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Towards a climate change ambition that (better) integrates biodiversity and land use

Alexandra Deprez, Lola Vallejo, Aleksandar Rankovic (IDDRI)

The climate change and biodiversity loss crises require an ambitious, coordinated response. Addressing them separately—as has largely been the case to date—risks compromising the world's ability to successfully halt climate change while preserving ecosystems and meeting other sustainable development goals. The recent high-level focus on Nature-Based Solutions (NBS) at the UN Climate Summit shows growing awareness that ecosystems conservation is a win-win-win solution for climate adaptation, mitigation and biodiversity. The Paris Agreement's 2050 carbon neutrality goal, and the recent Beijing Call for Biodiversity Conservation and Climate Change also evidence an emerging convergence between the two issues in the international political agenda.

Yet still lacking are open discussions on the specifics of *what* a coordinated ambitious response to climate change and biodiversity loss would actually look like, especially given the severely negative biodiversity impacts of some climate mitigation 'solutions' when deployed at a large scale.

This *Study* argues for the need to integrate biodiversity into ambitious climate action. This requires paying close attention to *how* the 1.5°C goal is reached, as some 1.5°C emission reductions pathways can be compatible with biodiversity protection, while others—namely those relying on widespread carbon-dioxide removal (CDR) deployment, through the use of widespread BECCS or afforestation—are set to severely negatively impact biodiversity. This paper primarily focuses on the climate-biodiversity nexus on land, but its main conclusions could also apply to the ocean.

KEY MESSAGES

The Paris Agreement's carbon neutrality goal requires a greater reliance on carbon sinks, therefore placing ecosystems at the centre of ambitious climate action. Yet despite the useful development of NBS, silos between climate and biodiversity responses remain in science, international governance, and civil society. It is therefore necessary to increase coordination between climate action and biodiversity conservation.

Crossing recent IPCC and IPBES reports and scientific literature—as done in this *Study*—reveals that some 1.5°C decarbonisation pathways raise severe risks for biodiversity and food security. Climate ambition should therefore be redefined as limiting temperature rise to 1.5°C through emission reduction pathways that are biodiversity and food security compatible.

Maximising climate and biodiversity synergies and minimising trade-offs requires (1) rapid and deep energy system decarbonisation and AFOLU emissions reduction, (2) significant energy demand reduction, and food system transformation (e.g. food waste reduction, diet shift), (3) optimisation of carbon sequestration in current land use, while conserving biodiversity, and (4) refrain from widespread deployment of land-based mitigation/CDR measures such as BECCS, which require massive land use change and have highly detrimental biodiversity impacts.

To support the integration of ambitious climate change and biodiversity action in national policies, increased coordinated action is needed internationally in science (scientific communities, IPCC and IPBES), international governance (between UNFCCC, CBD and UNCCD), and civil society.

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1. THE CLIMATE-BIODIVERSITY NEXUS: A FUNDAMENTALLY INTERWOVEN AMBITION

Climate change and biodiversity must be addressed urgently and ambitiously. While the scientific community warns that even 1.5°C warming will have significant impacts on human societies and ecosystems, countries' current nationally determined contribution (NDCs) submitted under the Paris Climate Agreement set the world on a 3°C or greater warming path (IPCC 1.5 SPM, 2018), well above the Paris Agreement's "well below 2°C" goal. Meanwhile, widespread biodiversity loss is occurring worldwide, with over 1 million species threatened with extinction in the coming decades if the main anthropogenic drivers (especially land use change, overexploitation of species, and climate change) are not reduced (IPBES SPM, 2019). The IPCC and IPBES' recent reports are clear: to address these crises, society-wide transformations across economic sectors are required throughout the coming decade.

As the crises worsen and the magnitude of the needed responses rise, the interconnections between climate change and biodiversity are becoming more accentuated. The scientific community's shift of focus from assessing the state of the crises to detailing the transformative responses needed is shedding greater light on these interactions. On the one hand, ecosystems play a major role in mitigating climate change and helping our societies adapt to it. Yet climate change accentuates biodiversity loss, and some climate mitigation measures have very detrimental biodiversity impacts, while others may promote biodiversity conservation. On the other hand, accelerating biodiversity loss may compromise the world's ability to successfully mitigate and adapt to climate change, while at the same time preserve the natural life system upon which human societies depend, and also pursue other societal goals such as ensuring food security and eradicating poverty.

The profound interactions between the climate change and biodiversity crises and solutions point to the urgency of better coordinating responses. Scientists, policymakers, and civil society must take a systemic look so as to overcome disciplinary silos and bridge the issue-specific international governance processes (e.g. UNFCCC, CBD, CCD, and marine governance), which despite some coordinated efforts have mostly evolved in parallel over the past 25 years. At the time, setting separate negotiation processes made sense for breaking a complex set of problems into actionable issues. Yet, when it comes to implementing solutions, the issues are in reality tightly interwoven, and increasingly so as the crises worsen.

To be successful, the strategies for addressing the climate and biodiversity crises must also acknowledge governments' economic and social development goals, and particularly the goal of ensuring food security (Sustainable Development Goal (SDG) number 2). These three goals are highly interdependent: food security is negatively impacted by biodiversity loss (Aizen *et al.*, 2019), as well as by climate change, with even a 1.5°C temperature rise projected to negatively affect agricultural yields (IPCC 1.5 SPM, 2018). Yet prioritising food security may also lead to tensions with climate and biodiversity efforts, especially around competing land uses (although "win-win-win" measures do exist) (IPCC Land SPM, 2019).

Three imperatives therefore emerge for advancing coordinated and ambitious climate and biodiversity action: 1) the climate ambition imperative, 2) the biodiversity ambition imperative, and 3) the sustainable land use imperative.

1.1. The climate ambition imperative: the importance of the 1.5°C goal for people and biodiversity

Ambitious climate mitigation is imperative to protect human societies and biodiversity from dangerous levels of climate change (i.e. above 2°C), and ambitious adaptation is important for human societies and natural ecosystems to face current and future warming (IPCC 1.5 SPM, 2018).

This paper focuses primarily on climate mitigation rather than adaptation, for two main reasons. First, because biodiversity conservation is already a commonly admitted climate adaptation strategy, with the CBD and UNFCCC promoting for the past several years Parties to undertake Ecosystem-Based Adaptation (Chong, 2014), and NBS. Secondly, because our entry point for this paper was to respect the carbon neutrality objective present in the Paris Agreement, and how to attain the ambitious 1.5°C climate objective, which requires reaching net-zero CO_2 emissions by around 2050 (IPCC 1.5 SPM, 2018).

The IPCC is clear: maintaining temperature rise to 1.5°C rather than 2°C markedly reduces the negative impacts of climate change on sustainable development goals such as eradicating poverty, reducing inequalities and ensuring food security (IPCC 1.5 SPM, 2018), and reduces adaptation needs (IPCC 1.5 SPM, 2018).

Ambitious climate action is also essential for biodiversity, as incremental global warming worsens negative biodiversity impacts sometimes exponentially (IPBES SPM, 2019). The IPBES finds that "even for global warming of 1.5°C to 2°C, the majority of terrestrial species ranges are projected to shrink profoundly," reducing the efficacy of national parks and other protected areas to preserve biodiversity, and significantly amplifying the risk of global extinctions: 5% of all species risk climate-related extinction at 2°C warming, versus 16% of species at 4.3°C warming (IPBES SPM, 2019).

The IPBES insists that limiting temperature rise to 1.5°C "plays a critical role in reducing adverse impacts on nature and its contributions to people" (IPBES SPM, 2019). Twice as many insect, plant, and vertebrate species are set to see their "climatically determined geographic range" slashed by 50% at 2°C than at 1.5°C warming (IPCC 1.5 SPM, 2018).[1] Limiting warming to 1.5°C rather than 2°C would also reduce by half the global natural land area at risk of climate-related degradation (especially tundra and boreal forests) (IPCC 1.5 SPM, 2018), and reduce other biodiversity risks (e.g. forest fires and invasive species dissemination) (IPCC 1.5 SPM, 2018). A 1.5°C (rather than 2°C) reduces ocean acidification and decreases of ocean oxygen levels, therefore limiting risks to marine ecosystems (IPCC 1.5 SPM, 2018), and especially coral reefs: at 2°C warming only 10-30% of their previous surface will remain, and at 1.5°C only 1% (IPBES SPM, 2019).

Therefore, limiting temperature rise at 1.5°C rather than at 2°C is essential. To attain the 1.5°C temperature goal, and the associated carbon neutrality goal around 2050, societies will need to take one of various 1.5°C pathways requiring deep emissions cuts and removal of carbon dioxide from the atmosphere—so called 'negative emissions.' Each pathway is comprised of a combination of mitigation and carbon-dioxide removal (CDR) measures, deployed at scales ranging from low to extensive. Mitigation measures span primarily across the energy sector and Agriculture, Forestry, and Other Land Use (AFOLU) sector, while the primary CDR measures projected in 1.5°C pathways are bioenergy carbon capture and storage (BECCS) and afforestation (IPCC 1.5 SPM, 2018). BECCS refers to the process of growing trees or crops to produce bioenergy for heating, electricity and fuels, while capturing the CO_2 released during the combustion process and storing it underground in geological formations. This process has not yet been tested at scale.

To depict the variety of possible paths to reach 1.5°C, the IPCC describes four illustrative pathways in its *1.5°C Special Report (SR) Summary for Policymakers*. These scenarios differ significantly in (1) how they use the energy and land (AFOLU) sectors to reduce emissions, (2) the emissions reduction timeline (rapid or late), and (3) the consequent extent of negative emissions (and hence CDR deployment) needed to reach 1.5°C.

Box 1 describes the key characteristics of two of these illustrative 1.5°C pathways: a late decarbonisation and BECCS intensive pathway (so-called 'P4'), and a rapid emissions reduction and decarbonisation pathway (so-called 'P2').[2]

BOX 1. KEY CHARACTERISTICS OF P2 AND P4 ILLUSTRATIVE MODEL PATHWAYS

P4 - Late decarbonisation & BECCS intensive pathway. In **P4** global CO_2 emissions grow strongly through 2020 and remain high through 2030 (37 Gt CO_2 emissions in 2030, versus 19 $GtCO_2$ emissions in 2030 for P2), are then halved between 2030 and 2040, and finally drastically reduced between 2040 and 2050 (going from 22 $GtCO_2$ in 2040 to 1 $GtCO_2$ in 2050) (Huppman *et al.*, 2018). Energy demand rises heavily (a 44 % increase in 2050 as relative to 2010), resulting in a rise of fossil fuel use through 2030 (almost exclusively non-CCS), and a primary energy production throughout 2030 to 2050 about 60% larger than that of P2 (Huppman *et al.*, 2018). To reach the 1.5°C goal in spite of these higher emissions, two measures are deployed in P4. First, a rapid decarbonisation of the energy system starting in 2030 but accelerating between 2040 and 2050 (non-CCS fossil-fuel energy goes from representing over half of total primary energy production in 2040 to 23% in 2050) (Huppman *et al.*, 2018). Second, massive deployment of CDR, primarily in the form of BECCS: energy production from BECCS rises exponentially between 2030 and 2050 (from 9 EJ/yr to 296 EJ/yr), resulting in 33% of global cropland in 2050 dedicated to bioenergy crops (Huppman *et al.*, 2018). The AFOLU sector is not managed to maximise emission reductions or carbon storage, and demand for livestock products rises considerably (a 68% between 2010 and 2050) (Huppman *et al.*, 2018). P4's high emissions result in a higher temperature overshoot probability (i.e. a temporary rise of temperatures well above 1.5°C throughout the 21st century) (IPCC 1.5 SPM, 2018).

1 Of 105,000 species studied, the number of insects at risk at 1.5°C warming are 9.6% versus 18% at 2°C, for plants 8% versus 16%, and for vertebrates 4% versus 8% (IPCC SPM 1.5, 2018).

2 Both pathways are drawn from the IPCC 1.5°C database which compiles over 200 climate scenarios that fed into the SR (Huppman *et al.*, 2018). P4 corresponds to the to the scenario *SSP5 REMIND-MAgPIE 1.5*, and P2 to *AIM/CGE 2.0 SSP1-19*.

P2 - Rapid emissions reduction and decarbonisation pathway. In contrast, **P2** is characterised by deep and progressive emissions reductions down to net-zero: emissions are halved between 2020 and 2030, again between 2030 and 2040, and reduced from 8 Gt CO_2 in 2040 to 2 in 2050 (Huppman *et al.*, 2018). These deep cuts are conducted in three main ways: (1) through significant demand reduction in the energy and agricultural sectors: i.e. energy demand reduction (only a 2% increase in energy demand in 2050 relative to 2010 (Huppman *et al.*, 2018), food loss and food waste reduction, and diet shift, (2) early energy system decarbonisation (e.g. fossil fuel energy production is almost halved between 2020 and 2030 (Huppman *et al.*, 2018)), and (3) the AFOLU sector managed for emissions reductions and increased carbon sink capacity (IPCC 1.5 SPM, 2018). Due to its early decarbonisation and emissions reduction, P2 does not have to recur to extensive CDR. Indeed, it uses some afforestation,[3] and very little BECCS: only 7% of agricultural land in 2050 is allocated to bioenergy crops (Huppman *et al.*, 2018). The likelihood of temperature overshoot in this pathway is little to none (IPCC 1.5 SPM, 2018).

1.2. The biodiversity ambition imperative: different 1.5°C worlds have different consequences for biodiversity

Tackling climate change while at the same time protecting biodiversity is essential, for several reasons. To start, because biodiversity is the natural life system upon which human societies depend to flourish, so preserving it is essential for our own survival (IPBES SPM, 2019). Furthermore, biodiversity and ecosystem conservation also supports adaptation to the climate impacts we are locked into (IPBES SPM, 2019), and offers significant mitigation potential: 'natural climate solutions' including conservation and restoration of natural ecosystems, and improved agricultural management can provide over a third of the mitigation needed up to 2030 to reach the 2°C, when implemented with biodiversity safeguards (Griscom *et al.*, 2017; see Anderson *et al.*, 2019, for an example of debates). Finally, it is becoming clear that failing to protect biodiversity and natural ecosystems will likely compromise our ability to meet ambitious climate goals while preserving food security, thus paving the way for rising tensions over time (IPBES SPM, 2019). Recent research also finds that climate change may reduce terrestrial and marine species' ability to absorb carbon, in turn potentially increasing by an additional 0.4°C above the previously calculated warming (Lade *et al,* 2019).

How the 1.5°C climate goal is reached is relevant for ambitious biodiversity conservation: indeed, it is necessary to pay close attention to the type of pathways used to reach 1.5°C, because while different pathways may attain the same climate goal, their biodiversity outcomes can differ widely. This because each mitigation and CDR measure has its own impact on biodiversity which can range widely from very positive to very detrimental, depending on each measure's intrinsic nature and how widely it is deployed in a particular pathway. For example, regarding BECCS, Hof *et al.* assess that a 1.5°C world with vast BECCS deployment would have a worse biodiversity impact than a 4°C world without bioenergy use (Hof *et al.*, 2018).

In this sense, comparing P2 and P4 scenarios helps to illustrate the biodiversity and food security impacts of different ways of reaching the 1.5°C goal. The very high usage of cropland for BECCS in P4 presages greater conflict with food security and other biodiversity conservation land uses than in P2.

The temperature overshoot likelihood of each pathway also leads to different biodiversity outcomes. A pathway such as P4 with a high temperature overshoot probability (i.e. a temporary rise over the 21st century of global temperatures above 1.7°C, before stabilising at 1.5°C) has a greater negative biodiversity impact than one with little to no overshoot probability (e.g. P2). This since reducing temperature of 1.7°C to 1.5°C necessitates very high levels of CDR deployment throughout the 21st century (IPCC 1.5 SPM, 2018; D.1.2), which are projected to have highly negative biodiversity impacts (IPBES SPM, 2019).

As climate ambition remains a priority, the aim should therefore be to shift the world onto a 1.5°C pathway that protects rather than destroys biodiversity.

1.3. The sustainable land use imperative: essential to ensure harmonious climate, biodiversity, and food security outcomes

Climate change and biodiversity ambition require paying close attention to land use, as it will be the main arena in which the climate change-biodiversity-food security nexus will unfold. This either towards increasingly severe tensions or towards a more harmonious balance between the land uses implied by these three goals.[4] The IPCC finds that land-based mitigation and removal of carbon dioxide is essential to reach carbon neutrality by 2050 (IPCC 1.5 SPM, 2018). Yet based on the type of emissions pathway deployed, the land-based mitigation/CDR component can range from being either compatible with biodiversity and food security goals, or result in intense land-use conflicts (IPBES SPM, 2019). Section 2.3 provides a more in-depth discussion of these land measures and their impacts.

To address climate change and biodiversity in a coordinated and ambitious manner, it is essential to place our societies on

3 The IPCC 1.5°C database does not specify the extent of afforestation deployment in P2.

4 The ocean is another important arena of climate-biodiversity interaction (see eds. H.- O. Pörtner *et al.*, 2019; IPCC Special Report on the Ocean and Cryosphere in a Changing Climate), and various ocean-based climate mitigation measures with potentially large mitigation impacts exist or are being developed (Gattuso *et al.*, 2018). Yet since the mitigation and CDR measures considered by 1.5°C climate scenarios and discussed in the IPCC 1.5 SR are on land, this paper primarily focuses on the climate-biodiversity nexus on land rather than in the ocean.

emissions reduction pathways that are compatible with biodiversity and food security goals. Therefore, climate ambition should be redefined as *rapid climate action to reach 1.5°C in a way that is biodiversity and food security-compatible*. In turn, biodiversity action should only be considered as truly ambitious if it takes profoundly into account the biodiversity impact not only of climate change *but of climate mitigation measures and their combinations across different emission reduction pathways*. In the context of finite land, we must maximise synergies and minimise trade-offs between climate and biodiversity responses. The rest of this paper presents evidence and discusses *why* and *how* to do so.

2. A TALE OF TWO 1.5 °C NET-ZERO WORLDS, AND THEIR CONSEQUENCES ON BIODIVERSITY (AND FOOD SECURITY)

2.1. Knowledge gaps on biodiversity-climate interaction

Fully maximising climate-biodiversity synergies and minimising trade-offs requires understanding how mitigation/CDR measures impact biodiversity and food security, when these measures are deployed in combinations needed in 1.5°C pathways. Recent IPCC and IPBES reports, as well as other recent scientific papers provide some degree of overview of different climate mitigation and CDR measures' impacts on biodiversity, yet no comprehensive overview exists to date of the different 1.5°C climate pathways' biodiversity impacts.

Indeed, at present the information available is limited as follows:

— 1. **On impact:** A comprehensive overview of mitigation and CDR measures' biodiversity and food security impacts appears to be limited. The IPCC SR Land assesses the food security impacts of land-based mitigation/CDR measures primarily when they are deployed at a large scale.[5] Concerning biodiversity impact—which was outside the scope of the IPCC SR Land—data is more fragmented: some research articles discuss the impacts of specific measures, yet to date the IPCC and the IPBES have not comprehensively assessed impacts from a range of measures.

— 2. **On deployment:** The over 200 1.5°C climate scenarios included in the IPCC 1.5°C database (Huppman *et al.*, 2018) only detail deployment data for BECCS and energy-based mitigation measures, not AFOLU ones.

It is important that the climate and biodiversity scientific communities work to close this knowledge gap, and that this research then feeds up to the IPCC and IPBES.

2.2. Overview of mitigation/CDR measures' and 1.5°C pathways' biodiversity impacts

Despite these knowledge gaps, clear synergies and trade-offs between the climate and biodiversity responses can be identified based on the latest IPCC and IPBES assessment reports, as well as recent scientific articles. It is in this context that we advance here a schematic representation of the impacts of mitigation/CDR measures on biodiversity and food security (Table 1), and an overview of the synergies and trade-offs of two types of 1.5°C pathways (Figure 1).

Table 1 presents an assessment of mitigation and CDR measures' impacts on biodiversity and food security, when the measures are deployed at a large scale (i.e. resulting in significant GHG sequestration).[6] Food security impacts are drawn from the IPCC SR Land and 1.5 reports,[7] while biodiversity impacts are assessed based on expert judgement and synthesis of available literature (IPCC, IPBES, and other peer-reviewed articles).[8]

Figure 1 depicts the biodiversity and food security impacts of the mitigation measures when deployed at scale in two 1.5°C emission reduction pathways: one with late energy transition and massive BECCS deployment (i.e. P4) and one with rapid energy transition, carbon sequestration in AFOLU and little CDR (i.e. P2). In this way, Figure 1 provides a schematic overview of the potential main negative or positive impacts on biodiversity that a BECCS-intensive pathway or a rapid deep decarbonisation and resource-sobriety 1.5°C pathway may have on biodiversity and food security.

1.5°C pathways with rapid and profound energy system transition (e.g. P2) are the most compatible with biodiversity and food security. The least compatible pathways are likely those that include climate inaction at present, and in latter decades decarbonisation and widespread BECCS dependency (e.g. P4). In the context of climate ambition and sustainable land use, the IPCC SR Land encourages namely two set of actions: (1) rapid and ambitious decarbonisation and emissions reductions through the energy and AFOLU sectors, and (2) promotion of land and forest management measures that capture carbon

5 Defined in the IPCC SR Land as providing sequestration of over 3 $GtCO_2$/yr. The report also assesses the impacts of BECCS, reforestation, afforestation, biochar when deployed at lower levels with best practices (IPCC Land SPM, 2019).

6 As per the 3 $GtCO_2$/yr IPCC Land SR definition. We therefore only assess here measures that have this high GHG emissions reduction potential. For AFOLU, we take up the measures that the IPCC Land SR lists as having this potential, (except for agroforestry and increased soil organic matter) (IPCC Land SPM, 2019). For CDR, we only take up BECCS and afforestation, the two CDR measures deployed extensively in 1.5°C scenarios (IPCC 1.5 SPM, 2018).

7 The food security impacts of AFOLU measures, BECCS, and bioenergy without CCS are drawn from IPCC Land SPM, Figure 3. The impact of the other energy sources and reduced energy demand are drawn from IPCC Land, CH 5. p.481-485.

8 No single criteria exist to assess the biodiversity impact across mitigation/CDR measures, in contrast with climate mitigation (CO_2 emissions) or food security (amount of food insecure people).

TABLE 1. Potential biodiversity and food security impacts of two 1.5°C climate pathways

MITIGATING CLIMATE CHANGE	CONSERVING BIODIVERSITY	ENSURING FOOD SECURITY
ENERGY SYSTEM DECARBONIZATION		
Renewables (bioenergy w/o CCS)	negative, large	negative, large
Renewables (hydro)	negative, moderate	
Renewables (wind, solar, geo.)	negative, small	
Nuclear	negative, small	NA
Fossil fuels (w/ CCS)	negative, moderate	
Reduced energy demand	positive, large	
AFOLU (Agriculture, forest and other land use)		
Ag. intensification (industrial)	negative, large	positive, moderate
Ag. intensification (agro-ecological)	positive, moderate	positive, large
Reduced deforestation	positive, large	positive, small
Reforestation (plantation-based)	negative, moderate	negative, moderate
Reforestation (natural regeneration)	positive, large	negative, moderate
Afforestation	negative, moderate	negative, large
Food loss & waste reduction	positive, large	positive, large
Dietary change	positive, large	positive, large
BECCS (Bioenergy with carbon capture and storage)		
BECCS	negative, large	negative, large

Magnitude of impact of each climate mitigation measure (when measure is deployed at scale)

positive / negative: large, moderate, small

Note: The magnitude of mitigation measures' biodiversity and food security impacts are not additive. The NA sign is to be understood as there being no direct interaction between those energy sector measures and food security (IPCC Land, CH 5. p.481-485).

within current land use rather than by recurring to massive new land conversion (IPCC Land SPM, 2019). While the report highlights primarily their food security, desertification, and land degradation related benefits, these actions at the same time also benefit biodiversity. In contrast, widespread BECCS deployment in coming decades would be highly negative for food security (IPCC Land SPM, 2019), as well as biodiversity (IPBES SPM, 2019; Hof *et al.*, 2018).

This begs the question: why is a late decarbonisation and widespread BECCS dependency pathway (i.e. P4) being presented in IPCC SR 1.5 as a viable 1.5°C pathway if it is set to have such highly negative biodiversity impacts? Two possible reasons are as follows. First, because it is a plausible future: indeed, given current trends, a significant expansion of energy demand, with late decarbonisation, is certainly a possibility for the future. This namely due to the difficulty of implementing demand side measures of reducing energy demand, food waste and loss, and of shifting diets, as well as the demonstrated difficulties of implementing NBS such as forest conservation and reforestation, even if they are cost-beneficial climate solutions. Second, this could also be viewed as symptomatic of the current disconnect between the climate and biodiversity expertise and international discussions.

2.3. Overview of biodiversity and food security impacts of mitigation/CDR measures when deployed at scale

All types of energy sources—both fossil-fuel and low-carbon—have a negative impact on biodiversity. This impact can range from insignificant to very large, based on each measure's inherent characteristics (e.g. land footprint, pollution and risks), and how widely they are deployed in a specific climate pathway.

Bioenergy and BECCS

Widespread bioenergy deployment (be it with CCS (i.e. BECCS) or without it)[9] has by far the largest negative biodiversity impact of all low-carbon energy sources (IPBES, 2019; CH 6). This is in addition to two other concerns regarding BECCS. First, the open questions BECCS faces regarding its net climate benefits (i.e. whether it would truly produce more energy than is needed to run the process) (IPCC Land, 2019; CH 6.3). Second, how widespread bioenergy deployment, by expanding into subsistence agricultural land, may raise the number of food insecure people by over 150 million (IPCC Land SPM, 2019), resulting in heightened local conflict and placing at risk the SDGs that depend on land-based resources (IPBES SPM, 2019).

Current modern **bioenergy** practices,[10] notably those in Europe, already face heavy criticism for their significant biodiversity impacts when safeguards are not put in place (Searchinger *et al.*, 2018). 800 scientists recently heavily denounced the EU's current biomass policy as causing the indiscriminate and widespread logging of forest in Southwest United States, and putting at risk of logging other forested areas worldwide (Beddington *et al.*, 2018).

In turn, widespread bioenergy (and especially widespread **BECCS**) deployment in the future[11] may have highly detrimental impacts on biodiversity that may be even difficult to clearly fathom today. The negative biodiversity impact of widespread bioenergy first results from the massive land footprint that it is expected to have. For instance, the P4-BECCS intensive pathway

9 The IPCC Land SPM defines 'high level' BECCS deployment as 11.3 $GtCO_2$/yr.

10 'Modern' biomass, in contrast to traditional biomass used in developing countries.

11 The levels of projected BECCS deployment in P4 in 2050 (16.1 $GtCO_2$/yr carbon-dioxide removal) are well above the IPCC Land SPM's 'high level' BECCS deployment (11.3 $GtCO_2$/yr).

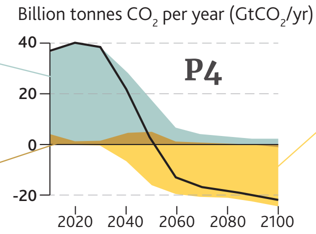
FIGURE 1. Overview of climate mitigation measures' biodiversity and food security impacts

A tale of two 1.5 °C net-zero worlds...

The role of the energy system, AFOLU, and BECCS in two 1.5°C pathways[1]

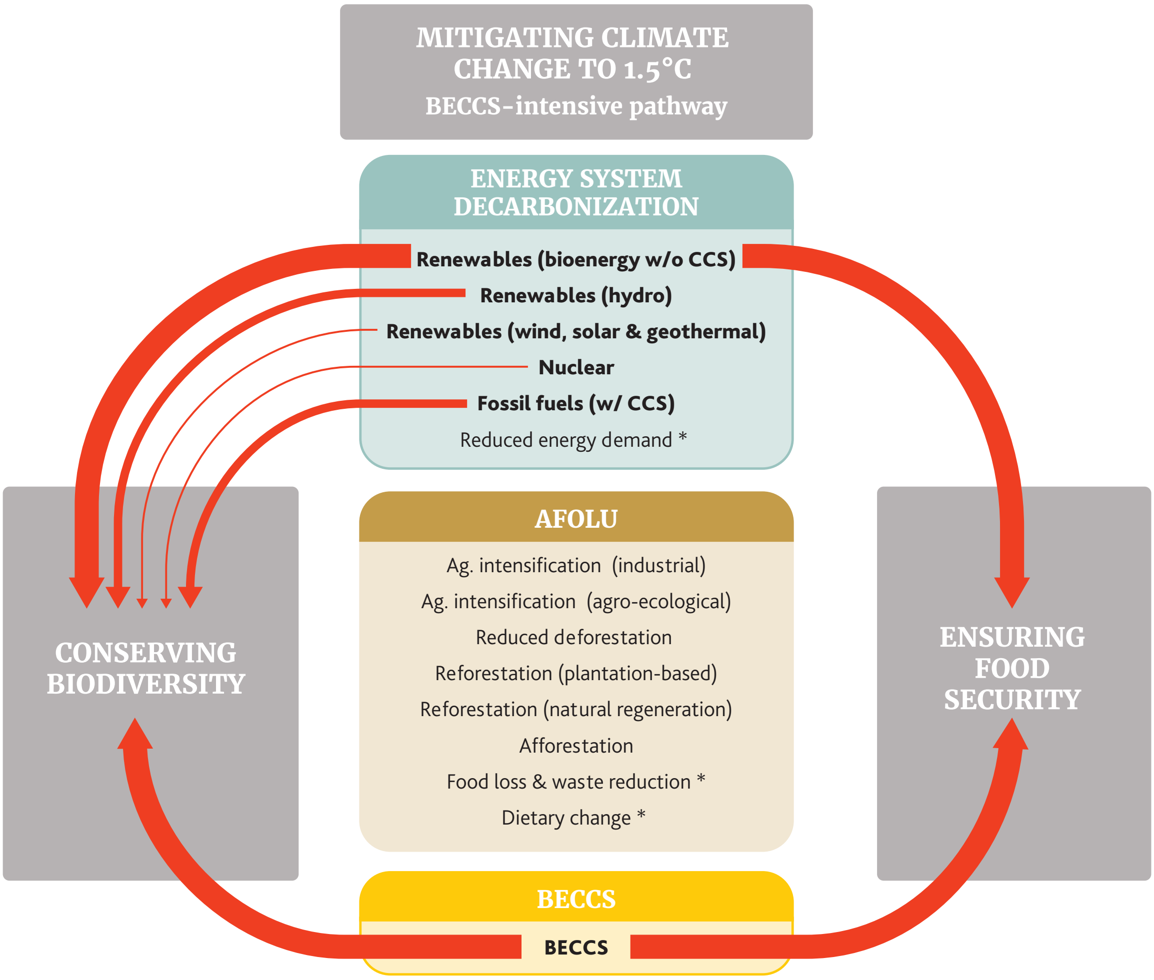
Slow **energy system** transition (i.e. late decarbonization with increased energy demand) requires greater efforts later efforts in coming decades.

AFOLU emissions are not consistently reduced through 2050 and the sector does not contribute to carbon-dioxide removal (CDR).



Reaching 1.5° C in spite of slow energy system transition requires massive CDR deployment—resulting in P4 in widespread Bioenergy with Carbon-Capture and Storage (**BECCS**) deployment (33% of global cropland in 2050 would be allocated to energy crops).[2]

The biodiversity and food security impacts of climate mitigation measures



KEY MESSAGES

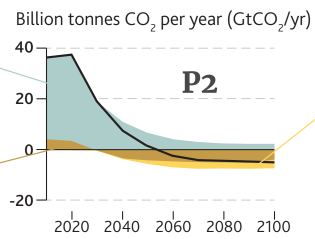
This Figure provides a schematic overview of the main positive or negative impacts on biodiversity and food security of two 1.5°C pathways: (1) one that is BECCS-intensive (e.g. P4), and (2) one with early deep decarbonization (e.g. P2). We highlight the impacts of measures within those families of measures that are deployed at scale in each pathway (i.e. energy system and BECCS in a P4-type pathway; energy system and AFOLU in a P2-type pathway). Climate and biodiversity interactions, and in particular the significant negative impacts of a BECCS intensive pathway reinforce three imperatives: 1) to rapidly decarbonise the energy system (privileging low-carbon energy sources that have the least negative biodiversity impacts) and reduce AFOLU emissions, 2) to reduce the demand of energy and other natural (e.g. agricultural) resources, and 3) to increase carbon sequestration in current land uses, avoiding massive land-use changes. These three elements should guide countries' enhanced Paris Agreement climate commitments in 2020.

1 The graphs representing the P4 and P2 emissions pathways are redrawn from Figure SPM3, IPCC, 2018: Summary for Policymakers. In: *Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels* (full citation at the end of the paper).
2 Huppman, D. *et al.*, (2018), IAMC 1.5°C Scenario Explorer and Data hosted by IIASA.

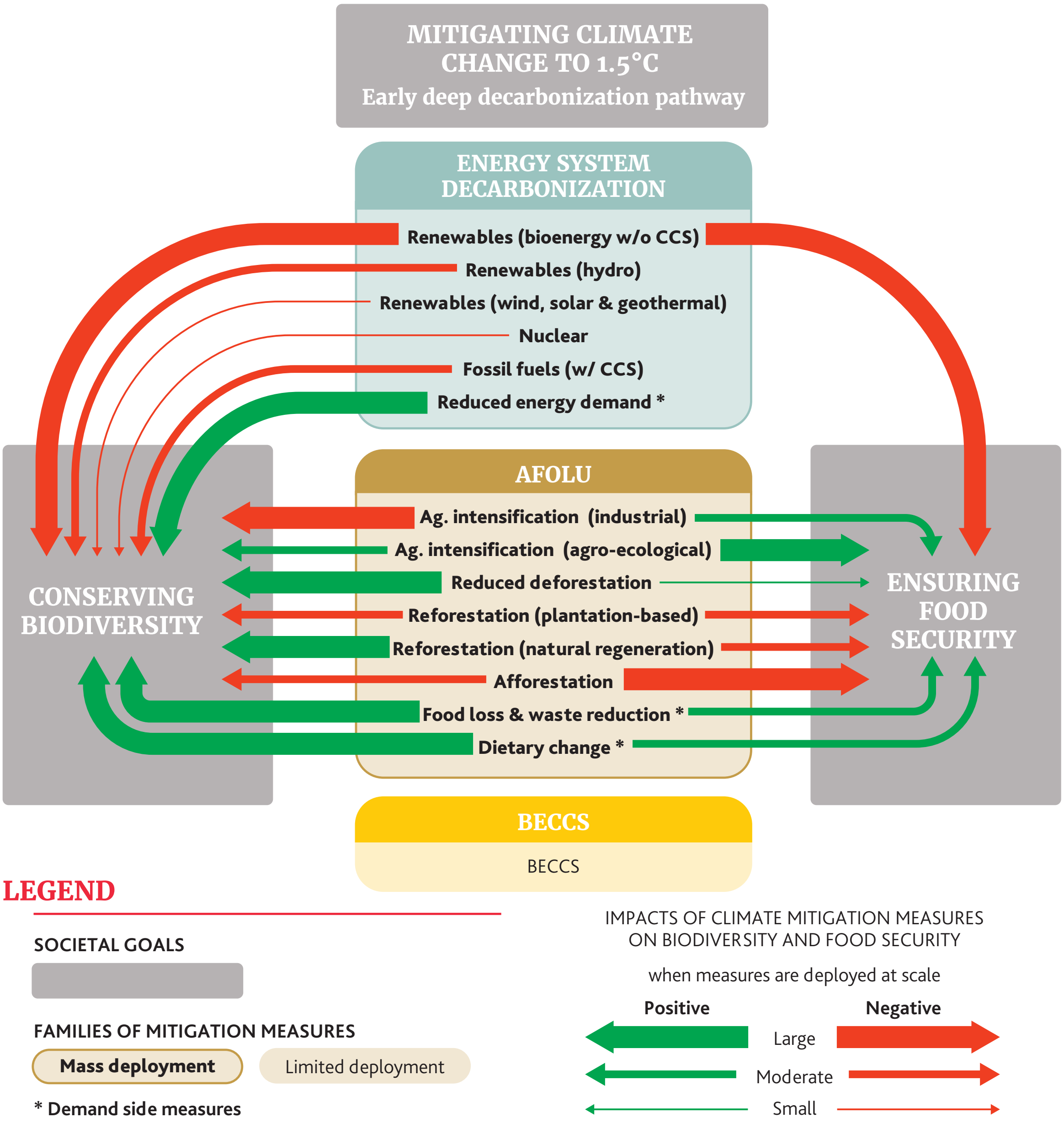
…and their biodiversity and food security impacts

Rapid **energy system** transition (i.e. deep decarbonization and strong energy demand reduction) results in steeper reductions now and need for less efforts in coming decades.

AFOLU sector goes from being net-emitter to a net sink (through emissions reductions and use of AFOLU CDR measures).



Rapid energy transition means significantly less CDR needed than in P4—resulting in low **BECCS** deployment (only 7% of global cropland in 2050 would be allocated to energy crops).[2]



suggests that bioenergy crops would exponentially expand from 20,000 km^2 in 2010 to 7.2 million km^2 in 2050, to cover at that date one third of global cropland (Huppman *et al.*, 2018). Widespread bioenergy deployment also has highly negative biodiversity consequences due to the geographic locations of its siting—bioenergy expansion is projected to be highest within tropical regions (taking advantage of faster growing conditions), displacing forest and pastureland, with one study projecting that half of the potential bioenergy production areas situated in biodiversity hotspots (i.e. areas with the third highest biodiversity) (Santangeli *et al.*, 2016). The IPBES warns that widespread bioenergy deployment is likely set to compete for land-use with conservation areas (IPBES SPM, 2019). Furthermore, bioenergy crops are projected to be planted in monocultures which negatively impacts biodiversity (IPBES SPM, 2019).

A lower biofuels deployment, such as that projected in P2 (e.g. 1.3 Gt CO_2/yr in 2050, using up only 7% of global agricultural land (Huppman *et al.*, 2018), combined with appropriate bioenergy feedstock and appropriate locations (e.g. marginal or abandoned cropland) would result in a lower negative impact on biodiversity (IPCC Land SPM, 2019). This especially if additional safeguards such as those called upon by the 800 scientists in their letter are put in practice (e.g. limiting bioenergy to agricultural and forest residues, etc.) (Beddington *et al.*, 2018). However, an in depth study of the biodiversity impacts of lower bioenergy/BECCS deployment at scales needed for 1.5°C pathways does not appear to exist yet.

Other low-carbon energy sources

Among non-biomass renewable energy sources, **hydropower** can have a relatively negative biodiversity impact. While the magnitude of hydropower's negative impact is significantly lesser than that of large-scale bioenergy deployment, it is still harmful for freshwater biodiversity (IPBES, 2019; CH 5, 5.3.2.2). Dams, by affecting river flow and water quality, are one of the leading causes of the decline of freshwater species and rise of extinction risks, with particular risks to migratory fish (Opperman *et al.*, 2019). Currently dams are being proposed on most of the remaining free-flowing rivers, especially throughout the main river basins in South America, Europe, most of Africa and Asia (IPBES, 2019; CH 4, 4.2.3.4). Hydropower's negative biodiversity impacts can be significantly limited by privileging low-impact siting. In turn, reducing the number of new dams built could keep up to hundreds of thousands kilometers from fragmentation (Opperman *et al.*, 2019).

The IPBES therefore recommends privileging the up-scaling of non-biomass renewable energy sources other than hydropower (IPBES, 2019; CH 5, 5.3.2.4)—**wind, solar and geothermal**. Solar and wind's biodiversity impacts are projected to be lower, namely because wind and solar allow to some extent of other concurrent land use (e.g. agricultural), and only one third of areas in which they could be deployed are outside biodiversity-rich areas (Santangeli *et al.*, 2016). While wind turbines, depending on the context and positioning, can cause biodiversity loss such as the death of migratory birds, these negative impacts can be mitigated through best practices including low-impact siting and turning off turbines during migratory phases (IPBES, 2019; CH 6, 6.3.6.6). While the biodiversity impacts of solar and wind deployment could in theory remain low, yet this is not guaranteed. One study estimated that just the solar and wind deployment needed to reach current NDC commitments could lead—if poorly sited—to the conversion of over 100,000 km^2 of natural land (Opperman *et al.*, 2019). Therefore, the negative biodiversity impact of solar and wind would rise further if future deployment occurs in protected or high-biodiversity areas (IPBES, 2019; CH 6, 6.3.6).

Data assessing the biodiversity impact of **nuclear** and **fossil fuels with CCS** appears to be relatively limited. Some researchers view nuclear as the energy source with the least negative impact on biodiversity (Brook *et al.*, 2015), while the IPBES remains silent on this energy source. However, the IPCC SR 1.5 raises concerns regarding the potential risks of uranium mining on terrestrial natural ecosystems (SDG 15) (IPCC 1.5, 2018; CH5 p.500). In turn, the biodiversity impact of fossil fuels with CCS will likely be similar to those of our current fossil fuels system. Fossil fuels extraction and transformation degrade, fragment and pollute ecosystems, and contribute to the expansion of invasive species, resulting in significant biodiversity impacts (IPBES, 2019; CH 6, 6.3.6). The risks and negative biodiversity impacts from fossil fuel extraction are set to become more accentuated if future fossil-fuel extraction is conducted in areas of higher biodiversity, which is probable (Butt *et al.*, 2013). In the context of 1.5°C emissions climate pathways, fossil fuel extraction must decline. One way to reduce fossil fuels' biodiversity impact may be to select the locations of future extraction using biodiversity safeguards (e.g. impeding new extraction in biodiversity hotpots).

The negative biodiversity impacts of our current fossil-fuel system and of a future energy system highly dependent on fossil fuels clearly demonstrate that renewable energy sources' negative biodiversity impacts is not a valid reason to not decarbonise the energy system and move away from fossil fuel production.

The IPBES states that **energy demand reduction** benefits biodiversity by reducing the demand for energy infrastructure that negatively impacts biodiversity (IPBES SPM, 2019), yet does not enter into much more detailed assessment of the impact of reduced energy demand on biodiversity conservation. The P4 and P2 pathways illustrate the importance of energy demand reduction for biodiversity protection in the context of climate ambition. Indeed, it is the significant increase of energy demand in P4 (a 44 % increase in 2050 relative to 2010), and the resulting extensive energy production system (about 60% higher throughout 2030-2050 in P4 than in P2) that lead this pathway to depend heavily on widespread BECCS deployment to reach the 1.5°C goal (Huppman *et al.*, 2018).

Given that all low-carbon energy sources have some degree of negative biodiversity impact, the climate and biodiversity ambition objectives for the energy system should be:

— 1. To decarbonise it as much as possible privileging those energy sources with lesser biodiversity impacts, and;
— 2. To strongly reduce energy demand through energy efficiency and behavior change.

AFOLU

Climate action in the AFOLU sector is essential to achieve the 1.5°C goal: all pathways use land-based mitigation, and some degree of land-based CDR (IPCC Land SPM, 2019). Conserving and increasing forest cover has the potential to represent about a quarter of carbon capture needed to keep on a 1.5°C path (Lewis *et al.*, 2019). More broadly speaking, NBS —nature conservation, restoration, and improved agricultural practices—can also play a significant role. While no in-depth study yet exists assessing the scale of NBS' contributions to reach the 1.5°C goal, they have been assessed to provide up to 37 % of mitigation needed up to 2030 to reach the 2°C, when implemented with biodiversity safeguards (Griscom *et al.*, 2017; see Anderson *et al.*, 2019, for an example of debates).

In contrast to the energy system, in which all energy sources have some degree of negative biodiversity impacts, AFOLU mitigation/CDR measures have biodiversity impacts ranging from very negative (e.g. widespread BECCS, widespread afforestation) to very positive (e.g. avoided deforestation). The type and magnitude of impact can also vary significantly within a measure depending on the practice it is implemented through (e.g. plantation based reforestation vs. natural regeneration). In the AFOLU sector, the IPCC and IPBES promote notably the investment in protecting and restoring ecosystems, as well as degraded land (CBD, 2018).

Avoiding deforestation and land degradation provides high climate-biodiversity synergies: it has significant biodiversity benefits (IPBES SPM, 2019) and a high mitigation potential (of up to 5.8 $GtCO_2$/yr (almost half of the carbon removal potential of 'high-level' BECCS deployment) (IPCC Land SPM, 2019). In particular, humid tropic forests take up carbon quickly and support particularly high carbon storage, and conserve biodiversity hotspots (Lewis *et al.*, 2019). Yet current forest fires and expanding agricultural commodity production in the Amazon and Congo basin demonstrate the difficulty that governments, the private sector and civil society have had so far in durably avoiding deforestation, despite long-term efforts to keep forests standing (e.g. REDD+ (Reducing Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries).

Reforestation (i.e. conversion to forest of areas previously forested in the past 50 years) and **afforestation** (i.e. the conversion to forest of land not forested over the past at least 50 years (or ever))[12] have been recently touted anew for their major carbon capture potential. Researchers have calculated that there is a potential to add 9 million km^2 of forest in land other than existing forests, agriculture and urban areas, with the potential to capture and store 25% of current atmospheric carbon (Bastin *et al.*, 2019). Yet careful attention must be given to the impacts on biodiversity of specific practices, as the biodiversity impacts of reforestation and afforestation may range from either very positive to very negative, depending on *which land* is being converted to forest, and *through which means*.

While **afforestation** of desertified or degraded land may likely have positive biodiversity impacts, widespread afforestation, and especially afforestation of grassy biomes such as savannas (which have naturally evolved to have few trees) would be highly detrimental to biodiversity. Increasing tree cover in these areas would drastically change the ecosystem: it would upend natural nutrient cycles, the hydrology, and harm the growing conditions of light-demanding vegetation, therefore reducing animals' food sources (Veldman *et al.*, 2015). Therefore, biodiversity safeguards are important here, starting with a formal recognition by the international community of the carbon and biodiversity value of non-forested biomes, with a first step being a review of the FAO definition of a forest (Veldman *et al.*, 2015)

Regarding **reforestation**, natural forest regeneration is not only superior to monoculture plantations from a biodiversity perspective, but also vastly surpasses it in terms of climate benefits. For example, if the 3.5 million km^2 of degraded land committed by countries in the Bonn Challenge are reforested through natural regeneration, they would capture 42 Gt of carbon through 2100; if reforested through plantations, they would capture only 1 Gt in the same period (Lewis *et al.*, 2019).

Regarding **agriculture**, there is strong evidence that the further intensification of input intensive industrial agricultural has severe negative impacts on biodiversity. Agricultural intensification—especially heavy pesticide use but also other practices such as intensive fertiliser use, year round tillage, no crop margins, and associated trends like simplification of crop rotations, homogeneisation of agricultural landscapes, as well as specialization of large production regions—has been demonstrated to cause declines in different species biodiversity (e.g. plants, birds, and insects) (Hallman *et al.*, 2017). Hallman *et al.* conclude that intensive agriculture is the main cause of the drastic 75%-80% decline in insect biomass over the past three decades in German protected natural areas embedded within agricultural landscapes (Hallman *et al.*, 2017). Other scientists have recently further revealed how natural land-use conversion to intensive agriculture, and heavy pesticide use are the main drivers of the worldwide insect declines, of placing 40% of insect species at risk of extinction in the coming decades (Sánchez-Bayo and Wyckhuys, 2019).

This impact of industrial agriculture on biodiversity is all the more problematic in that it is becoming clear that biodiversity is in itself a *production factor*, on which depends overall agricultural production level and capacity (Dainese *et al.*, 2019; Therond *et al.*, 2017). This is well illustrated in the case of pollination. Over 80% of all crops depend to some degree on pollination, and the dependence of global agriculture on pollinators is growing as the amount of agricultural land area cultivated with pollinator-dependent crops rises. Yet at the same time, industrial agricultural practices (e.g. extensive monocultures, widespread pesticide use) that negatively impact pollination continue to expand (Aizen *et al.*, 2019). The absence of crop

12 As per the UNFCCC's definition. UNFCCC (2001). Forest management activities under Article 3, paragraph 4, of the Kyoto Protocol, UNFCCC. Decision 12/CP.7

diversification (which would support pollination) in particular may lead to greater pollination deficit, in turn negatively affecting yields of pollination-dependent crops (Aizen *et al.*, 2019). Yet in the absence of significant demand side food shifts (e.g. massive food waste and loss reduction, and shifting diets), stagnating and declining yields would logically translate into greater land needed to produce the same amount of agricultural output. This could lead to greater land use conflicts with other climate mitigation (e.g. BECCS) and biodiversity conservation goals, presaging rising tensions among different land uses.

In this context, the IPBES in particular encourages that agriculture be intensified in a manner that is agro-ecological (IPBES, 2019; CH 6, 6.3.2.1). Within the AFOLU sector, the IPBES and IPCC also insist on the importance of **reducing agricultural waste and food loss reduction, and shifting diets** to be less animal-product intensive. By reducing the demand for natural resources, these demand side actions lighten the human footprint and therefore positively impact biodiversity and food security (IPCC Land; 2019; IPBES SPM, 2019). While the IPCC Land details this for food security, studies detailing the positive impact that demand-side measures have on biodiversity remain sparse.

The climate and biodiversity ambition strategy in the AFOLU sector should therefore be to:

— 1. Privilege—amidst those with high mitigation potential—AFOLU measures with the highest biodiversity and food security impacts, and;
— 2. Limit the deployment of AFOLU measures with the worst biodiversity impacts.

3. CONCLUSION

The interactions between climate and biodiversity, as well as the mitigation/CDR measures' impacts on biodiversity developed above make visible how deeply intertwined are the climate and biodiversity crises and responses, in this way reinforcing the need for a coordinated approach to the two issues.

To address both crises in an ambitious and successful manner, climate and biodiversity ambitious first needs to be reframed:

— 1. Climate ambition should be redefined as *limiting temperature rise to 1.5°C through emission reduction pathways that are biodiversity and food security compatible.*
— 2. Biodiversity action can only be truly ambitious if it takes profoundly into account the biodiversity impact not only of climate change *but of climate mitigation measures and their combinations across different emission reduction pathways*.

Food security efforts should also take further into account the impacts of climate change and biodiversity loss on agriculture, and the land-use interactions between the three goals of ensuring food security, mitigating climate change and preserving biodiversity.

All in all, maximising climate and biodiversity synergies reinforces four imperatives.

— 1. Ambitious supply-side climate mitigation and biodiversity action: A rapid deep decarbonisation of the energy system (privileging those low-carbon energy sources with the lowest negative biodiversity impacts), as well as a significant reduction of AFOLU sector emissions.
— 2. Ambitious demand-side climate mitigation and biodiversity action: Significantly reduce energy demand as well as demand of natural resources (especially agricultural ones, with food-waste and food loss reduction, and diet shift).
— 3. Land use ambition, i.e. optimising land-based carbon sequestration in current land use, while conserving biodiversity: This in two main ways: (a) maintaining current natural ecosystems, (b) increasing carbon sequestration in productive landscapes.
— 4. Widespread deployment of land-based mitigation/CDR requiring massive land change and with significant negative impacts must be avoided: i.e. a BECCS-intensive 1.5°C pathway is simply not compatible with biodiversity goals.

These four elements should guide countries' enhanced Paris Agreement climate commitments in 2020. Actors working on developing the post-2020 global biodiversity framework should also increase their understanding of climate change debates and negotiations, and how they impact key sectoral transformations in the biomass and land sectors. The integration of ambitious climate change and biodiversity action in national policies will have to overcome barrier and challenges—to facilitate this process, action is needed in science, international governance and civil society.

In the scientific realm, the climate and biodiversity scientific communities should work to develop a more comprehensive overview of the biodiversity impacts of mitigation and CDR measures, especially when they are deployed at scales needed in 1.5°C pathways, feeding their research up to the IPCC and IPBES. In turn, the IPBES technical paper on biodiversity and climate change[13] that is planned for 2020 using IPBES data and the IPCC Assessment Reports should analyse how joint solutions have been explored so far, and propose new avenues.

Parties to the UNFCCC and the CBD must develop greater coordination between these two international negotiation arenas, namely between the overlapping content between climate commitments (NDCs) and biodiversity strategies (NBSAPs—National Biodiversity Strategies and Action Plans). To this end, the conventions could for example develop a shared strategic workplan around joint topics such as carbon neutrality and NBS. Greater attention should also be paid to the work and experience of the UNCCD. Civil society also has a major role to play in raising importance of the climate-biodiversity nexus in the international arena and supporting a systemic approach to the responses given to the biodiversity and climate crises.

13 Decision IPBES-7/1: Rolling work programme of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services up to 2030. See also the work done by the CBD SBSTTA: CBD/SBSTTA/23/INF/1: Review of new scientific and technical information on biodiversity and climate change and potential implications for the work of the Convention on Biological Diversity.

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Towards a climate change ambition that (better) integrates biodiversity and land use

Alexandra Deprez, Lola Vallejo, Aleksandar Rankovic (IDDRI)

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CONTACT
alexandra.deprez@iddri.org

Institut du développement durable et des relations internationales 41, rue du Four - 75006 Paris – France

www.iddri.org
@IDDRI_ThinkTank