, implementation, and oversight of an intervention.

Community Agency: The ability of community stakeholders to organize, express their collective voice, participate actively, and wield power in the decision-making and outcomes that impact their livelihood.

Community Benefit(s): Positive outcomes that improve the quality of life for a community in a tangible and measurable way within a discrete time period. Community benefits are unique and specific to individual communities, reflecting community priorities for addressing barriers the community has identified. Community benefits can include co-benefits that arise from the implementation of an intervention, such as job creation and improved soil health, as well as broader benefits that don't arise from the implementation of an intervention, such as investments in affordable housing and partnerships with local institutions for workforce development programs.

Community Benefits Agreement (CBA): A legally binding contract (or set of related contracts), setting forth a range of community benefits regarding development, and resulting from substantial community involvement.

Community Benefits Ordinance (CBO): A law that requires developers to proactively engage with a community to identify community benefits and address potential negative impacts of certain development.

Community Benefits Plan (CBP): A written plan of engagement drafted by developers, and refined and finalized in partnership with host communities, outlining how developers will provide measurable benefits to a host community.

Community Engagement: A spectrum of processes that range from the one-way relaying of information from one stakeholder to another regarding an intervention, to shared and democratic decision-making between impacted stakeholders regarding an intervention.

Community Engagement Council (CEC): A representative advisory group that works with implementers to provide structured community input, as well as support community engagement efforts between implementers and the broader community.

Community Fatigue: The diminished interest, enthusiasm, and ability to participate in a process due to repetitive demands for prolonged involvement with limited or no support, and the historic inability to have meaningful influence on the outcomes of processes.

Community Listening Session: Shared spaces of deep listening and mutual learning between communities and implementers. These spaces can encompass a range of different listening session methods, where implementers actively and respectfully listen to communities share their expertise and experience.

Community Needs Assessment: A collaborative and inclusive examination of a community's assets, needs, and cultural and social structures to support informed decision-making for an intervention.

Community Visioning Session: A collaborative planning process in which community members come together to create a shared long-term vision for the future of their neighborhood, town, city, or region, and a plan to achieve their vision.

Community Wealth-Building: Mechanisms that expand community ownership, enable community-led investment decisions, and generate revenues from community-based assets that can further local economic prosperity and racial equity. Community wealth-building models can embrace a range of social outcomes such as job creation, environmental sustainability, neighborhood development, transit connectivity, food access, and health improvements.

Consensus Decision-Making: A collaborative and deliberate process of reaching mutual agreement across participating parties, where everyone must agree to a decision for it to move forward.

Consent-Based Decision-Making: A collaborative and deliberative process of reaching an agreement that is “good enough” across participating parties, where a decision can move forward without principled objection from any participant.

Community-Informed, Open Access, Reviewed, and Evaluated (CORE CDR): Carbon removal that meets Carbon180's CORE principles of justice, equity, transparency, accountability, enforceability, inclusion, additionality, and net negativity. It ensures that climate benefits are real and durable, communities are protected and empowered, and social and environmental outcomes are delivered with integrity throughout the intervention’s lifecycle.

Corresponding Adjustment: Accounting mechanism under Article 6 to prevent double claiming across jurisdictions.

Counterfactual: A baseline scenario representing what would likely occur in the absence of a carbon removal intervention. The counterfactual reflects expected natural carbon fluxes, land use, management practices, market trends, and policy conditions, and is used to determine whether an intervention generates additional carbon removal beyond what would have happened otherwise. A well-defined counterfactual is evidence-based, conservative, transparent, and updated as real-world conditions change. See also: Baseline.

Cumulative Burden: The combined environmental, health, economic, and social stressors that accumulate in a community over time from multiple sources or industries. Cumulative burden reflects not just a single intervention’s impacts but the layered effects of historic pollution, infrastructure siting, climate risks, economic precarity, and other structural inequities.

Deforestation: Conversion of forest to non-forest.

Developer: An entity (such as a company or organization) responsible for designing, financing, constructing, and operating a carbon removal intervention. Developers typically manage technical execution, regulatory compliance, monitoring and reporting, and community engagement.

Dignified Work: When trainees and workers of all identities are respected and valued, and have access to the necessary resources in support of a fulfilling life.

Direct Emissions (Scope 1): Emissions that are directly controllable and produced from within the system boundary.

Direct Measurement: The quantification of greenhouse gases, environmental impacts, or performance using physical instruments, sensors, sampling, or observational data.

Downstream Impacts: The environmental, social, and economic effects that occur after or as a consequence of a carbon removal intervention's operation. These include impacts associated with the transport, use, storage, disposal, or long-term stewardship of materials and byproducts; changes in land use or community conditions driven by the intervention; and end-of-life emissions.

Durability: The duration for which CO_2 can be stored in a stable and safe manner. Storage duration can differ significantly between reservoirs.

Ecosystem: An ecosystem is a functional unit consisting of living organisms, their non-living environment, and the interactions within and between them. The components included in a given ecosystem and its spatial boundaries depend on the purpose for which the ecosystem is defined. In some cases, they are relatively sharp, while in others they are diffuse. Ecosystem boundaries can change over time. Ecosystems are nested within other ecosystems, and their scale can range from very small to the entire biosphere. In the current era, most ecosystems either contain people as key organisms or are influenced by the effects of human activities in their environment.

Embodied Emissions (Scope 3): Emissions that result from the production or use of any good, or the provision of any service. For example, the embodied emissions of steel used for a reactor will include emissions associated with the acquisition of raw materials, processing, manufacturing, transportation, and the energy used in steel production.

Emergency Action Plan (EAP): A written document required by OSHA that outlines how employees and employers should respond to workplace emergencies. It details procedures for reporting emergencies, evacuating, accounting for all employees, and performing rescue or medical duties to ensure a safe and coordinated response.

Emergency Preparedness: Plans, systems, and procedures designed to anticipate, prevent, respond to, and communicate about emergencies that may arise from a carbon removal intervention. Emergency preparedness includes identifying potential hazards (such as leaks, blowouts, fires, equipment failures, or chemical exposures), coordinating with local first responders, training workers and residents, establishing clear communication channels, and ensuring materials are accessible in multiple languages and formats.

End-of-Life Impacts: Environmental and climate effects associated with the decommissioning, disposal, or long-term management of materials, equipment, land use changes, or infrastructure after a carbon removal intervention ceases operation. End-of-life impacts include emissions from dismantling and waste processing, residual contamination risks, land or ecosystem disturbance, and any ongoing obligations needed to ensure stored carbon remains secure.

Enforcement: Stakeholders complying with relevant laws, policies, directives, and missions while prioritizing and minimizing harms to vulnerable and/or marginalized people. Enforcement can look like: naming the regulations an approach is informed by, following polluter-pays models, providing access to legal aid, and sponsoring capacity-building partnerships.

Equity: This work addresses and alleviates existing unequal treatment and outcomes. Equity is achieved when a person's life conditions (locally unwanted land use proximity, poor air quality, incarceration) are not predicted by their characteristics (e.g., race, ethnicity, sex, and gender).

Work centering equity acknowledges that some people and groups require more assistance than others and creates conditions to close those inequitable gaps that are self-sustaining in that they do not rely on continued external assistance.

Eutrophication: The excessive accumulation of nutrients, primarily nitrogen and phosphorus, in water bodies, leading to harmful algal blooms, reduced oxygen levels, and the degradation of aquatic ecosystems.

Ex Ante: An evaluation, estimate, or verification conducted before a carbon removal intervention occurs or before credits or claims are issued.

Ex Post: An evaluation or verification conducted after a carbon removal intervention has occurred, based on measured data, observed performance, and documented outcomes.

Executive Board: A governing board that oversees the strategic direction and operations of a corporation, non-profit, or other institution. Members have a legal responsibility to oversee and run the institution. Executive board members are appointed by the chair or board of directors as dictated by the organization's bylaws.

Fair Chance Hiring: A hiring practice that reduces barriers to employment for individuals with conviction histories, where employers refrain from asking potential candidates about their conviction history before making a job offer. Fair chance hiring laws exist in many states across the US.

Family-Sustaining Wage: Income high enough for a worker and their household to cover minimum necessary expenses, including housing, food, childcare, and transportation, without relying on public assistance.

Feedstock: A raw material that can be converted to a good of higher value (i.e., fuel).

Financial Additionality: Financial additionality means the intervention would not be financially viable without selling carbon removal outcomes. In other words, the income from selling carbon credits must play a decisive role in enabling the undertaking.

Geologic Storage (of CO_2): Injection of carbon dioxide into porous geologic formations deeper than 800 meters (and preferably 1000 meters) for long-time storage (>1000 years). The carbon dioxide is kept at depth by various trapping mechanisms: mechanical trapping (impermeable caprock over the reservoir), residual gas trapping (capillary forces), solubility trapping (dissolution in brines or hydrocarbons), and mineralization (formation of carbonates). It is the last step of engineered carbon removal approaches that capture carbon from flue gas (bioenergy with carbon capture and storage) or from the air (direct air capture and storage).

Governing Board: A governing board may be a board of directors or a board of trustees that oversees the operations of a corporation, non-profit, or other institution. Members have a legal responsibility to oversee and run the institution. Boards may reserve seats for persons able to offer particular perspectives. For instance, it is not uncommon for a school or medical institution to reserve seats for specific stakeholders and for a community representative who can speak to community culture and needs.

Greenhouse Gas (GHG): Those gaseous constituents of the atmosphere, both natural and anthropogenic (human-caused), that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, by the atmosphere itself, and by clouds. This property causes the greenhouse effect, whereby heat is trapped in Earth's atmosphere. Water vapor (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) are the primary GHGs in the Earth's atmosphere. There are also a number of entirely human-made GHGs in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, managed under the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol). Besides CO_2, N_2O and CH_4, the Kyoto Protocol deals with the GHGs sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Grievance Mechanism: A formal, accessible process that allows community members, workers, or other stakeholders to raise concerns, report harms, seek clarification, or request corrective action related to a carbon removal intervention. A grievance mechanism provides clear steps for submitting complaints, ensures timely and transparent responses, and outlines how issues will be investigated and resolved.

Hazard Communication (HazComm): The OSHA Hazard Communication Standard (HCS) requires employers to inform employees about the hazards of chemicals in the workplace through written guidance that includes labels on containers, Safety Data Sheets (SDSs), and training.

Implementer: A person or organization responsible for carrying out a carbon removal intervention in practice. The implementer puts plans into action and ensures the intervention is executed as designed. *Note: Often, the developer and implementer may be the same entity, but in some cases, a developer might hand off to an implementing partner for construction/operation.*

Inclusion: Actors authentically involving traditionally excluded individuals and/or groups into processes, activities, and decision/policy-making in a way that shares power. A common pitfall of inclusion work is to involve traditionally excluded partners to the point of marginalization or tokenization rather than sharing power and ownership. Non inclusive work stops at public comments, fact sheets, and surveys. Truly inclusive work bridges the divide between community and intervention governance through efforts, like community-centered approach planning and community co-designed CDR research.

Indirect Emission (Scope 2): Emissions that occur as a result of the system activity, but do not occur within the system boundary.

Intervention: *See Carbon Removal Intervention.*

Job Hazard Analysis (JHA): A job hazard analysis is a technique that focuses on job tasks as a way to identify hazards before they occur. It focuses on the relationship between the worker, the task, the tools, and the work environment. Ideally, after you identify uncontrolled hazards, you will take steps to eliminate or reduce them to an acceptable risk level.

Jurisdiction: A geographic area or governing authority with the legal power to create, implement, or enforce policies, regulations, and oversight related to a carbon removal intervention. A jurisdiction may refer to a city, county, Tribal nation, state, province, or national government. In programmatic carbon removal, jurisdiction also defines the boundaries within which monitoring, accounting, and verification occur, and determines which public agencies or institutions hold decision-making and enforcement authority.

Justice: Existing systems and structures are changed to balance power, address past harms, and create systems to prevent those harms from reoccurring.

Justice is achieved when all people have access to the same freedoms (freedom from poor air and water quality) and processes (planning and management) without additional support or accommodations because the systemic barriers impeding justice have been removed.

This may be achieved by procedurally requiring fairness in the decision-making process; equitably distributing resources, risks, impacts, and benefits across society; repairing previous harms committed through interpersonal power dynamics, micro- and macro-aggressions, violations, and crimes; and transforming society's current systems and structures.

Knowledge: Knowledge is the expertise, information, experiences, insights, practices, and beliefs held by a person and/or group.

Knowledge Management: Maintaining built knowledge publicly (either online or in print) in a way that is (1) accessible, (2) attributed to its sources, (3) protective of sensitive information, and (4) frequently updated.

Knowledge Building: An educational approach where stakeholders actively and collectively share, create, and apply information, experiences, insights, and ideas.

Land steward: Land stewards are often potential land-based carbon deployers, while also remaining part of a community affected by landscape-level decisions, creating additional nuance that must be factored into a just, equitable, and highly accountable approach to land-based carbon removal.

Leakage (Economic): The effects of policies that result in a displacement of the environmental impact, thereby counteracting the intended effects of the initial policies. Leakage occurs when an intervention changes the availability or quantity of a product or service that results in changes in GHG emissions elsewhere.

Leakage (Physical): Refers to initially-stored CO_2 (or other GHG) that has left its storage state and returned to the atmosphere. Examples may include combustion of a fuel made from CO_2, burning of biomass, or migration of CO_2 from underground storage.

Leakage (Socioeconomic): Occurs when CDR activities displace emissions to other locations, times, or forms. For example, leakage occurs in forest carbon offset credit programs when a reduction in timber harvesting at a project site, incentivized due to its potential for emissions reductions and/or CDR, causes timber harvesting to increase somewhere else to meet demand. Similarly, if an engineered CDR approach coupled to CO_2 utilization results in higher costs, alternatives that emit more CO_2 may become economically favorable by comparison.

Liability: Legal responsibility for reversal, non-performance, or harm. This includes being held accountable if stored carbon is re-emitted (a reversal), if promised climate outcomes are not delivered, or if the undertaking causes environmental or social damage. In practice, liability determines who must take corrective action or bear the consequences when something goes wrong.

Life Cycle Assessment (LCA): An analysis of the balance of positive and negative emissions associated with a certain process, which includes all of the flows of CO_2 and other greenhouse gases, along with impacts to other environmental or social impacts of concern.

Lived Experience: Knowledge grounded in the firsthand experiences, observations, and insights of individuals and communities directly affected by an issue, place, or intervention. Lived experience reflects daily realities, historical context, cultural practices, and locally specific understanding that may not appear in technical data or formal expertise.

Machine-Readable (Data Format): A data format structured so that computers can easily access, parse, and analyze it without manual transcription. Machine-readable formats (such as CSV, JSON, or XML) enable transparency, reproducibility, and independent verification by allowing individuals to directly examine underlying data used in carbon accounting, monitoring, and reporting.

Measured Data: Information obtained directly through instruments, sensors, sampling, or physical observation. *See also Direct Measurement.*

Memorandum of Understanding (MOU): A formal, non-binding agreement between two or more parties that clearly outlines objectives, roles and responsibilities, information-sharing guidelines, decision-making processes, and conflict resolution strategies. MOUs serve as a mutual acknowledgement of processes and potential outcomes.

Modeled Estimates: Quantitative approximations derived from scientific models, assumptions, or statistical methods when direct measurement is not feasible. Modeled estimates use the best available data (such as emission factors, system dynamics, or scenario modeling) to infer greenhouse gas emissions, carbon storage, or other impacts.

Measurement, Monitoring, Reporting, and Verification (MMRV): The systems used to track, document, and validate the performance and impacts of carbon removal interventions. It ensures that key outcomes are measured accurately, reported transparently, and verified through independent review.

Measurement involves quantifying key variables at a given point in time, using methods such as field sampling, laboratory analysis, or remote sensing.

Monitoring involves collecting data over time to track key variables, using tools like field measurements, sensors, or remote sensing. Reporting means presenting that data in a standardized, transparent format, often for regulators, stakeholders, or the public. Verification is the independent review of the reported data to confirm its accuracy and credibility.

Natural Carbon Fluxes: The movement of carbon between the atmosphere, land, and oceans through natural processes such as photosynthesis, respiration, decomposition, weathering, and ocean-atmosphere exchange. Natural carbon fluxes vary across seasons, ecosystems, and climate conditions, and serve as the baseline against which additional carbon removal from an intervention is measured.

Net Negativity: Occurs when a carbon removal approach removes more greenhouse gases from the atmosphere than it emits across its full lifecycle.

Nitrogen Oxides (NO_x): A group of highly reactive gases. Nitrogen oxides react with other chemicals in the air to produce haze, nutrient pollution, acid rain, particulate matter (PM), ozone (O_3), and are harmful if inhaled.

Ocean steward: Ocean stewards are often potential ocean-based carbon deployers, while also remaining part of a community affected by landscape-level decisions, creating additional nuance that must be factored into a just, equitable, and highly accountable approach to ocean-based carbon removal.

Operational Emissions: Greenhouse gas emissions produced during the day-to-day operation of a carbon removal intervention. These include emissions from energy use, equipment and machinery, transportation, chemical inputs, waste handling, and other activities required to run the intervention.

Participatory Budgeting: Processes that allocate a portion of public spending to work selected via community-wide voting processes, used in municipal budgets or state and federal grant investments.

Particulate Matter 10 (PM_{10}): *(Also known as particle pollution)* Particulate matter, generally, is the term used to describe a mixture of solid particles and liquid droplets found in the air. Particles that have a diameter of 10 microns or less (PM_{10}) are inhalable and can induce adverse health effects. Sources of particulate matter include construction sites, unpaved roads, powerplants, and cars. PM_{10}, specifically, refers to inhalable particles with diameters that are generally 10 micrometers and smaller.

Particulate Matter 2.5 ($PM_{2.5}$): *(Also known as particle pollution)* Particulate matter, generally, is the term used to describe a mixture of solid particles and liquid droplets found in the air. Particles, generally, vary in size, shape, and chemical composition. Particles that have a diameter of 10 microns or less (PM_{10}) are inhalable and can induce adverse health effects. Sources of particulate matter include construction sites, unpaved roads, powerplants, and cars. $PM_{2.5}$, specifically, refers to fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.

Permissible Exposure Limit (PEL): The Permissible Exposure Limit (PEL) OSHA refers to the maximum allowable concentration or level of a substance that workers can be exposed to over a specific time period without experiencing adverse health effects. These limits are established by OSHA based on extensive research, scientific studies, and recommendations from organizations like the National Institute for Occupational Safety and Health (NIOSH).

Personal Protective Equipment (PPE): Equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses.

Planetary Boundary: A scientifically defined threshold that marks the safe operating limits of Earth's biophysical systems (such as climate stability, biodiversity, land use, and freshwater use) beyond which environmental change may become irreversible or destabilizing.

Power: The ability of individuals, communities, institutions, or systems to shape decisions, influence outcomes, and determine whose interests are centered in a carbon removal intervention. Power can be held, shared, or withheld, and it operates through formal structures (e.g., governance, regulation, funding) as well as informal dynamics (e.g., social capital, historical inequity, cultural authority).

Precautionary Principle: Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Program: A broad initiative or scheme, often at policy or sector level, that encompasses multiple projects or activities under a common framework.

Programmatic Intervention: A carbon removal effort implemented through a structured program rather than a single project. Programmatic interventions use standardized rules, aggregated data, and jurisdiction-wide governance to deliver and assess carbon removal outcomes across multiple sites, implementers, or activities.

Project: A specific set of activities, typically implemented at a site or local scale, that aims to achieve a defined carbon removal outcome. Projects are time-bound, spatially bounded, and may exist within a broader policy framework.

Project-Level Intervention: A carbon removal activity designed, implemented, and evaluated at the scale of an individual project. Project-level interventions use bottom-up data, site-specific monitoring, and direct community engagement to demonstrate their carbon, environmental, and social impacts.

Registry: A publicly accessible system that records, tracks, and stores key information about carbon removal activities — such as credits issued, monitoring data, ownership transfers, and retirement of claims.

Regulatory Additionality: Regulatory additionality (also called legal additionality) requires that the carbon removal is not mandated by laws or regulations. If an emission-reducing action is already required by law, it's deemed business-as-usual and cannot count as additional.

Reversal: The release of previously sequestered carbon back into the atmosphere, negating the earlier removal. In other words, if stored CO_2 leaks or a carbon-storing ecosystem (like a forest) loses carbon, that's a reversal.

Risk Assessment: A systematic process for identifying, evaluating, and characterizing potential sources of harm associated with a carbon removal intervention, including environmental, technical, social, or health risks. Risk assessments estimate the likelihood and severity of adverse outcomes, inform mitigation and monitoring plans, and support decision-making.

Social Additionality: Social additionality refers to changes in individual or collective behavior that result in greater carbon removal than would have occurred otherwise. This could include community-driven practices, education, or stakeholder engagement that enhances the effectiveness or scale of carbon removal beyond technical measures.

Stakeholder Mapping: A strategic process to identify, categorize, and assess people or groups who may be directly affected by an intervention, or have an effect on an intervention.

Successor Clauses: Contractual provisions that ensure all commitments, obligations, and responsibilities of a carbon removal intervention remain in force even if ownership, control, or operational authority changes hands. Successor clauses bind future owners or operators to the original agreements.

System: An interconnected set of components, such as technologies, actors, processes, and institutions, organized to achieve a shared purpose.

System Boundary: The divide between what is included in and what is excluded from a system under study. In carbon removal, the system boundary defines the scope of analysis, such as which emissions, inputs, or impacts are counted. A clearly defined system boundary ensures consistency, transparency, and comparability across different methods and interventions.

Technological Additionality: Technological additionality means the intervention implements a climate-friendly technology or practice faster or beyond what would normally occur. It asks whether the method is already common practice: if a carbon removal technique is widely adopted without credits, then crediting it would just reward the status quo.

Third Party: An independent person or organization that is not directly involved in the development, funding, or implementation of a carbon removal intervention and has no financial or operational stake in its outcomes.

Traceable / Traceability: The ability to track carbon removal activities, data, and outcomes back to their original source with clarity and confidence.

Traditional Ecological Knowledge (TEK): The term, Traditional Ecological Knowledge, was developed by Native American, Alaska Native, Native Hawaiian, and Indigenous communities and means a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmissions, about the relationship of living beings (including humans) with one another and their environments.

Transformative Investment: Transformative investment is the practice of aligning capital investments and opportunities with specific and identified community needs in ways that nourish local regenerative economies. It embeds a requirement for synergistic, long-standing, and durable connections between community needs, land and ocean stewardship needs, and opportunities presented by development.

Transparency: Parties exchange a robust accounting of all information essential to equitable and informed decision-making. Transparency applies both to how people are engaged and to how information and data are shared. It means that information is not only disclosed but made understandable and accessible to everyone affected.

Transparency allows all parties to see how decisions are made, who is responsible, and what impacts occur. It fosters trust by ensuring that claims and outcomes can be understood, questioned, and verified by others. It only works when key information is public, accessible, and usable — shared in forms that enable meaningful participation, oversight, and trust.

Uncertainty: Quantified range of confidence around carbon removal estimates due to measurement and modeling limitations.

Upstream Impacts: The environmental, social, and economic effects that occur before and in support of a carbon removal facility's operation. This includes all impacts associated with producing, extracting, processing, transporting, or manufacturing the materials, energy, equipment, labor, and infrastructure required to build or run the intervention. Upstream impacts may include supply-chain emissions, land disturbance from feedstock production, embodied carbon in construction materials, and impacts on workers or communities involved in source industries.

Verification: The process by which the claims, data, and methodologies associated with a carbon removal intervention are evaluated to determine whether they are accurate, credible, and compliant with defined standards.

Veto Power: The established authority of a body to reject a decision or proposal.

Volatile Organic Compounds (VOCs): Volatile organic compounds (VOCs) are chemicals that vaporize into the air and dissolve in water. VOCs are pervasive in daily life because they're used in industry, agriculture, transportation, and day-to-day activities around the home. Once released into groundwater, many VOCs are persistent and can migrate to drinking-water supply wells.

Workforce Agreements: Agreements between implementers, unions, contractors, subcontractors, and community organizations that detail commitments to the quantity and quality of jobs, workforce development, and/or other issues.

Workforce Development: Training, education, and certification processes to enhance the skills and competencies of people engaged in or available for work, and support their long-term career growth.

Workforce Development Board: A local or regional governing body, typically created under the federal Workforce Innovation and Opportunity Act (WIOA), that oversees workforce and job training within its area with the purpose of helping align workers, employers, training providers, and government resources to support local economic growth.

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