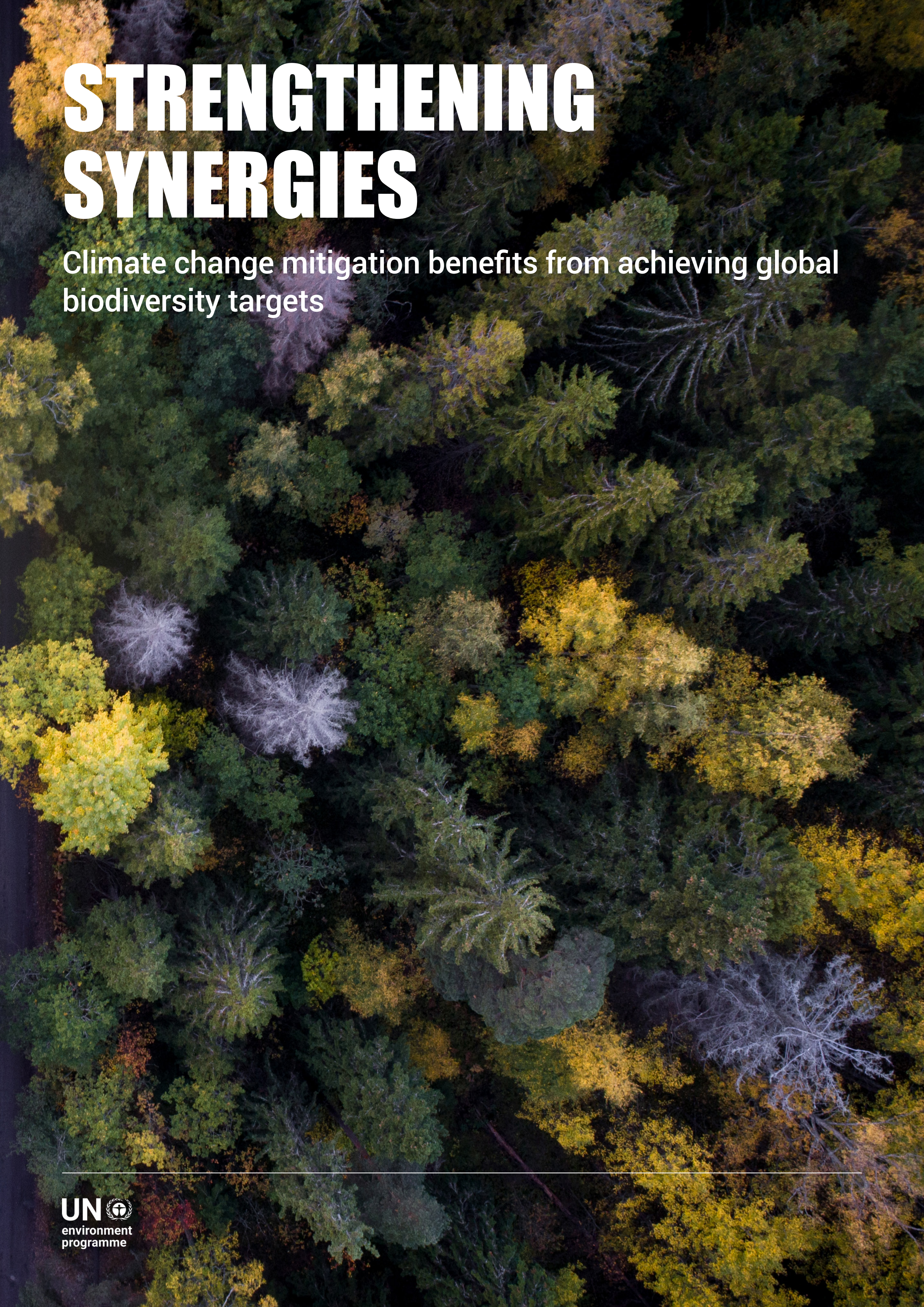
STRENGTHENING SYNERGIES

Climate change mitigation benefits from achieving global biodiversity targets



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Cover image

Aerial view of colorful fall foliage of boreal forest in nordic country, Jamo Images, Adobe Stock

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Strengthening synergies:
Climate change mitigation benefits from achieving global biodiversity targets

Contents

Key messages

1. Well-directed action to conserve and restore biodiversity in line with the targets being developed for the Convention on Biological Diversity's (CBD) post-2020 global biodiversity framework can substantially help to mitigate climate change by reducing carbon dioxide emissions and enhancing removals.

2. Synergies between conserving biodiversity and mitigating climate change can be promoted by identifying land areas of joint global importance for biodiversity objectives and terrestrial carbon, using map-based analyses. These are areas where conservation or restoration would reduce extinction risk for the greatest number of species and maximize carbon retention or sequestration.

3. Achieving a global 30% target on area-based conservation, as included in the draft post-2020 global biodiversity framework, can prevent land-use change in areas of joint global importance for biodiversity objectives and terrestrial carbon stocks. This could avoid as much as 40 $GtCO_2$ emissions by 2050 (nearly one third of global projected emissions from land-use change in that time frame).

4. Restoring ecosystems in the 15% of all areas converted to agriculture and pasture worldwide that are identified as of highest potential importance for biodiversity and carbon (~306 Mha, Figure 2) could sequester a further 22 $GtCO_2$ in biomass by 2050.

5. Furthermore, full implementation of the draft post-2020 global biodiversity framework will result in additional greenhouse gas emissions reductions and removals. For example, improving land management outside areas designated for conservation, restoring degraded (as well as converted) ecosystems and improving management effectiveness within protected areas can all contribute to climate change mitigation.

6. Applying approaches that consider biodiversity and climate goals together at national and jurisdictional levels is crucial for informing inclusive decision-making processes. Decisions on objectives and action to achieve them should involve indigenous peoples, local communities, and vulnerable groups including women and girls. This is essential to enable appropriate and effective action that secures multiple benefits and avoids adverse impacts.

7. The results highlight the overall potential contribution to climate change mitigation of biodiversity-focused conservation and restoration actions on land. Directing action towards areas important for both biodiversity conservation and climate mitigation is a key means to achieve both objectives. The distribution of areas of global importance for biodiversity and carbon among regions is uneven, with many being found in developing countries. International support is needed to help developing countries to contribute towards reaching these global goals.

1. Introduction

It is well recognised that the global crises of climate change and biodiversity loss are interlinked. Conversion of natural ecosystems to other land uses is a significant source of greenhouse gas emissions and a major driver of biodiversity loss. Climate change itself is projected to drive further biodiversity loss, which will reduce the resilience of natural ecosystems and release yet more stored carbon[1] (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES] 2019).

Increasingly, global policy discussions and mandates have highlighted the urgent need for carefully planned and coordinated action to address climate change and biodiversity loss. In their 25th Conference, Parties to the United Nations Framework Convention on Climate Change (UNFCCC) underlined the need to address biodiversity loss and climate change in an integrated manner (UNFCCC Decision 1/CP.25). The Glasgow Climate Pact agreed at UNFCCC COP26 has highlighted the importance of protecting, conserving and restoring nature in mitigating and adapting to climate change (UNFCCC Decision 1/CP.26). The use of nature-based solutions and ecosystem-based approaches to contribute to climate change mitigation and adaptation is relevant to Target 8 of the first draft of the Convention on Biological Diversity's post-2020 global biodiversity framework. This proposed a quantified contribution of at least 10 $GtCO_2e$ per year to global mitigation efforts (CBD/WG2020/3/3).

These mandates reflect growing recognition of the contribution that protecting, managing and restoring ecosystems can make to meeting both climate and biodiversity objectives. Such nature-based solutions (Cohen-Shacham et al. 2016; UNEP/EA.5/Res.5), can make an essential contribution to climate mitigation (United Nations Environment Programme [UNEP] and International Union for Conservation of Nature [IUCN] 2021) but are neither a substitute for – nor a reason to delay - urgent action to reduce fossil fuel use.

Countries are in the process of developing their approaches for responding to these global objectives and mandates. Through their Nationally Determined Contributions (NDCs), countries have made commitments to reduce their emissions to collectively achieve the goals of the Paris Agreement. They are developing long-term strategies for delivering on those commitments. Once the post-2020 global biodiversity framework is finalised, there is an expectation that countries will also be developing national strategies that reflect and contribute to achieving its goals and targets, including those on area-based conservation and ecosystem restoration.

The design and effectiveness of such strategies can potentially be enhanced, and the use of resources for their implementation be made more efficient by identifying and building on the links and potential synergies between them. In order to enable linkages among climate and biodiversity strategies at both global and national scales it is important to understand how much each can contribute to meeting the objectives of the other. A key question is: How large a contribution to meeting climate mitigation goals can be made by action to meet biodiversity targets on area-based conservation and ecosystem restoration? To date, scientific efforts to address this question (e.g., de Lamo et al. 2020; Strassburg et al. 2020; Jung et al. 2021 have focused primarily on ways of capitalising on the important geographic links between areas of high biodiversity and those with high terrestrial carbon stocks to guide selection of important areas for action.

This study goes one step further to estimate the mitigation potential of achieving area-based targets by 2030, through action in areas of highest global importance for both biodiversity and carbon. Drawing on land-use change projections it estimates mitigation potential quantitatively in $GtCO_2$:

a) emissions that could be avoided to 2050 by preventing land-use change through area-based measures to conserve ecosystems on the 30%[2] of land with the highest global importance for biodiversity and for carbon storage; and

b) carbon sequestration (removals from the atmosphere) that could be achieved to 2050 through restoration of natural ecosystems previously converted to other uses, for the 15%[3] of converted area that has the highest global potential for biodiversity and carbon.

It brings these estimates together to consider the climate mitigation impact by 2050 of achieving these elements of two of the draft global biodiversity framework targets. This report discusses both the uncertainties in the estimates and the relevance for other targets. It also highlights the potential to apply similar analyses at national scale as a contribution to participatory decision making that involves key stakeholders such as indigenous peoples, youth, women and men in the local communities.

1. These interlinked global crises also aggravate social inequalities. Climate change causes disadvantaged groups for example indigenous peoples and women to suffer disproportionately from its adverse effects by increasing both their exposure and susceptibility to disasters, further decreasing their ability to cope and recover from the damage suffered (Islam and Winkel, 2017).

2. The quantitative target for area to be conserved by 2030 included in the zero draft of the global biodiversity framework. This study calculates emissions that would be avoided by 2050 if targets are achieved by 2030. The 2050 time frame mirrors that of the 2050 Vision of the Convention on Biological Diversity and the goals of the zero draft of the post-2020 global biodiversity framework. It also aligns with the time horizon for reaching net zero global CO_2 emissions, assessed by the Intergovernmental Panel on Climate Change (Intergovernmental Panel on Climate Change [IPCC] 2018) as essential to limit global warming to 1.5°C.

3. Selected as a relevant level by the research team informed by the Aichi Biodiversity Target 15, in the absence of a quantitative target in the zero draft of the global biodiversity framework.

2. Assessing potential mitigation impacts

Spatial conservation prioritisation approaches recently developed by the Nature Map consortium enable joint consideration of potential carbon and biodiversity benefits in planning and implementing conservation action (de Lamo et al. 2020). These approaches have been applied to identify locations where area-based conservation (Jung et al. 2021) or ecosystem restoration (Strassburg et al. 2020) would make the greatest joint contribution to maintaining or increasing the area of habitat within species' ranges and to securing current or potential carbon stocks.

However, the potential mitigation impact of efforts to meet global biodiversity targets through conservation and ecosystem restoration in such areas depends not on carbon stocks alone, but on the emissions avoided and/or the carbon that can be sequestered. Estimating potential avoided emissions and sequestration depends on assessing the land-use change and associated emissions that would happen without ecosystem conservation or restoration. Integrated Assessment Models (IAMs), as used by the Intergovernmental Panel on Climate Change (IPCC), provide projections of land-use change globally under different scenarios. Applying the IPCC guidelines on estimating the emissions resulting from land-use changes (Intergovernmental Panel on Climate Change [IPCC] 2006; IPCC 2014; IPCC 2019) to these projections provides a basis for estimating the potential for avoided emissions and removals of CO_2 through preventing land-use change and restoring converted ecosystems, (conservation and restoration).

This report presents the results of an analysis that uses recent projections of land-use change up to 2050 and updated IPCC emission factors to spatially assess the emissions that could occur under business-as-usual scenarios (that is, in the absence of new area-based conservation and restoration measures). This makes it possible to calculate the emissions that could be prevented by effective area-based conservation and ecosystem restoration measures focused on areas of global importance for biodiversity and carbon. By assessing this for the total areas proposed in the draft global biodiversity framework, this report estimates the potential emissions reductions and carbon dioxide removals, that could be provided by achieving quantitative area elements of the draft global biodiversity targets on area-based conservation and ecosystem restoration (Figure 1). The 2050 time frame for this calculated mitigation potential mirrors the 2050 Vision of the Convention on Biological Diversity and the goals of the zero draft of the global biodiversity framework. It also aligns with the time horizon for reaching net zero CO_2 emissions globally, assessed by the IPCC (IPCC 2018) as essential to limit global warming to 1.5°C. This report also identifies sources of uncertainty in these estimates, such as from potential leakage, that is, displacement of land-use change and its associated emissions to other locations (Meyfroidt et al. 2020).

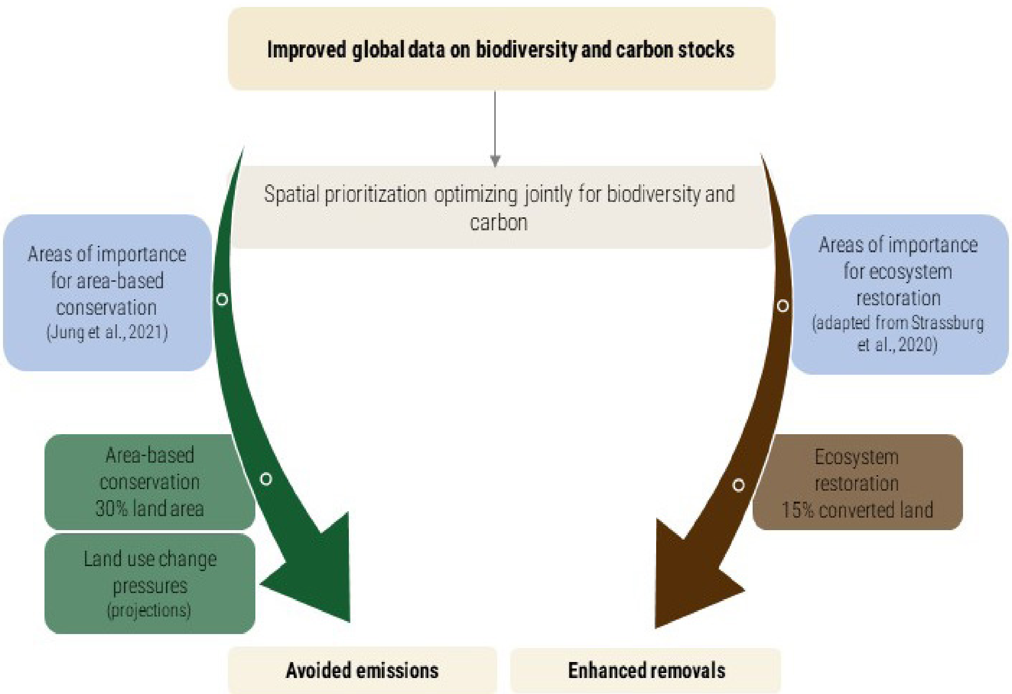
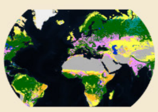
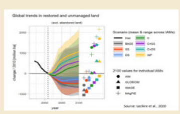


Figure 1. Approach for assessing avoided emissions and enhanced removals (sequestration and storage) resulting from preventing land-use change and restoring converted ecosystems through action to achieve quantitative elements of draft conservation and restoration targets. The data used are summarised in Box 1 and described in more detail along with the detailed methodology in a separate document (Miles *et al.* 2021).

Nature Map areas of global importance for biodiversity and carbon

The novel spatial conservation planning approaches developed by the Nature Map consortium take account jointly of potential biodiversity benefits and terrestrial carbon stocks (biomass and vulnerable soil carbon). These have been used to identify areas of global importance for biodiversity and carbon (hereafter 'areas of global importance'), which could be targeted for expanding areas managed for terrestrial conservation (de Lamo et al. 2020; Jung et al. 2021). The analysis considered a range of coverage thresholds (including the 30% of global land area proposed in the post-2020 global biodiversity framework). The Nature Map approaches have also been used separately to identify areas of global importance that could be targeted for ecosystem restoration (including restoring 15% of converted land, adapted from Strassburg et al. 2020, informed by Aichi Biodiversity Target 15).

These analyses were based on enhanced global data on biodiversity and carbon (Box 1) and started from a baseline coverage of terrestrial protected areas of 15%. The results showed that expanding areas managed for conservation to 30% of global land based on the identified areas of importance would protect over 500 Gt of carbon in biomass and vulnerable soil stocks (of which a proportion might otherwise be emitted as a result of land-use change). This would reduce extinction risk for nearly 88% of the species included in the prioritization (de Lamo et al. 2020).

Biodiversity Key datasets	**Species range** data developed and compiled by an extensive network of partners. Nearly **34,000 vertebrate species** comprising 95% of species known to science in these groups. **193,954 plant species** – 41% of those known to science (sub-sampled to remove geographic biases).
Carbon stock	**Above and below-ground biomass carbon** derived from aggregating several carbon datasets, following a similar approach as Soto-Navarro et al. (2020). **Vulnerable soil carbon** mapped using data from Hengl & Wheeler (2018) and Hengl & Nauman (2019), estimated separately for organic and mineral soils using IPCC stock change and emissions factor values.
Carbon sequestration potential	**Estimated CO2 sequestered following restoration to a reference natural ecosystem** in each geographical zone, considering above and below-ground biomass and soil carbon.
Habitat and land cover 	**Distribution of IUCN habitat classes** from Jung et al. (2020). **Copernicus Global Land Cover** data for 2019 reclassified as described in Miles et al., 2021.
Land-use change projections 	Projections created for the Bending the Curve study (Leclère et al., 2020) from **3 Integrated Assessment Models (IAMs)** using a scenario with limited climate mitigation efforts based on the Shared Socioeconomic Pathway 2 (SSP2 - Riahi et al., 2017). Each IAM takes account of components of economy, energy, agriculture, land-use, emissions and climate: AIM (Fujimori et al 2012, Hasegawa et al., 2017) GLOBIOM (Havlík et al., 2014) IMAGE (Stehfest et al., 2014)

Box 1: Enhanced global data compiled by the Nature Map consortium underpinned this analysis .

To estimate overall mitigation impacts of action in accordance with the quantitative area elements of global biodiversity targets on area-based conservation and ecosystem restoration, the current analysis combines versions of these two sets of areas of importance identified through integrated spatial prioritization for biodiversity and carbon[4] (Figure 2). Differences between the two prioritization sets in underlying data (spatial resolution and land-use class definitions) led to small overlaps between areas identified as important for conservation and for restoration. In these cases, the calculation of potential mitigation impacts uses the restoration impact to avoid overestimating the overall mitigation benefit.

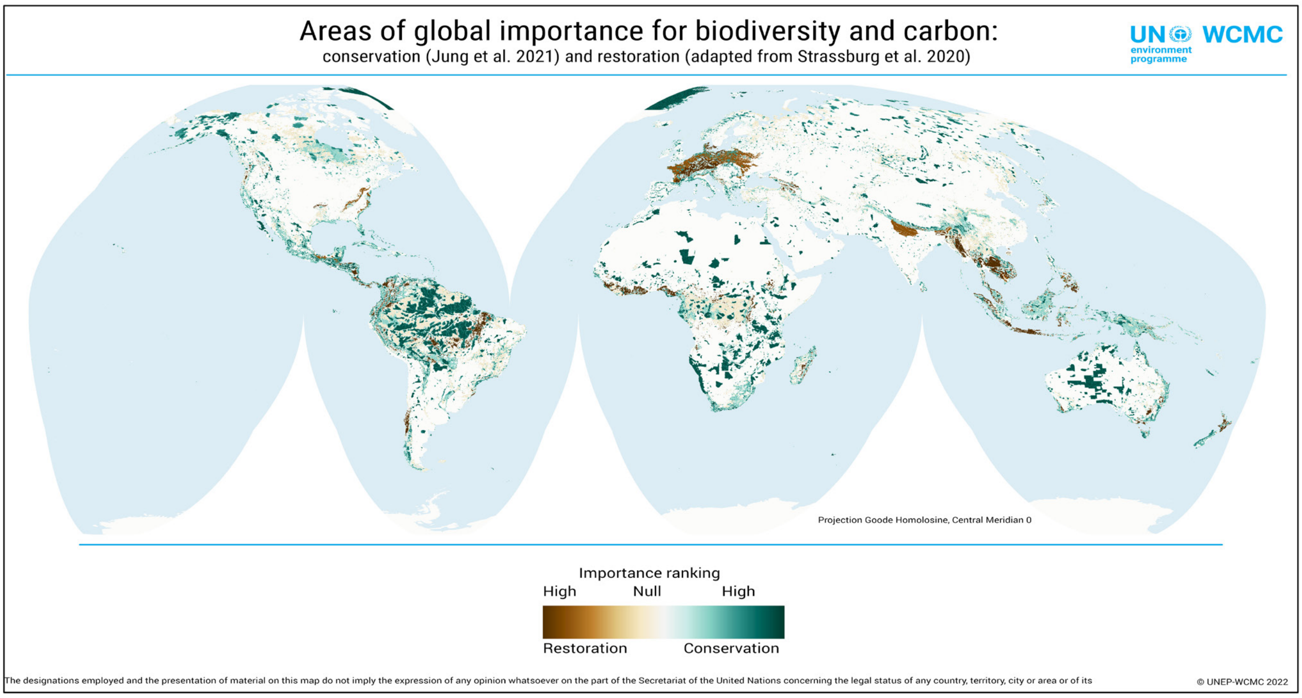


Figure 2. Global map showing areas of highest joint global importance for biodiversity and carbon benefits from conservation (top 30%) and restoration (top 15%). This combines results of prioritizations for area-based conservation and restoration using a harmonised version of the approaches applied by Jung et al. (2021) and Strassburg *et al.* (2020). Areas globally important for conservation build on the global network of protected areas existing at the time of the analysis (~15% land area). Locations important for restoration consider only lands converted to agriculture and pasture as available for this action. Colour scale shows the level of importance for conservation (light to dark green) and restoration (light to dark brown); while white shows areas that were not identified as of global importance by either of these approaches.

Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Land-use change pressures on carbon stocks

Growing human populations, economic growth and associated increasing demand for food, animal feed, timber, and energy are driving conversion of natural lands to agricultural production and other uses (Arneth *et al.* 2019). Globally, land-use change is a major threat to biodiversity (IPBES 2019) and a major source of carbon dioxide emissions. Indeed, this alone accounted for around 19% of all CO_2 emissions direct to the atmosphere over the 30-year period 1959-2019 (Friedlingstein *et al.* 2020).

A key contribution of conservation action to climate change mitigation derives from the role of conservation in preventing land-use change, thereby avoiding the emissions that would occur without such action. While the areas identified as globally important for conservation contain high carbon stocks, their identification does not take likely future land-use change into account. The potential contribution to mitigation of conserving these areas needs to be quantified in terms of the carbon associated with the natural habitat that, in the absence of effective area-based conservation, is projected to be converted to anthropogenic land-uses at a given time in the future.

Making such calculations requires projections of future land-use change without further conservation action (i.e., a 'business-as-usual scenario'), which can be derived from Integrated Assessment Models (IAMs). Such models, which have been extensively used to explore the connections between human and natural systems, form the basis for many of the analyses and projections developed by the Intergovernmental Panel on Climate Change (IPCC). The present analysis used projections to 2050 created for the Bending

4. The maps used in this analysis differ from the central ones in the published papers in the following ways:
i. the conservation analysis used here "locks in" existing protected areas (~ 15% of global land area) before identifying further priorities, and does not include inland water bodies
ii. unlike the published restoration paper, neither analysis includes opportunity or implementation costs (Miles *et al.* 2021); this affects the distribution of area identified as high priority, most notably increasing this area in Europe.

the Curve study (Leclère et al. 2020), based on a "middle-of-the-road scenario" that assumes limited climate mitigation efforts based on the Shared Socioeconomic Pathway 2 (SSP2 [Riahi et al. 2017]).

The global projections of land-use change from the three different models are consistent in showing a loss of forest area and some other types of natural land in all regions. They also show that cropland and grassland extent will increase in Africa and the Americas). However, there is less agreement amongst the models on the directions of change in other land uses in some regions (Figure 3). Incorporating all results from all three IAMs in the analysis helps to account for the uncertainty inherent in such projections.

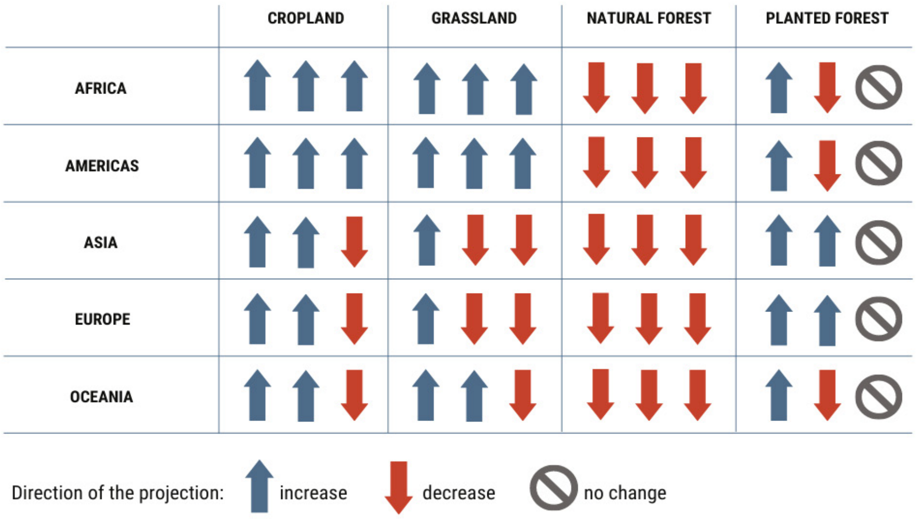


Figure 3. Projected changes to 2050 in the regional extent of major land-use classes, according the three Integrated Assessment Models (IAMs) using a scenario based on SSP2 (Leclère *et al.* 2020). The models agree on broad patterns of change in natural forest across the globe but differ in their projections for other land-use classes and in some regions.

Calculating emissions reductions

For areas of joint global importance for biodiversity and carbon in relation to conservation, the future land-use changes projected for 2020-2050 by each IAM are combined with geographically and ecologically appropriate emissions factors derived from Intergovernmental Panel on Climate Change (IPCC) guidelines (IPCC 2006; IPCC 2013; IPCC 2019) to calculate the CO_2 emissions that would occur if no additional conservation measures were implemented. Climate change mitigation potential from conservation is estimated over the period 2020-2050 as the emissions that would be avoided by preventing future land use change in areas of global importance for biodiversity and carbon totalling 30% of global land area. The analysis assumes that conservation measures in these areas will happen in time to prevent the projected future land-use change and that they will be effective in doing so up to 2050.

Uncertainty is addressed both through the use of multiple land-use projections in the analysis, and by applying literature-based estimates of potential leakage. Leakage is displacement of land-use change from areas that are conserved or restored to other locations (Meyfroidt *et al.* 2020). It is being considered to account for potential additional emissions that could reduce the total avoided emissions. Literature review suggests that overall leakage impacts could range from 10% to 33% of total emissions (Miles *et al.* 2021). These are used as uncertainty estimates for the overall result.

Calculating removals

Removals are calculated as the CO_2 that would be sequestered through restoration of converted lands (croplands or managed pasture) in the top 15% of areas of joint global potential importance for biodiversity and carbon – identified as areas globally important for restoration. This calculation is based on restoration to the relevant natural land cover class[5], using emissions factors derived from IPCC guidelines (IPCC 2006; IPCC 2013; IPCC 2019). As restoration will not start simultaneously worldwide, a 20-year period (2030-2050) was chosen to allow for some rapid and some slower initiation of restoration activities. However, achieving restoration area target by 2030 could enhance removals beyond 2050.

5. Forest, wetland, grassland, shrubland or desert according to the in the 2015 reclassified Copernicus land cover dataset (Miles *et al.*, 2021).

3. Potential mitigation impacts of achieving biodiversity targets

The analysis assesses the potential mitigation of conserving terrestrial ecosystems (preventing land-use change) in the areas of highest importance for biodiversity and carbon corresponding to 30% of global land area (~ 260 Mha, Figure 2). Such action could reduce projected global emissions of CO_2 from biomass due to land-use change to 2050 by as much as 40 Gt. This is about one third of equivalent 'business-as-usual' land-use change-related emissions (Popp *et al.* 2014; Doelman *et al.* 2018).

Restoring terrestrial ecosystems in the 15% of global areas previously converted to agriculture and pasture identified as of highest potential importance for biodiversity and carbon (~306 Mha) (Figure 2) could sequester up to 22.4 $GtCO_2$ in biomass in the same time frame[6].

Achieving these quantitative area-based elements of the global biodiversity targets on conservation and restoration by 2030 would represent an average annual contribution to climate change mitigation of up to 3.0 $GtCO_2$ (1.9 $GtCO_2$ through conservation and 1.1 $GtCO_2$ through restoration[7]) over the period 2020-2050 (Figure 4). This is a conservative estimate because it takes account only of CO_2 emissions from biomass and removals through sequestration (i.e., it does not include other greenhouse gases, which could represent 1–3 $GtCO_2$ equivalent/year of climate mitigation (Girardin *et al.* 2021) or soil carbon). It falls short of the ambition proposed in Target 8 of the first draft of the post-2020 global biodiversity framework (10 $GtCO_2$/year), which also considered contributions from sustainable land management, as well as protection, restoration and management of marine and coastal ecosystems. The estimate presented here is lower than some estimates of the total global potential of nature-based solutions (UNEP and IUCN 2021). This is because it is based on the lower total land area included in quantitative elements of Targets 2 and 3 of the draft global biodiversity framework (e.g., Girardin *et al.* 2021, Figure 4).

Careful targeting of conservation and restoration action to areas of highest global importance for biodiversity and carbon can deliver important biodiversity benefits, including reduced extinction risk (Jung *et al.* 2021). With the necessary levels of ambition they can also make an important contribution to meeting climate change mitigation goals. However, as flagged by many authors (summarised in UNEP and IUCN 2021) management of working lands also has an important role to play in achieving mitigation objectives.

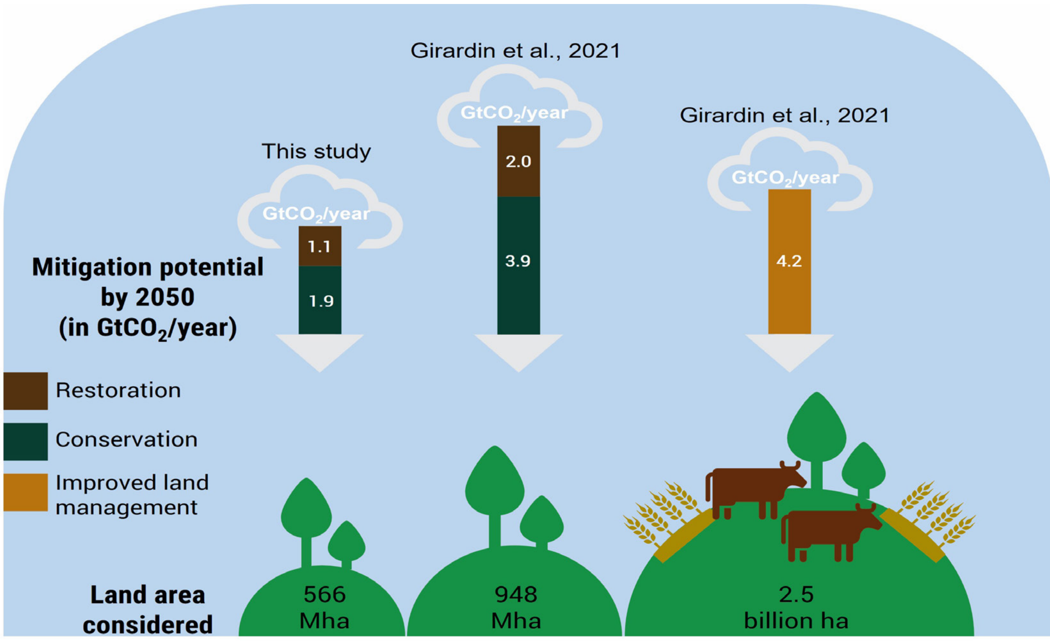


Figure 4. Potential average annual mitigation contribution from avoided emissions of CO_2 through conservation (averaged 2020-2050) and enhanced removals through restoration (averaged over 2030-2050 to account for time lags in carbon accumulation). Together these represent 3 $GtCO_2$ /year. These estimates correspond to the contribution that achieving quantitative elements of draft global biodiversity framework targets for conservation (30% of global land area) and restoration (15% of converted land) can make to climate change mitigation. The contribution from conservation results from preventing future land use change that would otherwise occur in some (an estimated 260 million ha) of the conserved area. The contribution from restoration represents sequestration by recovering ecosystems in land areas previously converted to agriculture and pasture (306 million ha). Shown for comparison are estimates by Girardin *et al.* (2021) of annual mitigation potential from conservation, restoration and improved land management totalling 10 $GtCO_2$/year. The Girardin *et al.* (2021) estimates consider a rapid increase in nature-based solutions by 2025 and are mainly constrained by cost-effectiveness and ensuring adequate global food and wood-based production.Thus they involve preventing land-use change, restoring ecosystems and/or improving land management over a larger total land area, as illustrated.

6. This estimate combines the maximum single IAM projection of area available for restoration for each region; estimate also assumes areas restored are not subject to further land-use change.
7. Annual estimates were calculated based on the total mitigation potential divided by relevant timeframe, 30-year for conservation, 20-year for restoration. See previous section and Miles *et al.* 2021.

The climate change mitigation potential from achieving conservation and restoration targets is unevenly distributed among regions. This is due to (i) differences in current land-use among regions, (ii) the uneven distribution of land area identified as globally important for conservation and restoration based on their importance for biodiversity and carbon, and (iii) the future land-use change those areas are projected to undergo within each region. The amount of biomass carbon characteristic of the different vegetation types occurring in different regions is also a factor.

The highest overall annual mitigation potential from protecting and restoring areas of highest global importance for biodiversity and carbon is found in Africa. This region has the greatest potential for avoiding emissions through conservation to prevent land-use change (1 $GtCO_2$/year). In contrast, Asia has the greatest potential for increasing removals (0.7 $GtCO_2$/year) through restoring converted lands (Figure 5). It is decisions at national and subnational scales that will determine the extent to which these potentials are realised, and how. Inclusive decision-making processes that involve indigenous peoples, men and women in local communities and other stakeholders enable appropriate and effective action that secures benefits and avoids adverse impacts on vulnerable groups. Furthermore, in many cases the feasibility of action to realise these potentials is dependent on the availability of financial and other resources. Developing countries are likely to require international support to achieve this.

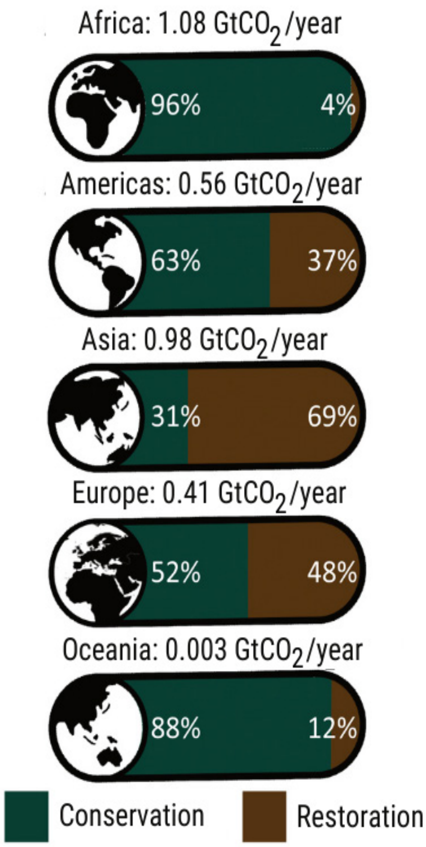


Figure 5. Regional distribution of maximum annual mitigation potential that could be delivered by 2050 if quantitative elements of draft global biodiversity framework targets on area-based conservation and restoration are met (data from this study). Percentages show the relative contribution of conservation and restoration to achieving each regional annual mitigation potential. Achieving the targets by 2030 through action in areas of highest global importance for biodiversity and carbon would avoid CO_2 emissions from land-use change and enhance removals through sequestration. Differences in regional mitigation potentials reflect differences among regions in current land-use, proportion of areas of global importance, and projected land-use change.

Caveats and uncertainties

Several uncertainties and limitations apply to these estimates:

Leakage estimates from the literature suggest that between 10 and 33% of the mitigation value of conservation and/or restoration could be negated by displacement of land-use change to other areas. Applying the higher estimate to the results presented in this report suggests that, without measures to counteract it (including other elements and targets of the global biodiversity framework), leakage could reduce the total mitigation potential to 2050 from the area-based targets to 42 $GtCO_2$.

The analysis takes little account of ecosystem degradation in relation to either biodiversity or carbon impacts due to a lack of scientific consensus on how to identify degraded ecosystems and consequent lack of spatial data on location, severity and extent of degradation (Prince *et al.* 2018). The restoration analysis considers only restoration of ecosystems on converted land (cropland and pastures). It does not consider the opportunities presented by restoration of degraded natural ecosystems. For example, degradation has affected nearly 65 million ha of carbon-rich peatlands (Bonn *et al.* eds. 2016). Similarly, current and future ecosystem degradation is not explicitly considered in the conservation analysis (i.e., the analysis does not consider degradation that has occurred in conserved areas or that which could occur if such areas are not effectively managed). The effects of these omissions on the overall estimates are likely to be mixed and to vary among regions. For some degraded ecosystems both current biodiversity value and carbon stock secured by area-based conservation may be over-estimated. On the other hand, the lower area considered available for restoration leads to an underestimation of the mitigation potential from this action. Furthermore, the removal (sink) function of areas identified as globally important for conservation is not included here. Thus, the mitigation contribution of conservation action in reversing degradation of these natural ecosystems has not been estimated.

The analyses provide an estimate of mitigation potential in terms of current carbon stocks that could be retained through conservation action to prevent future land-use change in areas of global importance for biodiversity and carbon. They also provide an estimate of the carbon that could be sequestered if converted lands in areas identified as globally important for restoration were actively restored. However, this potential may not be fully realised for a number of reasons including ineffective management, lack of finance or of capacity, increased natural disturbance (like drought, fire, and pest outbreaks) and the impacts of climate change. Such factors could result in further land-use conversion and greenhouse gas emissions or slow ecosystem recovery and carbon sequestration (Baldocchi and Penuelas 2019; Anderegg *et al.* 2020).

The analyses also ignore the effect of future climate change on plant physiology. More specifically, the work does not consider how increased CO_2 and altered climate will change photosynthetic activity and affect the capacity of ecosystems to sequester carbon. Soil organic carbon was a feature of the prioritization analysis, but not included in the estimate of avoided emissions or enhanced removals. Therefore, figures for conserving and restoring ecosystems with carbon rich soils, such as peatlands (mitigation potential of 0.92 $GtCO_2eq$/year, if globally restored [Leifield and Menichetti 2018]), are under-represented in these results.

These results provide no insight on the impacts on people, and particular groups of people, of action that would achieve these emissions reductions and sequestration. In principle, detailed agent-based models could provide insight into impacts on marginalised groups (Emmerling and Tavoni 2021). However, the most effective way to ensure that indigenous people, local communities, youth, women, girls and the poor benefit is to involve such stakeholders in decision-making.

4. Application at national scale

These prioritisations and analyses give insight into the overall potential contribution of global biodiversity targets to achieving climate objectives. However, the decisions on implementation, that will actually lead to achievement of the post-2020 global biodiversity framework and other targets are taken at national or finer scale in accordance with national priorities. While these can be guided by global data and analysis, using nationally sourced data and analyses tailored to national needs is much more appropriate and accurate. It will also more easily enable feedback from stakeholders involved in these policy processes.

To date, technical partners in three countries, Mexico, Colombia and Argentina, have been working with the support of the Nature Map consortium partners to adapt and apply the approaches described here to their own contexts. Broadly, they aim to develop their own approaches and share experience on steps that include:

- Engaging with key government stakeholders to review existing and anticipated policy commitments and plans on biodiversity conservation and climate change mitigation, with due consideration for gender and socio-economic factors;
- Reviewing, collating and updating as feasible the best available national spatial data on biodiversity, biomass and soil carbon stocks, emission factors, and land-use projections;
- Using or adapting Nature Map prioritization approaches, identifying national areas of importance for action that can contribute to both biodiversity and climate change objectives.

Combining these with land-use change projections for different scenarios will enable quantification of the emissions reductions and removals that could result from achieving the identified targets and commitments. Synthesising the results of such analyses in accessible forms and discussing their implications with all stakeholders can help to inform national or jurisdictional policy, both with respect to existing commitments and in response to the emerging global biodiversity framework, as well as ambitions under the UNFCCC.

The three country teams have made substantial progress in compiling nationally accepted data on biodiversity, carbon stocks and current and future land-use. They are using these data to identify areas of importance for conservation and restoration action to deliver biodiversity and climate outcomes in accordance with national objectives.

In **Mexico**, researchers at four universities have been working collaboratively with national biodiversity and carbon stock data to inform implementation of both biodiversity policy (National Biodiversity Strategy and Action Plan - NBSAP and future policies arising from the post-2020 framework) and climate change policy (Mexico's Special program for Climate Change). The former focuses, among other objectives, on ensuring provision of environmental services. The latter focuses on carbon storage and sequestration through maintaining natural carbon sinks and reforestation/restoration of areas that have been degraded. Identification and conservation of areas that provide fresh water, carbon sequestration and biodiversity conservation are priorities under this program.

The Mexican group is working with data on the potential distribution at national level of plant and animal species from the National Commission for the Knowledge and Use of Biodiversity in Mexico (CONABIO). The initial analysis focused on all species of conservation concern (endangered, endemic or restricted in distribution). The data used represent 90% of the estimated total bird, mammal and amphibian species, 62% of the estimated total arthropod species, 45% of reptile species, 7% of fish and 1.2% of plant species, altogether comprising 7% of the estimated species total for the country. Carbon data are from the national map of forest aboveground carbon stocks in Mexico (Cartus *et al.* 2014).

The first results identify areas that contribute to meeting both biodiversity and climate objectives. They potentially preserve within 30% of Mexico's terrestrial area as many as 92% of the species assessed and 62% of all aboveground biomass carbon. The greatest synergies between carbon and biodiversity benefits are found in mountain areas, which have high biomass carbon, are rich in endemism and important for water provision. The results (Figure 6) show the potential to conserve the most vulnerable species in Mexico while protecting ecosystem services that are vital for a country with two thirds of its territory occupied by arid and semiarid ecosystems.

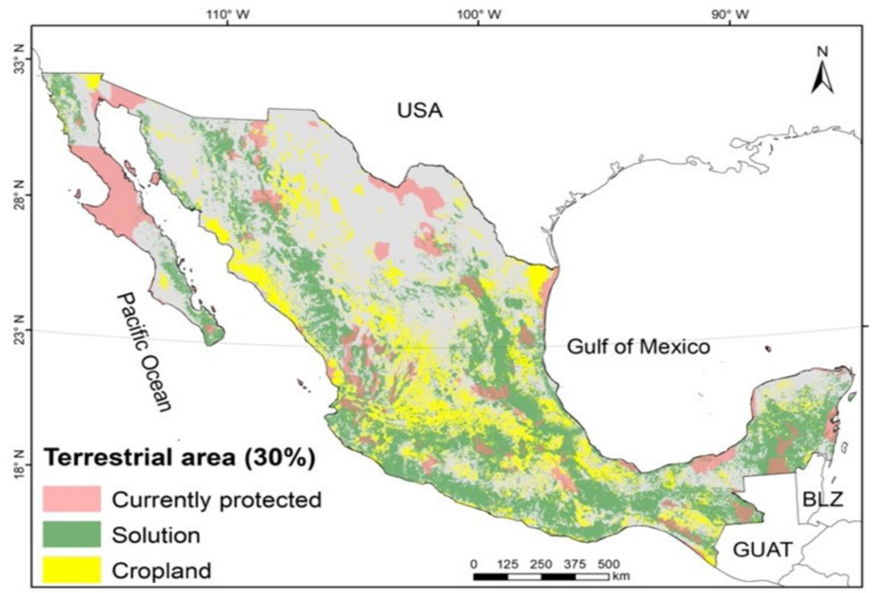


Figure 6. Areas of importance for both biodiversity conservation and climate change mitigation (in green) covering totalling 30% of Mexico's terrestrial surface, potentially contributing to preservation of 92% of the country's species and 62% of its carbon. Some 34% of this area is currently protected.

Data sources: Cartus et al. (2014); Comisión Nacional para el Conocimiento y Uso de la Biodiversidad ([CONABIO] 2020); Instituto Nacional de Estadística y Geografía ([INEGI] 2005); Secretaría de Medio Ambiente y Recursos Naturales ([SEMARNAT] 2015); CONABIO n.d.

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The Mexican group will soon incorporate land-use change projections, improved carbon data and information on water provision, and integrate all species in the CONABIO database, to enable better assessment of the contribution of the identified areas of importance to national policy objectives.

Colombia has recently announced its intention to adhere to the 30x30 post-2020 target and has set a national goal of zero deforestation by 2030. This announcement is in addition to other national and international commitments related to climate change mitigation and the protection of water and other environmental services. Thus, the country faces an urgent need to align existing land-use planning policies with national and international targets and commitments. A team from Colombia's Humboldt Institute (responsible for generating knowledge to evaluate the state of biodiversity and make sustainable decisions about it) has been working to assess and define achievable integrated targets for biodiversity and ecosystem services protection, and climate change mitigation. It developed an approach to identify areas of importance for conservation action where synergies are maximized among protecting biodiversity (species + ecosystems), carbon storage (above and belowground biomass carbon + soil organic carbon), avoiding deforestation (attaching importance to areas most likely to be to be deforested by 2030), water (supply, scarcity, quality), and other environmental services (adaptability to climate change and prevention of flooding and soil degradation).

This proposed methodology has been presented and accepted by the National Roundtable on Conservation Priorities of the National System of Protected Areas under a permanent collaboration. The results have been presented to diverse institutions such as the Ministry of Environment and Sustainable Development, Regional Environmental Authorities, NGOs, academia and GEOBON, among others.

The results show that conserving areas of importance totaling 30% of the country would meet 99% of the targets for threatened species (Figure 7). Using this prioritisation approach, even increasing protection to a less ambitious 20% of the national area (from the current 16%) could increase achievement of conservation planning targets for ecosystems and ecosystem services by more than two thirds. It would also contribute to climate change mitigation by protecting around 7.4 Gt of carbon in biomass and soils. New and improved data on biodiversity, carbon and water are now being incorporated in the analysis. So too is consideration of ecosystem restoration and improved management of productive systems to enable identification of synergies with new conservation targets and agreements.

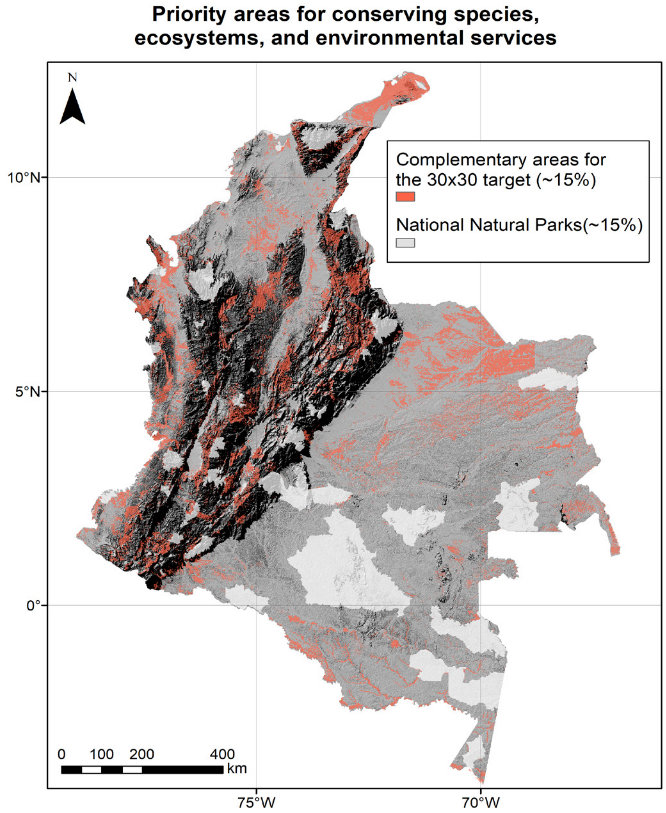

Figure 7. Additional conservation areas proposed to achieve a 30% protection target for Colombia by 2030. These are identified by considering jointly the distribution of biodiversity, carbon stocks and other ecosystem services. Conserving these additional areas would provide substantial additional biodiversity benefit and would contribute to climate change mitigation by protecting an average of 57 t carbon per hectare. Further information on this analysis and its data sources is available at http://portafolios.humboldt.org.co/

Data sources: Species: Velasquez-Tibata *et al.* (2019). Ecosystems: Etter *et al.* (2017). Biotic communities: Instituto de Hidrología, Meteorología y Estudios Ambientales ([IDEAM] 2017). Areas at risk of deforestation: Rosa *et al.* (2013). Critical areas for provision of ecosystem services: IDEAM (2010a, b, c; 2011; 2014; 2019). Biomass carbon: Spawn *et al.* (2020). Soil carbon: Food and Agriculture Organization and Intergovernmental Technical Panel on Soils ([FAO and ITPS] 2018).

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Argentina has committed to achieving carbon neutrality by 2050 and is developing the general guidelines for its Long-Term Strategy to be presented at the UNFCCC COP27 in Egypt. In cooperation with the National Cabinet of Climate Change, a team from Fundación Bariloche and the National Institute of Agricultural Technology (INTA) has combined several models to develop carbon-neutrality trajectories that meet a number of goals (conservation of carbon stocks in soil and biomass, protection of clean water sources, and conservation of biodiversity) concurrently, without compromising the country's food production systems. The team compared a business-as-usual scenario with a carbon-neutral one using the FABLE Calculator and DINAMICA land-use models and applied the Nature Map prioritization framework for further alignment with a global biodiversity conservation prioritization.

The first results show that for Argentina nature-based solutions can have substantial benefits. Conserving 81.8% of the area of habitat (AOH) of threatened tetrapod species (mammals, birds, amphibians and reptiles) would avoid large amounts (final quantification ongoing) of CO_2 emissions from biomass and soil carbon that would otherwise be released through land use change. This would also protect 80% of water basins. This implies protection of 30% of Argentina's land area to meet sustainability goals, with minimal overlap (2.1%) with areas important for the goal of producing and exporting food. The team corrected decarbonization trajectories to achieve greater compatibility with biodiversity targets, distinguishing between "carbon-neutrality" and "sustainable carbon-neutrality" (Figure 8).

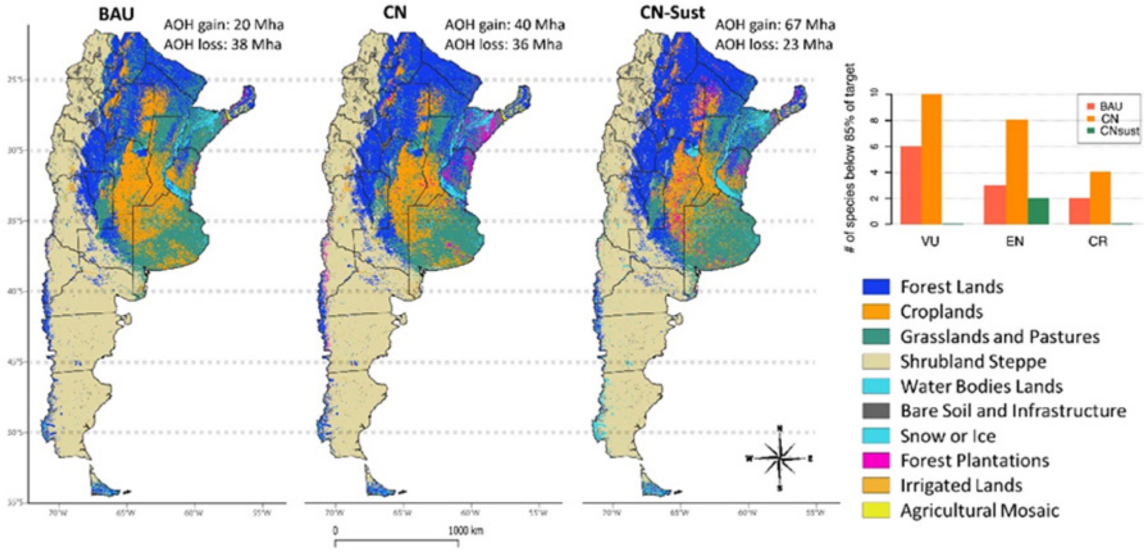

Figure 8. Comparison of modelled land use trajectories to 2050 in mainland Argentina and its impact on the gain and loss of area of habitat (AOH) in tetrapod species threatened with extinction. BAU: map of land uses for the business-as-usual scenario, CN: map of land uses for the carbon-neutrality scenario, CN-Sust: map of land uses for the biodiversity conservation-compatible carbon-neutrality scenario, also compatible with protection of water basins and food production. The histogram shows the % of threatened species that remain below the target of protecting 80% of the AOH comparing the 3 alternative trajectories

Data sources: see Volante *et al.* (2021)

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Among the actions included in the carbon neutral scenario are:

- Increasing natural forest area by 11% and planted forest area by 300%, which implies
- Stopping deforestation and fires and restoring native forests.
- Increasing agricultural production without expansion, doubling the productivity of crops and livestock.
- Increasing protected areas to 30% of the national surface, prioritizing the convergence between carbon conservation, biodiversity, and water provision.

Engagement with government and other stakeholders will help to evaluate the social and economic feasibility of the proposed pathway and is supported by development of a Nature Map viewer, which has helped decision-makers to visualise the implications of the analysis.

5. Conclusions and ways forward

Combined with appropriate levels of ambition, careful targeting of conservation and restoration action to areas of highest global importance for biodiversity and carbon can deliver biodiversity benefits, including reduced extinction risk (Jung *et al.* 2021), and make an important contribution to meeting climate change mitigation goals. This study develops a conservative estimate of the extent to which actions to deliver quantitative area-based targets on conservation and restoration of ecosystems can contribute to resolving both the climate change and biodiversity crises. Estimates have been made for two specific types of action at a global scale: preventing land-use change on 30% of land protected or effectively managed for biodiversity conservation; and, restoring ecosystems on 15% of lands previously converted for agriculture. With careful planning, including focussing action on areas of global importance for both biodiversity and carbon, achieving such targets globally could avoid emissions or enhance removals of CO_2 by around 3.0 Gt per year by 2030 (totalling 62 $GtCO_2$ by 2050). To achieve the higher published estimates of land-based mitigation potential (summarised by UNEP and IUCN 2021) would require action over larger areas, including implementation of nature-based solutions and ecosystem-based approaches in production lands.

Our estimates quantify two of the ways in which the post-2020 global biodiversity framework can contribute to climate change mitigation. The combined mitigation potential of the two actions that have been modelled in this study is less than one third of the contribution from nature to climate change mitigation proposed under Target 8 of the first draft post-2020 framework (10 $GtCO_2e$ / year by 2030). Full implementation of the draft post-2020 global biodiversity framework will result in additional greenhouse gas emissions reductions and removals. Improving land management outside areas designated for conservation and restoration, restoring degraded (as well as converted) ecosystems and more effective management of protected and conserved areas will all contribute to climate change mitigation, but have not been modelled in this study. Better management and restoration of marine ecosystems could also contribute. Further research is needed to better understand the magnitude of these contributions.

These findings show that targeted approaches can deliver the mitigation potential from managing lands sustainably and ensuring benefits for biodiversity, whilst addressing climate change and meeting other needs from land. Growing demand for land to meet the requirements of a growing population heightens the importance of reconciling multiple demands on areas of importance for biodiversity and climate through management of production landscapes, as well as conservation and restoration.

Integrated spatial planning represents an opportunity for countries to address goals for nature and climate change simultaneously. Prioritisation analyses such those performed by research teams in Mexico, Colombia, and Argentina can help set realistic targets and identify opportunities to achieve multiple objectives, e.g., on nature, climate, agriculture. Such spatial approaches can help to identify and resolve trade-offs between different land uses and estimate the benefits that each can provide in different locations. They also offer opportunities for stakeholders and decision makers to visualise the implications of particular choices and to optimise the benefits. Full and effective participation of stakeholders, including indigenous people and local communities, women and youth, will support effective decision making and action that help to meet people's needs and priorities.

Crucially, whether at global or at national scale, there are substantial opportunities for strengthening the synergies that can be achieved by addressing climate and nature objectives in tandem. Greater progress on both sets of objectives could be achieved through:

- Increasing the ambition embodied in the quantitative elements of the global biodiversity framework;
- Setting goals and targets that include restoration of degraded ecosystems and sustainable management of production lands, as well as natural ecosystems;
- Ensuring full and effective participation of stakeholders, including indigenous people and local communities, women and youth, in decision-making on goals and actions;
- Using spatially explicit approaches to help target action that achieve multiple objectives through nature-based solutions and ecosystem-based approaches and to provide a basis for tracking progress;
- Ensuring that strategies and action plans for climate and nature are explicit about their intended contributions to both sets of objectives and build on the results of spatial planning approaches that take account of these;
- Providing support to developing countries to enable them to make progress on climate and nature objectives jointly.

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