

Sustainable Biomass Sourcing Principles

Overview

Biomass is an attractive resource for cost-effective permanent carbon dioxide removal. It leverages photosynthesis to do the energy-intensive work of removing CO_2 from the atmosphere for free, and the biomass can be used to produce valuable coproducts like hydrogen, electricity, or bio-coke as part of the carbon removal process. These coproducts can serve to effectively subsidize the cost of carbon removal from biomass, as well as displace fossil fuel emissions associated with producing the products today.

However, biomass can be potentially problematic feedstock for carbon removal. There is a risk of supporting activities that could degrade ecosystems, displace existing utilization by communities, and have overall low net-negativity due to moving otherwise stable above-ground carbon stores into geologic storage.¹ There is an ongoing debate over biomass sourcing and its climate and ecosystem impacts, and concerns over some existing <u>practices</u>.

To ensure the responsible development and scaling of biomass-based carbon removal, Frontier has developed six high-level biomass sourcing principles that build on the deep thinking of many in the ecosystem on this topic. These principles are first used to diligence a supplier's biomass sourcing strategy and then used on an ongoing basis to ensure each ton of carbon removal delivered comes from biomass that meets these criteria.

High-level biomass sourcing principles

1. <u>Endorse biomass for carbon removal where there is no other, stronger near-term use case from a</u> <u>climate, ecosystem, or human impact perspective</u>

There is a sizable amount of biomass that could potentially be used for carbon removal. For example, the <u>BiCRS Roadmap</u> suggests that around 5.5 Gt of biomass could be used each year globally with minimal environmental impact. At the same time, using this biomass is not without tradeoffs. Biomass left on soils can add nutrients or contribute to soil organic carbon, while woody biomass not used for bioenergy carbon capture and storage (BECCS) might go toward other valuable applications. Larger stemwood or energy crops used as a feedstock may displace lumber or food production to other areas, resulting in secondary land use changes that undermine their climate benefits.

This is far from an academic question: today around 40% of the corn grown in the US is used for biofuels², and an <u>extensive literature review</u> of life cycle assessment studies suggests that corn ethanol may only be marginally beneficial for the climate compared to gasoline due to fossil energy inputs and secondary (indirect) land use impacts. When we approach a potential biomass feedstock, we will

¹ Fajardy and Mac Dowell 2017; Fajardy et al 2019; Brander et al 2021

² Ramsey et al 2023



carefully consider what alternative uses there may be for the biomass that will maximize benefits while minimizing negative impacts on the climate, ecosystems, markets, and food systems.

We will ensure that utilization of biomass feedstocks follows the cascading principle of biomass use established in the European Commission RED II Directive, which specifies that biomass should be used according to its highest economic and environmental added value. This includes accounting for other potential near-term uses of waste biomass for mitigation – such as the production of sustainable aviation fuels – before determining if carbon removal is the most effective use of a particular feedstock.



The optimal balance between economic and environmental added value involves some value judgment, and we will need to carefully assess both current and potential near-term utilization options for biomass feedstocks in the absence of their use for carbon removal.

2. Avoid substituting above ground durable carbon stocks for geologic storage

Carbon removal generated from biomass feedstocks effectively occurs when those feedstocks would have otherwise decayed and released their carbon content back to the atmosphere. If carbon removal is counted substantially in advance of when counterfactual decay would have otherwise occurred, it risks creating incentives to substitute durable above ground carbon stocks for geologic storage. This requires effectively quantifying when the carbon content would otherwise have been released for any biomass feedstocks utilized for carbon removal.

For some biomass feedstocks this is relatively straightforward: corn stover left in fields, small branches and leaves on forest floors, residues from sawmills or pulp and paper operations, and almond shells that are currently fed to burn piles are all examples of where atmospheric release of carbon content is expected to occur relatively quickly (e.g. often within 15 years). Where biomass is in excess of the amount necessary to be left on the land for nutrient cycling, this represents a useful feedstock for bio-based



carbon removal. For feedstocks where counterfactual decay can be clearly demonstrated to be rapid (e.g. will fully decompose on sub-15-year timescales), there is minimal risk of substituting durable biomass carbon storage for geologic sequestration.

In other cases the carbon content may have remained out of the atmosphere for decades in the absence of its use for carbon removal. This includes trees that would have otherwise remained standing, a portion of biomass waste that is currently landfilled, or biomass that would otherwise have been used for building materials or other durable storage pathways. These relatively stable carbon stocks should not count toward carbon removal over the period in which they would have remained out of the atmosphere in the absence of the project.³ It will be important to evaluate different biomass feedstocks on a case-by-case basis; for example, trees killed by natural factors - insect, disease, fire and blowdown – may take decades to fully re-release their carbon content in the absence of use for carbon removal – or may re-release that carbon rapidly if located in fire-prone or moist ecosystems.

We will also assess any secondary land use impacts from changes in agricultural or forestry production resulting from the creation of markets for waste. These effects may be hard to fully predict; for example, if payment for forestry residues results in prolonged management of forests, it could actually increase net CO_2 uptake as younger trees sequester more CO_2 per annum than unmanaged forests, provided that primary timber products are durable. Alternatively, an increase in the area of forest harvested or acres of crops planted could result in net land use change emissions that undermine the effectiveness of the carbon removal.

Before selecting to move forward with a project, we will undertake an assessment of the counterfactual durability and use of any given biomass source, as well as the secondary impacts on forestry or planting decisions of paying for waste streams.

3. <u>Ensure that sourcing biomass from a managed system does not reduce the stock of carbon in that</u> <u>system over time</u>

We will ensure that the rate of harvest from a managed system does not exceed the rate of regrowth within the system on sub-decadal timescales. The production of biomass feedstock necessarily requires removing some carbon from a system. If these processes are not clearly measured, there is a risk of decreasing the overall carbon stock in a system over time, effectively running afoul of the principle to avoid substituting above ground durable carbon stocks for geologic storage outlined above. To avoid this, it is important to ensure that when biomass feedstocks are sourced from managed systems, those systems are at a minimum not losing net carbon stored in the system over time (including both above-ground and below-ground carbon pools).

This can be verified in practice by a combination of remote sensing imagery and on the ground inspection or surveys. However, care still needs to be taken to ensure that system boundaries are drawn

³ Note that there is an ongoing discussion among registries and other market participants about whether the counterfactual decay timeline might be bridged by avoided emissions for biomass currently disposed of in ways that produce large amounts of methane.

at a landscape level in a way that does not game baselines and raise additionality concerns. For example, if the system would otherwise be gaining significant amounts of biomass over time (e.g. because of intensive clearcutting and replanting in the past), that does not necessarily justify the removal of additional biomass to keep stocks constant. We want to make sure – to the extent possible – that the demand for biomass feedstock for carbon removal does not result in a reduction in the stock of carbon in the system over time relative to the counterfactual case where that feedstock was not used for carbon removal.

We will aim for independent, third-party assessment of forest carbon stocks in the sourcing area to demonstrate that the forest carbon stock has increased (or at a minimum not decreased) during the last five years for which data are available compared to the prior five-year period. At a minimum, we will ensure that biomass is not sourced for carbon removal from countries where land use (LULUCF) emissions from the forestry sector harvest exceed removals⁴, though national-level accounting alone is insufficient to ensure increasing carbon stocks without accompanying strong regulatory controls. In addition, continuous monitoring of carbon stocks (including both aboveground and below-ground) should occur over the course of any project. If unintended imbalances in the carbon stock are found, the sourcing process should be adjusted to correct imbalances and mitigate future alterations in the system's carbon stock.

There are some exceptional circumstances, such as woody biomass removal from areas affected by windfall, fires, insects, or disease attacks, or where wood is removed for widely-recognized ecological reasons (e.g., to reduce wildfire hazard) where sourcing area carbon stocks need not be steady or increasing. Thorough documentation must be provided to demonstrate the specific nature of the disturbance and the ecological necessity of the wood removal.

4. Utilize existing waste and residues over purpose grown biomass

Whenever possible, we want to prioritize using waste and residue biomass – that otherwise does not have a utilization pathway today – over purpose-grown biomass. This means avoiding using purpose-grown energy crops as biomass feedstock, or managing timber plantations solely for bioenergy or carbon removal.

In practice, the differentiation between waste and non-waste biomass tends to be much clearer for agricultural systems than for woody biomass. In agricultural systems the crop residues (corn stover, rice husks, almond shells, etc.) have few cost-effective use cases today and are generally plowed into the soils or burnt. We will ensure that for biomass in use today (e.g. the role of residues in adding nitrogen, potassium, and phosphorus to soils), the project life cycle assessment is inclusive of any additional emissions (e.g. fertilizer production) required to replace its current use.

⁴Any country-level accounting should use a more conservative last 10 year period and require that 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.

For woody biomass, the definition of waste is often somewhat circular, with waste being defined as any wood that is not commercially viable as timber or other valuable products. Left unchecked, this could be used to justify nearly anything to be used as biomass feedstock provided that there is no more commercially viable use readily available. Some sources are more clearly identifiable as waste than others (e.g. tops and branches, residues from sawmills, black liquor from pulp and paper production, or residues from wildfire management), and these should be prioritized. Additional safeguards are necessary here, including avoiding harvesting forests solely for biomass feedstock and avoiding the use of larger-diameter stem wood outside of cases where fire damage, insect damage, cracking, warping, or other flaws makes them otherwise not economically utilizable.

When utilizing waste, it is important to leave enough residues behind to maintain ecosystem health, as decaying leaves and bark, crop residues, etc. provide important nutrients and soil organic carbon benefits. The specific portion that should be retained will vary by system and require expert input to assess.

Finally, there are some cases where purpose-grown biomass may be considered if there is no risk of displacing agricultural or other activities. For example, perennial grass established on fallow lands or bioenergy crops grown on marginal or degraded lands that are not usable for food crops. Given the challenge of verifying the absence of viable uses in practice, however, Frontier will generally avoid purchasing from BiCRS projects using non-waste (e.g. purpose-grown) biomass until stronger standards and best-practices are developed.

5. <u>Use feedstocks with sustainable sourcing certification from highly regulated jurisdictions while avoiding</u> sourcing from primary forests or supporting forest conversion.

Maximizing net carbon removal is not the only goal of sustainable biomass. We will ensure that systems we source biomass from also are managed to avoid soil erosion, habitat destruction, and depletion of biodiversity among other environmental impacts. We will aim to require that woody biomass feedstocks are sourced from forests that are Forest Stewardship Council (FSC) certified or utilize a comparably robust sustainability certification (e.g. PEFC, SFI or SBP). Companies sourcing biomass should ideally abide by the same principles as the biomass procurer across their operations.

Forests can be broadly classified as managed plantations, secondary forests, or primary forests.⁵ As a general principle, we will avoid sourcing biomass from projects that involve the conversion of primary or secondary forests to managed plantations even if there is no net loss in forest carbon stocks over time between the forest and managed plantation. This is due to the ecosystem benefits (biodiversity, habitat, etc.) of natural forest systems over managed plantations, as plantations generally have reduced species richness compared to natural systems. We will apply this principle retrospectively (e.g. in the case of a

⁵ Primary forests are those that have remained relatively undisturbed by human activity. Secondary forests have been logged in the past. These may or may not be actively managed for timber products, but are left to grow naturally. Managed plantations are actively managed purposefully planted systems.



natural forest converted to a managed plantation a year ago), though how far back this should be applied remains somewhat unclear.⁶

Primary forests are those that have to-date remained relatively undisturbed by human activity, and hold particular ecological significance. Frontier will avoid sourcing waste or non-waste biomass from commercial timber operations in primary (old growth) forests or other high-integrity ecosystems (e.g. those that are proven to have exceptional biodiversity benefits or other unique significance, including cultural significance). While the utilization of waste biomass is generally preferable to letting it decompose, the risk of indirectly supporting primary forest loss or degradation associated with paying for waste is unacceptably high, as is the risk to the social license of carbon removal if it is associated with primary forest loss.

The exception is for biomass waste produced as a byproduct of thinning for forest fire management and similar activities intended to improve the long-term health of primary or secondary forest systems. Even here, clear safeguards are needed to ensure that commercial forestry is not being pursued under the guise of forest fire management.

The use of biomass feedstock from secondary forests is a more complex issue; for example, many national and state forests in the United States are managed for multiple uses, including both timber production and recreation. We recommend closely evaluating projects relying on waste biomass feedstocks from these on a case-by-case basis, and ensuring that projects have third-party sustainability certification.

Many parts of the world lack clear property rights to forested areas or may have multiple use claims on the same system. We will prioritize sourcing woody biomass from forests in highly regulated jurisdictions, where we trust that regulations are being enforced and where an evidence chain can be provided. We will also ensure that the sourcing of woody biomass will not displace other activities such as non-timber forest products utilized by local communities or result in the displacement of communities that exist within or in proximity to the forested areas.

Finally, we will require proactive engagement with local communities on biomass practices and ensure that fair labor standards are followed. This should be reflected in a community benefit plan, or similar community impact assessment, that evaluates accessibility, community stakeholder engagement, health and wellbeing, and job creation.

6. <u>Undertake a comprehensive accounting of project lifecycle emissions</u>

When assessing the sourcing of biomass feedstocks we need to ensure a thorough accounting of life cycle impacts and their effects on the net-negativity of the resulting project. This means setting appropriate system boundaries, including accounting for life cycle assessment (LCA) components like

⁶ FSC, SBP and RED offer dates after which conversion cannot have occurred, e.g. 1 Jan 2008. SBTi uses 20 years in their <u>FLAG</u> <u>guidance</u>.





Sustainable Biomass Sourcing Decision Tree