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Undoing Equivalence: Rethinking Carbon Accounting for Just Carbon Removal

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Concerns are increasingly raised over the centrality of carbon removal in climate policy, particularly in the guise of "net-zero" targets. Most significantly perhaps, treating emissions and removals as equivalent obscures emission reductions, resulting in "mitigation deterrence." Yet the conflation of emission reductions and removals is only one among several implicit equivalences in carbon removal accounting. Here, we examine three other forms—carbon, geographical, and temporal equivalence—and discuss their implications for climate justice and the environmental risks with carbon removal. We conclude that "undoing" these equivalences would further a just response to the climate crisis and tentatively explore what such undoing might look like in practice.

Keywords: carbon removal, negative emissions, equivalence, carbon accounting, climate justice, net-zero

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INTRODUCTION

Carbon removal is steadily making its way into mainstream climate governance. As countries and corporations embrace net-zero emission goals, the ambition to remove large amounts of carbon from the atmosphere is becoming an implied if not always outspoken pillar of mitigation policies. This development raises a number of, by now, well-known concerns about the feasibility of proposed "negative emission technologies" (Low and Schäfer, 2020; Waller et al., 2020) and the likely environmental and social justice impacts of their implementation (Dooley and Kartha, 2018; Doelman et al., 2020). These concerns remain largely invisible in the modeled pathways that assume large-scale deployment of negative emissions later in this century (Larkin et al., 2017; Beck and Mahony, 2018). Apprehensions are also voiced about the likely "moral hazard" or "mitigation deterrence" effects that promises of future carbon removal have on current emission reduction efforts (Anderson and Peters, 2016; McLaren, 2020; McLaren and Markusson, 2020).

To address some of these issues, McLaren et al. (2019) propose to disaggregate net-zero targets into separate objectives for carbon removal and emission reductions. Doing so, they argue, would "expose interests and politics" in the formulation of emission targets and "reveal both where negative emissions investment and development is inadequate, and where negative emissions (or future promises thereof) could undermine emissions reduction" (p. 4). McLaren et al.'s proposal reflects a long-standing social science critique of carbon accounting as an often misguided exercise in "making things the same" (MacKenzie, 2009).

This critique asserts that common carbon accounting practices are rendering disparate technologies, socioeconomic contexts, and climate change temporalities equivalent, while concerns for climate justice and environmental integrity demand that they are kept separate (Lohmann, 2009, 2011). It fundamentally questions the idea that a ton of CO_2 should be treated as functionally equivalent irrespective of how, where or when it is avoided, removed, or stored. While "a ton is a ton" might be a useful abstraction for creating and apportioning carbon budgets, the argument goes, it is a poor guide in the design of climate policy, where different options for mitigation and their distribution in time and space correspond to radically different values, socioeconomic effects, and risk profiles (Lövbrand, 2009; Corbera and Brown, 2010; Leach and Scoones, 2015; Turnhout et al., 2015). Hence, while carbon accounting fulfills an important function to create consistency and unity in assessing progress toward identified targets, the specific forms it takes are not neutral and require close consideration.

Seen in this light, the conflation of removals and emission reductions that McLaren et al. are concerned with, is one among several implicit equivalences in carbon accounting. In this perspective piece, we critically examine the social and environmental implications of three other equivalences. We argue that these too must be undone as part of a movement toward ensuring socially and environmentally just carbon removal and mitigation policies—which require that states with greater capability take the lead on climate action and that the needs of the most vulnerable are protected against the effects of climate change and of measures taken to limit it (Shue, 2019; Dooley et al., 2021). While concerns over the equivalences that we examine have long been raised in the social science literature on e.g., carbon accounting and carbon markets (Lohmann, 2009; Carton et al., 2020), they are now resurfacing under the guise of a rapidly evolving carbon removal agenda, and therefore warrant being discussed and scrutinized as part of this new conversation.

UNDOING EQUIVALENCE

We describe three common forms of equivalence in carbon accounting and discuss their implications for climate justice concerns and risks with respect to carbon removal. We then suggest what "undoing" these equivalences might look like in practice.

Carbon Equivalence

Carbon accounting often renders fossil and biotic forms of carbon, i.e., from fossil fuels vs. land use, land use change, and forestry, equivalent. Both categories of carbon are commonly included under the same climate targets, which allows fossil fuel emissions to be "offset" by increases in biological carbon sequestration. The European Union's new 2030 "net-emissions" target, for instance, now includes forests and land use within the bloc's overall mitigation target, which though constrained by accounting rules introduces a degree of flexibility between fossil and land sector emissions (Kulovesi and Oberthür, 2020). Such accounting practices are responding to political rather than scientific considerations and involve a number of risks and complexities (Lövbrand, 2004; Höhne et al., 2007), raising concerns about the weakening of targets (Climate Action Tracker, 2020). While the technical accounting difficulties with making fossil and biotic carbon equivalent have long been recognized, the social, environmental, and climate implications often remain obscured (Fogel, 2005; Dooley and Gupta, 2017).

A key concern with this equivalence pertains to the different timescales involved: fossil carbon sinks are essentially permanent (or inert) if left unused, while biotic carbon is part of the short-term (or active) carbon cycle. While accounting systems try to deal with the risk of reversal from biotic sinks in various ways, for example through temporary crediting, these solutions do not take away the long-term uncertainties involved (Brander et al., 2021). The different temporal characteristics of fossil vs. biotic carbon represent a fundamental barrier to equivalence.

Mackey et al. (2013) explain why using carbon sinks on land as a means to "offset" emissions from burning fossil fuels is scientifically flawed. Current terrestrial removal and storage potential primarily reflects the depletion of carbon sinks due to past land use. Since the capacity of forests and other ecosystems to sequester carbon is finite, increasing carbon in terrestrial sinks simply replaces carbon that has been lost to the atmosphere over past centuries. Fossil carbon, on the other hand, is permanently locked away. Thus, burning fossil fuels moves carbon from permanent storage into the active carbon cycle, causing an aggregate increase in land, ocean, and atmospheric carbon. Once added, this additional carbon cannot be removed through natural sinks on time-scales relevant to climate mitigation, leading to increased warming (Steffen et al., 2016).

Rendering biotic and fossil carbon equivalent also conflates the drivers of climate change. It obscures whether mitigation is achieved through reduced fossil emissions or increased biotic sequestration (Dooley and Gupta, 2017), suggesting that full decarbonization of the energy sector can be avoided (or delayed) by sufficient "greening" in the land sector. However, the technological, social, and economic transitions required in these sectors differ significantly, as do their relative contributions to climate change. Considering them fully fungible therefore has considerable social and environmental implications. Bioenergy with carbon capture and storage (BECCS), for example, is promoted as a biotic carbon removal solution that largely overcomes the permanence issue by geologically sequestering the carbon captured from bioenergy combustion. Yet treating BECCS as a solution to continued fossil fuel emissions implicitly shifts the burden of mitigation from energy, industry, and transport to the land use sector, with ramifications for distributional justice and ecosystem functioning (Buck, 2016; DeCicco and Schlesinger, 2018; Seddon et al., 2020).

A similar suite of issues arises from the establishment of equivalence across different biotic systems. The quality, integrity, and stability of biotic carbon stocks differs between different land-uses. Ecosystem integrity and function, including carbon storage, depends on biodiversity (Labrière et al., 2016), with diverse intact natural ecosystems known to be more resilient and stable than monocultures of non-native species (Seddon et al., 2019). Yet, carbon accounting systems do not differentiate between the "quality" of terrestrial carbon stocks on the basis of ecosystem health or diversity (Keith et al., 2021).

A just framing of carbon removal would require separate accounting and policy agendas on biotic and fossil fuel emissions. Such separation was already recommended several decades ago (WGBU, 1998) and has recently reappeared in the academic and political debate (NewClimate Institute, 2020; Skelton et al., 2020; Smith, 2021). Separation would help avoid the substitution of fossil fuel emission reductions for land-based actions that risk exacerbating climate injustices through environmental and social impacts. Rather than using biotic carbon removals to compensate for past, ongoing, or residual fossil emissions, restricting removals on a sectoral basis (e.g., land-based removals for land-based emissions) would encourage improved agricultural practices, minimize reliance on land sequestration, and force a faster transformation of sectors reliant on fossil fuels (Upton, 2019).

A further step should be to separate different land-based efforts, recognizing that these come with very different social and ecological implications. A further undoing of equivalences within the "biotic carbon" category is therefore necessary. Actions that minimize problems of impermanence through geological storage (such as BECCS) or create equivalences between terrestrial carbon stocks of different quality (such as between diverse forest ecosystems and monoculture plantations) need to be assessed for their impacts and risks related to *both* social impacts *and* biodiversity, ecosystems, and mitigation effectiveness. Taken together, this means that research and policy agendas need to distinguish between emissions avoided or removed in the land sector; the difference in quality of carbon stocks between different land-uses and ecosystems; and mitigation action in sectors reliant on fossil fuels.

Geographical Equivalence

A second equivalence embedded in carbon accounting is between carbon emissions and removals across different geographies, i.e., across locations that differ widely in terms of their biophysical and socio-political characteristics.

Climate change is commonly construed as a global problem where the spatial location of emissions and removals is irrelevant. It is also widely seen as a problem that should be mitigated at the lowest possible cost, a principle that is written into the U.N. Framework Convention on Climate Change (Article 3.3) (Boyd et al., 2009). This combination of factors makes the idea of geographical equivalence intuitively appealing. From a neoclassical economics perspective, differences in the marginal costs of mitigation efforts across the world derive from comparative advantage premised on different innate abilities and preferences, i.e., some places provide better conditions for carbon removal than others and some people prefer low-carbon lifestyles over others. This logic has given rise to a variety of mechanisms to facilitate the international exchange of mitigation responsibilities, allowing countries and corporations to finance climate action elsewhere to meet their targets. The use of carbon removal within such mechanisms is already common practice on the voluntary carbon market and is actively discussed in the context of a future trading mechanism under the Paris Agreement (Mace et al., 2021).

Carbon removal and storage does come with specific geo- and biophysical conditions that lend support to geographical equivalence and the international exchange of removal responsibilities. Geological storage capacity, for instance, is unevenly distributed across space, implying that some countries will be unable to store captured CO_2 within their jurisdictions (Kelemen et al., 2019; Wei et al., 2021). Similarly, higher biological sequestration rates in the tropics favors them as locations for afforestation/reforestation and bioenergy production in global estimates of mitigation potentials (Griscom et al., 2017). Yet prioritizing such geo- and biophysical conditions in global carbon removal estimates tends to disregard important social and political factors that put these estimates in question (Creutzig et al., 2021), and that caution against the adoption of geographical equivalence. Studies that identify "available" locations for land-based carbon removal (Griscom et al., 2017; Bastin et al., 2019; Pozo et al., 2020), for instance, commonly disregard the existing uses and users (such as pastoralists) of these areas. This amounts to a discursive marginalization of certain land uses and users and may implicitly legitimate processes of "green grabbing" (Fairhead et al., 2012).

Similarly, the notion of comparative advantage, which underpins the alleged mutual benefits of exchanging mitigation responsibilities, has been repeatedly criticized for disregarding global inequality and power structures (Sheppard, 2012; McAfee, 2016). Critics point out that the differences allowing for market exchange reflect uneven capacities and opportunities within a structurally unequal world, and are predicated on historical and present exploitation and unequal power relations (Smith, 2008). Focusing on cost-effectiveness as the driving criterion for the location of carbon removal efforts will therefore, inter alia, tend to reproduce climate injustices (Fairhead et al., 2012).

We currently see rapid growth in the use of offsetting to offer "climate neutral" products and services and/or to make good on corporate and country-level net-zero pledges (Gross, 2020; NewClimate Institute, 2020). Many of these promises build on geographical equivalence, where offsetting occurs through carbon removal—often in the form of afforestation projects—in countries in the global South. This incentivizes delay—by providing cheap alternatives to difficult or inconvenient emission reductions—and deepens climate injustice in several ways. First, by depriving poor nations and regions of "cheap" carbon removal options, making their path toward the coveted "net-zero" harder, while giving wealthy nations and regions an easier path toward realizing the same goal (Rogelj et al., 2021). Second, by limiting the livelihood opportunities afforded to poor (mostly rural) people so that a wealthy global elite can continue its ways (Shue, 2017; Gore et al., 2020). Third, by facilitating the continued release of fossil carbon into the atmosphere (Pearse and Böhm, 2014; Green, 2021), thereby contributing to future demand for carbon removal rollout as well as inflicting more severe climate damages that will shape the lives of poor and vulnerable people in the global South the most [Intergovernmental Panel on Climate Change (IPCC), 2014a].

Just climate policy requires that we abandon the notion of geographical equivalence. Undoing the equivalence between biotic and fossil carbon would contribute toward undoing geographical equivalence in practice, because much of the offsetting done by global North corporations occurs via forest offsets. However, further efforts are necessary to avoid the deepening of climate injustices entailed by global carbon markets. This involves a stronger prioritization of domestic or at least regional mitigation efforts, and a move away from global market mechanisms that neglect differentiated social and economic capabilities. Efforts to reform such mechanisms have so far failed to curb their negative social fallout as well as concerns related to additionality and leakage, among others (Asiyanbi and Lund, 2020; Cullenward and Victor, 2020; West et al., 2020). Current discussions surrounding voluntary market standards and a possible global compliance market under the Paris Agreement do not indicate a substantial break with failures of the past (Timperley, 2019; Harvey, 2021), hence offer little hope that markets can be reformed to the extent needed. Rather than relying on the principle of geographical equivalence, shared responsibility for carbon removal must start from an acknowledgment of wealthy nations' historical responsibility for climate change and a moral imperative that mandates against shifting the burden and risks associated with removal to poor and vulnerable parts of the world. Ultimately, this means decoupling support for mitigation and adaptation efforts in the global South from any trade in carbon removal claims.

Temporal Equivalence

A third prominent equivalence in discussions on carbon removal is between present (and near-term) mitigation actions, and those projected to occur in the more distant future. This temporal equivalence underpins much of the current discourse on large-scale removal but raises a number of concerns.

Proposals for large-scale removal derive from modeled pathways that seek to stay within 1.5 or 2°C warming limits. In the majority of these pathways carbon removal compensates for a temporary overshoot of the temperature target [Intergovernmental Panel on Climate Change (IPCC), 2014b, 2018]. For instance, more than 80% of scenarios in the IPCC's Special Report on 1.5°C overshoot the 1.5°C temperature threshold before returning to these levels using large-scale carbon removal in the second half of the twenty-first century [Intergovernmental Panel on Climate Change (IPCC), 2018; Rogelj et al., 2019]. This use of temperature overshoot and subsequent decline suggests that it does not matter when, over the next 80 years, mitigation actions occur, as long as the end-result by 2100 stays within agreed-upon temperature targets. It assumes substitutability between emission reductions in the near-term and further-off removals, a notion that is rapidly being institutionalized in net-zero targets. It is this equivalence that most directly lies behind concerns with "mitigation deterrence," because if it does not matter *when* we balance the carbon budget, then there might be incentives to push uncomfortable and difficult decisions and investments into the future.

The idea that future actions can straightforwardly be substituted for present ones is however problematic. For one, as Anderson and Peters (2016) point out, it neglects the different risk profiles that characterize different time horizons: we know what can be done in the present and what technologies are available, and can therefore reasonably assess their risks, flaws, and economic and political feasibility. Future removals on the other hand often rely on technologies that are hypothetical at scale and their roll-out is therefore inherently more difficult to assess. Second, significant uncertainties remain concerning future climate feedback processes and tipping points (Tokarska and Zickfeld, 2015; Lenton et al., 2019; Creutzig et al., 2021), which could affect the effectiveness of carbon removal to reduce temperatures (Rogelj et al., 2018, p. 127). If increased warming weakens natural carbon sinks (Hubau et al., 2020; Li et al., 2020; Wang et al., 2020; Duffy et al., 2021) or turns them into sources of carbon emissions (Wang et al., 2018), then assumptions about our ability to bring down atmospheric CO_2 concentrations in the second half of the century might prove overly optimistic.

Third, equating present with future actions ignores potentially important differences in the climate damages and mitigation burdens that occur as a result of different peak CO_2 concentrations. While the geophysical implications of temporary temperature overshoot remain unclear (Geden and Löschel, 2017), an increasing amount of research points to levels of sea level rise, changes in ocean circulation, and changes in other aspects of the cryosphere that exceed those under straightforward temperature stabilization scenarios and that would be difficult to reverse (Palter et al., 2018; ICCINET, 2019). In other words, while temperature overshoots might be reversible, this is not necessarily the case for other climate and geophysical dynamics. Fourth, the more societies push actions into the future, the greater the scale at which removals will need to happen, and the larger the social and economic burdens associated with mitigation [Intergovernmental Panel on Climate Change (IPCC), 2018]. Rapid short-term emission reductions also entail a significant burden, but there are clear societal co-benefits from transitioning to a renewable energy-oriented transport and industry system, and from making agricultural systems more sustainable. That is not necessarily the case with large-scale carbon removal. Technologies such as Direct Air Capture would likely be a pure cost to society, while in the case of "natural climate solutions" any co-benefits are highly dependent on the form and scale they end up taking [Intergovernmental Panel on Climate Change (IPCC), 2019; Fyson et al., 2020].

Cutting across these different concerns are the uneven intergenerational effects of temporal equivalence. As Shue (2017) notes, the conflation of present with future climate actions entails a risk-transfer to future generations, in which the people deciding that future removal is a reasonable strategy to pursue are different from those that will need to deal with any of the consequences arising should that strategy fail. Substituting near-term mitigation for future removals "sentences young people to either a massive, implausible cleanup or growing deleterious climate impacts or both' (Hansen et al., 2016, p. 578). This occurs against a background where any costs of mitigating climate change in the face of insufficient removal will be significantly larger than today, and where those costs and consequences are likely to disproportionately fall on the poorest.

A commitment to climate justice therefore demands a clear distinction between actions in the present, and more hypothetical, future promises of mitigation (mostly in the form of carbon removal). It demands the introduction of barriers to substitution, for example by moving away from the use of high discount rates in models, which value future generations less than present ones (Stanton et al., 2009) and hence facilitate substitution and bias results in favor of future removals (Emmerling et al., 2019). Foregrounding justice considerations also requires constraints on the use of overshoot scenarios (Geden and Löschel, 2017) and a carbon accounting system that internalizes the considerable added risks of delaying mitigation, for instance by institutionalizing a risk premium in mitigation pathways. For policy makers, minimizing risk transfer means much stronger prioritization of ambitious near-term actions over distant mitigation targets and open acknowledgment of the important differences between the two. This would guarantee that a majority of the mitigation burden is borne by those most responsible for the problem.

CONCLUSION

In sum, we argue that a just research and policy agenda on carbon removal needs to, first, distinguish between removals in the land use sector, and emissions from the use of fossil fuels in energy production, industry and transport. The purpose here should be to question the logic that allows biotic carbon sinks to be used as offsets for fossil fuel emissions, while also problematizing substitution between biotic sinks without regard for ecosystem quality or justice effects. Second, it needs to resist the temptations of global markets in carbon removal, where the domestic climate obligations of corporations or countries are substituted for removals in distant, often less affluent places. Such cost-shifting perpetuates existing inequalities by outsourcing the responsibility for climate action on economic grounds. Third, it needs to take a cautionary approach to tipping points, climate feedbacks, and the reversibility of climate impacts so as to avoid shifting the risks of climate change onto future generations. Taking these risks seriously would significantly constrain the use of future carbon removal as a way to compensate for continued emissions, and allow an open discussion on when such strategy might be justified, and when it is not.

In practice, the three equivalences that we have discussed are difficult to keep apart. They do not stand side by side but in numerous ways overlap and intersect with each other, and with the "net" equivalence that McLaren et al. (2019) problematize. Attention to these interrelations highlights that the problems and perverse incentives characterizing the carbon removal conversation run deeper than the conflation of removals and emission reductions alone—acknowledgment of which might help overcome some of the criticisms raised against a proposed undoing of the "net" equivalence (see Smith, 2021). Indeed, our discussion here does not exhaust the full range of concerns pervading the construction of equivalence in climate research and policy (Lohmann, 2011). Other equivalences are worthy of renewed scrutiny as well, including for example the conflation of different greenhouse gas emissions under a single CO_2 equivalent metric (see e.g., MacKenzie, 2009; Cooper, 2015). In this article, we merely sought to illustrate how common approaches to carbon accounting tend to disregard important social, environmental, and geophysical differences—among others—between different sources and sinks of greenhouse gas emissions. This accounting logic serves the interest of simplicity, substitutability, and economic flexibility but introduces important social and environmental concerns that undermine climate justice. It is time to acknowledge that carbon accounting equivalences are political choices fulfilling political functions, with important consequences for climate policy. If researchers and policy makers are serious about incorporating social and environmental justice considerations into their climate mitigation work, then models and accounting frameworks must make explicit, and indeed actively minimize, the risks involved in the creation of multiple equivalences.

Beyond separate targets for emission reductions and removals, we also need differentiated targets and policies that separate land-use from fossil fuel emissions, and that prioritize and incentivize near-term domestic actions, using existing technologies, over distant net-zero targets. This would help to direct wealthy corporations and nations—those mainly responsible for climate change and most capable of mitigating it—toward ambitious emissions reductions and just forms of carbon removal, putting us on a path toward stabilizing the climate.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

WC conceived of the article idea and drafted the introduction, the section on temporal equivalence, and the conclusion. JL drafted the section on geographical equivalence. KD drafted the section on carbon equivalence. All authors helped conceptualize the argument and contributed to extensive editing and revising of the text.

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