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# Contracted Durability

A Framework for  
Performance-Based  
Carbon Removal



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# Executive Summary



Policymakers designing carbon removal markets today have an opportunity to lay the groundwork for **contracted durability** — enabling the full range of CDR pathways to participate while ensuring that every credit delivers the climate impact it promises.

## The durability challenge

**Carbon dioxide removal (CDR) is not optional.** Alongside rapid emissions reductions, CDR is essential to meeting global climate goals, including limiting near-term warming, achieving net-zero emissions, and ultimately drawing down the accumulated stock of carbon dioxide already in the atmosphere (IPCC, 2022). There are many pathways for removing and storing carbon, spanning biogenic (e.g., afforestation, bioenergy with carbon capture and storage), geochemical (e.g., enhanced weathering, ocean alkalinity enhancement) and synthetic (e.g., direct air capture). No single pathway is sufficient to meet the volumes of CDR required for net-zero or net-negative emissions; policymakers must therefore establish policies to support the full range of CDR pathways while ensuring verified climate impact.

**Durability is one key determinant of that impact.** ‘Durability’ refers to the length of time that a tonne of carbon dioxide (CO<sub>2</sub>) represented by a CDR credit remains out of the atmosphere. However, durability is variable; not all credits represent CO<sub>2</sub> stored for the same duration. Durability is also uncertain, meaning the duration of storage is often unknown until a reversal (a net loss of carbon storage) occurs. This is particularly true for nature-based pathways, which rely on naturally occurring biogenic carbon fixation to capture and store CO<sub>2</sub> and face reversal risks such as wildfires, pests and disease, and human intervention.

**The climate impact of carbon removal therefore depends on durability: i.e., how long the CO<sub>2</sub> stays out of the atmosphere.** Much of the policy debate around carbon removal has necessarily centered on durability. Establishing an appropriate durability threshold (i.e., the time period over which carbon must remain out of the atmosphere as defined by the policy, standard, use case, or claim being made) is a central concern, alongside defining how projects can reliably meet that threshold. Effective policy must support the full range of removal pathways while credibly managing variability and uncertainty in durability. Current approaches, however, have typically failed for one of two reasons:

**1. Locking out necessary pathways:** some policies and policy proposals restrict CDR credits to those with 1,000-year durability or geologic storage, excluding nature-based pathways that have a higher risk of reversal but are economically feasible today, essential to near-term climate goals, and capable of delivering significant social and environmental benefits.

**2. Undermining environmental integrity:** other approaches that are inclusive of nature-based credits have failed to ensure storage over sufficient timescales because the durability threshold set in policy often exceeds the monitoring and liability commitments of underlying projects, leaving a gap over which reversals go unmonitored and uncompensated.

What is needed instead is an approach that neither locks out nature-based pathways nor leaves gaps in monitoring and liability for reversals, ensuring that credits represent carbon dioxide that remains out of the atmosphere over timescales relevant to both near- and long-term climate objectives. We call this approach ‘contracted durability’.

## Contracted durability as a solution

**Contracted durability offers a way forward by using legal and financial mechanisms to ensure carbon removal over a defined duration.** This paper introduces ‘contracted durability’ as a new concept that centers durability as an explicit, enforceable obligation at the credit level, fulfilling two core functions across the durability threshold: 1. assigning contractually enforceable liability for reversals, and 2. providing the resources and tools to compensate for any reversals that occur. Together, these functions ensure that one credit continues to represent one tonne of carbon removed from the atmosphere for the entirety of the required storage period — regardless of whether the original credit’s storage persists.

**Contracted durability introduces a new way of thinking about durability** — one that relies on contracted mechanisms to achieve desired durability performance as opposed to assuming durability based on pathway. In practice, contracted durability may operate through a combination of the following mechanisms:

- **Buffer pools**, which provide first-loss protection by withholding a portion of issued credits to compensate for reversals during the crediting and monitoring period;
- **Insurance**, which provides coverage for specific reversal events, particularly correlated losses that could overwhelm a buffer pool;
- **Horizontal stacking**, which replaces an original credit with a new one at the end of the monitoring period or following a reversal, carrying the storage obligation forward; and
- **A permanence trust**, which is an endowed institution that assumes ongoing liability for reversals, funded through a per-credit fee at issuance and actively managing risk through monitoring, reversal prevention, and

replacement.

Together these mechanisms form a financial and legal toolkit that can enable high integrity removal pathways to meet the durability threshold that the policymaker or standard-setter sets. Contracted durability draws on established practices in insurance, finance, and institutional design, but combining these mechanisms into integrated approaches for carbon markets is new ground.

**Buffer pools or insurance alone, however, cannot deliver contracted durability.** These mechanisms, designed to compensate for reversals during the crediting and post-crediting monitoring period, require either a permanence trust or horizontal stacking to assign liability for the duration of the durability threshold. Critically, credits with a negligible risk of reversal over the durability threshold can release the liability for ongoing monitoring and compensation, whereas those with non-negligible risk of reversal require either horizontal stacking or a permanence trust to ensure ongoing monitoring and compensation. **Exhibit ES1 on the next page illustrates how contracted durability could work in practice.**

## Contracted durability in policy and standards

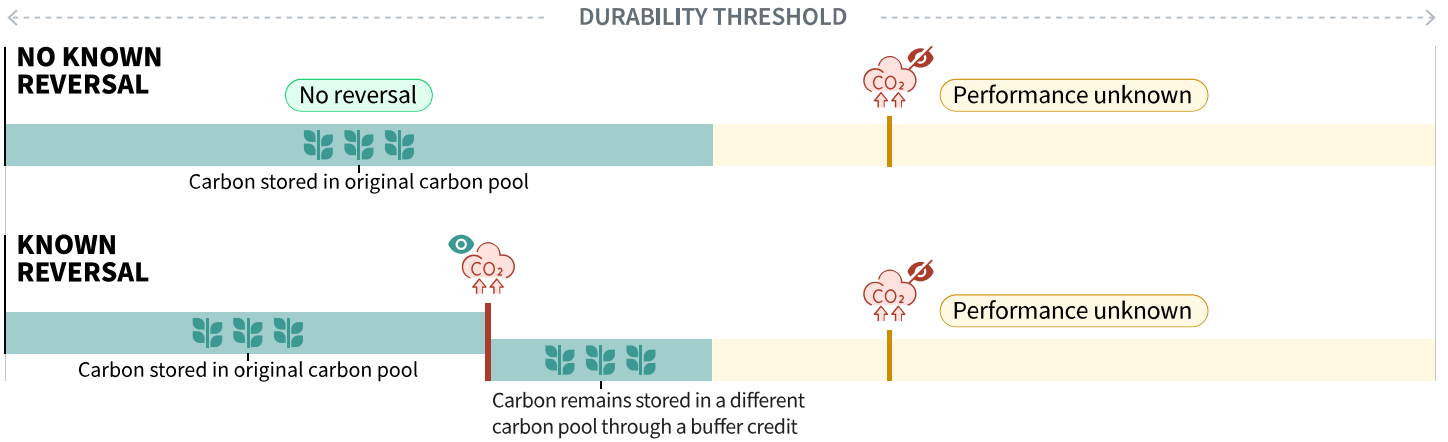
**A number of active policy and standard-setting processes are determining how to regulate, incentivize, and set quality benchmarks for carbon removal,** each grappling with shared questions around durability standards, reversal risk management, and long-term liability. We argue that contracted durability can be integrated into these existing policy and standard-setting processes, as follows:

- **California** is developing overlapping regulatory instruments under SB 905 and Cap-and-Invest that include durability requirements. Contracted durability can satisfy this standard across a diversity of pathways while resolving gaps in liability after project agreements expire.
- As the **European Union** assesses how removals certified by the Carbon Removals and Carbon Farming (CRCF) Framework might be integrated into the EU ETS and defines quality requirements for international credits toward its 2040 target, contracted durability could enable a broader set of removal pathways to qualify. This would ensure credits deliver the impact EU climate policy is designed to achieve.
- The **Paris Agreement Crediting Mechanism** (Article 6.4) has already embedded contracted durability concepts in its design, requiring monitoring and remediation of reversals after the crediting period and actively developing reversal risk assessment tools, insurance mechanisms, and guidance on negligible risk of reversal.
- The **Science Based Targets initiative's** Corporate Net-Zero Standard V2 requires companies to source an increasing share of “long-lived” removals over time to compensate for “long-lived greenhouse gases (GHGs).” Contracted durability offers a practical path forward: a performance-based durability threshold that credits can meet regardless of pathway.
- The **Integrity Council for the Voluntary Carbon Market** sets quality benchmarks, with Core Carbon Principle-eligible programs covering approximately 98% of the voluntary carbon market. Its second Continuous Improvement Work Program on Permanence is actively exploring mechanisms aligned with contracted durability.

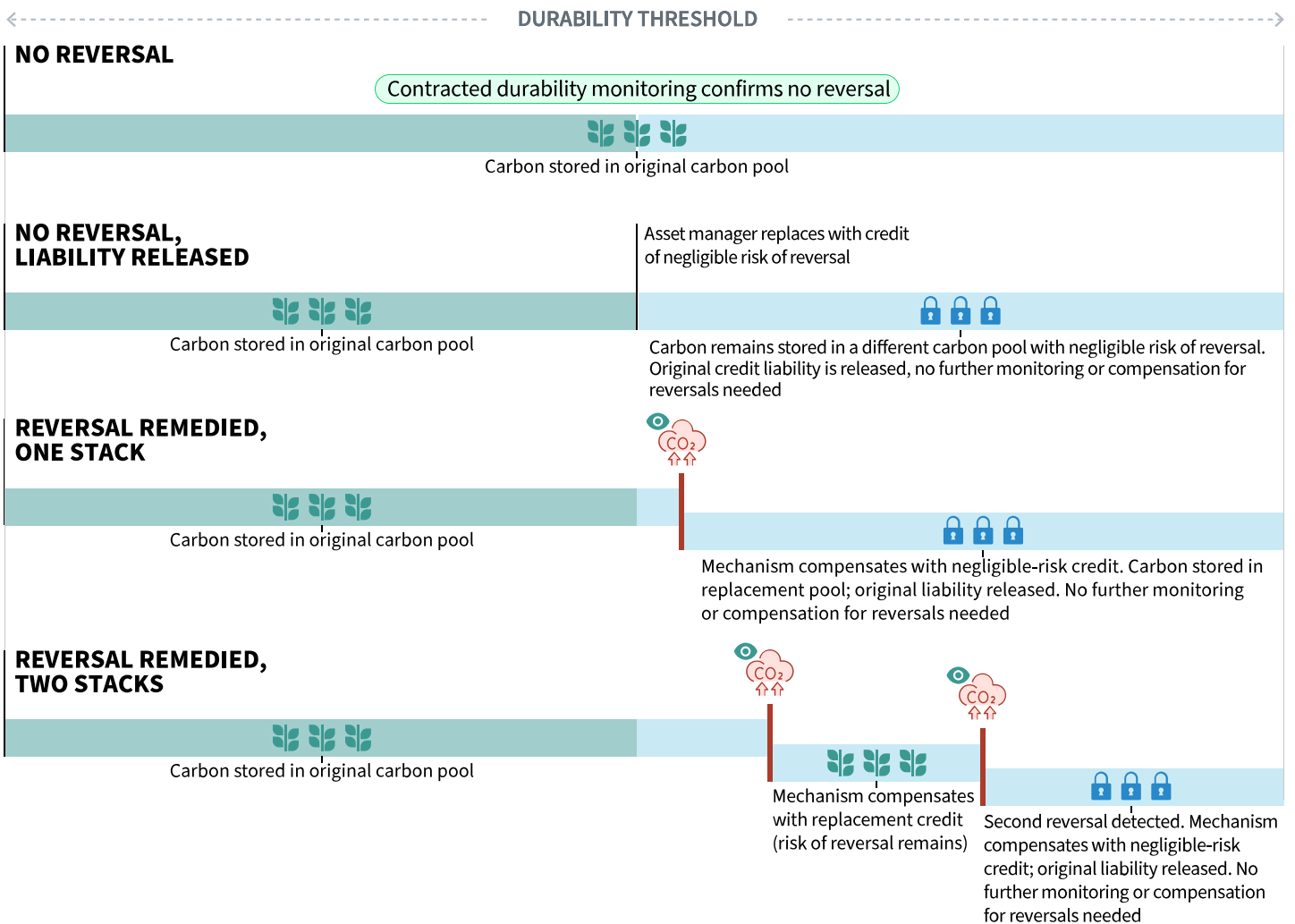
**Exhibit ES1: Contracted durability in practice**

- Crediting + post-crediting monitoring periods
- No contracted durability monitoring
- Contracted durability monitoring
- Non-negligible risk of reversal credit
- Negligible risk of reversal credit
- Possible undetected reversal
- Detected reversal occurs

**NO CONTRACTED DURABILITY SCENARIOS (STATUS QUO)**



**CONTRACTED DURABILITY SCENARIOS**



## Limits of contracted durability

**Contracted durability addresses one specific challenge: ensuring that a credit represents carbon stored for an established duration.** It does not address cost parity between nature-based CDR and novel engineered pathways. Contracted durability is likely to raise the price of credits with higher reversal risk, but the gap in costs between pathway types will likely persist and require dedicated policy measures to address that, including subsidies, public procurement, and R&D funding for novel CDR. Contracted durability carries an additional risk: if implemented with a durability threshold that is too low, it could slow investment in novel CDR by enabling markets to be satisfied with more affordable, shorter-duration credits in the near term. Contracted durability should therefore be understood as part of a broader policy portfolio, addressing the integrity of the credits traded in markets today while complementary measures accelerate the cost-down and scale-up of novel pathways.

## What's next?

Contracted durability is not a silver bullet, nor is it yet a proven solution. Moving contracted durability from concept to implementation requires near-term progress across three areas:

- **Policy engagement.** Key near-term priorities include adopting performance-based durability language in active standard-setting processes and defining what constitutes negligible risk of reversal — a concept introduced in the Article 6.4 standards but not yet operationalized.
- **Research and development.** Translating contracted durability into operational tools requires risk assessment frameworks, models for pricing reversal risk, institutional designs for permanence trusts that can outlast the organizations that create them, and legal frameworks for binding obligations across decades.
- **Piloting.** Real-world testing is essential to build the evidence base that policymakers and standard-setters require before broader adoption. Several vehicles are already available, including the ICVCM's Innovation Sandbox, the American Forest Foundation's Permanence Trust Feasibility Study, and Verra's Durability Pilot.

Policymakers designing carbon removal markets today have an opportunity to lay the groundwork for contracted durability — enabling the full range of CDR pathways to participate while ensuring that every credit delivers the climate impact it promises.

## SECTION 1

# Introduction



Carbon dioxide removal (CDR) is not optional. Alongside rapid emissions reductions, CDR is essential to meeting global climate goals. As the IPCC Mitigation of Climate Change report states, “The deployment of carbon dioxide removal (CDR) to counterbalance hard-to-abate residual emissions is unavoidable if net zero CO<sub>2</sub> or GHG emissions are to be achieved” (IPCC, 2022). Beyond net zero, CDR is also needed to limit near-term warming and ultimately draw down the accumulated stock of CO<sub>2</sub> already in the atmosphere. Multiple pathways exist for removing and storing carbon, and no single pathway is sufficient to meet the volumes of CDR required for net-zero or net-negative emissions. Policymakers must therefore establish policies to support the full range of CDR pathways while also ensuring verified climate impact.

There are a number of factors that determine the climate impact of a credit, such as additionality, robust quantification, social and environmental co-benefits, and, crucially, durability: the length of time that a tonne of carbon dioxide represented by a CDR credit remains out of the atmosphere (see Box 1). Durability, however, is variable: not all credits represent carbon stored for the same duration. Durability can also be uncertain, meaning the duration of storage is often unknown until stored carbon is re-released into the atmosphere (i.e., a “reversal”, meaning a net loss of the stored carbon). This is particularly true for nature-based pathways, which, while capable of storing carbon for long timescales, face risks of reversals from wildfires, pests and disease, and human intervention.

Durability matters because the climate impact of carbon removal depends, among other factors, on how long that carbon stays out of the atmosphere. Much of the policy debate around carbon removal has therefore centered on durability: the durability threshold or level of durability required to make claims and meet compliance requirements; the assumptions around the durability of various carbon removal pathways; and the challenge of ensuring durability over periods that may exceed the monitoring requirements of the carbon removal project.

In short, the challenge is: how can policymakers support the full range of removal pathways while credibly managing variability and uncertainty in durability?

Current approaches to durability across policy and standards have not yet resolved this question, and have typically failed for one of two reasons:

- 1. Locking out necessary pathways:** some policies and proposals have restricted the use of CDR credits to those with 1,000-year durability or geologic storage, excluding credits from nature-based pathways with greater variability and uncertainty in durability. These pathways, however, play a key role in achieving short- to medium-term climate goals (e.g., reducing peak temperature and avoiding climate tipping points) (Streck *et al.*, 2025). Further, these approaches are economically feasible today and offer additional social and environmental benefits.
- 2. Undermining environmental integrity:** other policies and proposals have supported credits from nature-based pathways but have not ensured that these credits represent carbon stored for sufficient timescales. This challenge stems from the fact that the durability thresholds established in policy often exceed the monitoring and liability commitments of the project. Under this approach, credits are priced to monitor and compensate for reversals over a period shorter than the durability threshold established by policy. Meanwhile, reversals may occur with no party liable for compensation.

What is needed is an approach that neither locks out nature-based pathways nor leaves gaps in the monitoring and liability for reversals — ensuring that credits represent carbon that remains out of the atmosphere for the entirety of the durability threshold.

## 1.1 Contracted durability as a solution

Contracted durability — which we define as “the use of legal and financial mechanisms to ensure carbon removal and storage over a defined duration” — offers a way forward. Contracted durability delivers two core functions: assigning contractually enforceable liability for reversals, and providing the resources and tools to compensate for any reversals that occur. Together, these functions ensure that one credit continues to represent one tonne of carbon removed from the atmosphere for the entirety of the durability threshold, regardless of whether the original credit’s storage persists.

Contracted durability may operate through one or more mechanisms:

- **Buffer pools**, which provide first-loss protection by withholding a portion of issued credits to compensate for reversals during the crediting and monitoring period;
- **Insurance**, which provides coverage for specific reversal events, particularly correlated losses that could overwhelm a buffer pool;
- **Horizontal stacking**, which replaces an original credit with a new one at the end of the monitoring period or following a reversal, carrying the storage obligation forward; and
- **A permanence trust**, an endowed financial institution that assumes liability for the ongoing monitoring and compensation for reversals, funded through a per-credit fee at issuance and actively managing risk through monitoring, reversal prevention, and replacement.

Taken together, these mechanisms form a financial and legal toolkit which enable all high integrity removal pathways to meet whatever durability threshold that a policymaker chooses to set. Contracted durability draws on established practices in insurance, finance, and institutional design, but combining these mechanisms into integrated approaches for carbon markets is new ground.

Contracted durability works best through a combination of these mechanisms, where possible.

Buffer pools or insurance alone, however, cannot deliver contracted durability. These mechanisms, designed to compensate for reversals during the crediting and post-crediting monitoring period, require either a permanence trust or horizontal stacking to assign liability for the duration of the durability threshold, assuming that the durability threshold extends beyond the monitoring period.<sup>1</sup> Critically, credits with a negligible risk of reversal over the durability threshold can release the liability for ongoing monitoring and compensation, whereas those with non-negligible risk of reversal require either horizontal stacking or a permanence trust to ensure ongoing monitoring and compensation.<sup>2</sup>

## 1.2 Limits of contracted durability

Contracted durability is not a silver bullet, nor is it yet a proven solution. It is designed to address one challenge: providing assurance that a credit represents carbon stored for an established duration. While contracted durability is likely to raise the price of credits with higher reversal risk, it is not intended to equalize costs across different carbon removal pathways. Instead, it functions as a tool to ensure the integrity of credits in the market. At the same time, if implemented with a relatively modest durability threshold, contracted durability may concentrate demand in lower-cost nature-based solutions, thereby constraining demand for higher-cost, novel CDR pathways that are essential to meeting climate goals. Addressing this risk requires complementary policies that actively support all pathways — through subsidies, public procurement, and R&D funding. Contracted durability should therefore be understood as part of a broader policy portfolio: maintaining market credibility while complementary policies enable innovation and scale across the full range of CDR pathways.

## 1.3 Scope and structure of this paper

This paper offers a framework for how contracted durability mechanisms can work:

- **Section 2** outlines the current system — the policies and projects currently addressing durability — and the benefits and structural limitations of contemporary approaches.
- **Section 3** introduces contracted durability mechanisms, including how combinations of mechanisms can ensure both liability and compensation for reversals over relevant timescales, and how contracted durability could work in practice.

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<sup>1</sup> If the monitoring period matches or exceeds the durability threshold, buffer pools and insurance would meet the requirements of contracted durability but could encounter practical implementation challenges for longer durability thresholds.

<sup>2</sup> Throughout this paper, ‘release’ is used as a general term to describe conditions under which liability for ongoing monitoring and compensation no longer applies. The precise legal characterization may vary by mechanism and jurisdiction (e.g., defeasance, discharge, or satisfaction of a condition subsequent).

- **Section 4** examines how contracted durability could be integrated into policies and standards being developed under five key jurisdictions and frameworks: California, the European Union, the Paris Agreement Crediting Mechanism, the Science Based Targets initiative, and the Integrity Council for the Voluntary Carbon Market.
- **Section 5** identifies three areas for near-term action: policy engagement, research and development, and piloting.

**Several important questions fall outside the scope of this paper.** Most notably, we do not define the durability threshold — the required duration of storage that a credit must meet to satisfy a given policy or claim. Defining this threshold is a task for policymakers and standard setters, informed by science and shaped by the specific goals they are trying to achieve: a policy aimed at reducing peak temperature or avoiding climate tipping points may require a lower threshold, whereas one aimed at balancing anthropogenic emissions over the full atmospheric lifetime of the emitted CO<sub>2</sub> may require a higher threshold. Each of these objectives is critical to a comprehensive climate strategy (de Wit *et al.*, 2025), and each can be supported by contracted durability. Additionally, this paper does not establish a threshold for negligible risk of reversal, nor does it establish criteria for reversal risk assessment or model the price impacts of contracted durability mechanisms. Finally, this paper addresses carbon dioxide removal and does not extend to avoidance or emission reduction credits. Contracted durability as defined here centers on ensuring that removed carbon remains out of the atmosphere; avoidance credits present distinct considerations that warrant separate analysis.

## Box 1: Defining durability

There are no universally accepted definitions of durability or permanence, which are often used interchangeably. Whereas “permanence” often implies a binary classification (i.e., labeling carbon storage as “permanent” or “not permanent”), “durability” often refers to storage duration that varies along a spectrum. This paper uses the term durability as opposed to permanence, and further distinguishes between three types of durability while also defining durability threshold:

- **Estimated durability:** An estimated length of time that a tonne of carbon dioxide represented by a carbon credit is likely to remain out of the atmosphere, given risks of reversal. Estimated durability is often applied at the CDR pathway level, but may also apply at the project or credit level.
- **Contracted durability:** The length of time a tonne of carbon dioxide represented by a carbon credit is contractually guaranteed to remain out of the atmosphere. Contracted durability applies at the project or credit level.
- **Realized durability:** The length of time that a tonne of carbon dioxide represented by a carbon credit is proven to remain out of the atmosphere, which can only be confirmed in the case of a reversal. Realized durability applies at the credit level.
- **Durability threshold:** The time period over which carbon must remain stored out of the atmosphere as defined by the policy, standard, use case, or claim being made.

## SECTION 2

# Challenges to the Current System



While existing frameworks have established important foundations for managing durability, structural limitations merit further attention.

Durability has become central to debates around carbon removal and carbon market design. This section examines how the current system addresses durability, within the policies and standards that govern carbon markets and at the project level, and the structural limitations to this system. Finally, this section outlines emerging initiatives that are beginning to address these challenges.

### 2.1 The current system

#### How policies and standards address durability

There is currently no singular approach to durability across policies and standards: some specify a year threshold; others a share of “short-lived” versus “long-lived” removals characterized by the relative length of the removal pathway’s estimated durability; and some mandate specific risk management tools or define durability based on liability assignment. Equally there are policies that do not explicitly define specific durability requirements but define monitoring requirements. While the required durability will vary *between* different use cases for a CDR credit, the variety in requirements *within* use cases (e.g., making a compensatory claim) creates challenges for market participants and slows scale-up in both compliance and voluntary segments. Table 1 offers a non-exhaustive summary of how existing policies and voluntary standards define durability requirements.<sup>3</sup>

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<sup>3</sup> More information on each of the policies and standards can be found in Section 4.

**Table 1.** Summary of existing durability requirements in select policies and voluntary standards

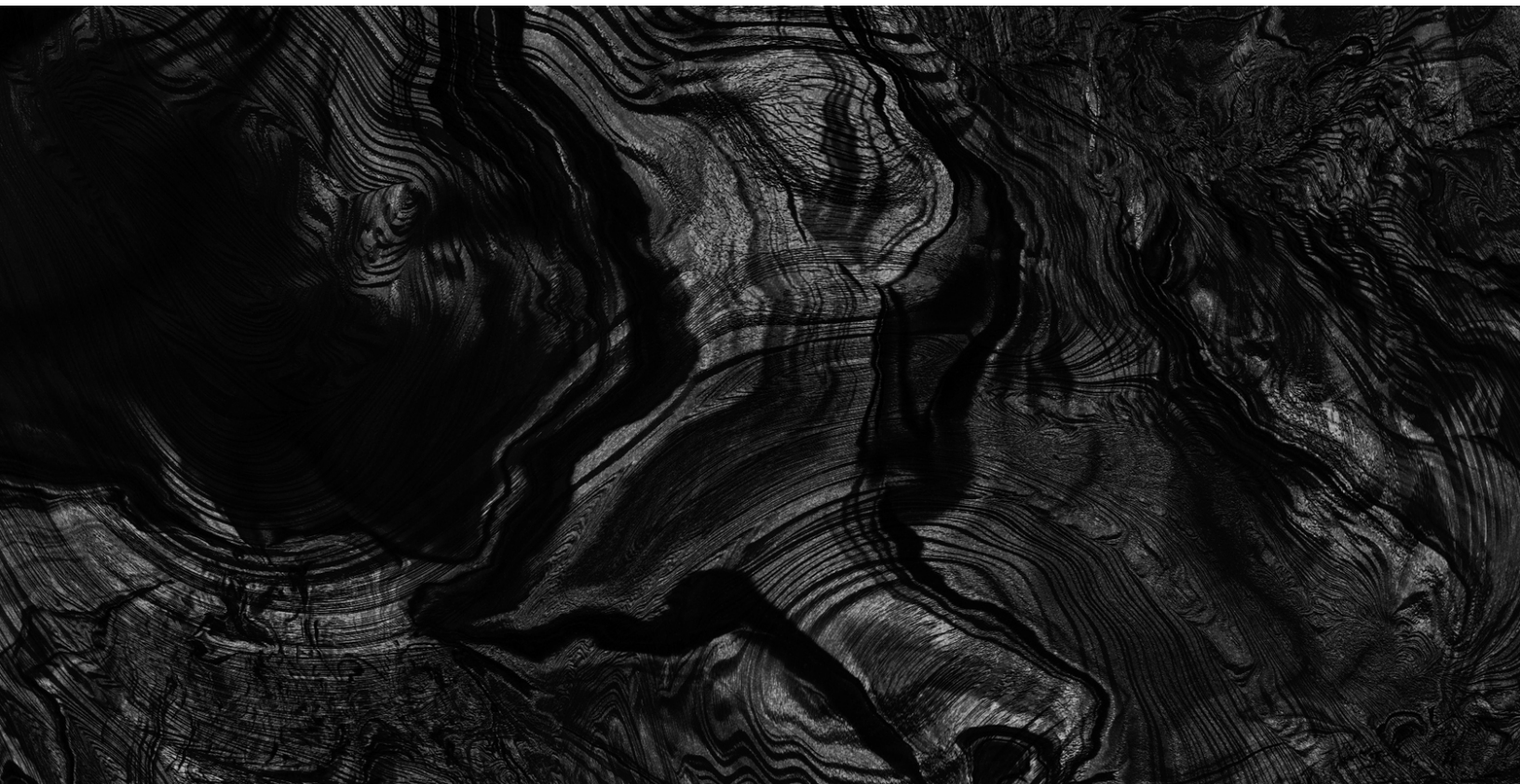
Policy or Voluntary Standard	Approach to Durability
<i>Policy</i>	
<a href="#">California Air Resources Board (CARB) Carbon Capture and Sequestration Protocol under the Low Carbon Fuel Standard</a>	Establishes the requirements for Carbon Capture and Sequestration projects and defines permanence as CO <sub>2</sub> storage for at least 100 years. This definition may be applied to other California policies such as the Cap-and-Invest program and SB 905, which are undergoing amendment or development processes.
<a href="#">EU Carbon Removals and Carbon Farming Regulation</a>	Establishes a voluntary certification framework, which categorizes carbon removal as either permanent (storage for several centuries, i.e., 200 years); carbon farming (storage for 5 years); or carbon storage in products (storage for 35 years). Specifies CDR pathways that fall into each category (e.g., created a certification methodology for Direct Air Capture (DAC) projects to demonstrate permanent carbon removal).
<a href="#">Paris Agreement Crediting Mechanism (Article 6.4)</a>	Creates standards for carbon credits, including CDR, in order to use the crediting mechanism. In the standard on addressing “non-permanence and reversals,” defines a negligible risk of reversal at the methodology level over 100 years. Requires project developers to contribute to a buffer pool based on project risk and to prove a negligible risk of reversal before post-crediting monitoring requirements are no longer in effect. Currently developing a reversal risk assessment tool.
<i>Voluntary Standard</i>	
<a href="#">SBTi Corporate Net-Zero Standard v2</a>	Establishes requirements for the durability of carbon removal used to neutralize emissions and achieve SBTi targets. Requires at net zero that “long-lived GHGs” are neutralized with “long-lived removals,” but has indicated that these requirements will be reviewed in future revisions of the standard. Intends to issue a call for evidence on “contractual, financial, or stewardship mechanisms” that can allow “shorter-lived carbon removals [to] deliver climate-equivalent permanence to long-lived removals.”
<a href="#">ICVCM</a>	Develops quality frameworks for credits on the voluntary carbon market, including the requirement to monitor for reversals for at least 40 years after the start of the crediting period and for projects to contribute to a buffer pool. Currently exploring other mechanisms through its Continuous Improvement Work Program on Permanence.

## How projects currently address durability

Projects in the carbon removal market currently address durability over varying timeframes. Project developers generating credits in today’s markets do so by first selecting a methodology or protocol containing specifications for how the carbon removal occurs, how it is measured, over what period of time the project issues credits (the “crediting period”) and over what period of time the developer or registry remains responsible for tracking stored carbon and remediating reversals (the “post-crediting monitoring period”).

While protocols are based on rigorous development processes, these requirements vary significantly; there is no overarching standard for the length of time over which a project is guaranteed to deliver climate impact. Even within a project, credits may differ in the length of time they are required to store carbon depending on whether they are issued at the start or end of a project’s crediting period. Furthermore, at the end of the post-crediting monitoring period, in many cases there is no longer any party responsible for ensuring carbon remains in storage, leaving a gap in liability that varies across the market.

As shown in Exhibit 1 on the next page, post-crediting monitoring requirements for a selection of existing protocols and methodologies range from 5 years to 100 years (if required at all) depending on the registry and CDR pathway. And as shown in Table 2 below, nearly all these programs rely on buffer pools as the primary mechanism to address reversals. Buffer pools are a mechanism that manages reversal risk by requiring a portion of the CDR credits from a project to be withheld from sale and used to replace credits in the event of a reversal. Neither Exhibit 1 nor Table 2 are exhaustive and do not cover all CDR pathways, but rather illustrate the variability among even a subset of protocols and methodologies.




**Exhibit 1.** A non-exhaustive summary of post-crediting monitoring requirements from select registries

Registry	Protocol / methodology	Requirement
American Carbon Registry	AFOLU projects	None <i>*Minimum crediting and monitoring period of 40 years</i>
	CCS projects	5 years post-crediting
ART	TREES projects	None <i>*Minimum crediting period of 5 years</i>
Climate Action Reserve	U.S. Forest Protocol	100 years post-crediting
	Mexican Forest Protocol	30 years post-crediting
Equitable Earth	Terrestrial Forest Restoration	100 years post-crediting <i>*Registry is responsible for monitoring post-crediting</i>
The Gold Standard	Land Use and Forests projects	None <i>*Minimum crediting period of 30 years for afforestation and reforestation projects and 10 years for agriculture projects</i>
Isometric	CO <sub>2</sub> storage in saline aquifers	50 years post-crediting <i>*Local regulatory guidance may define different requirements</i>
	Subsurface biomass storage	50 years post-crediting
Puro.earth	Carbonated Materials	1,000 years storage plan
	Terrestrial Biomass	100 years post-crediting <i>*Defines project developer liability for reversal as 100 years after credit issuance</i>
Verra	AFOLU projects	None <i>*Minimum crediting and monitoring period of 40 years</i>
	Geologic carbon sequestration	7 years post-crediting

**Table 2.** A non-exhaustive summary of how existing registries address reversals.

Registry	Protocol / Methodology	How are reversals addressed?
	<a href="#"><u>AFOLU projects</u></a>	Projects contribute a percentage of project credits to a buffer pool, based on the ACR Tool for Reversal Risk Analysis and Buffer Pool Contribution Determination. Calculated at the start of project verification and every 5 years after
	<a href="#"><u>Carbon Capture and Storage (CCS) projects</u></a>	Projects must have approved insurance or contribute to a buffer pool (10% of project credits) and requires a Risk Mitigation Covenant post-project term
	<a href="#"><u>TREES projects</u></a>	Projects contribute a percentage of project credits to a buffer pool (5 to 25% of project credits, depending on the existence of ART-defined “mitigating factors”)
	<a href="#"><u>U.S. Forest Protocol</u></a>	Projects contribute a percentage of project credits to a buffer pool, based on the project’s “Reversal Risk Rating” as defined in the protocol’s Appendix A
	<a href="#"><u>Mexican Forest Protocol</u></a>	Projects contribute a percentage of project credits to a buffer pool, based on the project’s “Reversal Risk Rating” as defined in the protocol’s Appendix G
	<a href="#"><u>Terrestrial Forest Restoration</u></a>	Projects contribute 20% of project credits to a buffer pool. For unavoidable reversals, the buffer pool absorbs the loss; for avoidable reversals, the developer must also replenish the pool.
	<a href="#"><u>Land Use and Forests projects</u></a>	Projects contribute 20% of project credits to a buffer pool
	<a href="#"><u>CO<sub>2</sub> storage in saline aquifers</u></a>	Projects contribute 2% of project credits to a buffer pool
	<a href="#"><u>Subsurface Biomass Storage</u></a>	Projects contribute a percentage of project credits to a buffer pool (up to 20% of project credits depending on the Isometric Standard Risk Assessment Questionnaire)
	<a href="#"><u>Carbonated Materials</u></a>	Requires projects to develop a risk assessment and mitigation plan and a long-term (1,000 years) storage plan
	<a href="#"><u>Terrestrial Biomass</u></a>	Outlines risks relevant to the project type and provides methods for mitigation and outlines eligible contractual frameworks for ensuring reversals are remediated

Registry	Protocol / Methodology	How are reversals addressed?
	<a href="#">AFOLU projects</a>	Projects contribute a percentage of project credits to a buffer pool, based on assessment of the AFOLU Non-Permanence Risk Tool. Verra is currently conducting a three-year pilot testing insurance and fund-based mechanisms as alternatives to the buffer pool.
	<a href="#">Geologic carbon sequestration</a>	Projects contribute a percentage of project credits to a buffer pool, based on assessment of the Geologic Carbon Sequestration Non-Permanence Risk Tool. Verra is currently conducting a three-year pilot testing insurance and fund-based mechanisms as alternatives to the buffer pool.

## 2.2 Gaps in the current system

While existing frameworks have established important foundations for managing durability, three structural limitations merit further attention. These are not critiques of any individual program or mechanism; rather, they are systemic features that contracted durability seeks to address.

### Pathway-level assumptions obscure project-level variation

Realized durability is not a fixed property of a CDR pathway. Streck *et al.* (2025) define durability as an inherently probabilistic rather than a binary concept; Mitchell-Larson *et al.* (2022) frame it quantitatively, with very high durability corresponding to approximately 0.01% annual reversal risk (roughly 10,000 years of expected storage), while low durability aligns with an approximately 1-10% annual reversal risk (roughly 100 years). In both cases, durability varies along a spectrum.

All carbon removal projects are exposed to some risk of reversal, though the nature, likelihood, and ease of remediation of that risk varies significantly across and within pathways. For some pathways (e.g., those that use geological storage), reversal risk can range from minimal to significant depending on site characteristics, regulatory environment, and the degree to which stored carbon has stabilized (Alcalde *et al.*, 2018; Lee *et al.*, 2026). For others, including many nature-based pathways, risk profiles are shaped by ongoing environmental and management factors that evolve over time. Yet the prevailing approach across both voluntary and compliance frameworks treats durability as a property of the pathway rather than the individual project or credit. While some programs require project-level risk assessments to inform buffer pool contributions, the overarching durability classification and the duration of storage commitments are typically set at the pathway level rather than calibrated to individual project- or credit-level risk profiles (Hunnable *et al.*, 2024; Streck *et al.*, 2025).

### Liability for reversals is unclear, time-limited, and misallocated

In most crediting programs, no party is liable for ensuring carbon remains in storage after the post-crediting monitoring period ends. During the crediting and monitoring periods, liability may sit with project developers, landowners, registries, or buyers, but even within those periods, the assignment of responsibility is often ambiguous or unspecified (Hunnable *et al.*, 2024).

Compounding these liability gaps, the definitions of “avoidable” reversals (caused by negligence or willful acts) and “unavoidable” reversals (caused by natural events such as wildfire or disease) are inconsistent across crediting programs. This has direct implications on liability. Programs such as Verra and CAR use different definitions for negligence, meaning the same reversal event could trigger different liability consequences depending on where the project is registered (ICVCM Continuous Improvement Work Program [CIWP], 2025).

Further, a significant gap exists between policy durability thresholds and what is actually guaranteed via the requirements of crediting programs. For example, the ICVCM requires monitoring and compensation for at least 40 years from the start of the crediting period, despite policies sometimes referencing 100-year durability thresholds. California’s Cap-and-Invest program requires monitoring to ensure permanence for at least 100 years after the last credit is issued to a project (CARB, 2026), yet many of the crediting protocols eligible for use outside of compliance have combined crediting and monitoring periods well short of that mark (Exhibit 1). After the post-crediting monitoring period ends, there is no longer an entity responsible for ensuring carbon remains in storage.

Meanwhile, systems that assign long-term liability to individual developers or small landowners face fundamental feasibility constraints. Under California’s compliance offset program, for example, project agreements are tied to the property itself, meaning reversal liability transfers automatically to any future landowner for 100 years, requiring them to either maintain the project’s carbon stocks and monitoring commitments or, if the project is terminated, purchase and retire carbon credits or allowances to cover the credits the project has generated. Research on family forest landowners has found that willingness to participate in carbon programs declines significantly as contract length increases (Gazal *et al.*, 2025), a finding echoed by the American Forest Foundation’s (AFF) experience that contract length was a significant obstacle to engaging small landowners needed to develop projects (Truitt & Riley, 2025).

This risk is not limited to long time horizons. A newly funded project developer could cease operations well within a standard crediting period. If any liable entity ceases to exist and storage subsequently reverses, the buffer pool may provide partial compensation, but no party retains active responsibility for remediation or for ensuring the buffer pool itself remains adequate (Kaplan & Ramanna, 2025).

### **Buffer pools have structural limitations**

Buffer pools are the predominant mechanism for managing reversal risk in carbon markets, with major registries including Verra, CAR, ACR, and Gold Standard all employing some form of buffer pool design. Buffer pools have successfully compensated for individual project-level reversals to date. At the same time, there has also been significant research that questions whether buffer pools are sufficient on their own to manage reversals. Observations include:

- **Buffer pools can concentrate credits with correlated risk exposure, meaning the conditions that cause a reversal in one project may simultaneously affect the buffer credits intended to compensate for it** (Lee *et al.*, 2026; Truitt & Riley, 2025). Cooley *et al.* (2012) warned more than a decade ago that correlated and large-scale disturbance events (e.g., wildfires, insect and pathogen outbreaks) could overwhelm pooled reserves by affecting entire project portfolios at once. The degree of this correlation varies based on program rules around whether a reversal is compensated from a project’s own credits, from buffer credits limited to the same project type or region, or from any credits held in the broader buffer pool.

- **Buffer pool contributions are determined by risk assessment tools that rely on historical data and do not account for how climate change may increase risks over time.** A recent review of 20 forest carbon protocols found that none account for climate change impacts in estimating buffer pool allocations, concluding that current approaches to assessing risk and capitalizing buffer pools are “not based on the best available science” (Sanders-DeMott *et al.*, 2025). A cross-program comparative analysis by the Perspectives Climate Group (2025) also found that programs generally do not explain the scientific basis for the specific risk scores assigned to projects, which determines buffer contribution requirements.
- **If reversals exceed a buffer pool’s capacity, there is no mechanism to make the atmosphere whole.** Questions have also been raised about the capitalization and legal enforceability of buffer pool commitments more broadly (Roston, 2025).

These structural concerns are supported by a growing body of empirical evidence. When Anderegg *et al.* (2025) evaluated Verra’s Non-Permanence Risk Tool against modeled forest biomass trajectories under realistic disturbance scenarios, they found that buffer pool contributions are insufficient to insure the carbon stored by the majority of projects globally. These findings are consistent with a broader body of research documenting gaps between buffer pool design parameters and observed disturbance patterns (Anderegg *et al.*, 2020; Anderegg *et al.*, 2022).

Registries have begun to respond. CAR launched a formal re-evaluation of its permanence framework in 2025, with its leadership calling for “significantly more sophisticated models to quantify risk and account for reversals” (Rix & Remucal, 2025). ACR released a substantially revised risk assessment tool incorporating spatially explicit disturbance data (ACR, 2024). Several additional reform initiatives, including the ICVCM’s recommendation for mandatory buffer pool stress testing and Verra’s pilot of insurance and fund-based alternatives, are discussed below in Section 2.3.

The consequence of these limitations may be further intergenerational inequity in addition to inequities already in motion by climate warming to-date — if buffer pools alone prove insufficient, the need to recapture carbon dioxide could fall to future generations who had no role in the original transaction (Arcusa & Lackner, 2025). The ICVCM CIWP (2025) acknowledges this dynamic by recommending that buffer pools be periodically stress tested for adequacy as a step toward addressing it. At the same time, these durability concerns should not be mistaken as a reason to delay the deployment of available CDR, which carries its own intergenerational costs. Rather, as this paper argues, it is further evidence to use buffer pools in combination with one or more of the other contracted durability mechanisms, namely: horizontal stacking, and/or a permanence trust.

## 2.3 Emerging initiatives

A growing number of frameworks, standards, and initiatives have emerged to strengthen how durability is measured, managed, accounted for, and assured (Table 3). This paper builds upon these existing efforts with the aim of contributing to and informing these ongoing initiatives.

This paper proposes a new way of thinking about durability — one that enables any CDR pathway to achieve a desired durability performance as opposed to assuming durability based on a pathway. Rather than classifying credits as “permanent” or “non-permanent” based on their pathway, contracted durability evaluates credits based on what mechanisms are in place to ensure their durability over the required timescale.

**Table 3.** A non-exhaustive list of emerging initiatives to address durability gaps, listed alphabetically

<b>Initiative, Organization (Published reference)</b>	<b>Description of initiative</b>
<b>Atmospheric Impact Framework</b> <i>Three Cairns Group</i> (Lamarque <i>et al.</i> , 2026)	The Atmospheric Impact Framework (AIF), being developed by the Three Cairns Group, is a standardized scoring system designed to bring comparability to carbon credits. It works by applying quantitative adjustment factors across four analytical layers – project design, methodology, earth system dynamics, and economic behavior – to translate carbon credits into a common, fungible unit. The framework is designed to evolve annually through expert review and public consultation, with a minimum viable product targeted for mid-2026.
<b>Carbon at Risk Framework</b> <i>Carbon at Risk</i> (Lee <i>et al.</i> , 2026)	Inspired by Value at Risk in financial markets, Carbon at Risk (CaR) provides a standardized metric to quantify the anticipated performance of carbon removal pathways, measuring expected CO <sub>2</sub> losses over specified time horizons. The initiative has published CaR assessments across ARR, biochar, ERW, and geological storage, drawing on collaboration with academics and a broad coalition of financial institutions, insurers, standards bodies, and climate nonprofits.
<b>E-Asset Proto Standard</b> <i>E-Ledgers Institute</i> (Kaplan & Ramanna, 2025)	The E-Asset Proto Standard, currently being developed by the E-Ledgers Institute, aims to establish a GAAP-like accounting foundation for carbon removals so that they can be reliably recorded, transferred, and netted within the E-Ledgers accounting system. By providing these accounting foundations, the working group seeks to support the development of more credible and scalable carbon removal markets.
<b>ICVCM CIWP on Permanence</b> <i>ICVCM</i> (ICVCM, 2025)	The ICVCM’s second Continuous Improvement Work Program on Permanence builds on a first phase report published in May 2025, and is focusing on innovative solutions to improve how reversal risk is assessed and mitigated — including exploring the feasibility of a permanence trust, industry-wide pooled buffer reserves, and insurance products.
<b>Permanence Trust</b> <i>American Forest Foundation</i> (Truitt & Riley, 2025)	Conceived by the American Forest Foundation, the Permanence Trust shifts permanence assurance from a passive approach of holding reserves to an active strategy that funds prevention, monitoring, and replacement of future reversals — pooling collective risk and resources across all project types and sizes. AFF has partnered with carbon insurance specialist Kita to conduct a design and feasibility study, CaR to quantify and standardize risk assessments, and hosts expert advisory groups supervising the work.
<b>VCS Durability Pilot</b> <i>Verra</i> (Verra, 2025)	Verra, which develops and manages the Verified Carbon Standard, is piloting alternative ways for project proponents to manage the reversal risk of credits issued under its standard, including an option to purchase an insurance policy under which an insurer would remedy a reversal with additional carbon credits or financial payments. This sits within a broader VCS Version 5 revision covering baselines, safeguards, and program workability.
<b>Warming Neutralization Approach</b> <i>Google, Stripe</i> (Hughes, <i>et al.</i> , 2026)	Part of a broader effort to codify what a contracted durability system looks like in practice, the Warming Neutralization Approach is a methodological framework that models the temperature impact of emissions and mitigation over time. It sets up a system for managing emissions that enables strategies of varying durability — including shorter-lived CDR and short-lived climate pollutant abatement — to be stacked together with longer-lived CDR to ensure warming remains consistently neutralized over multiple time horizons.

## SECTION 3

# Contracted Durability as a Solution



The implementation of **contracted durability** will depend on the durability threshold as set by the policy, standard, use case, or claim being made.

### 3.1 Defining contracted durability

Contracted durability refers to the length of time that a tonne of carbon dioxide represented by a carbon credit is contractually guaranteed to remain out of the atmosphere. The implementation of contracted durability will depend on the durability threshold as set by the policy, standard, use case, or claim being made. Different durability thresholds may be set depending on the climate goal (e.g., offsetting an emission, delaying peak warming, lowering peak warming). Because the durability threshold often exceeds the post-crediting monitoring period required by registries, there is a need for contracted durability to ensure ongoing liability and compensation for reversals. Contracted durability is similar to the concept of guaranteed durability (Gupton *et al.*, 2026).

Contracted durability *mechanisms* are a set of legal and financial tools that ensure carbon removal over a specified time period. These contracted durability mechanisms allow CDR credits, regardless of pathway, to reach a level of guaranteed durability performance as specified in the contract. Furthermore, contracted durability mechanisms can enable CDR projects with non-negligible reversal risk to guarantee higher levels of durability provided adequate mechanisms are in place to ensure both liability and compensation for reversals.

It is important to note that contracted durability mechanisms have the potential to impose perpetual monitoring requirements if the durability threshold is sufficiently long, which may be costly. However, we propose that contracted durability mechanisms can also enable CDR credits that have a negligible risk of reversal to release liability for ongoing monitoring and compensation for future reversals, allowing the system to reach a clear endpoint rather than requiring perpetual monitoring. In all cases, contracted durability mechanisms rely upon rigorous long-term reversal risk assessments, enabling credits to be priced to cover the costs of ongoing liability and compensation for reversals.

Contracted durability mechanisms deliver two core functions, both of which must be met across the entire durability threshold established by a policy or standard. Both functions may need to be met through a combination of mechanisms.

- 1. Ongoing liability.** They provide ongoing liability for addressing reversals by clarifying the party(ies) responsible for monitoring and compensating for reversals at all points in time, including under what conditions these responsibilities may be released.
- 2. Compensating for reversals.** They provide ways to compensate for reversals so that the credit delivers ongoing removal and the same credited level of removal is achieved.

## Ongoing liability

Contracted durability mechanisms can be categorized by which function of contracted durability they achieve. A combination of contracted durability mechanisms may be needed to ensure both functions are met at all times.

Both a permanence trust and horizontal stacking can establish ongoing liability for monitoring and addressing reversals. Each of these mechanisms assigns a party responsibility to remediate reversals and therefore ensures carbon removal for the entire durability threshold.

- A **permanence trust** is a risk-transfer approach in which CDR credit purchases include a fee, based on the credit's risk of reversal, that gets deposited into a financial trust to be managed by an independent entity. The trust takes on liability for monitoring, reversal prevention, and ensuring removal, likely starting after the credit's post-crediting monitoring period. The trust may continue to monitor the original credit or the trust may release its liabilities for ongoing compensation and monitoring for reversals through a credit with negligible reversal risk (Gupton *et al.*, 2026; Truitt & Riley, 2025).
- **Horizontal stacking** after the post-crediting monitoring period entails a new CDR credit replacing the original credit after a specified time period, likely the original credit's crediting period and post-crediting monitoring period (Gupton *et al.*, 2026). In this case, the liability falls on the buyer, project developer, or entity claiming to meet the durability threshold to continually replace credits as they expire so that they are monitored for the entire durability threshold. The liability for ongoing compensation and monitoring for reversals can be released through compensation with a credit with negligible reversal risk, depending on the contract.

## Compensating for reversals

The success of these mechanisms to address ongoing liability depends upon the ability to compensate for reversals in a way that ensures the same level of removal is achieved. This includes ensuring that replacement credits meet quality criteria beyond durability alone. Three mechanisms that can serve this function include buffer pools, insurance, and horizontal stacking after a reversal. A permanence trust can further serve this function by employing combinations of these three mechanisms, depending on the portfolio's collective risk.

- **Buffer pools** require a portion of the CDR credits from a project to be withheld from sale and used to replace credits in the event a reversal occurs, over a specified time period (Gupton *et al.*, 2026).
- **Insurance** is a legal mechanism whereby an entity (insurance provider) provides compensation in the event of a covered loss (Gupton *et al.*, 2026). To be a contracted durability mechanism, covered losses are reversals and compensation is in the form of CDR credits. Insurance applies only when the insurance policy is active (which is usually one to five years), which can be renewed. Although insurance typically replaces credits with those of a similar type, it could in theory release liability for ongoing compensation and monitoring for reversals if the policy replaces reversed credits with credits of negligible risk of reversal.
- **Horizontal stacking after a reversal** requires a new CDR credit to replace the original credit when a reversal occurs (Gupton *et al.*, 2026). A buyer, project developer, or entity claiming to meet the durability threshold can release liabilities by replacing the reversed credit with a credit with negligible reversal risk, but otherwise resets the start of the crediting period and post-crediting monitoring period with the purchase of a replacement credit.

## Box 2. State-of-Play: Insurance as an Emerging Mechanism

Today, insurance is developing as an alternative and/or complement to buffer pools, such as through Verra's Durability Pilot. Insurance can cover many types of risk, such as political or delivery risk (Hunnable *et al.*, 2024). Additionally, insurance policies can compensate for reversals either via credit replacement or financially (Gupton *et al.*, 2026); however, financial compensation is not considered a contracted durability mechanism because it does not guarantee the same level of removal is achieved.





In practice, insurance is typically offered through a third-party, as opposed to through a registry as is typical for buffer pools. Moreover, insurance typically applies over short time periods, with insurance policies generally ranging from one to five years (Gupton *et al.*, 2026). Project developers as well as CDR credit buyers can purchase insurance.

Open questions remain on the most effective way to implement insurance as a tool to compensate for reversals. Does the same type of credits as the original credits need to be used to remediate a reversal when insurance is used as a contracted durability mechanism? Who is the optimal purchaser of insurance? At what timescales should insurance operate? Addressing these questions will be key to establishing the role of insurance as a short-term mechanism within contracted durability as development and piloting continue.

Importantly, to serve both core functions discussed above, a credit must be paired with 1) a permanence trust or 2) horizontal stacking after the post-crediting monitoring period. Buffer pools and insurance alone will not satisfy both functions assuming the durability threshold extends beyond the monitoring period. Examples of contracted durability in practice are outlined in Section 3.2.

Exhibit 2 summarizes the functions that each contracted durability mechanism fulfills.

**Exhibit 2.** Functions of contracted durability mechanisms

	 Buffer pools	 Insurance	 Horizontal stacking	 Permanence trust
Ensure ongoing liability for reversals	No	No	Yes	Yes
Provide tools to compensate for reversals	Yes	Yes	Yes	Yes

### Mechanism development is needed

Each of the mechanisms presented above still require further development to be able to bring contracted durability to maturity. Buffer pools are the most established and the most commonly used of these mechanisms, but as described in Section 2, require additional iteration to better manage reversal risk. Insurance is the next most developed of these mechanisms, though the type of insurance included within contracted durability (replacing reversals through credits instead of financial compensation) is still maturing in terms of the diversification and sophistication of offered policies (see Box 2.). Horizontal stacking is being implemented as a purchasing strategy only by a small number of buyers today, though it is being considered as a strategy for releasing post-crediting monitoring obligations under Article 6.4. A market-wide permanence trust has yet to be implemented at scale and is currently being studied for feasibility. Project-level permanence funds exist, but are nascent. Many outstanding questions also exist on implementation and governance, as described later in Section 3.3.

Despite the work to be done, the functions of contracted durability mechanisms presented here provide a north star for implementation, ensuring that: 1) ongoing liability over the entire durability threshold has been assigned to an entity resourced to take that on, and 2) that tools are available to compensate for reversals which achieve the same level of removal.

## 3.2 Contracted durability in practice: An illustrative example

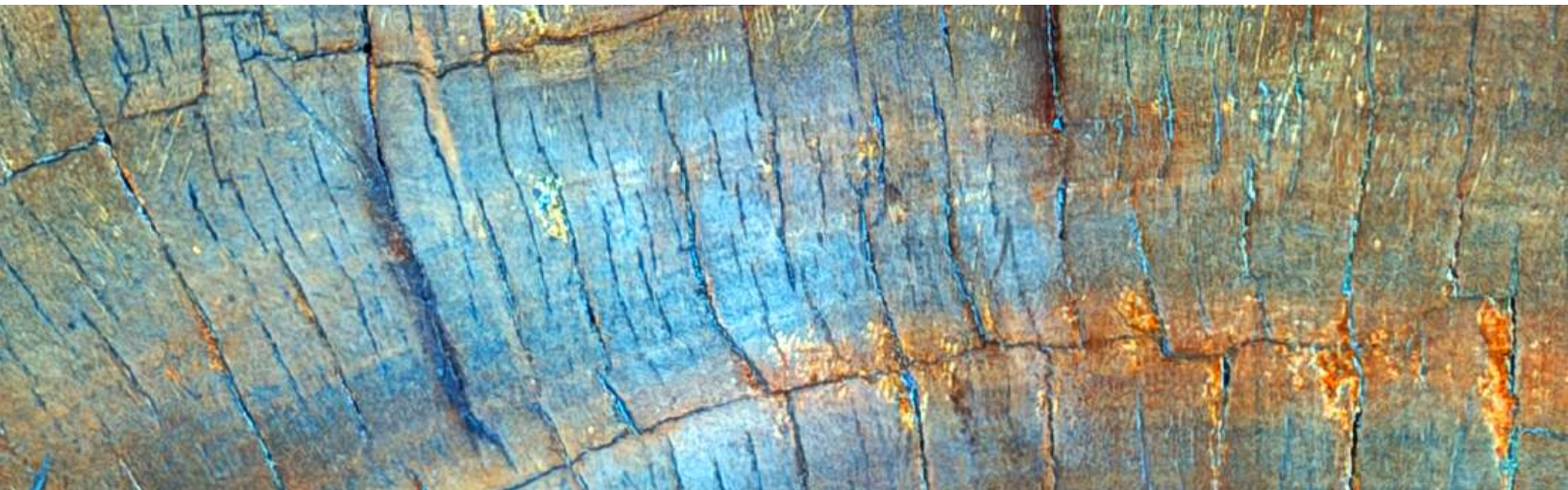
This section illustrates one example of how contracted durability mechanisms could operate in practice; specifically, it considers how a reforestation project could achieve contracted durability via a permanence trust.

Durability for all project types begins with good project design: smart and safe development and operating practices, meaningful stakeholder engagement, and positive impacts that persist beyond the crediting period. Design decisions in reforestation projects – when to plant, what to plant, how to plant, ongoing maintenance – are key steps that will impact project durability from the start.

Once the project is designed and implemented, the crediting period and then post-crediting monitoring period occur. In a reforestation project, carbon is stored usually in some combination of aboveground and belowground biomass, soils, and wood products. Under existing systems, the landowner, project developer, and registry each play a role in maintaining carbon storage for the duration of the post-crediting monitoring period:

- **The project developer** is responsible for contributing to the buffer pool, monitoring the project, and compensating the buffer should reversals occur according to the standard being followed.
- **Landowners** carry out their commitments on the ground, such as not harvesting a forest prior to when planned.
- **The carbon registry** manages the buffer pool, making sure that buffer credits are used when needed and the pool is sufficiently resourced for the time period the buffer covers.

In many cases, the durability threshold extends past the crediting and post-crediting monitoring periods, leaving a gap in which liability is unassigned and reversals go unmonitored and unremediated (Exhibit 3). A permanence trust fills this gap. At issuance, a fee calculated per credit based on the cost to manage that credit’s reversal risk is paid into a regional-scale, multi-project endowed fund. Following the post-crediting monitoring period, the trust assumes full liability for monitoring, reversal prevention, and compensation for the remainder of the durability threshold — removing the need to extend these obligations to project developers, landowners, or registries. This fee is based on the risk to the stored carbon and the durability threshold covered. Risk can be mitigated by good project design and trust diversification, and may be higher where there are correlated risks and poor project design. Buyers needing higher durability thresholds for their claims and policy frameworks will thus have those costs priced in accordingly. Pooled together, the funds within the trust grow and make disbursements to scale a supply of credits that will be needed to compensate for reversals, operationalize monitoring of stored carbon, prevent reversals with ongoing stewardship support for hotspots of risk, and compensate for reversals identified.



In practice, many credits will maintain their storage through the durability threshold without incident. But if a reversal does occur, the trust is prepared to compensate — ensuring the credit continues to represent one tonne of carbon removal. For example, a trust might use a credit with negligible reversal risk, such as geologic storage, to replace a reversal from a reforestation project. Whether through long-term monitoring of original carbon pools or investment in credits with negligible risk of reversal, the trust ensures carbon remains stored without gaps — even across extended durability thresholds.

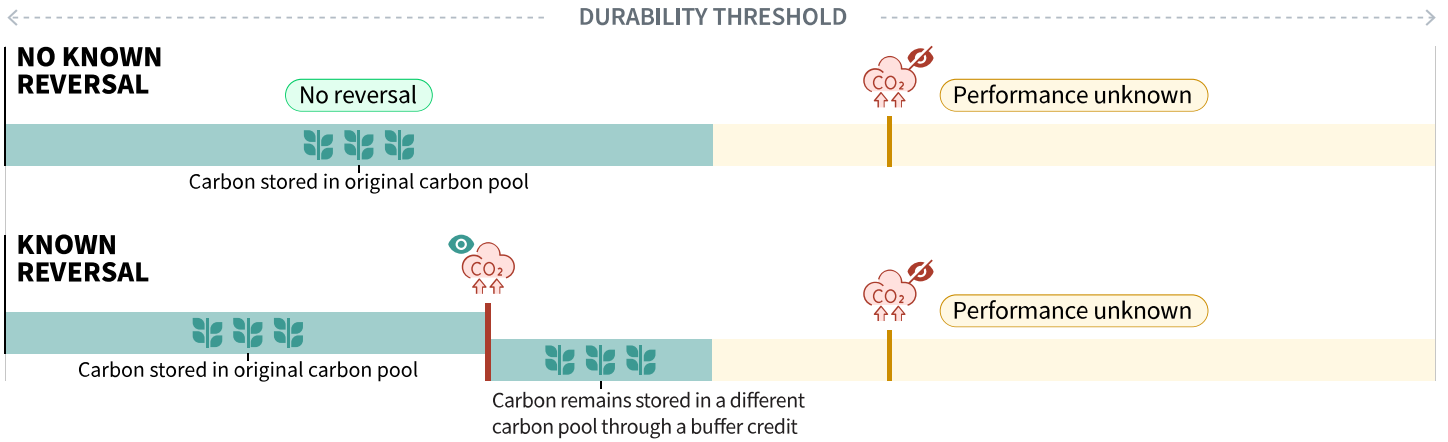
Exhibit 3 on the next page visualizes a select few scenarios to illustrate the flexibility of contracted durability.

**Exhibit 3: Contracted durability in practice**

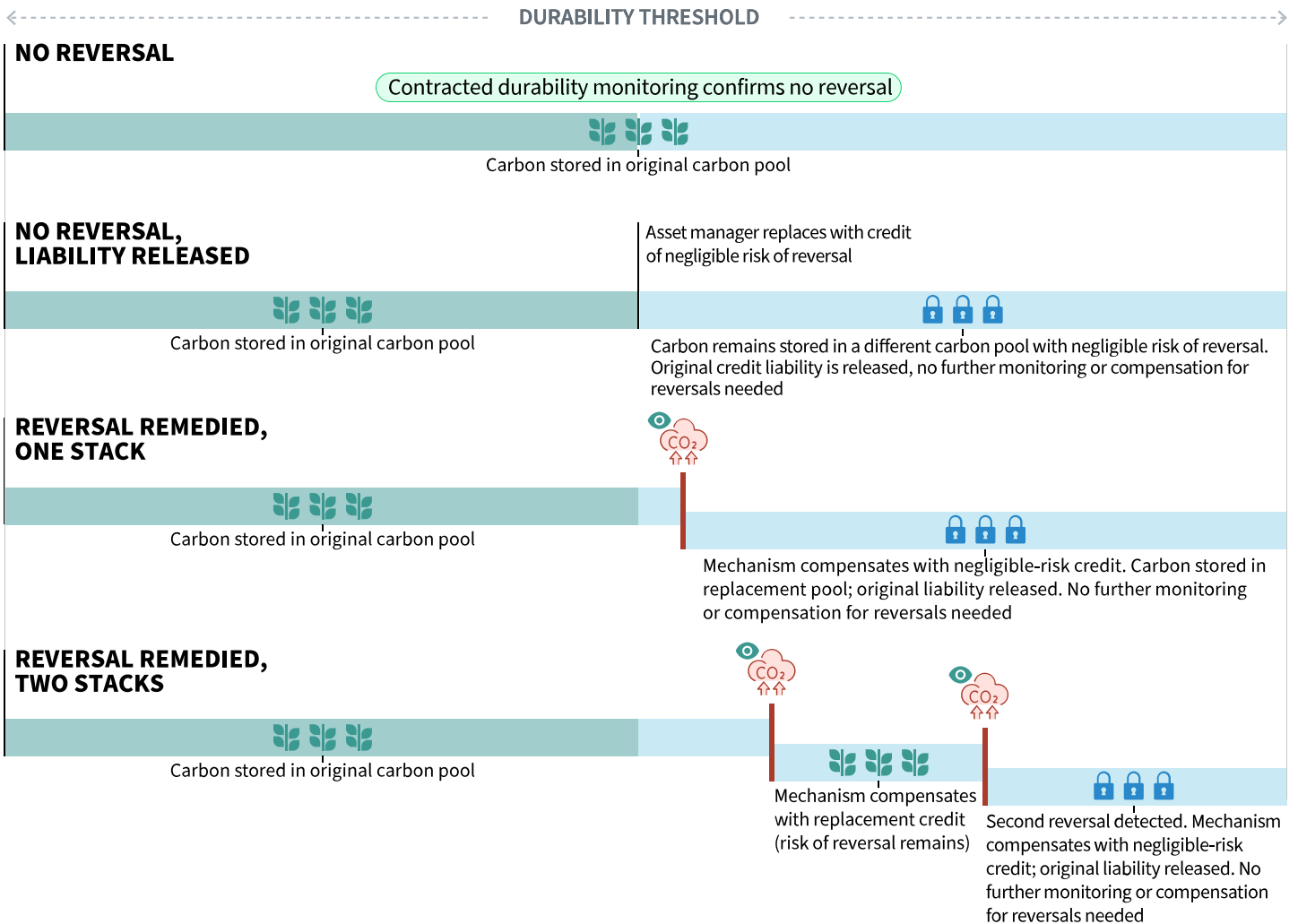
Crediting + post-crediting monitoring periods
  No contracted durability monitoring
  Contracted durability monitoring

Non-negligible risk of reversal credit
  Negligible risk of reversal credit
  Possible undetected reversal
  Detected reversal occurs

**NO CONTRACTED DURABILITY SCENARIOS (STATUS QUO)**



**CONTRACTED DURABILITY SCENARIOS**



### 3.3 Outstanding questions

Several questions remain that require further research. These set the agenda for the next steps outlined in Section 5.

**Assessing reversal risk:** Contracted durability mechanisms are only as effective as the risk assessments that underpin them. A contracted durability mechanism that misprices reversal risk — whether by underestimating the likelihood of a reversal, the scale of correlated losses, or how risk evolves over time under changing climate conditions — will systematically under-provision the compensation needed to maintain the climate impact of the removal. Frameworks such as Carbon at Risk (see *Table 3.*) must be translated into standardized, operational risk assessments applicable across contracted durability mechanisms, leveraging precedence and experience from other industries managing long-term risks. Independent risk-based pricing of these mechanisms can also incentivize project-level investment in risk mitigation, as projects with stronger risk profiles would face lower costs.

**Defining negligible risk of reversal:** Contracted durability mechanisms depend on a clear, operationalizable definition of what it means for reversal risk to be negligible, which determines when ongoing liability can be released and monitoring obligations concluded. This concept is foundational — without it, there is no endpoint to the liability chain, and contracted durability cannot function as a finite, bounded system. This definition should be grounded in climate science, considering the level of performance needed to make a range of claims with respect to the atmospheric impact of the removals.

**Institutional design:** Contracted durability requires institutions capable of assuming and managing liability over timescales that exceed the lifespan of most organizations. What governance structures, investment mandates, and transparency mechanisms can ensure that these institutions remain functional, well-capitalized, and accountable across decades? Long-lived institutions such as endowments and conservation land trusts offer relevant precedents, but adapting them to the specific demands of both voluntary and compliance carbon markets requires further design work.

**Scaling compensation supply:** Contracted durability mechanisms that assign ongoing liability depend on the availability of CDR credits with negligible reversal risk to release that liability. The supply of such credits — such as from geological storage pathways — remains limited today. Scaling these pathways sufficiently to meet future compensation needs is a prerequisite for contracted durability mechanisms to release liabilities at market-wide scale, but also a likely outcome of establishing these mechanisms in the first place. Further work is also needed to define the quality criteria that replacement credits should meet beyond durability, including how those criteria are established and governed.

**Policy and standards readiness:** Contracted durability can only function if the policies and standards that govern carbon markets create space for it. This requires both performance-based durability language that allows contractual mechanisms to satisfy requirements regardless of CDR pathway, and transparency requirements so that the durability obligations attached to any given credit are visible and verifiable. Several standards are already moving in this direction, and their progress will generate important evidence for wider adoption.

## SECTION 4

# Contracted Durability in Policy and Standards



A number of active policy and standard-setting processes are determining how to regulate, incentivize, and set quality benchmarks for carbon removal. These processes are grappling with shared questions: what durability standards to set, how to manage reversal risk across diverse CDR pathways, and how to assign liability when storage commitments extend well beyond crediting periods. Contracted durability offers a framework for addressing these questions, not by prescribing which pathways qualify, but by providing performance-based mechanisms through which projects can implement liability mechanisms to better achieve the required durability standard. In compliance contexts, these mechanisms would typically be standardized at the protocol or regulatory level, rather than negotiated on a contract-by-contract basis; in voluntary markets, buyers and sellers may tailor mechanism selection to specific transactions.

The possibilities for contracted durability mechanisms described in this paper are not exhaustive, and these approaches require further refinement and validation. In particular, contracted durability mechanisms rely on our ability to assess and price the risk of reversal, while also establishing institutional and governance structures capable of assuming this liability over long durations.

This section presents five case studies, each focused on a policy jurisdiction or standard-setting body. For each case study, we discuss what policymakers or standard setters are trying to achieve, the durability challenges that they face, and how contracted durability mechanisms can address these challenges.

### What policymakers are trying to achieve

California has established among the most ambitious CDR targets of any jurisdiction globally. AB 1279 (2022) commits the state to net-zero greenhouse gas emissions by 2045, and requires that this target is met by at least 85% emissions reductions. CARB’s 2022 Scoping Plan sets CDR targets of 7 Mt/yr by 2030 and 75 Mt/yr by 2045, and has concluded that natural and working lands will contribute only approximately 1.5 Mt/yr on average — meaning other forms of CDR must deliver the vast majority of scaling.

The state is building regulatory infrastructure to integrate CDR into compliance markets across multiple overlapping instruments, with SB 905, the Cap-and-Invest program, and proposed legislation all shaping durability requirements. Table 4 summarizes the key active policy processes and their relevance to durability. Notably, AB 1207 (2025) places compliance offsets “under the cap,” meaning that when a regulated entity surrenders a carbon credit, the state’s allowance budget is reduced by an equivalent amount the following year. Proposed amendments to the Cap-and-Invest regulation expand accepted sequestration beyond geologic storage to include methodologies meeting Board-approved permanence standards of at least 100 years (CARB, 2026).

**Table 4.** Key California policy instruments relevant to CDR durability.

Policy Instrument	Summary	Durability Relevance
<b>SB 905 (2022)</b>	Requires CARB to establish a comprehensive CCS/CDR program, including monitoring, permitting, tracking, and financial responsibility. Main implementation proceedings began March 2025.	Financial responsibility mechanisms for CDR projects are being defined in the 2026 rulemaking — an opportunity to recognize contracted durability.
<b>Cap-and-Invest (AB 1207 / SB 840, 2025)</b>	AB 1207 mandates CARB to consider developing CDR offset protocols and places offsets ‘under the cap,’ with offset usage limits rising to 6% of compliance obligations (2026–2045). SB 840 reserves \$85M from the Greenhouse Gas Reduction Fund for climate innovation, requires an offset study by December 2026 and protocol updates by January 2029.	Proposed amendments specify a permanence standard of at least 100 years, consistent with existing forestry and Carbon Capture and Sequestration (CCS) Protocol under LCFS (CARB, 2026). Forestry Protocol update over next 2–3 years; offset study provides input opportunity.
<b>AB 32 / Scoping Plan</b>	Foundational legislation requiring CARB to update the Scoping Plan every 5 years. Next update is expected end of 2027.	Opportunity to inform how CARB accounts for CDR contributions, including how durability assessments incorporate financial and legal mechanisms for managing reversal risk.

Policy Instrument	Summary	Durability Relevance
<b>Proposed Legislation (Not Enacted)</b>		
<b>SB 308 (Becker, 2023–2024)</b>	The Carbon Dioxide Removal Market Development Act proposed a technology-neutral, targets-based framework for CDR. The bill authorized nature-based CDR to meet durability requirements through contracted mechanisms or through coupling with longer-duration storage. Held in Assembly Appropriations.	Proposed horizontal stacking as a statutory mechanism (the ‘two-phase credit’), with financial responsibility requirements consistent with SB 905.
<b>SB 285 (Becker, 2025)</b>	SB 285 would have applied a like-for-like principle (requiring that offsets match the durability of the emissions they compensate for) for net-zero tracking and corporate reporting within California. Held in Senate Appropriations, May 2025, and not reintroduced in 2026.	Signals legislative interest in durability matching; held amid a range of stakeholder concerns, including cost, the treatment of nature-based solutions, and implementation readiness.
<b>SB 643 (Caballero, 2025)</b>	SB 643 would have established a \$50M state CDR purchase program requiring a minimum of 100 years of storage. The bill received near-unanimous bipartisan support but was vetoed by the Governor, citing overlap with GGFR allocation under SB 840.	Demonstrates bipartisan legislative support for state investment in CDR; the veto was procedural rather than substantive.

The Legislature has also considered more prescriptive approaches which have not been enacted. SB 390 (Limón, 2023), which included durability provisions referencing the atmospheric lifetime of CO<sub>2</sub>, was vetoed, and SB 1036 (Limón, 2024), which proposed a 1,000-year durability floor, was withdrawn. These outcomes demonstrate that California’s Legislature has a strong interest in high-quality and cost-effective standards that enforce durability but that more prescriptive approaches relying on rigid atmospheric-lifetime benchmarks or binary classifications have not been enacted — creating a clear opening for performance-based alternatives.

### The durability challenge

California faces a trilemma: policymakers simultaneously seek to ensure meaningful climate impacts, recognize nature-based solutions and their social and environmental benefits, and manage costs in order to incentivize near-term CDR development and deploy at the required scale. Under conventional durability frameworks, these objectives are in tension. Setting high durability thresholds tends to favor pathways with higher near-term costs, potentially excluding nature-based solutions that deliver essential social and environmental benefits, near-term climate impact, and deployment feasibility. Relaxing those thresholds to accommodate a broader range of storage pathways weakens the climate integrity of the credits produced for their intended use, and can undermine the investment case for longer-duration storage approaches that will be needed at scale. Further, the cost of achieving 75 Mt/yr of highly durable CDR by 2045 creates cost concerns across regulated entities and policymakers alike.

Two structural issues compound this challenge:

- First, a permanence standard of at least 100 years is emerging as a reference point across California’s regulatory instruments (CARB, 2026), but no unified framework specifies how projects demonstrate that they meet this threshold.
- Second, the liability chain for reversal risk is fragmented. California’s existing compliance offset system includes mechanisms for managing certain risks during the crediting and monitoring period, but no existing policy instrument specifies who is liable for reversal risk once a project agreement expires. Without clear answers to either question, project developers and investors face uncertainty that can slow deployment at the very moment California needs investment at unprecedented scale.

### **How contracted durability can help**

Contracted durability resolves the trilemma by decoupling durability requirements from the removal pathway. Under this approach, CARB could set a durability threshold as a performance standard. Credits determined to have a negligible risk of reversal over the full threshold would meet it directly; credits with non-negligible reversal risk would meet it through contracted durability mechanisms, standardized at the protocol level, that ensure accountability for the residual risk. A project with a crediting and monitoring period of 30–50 years can meet a longer durability standard if contracted mechanisms are in place to maintain accountability beyond that window — whether by replacing reversed carbon or stacking into longer-duration storage. A project with centuries-long estimated durability needs some, but likely less, contracted enhancement than a project with shorter estimated durability, and both can qualify under the same standard.

The cost of contracted enhancement would be proportional to a project’s reversal risk, meaning credits from pathways with higher reversal risk would carry higher costs, narrowing the price gap with longer-duration approaches. Contracted durability would not eliminate cost differentials between pathways, nor is that its purpose; rather, it would make the cost of durability transparent and project-specific rather than obscured by pathway-level assumptions. As noted in Table 4, the Legislature has already explored elements of this approach with SB 308 (2023–2024).

Contracted durability can be integrated into each of California’s active regulatory processes: the SB 905 rulemaking (as a recognized form of financial responsibility), Cap-and-Invest offset protocol development (as a framework for meeting the permanence standard), the GGRF offset study due December 2026 (as a constructive recommendation), and the Scoping Plan update expected end of 2027 (informing how CARB accounts for CDR contributions). In addition to horizontal stacking, mechanisms such as permanence trusts for post-monitoring liability and insurance for correlated-loss coverage can help ensure that liability is always assigned to an identifiable, resourced entity. By making durability guarantees transparent, enforceable, and backed by funded institutions, contracted durability offers a pragmatic path forward without demanding that the Legislature resolve the atmospheric-lifetime question through statute.

### What policymakers are trying to achieve

The European Union's climate framework relies on several complementary instruments. The EU Emissions Trading System (ETS) is the EU's flagship cap-and-trade mechanism, designed to reduce greenhouse gas emissions cost effectively by setting a declining ceiling on total emissions and creating financial incentives for companies to decarbonize over time. The Effort Sharing Regulation (ESR) sets binding national targets for sectors not covered by the ETS. Alongside these, the Carbon Removals and Carbon Farming Regulation (CRCF) establishes a certification framework for high-integrity carbon removals across the EU, covering three distinct categories: permanent (storage for several centuries), carbon farming (storage for 5 years), and carbon storage in products (storage for 35 years). For permanent removals involving geological storage, the Carbon Capture and Storage (CCS) Directive provides an additional regulatory layer with requirements for monitoring, addressing reversals, and transferring long-term storage liability to the member state once storage stability has been demonstrated.

While CRCF-certified units are not yet eligible as compliance instruments under the ETS, the two frameworks are designed to work together. In a forthcoming report (July 2026), the European Commission is expected to assess the potential inclusion of carbon removals with permanent storage in the ETS. Separately, in March 2026, the European Climate Law was amended to allow a limited contribution of high-quality international credits under Article 6 of the Paris Agreement toward the EU's 2040 climate target, up to 5% of 1990 net emissions (European Union, 2026). The quality requirements for these credits, including durability criteria, will be defined through legislative proposals expected in Q4 2026.

### The durability challenge

Current discussions around integrating removals into the EU ETS have focused on permanent carbon removals. The ETS is built on the principle that surrendering an allowance irreversibly settles an emissions obligation, and the CRCF's "permanent" removals, defined as those with negligible risk of reversal, are the category that current ETS integration discussions have prioritized. The Commission's July 2026 assessment is framed accordingly, with its mandate limited to how carbon removals with permanent storage can be accounted for and covered by emissions trading.

This framing reflects a genuine concern about environmental integrity, but it comes with tradeoffs. Scaling the supply and driving down the costs of removals with negligible risk of reversal will take time. Removals with a non-negligible risk of reversal are more affordable and deployable today, but carry higher reversal risk and currently lack the mechanisms needed to monitor and compensate for that risk over long time horizons. The result is a framework that creates a tradeoff between long-term climate certainty and near-term scale and affordability.

### How contracted durability can help

Contracted durability mechanisms close this gap by making durability an enforceable, ongoing obligation rather than a one-time project outcome. Where CRCF's regulatory monitoring periods end, contracted durability picks up: project developers or third-party entities can make contractual agreements to maintain carbon stocks, replace reversed tonnes, or provide financial backstops that keep these commitments credible over the long time horizons that ETS compliance demands. EU law already provides a foundation for this approach, with the CCS Directive establishing a liability-transfer mechanism for geological storage; contracted durability could extend this principle to a broader set of removal pathways by providing equivalent liability structures for projects with non-negligible reversal risk.

For the EU, this has a specific and consequential implication. If contracted durability mechanisms are recognized within the ETS integration framework, policymakers could allow a broader set of CDR pathways to qualify, provided their reversal risks are matched by enforceable durability requirements. For example, a high-performing carbon farming project could meet the CRCF’s definition of “permanent” by horizontally stacking the credit with a CDR credit of negligible risk of reversal. This logic extends beyond ETS integration. As the EU defines quality requirements for international credits eligible toward its 2040 target, contracted durability mechanisms could provide the durability assurance needed for these credits to meet those requirements across a wider range of removal pathways.

The July 2026 Commission assessment represents a critical window. How the EU chooses to define the durability requirements for ETS integration will shape not just which CDR pathways gain access to Europe’s carbon market, but which technologies receive the investment signals needed to scale. Contracted durability offers a path to a more inclusive and cost-effective framework — one that maintains the integrity the ETS demands without foreclosing the climate value that a broader set of CDR pathways can deliver.

## Case Study 4.3 Paris Agreement Crediting Mechanism

### What policymakers are trying to achieve

The Paris Agreement Crediting Mechanism (PACM), established under Article 6.4, is a United Nations Framework Convention on Climate Change (UNFCCC)-led, high-integrity international crediting mechanism that enables countries and authorized entities to cooperate in achieving their Nationally Determined Contributions (NDCs). By enabling emissions reductions and removals to be generated where they are most cost-effective and then transferred across borders, PACM aims to lower the global cost of climate mitigation while ensuring environmental integrity.

PACM builds on the experience of the Clean Development Mechanism (CDM) established under the Kyoto Protocol. While the CDM succeeded in mobilizing large volumes of mitigation finance, it also highlighted areas for improvement, particularly around additionality, the treatment of permanence, and long-term climate outcomes. In particular, the CDM’s temporary crediting mechanism (Temporary Certified Emission Reductions (tCERs) and Long-term Certified Emission Reductions (ICERs)) placed the replacement obligation on individual buyers and required compliance authorities to track individual credit expirations, creating an administrative burden that contributed to low uptake. Contracted durability mechanisms, particularly permanence trusts, are designed to avoid this by centralizing the replacement and monitoring function within a dedicated institution.

PACM reflects those lessons, placing a strong emphasis on environmental integrity and the contribution to global mitigation outcomes. Removals under the mechanism are required to be consistent with the IPCC definition of carbon dioxide removal, including “...anthropogenic activities removing CO<sub>2</sub> from the atmosphere and durably storing it...” (IPCC, 2022), reflecting the mechanism’s emphasis on both quantification and long-term climate benefit.

PACM is already advancing the contracted durability concept in its design through the adoption of standards that require the assessment and remediation of reversal risk and the consideration of a variety of contracted durability mechanisms.

## The durability challenge

A central design question for PACM has been how to maintain environmental integrity across CDR pathways that differ widely in storage durability and reversal risk, while cost-effectively mobilizing removals at scale. Early negotiations under Article 6 revealed significant disagreement among Parties about whether and how lower durability removals should be credited, and what obligations should apply in the event that stored carbon is later released.

In response, the Article 6.4 Supervisory Body, the UNFCCC-appointed governing body responsible for overseeing PACM's development, has taken a phased approach. A dedicated standard for CDR was adopted in 2024, establishing eligibility criteria, system boundaries, and accounting requirements. This was followed by the adoption of a non-permanence and reversals standard in 2025, which focuses specifically on how reversal risk is assessed, monitored, and remediated over time (UNFCCC, 2025). Together, these standards explicitly recognize the need to quantify and manage the risk of reversal.

Under these standards, project developers are required to conduct monitoring for, and remediation of, reversals during and after the crediting period. This requirement for ongoing monitoring is lifted only if, at the end of the post-crediting monitoring period, the stored GHGs are at negligible risk of reversal or if potential future reversals are otherwise remediated. Remediation potentially could occur through mechanisms such as retirement of credits from a buffer pool, insurance or other guarantee products, or a monetary reserve for purchasing other Article 6.4 credits with negligible reversal risk.

Many of these design elements remain under active development. The Methodological Expert Panel's 2026 workplan includes development of a standardized reversal risk assessment tool, further clarification of what constitutes "negligible risk of reversal" at the methodology level, and consideration of options and requirements for insurance products and monetary reserve mechanisms. Depending on the final configuration of these instruments, PACM may ultimately operationalize a form of horizontal stacking.

## How contracted durability fits within PACM

PACM is already among the most advanced international crediting frameworks in explicitly integrating contracted durability concepts into its regulatory design. The adoption of the non-permanence and reversals standard formalizes the recognition that not all removal pathways achieve permanent storage by default, and that reversal risk can be managed through contractual, financial, and institutional mechanisms rather than by excluding pathways outright.

The Methodological Expert Panel's ongoing work to operationalize reversal risk assessment tools, define negligible risk thresholds, and specify requirements for financial and insurance-based remedies further embeds contracted durability into PACM's architecture. Together, these elements indicate that PACM is not merely compatible with contracted durability approaches, but is actively developing the institutional infrastructure needed to scale them across diverse CDR pathways while maintaining climate integrity.

This has implications beyond PACM itself. As jurisdictions such as the EU develop quality criteria for international credits toward their climate targets, how PACM operationalizes reversal risk management — including its provisions for insurance, monetary reserves, and buffer pool mechanisms — will influence which CDR pathways can generate eligible credits at scale.

### What standard setters are trying to achieve

The Science Based Targets initiative (SBTi) establishes frameworks for how companies can set credible climate targets, including near-term, long-term, and net-zero emissions reduction targets. As of early 2026, SBTi has validated the targets of over 10,000 companies, with over 2,000 companies setting net-zero targets. SBTi's frameworks undergo periodic revisions to reflect advances in climate science, market development, and best practices in corporate decarbonization.

SBTi's Corporate Net-Zero Standard (CNZS) V2 has recently been released, including updates to its definitions and guidelines on CDR. While the original (V1) standard required the use of permanent removals to address residual emissions at the point of net-zero, the latest standard (V2) requires companies to start neutralizing a share of their ongoing emissions in 2035 and expands the eligibility of removals from "permanent" to both "long-lived" and "short-lived" (SBTi, 2026). The standard requires that companies use CDR for at least 1% of ongoing scope 1, scope 2, and scope 3 emissions in 2035, which rises linearly to 100% by the company's net-zero target year, and no later than 2050. A company must use long-lived removals to neutralize 10% of the 1% of emissions that are long-lived starting in 2035, with this percentage increasing to 100% by net-zero, though SBTi has indicated this will be reviewed in future revision cycles. Long-lived removals are defined as "carbon dioxide removal activities that are capable of retaining carbon for centuries to millennia" and short-lived removals are defined as "carbon dioxide removal activities that are capable of retaining carbon for decades to centuries" (SBTi, 2026).

### The durability challenge

SBTi's latest draft poses a key question for CDR: how can the standard uphold scientific integrity while ensuring companies can realistically source sufficient CDR to meet both near-term and long-term targets? SBTi's proposed distinction between short-lived and long-lived removals encourages companies to lean on more cost-effective CDR options today with a higher risk of reversal, while transitioning toward solutions with lower risk of reversal over time. This approach, however, raises many questions: should CDR with different estimated durability count equally towards progress on a net-zero target, especially when at the point of net-zero all residual fossil carbon emissions must be neutralized with long-lived removals? And without a strong demand signal for CDR with lower risk of reversal, how can we ensure that this supply will exist at the scales required in the future?

### How contracted durability can help

Contracted durability mechanisms offer a practical path forward — one that is grounded in climate science without locking companies into a rigid, prescriptive framework. If SBTi sets a science-based durability threshold for all of its CDR requirements and allows contracted durability mechanisms to satisfy that threshold, companies can use cost-effective CDR pathways today while still delivering credible, accountable climate outcomes.

The deeper advantage is structural. Contracted durability removes the need for SBTi to prescribe specific percentage splits between short-lived and long-lived removal categories — a distinction that depends on estimated durabilities that are inherently uncertain. Instead, SBTi can define what climate outcomes are required, and let the market determine the most efficient way to deliver them while still building capacity for CDR with negligible risk of reversal. Because contracted durability prices in the costs of ongoing liability and compensation for reversals, it creates strong incentives for quality without mandating a particular technology or pathway. In practice, this could mean not predefining "short-lived" and "long-lived," but rather, defining durability thresholds and then allowing contracted durability mechanisms to demonstrate performance against them.

SBTi has recognized this potential, signaling its intention to open a call for evidence on “whether shorter-lived carbon removals can deliver climate-equivalent permanence to long-lived removals and neutralize long-lived GHGs through contractual, financial, or stewardship mechanisms” (SBTi, 2026).

## Case Study

### 4.5 Integrity Council for the Voluntary Carbon Market

#### What standard setters are trying to achieve

The Integrity Council for the Voluntary Carbon Market (ICVCM) establishes quality benchmarks for the voluntary carbon market through its Core Carbon Principles (CCPs) and Assessment Framework. The CCP label signals to buyers that a credit meets rigorous integrity criteria, including for permanence. Under the current Assessment Framework, CCP Criterion 9 requires a minimum 40-year monitoring and compensation period for activities with material reversal risk. Buffer pool contributions must be set either at a minimum of 20% or proportional to the assessed reversal risk of each activity, and the majority of CCP-eligible programs use risk-proportional approaches (ICVCM, 2025). For activities with lower reversal risk, such as geological carbon storage, the framework requires a general risk assessment and implementation of appropriate mitigation measures. As the primary quality-standard setter for the voluntary carbon market — with CCP-eligible programs covering approximately 98% of the voluntary carbon market (VCM) — ICVCM directly shapes how registries, project developers, and buyers manage durability across the market (ICVCM, 2024).

#### The durability challenge

The ICVCM’s CIWP on Permanence (2025) identified several structural features of the CCP permanence requirements that merit attention as the market scales. Buffer pool contribution rates are often set using static risk percentages based on historical data, which may not account for non-stationary climate risk. Credits issued later in a project’s crediting period receive less monitoring coverage than those issued earlier, creating unequal durability assurance across credits from the same project. Definitions of avoidable versus unavoidable reversals vary across registries, producing inconsistent liability standards (ICVCM, 2025). Under the current framework, responsibility for maintaining durability does not extend beyond the 40-year monitoring period, and no market-level mechanism currently ensures storage beyond that period.

At the same time, registries are beginning to test alternatives: Verra’s three-year Durability Pilot, launched with VCS Program Version 5, allows project proponents to use insurance or fund-based approaches in place of the pooled buffer, with participating projects applying Verra’s Non-Permanence Risk Tools (AFOLU or Geological Carbon Storage) and receiving an “Innovation” label on issued VCUs (Verra, 2025a; Verra, 2025b; Verra, 2025c). However, VCUs with the Innovation label are not presently CCP-eligible, creating a gap between registry-level innovation and market-wide quality recognition.

Separately, Verra’s existing Non-Permanence Risk Tools (NPRTs) already contain structural incentives that align with contracted durability’s approach. Under the AFOLU NPRT, for example, a legally enforceable agreement or requirement — such as a conservation easement or protected area law — that protects credited carbon stocks for at least 100 years can reduce a project’s risk score across multiple sub-categories (e.g., project longevity and opportunity cost), potentially lowering the project’s overall buffer pool contribution (Verra, 2025a). However, the NPRT does not specify which parties must be bound by such agreements, nor does it address who bears responsibility for maintaining storage if the agreement is breached or the liable entity ceases to exist after the 40-year monitoring period ends.

Whether contracted durability mechanisms such as permanence trust obligations or insurance-backed guarantees could serve as qualifying agreements under the NPRT’s current definitions, while also filling this liability gap, warrants engagement with Verra and other registries as these tools evolve.

### **How contracted durability can help**

In February 2026, the ICVCM launched a second CIWP on Permanence, “Monitoring and Compensation,” that moves from diagnosis to implementation. The new work program is organized into three workstreams: strengthening pooled buffer reserves through a standardized stress test protocol, developing standardized reversal definitions and risk assessment guidance, and exploring novel compensation mechanisms — including, notably, the feasibility of a permanence trust, industry-wide pooled buffer reserves, and insurance products (ICVCM, 2026).

This third workstream maps directly onto contracted durability’s core mechanisms. Buffer pools provide first-loss protection during active monitoring; insurance provides compensation for covered reversal events in the form of replacement credits; and permanence trusts assume liability beyond the monitoring period through endowed capital that funds long-term monitoring and replacement. The ICVCM’s first CIWP also recommended an ‘Innovation Sandbox’ to pilot novel permanence approaches without losing CCP approval, offering a direct pathway for testing contracted durability mechanisms within the CCP architecture (ICVCM, 2025). The second CIWP’s active exploration of permanence trusts, insurance products, and industry-wide reserves signals that the voluntary carbon market’s primary quality-standard setter is moving toward recognizing performance-based durability mechanisms alongside buffer pools.

### **Beyond these case studies**

The five case studies examined in this section are not exhaustive. Durability questions are emerging across a growing range of policy contexts. In the United States, the Foreign Pollution Fee Act (Cassidy & Graham, 2025) would explicitly weight the durability of carbon storage in calculating import fees, giving greater credit to permanent removal solutions over temporary pathways. The United Kingdom’s July 2025 response on integrating greenhouse gas removals into the UK ETS established a 200-year minimum storage requirement, with liability measures, buffer pools, and plans for operational integration by 2029 (UK ETS Authority, 2025). Other jurisdictions are also beginning to address how carbon removals are defined and verified within their climate frameworks. Further work is needed to map contracted durability solutions onto this broader suite of policies and standards.

## SECTION 5

# What's Next for Contracted Durability?



This paper has presented contracted durability as a performance-based framework for managing reversal risk and examined how it could be integrated into existing policies and standards under active development. Moving from concept to implementation now requires parallel progress across three areas: 1. shaping the policies and standards being written today, 2. resolving research and design questions, and 3. piloting mechanisms in real-world settings. Exhibit 4 distills design guidance for each of these areas.

### 5.1 Policy and standard setting

Policies and standards under active development should reference contracted durability mechanisms, leaving the door open to contracted durability while acknowledging the need to prove out these mechanisms. Two cross-cutting priorities are particularly important.

- First, **defining what constitutes negligible risk of reversal**, including how this varies over different durability thresholds, would give contracted durability a clear performance target. The Article 6.4 non-permanence and reversals standard (UNFCCC, 2025) established the concept, though it has not yet been operationalized with specific criteria. The Methodological Expert Panel's 2026 workplan includes a reversal risk assessment tool expected for public comment later this year (UNFCCC, 2026). To avoid fragmentation and support a cohesive market, jurisdictions and standards should seek to align on how they define negligible risk of reversal, grounding the definition in scientific methods and evidence.
- Second, **adopting performance-based language** in policies and standards would allow contractual mechanisms attached to a credit to meet durability requirements, rather than designing policy based on the CDR pathway alone. This second priority depends on the first; performance-based language built on poorly defined or undefined reversal risk and durability thresholds opens the door for allowing or incentivizing lower-quality CDR.

Section 4 identified specific entry points for this work across five jurisdictions and frameworks. Embedding contracted durability into these processes will strengthen the foundation for the scaled deployment of carbon removal needed to meet mid-century climate targets. As evidence builds from the research and piloting described below, policies and standards should evolve to reflect it.

## 5.2 Research, development, and design

**The effectiveness of all contracted durability mechanisms depends on the ability to assess and price reversal risk.** Existing crediting protocols already incorporate project-level risk assessments, but developing actuarially-grounded pricing for contracted durability mechanisms is a distinct and largely unresolved task. This requires actuarial modeling of reversal probabilities across project types, geographies, and climate scenarios, combined with assumptions about investment returns and the future cost of replacement credits. The Carbon at Risk framework (Lee *et al.*, 2026) provides a foundation, but translating it into operational fee structures for buffer pools, insurance products, and permanence trust contributions will require both technical research and stakeholder engagement.

**Institutional design work is also needed, particularly for the permanence trust.** Key questions include governance structure, investment mandate, conditions for deploying capital to procure replacement credits, and transparency mechanisms. The American Forest Foundation and partners have launched a feasibility study and advisory group that is actively addressing these questions (AFF, 2025). Work is also needed on the legal and contractual structures, including trust deeds, insurance policy terms, and stacking agreements, that can bind parties over time and across jurisdictions, along with practical guidance for how market participants interact with these mechanisms within existing crediting frameworks.

## 5.3 Piloting

**Several mechanisms are ready for real-world testing, and some efforts are already underway.** The market-level permanence trust concept has stakeholders in early piloting phases, with several project-level instances already in full operation. Verra has established a pathway for testing novel compensation mechanisms and approaches to durability (Verra, 2025). Insurance products addressing reversal risk are being developed, though questions remain around product design, settlement terms, and how insurance interacts with other contracted durability mechanisms. Horizontal stacking has a foundation in policy: the Article 6.4 standards contemplate credit replacement as a means of releasing monitoring obligations (UNFCCC, 2025), and California’s SB 308, though not enacted, supported the concept as a “two-phase credit.” However, operationalizing horizontal stacking through structured contractual agreements remains untested and is a priority for piloting. Across these efforts, pilot design should ensure that risk-based pricing does not create unintended barriers for community-based projects in developing economies, where factors such as land tenure insecurity and climate vulnerability may drive higher costs. Policymakers and standards need to leave the door open to innovation, piloting, and testing instead of shutting the door on removal pathways when we need them most.

**Policy and standards engagement, research and development, and piloting should proceed in parallel.** Each of the mechanisms described in this paper draws on established practices in insurance, finance, and institutional design, but combining them into integrated approaches for carbon markets is new ground. The policy processes identified here offer near-term entry points for this work. Ensuring atmospheric integrity and avoiding the transfer of unmanaged reversal risk to future generations are objectives that warrant action now, even as the evidence base continues to develop.

See Exhibit 4 below for actionable recommendations for policymakers and standard setters.

#### **Exhibit 4.** Recommended Near-Term Actions

The following design guidance distills the paper's analysis into actionable criteria for policymakers, standard setters, and market actors. It applies across jurisdictions, standards, and policy contexts.

### **Define negligible risk of reversal**

**01**

*Ground definitions in science and empirical data across project types, not pathway-level assumptions.*

- › **Consider durability in tandem.** Negligible risk of reversal should be operationalized in context of desired durability; longer thresholds demand lower acceptable reversal probabilities to reflect cumulative exposure over time.
- › **Be quantitative — and choose the metric carefully.** Annual probabilities can appear deceptively low when compounded; cumulative probabilities can overstate risk. The metric should support accurate pricing of contracted durability mechanisms.
- › **Differentiate by project, not pathway.** Use site characteristics, management practices, climate exposure, and monitoring infrastructure rather than broad pathway categories.
- › **Develop risk frameworks in parallel with mechanisms.** Risk assessment is a prerequisite input, not a function of the mechanisms themselves.

### **Adopt performance-based policy language**

**02**

*Set the bar by what a credit must achieve based on the goal of the policy, not by which pathways may achieve it.*

- › **Require both core functions.** Any mechanism or combination of mechanisms must deliver ongoing liability for monitoring and compensation for reversals across the full durability threshold.
- › **Be outcome-based and mechanism-neutral.** Define the outcomes that must be achieved rather than prescribing specific mechanisms, preserving space for innovation.
- › **Complement — don't replace — policy support for nascent pathways.** Consider how eligibility criteria affect investment signals across different CDR pathways.
- › **Specify verification.** Include provisions for how compliance is verified, by whom, and at what intervals across the durability threshold.
- › **Allow phased adoption.** Where crediting frameworks already exist, design contracted durability as a complementary or alternative pathway, enabling phased adoption as mechanisms are proven.

### **Assess and price reversal risk**

**03**

*Strengthen and standardize reversal risk assessment frameworks, while ensuring that credit pricing and fee structures are sufficient to fund remediation of reversals.*

- › **Use project-specific probabilities.** Inform fee structures with project-level reversal probabilities rather than broadly generalized risk categories.
- › **Account for all cost drivers.** Factor in investment growth on contributions over time, projected replacement credit costs, and correlation risk within credit portfolios.
- › **Disclose pricing assumptions publicly.** Reversal probability estimates, discount rates, and projected replacement costs — so stakeholders can evaluate whether price signals reflect actual risk differences.
- › **Recalibrate regularly.** Build in periodic review to maintain financial adequacy over multi-decadal time horizons.

### **Pilot integrated mechanisms**

**04**

*Test how mechanisms interact in combination, not just how each performs alone.*

- › **Test the full chain.** Liability assignment, monitoring, reversal detection, compensation trigger, and credit replacement — together, end to end.
- › **Vet the long-term liability holder.** Verify governance, funding, and institutional persistence across the durability threshold, with contingency provisions if the entity cannot fulfill obligations. Draw on models such as endowments, sovereign wealth funds, or decommissioning trusts.
- › **Stress-test trust and stacking design.** Test whether and how the liable entity can release liabilities over time — e.g., transitioning credits to negligible-risk storage — rather than accumulating open-ended obligations.
- › **Publish the evidence.** Require public evidence on mechanism performance, cost, and scalability to build the evidence base for broader adoption.

# Glossary

**Buffer Pool:** A mechanism to manage reversal risk by requiring a portion of the CDR credits from a project to be withheld from sale and used to replace credits in the event a reversal occurs, over a specified time period.

**Buyer:** An individual or organization that purchases carbon dioxide removal credits.

**Carbon Dioxide Removal (CDR):** Anthropogenic activities that remove carbon dioxide from the atmosphere and durably store it in geologic, terrestrial, or ocean reservoirs, or in products. CDR can be further categorized: synthetic CDR includes approaches that use engineered systems powered by low carbon energy, geochemical CDR includes approaches that use naturally occurring neutralization reactions between acidic forms of carbon and alkaline minerals, and biogenic CDR includes any approach that uses naturally occurring, biogenic carbon fixation to capture CO<sub>2</sub> from the atmosphere.

**Carbon Dioxide Removal Credit:** A tradeable instrument that is issued by a carbon-crediting program, representing one metric tonne of carbon dioxide removal from the atmosphere.

**Carbon Dioxide Removal Pathway:** A method of removing and storing carbon dioxide from the atmosphere.

**Carbon Dioxide Removal Project:** Activities undertaken to remove carbon dioxide from the atmosphere. Projects removing and storing carbon dioxide generate CDR credits.

**Contracted Durability Mechanisms:** A set of legal and financial mechanisms to ensure carbon removal over a specified time period, including assigning liability and remedies for reversals in order to maintain the climate impact of the removal. Contracted durability mechanisms apply at the CDR credit level.

**Crediting Period:** The time period over which a CDR project generates credits, as defined by the issuing carbon credit registry.

**Durability:** The length of time that a tonne of carbon dioxide represented by a carbon credit remains out of the atmosphere. Durability may refer to the credit, project, and/or pathway level, depending on the type of durability. Durability can be further categorized as follows:

- **Estimated Durability:** An estimated length of time that a tonne of carbon dioxide represented by a carbon credit is likely to remain out of the atmosphere, given risks of reversal. Estimated durability is often applied at the pathway level, but may also apply at the project or credit level.
- **Realized Durability:** The length of time that a tonne of carbon dioxide represented by a carbon credit is proven to remain out of the atmosphere, which can only be known in the case of a reversal. Realized durability applies at the credit level, and may apply at the project level in the case that an entire project experiences a reversal.
- **Contracted Durability:** The length of time a tonne of carbon dioxide represented by a carbon credit is contractually guaranteed to remain out of the atmosphere. Contracted durability applies at the credit level, and may apply at the project level in the case that all credits issued by a project employ contracted durability. This is also referred to as guaranteed durability.

**Durability Threshold:** The time period over which carbon must remain stored out of the atmosphere as defined by the policy, standard, use case, or claim being made.

**Ex Ante:** Based on predicted or expected results; forecast, anticipated.

**Ex Post:** Based on or determined by actual results, rather than expectations; calculated retrospectively.

**Horizontal Stacking:** A mechanism to manage reversal risk and actual reversals, in which a new CDR credit replaces an original credit. Replacement could occur at the end of a post-crediting monitoring period or after a reversal.

**Insurance:** A legal mechanism whereby an entity (insurance provider) provides compensation in the event of a covered loss. In this context, covered losses could include reversals, and compensation could be monetary, CDR credits, or other.

**Nature-Based Carbon Dioxide Removal:** CDR that relies on naturally occurring biogenic carbon fixation to capture and store CO<sub>2</sub> from the atmosphere, through the protection, restoration, and improved management of ecosystems.

**Permanence:** A term often used in policy contexts to refer to the intended length of time that carbon remains out of the atmosphere. Typically leads to binary classification as “permanent” or “non-permanent”. Related to but differs from durability (defined above), which aims to reflect the physical reality that durability varies along a spectrum.

**Permanence Trust:** A risk-transfer mechanism in which CDR credit purchases include a fee, based on the credit’s risk of reversal, that gets deposited into a financial trust to be managed by an independent market entity. The trust takes on liability for monitoring, reversal prevention, and ensuring removal.

**Post-Crediting Monitoring Period:** The time period after the crediting period of a CDR project over which the developer remains responsible for tracking stored carbon and remediating reversals.

**Project Developer:** An individual or organization that may design, develop, and/or implement CDR pathways to produce CDR credits.

**Reversal:** A net loss in the storage of carbon dioxide equivalent calculated across all applicable greenhouse gas reservoir(s) over a period of time in a defined area.

**Risk of Reversal (also Reversal Risk):** The likelihood that stored carbon is re-released into the atmosphere. Risk of reversal is typically defined as a percentage over a defined period of time and can apply at both the pathway and the project level.

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