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Sustainable Forest Biomass Sourcing for CDR

A BUYER'S GUIDE

January 2025 • Version 1.2



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We welcome additional signatories in this collective effort to advance the market towards sustainable biomass sourcing.

The Buyer's Guide to Sustainable Biomass Sourcing for Carbon Dioxide Removal (CDR) is the result of collaboration between buyers and an expert advisory group convened by Carbon Direct. It is meant as a practical tool for contracting in CDR agreements. This report echoes the collective understanding of the Sustainable Biomass Coalition Signatories. The Signatories acknowledge the potential role of biomass-based carbon dioxide removal within a portfolio of solutions for achieving net-zero emissions, even as the impacts of specific applications remain under exploration. Recognizing that the efficacy of biomass-based CDR critically depends on sustainable biomass sourcing, we highlight the urgent need for robust guardrails to avoid adverse outcomes. With appropriate standards and vigilance, biomass-based CDR can play an important role in limiting global warming to well below 2°C.

This was a collective effort. The development of this guide involved in-depth consultations with an array of professionals, from corporate experts and academic scholars, to representatives of international organizations, industry initiatives, CDR suppliers, and non-governmental organizations. The generous financial support of Microsoft Corporation and Stripe, Inc. facilitated the consultation process and the subsequent report. We extend our deepest appreciation to our knowledge partners and contributors for their invaluable input. Signatories endorse the overarching sentiments and arguments presented in this publication, but this should not be misconstrued as agreement with every detail or recommendation.

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Preface

The voluntary carbon market is at a juncture where biomass-based carbon dioxide removal (CDR) capacity is growing rapidly. As CDR buyers, we recognize the precedent-setting nature of the deals underlying this growth and the need to balance timely climate action with thoughtful caution. This guide is the first step in what will be an ongoing effort to set effective guardrails on sourcing biomass sustainably. It is designed to be a practical tool for use in guiding outcomes of biomass sourcing in CDR contracts. As a tool, it is intended to reduce risk of adverse outcomes in the emerging offtake agreements needed to scale the biomass-based CDR industry. Developed with consideration of existing frameworks, this guidance will inform future strategies and practices in the field but is not itself a standard or certification. Further, this guidance is flexible: multiple implementation pathways for each criteria enable application at scale while also outlining options that minimize risk. This document serves as both a reflection of the current state of the market and a signpost for future directions. It will be updated as the market and frameworks surrounding biomass sourced for CDR evolve.

Version 1.2 of this document incorporates technical clarifications to the “Principles and Criteria for Sustainable CDR Biomass Sourcing” section. This report will continue to be updated based on wide community input and the experience gained from implementation.

Introduction

The biomass-based CDR industry is growing rapidly. As demand for high-durability, large-scale CDR increases, biomass-based solutions have emerged as a clear frontrunner. Solutions like bioenergy with carbon capture and storage (BECCS), biochar, and other biomass carbon removal and storage (BiCRS) pathways have, to date, comprised most of the available supply of durable CDR. Biomass-based CDR projects have potential to scale rapidly in the coming decade, and multi-million-tonne offtake agreements are already being announced. The potential to capture existing biogenic CO_2 emissions is measured in at least hundreds of millions of tonnes each year, even without considering the synergistic growth of industries like paper products, carbon-negative fuels, and others.[1, 2]

However, biomass is a finite resource. The availability of true waste biomass is limited, and existing bioenergy operations currently source significant volumes of wood that clearly have alternative uses. Innovation in the bioeconomy—including biofuels, BECCS, and biomaterials—may create demand that quickly outstrips the availability of waste material.[3] Sourcing sustainable biomass while limiting land-use change impacts is similarly challenging.[4] Without comprehensive safeguards in place to ensure judicious sourcing, there is significant risk of overdrawing biomass—even beyond strictly waste material. Global estimates suggest that biomass demand in aggressive decarbonization scenarios could exceed prudent estimates of sustainable, low-lifecycle-emissions supply by a factor of eleven to sixteen in 2050.[5] Estimates in these studies vary significantly,[6] but all suggest a substantial mismatch between the available biomass resource and its many potential end uses in a net-zero emissions economy (Figure 1).

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[1] *Sagues WJ et al. 2020. Prospects for bioenergy with carbon capture & storage (BECCS) in the United States pulp and paper industry. Energy & Environmental Science, 13(8), 2243-2261.*

[2] *Sanchez DL et al. 2018. Near-term deployment of carbon capture and sequestration from biorefineries in the United States. Proceedings of the National Academy of Sciences, 115(19), 4875-4880.*

[3] *Energy Transitions Commission. 2021. Bioresources within a Net-Zero Emissions Economy: Making a Sustainable Approach Possible.*

[4] *Funk J et al. 2022. Assessing the potential for unaccounted emissions from bioenergy and the implications for forests: The United States and global. GCB Bioenergy 14(3): 322-345.*

[5] *Energy Transitions Commission. 2021.*

[6] *International Energy Agency. 2021. What does net-zero emissions by 2050 mean for bioenergy and land use?*

The largest potential source of new demand for biomass is for conversion to energy—some estimates predict that biomass demand from biopower alone could claim all existing supply by 2050.[7] These projections emphasize the importance of developing sound guardrails on biomass use before these industries scale up.

Many investigations have highlighted the risks and opportunities associated with sourcing biomass for bioenergy. Reports by academics, watchdog groups, and journalists have identified pitfalls in forest biomass sourcing. In Europe and North America, critiques of bioenergy have uncovered issues such as use of wood harvested from old growth forests, corrupt oversight of biomass supply chains, and conflict over increased harvesting in forests with high social values.[8,9,10] The rapid increase in global wood pellet production compounds this challenge.[11] Conversely, in some contexts—as in wildfire hazard reduction treatments—predictable demand for biomass can drive outcomes with significant ecological, climate, and social benefits.[12,13] These findings underscore the complexity of biomass sourcing and the urgent need for stringent oversight and alignment on best practices.

Many uncertainties around the use of wood for bioenergy point back to fundamental, contested questions on how society should use forests. For CDR, the answers to these questions are complex and must take into account wider issues beyond simply climate impact or economics. On its own, climate is too narrow a lens for evaluating forest management strategies and can lead to poor outcomes.

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[7] *Committee on Climate Change. 2018. Biomass in a Low-Carbon Economy.*

[8] *Crowley J and Robinson T. 2022. UK power station owner cuts down primary forests in Canada. BBC Panorama.*

[9] *Hurtes S and Cai W. 2022. Europe is Sacrificing Its Ancient Forests for Energy. The New York Times.*

[10] *Elbein S. 2020. In tiny Estonia, a fraught debate: What are forests for? National Geographic.*

[11] *Fingerman K et al. 2017. Opportunities and risks for sustainable biomass export from the south-eastern United States to Europe. Biofuels, Bioproducts & Biorefining 13(2): 291-292.*

[12] *Cabiyo B et al. 2021. Innovative wood use can enable carbon-beneficial forest management in California. Proceedings of the National Academy of Sciences, 118(49), e2019073118.*

[13] *Cowie, Annette L., et al. 2021. "Applying a science-based systems perspective to dispel misconceptions about climate effects of forest bioenergy." GCB Bioenergy 13.8: 1210-1231.*

While the social, economic, and ecological implications of increased biomass demand are difficult to constrain, important opportunities exist for buyers to implement safeguards for CDR projects dependent upon this limited resource. Ongoing engagement on this topic will help refine, implement, and lead on the guidance contained in this report.

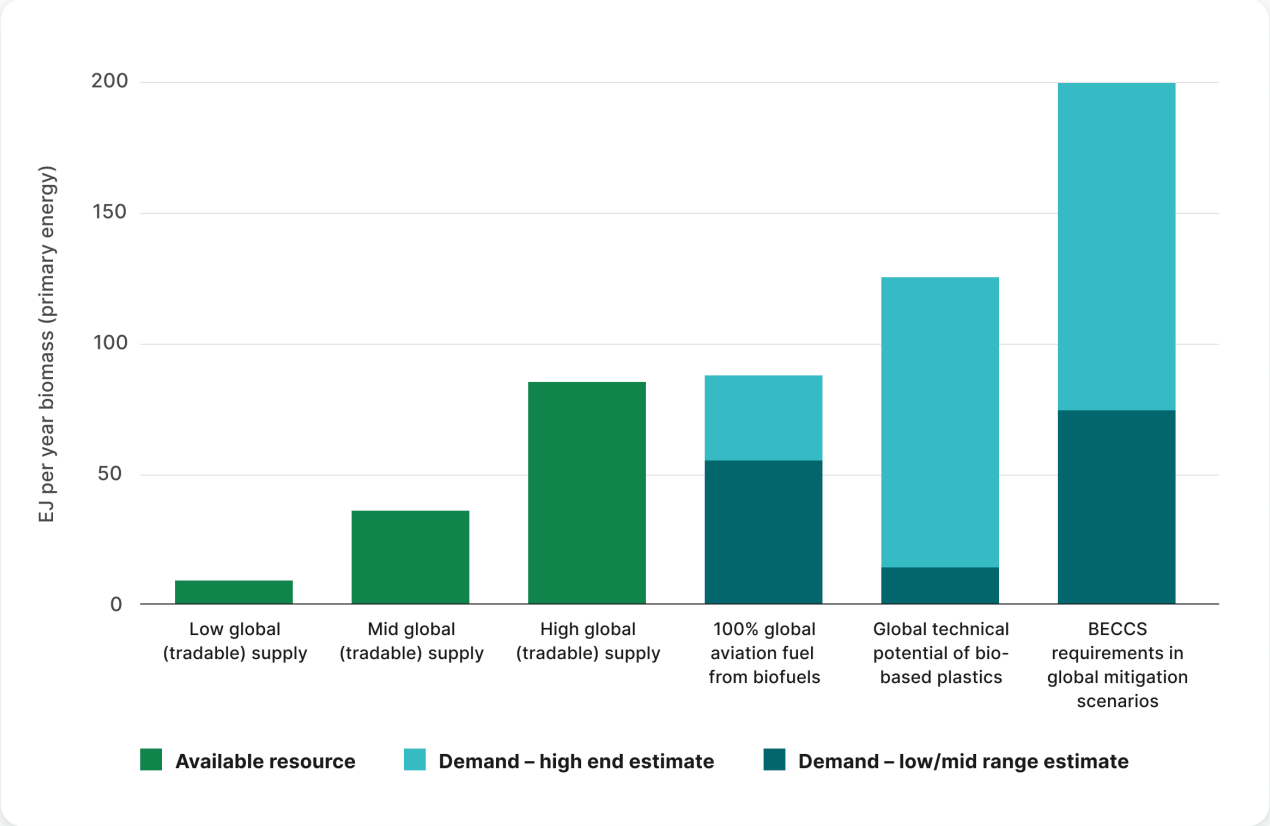


Figure 1. *Potential demand outstrips supply of available biomass in high biomass-use scenarios by 2050. Source: Committee on Climate Change. 2018.* [*Biomass in a Low-Carbon Economy.*]

The Focus of This Report

As market actors navigate the complex landscape of biomass-based CDR, it is crucial that biomass sourcing guidance remains grounded in the realities of a global market and the nuances of local implementation. This report is designed to provide pragmatic, evidence-based guidance informed by the challenges faced by stakeholders in the field. Specifically, this guidance is designed to reduce risk in the context of contracting for biomass-based CDR offtake agreements. The following considerations guided this report in the pursuit of solving this discrete, pressing need in the near-term deployment of biomass-based CDR.

Leveraging Existing Oversight

Numerous regulatory and voluntary systems have been developed for specific use cases within the realm of biomass sourcing and forest management. Nearly twenty such schemes were considered during the production of this report—an approach which integrates, distills, and adapts this wealth of knowledge. This report leverages existing oversight frameworks, while providing a flexible, robust, and pragmatic solution that resolves the needs of a rapidly growing market. Due to the sheer diversity and volume of existing standards, reference to specific standards was avoided.

Implementation by 2026

The largest biomass-based CDR projects will begin storing carbon as soon as 2026, so this guidance is focused on tools and frameworks that will be implemented within the next few years. By focusing on near-term feasibility, recommendations are provided that can be integrated seamlessly into contracts spanning a diverse array of biomass-based CDR applications and contexts.

Northern Forests

This report focuses primarily on forest biomass in northern latitudes. While the principles outlined here may have broader relevance, their primary goal is in addressing areas where the bulk of emerging biomass-based CDR projects are being developed. Future work will test the applicability of this guidance to other contexts, and it will be amended as it is applied in a range of localized cases.

Core Sourcing Principles

The following core sourcing principles encompass the objective to reduce risk in biomass sourcing for biomass-based CDR projects. The principles are achieved through the satisfaction of specific criteria and implementation options.

1. Biomass must come from sources with operational integrity and oversight through strong governance, standards, and supply chain transparency.
2. Biomass must come from sources for which operations minimize negative impacts on Indigenous Peoples, workers, and local communities.
3. Biomass must come from sources where biomass can be produced without threatening protected areas or reducing regional carbon stocks.
4. Biomass must come from sources that do not distort markets for agriculture or forestry products.



Using the Report

This report is designed as a tool for mitigating risk in biomass-based CDR offtake agreements. The implementation guidance given for each criteria is written as draft contract language that can be added as an appendix or as a direct amendment to negotiated offtake agreements. For each principle, the underlying criteria are intended to provide specific, tangible outcomes that can be monitored or proven. Each criterion includes multiple implementation options providing flexibility to meet a diversity of settings. However, these options are not necessarily equivalent. The most conservative option, where one exists, is indicated as “preferred.” Even so, bespoke oversight may prove to be more rigorous than the preferred option in some cases. These alternatives are meant to strike a balance between pragmatic and conservative approaches, but buyers should understand that more pragmatic options may carry a greater risk of adverse outcomes. **Buyers may choose to include one, multiple, or none of the provided options in negotiated biomass-based CDR contracts.**

This guidance presents a conservative set of initial measures to mitigate risks and drive positive outcomes in biomass-based CDR deals on a global scale. However, it is likely that each jurisdiction where biomass is sourced will introduce complex, localized management challenges and economic incentives not entirely captured by these general principles. As such, buyers and sellers of biomass-based CDR should work to contextualize and translate the intent of these principles for their specific application.

Areas for Further Work

For the sake of expediency and simplicity, this guidance leaves several areas for future assessment. Some of these areas are considered in the Criteria for High-Quality Carbon Dioxide Removal[14] and the CDR Verification Framework.[15] Exclusion from this report does not indicate relative unimportance—rather, biomass sourcing is simply one important piece of the complex puzzle of effective biomass use. The following topics are outside the scope of this report. Still, they are essential to get right, when considering projects in development today and regulatory frameworks of the future.

Other feedstocks

Non-forest biomass and purpose-grown crops already play a central role in many proposed biomass-based CDR projects, such as BECCS facilities that plan to use agricultural residues or those planning to add carbon capture and storage (CCS) to corn bioethanol production. Many of the considerations in this report directly, but imperfectly, overlap with those that might be applied to other feedstocks. For example, guidance on the use of dedicated feedstock invites an additional set of difficult questions around direct and indirect land-use change. Questions surrounding the use of other feedstocks will need to be tackled explicitly in future work.

Carbon accounting

Robust carbon accounting for biomass-based CDR projects is crucial and must prove the net negativity of the application. Carbon accounting is tied to biomass sourcing in four key ways.

1. First, carbon accounting for biomass-based CDR should consider the full lifecycle of production, from the point of harvest to the point of biomass conversion and storage. Biomass harvesting, transport, and processing all involve emissions that must be incorporated into the final carbon math of any biomass-based CDR project.

[14] *Carbon Direct and Microsoft. 2023. Criteria for High-Quality Carbon Dioxide Removal.*

[15] *CarbonPlan. 2022. CDR Verification Framework.*

2. Second, land-use change associated with biomass can affect the net carbon impact of biomass use, either positively or negatively. High demand for biomass can theoretically drive both forestation and deforestation—directly or indirectly—depending on the prior land use that is displaced. Impacts of biomass demand on land-use change are an area of active research. Given the salient examples of existing land-use change associated with relatively constrained bioenergy demand, this represents a key uncertainty to understand alongside a growing biomass market. However, this level of uncertainty is not unique in climate policy and should not preclude effective, rapid climate action.

3. Third, stable or increasing forest carbon stocks predicate assumptions regarding the carbon neutrality of biomass. These assumptions are invalidated if biomass is sourced from forests with declining carbon stocks—except when that biomass has no alternative fate that stores carbon. This concern is addressed in Criterion 3.4 of this report.

4. Fourth, accurate assessments of counterfactual fate of biomass are critical to incorporate into carbon storage claims of biomass-based CDR projects. Biomass frequently has a counterfactual fate that involves carbon storage, including through natural processes like forest decay. Accounting for how much carbon would be stored in the most likely counterfactual—and, importantly, when that carbon would be released—is essential for understanding the true carbon benefits of biomass-based CDR.

Environmental justice

Biomass-based CDR efforts must not cause inequitable impacts on people or local communities within the biomass supply chain or at processing facilities. Environmental justice embodies the idea that all individuals must be equitably protected from environmental risk, and equitably empowered to participate in environmental decision-making processes that could affect them. It recognizes the importance of addressing past and present harms on Black, Indigenous, and People of Color (BIPOC) and low income-communities that have hindered wealth building, self-determination, equitable use of natural resources, and protection of biodiversity.

This report includes considerations for mitigating some environmental justice risks in biomass sourcing. However, the greatest risk of harm may in fact be at the point of biomass conversion for CDR, rather than within the biomass supply chain. CDR project developers should work to identify and mitigate risks beyond the biomass supply chain, including point source pollution associated with CDR facilities

Cascading use

The widely recognized cascading use principle acknowledges the need to prioritize use of limited biomass resources to maximize societal benefits. True “waste” biomass is limited and will become more so as innovation in the bioeconomy scales. This report focuses on CDR, but the principles and criteria laid out here may have application across other biomass uses, like sustainable aviation fuels or biomaterials. As such, this guidance is given as a response to an emerging demand for biomass, not as an endorsement of CDR as the highest-priority use. Until robust frameworks for cascading use are widely adopted, CDR buyers are advised to prioritize projects that are designed to capture existing carbon emissions, create valuable co-products, and/or make use of biomass that is unambiguously waste.

Future iterations of this work may explore the topics above as an appetite for these solutions emerges. The existing report is built to address a discrete challenge in biomass-based CDR procurement and, as such, its scope will be expanded as the market progresses.

Next Steps

This guidance sits within a dynamic socio-political landscape, epitomized by long-standing debates over the role of bioenergy in the global energy mix. The cascading use principle prioritizes biomass use based on an optimal set of economic, social, and environmental values which are not yet fully defined. Where biomass-based CDR sits in the hierarchy of priorities is still an active point of discussion. This debate is highlighted by recent amendments to the EU Renewable Energy Directive (RED), which now contains stipulations against supporting electricity production solely from forest biomass but allows exceptions for BECCS.[16] Policy actions will play a vital role in operationalizing and refining the biomass sourcing principles outlined in this report.

In addition, voluntary and regulatory certification schemes play a critical role in systematically reducing risk in forest management and biomass sourcing. There are many such programs developed specifically for biomass sourcing, many of which have emerged or evolved recently (see Appendix). Forest management certifications grounded in stringent, performance-based requirements offer the highest level of assurance to CDR buyers. These certifications, like FSC forest management certification, are recommended in this report and by some biomass certification schemes—for example, the Roundtable on Sustainable Biomaterials (RSB). However, the reduced risk of sourcing from certified forests can come at additional cost and presently limited scale. In contrast, some biomass-specific certifications are supply chain certifications[17] that assess risk from a vantage distant from the forest (e.g., the biomass supplier), losing site-specific, outcome-based granularity. As such, supply chain certifications provide lower certainty in meeting desired outcomes of, for example, sustainable forest practice (Figure 2). Today, biomass supply for CDR projects is often obtained through multiple sources and certifications, which necessitates near-term flexibility. To reduce overall risk, buyers should preferentially source biomass under more stringent forest certification schemes that include outcome-based indicators across a broad scope of criteria, verified at the forest management unit.

[16] *European Commission. 2022. Renewable Energy Directive Amendment.*

[17] *Referring to "systems that require certification or verification of actors downstream in the supply chain… i.e., from mill and downstream to the energy plants, with no certification of forest management units upstream from the mill." (Kittler et al. 2020).*

Broad industry alignment on this goal can incentivize investment in robust forest certification and ultimately reduce the need for bespoke risk management in biomass sourcing contracts.

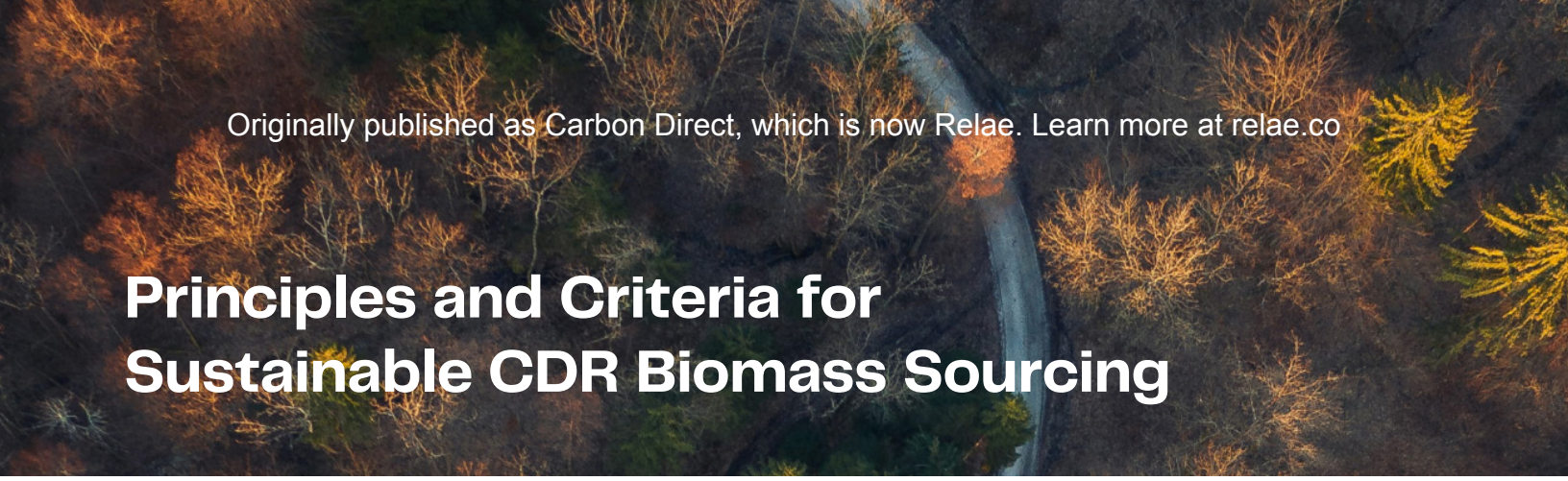
This guidance is neither static nor definitive. It will evolve with a rapidly changing CDR industry. This report aims to stimulate continued collaboration and progress on sustainable biomass sourcing and, ultimately, contribute to effective oversight that supersedes the necessity of reports like this one. Meanwhile, broad community input on version 1.2 is welcomed and encouraged.

Acknowledging all the uncertainties and work still to come, these principles provide initial guardrails for thoughtful and responsible deployment of the first generation of large-scale biomass-based CDR.



Figure 2. *CDR buyer risk from projects sourcing biomass versus stringency and costs.*

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Principles and Criteria for Sustainable CDR Biomass Sourcing

Preamble

The forest biomass feedstock ("Biomass") sourcing requirements set forth below shall be applied by the seller ("Seller") in the generation of biomass-based carbon credits or similar services ("Credits") for sale to the buyer ("Buyer"). Any non-forest feedstock may only be used in the generation of Credits upon separate agreement. The Sourcing Area from which Biomass originates is defined as the region with contiguous ecological characteristics, including species composition, which are similar to those of Biomass source forests, as defined by relevant regional authorities. Projects may have multiple Sourcing Areas. For the purposes of these requirements, Biomass shall be defined as either:

Option A (Preferred): All forest-derived biomass feedstock used in the production of Credits, including that which is already sourced for pre-existing, associated energy and non-energy products.

Option B: All additional forest-derived biomass feedstock used directly in the production of Credits beyond that which is already sourced for pre-existing, associated non-energy products.

Except where waived by Buyer, Credits produced in violation of the requirements do not qualify for delivery to Buyer.

Explanation

Option A encompasses all biomass utilized at a facility, whether it is newly sourced or already part of pre-existing operations. Option B encompasses only new biomass specifically sourced to support CDR activities at an existing facility. Biomass already used for pre-existing products, such as pulp and paper production, is excluded under this definition.

Principle 1

Biomass must come from sources with operational integrity and oversight through strong governance, standards, and supply chain transparency. Compliance with this principle is met through three criteria.

Criterion 1.1

Biomass must be sourced from areas certified through an independent, third-party-audited forest certification standard, or be sourced from areas of low risk, as determined by risk-based assessment.

Option A (Preferred)
Biomass shall be certified under FSC and/or other forest management and chain-of-custody certification programs with demonstrably equivalent and stringent social and ecological indicators for forest management and chain-of-custody oversight. Biomass certifications are acceptable only in cases where they exclusively utilize existing FSC certification of forests, e.g., through RSB certification of forest harvesting residues or Sustainable Biomass Program (SBP) certification.[18]

Option B
Biomass shall meet the requirements outlined in Option A, or shall be certified under Programme for the Endorsement of Forest Certification (PEFC)-endorsed forest management schemes (or other forest management and chain-of-custody certification programs with demonstrably equivalent forest management and chain-of-custody oversight and principles).

[18] *SBP has recently undergone revision and guidance is now available on how FSC and PEFC-endorsed forest management certifications benchmark against Version 2.0 of the SBP Standard 3.*

Option C

Seller shall provide independent, third-party, risk-based determinations of low risk[19] that non-certified Biomass from specific geographic areas is non-compliant with sustainability principles equivalent to those used by FSC and PEFC-endorsed schemes, biomass certifications such as the SBP or bespoke methodologies utilizing independent assessment of risks associated with Biomass sources. In cases where specified risk is present, risk mitigation measures,[20] and any additional due diligence appropriate to the degree of risk must be implemented and demonstrated to the Buyer.

Explanation

Forest certification schemes build on compliance with legal frameworks, regulations, and best management practices around forest management and their application has been motivated by the need to demonstrate forest product sustainability. The strongest forest certification schemes are based on multi-stakeholder governance and rely on independent, third-party auditing of practices against forest certification standards. FSC's Principles and Criteria[21] and specific indicators are recognized as a global benchmark by leading environmental NGOs,[22] sustainability initiatives,[23] corporate actors,[24] researchers,[25] and national assessment bodies[26] for implementing forest certification inclusive of robust sustainability criteria.[27] The FSC Standard often goes further than other competing standards and regulations applicable to forests by being more stringent in terms of scope (i.e., elaborating more ecological and social criteria for certification) and in substantive, outcome-based performance measures. Regional standards, such as the Sustainable Forest Initiative (SFI) as applied in the United States, may offer comparable protections and should be assessed on a case-by-case basis.

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[19] *Further explanation of risk-based assessment relevant to biomass sourcing is available at: A) Department of Energy & Climate Change. 2014. Risk Based Regional Assessment: A Checklist Approach and B) [SURE] Sustainable Resources Verification Scheme GmbH. 2021. Technical guidance for the assessment of the risk of unsustainable production of forest biomass.*

[20] *For examples of mitigation options, see FSC's US National Risk Assessment Implementation Resources.*

[21] *[FSC] Forest Stewardship Council. 2023. FSC Principles and Criteria.*

[22] *For examples, see WWF and Sierra Club.*

[23] *For an example, see International Living Future Institute.*

[24] *For an example, see Walmart's Project Gigaton.*

[25] *For examples, see Mai-Moulin T et al. 2021, Gutierrez Garzon AR et al. 2020, Judge-Lord D et al. 2020; Sikkema R et al. 2014, and Moore SE et al. 2012.*

[26] *For an example, see: Advisory Commission on Sustainability of Biomass for Energy Applications. 2019. Public report on the assessment of certification scheme FSC United States against the Dutch legal sustainability criteria for solid biomass for energy applications.*

[27] *For an example, see: Netherlands Enterprise Agency. 2017. Verification Protocol for Sustainable Solid Biomass for Energy Applications: Commissioned by the Ministry of Economic Affairs and Climate policy. Also see Mai-Moulin T et al. 2021.*

The PEFC acts as an umbrella organization that endorses national standards. For the United States, SFI and American Tree Farm System (ATFS) forest management certifications are endorsed through the PEFC. These certification schemes include many of the same elements as the FSC Standard but their implementation focuses more on process than outcomes and have been assessed to typically cover fewer sustainability criteria relevant to biomass sourcing.[28]

For example, these certification schemes are less focused on indicators relevant to sustainable biomass sourcing such as protected and high conservation value (HCV) forests and biodiversity. To achieve a higher degree of confidence, buyers may select additional diligence/verification beyond what these certification schemes can provide.

Risk-based determinations of low risk of non-compliance with selected criteria can occur as part of supply chain certification or a bespoke methodology. The strength of these approaches is dependent on the quality of source data on risks, scale of analysis and how the risk assessment is integrated into the procurement practices.[29] *Even in areas where evidence of low-risk cannot be provided, actors along the supply chain can implement risk mitigation activities that include bespoke verification and diligence work, vertically integrated forest management operations, or sourcing from a different area. Some biomass certifications (e.g., SBP and RSB) may also include additional sustainability criteria relevant to sustainable biomass sourcing (i.e., carbon accounting, indirect land use change, cascading use principle).*[30]

[28] *For an example, see: Advisory Commission on Sustainability of Biomass for Energy Applications. 2019. Public report on the assessment of certification scheme FSC United States against the Dutch legal sustainability criteria for solid biomass for energy applications. Also see Mai-Moulin T et al. 2021 and Rijksdienst voor Ondernemend n.d.*

[29] *Kittler et al. 2020. Assessing the wood sourcing practices of the U.S. industrial wood pellet industry supplying European energy demand. Energy, Sustainability, and Society. 10(23).*

[30] *Given the ongoing evolution of voluntary schemes, it is possible that forest management certifications will eventually adapt to include some of these additional sustainability criteria.*

Criterion 1.2

Biomass must be from jurisdictions with strong forest governance and/or strong oversight of forest certification standards.

Seller shall evaluate corruption for each source country using the Corruption Perception Index (CPI) published by Transparency International, Chatham House Forest Policy Assessments,[31] the World Bank Global Worldwide Governance Indicators,[32] or other equivalent national/subnational assessments of political corruption and regulatory implementation. If Biomass sourced for the project originates from a country with a CPI score of less than 50 for the most recent year available or other resources show an elevated forest governance risk profile, then:

- All Biomass shall be FSC forest management and chain-of-custody certified (i.e., FSC-100%); or
- Seller shall provide exceptional documentation affirming that all Biomass adheres to forest management and chain-of-custody principles that are demonstrably equivalent to FSC forest management and chain-of-custody certification (i.e., FSC-100%); or
- Seller shall avoid sourcing Biomass from such countries.

Explanation

This criterion is intended to mitigate governance risks by requiring biomass to be sourced from jurisdictions with strong forest governance or stringent oversight of forest certification standards. The CPI and similar resources are used to assess the governance landscape of source countries. If a country has low scores on the CPI or is otherwise flagged for forest governance concerns, strict conditions kick in. Either the biomass must be FSC certified both for forest management and chain-of-custody, or the seller must provide compelling documentation proving equivalent standards are met. Alternatively, sellers are advised to simply avoid sourcing biomass from such countries. Buyers may choose to adjust the CPI threshold up to further reduce risk.

[31] *Chatham House. 2023. Forest Governance and Legality.*

[32] *World Bank. 2022. World Governance Indicators.*

Criterion 1.3

Biomass must be fully traceable across the Biomass supply chain from the point of origin to the point of conversion for CDR (e.g., combustion for BECCS).

Option A (Preferred)

Certification through an independent, third-party-audited forest certification standard with complementary chain-of-custody certification that tracks Biomass from the point of harvest from certified forests and keeps non-certified biomass segregated, such as FSC-100% (via FSC-STD-40-004).

Option B

Certification through an independent, third-party audited, chain-of-custody certification standard that tracks Biomass from the point of forest harvest through mass balance, credits, or segregation such as FSC-Mix (via FSC-STD-40-004) or programs compliant with the European Union Deforestation Regulation (EUDR).

Option C

Certification through an auditable chain-of-custody program which traces Biomass supply from the point of origin (e.g., where sawmill residues are produced).

Explanation

Ensuring the sustainability of products within supply chains is a complex task, and chain-of-custody (CoC) is a key method to trace products from their source to their final destination. CoC tracking has historically been a challenging endeavor due to the intricacies of global supply chains and the variety of actors involved. Currently, most forest certifications (and other industries) employ a mass balance approach, which tracks the total input and output without detailing the journey of every product. As such, Option A is aspirational for large-scale projects and likely infeasible in the near term. However, the EUDR[33] is likely to change this landscape by 2026. Under EUDR, operators will be required to provide precise geolocation coordinates for the origin of agricultural products, ensuring traceability down to the point of harvest for forest products. This shift, driven by concerns about deforestation, will ensure greater transparency within the EU market and may drive wider adoption of CoC tracking globally.

[33] *See EU Deforestation Regulation FAQ.*

Principle 2

Biomass must come from sources with operations that minimize negative impacts on local communities, workers, and Indigenous Peoples. Compliance with this principle is met through three criteria.

Criterion 2.1

Biomass must be sourced from wood processing operations that have a low risk of community health impacts and provide a strategy for mitigating any such health risks.

Option A

Any Biomass supply chain that (a) does not involve centralized processing (e.g., most chipped biomass) or (b) where Biomass is a byproduct of pre-existing centralized processing (e.g., sawmill residues) shall be considered compliant with this criterion. The nature of the sourcing and processing methods must be sufficiently documented to demonstrate compliance with (a) or (b) above.

Option B

Seller shall conduct a thorough impact assessment on local communities and workers to evaluate potential health risks associated with wood processing operations. This assessment must include an examination of potential hazards, the vulnerability of the community, and a clearly defined strategy for mitigating identified risks. The assessment shall be transparent and shall involve consultation with local stakeholders (as defined by the Spectrum of Community Engagement to Ownership)[34] and relevant community advocacy groups (e.g., Community Action Agencies) to ensure that community perspectives are adequately represented.

[34] *Facilitating Power. 2021. The Spectrum of Community Engagement to Ownership. [accessed 2024 Dec 18].* https://movementstrategy.org/wp-content/uploads/2021/08/The-Spectrum-of-Community-Engagement-to-Ownership.pdf.

Explanation

While wood processing operations provide economic benefits, they can also pose environmental and health risks, such as air and water pollution. This criterion offers two implementation options to ensure that community health is not compromised. Option A assumes that decentralized processing methods, like chipping, inherently carry a lower risk of community health impacts, thus bypassing the need for additional assessments. Option B, on the other hand, calls for a more proactive approach: conducting a comprehensive impact assessment that takes into account potential hazards and community vulnerability. This option places a strong emphasis on transparency and stakeholder engagement, requiring consultation with local community groups to ensure that all perspectives are considered and adequately addressed. Through these options, the criterion aims to offer a flexible yet robust framework to safeguard community health.

Criterion 2.2

Biomass must be sourced from forest operations that recognize and respect the legal and customary rights of Indigenous Peoples, including both ownership and use of forests beyond economic activity.

Option A (Preferred)

Refer to Criterion 1.1, Option A. Biomass shall be sourced from areas certified under forest management certification programs, such as FSC, that specifically safeguard the rights and interests of Indigenous Peoples.

Option B

Seller shall furnish evidence regarding the ownership of all forest land under management, that there is no dispute regarding ownership, and that the statutory and customary rights of Indigenous Peoples that exist over said managed land, territories, or resources are recognized, included, and respected. This evidence may require the presentation of legal documentation, such as title deeds, court decrees, tribal documentation, or other authoritative records, to verify clear and uncontested ownership, and the absence of any conflicts related to resource rights.

Option C

Seller shall provide substantial evidence demonstrating that no legal or customary rights of Indigenous Peoples are present in the Biomass harvest area. Such evidence must be corroborative and verifiable, confirming that the land is free from disputes related to ownership, usage, or management by Indigenous Peoples or local communities.

Explanation

This criterion aims to ensure that biomass sourcing doesn't infringe on the legal and customary rights of Indigenous communities. The three options increase in flexibility from A to C. Option A leans on established forest management certifications like FSC, which have comprehensive criteria safeguarding the rights and interests of Indigenous Peoples. In doing so, it links this particular concern with a broader set of sustainability measures. Option B is flexible but puts a high burden of proof on the seller to provide evidence affirming that the rights of Indigenous Peoples are recognized and respected. Finally, Option C caters to scenarios where the most efficient pathway is to show that no legal or customary rights of Indigenous Peoples exist in the harvest area. This involves rigorous corroborative evidence, ensuring that the land is genuinely free from disputes. The multiple options make this criterion adaptable to diverse sourcing scenarios while upholding a non-negotiable respect for Indigenous rights.

Criterion 2.3

Biomass must be sourced from forest operations that ensure the economic, environmental, and social well-being of workers, including through fair compensation and respect of labor rights.

Option A (Preferred)

Refer to Criterion 1.1, Option A.

Option B

Refer to Criterion 1.1, Option B.

Option C

Refer to Criterion 1.1, Option C. Risk-based assessment shall at minimum assess the risk of violating the International Labor Organization (ILO) Declaration on Fundamental Principles and Rights at Work.[35]

Explanation

Protecting the rights and well-being of workers is paramount in any forest management operation, and the ILO Declaration on Fundamental Principles and Rights at Work provides foundational global guidelines to this end. For instance, upholding recognized labor rights, ensuring safety in the workplace,[36] and guaranteeing a minimum living wage[37] are essential to ensure the well-being of workers. Adhering to such benchmarks, as exemplified by the ILO Declaration, underscores the organization's dedication to its workforce and reaffirms the critical role of workers in sustainable practices. Existing national and/or subnational governance may satisfactorily meet these benchmarks.

[35] *[ILO] International Labor Organization. 1998, amended 2022. Declaration on Fundamental Principles and Rights at Work.*

[36] *[ILO] International Labor Organization. 2022. A safe and healthy working environment is a fundamental principle and right at work.*

[37] *[ILO] International Labor Organization. 2008. ILO Declaration on Social Justice for a Fair Globalization.*

Principle 3

Biomass must come from sources where it can be produced without threatening protected areas or reducing regional carbon stocks. Compliance with this principle is met through four criteria.

Criterion 3.1

Biomass must not originate from areas of primary forest, as defined by the Food and Agriculture Organization of the United Nations (UN FAO),[38] or old-growth forest, per relevant national and subnational definitions.

Option A

Refer to Criterion 1.1, Options A and B for indicators pertaining to damage or threats to forests of High Conservation Value and other areas with higher likelihood to be primary forests. In addition, Seller must provide evidence (as appropriate to the context) to support assurances that Biomass is not sourced from primary or old-growth forests, as defined by international (i.e., UN FAO), national, and subnational definitions.

Explanation

Sellers shall provide evidence, as specifically as possible, that sourcing of biomass does not come from primary or old-growth forests. Risk-based assessment can utilize available data to recognize and flag potential geographies of concern. Many data sources are available to assist with identifying and measuring the extent of primary forests.[39,40] Please be advised that definitions of primary forest can differ by source, geography, and forest type. Reviews of conflict over primary forests within academic literature and other credible resources can provide specific detail to perform due diligence. In some cases, management of primary and old-growth forest may be condoned by government and/or relevant oversight bodies. Still, these cases are likely to remain contested and pose meaningful risk to the perceived and real sustainability of biomass.

[38] *[UN FAO] Food and Agriculture Organization of the United Nations. 2020. FAO Global Forest Resources Assessment 2020.*

[39] *See methods for measuring, monitoring and mapping primary forest and potential data sources in: Mackey B et al. 2021. A review of definitions, data, and methods for country-level assessment and reporting of primary forest. Griffith Climate Action Beacon. 1–21.*

[40] *See a recent European primary forest database in Sabatini FM et al. 2021. European primary forest database v2.0. Scientific data. 8(1): 220.*

Criterion 3.2

Biomass must come from forest management operations that do not threaten areas designated as protected or High Conservation Value forests, except where forest harvest is explicitly recognized in the designation.

Option A

Refer to Criterion 1.1, Option A.

Option B

Refer to Criterion 1.1, Option B.

Option C

Refer to Criterion 1.1, Option C. Risk-based assessment shall at minimum assess the risk of sourcing Biomass from IUCN Protected Area Category I or II and High Conservation Value areas, except where forest harvest is explicitly recognized in the designation.

Explanation

Sellers shall provide evidence, as specifically as possible, that sourcing of biomass does not come from primary or old-growth forest. Risk-based assessment can utilize available data to recognize and flag potential geographies of concern. Many data sources are available to assist with identifying and measuring the extent of primary forests.[40,41] *Please be advised that definitions of primary forest can differ by source, geography, and forest type. Reviews of conflict over primary forests within academic and popular media sources can provide specific detail to perform due diligence.*

Criterion 3.3

Biomass must come from forest management operations that maintain or enhance ecological function including, critically: biodiversity, nutrient cycling, soil health, forest regeneration, landscape connectivity, and hydrologic function.

Option A

Refer to Criterion 1.1, Option A.

Option B

Refer to Criterion 1.1, Option B.

Option C

Refer to Criterion 1.1, Option C.

Explanation

The procurement of biomass from forests necessitates an expansive ecological perspective, extending beyond immediate concerns such as protecting primary forests. This criterion specifies that forest management operations maintain or enhance a comprehensive set of ecological functions. This includes forest regeneration and natural succession processes, ensuring that forests have the capability to rejuvenate and progress through various ecological stages autonomously. Furthermore, the criterion emphasizes the protection of genetic, species, and ecosystem diversity, and the maintenance of natural cycles affecting the forest ecosystem's productivity. This includes, for example, retention of biomass, like stumps and slash, in the forest after harvest to maintain sufficient nutrient cycling.[41] The operationalization of these ecological standards is best achieved through forest management certifications such as FSC and PEFC. These certifications offer stringent guidelines and undergo rigorous auditing procedures to ascertain that forest management sustains or enhances ecological function.

[41] *Janowiak MK and Webster CR. 2010. Promoting ecological sustainability in woody biomass harvesting. Journal of Forestry. 108(1): 16–23.*

Criterion 3.4

Biomass must be from regions where forest stocks are increasing or in steady-state, except where changes in forest carbon stock can be directly attributed to management for ecological restoration or widespread ecological disturbance.

Option A (Preferred)

Both Option B and Option C shall be satisfied for the same Sourcing Area and for the most recent time period that the data permits.

Option B

Seller shall provide an independent, third-party assessment of forest carbon stocks in the Sourcing Area which is based on public inventory data. This assessment must demonstrate that the forest carbon stock has not decreased during the last five years for which data are available, compared to the average forest carbon stock in the previous five-year period. Data for live, aboveground biomass (standing stocking level) must be included, and deadwood pools may be included if reliable data are available.

Option C

Seller shall provide evidence that Land Use, Land-Use Change, and Forestry (LULUCF) emissions from the forestry sector (Category 4A) in the country of harvest do not exceed removals. This requirement is met if, over the last 10 years, the average net emissions from the forestry sector are zero or negative, as reported in national greenhouse gas emissions to the UN Convention on Climate Change. In countries of harvest greater than five million square kilometers, Seller shall provide additional evidence that forest carbon stocks in the Sourcing Area are not decreasing over the same period.

Option D

In specific exceptional situations, such as wood removal from areas affected by windfall, fires, insect, or disease attacks, or where wood is removed for widely-recognized ecological reasons (e.g., to reduce wildfire hazard), Sourcing Area carbon stocks need not be steady or increasing. Thorough documentation must be provided to demonstrate the specific nature of the disturbance, or the ecological necessity of the wood removal, and how this circumstance complies with the intent of the criterion.

Explanation

The primary intent of this criterion is to avoid situations where biomass demand drives diminished forest carbon stocks. This is one of the most difficult and contentious topics in biomass sourcing and will require evolving guidance as market consensus emerges. Most biomass-based CDR projects assume that biomass feedstock is carbon neutral, but this assumption is invalidated if harvesting leads to reduced carbon in source forests. Both temporal and spatial scales are critical to this assumption, as well: the use of different scales can lead to divergent conclusions on whether carbon stocks are stable.

This effect is not limited to just aboveground carbon, but other pools are often left out of regional inventory programs. For example, losses from soils in some ecosystems may delay the net carbon recovery after harvest.[42] Further, in some cases, background carbon stocks may be increasing absent biomass demand. In these cases, even stable carbon stocks would be insufficient to prove biomass carbon neutrality, because some of that carbon would remain stored if not harvested. While the above options are a practical starting place, they do not fully capture the range of considerations and may still allow for inaccurate carbon accounting. The magnitude of this challenge will scale with the industry as deployment increases.

[42] *Hamburg SP et al. 2019. Losses of mineral soil carbon largely offset biomass accumulation 15 years after whole-tree harvest in a northern hardwood forest. Biogeochemistry. 144: 1–14*

Principle 4

Biomass must come from sources that do not distort markets for agriculture or forestry products. Compliance with this principle is met through three criteria.

Criterion 4.1

Biomass must be a by-product of non-energy products or services.

Option A

Seller shall furnish competent and independent third-party analysis of wood and biomass feedstock markets for each Sourcing Area showing that Biomass is a by-product of non-energy products or services. In this case, "by-product" indicates that less than 50% of the total processed biomass, by both volume and value, is allocated for energy or CDR purposes. This analysis shall include, wherever available, assessment of Biomass characteristics, regional sawmill capacity and realized utilization, and any relative prices of delivered wood feedstocks, inclusive of at least processed biomass, pulpwood, and sawtimber. If the analysis finds that local sawmill production is markedly declining relative to the average utilization from the past five years, further affirmative documentation shall be provided by Seller. This documentation must analyze whether that decline has resulted from Seller's demand for Biomass that would otherwise be used for long-lived wood products. Documentation must be provided to verify this analysis, including detailed information about the composition, source, and intended use of the harvested wood.

Option B

In specific exceptional situations, such as areas affected by windfall, fires, insect or disease attacks, where legislation mandates the removal of wood, or where wood is removed for widely-recognized ecological reasons (e.g., to reduce wildfire hazard), the by-product rule may be relaxed. Thorough documentation must be provided to demonstrate the specific nature of the disturbance, the legislative requirement, or the ecological necessity of the wood removal, and how this circumstance complies with the intent of the criterion.

Explanation

The intent of this criterion is to avoid biomass-based CDR and bioenergy becoming the dominant market for forest products. The industry is still aligning on a practical definition of what constitutes a by-product. Some cases offer clear examples of waste material from forest management, like slash piles that would be burned in the absence of demand for CDR. At the same time, there are many ambiguous cases. For example, logs with a diameter at breast height (DBH) of <10 inches (25cm) may be suitable for pulp and paper production or may have no viable use, depending on the market context. Even for clear waste materials, the marginal revenue from biomass may still enable expanded management, which may have positive or negative effects. To avoid ambiguity, "by-product" is defined here in the broadest possible way (i.e., less than 50% of total product). This definition does not work in isolation, though: it augments the other criteria, like Criterion 4.2, to reduce the risk that biomass demand is causing adverse outcomes. Buyers may choose to reduce the 50% threshold to further mitigate risk in specific contexts. This criterion will evolve with the industry as frameworks for cascading use are widely adopted. For Option B, care should be taken to confirm that biomass removal is justified and aligned with ecologically sound forest management.

Criterion 4.2

Biomass must be sourced from wood for which carbon accounting will transparently and conservatively reflect existing, economical counterfactual Biomass uses.

Option A (Preferred)

In alignment with Criterion 4.1, Seller shall furnish competent and independent third-party analysis of wood and Biomass markets for each Sourcing Area which shows the most likely counterfactual scenarios for Biomass across all relevant size classes (i.e., a business-as-usual scenario). The analysis must consider existing, economical uses for each class of wood, reflecting market trends in the source region. The analysis shall also include a breakdown of feedstock material used for Biomass by size class.

The analysis shall be conducted at the Sourcing Area scale or smaller and may include, wherever available and in alignment with Criterion 4.1, non-comprehensive assessment of Biomass characteristics, regional sawmill capacity and realized utilization, and any relative prices of delivered wood feedstocks, inclusive of at least processed biomass, pulpwood, and sawtimber. The analysis shall also, within reason, indicate sources of emissions in the Biomass supply chain upstream of CDR conversion as well as the duration of counterfactual carbon storage.

Option B

Biomass shall be certified under SBP version 2.0 or higher, RSB Standard, or a biomass certification program that equivalently demonstrates that Biomass sourcing does not directly divert wood from long-lived wood products.

Explanation

Biomass frequently has a counterfactual fate that involves carbon storage, including through natural processes like forest decay. Accounting for these potential counterfactuals is essential for understanding the true carbon benefits of biomass-based CDR. This criterion ensures the availability of the data necessary for accurate carbon accounting. It does not describe how carbon accounting should be approached, nor is it prescriptive about determining the “best” or “highest value” use for any particular piece of biomass. Beyond counterfactual fate of biomass, the necessary data includes clear reporting of upstream emission sources and the duration for which carbon will remain stored in the counterfactual scenario. The timing of carbon storage is particularly salient for determining when effective CDR occurs, relative to the counterfactual scenario. Promoting rigorous carbon accounting not only ensures that the impact on the atmosphere is well-understood, but it also creates market incentives that can encourage the highest value uses for biomass. Eventually, counterfactual accounting should work to include market dynamics, such as the relationship between pulpwood, sawtimber, and sawmill residue production. Option B does not explicitly satisfy the need for a counterfactual scenario, but biomass certifications can reduce the risk of the worst outcomes, partially validating carbon neutrality assumptions.

Criterion 4.3

Biomass must not be sourced from plantation forests established within the past 20 years, unless the prior land use was agriculture (pasture or row crop) for 10 or more continuous years and natural regeneration is very unlikely. Plantation forest is understood to meet the definition used in the UN FAO Forest Resource Assessment: "Planted forest which is intensively managed and meets all the following criteria at planting and stand maturity: one or two species, even age class, and regular spacing. Plantation forests are established for the production of timber, fiber, energy and non-wood forest products." Plantation forest is also understood to "lack key elements of natural forests native to the area, such as species composition and structural diversity," as defined in the Accountability Framework Initiative.

Option A

Seller shall document evidence of adherence with this criterion within each harvest area, such as through remote sensing analysis or historical land use records. The likelihood of natural regeneration shall be evaluated across the Sourcing Area.

Explanation

Plantation forests, although valuable for economic and social reasons, often lack the biodiversity and complex ecological functions of natural forests. Biomass production through plantation forestry may also be associated with land use changes, both positive and negative. This criterion takes a conservative approach until frameworks for land use change are widely adopted for application to biomass-based CDR. However, an exception is made for land that has a clear history of agricultural land use in order to allow for cases where land use change may have positive impacts (e.g., additional carbon storage). In these cases, it is critical that the likelihood of natural forest regeneration is low to reduce the risk of plantation establishment displacing new natural forests. This conservative, nuanced approach allows for the sustainable use of agricultural lands while prioritizing the protection and restoration of natural forest ecosystems. Additional work will be needed to further mitigate risks from land use change.

Appendix: Biomass Certification Schemes

Table 1. *Prominent voluntary and regulatory certification schemes that certify forest biomass.*

Title	Voluntary or Regulatory	Status	Date of last update	Geographical scope
Better Biomass	Voluntary	Active	April 12th, 2022	Global, based out of Netherlands
Bioenergy Renewable Auction Mechanism (BioRAM)	Regulatory	Active	September, 2018	California
Biomass Biofuels voluntary scheme (2BSvs)	Voluntary	Active	June 14, 2022	Global
Green Gold Label (GGL)	Voluntary	Active	May, 2018	Global
International Sustainability and Carbon Certification (ISCC EU)	Voluntary	Active	July, 2023	Global
KZR INig system	Voluntary	Active	December 14th, 2022	Global, but primarily Poland
Netherlands Programme Sustainable Biomass (NPBS)	Regulatory	Inactive	Last updated in 2013	Netherlands
Responsible Biomass Program (RBP)	Regulatory	Active	August, 2022	Denmark
Roundtable on Sustainable Biomaterials (RSB)	Voluntary	Active	March 22, 2022	Global
Sustainable Biomass Program (SBP)	Voluntary	Active	June 16, 2023	Global
Sustainable Resources (SURE)	Voluntary	Active	October, 2020	Global

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