FABLE CONSORTIUM

Pathways for food and land use systems to contribute to global biodiversity targets

The Food and Land Use Coalition

FABLE Policy Brief
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Contents

Headlines

- Biodiversity flourishes in areas where natural processes, such as plant and animal reproduction and dispersion, take place without human interruption. At present, we estimate that such land where **natural processes predominate (LNPP) covers 56% of terrestrial land**.
- The evolution of **global biodiversity** is modelled, as indicated by LNPP, for **two scenarios for food and land-use systems change to 2050**: a "Current Trends" pathway, based on current policies and historical trends, and a "Sustainable" pathway, depicting ambitious assumptions aimed at sustainable development.
- The 15% expansion target proposed by the Convention for Biological Diversity (CBD) is missed under both pathways, yet the shortfall is much smaller when ambitious actions are taken. **The area of LNPP expands by 14% between 2010 and 2050 in the Sustainable pathway compared to only 2% under Current Trends**.
- Increases in LNPP would be achieved **while also improving global food security and climate mitigation outcomes.**
- While restoration would enable the area of LNPP to expand, existing LNPP including mature forest would continue to disappear.
- **Shifting diets, increasing crop and livestock productivity, and limiting agricultural land expansion**, were the strongest drivers of positive change in global biodiversity. Implementing these reforms in multiple countries would **help put us on track to achieve global biodiversity, food security and climate mitigation goals by 2050.**

About FABLE

The Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium is a collaborative initiative to support the development of globally consistent mid-century national food and land-use pathways that could inform policies towards greater sustainability. FABLE is convened as part of the Food and Land Use Coalition (FOLU). The Consortium brings together teams of researchers from 20 countries and international partners from Sustainable Development Solutions Network (SDSN), the International Institute for Applied Systems Analysis (IIASA), the Alliance of Bioversity International and CIAT, and the Potsdam Institute for Climate Impact Research (PIK). Reports published in 2019 and 2020 further describe the FABLE approach to developing pathways to sustainable food and land-use systems.

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1. Biodiversity in food and land-use systems

The challenges of halting biodiversity loss and meeting future food requirements are intrinsically linked.

Biodiversity and healthy ecosystems are critical to our food systems[1]. Biodiversity includes the wide diversity of genetic resources which underpin vibrant food systems[2]. Pollinating animals like bees are so crucial for producing nutrient-rich crops[3] that more than half of the population in some developing countries would experience malnutrition (nutrient deficiencies, especially of Vitamin A) if pollinators disappeared[4]. The very diverse species that live in soils make up the often overlooked biodiversity that maintain healthy soils, helping micronutrients reach plants and ultimately our plates[5]. Biodiversity in healthy ecosystems also plays a vital role in climate regulation, and in lessening the impact of floods, heatwaves and rainfall shortages on food production and people [6].

Human activities such as logging of forests, agricultural expansion, and agricultural intensification, have put massive pressure on global biodiversity, resulting in rapidly increasing rates of species loss everywhere[7-9]. Over the past two decades, global cropland expansion has accelerated, with half of the expanded area replacing natural vegetation[10]. Populations of mammals, birds, amphibians, reptiles and fish declined globally by 68% between 1970 and 2016, driven mainly by conversion of pristine habitats into agricultural land[11]. Multiple studies show insect populations are also shrinking[12-14]. While numbers of freshwater insects have increased, populations of terrestrial insects like butterflies, beetles, and bees have shrunk by 9% per decade since 1925[15].

The Convention for Biological Diversity (CBD) brings governments together to agree international commitments to ensure biodiversity conservation. The CBD post-2020 global biodiversity framework proposes a set of global biodiversity goals and targets to achieve by 2050. The framework, once ratified, will shape the next few decades of policy action on biodiversity. It aims to stimulate 'urgent and transformative action' to achieve the vision of living in harmony with nature by 2050. It includes an explicit call for biodiversity-inclusive spatial planning to help achieve global biodiversity goals. Embedding biodiversity conservation into land-use planning and food production systems is also an opportunity to achieve food and nutrition security (SDG 2) and meet the Paris Climate Agreement targets[16,17].

While demand for agricultural commodities and timber continues to grow, for the benefit of nature and people we need renewed efforts to safeguard the world's last remaining wilderness areas[18-25], restore degraded natural habitat[26,27], and improve the environmental sustainability of agricultural lands[27-29].

Comparing alternative pathways for food and land-use systems can help identify ways to achieve multiple wins. This brief presents results from the Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium, a collaborative initiative that brings together independent researchers from 20 countries. Using the FABLE modelling framework[30], this brief analyzes baseline conditions for biodiversity and potential pathways to meeting three of the CBD post-2020 global biodiversity framework targets, while considering synergies and trade-offs with food security and climate mitigation goals.

2. Global biodiversity targets and indicators

Biodiversity conservation generally refers to preventing species extinctions. For many species, it is difficult to get data on where they are and if they are threatened. This is a problem for monitoring progress towards species-based biodiversity targets[31-34]. Area-based measures are another important approach to monitoring biodiversity[8]. These may involve, for example, monitoring changes in land that is important for one or multiple species, because it allows these species to reproduce, nest, eat or move.

This brief uses an indicator of land where natural processes predominate (LNPP) to monitor progress towards three of the area-based global biodiversity targets embedded in the CBD's post-2020 framework[35] (Table 1). LNPP refers to land where there is a low human disturbance and/or ecologically relatively intact vegetation, providing space and habitat for biodiversity to thrive.

Table 1: Global biodiversity targets from the CBD post-2020 framework (*)

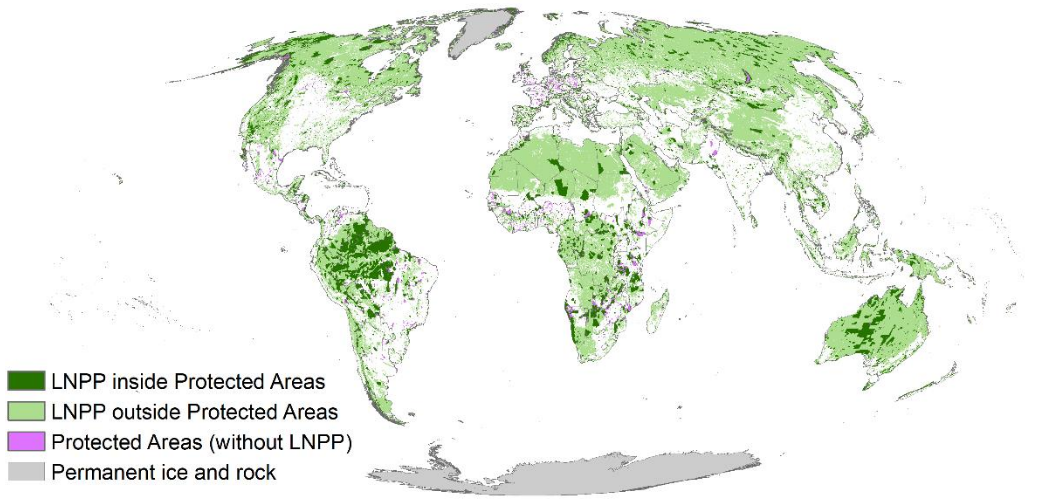
Goal A	Enhance the integrity of all ecosystems, *"with **an increase of at least 15%** in the area, connectivity, and integrity of natural ecosystems, supporting healthy and resilient populations of all species"* **by 2050**
Milestone A.1	Achieve a *"**net gain** in the area, connectivity, and integrity of natural systems **of at least 5%**"* **by 2030**
Target 1	Retain *"existing intact and wilderness areas"*, **halting losses by 2030** or before

(*) For simplicity, we refer to CBD Goal A, Milestone A.1 and Target 1 all as targets in this brief.

We aim for no loss of land where natural processes predominate after 2030 and increases of 5% by 2030 and 15% by 2050.

To represent LNPP, this analysis uses the total land area covered by these datasets: low impact areas[24], key biodiversity areas[36], and intact forest landscapes[37] (Figure 1, Annex). These datasets have some limitations in a few countries, e.g., inclusion of plantation forests in Norway, Finland and Sweden, and exclusion of large undisturbed desert regions in Mexico.

Figure 1: Map of LNPP and protected areas on terrestrial land



Data sources: Land where natural processes predominate (LNPP) represents areas inside: low impact areas [24], key biodiversity areas[36], and intact forest landscapes for 2016[37]. Protected areas are from WDPA (2019)[38]. Country administrative boundaries are from GADM v36.

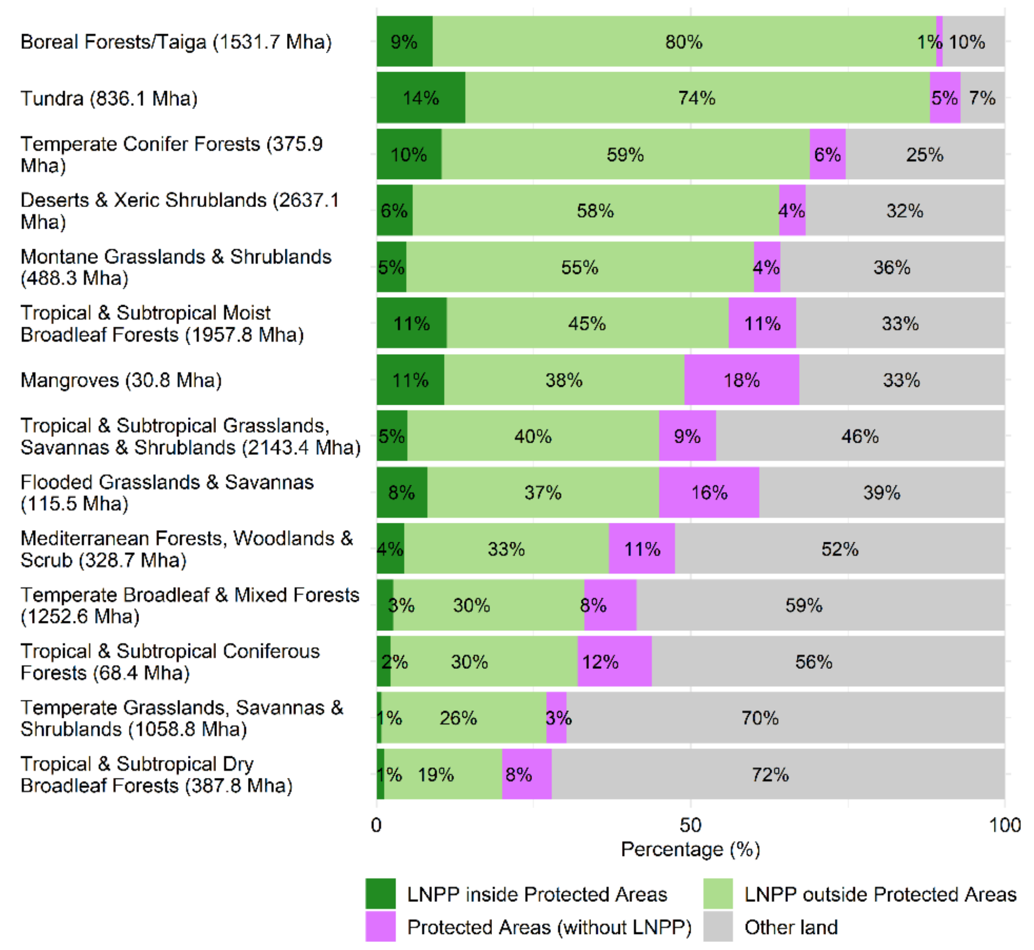
3. Current share of land where natural processes predominate

Our analysis finds that, currently, LNPP covers around 56% of terrestrial land, excluding permanent ice and rock. However, only 20% of this land is formally protected[38]. This means that, excluding permanent ice and rock, only 11% of the world's land is covered by LNPP inside protected areas. This presents a serious risk since the CBD post-2020 framework[35] proposes at least 30% of land be protected by 2030 with scientists calling for this coverage to focus on ecologically intact land[39].

Representation of LNPP, and the level of protection of these areas, is unevenly distributed across the world's ecologically unique biomes[40] (Figure 2). While LNPP covers 89% of boreal forests, this falls to only 20% in tropical and subtropical dry broadleaf forests, with only 5% of this land protected. Deserts, boreal forests, and tundra together account for 51.3% of the world's terrestrial LNPP. This information could be used to prioritize protected area expansion, e.g., to increase protection in biomes where the share of land for nature is low and pressure to convert this land is high.

Globally, natural processes predominate on about 56% of ice-free land but only 20% of this land is formally protected.

Figure 2: Share of LNPP, protected and unprotected on terrestrial land, per biome



Source: Authors' calculations (cf. Annex).

The 20 FABLE countries represent a wide range of biomes, providing an opportunity to explore scenarios for different starting conditions. This brief classifies these countries into three broad groups with contrasting conservation contexts (Figure 3):

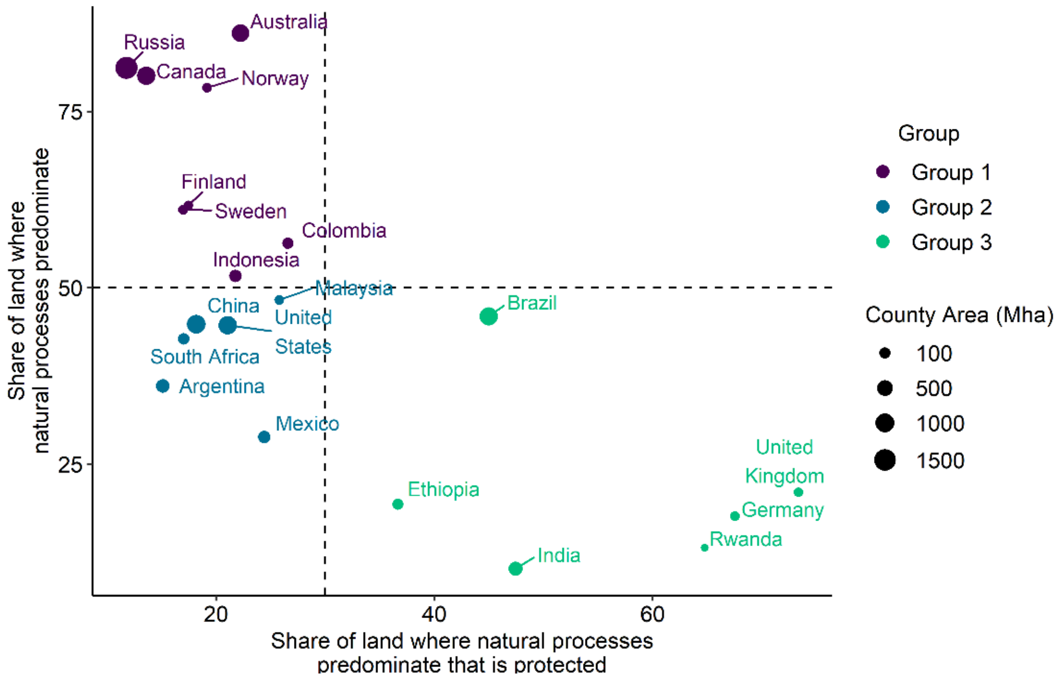
Group 1 - High Nature, Low Protection: more than half of the land is LNPP, and less than 30% of this land is protected. This includes countries with parts of their territory in the sub-polar zone, i.e., Canada, Russia, Norway, Sweden, and Finland, where human pressure is low. It also includes Australia, Colombia, and Indonesia.

Group 2 - Low Nature, Low Protection: less than half of the land is LNPP, and less than 30% of this land is protected. Malaysia's share of LNPP is just below 50% and a significantly higher share is protected compared to most other countries in this group. This group also includes Argentina, China, Mexico, South Africa, and the US.

Group 3 - Low Nature, High Protection: less than half of the land is LNPP, and more than 30% of this land is protected. The share of LNPP is critically low in India and Rwanda but while Rwanda protects more than 60% of this land, India protects less than half. Brazil is an outlier with relatively high shares of LNPP (close to 50%) and high shares of protection over this land (>40%). This group also includes Ethiopia, Germany, and the UK.

Figure 3. Current percentage of terrestrial LNPP and percentage of this land that is protected, by country.

Dashed lines show the group cutoffs and represent 50% of land where natural processes predominate (horizontal line) and 30% of this land is protected (vertical line).



Source: Authors' calculations (cf. Annex).

4. Pathways to improved future biodiversity outcomes

Comparing trajectories

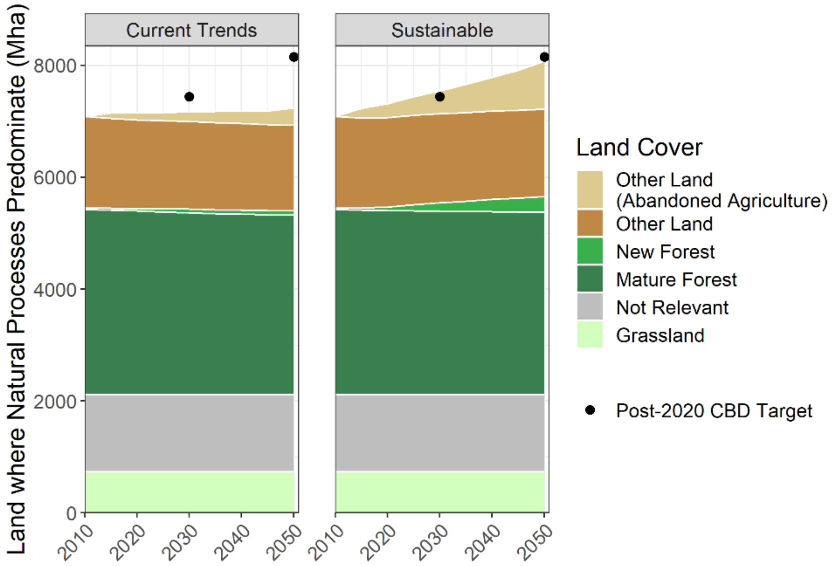
This brief compares future outcomes for LNPP across two pathways:

The *Current Trends* pathway depicts a low ambition of feasible action towards environmental sustainability with a future strongly dependent on current policy and historical trends.

The *Sustainable* pathway corresponds to a higher ambition of feasible action towards environmental sustainability. It includes measures such as the adoption of Bonn Challenge afforestation targets, constraints on agricultural land expansion, increases in crop and livestock productivity, shifts to healthier diets[41], and decreases in food loss and waste (see Annex).

Globally, with ambitious actions, we can achieve a 7% increase by 2030 and 14% increase by 2050 in land where natural processes predominate, representing more than five-times the increases expected in Current Trends.

Figure 4. Global changes in LNPP by 2050, compared to 2010, by land cover



Source: FABLE 2021 Scenathon (https://scenathon.org/).

Our models assume that LNPP 1) is lost when it is converted into agricultural or urban land, and 2) increases through passive restoration in areas where cropland or pasture is abandoned, and through afforestation.

Based on these assumptions, our analysis shows that **global biodiversity targets will not be achieved under Current Trends**. Following this pathway leads to only a 1.1% increase in LNPP by 2030 and 2.2% by 2050, compared to 2010. **Under the Sustainable pathway, LNPP increases by 6.5% by 2030 achieving one of the CBD's proposed post-2020 targets, and by 13.9% by 2050, almost achieving a second post-2020 target** (Figure 4).

A third CBD-proposed target (halt losses by 2030) is not achieved in either pathway, but losses are

Halting the loss of existing land where natural processes predominate by 2030 is a challenging target and neither pathway achieves it. More ambitious actions would be needed to halt losses.

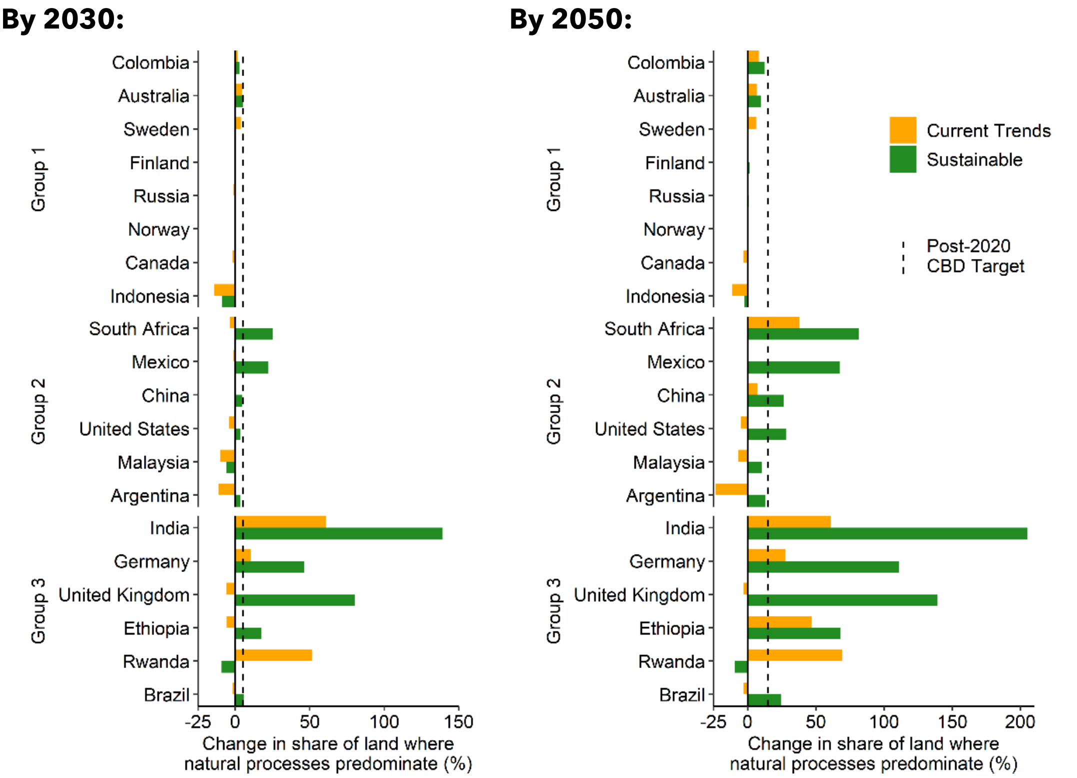
substantially reduced in the Sustainable pathway. Under Current Trends, 58 Mha of mature forest where natural processes predominate is lost by 2030, and a further 44 Mha by 2050, while 71 Mha of other natural land is lost by 2030 and an additional 39 Mha by 2050. In our Sustainable pathway, loss of mature forest where natural processes predominate is halved overall, with losses of 32 Mha by 2030 and a further 23 Mha by 2050, together with a loss of 45 Mha of other natural land by 2030 and an additional 28 Mha by 2050.

In our Sustainable pathway, China, US, Brazil, India, and Australia are the countries with the largest area increases in LNPP, thus contributing the most to achieving the global target of expanding these areas by 15% by 2050 (see Annex). These countries span Groups 1, 2 and 3 (see Section 3), indicating that even in countries that already have a high share of LNPP, restoration will be critical to achieve global biodiversity targets. The largest relative increases in LNPP are for countries in Groups 2 and 3 (Figure 5), suggesting that appropriate national targets may vary with countries' conservation contexts.

Under Current Trends, while most countries achieve net gains in LNPP between 2010 and 2050, seven countries experience net losses with losses of 25% in Argentina (Figure 5). In our Sustainable pathway, over the same period, there are net gains in LNPP in all countries except Indonesia and Rwanda.

Restoration will be needed everywhere. Even small relative increases in land where natural process predominate will be important for reaching global targets

Figure 5. Modelled percentage changes in LNPP, compared to 2010



Source: FABLE 2021 Scenathon (https://scenathon.org/).

Indonesia holds one of the world's largest remaining expanses of rainforest, the preservation of which is critical to the welfare of thousands of plant and animal species, including Sumatran tigers and orangutans. Compared to 2010, LNPP is reduced by 11.5% by 2050 under Current Trends, and by 2.5% in our Sustainable pathway. Under both pathways, restoration is enabled through a reduction in cropland area after 2030 due to the combination of lower international demand for palm oil and domestic productivity gains for the main crops. Higher LNPP under the Sustainable pathway is explained by the assumption that action will be taken to completely halt deforestation after 2030.

In Rwanda, LNPP increases more under Current Trends than in the Sustainable pathway which is driven by a larger increase in consumption of meat and milk compared to Current Trends (current animal-sourced food consumption is low). Even if in the Sustainable pathway, Rwanda would pledge no conversion of forests to agricultural land by 2030 (compared to free agricultural land expansion under Current Trends) and assume larger than expected increases in livestock productivity, pastureland expands into other natural land areas.

Levers for positive change

Increases in land where natural processes predominate are driven mainly by shifts in diets, increases in crop and livestock productivity, and constraints on agricultural land expansion.

Assumptions about changes in diets, crop and livestock productivity, food waste, population growth, and other factors, in each of the pathways varied with each country (see Annex). Constraints are also introduced to ensure estimated future imports are balanced against future exports. This section considers which assumptions and model constraints drive positive changes in LNPP.

All countries where the share of LNPP increased in the Sustainable Pathway have decreases, or smaller increases, in per capita calorie intake compared to Current Trends, except for Argentina, Malaysia and Russia where no dietary shifts occurred in either pathway. All these countries also assumed either forbidden or very limited agricultural land expansion. Most of these countries, including the six countries with the largest percentage increases in LNPP (Figure 5), also assumed larger increases in crop productivity and (except Ethiopia and the UK) livestock productivity, compared to Current Trends.

In the seven countries with the largest area increases in LNPP (see Annex), other assumptions include substantial decreases in population growth (Brazil, India, China), a higher livestock stocking density (Australia, Brazil, and Mexico), and more extensive afforestation (Australia, US), compared to Current Trends.

Trade-offs and synergies

In our Sustainable pathway, **globally increasing the share of LNPP by 14% by 2050 can be achieved while simultaneously achieving increases in global food security and reducing greenhouse gas emissions (GHG) from agriculture**[a]. Global food consumption per person per day reaches 2350 kcal in 2050 and includes enough food to meet

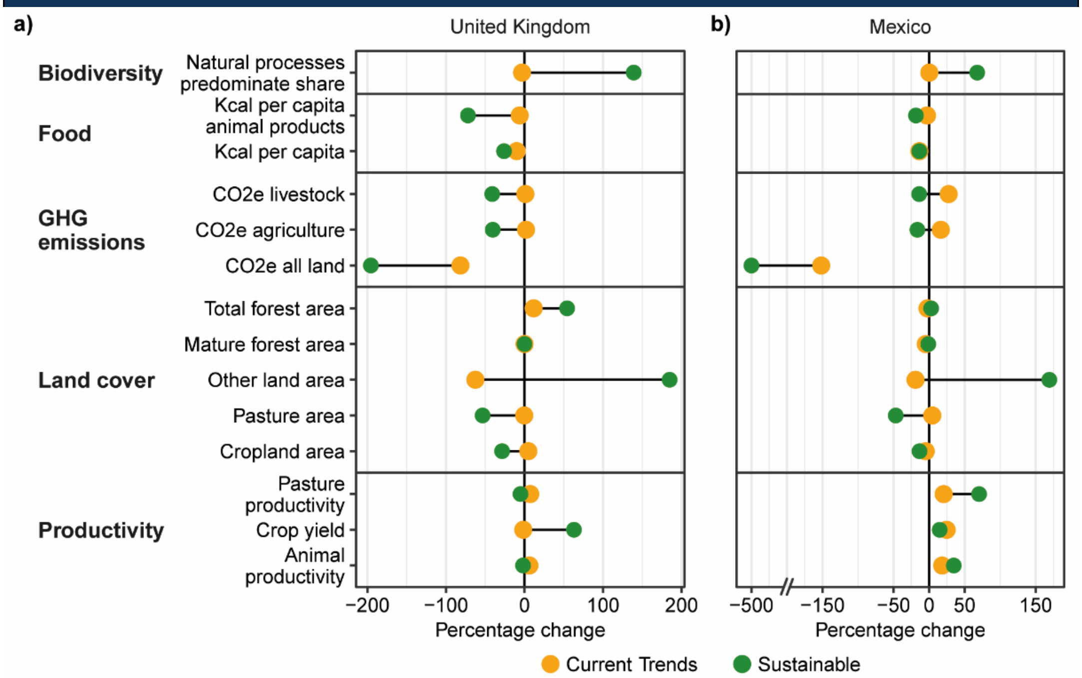
[a] FABLE 2021 Scenathon (https://scenathon.org/).

minimum daily calorie intake recommendations. Global GHG from crops and livestock would be reduced to 3.3 $GtCO_2e$/yr in 2050 (compared to 6.4 $GtCO_2e$/yr under Current Trends).

Expanding the area of LNPP often involves restoration of agricultural land. In countries with an over-consumption of food and in particular of animal-based products, this is enabled by shifting to healthier diets[41], for example by reducing total daily food consumption and per capita meat intake, and increasing food and vegetable consumption. Together with an increase in agricultural land productivity, this can create synergistic improvements for human nutrition[42-45] and biodiversity conservation.

For instance, **in the UK, the share of LNPP would more than double to cover 50% of the country by 2050 in the Sustainable Pathway,** through restoration of 7 Mha of abandoned crop and pastureland to woodland, heathland, shrubland, wetlands and other natural land (Figure 6a). The UK continues to meet its food needs, by shifting to a diet based on the UK national guidelines for a balanced diet[46]. This diet includes reduced fat and sugar consumption and calorie intake to just above minimum recommended levels, driving a reduction in consumption of livestock products (notably red meat, milk, and animal fats). Agricultural land is further freed up by productivity gains for some crops by 2030 (including +57% for wheat to 12t/ha), a 50% increase in livestock stocking density, increased reliance on fruit and vegetable imports, and a 50% reduction in household food waste and post-harvest losses. **Under the Sustainable Pathway, the UK achieves to cut its GHG emissions from agriculture by 39%** (from 38 $MtCO_2e$/yr in 2010 to 23 $MtCO_2e$/yr in 2050), driven largely by reduced emissions from the livestock sector.

Figure 6: Modelled changes in biodiversity and other outcomes in UK and Mexico between 2010 and 2050.



Source: FABLE 2021 Scenathon (https://scenathon.org/).

Careful planning will be needed to secure synergistic positive outcomes for biodiversity conservation, nutritional health, and climate mitigation.

Win-win outcomes for biodiversity conservation and climate mitigation are probable when actions involve halting deforestation (especially of mature forests) and afforestation with a diversity of local species. These actions increase LNPP while also increasing carbon storage and sequestration.

But restoring forest cover alone is not sufficient for biodiversity recovery because there are many organisms which depend on habitat with low or no tree cover, such as grasslands, savanna, and wetlands. Restoration of grassland, wetlands and other natural land positively impacts on biodiversity outcomes. In this situation, win-win outcomes for biodiversity conservation and climate mitigation can still be achieved by, for example, simultaneously increasing productivity to reduce GHG emissions from cattle production and other agricultural sources.

For instance, **in Mexico, in the Sustainable pathway, LNPP achieves an increase of 72%, with a mature forest loss of 0.7 Mha but net forest gain of 1.9Mha** (Figure 6b). It would require the restoration of 35.8 Mha of abandoned crop and pastureland to shrubland, wetland, and other natural land to achieve such increases in LNPP. This reduction in agricultural land would be possible through a decline in meat and animal products in Mexican diets and an increase in imports of livestock products (notably milk) and animal feed (corn). Pastureland would also decline through large increases in pasture productivity. In the Sustainable pathway, **Mexico would be able to cut its GHG emissions from agriculture by 28%** (from 70 $MtCO_2e$/yr in 2010 to 50 $MtCO_2e$/yr in 2050), largely through reduced emissions from livestock.

5. Policy implications

The pathway to sustainable food and land-use systems requires ambitious actions by government, agribusinesses, farmers, and consumers.

As countries enter the final negotiations at the CBD COP15, global action is needed to bring about a transformation in society's relationship with biodiversity.

The Sustainable pathway modelled in this brief, demonstrates that ambitious actions can help safeguard the world's remaining biodiversity and achieve synergies with food and climate mitigation objectives. Shifting to healthier diets, increasing crop and livestock productivity, limiting agricultural expansion, and large-scale restoration are pivotal actions needed to lead countries into a sustainable trajectory. In our Sustainable pathway, LNPP would increase by 14% globally by 2050 compared to 2010, achieving the 2030 target (5% increase) and almost achieving the 2050 target (15% increase) proposed in the post-2020 framework. We would fall far short of both targets under Current Trends. Even though in our Sustainable pathway, we are not able to meet a third global target (halt losses by 2030), loss of mature forest would be halved compared to Current Trends.

Our analysis shows that countries with different biodiversity conservation contexts can each contribute to meeting global biodiversity targets. For countries with high shares of LNPP (Group 1), halting losses and even relatively small restoration efforts can make major contributions to global biodiversity targets. In countries with low shares of LNPP (Group 2 & 3), it may be easier to achieve large relative increases. This is likely to have major benefits for biodiversity especially in biomes with critically low levels of land left for nature, such as tropical dry broadleaf forests and temperate grasslands. In all countries, further agricultural land expansion should be avoided. Degraded land, together with some agricultural land, will need to be freed up and restored to natural land. Finding ways to increase crop and livestock productivity through biodiversity-friendly agricultural practices is likely to be critical, to free up agricultural land while making it easier for species to inhabit managed landscapes and move between natural land areas.

To help halt biodiversity loss, countries should strengthen and expand protected areas to cover more LNPP. Such initiatives should recognize the essential stewardship role of indigenous peoples and seek locally appropriate conservation approaches that empower local people[47,48]. Thus, conservation strategies should target key species, land-use types, and traditional practices, integrating the entire socioecological system[49].

Our study shows how countries can contribute to achieving global biodiversity targets, without compromising food security or climate mitigation goals. The challenge lies in implementation. Immediate action is crucial and will require that governments, education systems, farmers, agri-food businesses, and consumers mobilize to catalyze a transition towards sustainable food and land systems. Importantly, it requires cooperation between countries to collectively achieve targets, recognizing that choices made by one country can have a profound impact on global biodiversity, and the whole food and land system.

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Annex

Data sources and processing to calculate the current share of land where natural processes predominate

Land where natural processes predominate represents areas inside low impact areas[24], Key Biodiversity Areas[36], and intact forest landscapes for 2016[37]. Protected area data obtained from the World Database of Protected Areas (2019)[38] were cleaned and converted into raster layers following UNEP-WCMC guidelines. GADM v36 data were used to delineate country boundaries and were intersected with globally unique ecoregions obtained from Dinerstein et al. (2017)[40], excluding ecoregions classified as permanent ice and rock, to create country-ecoregion boundaries. We used ESACCI land cover maps to compute the share of LNPP and protected land inside each country-ecoregion. We reclassified the 24 ESACCI land cover classes into eight classes (Table 1) for consistency with the FAO land cover classification system used in the FABLE calculator. The land covers used have two major limitations. First, natural grasslands and intensive or extensive pasture are not distinguished in the ESACCI land cover map, or in any other readily available global dataset, and are both classified as 'grassland' in our analysis. Second, natural and plantation forests are not distinguished in the ESACCI land cover map, or in any other global dataset, and are both classified as 'forest' in our analysis. All data processing was completed using tools in ArcGIS and R.

Table 2: ESACCI to FABLE land cover reclassifications

FABLE classes	ESA classes (codes)
Cropland	Cropland (10,11,12,20), Mosaic cropland>50% - natural vegetation <50% (30), Mosaic cropland><50% - natural vegetation >50% (40)
Forest	Broadleaved tree cover (50,60,61,62), Needleleaved tree cover (70,71,72,80,82,82), Mosaic trees and shrub >50% - herbaceous <50% (100), Tree cover flooded water (160,170)
Grassland	Mosaic herbaceous >50% - trees and shrubs <50% (110), Grassland (130)
Other land	Shrubland (120,121,122), Lichens and mosses (140), Sparse vegetation (150,151,152,153), Shrub or herbaceous flooded (180)
Bare areas	Bare areas (200,201,202)
Snow and ice	Snow and ice (220)
Urban	Urban (190)
Water	Water (210)

Models

For the Scenathon 2021, two models have been used: the FABLE Calculator for 19 countries and the rest of the world regions, and MAgPIE for India.

- The FABLE Calculator is an Excel accounting tool[b] used to study the potential evolution of food and land-use systems over the period 2000-2050 for each five-year time step. It focuses on agriculture as the main driver of land-use change. It includes 76 raw and processed agricultural products from the crop and livestock sectors. Details are provided in the model documentation. The FABLE Calculator can be downloaded here.
- MAgPIE is a recursive dynamic cost-minimization model of global land systems developed at PIK. The model simulates crop production, land-use patterns, water use for irrigation, and carbon stock changes at a spatial resolution of 0.5° × 0.5°. Associated with the REMIND energy-economy model, it is used in global integrated assessments to support the IPCC[52].

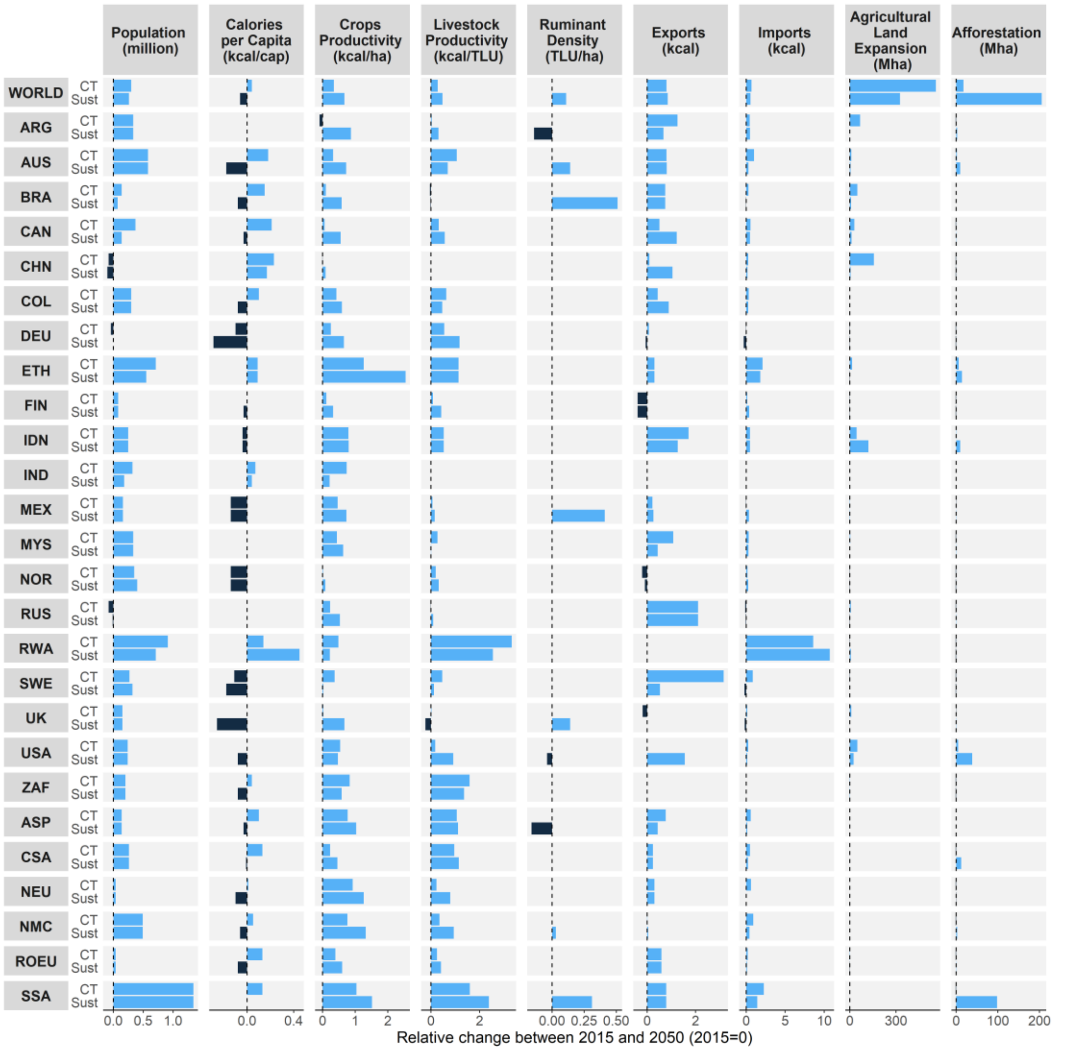
Each pathway is defined by a combination of scenarios that allow for variation across key parameters of the models. Each of our country teams could select different values for the

[b] The FABLE Calculator has a very similar structure as the GLOBAGRI[50] and TYFA models[51].

following parameters: affecting demand (GDP, diets, biofuel use), trade, food loss and waste, productivity, land-use restrictions, afforestation, and climate change. In the MAgPIE model, carbon tax is an additional scenario.

Assumptions for all countries

Figure 7: Assumptions per country



Note: crop productivity is computed as the sum of kilocalories produced from crops divided by the total cropland area; pasture productivity is the sum of kilocalorie production from all animal products divided by all livestock units; ruminant density is computed as the total ruminant livestock units (beef, sheep and goats) divided by the total pasture area.

Result Indicators

Land where natural processes predominate: A country's projected share of land where natural processes predominate is computed by summing the baseline area to the sum of loss and gain in land area where natural processes predominate and dividing by the total country area based on GADM v36.

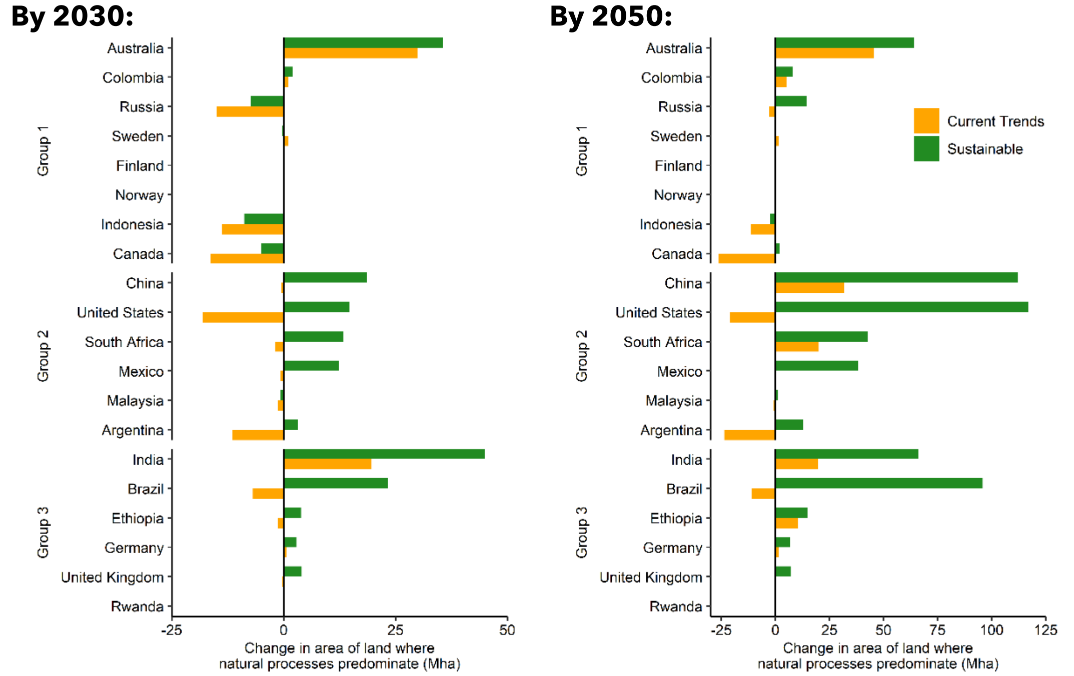
Food intake overall and for animal-sourced products: Average per capita food calorie intake based on consumption at the national level. Animal-sourced products refer to beef, mutton, goat, pork, chicken, milk, and eggs.

GHG emissions from agriculture and livestock: GHG emissions from agriculture include emissions from enteric fermentation, manure management, rice cultivation, agricultural soils, and on-farm energy use. GHG emissions from the cultivation of organic soils are included for Finland and Indonesia.

Land cover change: Land cover change is the sum of land cover loss and gain for each land cover type (cropland, pasture, forest, other natural land). Forest loss is the deforestation associated with agriculture and urban expansion. Forest gain is the land which is taken out of pasture, cropland and/or other natural land to be afforested.

Extended results

Figure 8: Modelled area changes in land where natural processes predominate, compared to 2010



Limitations and future research priorities

Several refinements of our analysis will be needed to support national biodiversity strategies. Our assumptions that passive rewilding of abandoned agricultural land, or afforestation, can restore areas where natural processes predominate might be too optimistic in certain contexts. Too many restoration efforts have followed a mono-species approach that ultimately threatens biodiversity. We assume that future restoration efforts will be centered on diverse, local species of trees and other plants, arranged to increase complexity and connectivity across scales to support biodiversity. The pollution risks associated with higher fertilizer and pesticide use to increase productivity, especially for aquatic biodiversity and insects, have not been considered in this study. New maps with a better representation of current land management, e.g., for forestry activities or natural grassland use, would also improve the assessment of the evolution of the land where natural processes predominate. Finally, our analysis would be strengthened with a spatially-explicit representation of where restoration of land where natural processes predominate should be prioritized to ensure positive outcomes for biodiversity and minimize trade-offs with food production and climate mitigation goals. Several countries in the FABLE network are already moving forward with this approach, such as Argentina, where researchers are considering the implications of land-use change on different ecoregions, local and threatened species.