CNCE Report

Working Paper Series

Nov. 2022
Issue #2

Addressing open questions in the development of standards for the certification of carbon removal

Critical insights from an international consultation process

Center for Negative Carbon Emissions

Arizona State University

Global Carbon Removal Partnership, Thunderbird School of Global Management, Global Futures Laboratory, & Conservation International

Addressing Open Questions in the Development of Standards for the Certification of Carbon Removal

Critical Insights from an International Consultation Process

November 2022

GLOBAL CARBON REMOVAL PARTNERSHIP

THUNDERBIRD SCHOOL OF GLOBAL MANAGEMENT
A unit of the Arizona State University Enterprise

ASU Julie Ann Wrigley Global Futures Laboratory
Arizona State University

CONSERVATION INTERNATIONAL

Authors: Stephanie Arcusa[1] and Starry Sprenkle-Hyppolite[2], Aditya Agrawal[3]

[1] Center for Negative Carbon Emissions, Arizona State University, Tempe, Arizona, USA

[2] Center for Natural Climate Solutions, Conservation International, Arlington, Virginia, USA

[3] Thunderbird School of Global Management, Arizona State University, Phoenix, Arizona, USA

Global Carbon Removal Partnership

The Global Carbon Removal Partnership (GCRP), hosted at Thunderbird School of Global Management, is a multi-stakeholder global partnership led by the Global South focused on creating the enabling mechanisms to scale responsible natural and technological carbon removal solutions. We do this through engagement, policy, and agenda setting, creating incentives, and connecting supply and demand. For more information visit carbonremovalpartnership.net

Thunderbird School of Global Management

The vision of Thunderbird School at Arizona State University is a world of sustainable and inclusive prosperity and peace. Thunderbird's mission is to educate, empower and influence global leaders and managers, entrepreneurs and intrapraneurs, across the private, public and nonprofit sectors worldwide for the 4th Industrial Revolution and Anthropocene.

Global Futures Laboratory

The Julie Ann Wrigley Global Futures Laboratory at Arizona State University represents the urgent belief that we can and must make a meaningful contribution to ensuring a habitable planet and a future in which well-being is attainable. The Global Futures Laboratory is the world's first laboratory dedicated to the health of the planet and its inhabitants. For more information visit globalfutures.asu.edu.

Conservation International

Conservation International works to spotlight and secure the critical benefits that nature provides to humanity. Since our inception, we've helped to protect more than 6 million square kilometers (2.3 million square miles) of land and sea across more than 70 countries. Building upon a strong foundation of science, partnership and field demonstration, CI empowers societies to responsibly and sustainably care for nature, our global biodiversity, for the well-being of humanity. For more information visit https://www.conservation.org

Preface by Dr. Sanjeev Khagram, Director-General of the Thunderbird School of Global Management, Founder of the Global Carbon Removal Partnership

The Thunderbird School of Global Management launched the multi-stakeholder Global Carbon Removal Taskforce in January, 2020 with a white paper on the potential financial and economic benefits of innovating and scaling carbon removal.

After nearly two years of action-learning with the Taskforce, the multi-stakeholder Global Carbon Removal Partnership (GCRP) was launched at COP27 at Glasgow. The GCRP is committed to agenda setting at the global, regional, national and local levels; the development of norms, standards, policies, and laws; and increasing both the demand for and supply of innovations and solutions to scale carbon removal worldwide. This white paper on carbon removal standards is another major contribution of the GCRP. Deep gratitude to the authors – Stephanie, Starry and Aditya – for their incredible effort in assembling, and all the consultation participants and staff from around the world that supported the development of this white paper.

(*https://www.carbonremovalpartnership.net/sites/thunderbird-micro/ iles/thunderbird-micro/resources/new-investments-and-research-indicate-multi-trillion-dollar-market-for-climate.pdf*).

Acknowledgments

The coordinating team of the Global Carbon Removal Partnership thanks all consultation participants, faculty and staff from Arizona State University (ASU) and Conservation International for supporting this project. This work was

funded through Dr. Arcusa's postdoctoral work that ASU supports to advance the certification of carbon removal.

Executive Summary

Carbon Dioxide Removal (CDR) is essential to meet the Paris Agreement's commitment to stay below a 1.5 degrees Celsius average temperature increase. To provide critical foundational support to the development, deployment, and scaling of CDR, certification of carbon removal is needed. The international community is developing rules for the functioning of carbon markets. To support that process, we explored open questions on four key themes in the development of standards and certification of carbon removal through an international multi-stakeholder consultation process hosted by the Global Carbon Removal Partnership, Arizona State University, and Conservation International. Categories of stakeholders included standard developing organizations, non-governmental organizations, governments, and academics. Discussions covered 1. the treatment of emission reduction, avoidance, and removal in certification, 2. the role of additionality in carbon removal, 3. the choice of certification instrument for carbon removal, and 4. the treatment of durability in certification. They revealed fundamental differences in viewpoints on how certification should work. We highlight areas of further exploration, concluding that providing transparency on assumptions made at the certification level will be crucial to progress and, eventually, the acceptance and success of carbon removal as a climate solution.

Introduction

Carbon Dioxide Removal (CDR) is a set of activities consisting of capturing carbon from the atmosphere using various photosynthetic and chemical processes and storing it durably in biotic, oceanic, and geologic reservoirs or products[1]. CDR supports goals of reaching net-negative CO_2 emissions to return CO_2 atmospheric concentrations to pre-industrial levels. With every year, CDR's needed scale increases due to insufficient action tackling climate change. In fact, without CDR, the Paris Agreement's commitment to stay below 1.5 degrees Celsius average temperature increase is already out of reach[2,3].

A CDR industry is emerging to respond to this urgency. And, like every other industry, a whole ecosystem of standards and certification programs has also evolved to provide the supporting infrastructure[4]. Standards and third-party certification, in tandem with the actions of project developers and the rigor of verification processes, will be the foundations of trust in the CDR industry. While specific buyers may directly engage with project developers, those making claims from the removed carbon may not, and neither will most citizens. Although reasons will diverge, entities finding themselves, directly and indirectly, connected to CDR will care about standards and certification. One of the ways that CDR will be judged as a solution to climate change will be through standards and certification.

This ecosystem had innovated and tested the development of standards for emission reduction and avoidance decades before the term "CDR" was coined. Much of this legacy is being passed on to standards for carbon removal. However, without an overarching framework for its developmental progression, the ecosystem is now at a stage of vast differences. Studies delving into existing standards have found divergence in many core facets, specifically the measurement methods, treatment of durability, testing for additionality, and implementation of safeguards[5-10]. The fragmentation of standards raises questions around the quality of certified removed carbon, creating issues related to fungibility and eligibility to meet future voluntary and compliance requirements.

If removed carbon is to become fungible, tradable, and purchased to neutralize emissions for climate mitigation, one certification program must produce something comparable to another. For an equivalent result, the ecosystem must find a form of coherence, top-down or bottom-up. We posit that differences in the standards exist because their underlying assumptions diverge. Yet, since these are rarely made explicit, the ecosystem may not find that coherence in a bottom-up approach. If this is true, discovering how to create comparable certification begins by uncovering the assumptions. Assumptions surrounding the core facets can be explored as open questions in the development of standards for carbon removal, and bringing them to light will help advance the CDR industry. First, such an exercise maps the gaps, the divergence, and the common ground which could be used to innovate a common framework. Second, it brings transparency to the decision-making in the development of standards.

To further the existing bottom-up and top-down efforts working to advance toward coherent standards and certification for carbon removal, in this white paper, we articulate viewpoints on four major open questions in the development of standards for the certification of carbon removal. A consultation process with international standard developing organizations, governments, civil society organizations, private sector, and other stakeholders gathered the views. The reporting of the insights from the consultations should by no means be read as definitive but rather as part of a broader process that supports the CDR industry in developing more transparent, equitable, and responsible standards.

Approach

From literature reviews and interviews with experts, a collaborative team from the Center for Negative Carbon Emissions (CNCE) at Arizona State University, Conservation International (CI), and the Global Carbon Removal Partnership (GCRP) (hereafter 'the coordinating team'), identified topics of open questions in the development of standards. These were (1) whether emission avoidance, reduction, and removal should be certified under the same certification instrument, (2) what role additionality may play in the certification of carbon sequestration, (3) what certification instrument choice and its tracking may be appropriate for carbon sequestration, and (4) what may be the appropriate definition and treatment of durability, its risks, and governance. During the pre-consultation, participants reviewed the proposed topics and suggested a fifth topic on the connection between carbon accounting and co-benefits. Due to low participation, we did not develop this fifth topic further.

We developed four consultations to address these topics, plus a pre- and post-consultation (**Figure 1**). We invited standard developing organizations from across the world to the process. In addition, we extended the invitation to all members of the GCRP, which included non-governmental organizations and governments of the Global South. Before and during the meetings, the coordinating team provided a problem statement and background information to bring all participants to the same baseline. A Mural board was open to gather thoughts in writing before and during the discussions. Each consultation had time reserved for targeted discussions. The aim was to identify all possible viewpoints on the open questions. We prepared a detailed summary for each consultation which aimed to record all views and areas of alignment or misalignment when possible. The post-consultation sought to refine and correct those observations of alignment or misalignment.

In this white paper, we are distilling the detailed summaries to provide as nuanced a discussion as possible for each open questions. Then we analyze the insights, question assumptions, and identify where additional exploration could be worthwhile. We conclude with overall recommendations to catalyze the development of the standards and certification community towards coherence. We do not attribute any viewpoints to specific organizations; instead, the document should be read as a collective narrative. The coordinating team wrote this white paper with the participants providing feedback and revisions to capture the nuances in the viewpoints as best as possible. All participants may not agree with the final version of the text.

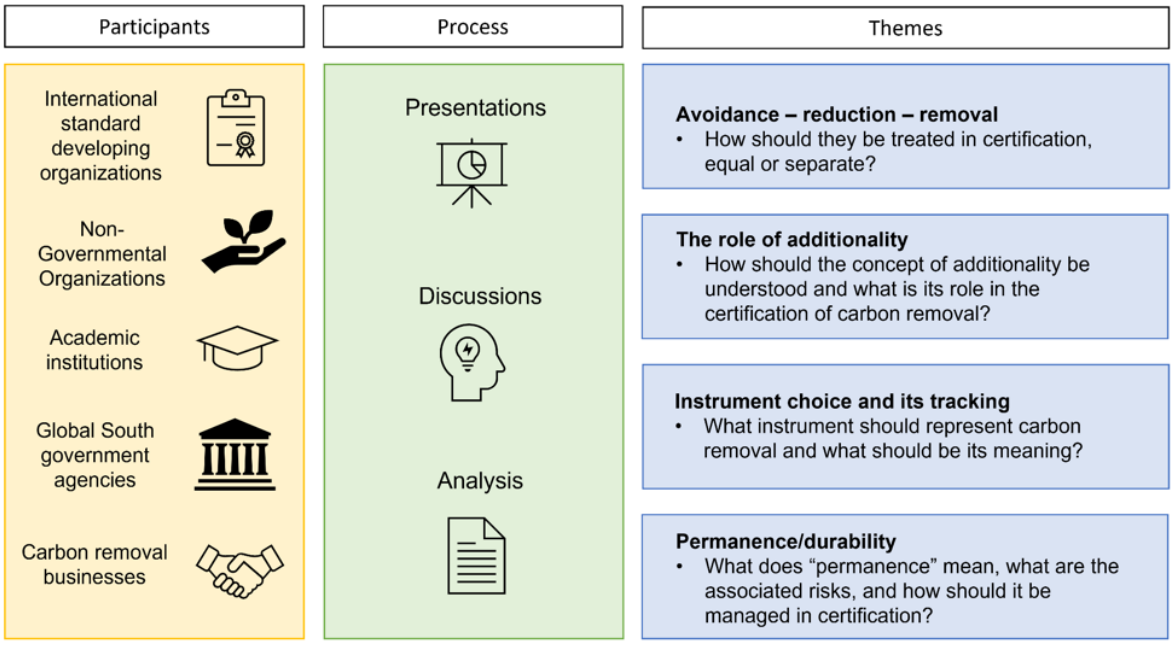

Figure 1. Summary of the consultation participants, process, and themes.

Themes: insights and discussion

Avoidance-Reduction-Removal

Insights

Efforts to mitigate climate change must seek to eliminate CO_2 emissions to stay within a total finite carbon allowance (i.e., a carbon budget)[3]. Staying within a carbon budget can be done by preventing the release of new emissions (i.e., avoidance and reduction) and removing emissions (i.e., removal) through CDR. In terms of climate impact, emission avoidance and reduction are essentially interchangeable; if emission avoidance can be understood as preventing new emissions, emission reduction only prevents some new emissions. Today, standards certify emission avoidance, reduction, and removal. Some standards treat them equally; some do not. Hence, our question is: how should emission avoidance, reduction, and removal be treated in certification programs?

We found that viewpoints aligned on several themes. Emission avoidance, reduction, and removal were all agreed to be needed for climate action, even if their relative importance will change over time. Moreover, consistent tracking of each was thought to be essential to understand the whole situation of using carbon instruments in mitigation efforts in the present and projecting them into the future. Participants agreed that different methodologies are required to quantify each.

Despite those agreements, two schools of thought became clear. One school argued that emission avoidance, reduction, and removal should be treated differently in standards. The arguments included concerns regarding market integrity and the recognition of the different methods required by each. Emission avoidance, reduction, and removal were described as conceptually and functionally distinct because of their different impact on the climate over time[11] and because of the time component of storage maintenance. Carbon removal was described as a service requiring a different set of actors than projects that reduce or avoid emissions. Furthermore, climate policies should aim to operate within a global carbon allowance. In that world, one would not pay someone else for not emitting or reducing their carbon emissions because everyone would be obligated to avoid emitting carbon. All emitters would have to pay for their carbon emissions to be removed[12,13,14].

The second school of thought argued that emission avoidance, reduction, and removal should be treated as interchangeable in certification, based on the idea of creating a commodity or a common currency. This school of thought suggested that labeling credits based on their type of mitigation (in addition to transparency about origin and other metadata) or using conversion factors could help emission avoidance, reduction, and removal to be treated as interchangeable. However, disagreements on labels and conversion factors return to the first school of thought's argument that emissions avoided, reduced, and removed are quantities with incompatible units. Under this school of thought, it was argued that fungibility (i.e., interchangeability) between emissions avoided, reduced, or removed would ensure efficiency in market functioning. We note that this contradicts the other school of thought, which, instead, argued that separating removed carbon from emissions reduced or avoided is what is necessary to ensure market integrity and commoditization.

Discussion

One underlying reason for the two schools of thought on whether to treat emission avoidance, reduction, and removal as interchangeable or not in certification appears to be different views on fundamental questions: what is the role of the market? Who pays for what? And what does a finite carbon budget mean for carbon management?

International climate agreements created carbon markets to fulfill the public purpose of reducing greenhouse gases in the atmosphere at the lowest possible cost[15]. Carbon removal has been included in this market since the Kyoto Protocol's operationalization of the UNFCCC to credit emission removal by sinks[16,17]. However, from the beginning, emission removal crediting in the Clean Development Mechanism (CDM) was limited to the forestry sector to afforestation and reforestation projects[18,19]. Only recently have other forms of removal activities been considered in carbon markets.

Despite the broadening of the types of carbon removal activities over time, and if the purpose of the market has not changed, then carbon markets are still intended to provide the public purpose of meeting internationally agreed

climate goals. This intent means that carbon markets ought to work to gain and keep the public's trust, regulators, investors, and NGOs as credible tools for climate action[15]. This goal takes on two objectives.

The first objective is for the markets to attract and sustain a level of liquidity. This involves resolving the questions of who pays and for what[20] while allowing for a transition that may involve more advanced purchases. It also involves recognizing that carbon removal can tackle historical emissions, which emission avoidance and reduction cannot. Tackling historical emissions has a value that is not accounted for if emissions avoided or reduced are treated the same as removed carbon, which could hinder the scaling of carbon removal capacity.

The second objective raises the question of what it means for carbon management to operate within a carbon budget. As previously mentioned, the frames climate change as an emission stock problem[3]. The amount of carbon in the atmosphere rather than the emission rate in a particular year causes climate change. This understanding requires the world to set a limit on cumulative emissions to stop the increase in global temperature: the world must stay within a total carbon budget[3]. The options are either not to produce emissions (i.e., not draw out money) or to neutralize produced emissions (i.e., repay debts).

On the one hand, a limited carbon budget provides clear guidance on long-term government policies designed to combat climate change, helping to create a state of certainty that incentivizes business investment in emission-reducing technologies and CDR. Conversely, some tension surrounding how to treat emission avoidance-reduction-removal touches on carbon budgets. The idea of crediting emission reductions for offsetting purposes will continue to consume the budget. Sustaining liquidity and operating within a carbon budget require clarity on whether emission avoidance, reduction, and removal can effectively be treated interchangeably or not in certification.

The role of additionality

Insights

The concept of *additionality* has been the cornerstone of defining quality credits since the international climate agreements introduced carbon markets for climate action. The rationale for additionality is to ensure that policy interventions are causing activity to take place and thus reward only activities that would not otherwise occur[21], whether these activities would have happened due to regulatory requirements, natural processes, or common practice.

Looking at programs that develop standards serving voluntary and mandatory markets internationally, just over half require an additionality assessment. Those that do require an assessment include some of the world's prominent organizations by the number of standards of carbon removal produced and credits sold, meaning that proportionally most credits available have undergone an additionality assessment.

Despite the concept's use in most carbon removal standards, it is defined and applied in at least a dozen ways, including regulatory, investment, and performance. Why some standards and not others would use assessments for the same type of carbon removal remains unclear. Furthermore, in a world where all engineered carbon removal is new and many carbon removal activities are impossible without incentive, how should the concept of additionality be understood for technological carbon removal and CDR more generally? Finally, we considered the question, if certification is to treat avoidance, reduction, and removal as interchangeable, then what will be the consequences for the concept of additionality?

Experts agreed on the understanding of additionality as a general concept. Yet, viewpoints diverged on whether the concept can test for a net climate benefit and whether the idea is necessary for all carbon removal. Several arguments were provided in favor and opposed. On the one hand, much effort has already been expended to instill the concept of additionality as the cornerstone for solely rewarding anthropogenic removal within nature-based solutions. It was suggested that an equivalent to the concept of additionality for nature-based solutions exists for engineered ones through Life Cycle Assessments (LCA). On the other hand, the focus on additionality is creating a schism between technology-and nature-based carbon removal approaches, alienating communities that culturally steward nature, complicating the development of robust certification, and hindering the development of a profitable carbon removal industry. Despite disagreement in this consultation, the general trust in carbon removal and offsets more generally, is still housed within the concept of additionality. Given the lack of a coherent application, it is thus primordial to find a solution.

Discussion

The ambiguity around the concept of additionality result from regulatory policies colliding with the provision of emission reduction and avoidance credits. As carbon removal expands in terms of types of technology, certification attempts to straddle the many worlds: to retain credits of emission reduction and avoidance and cover carbon removal.

Initially, the concept of additionality can be traced back to shortly after the 1992 Rio Earth Summit when the pilot program Activities Implemented Jointly (AIJ) was being developed[22]. Then and every new accord used the term additionality in the context of international climate finance[22,23]. In that context, developing nations desired new and additional resources to support country adaptation and mitigation efforts, i.e., additional funds that were not already promised. By the time of the Kyoto Protocol, additionality also became synonymous with the supplementarity of an emission reduction effort in activities outside the emission cap assumed on developed countries[22]. In both instances, proving additionality required a measurement against a counterfactual (i.e., a claim contrary to the facts) as a test of causality between international support for an activity and the extent to which the activity would have happened in the absence of international support[22].

Since then, the concept of additionality has been taken out of context and has gathered different meanings related to program and environmental integrity. When looking at only emission avoidance or reduction standards, at least 17 different meanings have been identified[21]. Each standard uses the term additionality differently, partly because the method to prove additionality depends on the context and the mitigation action in question.

While the overarching definition is clear, the many ways of measuring it are not. This subjectivity, or imprecision in meaning, leads to confusion, exposure to criticism, and claims of flaws[21]. There would be value in elaborating precise and theoretically well-grounded definitions of the different types of additionality, clear indications of their proper use, and transparent reporting on the type of additionality being considered when one speaks of "additionality." This is a necessary precursor to their application in real-world programs in a way that allows programs to operate with greater credibility and effectiveness. At the same time, it is problematic to continue with the concept of additionality for carbon removal as a cornerstone for quality (e.g., the mantra that quality credits must be additional along with verifiable and real), or as an instrument to assess the impact of the incentive (e.g., not rewarding mandated and existing activity), for several reasons.

The first issue relates to the methodology. Assessing for additionality relies on the analysis of hypothetical scenarios. For example, when additionality is understood to mean "the removals would not have occurred in the absence of the incentive created by carbon credit revenues," i.e., financial additionality, the concept of additionality relies on an analysis of returns on investments (ROI) in hypothetical scenarios with and without carbon finance. Crediting the amount of carbon reduced or removed may also rely on a counterfactual for its baseline. The counterfactual baseline models a hypothetical situation where the emission reduction or removal activity does not happen. The carbon accounting then relies on the difference between the counterfactual baseline scenario and either some form of a Life Cycle Analysis of the emission reduction or removal activity that takes place in the case of technological activities or measurements of carbon in ecosystem pools in the case of nature-based activities. The impossibility of demonstrating that the alternate reality would have happened as modeled in the counterfactual scenario makes accurate carbon accounting and verification very challenging.

The second issue relates to the distinction between technology- and nature-based removal. While technology-based removals would not occur without human intervention, ecosystems remove large amounts of carbon in plants, oceans, and soil. They do this naturally as an ecosystem service that regulates the climate without crediting or carbon markets. More importantly, natural sinks remove carbon at a volume far exceeding the current carbon removals market's scope. Their natural action is not a part of the climate mitigation targets, which are presumed to be additional. That is why great pains are being taken to ensure the additionality of natural climate solutions (NCS) in terms of their impact on naturally occurring processes.

If credits are issued for natural processes without proof of additionality, the potential supply would be much larger than the current demand. Therefore, how the new "natural" supply would enter the market would have to be managed carefully, and baselines and targets would also have to shift, to reflect this change in accounting. One perspective discussed considers the biosphere as a "carbon grid," analogous to an energy grid. What matters is the capacity of

the grid to sustain a volume of carbon. In that context, additionality would answer the question, "does this activity increase the capacity of the carbon grid?". An accounting framework that includes stocks in reservoirs may resolve the accounting challenge better without the counterfactual baseline, for example, by taking responsibility for losses to stocks.

Whereas the estimation of avoided and reduced emissions must rely on counterfactual scenarios due to their nature, one can directly measure the accounting of removed carbon. The observation that removals do not need to rely on counterfactuals for accounting has implications for certification. Insofar as this consultation process was solely concerned about standards for carbon removal, one viewpoint is that the simplicity of not relying on counterfactual scenarios is a strength of carbon removal that must be taken advantage of in certification, suggesting leaving complex additionality out of certification systems. What may not be possible without a counterfactual is partitioning what is natural and what is anthropogenic (artificial) within some categories of NCS (especially forestry, soil) and many types of oceanic CDR. This would go against the above arguments that standards should not credit natural processes.

An opposing viewpoint is that robust criteria for proving additionality in the quantification of removed carbon ought to be included for the above reasons (i.e., maintaining the integrity of NCS), despite the technical challenges and complexity involved. The challenge with that viewpoint is whether certification can avoid double standards if only NCS are subject to proof of additionality. The answer might be to minimize the use of counterfactuals for carbon accounting by only allowing removal activities where the additionality to natural processes can be demonstrated to be plausible simply and convincingly. The challenge will then be to define where to draw the line between a simple and complicated case of additionality. Of course, stricter inclusion rules would also mean that the LCA of technological removal activities would also need to demonstrate the plausible use of counterfactuals.

The community should question the transfer of the methods developed for avoided or reduced emissions to standards for removed carbon to avoid unnecessary propagation of the lack of clarity surrounding the concept of additionality in CDR. This challenge brings us back to the previous open question of whether emission avoidance, reduction, and removals should be treated interchangeably under the same certification program. The way additionality has been quantified in the past (for reductions and avoidance) does not necessarily mean it is fit for the purpose of carbon removal accounting.

Instrument choice and its tracking

Insights

Today many different certification instruments, including offsets, credits, certificates, units, and permits, represent removed carbon. Each certification program has its instrument and its understanding of what it means. What instrument should represent removed carbon, and what should be its meaning?

We found only three points of alignment: 1) Generally, broadscale confusion exists surrounding the definition of different instruments, and the abstraction of terms from the policy contexts was put forth as a reason. 2) Instruments should not expire because expiration limits liquidity, adds confusion, reduces confidence, and undermines the reason for creating credits. 3) Benefits exist from having a transparent system to track the instruments internationally, including supporting the Paris Agreement Article 6 and coordinating of voluntary efforts amidst nationally determined contributions.

Participants were split into two schools of thought, highlighting several points for further discussion. The first school saw removed carbon as best represented by carbon offsets to allow greater access to existing markets. That distinction is nuanced by the recognition that a carbon offset has a specific meaning because it also describes the usage and thus is not an instrument per se. For example, carbon credits can be used or not for offsetting purposes. The second school of thought saw removed carbon as best represented by some other instrument to reflect the uniqueness of carbon removal and to temper perceptions of greenwashing associated with offsets. A further reason included the possibility to reflect the durability metric that is not currently included in pricing carbon instruments, supporting the position that removed carbon ought to be differentiated from emission reduced and avoided. Interestingly, those that expressed the first view tended to certify or sell emission avoidance, reduction, and removal; those that expressed the second tended only to certify or sell carbon removal.

Discussion

One underlying reason for the many types of instruments for carbon removal appears to be that the community has not yet decided on what carbon removal means nor whether removed carbon is a public good, an asset, a currency, a commodity, a service, or a mixture of these. These decisions will influence what instrument it should be represented by and how the international community should track those instruments.

Although the IPCC clearly defined what carbon removal means, in practice the distinction can be unclear. Activities such as improved forest management and injection of CO_2 in carbonated materials are sometimes included under the category of carbon removal. However, like point source capture, they avoid emissions by storing emissions. This ambiguity reinforces the need to answer whether emissions avoided and reduced can be considered interchangeable with removed carbon.

We must make two distinctions to avoid conflating ownership with responsibility: carbon removal is the activity, while removed carbon is the result. Given the need for maintenance through time, carbon removal may be more accurately described as an activity that provides a service in a similar fashion as waste management is a service rather than an activity that produces products. However, service businesses are generally understood to provide value through intangible skills, expertise, and time. In the example of waste management, the value is beautification and sanitation. On the contrary, the carbon removal business can rely on the measurements of the physical properties of carbon. The value created is tangible, as it would be when made by a product business. Yet, the value created is not like a product as generally understood; the buyer only goes home with what is essentially a statement of facts. The similarity of carbon removal to a service industry may end where the result begins.

If removed carbon certification is essentially a statement (verification) of facts, does that make it a public good, an asset, a currency, a commodity, or something new? Removed carbon may appear to be public goods in that economies of scale apply and that they are transferable. However, not in the technical sense, since it does not meet the conditions of non-rivalry (i.e., public goods that are consumed by people but whose supply is not affected by people's consumption) nor non-exclusivity (i.e., not limited to only one person or organization). Removed carbon may be an asset in the sense that it has an intrinsic value that can be exchanged for cash. Moreover, it may be an asset in the sense that some groups may experience indirect or non-financial returns on investment. For example, the cost of CDR may be lower than the sum of damages caused by climate change and, in some cases, lower than certain decarbonization activities. Returns may also come in terms of provisioning ecosystem services. However, assets are defined as goods that are not consumed through their use. Removed carbon can only be consumed once because no matter how many times it is transferred, it will only neutralize one emission.

Removed carbon may become currency, as understood to be a medium of exchange for goods and services. For this, whether removed carbon is equivalent to reduced or avoided emissions would need to be answered. Moreover, an efficient pricing system, including carbon pricing and markets, would need to be developed with a way to identify potential free-rider countries to maintain the system's integrity[24], and the players would need to reach the understanding that global climate goals would constrain supply[25]. While removed carbon may become a currency, it is also possible to be considered a commodity, a basic item that can be bought and sold and is interchangeable with other commodities of the same type. Although the quality of a commodity may differ slightly, specific standards are expected to be met to ensure the commodity is essentially the same, regardless of producer. This would be true of removed carbon once standards become coherent or a single framework is established.

The categorization of removed carbon will influence what instrument would best represent it within the carbon markets while acknowledging that it may also take several forms to fulfill different parties' needs. Credits, units, or certificates may meet trade agreements, whereas offsets may represent one of their usages. The differences between credits, units, or certificates may be rooted in historical legacy, as they were created for specific policy contexts. With the expansion of carbon markets and the infusion of new terminology, at the very least, definitions ought to be made clear and broadly applied to reduce confusion and enhance coherence.

Tracking these instruments is also yet to be determined in a formal, global effort, although various projects are underway, including Microsoft's Carbon Call[26] and the IHS Markit Meta-Registry[27]. Tracking projects and credits and their claims across jurisdictions, programs, and standards is critical to stamping out double counting. Doing so efficiently through a single global registry that leverages distributed dual ledger technologies will promote liquidity, transparency, and trust in the carbon removal market. This would be true if it is open to public scrutiny and tracks

instrument supply and use. Linking national registries and voluntary program registries under one database would be one way to support the rules of article 6 in the Paris Agreement.

Durability: definition, risks, and governance

Insights

Carbon removal has a time component that is generally encapsulated by the concept of durability - often referred to as "permanence." The debate surrounding how durability should be understood[28-33] is exemplified in the range of definitions used by certification programs, varying from 10 years to over 100 years. What does "durability" mean, what are the associated risks, and how should it be managed in certification?

We found two focused points of alignment. First, the community agreed on the need to clearly define "durability" and move away from the term "permanence" since nothing in the Earth System is permanent - suggested alternatives included durability and persistence. To reflect this sentiment, the term durability is used hereafter in this document. Second, the certification of carbon removal in dynamic reservoirs (i.e., where carbon may flow in and out) ought to focus on the accumulation of carbon stock rather than its flow. For example, one may consider the total carbon stock of a forest rather than the individual trees when considering durability. This recognition highlighted that monitoring through time is a more helpful durability metric than commitments of specific durations.

Several other points will need further clarification. First, the understanding of the meaning and role of durability differs significantly, along with how to treat the potential failure of storage to be durable. One viewpoint suggested that durability could be understood as a system across time that ensures the reservoirs that store carbon trend towards stability. An alternative view told that durability could be understood as the point at which the entity, likely the storage operator, can be released from the responsibility of the risk of the intervention (i.e., the storage activity). Under this second viewpoint, short-term storage was considered viable if the obligation to reach durable storage to maintain the beneficial impact of carbon removal did not disappear. Second, disagreement also persisted on whether durability was a concept that could be treated equally across all reservoirs without compromising the integrity of the certification. Lastly, another disagreement remained about how to treat reservoirs that could be deemed effectively permanent – should they continue to be periodically monitored indefinitely, and can a set of conditions be determined that would define a reservoir as functionally stable.

Discussion

The IPCC defines carbon removal as removing CO_2 from the atmosphere and storing it durably[1]. It leaves "durable storage" undefined despite decades of debates, probably because what constitutes "durable storage" is a societal choice that observations can, at most, inform. The scientific community agrees that a sizeable fraction of CO_2 released from the burning of fossil carbon will remain in the atmosphere for hundreds of thousands of years[3,34,35]. CO_2 is removed from the atmosphere at various speeds and scales through the carbon cycle: absorption by the land biosphere and the upper ocean in the faster cycle, invasion into the deep oceans, and reaction with carbonates and basic igneous rocks in the slower cycle. The long lifetime of this fossil CO_2 in the atmosphere makes climate change a multi-millennial problem, not a century-timescale one.

With this scientific understanding in mind, treating the time component of carbon removal is a societal decision that will standards and certification will make. Given the wide range of definitions used in standards, the breadth of meanings attributed to the concept, and the variety of opinions on how to treat the potential failure of storage to be "permanent," the choice is not yet resolved.

In addition to settling on terminology, the community will need to develop a more precise common understanding of expected durability. Commitment periods usually used in standards are arbitrary and incompatible with the scientific knowledge of the carbon problem and project or even human lifetimes. Instead, durability may be understood as a long-term risk management problem. The pertinent question is, can systems be put in place to ensure continuous responsibility for the removed carbon stored in reservoirs? Follow-up questions that need addressing include how to identify releases, what to do about them, and who should deal with them. What makes sense as a monitoring plan for each carbon reservoir? What are the risks associated with each reservoir? What monitoring frequency is acceptable, and how should monitoring plans be designed to last over multi-generational timescales?

Nevertheless, it may be valuable to consider the conditions to an eventual end of responsibility, akin to functional stability in landfills, for certain storage activities where science can demonstrate the expected storage duration can reach a specific threshold. Considerations on what timescales to target may include (1) what impacts society wishes to protect itself from, whether this be temperature-related changes (i.e., requiring storage for at least a millennia) or from environmental degradation such as ocean acidification (i.e., requiring tens to hundreds of thousands of years); (2) whom society wishes to protect (i.e., which generations and species) from climate impacts; (3) how society wishes to treat the responsibility of carbon producers (i.e., accountability and liability in offsetting practices); and (4) what information would need to be known about the condition of the carbon, the reservoir, and the risks to reach a scientific consensus. The decision will dictate if certification and standards should view carbon removal as a multi-generational enterprise, similar in scale to cathedral construction or other heritage sites.

Considerations also ought to be made for the fact that individual CO_2 storage activities need not be "permanent" nor leak-free if the sum of all storage does not decrease or if remediation (i.e., intentional or unintentional released carbon is re-sequestered) takes place at a particular site. In this context, the treatment of the potential that storage will not be "permanent" is a critical question that ought to be addressed transparently by standards and certification because it is an externality that neither the buyer nor the seller of carbon removal has incentives to fix.

Addressing the problem of non-durable storage relates to the societal decisions outlined above; pertains to risk management; will dictate if and how standards can bridge across reservoir types; questions what carbon removal is and is not; and involves the public in a way that does not affect emission avoidance and reduction activities.

Recommendations

Due to time constraints, the consultations could not address all open topics. Questions remain open on whether to take a practical or holistic approach to carbon accounting. For instance, the consultations did not fully address co-benefits and their role in carbon accounting other than discussing allowing them to be optional additional tags. Should co-benefits, in the form of furthering sustainable development goals or educational, environmental, economic, or social impacts, be quantified as part of the certification of carbon removal?

Also not discussed in the consultations was the role for and recognition of private-sector initiatives, currently mostly excluded from international agreements, in the development of carbon removal. Do standards offer the possibility of scaling to small and medium-sized removal activities, as these can add substantially to overall efforts? In what form and under what capacity should the issues of scale be addressed remains unclear in the certification of carbon removal.

Outcomes of the themes that could benefit from further discussions are summarized in this white paper to provide insights and highlight targeted areas to catalyze and accelerate progress in the certification community. The process revealed some alignment on specific aspects amidst different viewpoints on some fundamental questions. (**Figure 2**) As they represent core assumptions regarding how certification of carbon removal should work, further exploring these areas of misalignment is a priority.

Regarding the treatment of avoidance-reduction-removal, the key may be to find alignment on the goals and let the solution follow. What are carbon markets trying to achieve? Suppose it is attaining climate goals, providing asset liquidity, rewarding effort, or some other purposes. In that case, the answer will guide the treatment of avoidance-reduction-removal in developing standards for the certification of carbon credits. The solution will also extend into spaces beyond certification, such as how commodities are regulated, how climate risks and finances are disclosed, and how credits are rated.

Concerning additionality, moving forward on this topic requires rethinking assumptions and goals. Regarding accounting for removed carbon, the international climate policy and certification community ought to explore taking advantage of the strengths of carbon removal to develop methods that produce results verifiable with measurements. In terms of the importance of not crediting natural carbon removal not influenced by human action, the community ought to decide where to draw the line in terms of allowed complexity in proving additionality.

On the topic of instruments, concerted efforts are required to dispel the confusion surrounding definitions among stakeholders in the carbon market ecosystem. The world is at a unique point in developing certification, carbon markets, and the carbon removal industry, whereby the international community could rethink certification instruments. Harnessing that unique opportunity would mean clarifying what certified removed carbon is (i.e., an asset, good, service, commodity), what the certification instrument is trying to achieve, and what would be its necessary attributes.

As for durability, the community must articulate the concept more succinctly. This may mean moving away from conceptualizing "permanence" as "how long of a storage duration should the certification instrument represent" to "what are the systems to address the risk of reversal." Understanding, defining, and managing durability is a scientific endeavor and a business practice.

Although not exhaustive, the insights presented here are bellwethers for developing rules for the larger carbon removal market. Each topic explored during the consultation revealed alternative viewpoints that raised questions about the fundamental design of standards for carbon removal. At least, the breadth of view revealed that when assumptions are made and not clearly explained, the lack of transparency percolates through the system, fueling distrust. At most, the range of viewpoints indicates that the community should still be given the space to explore the options that will bring the most credibility to carbon removal. Transparency on assumptions made and getting structures right at the certification level will be crucial to the success of carbon removal as a climate solution.

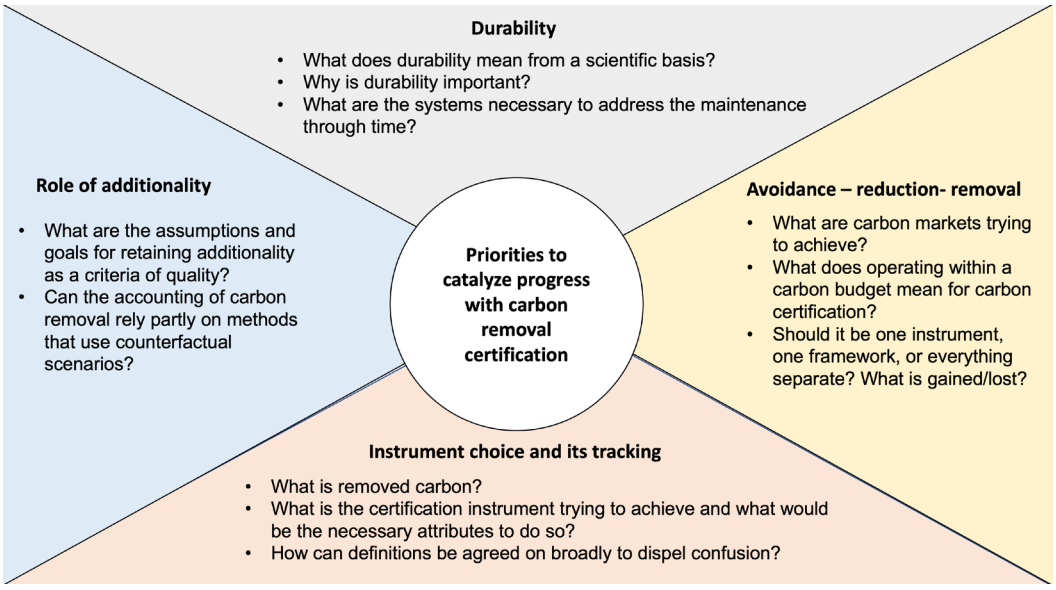

Figure 2. Questions that will need further exploration to advance the development of standards for the certification of carbon removal.

References

[1] IPCC (2021). Annex VII: Glossary [Matthews, J. B. R., J. S. Fuglestvedt, V. Masson-Delmotte, V. Möller, C. Méndez, R. van Diemen, A. Reisinger, S. Semenov (ed.)]. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L.Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

[2] IPCC (2018). Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press

[3] IPCC (2022). Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926

[4] Arcusa, S. and Sprenkle-Hyppolite, S. (2022). Snapshot of the Carbon Dioxide Removal certification and standards ecosystem (2021–2022). Climate Policy, pp.1-14. https://doi.org/10.1080/14693062.2022.2094308

[5] Zelikova, J., Chay, F. Freeman, J.Cullenward D. (2021). A buyer's guide to soil carbon offsets. CarbonPlan https://carbonplan.org/research/soil-protocols-explainer

[6] McDonald, H., Bey, N., Duin, L., Frelih-Larsen, A., Maya-Drysdale, L., Stewart, R., Paetz, C., Hornsleth, M.N., Heller, C., Zakkour, P. (2021). Certification of Carbon Removals. Part 2: A review of carbon removal certification mechanisms and methodologies (No. REP-0796), Certification of carbon removals. Environment Agency Austria.

[7] Plastina, A., (2021). How to Grow and Sell Carbon Credits in US Agriculture. Ag Decision Maker.

[8] Richards, K.R., Huebner, G.E., (2012a). Evaluating protocols and standards for forest carbon-offset programs, Part A: additionality, baselines and permanence. Carbon Management 3, 393–410. https://doi.org/10.4155/cmt.12.38

[9] Richards, K.R., Huebner, G.E., (2012b). Evaluating protocols and standards for forest carbon-offset programs, Part B: leakage assessment, wood products, validation and verification. Carbon Management 3, 411–425. https://doi.org/10.4155/cmt.12.39

[10] Unger, M. von, Emmer, I., Joosten, H., Couwenberg, J., (2019). Designing an International Peatland Carbon Standard: Criteria, Best Practices and Opportunities. German Environment Agency.

[11] Zickfeld, K., Azevedo, D., Mathesius, S., Matthews, H.D., (2021). Asymmetry in the climate-carbon cycle response to positive and negative CO_2 emissions. Nature Climate Change 11, 613–617. https://doi.org/10.1038/s41558-021-01061-2

[12] Lackner, K.S., Wilson, R., Ziock, H.-J., (2000). Free-Market Approaches to Controlling Carbon Dioxide Emissions to the Atmosphere. Global Warming and Energy Policy 31–46. https://doi.org/10.1007/978-1-4615-1323-0_3

[13] Allen, M.R., Frame, D.J., Mason, C.F., (2009). The case for mandatory sequestration. Nature Geoscience 2, 813–814. https://doi.org/10.1038/ngeo709

[14] Carbon Take Back Obligation. Available at: https://carbontakeback.org/about/

[15] Florini, A., LaForge, G., (2022). Governing carbon markets. Finance for Biodiversity Initiative. https://www.f4b-initiative.net/_files/ugd/643e85_e4605eb6bee144a7ba02d1fd49679813.pdf

[16] United Nations (UN) (1992). United Nations Framework Convention on Climate Change. FCC/INFORMAL/84/Rev.1 http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm

[17] UNFCCC (1997). Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 10, 1997, 2303 U.N.T.S. 162. http://unfccc.int/cop5/resource/docs/cop3/l07a01.pdf

[18] UNFCCC (2006). Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its first session, held at Montreal from 28 November to 10 December 2005. Part Two: Action taken by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol at its first session. https://cdm.unfccc.int/Reference/COPMOP/08a01_abbr.pdf

[19] World Bank Group, (2022). State and Trends of Carbon Pricing 2022. State and Trends of Carbon Pricing. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/37455 License: CC BY 3.0 IGO.

[20] Honegger, M., Poralla, M., Michaelowa, A., Ahonen, H.-M. (2021). Who Is Paying for Carbon Dioxide Removal? Designing Policy Instruments for Mobilizing Negative Emissions Technologies. Front. Clim. 3, 672996. https://doi.org/10.3389/fclim.2021.672996
[21] Gillenwater, M., (2012). What is Additionality? Part 1: a long-standing problem. GHG Management Institute, Discussion Paper n. 1 / vers. 03.
[22] Streck, C. (2011). Ensuring New Finance and Real Emission Reduction: A Critical Review of the Additionality Concept. Carbon & Climate Law Review 5, 158–168. https://doi.org/10.21552/cclr/2011/2/176
[23] Brown J., Bird, N. and Schalatek, L. (2010). Climate Finance Additionality: Emerging Definitions and their Implications. Climate Finance Policy Brief No.2, ODI and Heinrich Boll Foundation.
[24] Browne, J., Villarreal, D., Lackner, K., Brennan, L., (2020). Incentivizing a Carbon-Free Economy: A Method to Identify Free-Riders. EP 15, 68–85. https://doi.org/10.18288/1994-5124-2020-2-68-85
[25] Liu, Q., Chen, Z., Xiao, S.X., (2022). A theory of carbon currency. Fundamental Research 2, 375–383. https://doi.org/10.1016/j.fmre.2022.02.007
[26] Microsoft's Carbon Call. Available at: https://blogs.microsoft.com/on-the-issues/2022/02/10/carbon-call-sustainability-net-zero/
[27] IHS Markit Meta-Registry. Available at: https://metaregistry.ihsmarkit.com/
[28] Dornburg, V., Marland, G., (2008). Temporary storage of carbon in the biosphere does have value for climate change mitigation: A response to the paper by Miko Kirschbaum. Mitigation and Adaptation Strategies for Global Change 13, 211–217. https://doi.org/10.1007/s11027-007-9113-6
[29] Fearnside, P.M., (2002). Why a 100-year time horizon should be used for global warming mitigation calculations. Mitigation and Adaptation Strategies for Global Change 7, 19–30. https://doi.org/10.1023/A:1015885027530
[30] Fearnside, P.M., Lashof, D.A., Moura-costa, P., (2000). Accounting for time in mitigating global warming through land-use change and forestry. Mitigation and Adaptation Strategies for Global Change 5, 239–270.
[31] Herzog, H., Caldeira, K., Reilly, J., (2003). An issue of permanence: Assessing the effectiveness of temporary carbon storage. Climatic Change 59, 293–310. https://doi.org/10.1023/A:1024801618900
[32] Kirschbaum, M.U.F., (2006). Temporary carbon sequestration cannot prevent climate change. Mitigation and Adaptation Strategies for Global Change 11, 1151–1164. https://doi.org/10.1007/s11027-006-9027-8
[33] Marland, G., Fruit, K., Sedjo, R., (2001). Accounting for sequestered carbon: The question of permanence. Environmental Science and Policy 4, 259–268. https://doi.org/10.1016/S1462-9011(01)00038-7
[34] Archer, D., Kheshgi, H., Maier-Reimer, E., (1997). Multiple timescales for neutralization of fossil fuel CO_2. Geophys. Res. Lett. 24, 405–408. https://doi.org/10.1029/97GL00168
[35] Archer, D., Eby, M., Brovkin, V., Ridgwell, A., Cao, L., Mikolajewicz, U., Caldeira, K., Matsumoto, K., Munhoven, G., Montenegro, A., Tokos, K., (2009). Atmospheric lifetime of fossil-fuel carbon dioxide. Annual Reviews of Earth and Planetary Sciences 37.

Appendix

Full list of participants who attended the consultations

Surname	Name	Organization
Agrawal	Aditya	GCRP and D4DInsights
Aguilar	Christian	Bogota Chamber of Commerce
Aguilar	Diana	Bogota Chamber of Commerce
Arcusa	Stephanie	ASU Center for Negative Carbon Emissions
Azarabadi	Habib	Boston Consulting Group
Baker	Andrew	Scottish Forestry WCC
Bukoski	Jacob	Conservation International
Calvo	Sofia	Alberta Environment and Parks, Canada
Chu	Hong-Hanh	Commonwealth of Massachusetts Executive Office of Energy and Environmental Affairs
Dailey	Merritt	ASU and Carbon Direct
Dockett	Andy	Climate Cleanup
Dodds	Erica	Foundation for Climate Restoration
Garay	Henry	Bogota Chamber of Commerce
Garzon	Nicol	Bogota Chamber of Commerce
Givens	Jessica	ASU Global Futures Laboratory
Green	Michael	Carbon Capital Advisors
Hagood	Emily	ASU Center for Negative Carbon Emissions
Hole	David	Conservation International
Jense	Sven	Climate Cleanup
Kasprzyk	Kiryssa	Conservation International
Khagram	Sanjeev	GCRP and Thunderbird School of Global Management
Khorshidi	Ghazal	GCRP and Thunderbird School of Global Management
Klenner	Ryan	ASU Lightworks
Kuwahara	Ian	Verra
Lackner	Klaus	ASU Center for Negative Carbon Emissions
Leugers	Sarah	Gold Standard Foundation
López	Julián	
Minor	Peter	Carbon180
Moolgavkar	Radhika	Nori
Moss	Philip	South Pole
Oosterbroek	Melissa	Climate Cleanup
Page	Robert	ASU Center for Negative Carbon Emissions
Qadir	Saima	Conservation International
Remucal	Jon	Climate Action Reserve
Rodriguez Silva	Luisa	Bogota Chamber of Commerce
Rojas	Alex	South Pole
Rojas	Ferney	Bogota Chamber of Commerce
Salgado	Col. Fabio	CAEM
Sawant	Juily	GCRP and Thunderbird School of Global Management
Smith	Leonard	Puro.Earth
Sprenkle-Hyppolite	Starry	Conservation International
Turner	Wil	Conservation International
Vinke	Candace	Verra
Wayman	Rick	Foundation for Climate Restoration
Yamani	Jamila	Salesforce