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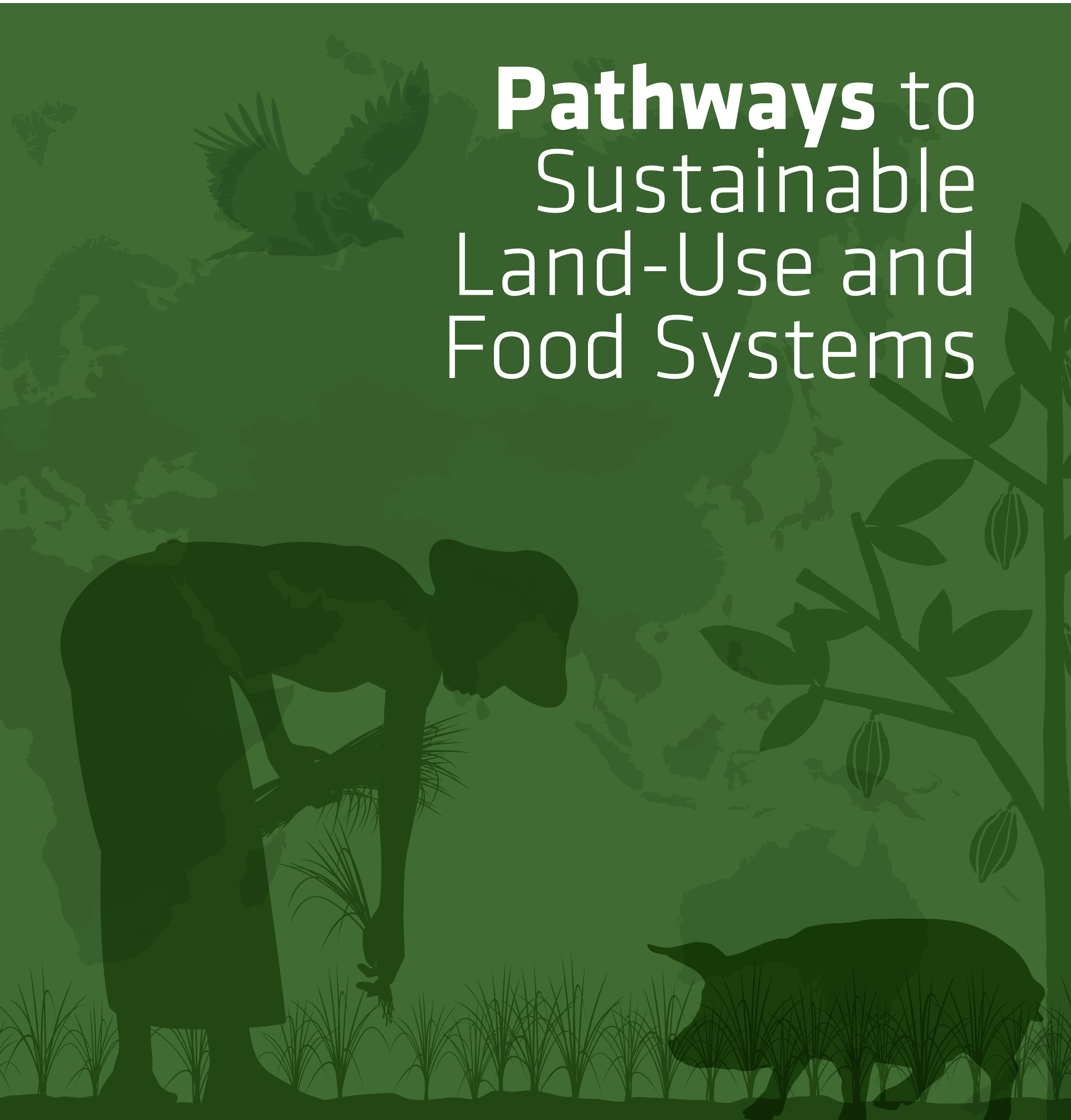
The Food and Land Use Coalition

2020 Report of the FABLE Consortium

Pathways to Sustainable Land-Use and Food Systems



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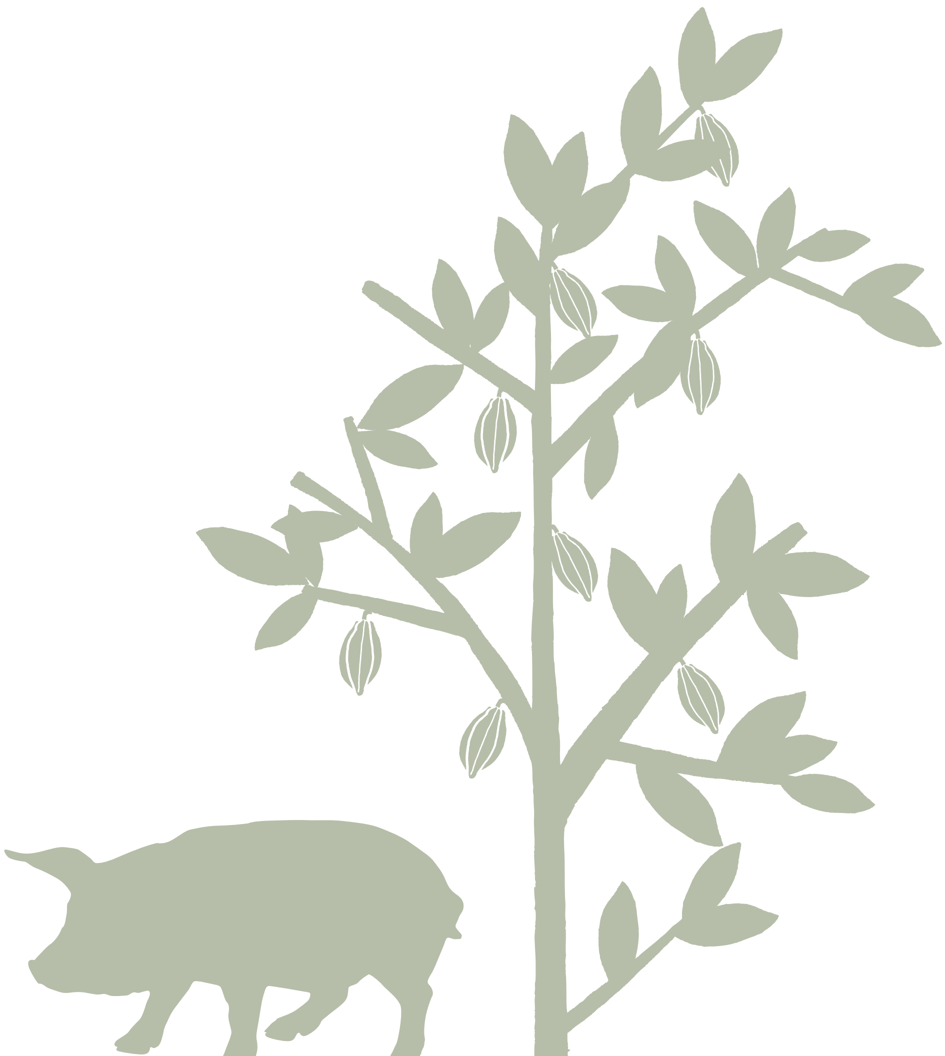
2020 Report of the FABLE Consortium

Pathways to Sustainable Land-Use and Food Systems in Argentina by 2050



Argentina

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This chapter of the 2020 Report of the FABLE Consortium *Pathways to Sustainable Land-Use and Food Systems* outlines how sustainable food and land-use systems can contribute to raising climate ambition, aligning climate mitigation and biodiversity protection policies, and achieving other sustainable development priorities in Argentina. It presents two pathways for food and land-use systems for the period 2020-2050: Current Trends and Sustainable. These pathways examine the trade-offs between achieving the FABLE Targets under limited land availability and constraints to balance supply and demand at national and global levels. We developed these pathways in consultation with national stakeholders from Instituto Nacional de Tecnología Agropecuaria (INTA), Fundación Bariloche, Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Ministerio de Ambiente y Desarrollo Sustentable (MAyDS), FUNDAPAZ, Fundación "Nuestros Bosques", AAPRESID, Fundación Vida Silvestre Argentina, and others, and modeled them with the FABLE Calculator (Mosnier, Penescu, Thomson, and Perez-Guzman, 2019). See Annex 1 for more details on the adaptation of the model to the national context.

Climate and Biodiversity Strategies and Current Commitments

Countries are expected to renew and revise their climate and biodiversity commitments ahead of the 26th session of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) and the 15th COP to the United Nations Convention on Biological Diversity (CBD). Agriculture, land-use, and other dimensions of the FABLE analysis are key drivers of both greenhouse gas (GHG) emissions and biodiversity loss and offer critical adaptation opportunities. Similarly, nature-based solutions, such as reforestation and carbon sequestration, can meet up to a third of the emission reduction needs for the Paris Agreement (Roe et al., 2019). Countries' biodiversity and climate strategies under the two Conventions should therefore develop integrated and coherent policies that cut across these domains, in particular through land-use planning which accounts for spatial heterogeneity.

Table 1 summarizes how Argentina's Nationally Determined Contribution (NDC), long-term low greenhouse gas emissions development strategy (LT-LEDS), and Forest Reference Emission Level (FREL) treat the FABLE domains. According to its NDC, Argentina has committed to reducing its GHG emissions by 18% (unconditional) or 37% (conditional upon receiving international funding) by 2030 compared to a business-as-usual (BAU) scenario (MAyDS, 2017). Moreover, according to the latest advances in the ongoing LT-LEDS preparations (INTA, 2020), Argentina is working to develop four targets on GHG emissions reductions for the agriculture, forestry, and other land use (AFOLU) sector, including "carbon neutral agriculture". This process, which should be merged with the ongoing Energy 2050 Long Term Strategy (Climate Transparency, 2019), includes emission reduction efforts from the AFOLU sector, including afforestation, rehabilitation of deteriorated forests and other ecosystems, intensification of production, and land sparing. Under its current commitments to the UNFCCC, Argentina does not mention biodiversity conservation, at least not explicitly (MAyDS, 2017).

Table 1 | Summary of the mitigation target, sectoral coverage, and references to biodiversity and spatially-explicit planning in current NDC, LT-LEDS, and FREL

	Total GHG Mitigation					Mitigation Measures Related to AFOLU (Y/N)	Mention of Biodiversity (Y/N)	Inclusion of Actionable Maps for Land-Use Planning[1] (Y/N)	Links to Other FABLE Targets
	Baseline		Mitigation target		Sectors included				
	Year	GHG emissions (Mt CO_2e/yr)	Year	Target					
NDC (2016)	2030	570	2030	483 (18% unconditional reduction from BAU) 369 (37% conditional reduction from BAU)	energy, industrial processes, agriculture, land-use change and forestry, and waste	Y	N	N	Forests Water Biodiversity
LT-LEDS (2020)	2016 (submission in preparation)	136	2050	Four levels for AFOLU sector: 73, 59, 15 and 0	agriculture, land-use change and forestry	Y	N	Y	Forests Water Food
FREL (2019)	Average 2002-2013 (submission in 2019)	101	2030	Reduction of 27 Mt from this sector (included in NDCs)	land-use change and forestry	Y	N	N	Forests

Note. The NDC "Total GHG Mitigation" and "Mitigation Measures Related to AFOLU" columns are adapted from IGES NDC Database (Hattori, 2019).
Source: Argentina (2016)

1 We follow the United Nations Development Programme definition, "maps that provide information that allowed planners to take action" (Cadena et al., 2019).

Table 2 provides an overview of the targets listed in the National Biodiversity Strategies and Action Plan (NBSAP) from 2016, as listed on the CBD website (CBD, 2020), which are related to at least one of the FABLE Targets. In comparison with the FABLE Targets, the NBSAP targets are less ambitious, but cover a broader range of issues (e.g. education, indigenous knowledge, marine ecosystems, etc.).

Argentina's new Biodiversity Strategy and Action Plan (2016-2020) represents a cross-cutting component of the public agenda and an essential tool for achieving inclusive sustainable development, calling for the involvement of all ministries, levels of government, institutions, academics and scientists, indigenous peoples, the private sector and civil society organizations in implementation. It is made up of 9 strategic objectives and 21 priority national targets. The National Biodiversity Commission (CONADIBIO) will be responsible for coordinating activities and monitoring implementation, and the actions will be implemented by competent State entities. Environmental protection efforts are increasingly being assumed by national and provincial entities. In 2012, national spending on biodiversity conservation represented 0.48% of the GDP, while a growth rate of 350% in such spending was determined for the 2006-2012 period (MAyDS, 2015).

Table 2 | Overview of the latest NBSAP Targets in relation to FABLE Targets

NBSAP Target	FABLE Target
(1) **The adequate proportions (of protected areas) will be maintained to fulfil the viability of long-term conservation, buffering, and connectivity among protected areas, according to each region's characteristics and conservation objectives.**	**BIODIVERSITY:** No net loss by 2030 and an increase of at least 20% by 2050 in the area of land where natural processes predominate. At least 30% of global terrestrial area protected by 2030.
(2) **Reaching a minimum protected area of 13% of the national land, setting priorities in relation to the existing percentage of protected areas and their connectivity, endemism, and threatened species and ecosystems, and a minimum of 4% in each ecoregion. While the minimum goal is 13% coverage, the NBSAP refers to 17% coverage (as per CBD Aichi Biodiversity Target 11) as desirable.**	**BIODIVERSITY:** No net loss by 2030 and an increase of at least 20% by 2050 in the area of land where natural processes predominate. At least 30% of global terrestrial area protected by 2030.
(4) **Augmenting by 20% the current protected wetland areas and integrating them into the public planning system at the local, regional, and national levels.**	**BIODIVERSITY:** No net loss by 2030 and an increase of at least 20% by 2050 in the area of land where natural processes predominate. At least 30% of global terrestrial area protected by 2030.
(7) **Fostering sustainable production in regional economies, together with family farming and indigenous populations (...). Incorporation of agroecological production, integrated livestock production and others, compatible with sustainable use and conservation of biodiversity and its ecosystem services.**	**BIODIVERSITY:** No net loss by 2030 and an increase of at least 20% by 2050 in the area of land where natural processes predominate

Brief Description of National Pathways

Among possible futures, we present two alternative pathways for reaching sustainable objectives, in line with the FABLE Targets, for food and land-use systems in Argentina.

Our Current Trends Pathway corresponds to the lower boundary of feasible action, even though it is not a continuation of ongoing trends (e.g. 2000-2020). It represents a strong decision to improve Argentina's sustainability without losing competitiveness or total production or income. It is characterized by high population growth (from 45 million inhabitants in 2020 to 65 million in 2050), limited constraints on agricultural expansion, a low afforestation target, high productivity increases in the agricultural sector, no change in diets, and a significant increase in the balance of trade (both an increase in exports and a decline in imports) (see Annex 2). This corresponds to a future based on current policy and historical trends that would also see considerable progress with regards to stopping deforestation (MJyDH, 2007) and reducing post-harvest losses. Moreover, as with all FABLE country teams, we embed this Current Trends Pathway in a global GHG concentration trajectory that would lead to a radiative forcing level of 6 W/m^2 (RCP 6.0), or a global mean warming increase *likely* between 2°C and 3°C above pre-industrial temperatures, by 2100. Our model includes the corresponding climate change impacts on yields by 2050 for corn, rice, soybean, wheat, sugarcane, sunflower, and other minor crops (see Annex 2).

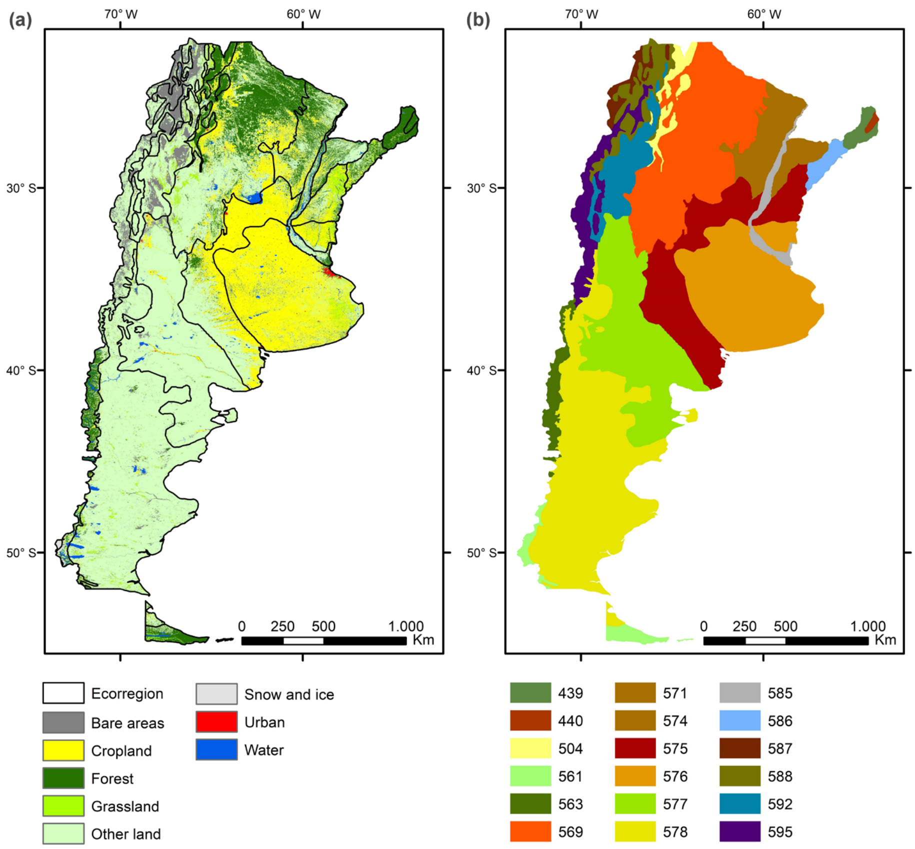
Our Sustainable Pathway represents a future in which further significant efforts are made to adopt sustainable policies and practices and corresponds to a high boundary of feasible action. Compared to the Current Trends Pathway, we assume that this future would lead to comparatively lower exports and higher imports of commodities, together with a significant reduction in food waste, releasing pressure on the environment (see Annex 2). This corresponds to a future based on no expansion of agricultural areas, increased afforestation (INTA, 2020), and increased irrigation water efficiency (banning gravitational irrigation, as many provinces have begun to do). With the other FABLE country teams, we embed this Sustainable Pathway in a global GHG concentration trajectory that would lead to a lower radiative forcing level of 2.6 W/m^2 by 2100 (RCP 2.6), in line with limiting warming to 2°C.

Land and Biodiversity

Current State

In 2016, Argentina was covered by around 15% cropland, 40% grassland and pastures, 12% forest, less than 1% urban area, and 32% other natural land. Most agricultural area is located in the center-east, while forest can be mostly found in the north (504-Southern Andean Yunga, 569-Dry Chaco, 586-Southern Cone Mesopotamian Savanna, 439-Alto Parana Atlantic Forest, and 574-Uruguayan Savanna) and in the southwest (440-Araucaria Moist Forests, 561-Magellanic Subpolar Forests, and 563-Valdivian Temperate Forests). Other natural lands, such as grasslands and shrublands (including semi-arid ones) occupy Argentina's entire western latitude (Map 1). Following the IUCN's threats classification scheme, the most important threats to biodiversity are due to changes in land use for agriculture and livestock (threats 2.11, 2.32, 5.1.2, 7.1.1., 8.1) and fires (9.3.3), where an important displacement fauna of has occurred. However, the main threat to biodiversity-rich areas, such as protected areas, is the high-level of tourist activity (threat 1.3).

Map 1 | Land cover in 2010 by aggregated land cover types (a) and ecoregions (b)

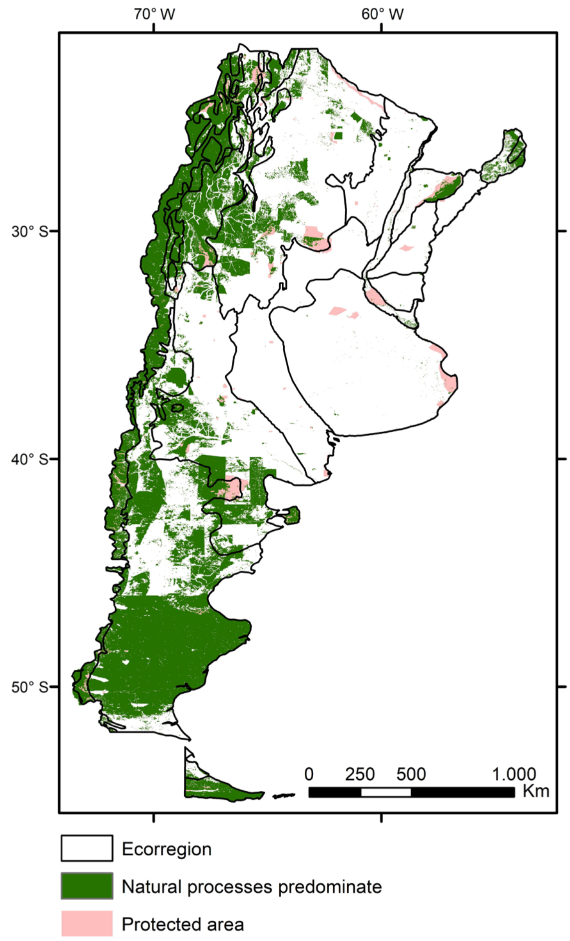


Notes. See ecoregion names in Annex 4. Correspondence between original ESACCI land cover classes and aggregated land cover classes displayed on the map can be found in Annex 3.
Sources. countries - GADM v3.6; ecoregions – Dinerstein et al. (2017); land cover – ESA CCI land cover 2015 (ESA, 2017)

We estimate that land where natural processes predominate[2] accounted for 37.3% of Argentina's terrestrial land area in 2010 (Map 2). The 578-Patagonian steppe (semi-arid grassland) holds the greatest share of land where natural processes predominate, followed by 569-Dry Chaco (temperate forest) and 577-Low Monte, a semi-arid shrubland (Annex 4). Across the country, while nearly 23 Mha of land are under formal protection, falling short of the 30% zero-draft CBD post-2020 target, only 17.5% of land where natural processes predominate is formally protected. This indicates that the area under legal protection must be expanded to achieve these goals. The ecoregion areas 439-Alto Paraná Atlantic Forest, 504-Southern Andean Yungas, 569/571-Chaco forest, 578-Patagonian Steppe, 563-Valdivian, and 561-Magellan Subpolar forests contain the highest biodiversity and ecosystem service values. Given that at least 50% of currently protected areas lack effective protection (MAyDS, 2015), it is critical to strengthen conservation management, which should be treated with the same level of importance as protected area expansion.

Approximately 35% of Argentina's cropland was in landscapes with at least 10% natural vegetation in 2010 (Annex 4). These relatively biodiversity-friendly croplands are most widespread in 576-Humid Pampas, followed by 575-Espinal, 569-Dry Chaco, and 571-Humid Chaco. However, most of the area in 576-Humid Pampas is either cropland or pastures, while in 575-Espinal, 569-Dry Chaco, and 571-Humid Chaco it is a matrix of natural vegetation that has been colonized by cultivation. In the Monte, Patagonian Steppe, and the Andean regions, the percentage of cultivation is low due to unfavorable climate and soil conditions.

Map 2 | Land where natural processes predominated in 2010, protected areas and ecoregions



Source. countries - GADM v3.6; ecoregions – Dinerstein et al. (2017); protected areas – UNEP-WCMC and IUCN (2020); natural processes predominate comprises key biodiversity areas – BirdLife International (2019), intact forest landscapes in 2016 – Potapov et al. (2016), and low impact areas – Jacobson et al. (2019)

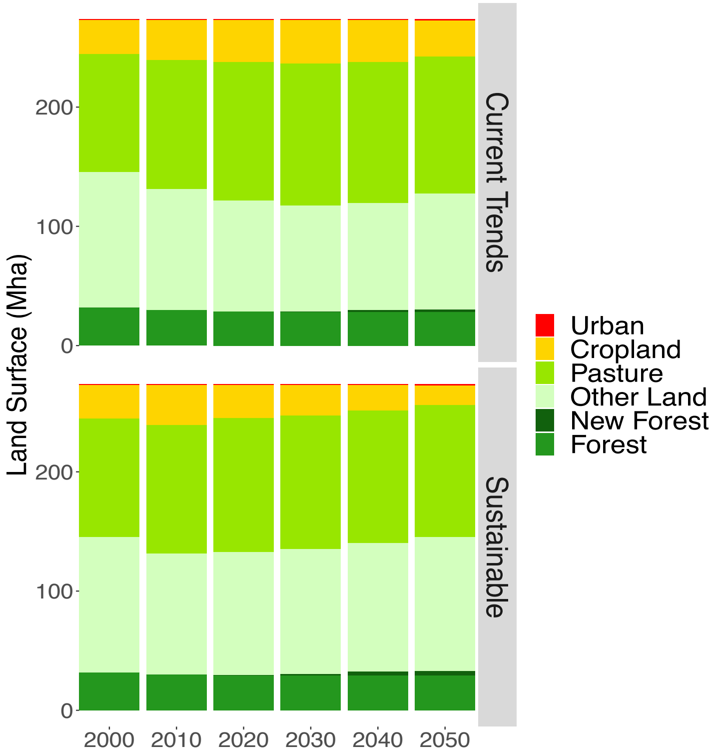
2 We follow Jacobson, Riggio, Tait, and Baillie (2019) definition: "Landscapes that currently have low human density and impacts and are not primarily managed for human needs. These are areas where natural processes predominate, but are not necessarily places with intact natural vegetation, ecosystem processes or faunal assemblages".

Pathways and Results

Projected land use in the Current Trends Pathway is based on several assumptions, including the prevention of deforestation by 2030, 2 Mha of afforestation by 2050, and maintaining protected areas at 23 Mha, representing 8.4% of total land cover (see Annex 2).

By 2030, we estimate that the main changes in land cover in the Current Trends Pathway will result from an increase in pasture and cropland area and a decrease in the area of other land, a trend that stabilizes by 2050 (Figure 1). The expansion of the planted area for soybean, corn, and groundnut explain almost 80% of total cropland expansion between 2010 and 2030. Soybean expansion is explained by an increase in exports (international demand for feed) and high revenues, while corn and groundnut expansion are due mainly to an increase of internal feed consumption and exports and an increase of internal demand for nonfood consumption, respectively. Pasture expansion is mainly driven by the increase in internal demand for beef and milk consumption, while livestock productivity per head also increases and ruminant density per hectare of pasture remains constant over the period 2020-2030. Between 2030-2050, the stabilization of land use classes is explained by limiting deforestation and meeting Argentina's export targets (without further intensification). This is a promising result for this less ambitious pathway, even if these changes initially result in a decline in the area where natural processes predominate, falling to approximately 34% of total land by 2030, and only increase in later years, reaching a little over 37% by 2050 (Figure 2).

Figure 1 | Evolution of area by land cover type and protected areas under each pathway

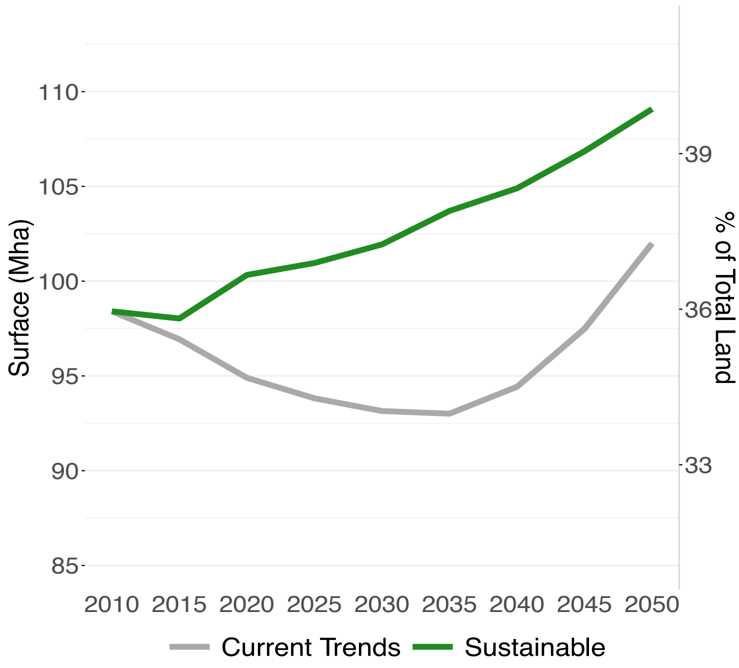


Source: Authors' computation based on FAOSTAT (FAO, 2020) for the area by land cover type for 2000.

In the Sustainable Pathway, assumptions on agricultural land expansion and reforestation have been changed to reflect ongoing discussions and projections made by stakeholders during the Strategic Partnerships for the Implementation of the Paris Agreement (SPIPA) Project (INTA, 2020). The main assumptions include constraints on the expansion of agricultural land beyond its current extent, and 4 Mha of reforestation or afforestation by 2030 (see Annex 2).

Compared to the Current Trends Pathway, we observe the following changes regarding the evolution of land cover in Argentina in the Sustainable Pathway: (i) a decline in cultivated area and the stabilization of pasture area, (ii) a moderate increase in forests and new forests areas, (iii) an increase in other lands (due to the decrease in cropland area). In addition to the changes in assumptions regarding land-use planning, these changes compared to the Current Trends Pathway are explained by an increase in productivity, a decrease in food loss, and more balanced international trade for foodstuffs (all of which relieve pressure on land). This leads to a 10% increase in the area where natural processes predominate between 2020 and 2050.

Figure 2 | Evolution of the area where natural processes predominate

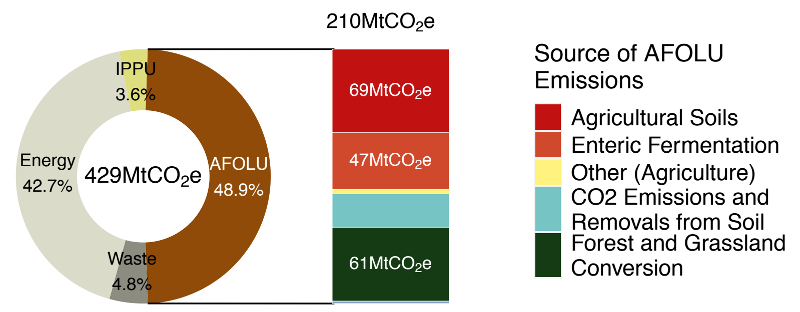


GHG emissions from AFOLU

Current State

Direct GHG emissions from Agriculture, Forestry, and Other Land Use (AFOLU) accounted for 48.9% of total emissions in 2012 (Figure 3). The principle source of AFOLU emissions is agricultural soils, followed by land conversion, and enteric fermentation. This can be explained both by the historical importance of agriculture and animal husbandry in Argentina's economy and deforestation, with over 600 kha deforested in 2012 (Gómez Lende, 2018). Currently, deforestation for agricultural purposes is prohibited, although illegal deforestation remains an issue.

Figure 3 | Historical share of GHG emissions from Agriculture, Forestry, and Other Land Use (AFOLU) to total AFOLU emissions and removals by source in 2012

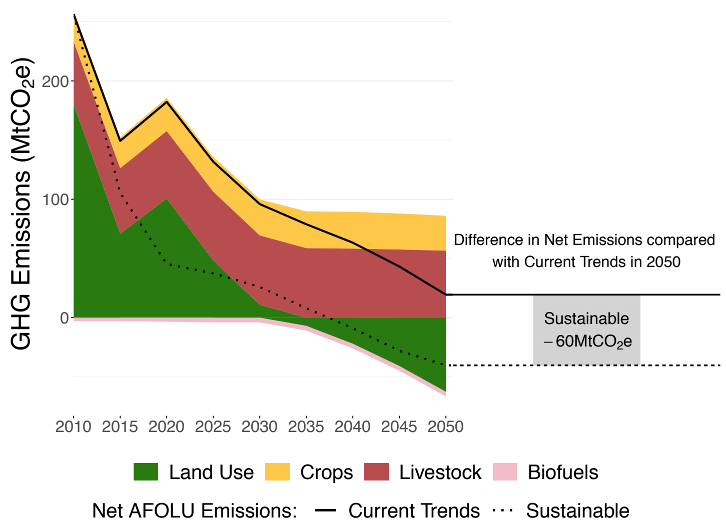


Note. IPPU = Industrial Processes and Product Use
Source. Adapted from GHG National Inventory (UNFCCC, 2020)

Pathways and Results

Under the Current Trends Pathway, annual GHG emissions from AFOLU decrease to 96 Mt CO_2e/yr in 2030, before reaching 19 Mt CO2e/yr in 2050 (Figure 4). In 2050, livestock is the largest source of emissions (57 Mt CO_2e/yr) while land-use change (afforestation) acts as a sink (-64 Mt CO_2e/yr). Over the period 2020-2050, the strongest relative increases in GHG emissions are for crops (70%), while emissions from livestock increased around 7%. There is a strong relative increase in GHG sequestration, which reduces Argentina's total emissions by around 33%.

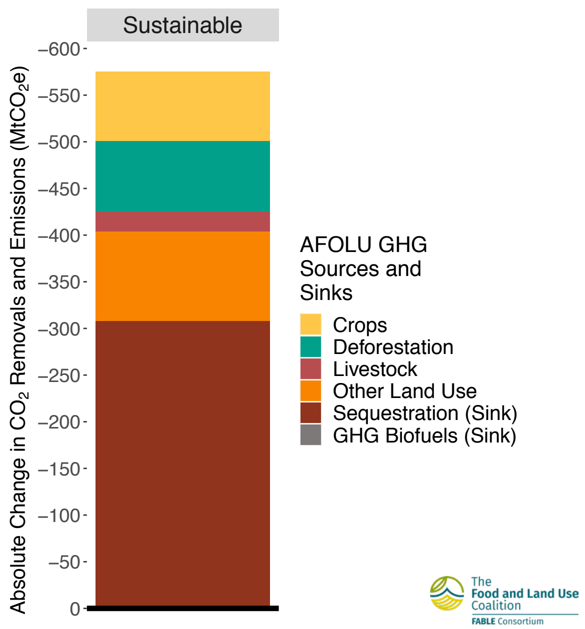
Figure 4 | Projected AFOLU emissions and removals between 2010 and 2050 by main sources and sinks for the Current Trends Pathway



In comparison, the Sustainable Pathway leads to a reduction of AFOLU GHG emissions by 70% by 2050 compared to the Current Trends Pathway (Figure 4). The potential emissions reductions under the Sustainable Pathway are achieved by a reduction in GHG emissions from crops (due to the comparative reduction in total crop area) and a noticeable increase in carbon sequestration due to land use changes (no deforestation and increased afforestation), while there are less significant changes regarding emissions from livestock (Figure 5).

Compared to Argentina's commitments under the UNFCCC (Table 1), our results show that AFOLU could contribute to as much as 33% of its total conditional objective for GHG emissions reduction by 2030. Such reductions could be achieved through the following policy measures: halting all deforestation, promoting afforestation, and enhancing productivity in order to spare natural lands. These measures could be particularly important when considering options for long-term strategies for reducing GHG emissions. Regarding the ongoing LT-LEDS preparation process, the Sustainable Pathway results point to how Argentina could fulfill its less ambitious goal of "less than 2°C", although they would still fall short a "carbon neutral agriculture" goal.

Figure 5 | Cumulated GHG emissions reduction computed over 2020–2050 by AFOLU GHG emissions and sequestration source compared to the Current Trends Pathway



Food Security

Current State

The "Triple Burden" of Malnutrition

Undernutrition

4.6% of the population was undernourished in 2016-2018. This share has increased since 2015, when the share stood at around 3.3%.

In 2005, 8.2% of children under 5 were stunted and 1.2% were wasted (FAO, 2017).

Micronutrient Deficiency

18.6% of women of reproductive age suffered from anemia in 2016, which can lead to maternal death (FAO, 2017).

14.3% of children are deficient in vitamin A, which can notably lead to blindness and child mortality, and most children and pregnant women from northern provinces are deficient in iodine, which can lead to developmental abnormalities (Disalvo et al., 2019).

Overweight/ Obesity

22.5% of adults and 9.9% of children were obese in 2005. The share of adult obesity has since increased linearly and reached 28.5% in 2016 (FAO, 2017).

Disease Burden due to Dietary Risks

Each year, 203 deaths per 100,000 population are attributable to dietary risks (Afshin et al., 2019).

10% of the adult population suffers from diabetes and 24% of all deaths in 2012 were caused by cardiovascular diseases, both closely related to dietary risks (INDEC & MINSAL, 2013).

Table 3 | Daily average fats, proteins and kilocalories intake under the Current Trends and Sustainable pathways in 2030 and 2050

	2010	2030		2050	
	Historical Diet (FAO)	Current Trends	Sustainable	Current Trends	Sustainable
Kilocalories (MDER)	2,921 (2,051)	2,903 (2,070)	2,875 (2,070)	2,905 (2,070)	2,898 (2,070)
Fats (g) (recommended range	108 (65-97)	108 (65-97)	106 (64-96)	108 (65-97)	107 (64-97)
Proteins (g) (recommended range	93 (73-256)	93 (73-254)	91 (72-252)	93 (73-254)	92 (72-252)

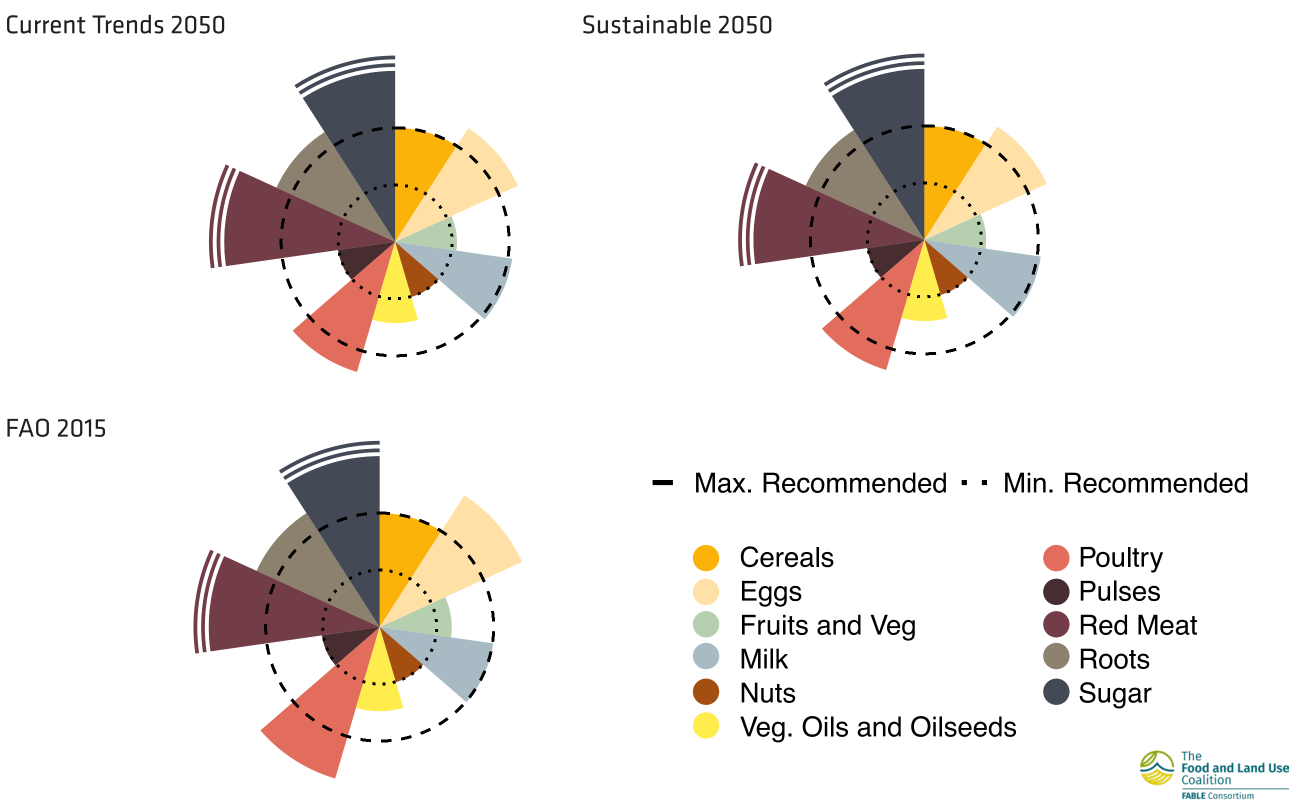
Notes. Minimum Dietary Energy Requirement (MDER) is computed as a weighted average of energy requirement by sex, age class, and activity level (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015) and the population projections by sex and age class (UN DESA, 2017) following the FAO methodology (Wanner et al., 2014). For fats, the dietary reference intake is 20% to 30% of kilocalories consumption. For proteins, the dietary reference intake is 10% to 35% of kilocalorie consumption. The recommended range in grams has been computed using 9 kcal/g of fats and 4kcal/g of proteins.

Pathways and Results

Under the Current Trends Pathway, compared to the average Minimum Dietary Energy Requirement (MDER) at the national level, our computed average calorie intake is 40% higher in 2030 and 2050 (Table 3). The current average intake is mostly satisfied by cereals, sugar, red meat, and milk, while animal products represent 31% of the total calorie intake. We assume that the consumption of animal products and in particular red meat will remain constant between 2020 and 2050. The same assumption stands for eggs, poultry, cereals, sugar, and oils consumption. Compared to the average EAT-Lancet recommendations (Willett et al., 2019), red meat, sugar, eggs, poultry and cereals are over-consumed (Figure 6).

Under the Sustainable Pathway, we assume that diets will remain similar to those under the Current Trends Pathway, as we have primarily prioritized discussing environmental concerns with stakeholders. Although this assumption may not be internally consistent with the rest of the Sustainable Pathway storyline, we will be reaching out to national stakeholders and experts regarding these issues in the future stages of our analyses.

Figure 6 | Comparison of the computed daily average kilocalories intake per capita per food category across pathways in 2050 with the EAT-Lancet recommendations



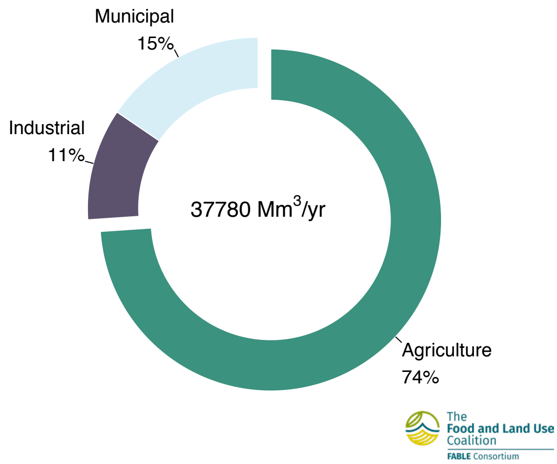
Notes. These figures are computed using the relative distances to the minimum and maximum recommended levels (i.e. the rings), therefore, different kilocalorie consumption levels correspond to each circle depending on the food group. The EAT-Lancet Commission does not provide minimum and maximum recommended values for cereals: when the kcal intake is lower than the average recommendation it is displayed on the minimum ring and if it is higher it is displayed on the maximum ring. The discontinuous lines that appear at the outer edge of sugar and red meat indicate that the average kilocalorie consumption of these food categories is significantly higher than the maximum recommended.

Water

Current State

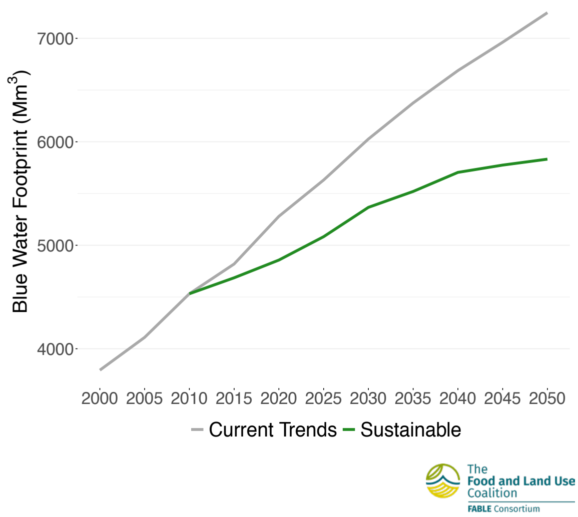
Due to its size, its predominantly latitudinal extension (3,780 km, from 21° 46′ 52″ S to 55° 03′ 21″ S) and an altitude variation of almost 8,000 meters, Argentina contains a wide range of climate types. Summers are the warmest and wettest season in most of the country except in most of Patagonia, where it is the driest. Winters are normally mild in the north, cool in the center and cold in the south, which experiences frequent frost and snow. In general, the north is characterized by hot, humid, rainy summers and mild winters with periodic droughts. Mesopotamia, in the northeast, is characterized by high temperatures and abundant precipitation throughout the year, with droughts being uncommon. West of this lies the Chaco region, where precipitation decreases, resulting in the vegetation changing from forests in the east to shrubs in the west. Northwest Argentina is predominantly dry and hot although the rugged topography makes it climatically diverse, ranging from the cold, dry Puna to thick jungles. The center of the country, which includes the Pampas to the east and the drier Cuyo region to the west has hot summers with frequent tornadoes and thunderstorms, and cool, dry winters. Patagonia, in the south, has a dry climate with warm summers and cold winters, strong winds throughout the year and one of the strongest precipitation gradients in the world. In terms of water withdrawals, agriculture is the main source, accounting for 74% in 2011 (FAO, 2020), with most of it occuring in the central part of the country. Moreover, from the 40 Mha suitable for crop and cattle production, only 2.4 Mha are irrigated, most of them through gravitational irrigation (MAGyP, 2020) .

Figure 7 | Water withdrawals by sector in 2011



Source. Adapted from AQUSTAT Database (FAO, 2017).

Figure 8 | Evolution of blue water footprint in the Current Trends and Sustainable Pathways



Pathways and Results

Under the Current Trends Pathway, annual blue water use increases between 2000-2015 (3,793 Mm³/yr and 4,819 Mm³/yr), before reaching 6,027 Mm3/yr and 7,248 Mm³/yr in 2030 and 2050, respectively (Figure 8), with sugarcane, rice, and grape representing respectively 14.6%, 13.8% and 12.3% of computed blue water use for agriculture by 2050[3]. In contrast, under the Sustainable Pathway, blue water footprint in agriculture reaches 5,366 Mm³/yr in 2030 and 5,832 Mm3/yr in 2050, respectively. This improvement is explained by changes in the crop composition of the harvested area (i.e. each crop has a different water consumption coefficient) and climate change impacts.

3 We compute the blue water footprint as the average blue fraction per tonne of product times the total production of this product. The blue water fraction per tonne comes from Mekonnen and Hoekstra (2010a, 2010b, 2011). In this study, it can only change over time because of climate change. Constraints on water availability are not taken into account.

Resilience of the Food and Land-Use System

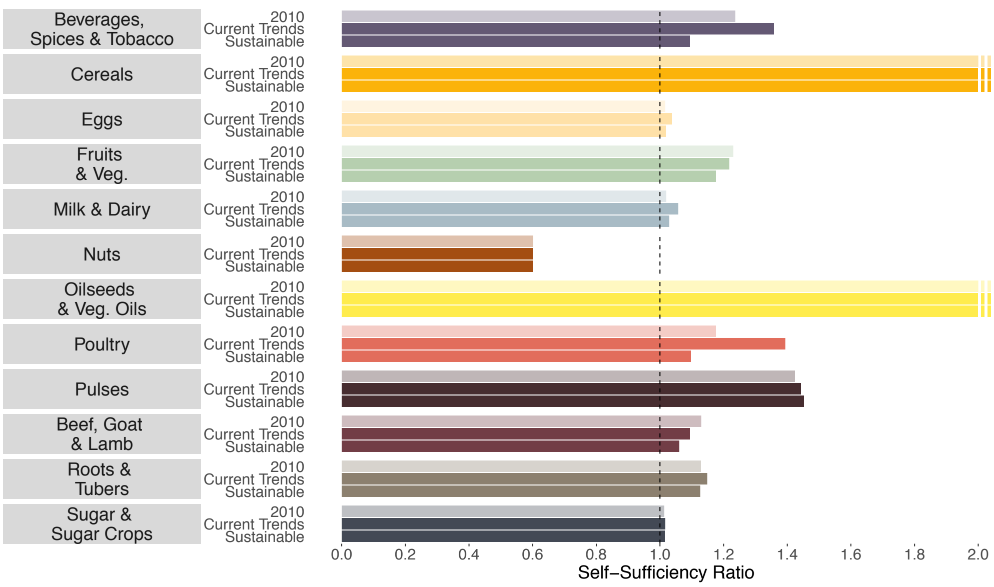
The COVID-19 crisis has exposed the fragility of food and land-use systems by bringing to the fore vulnerabilities in international supply chains and national production systems. Here we examine two indicators to gauge Argentina resilience to agricultural-trade and supply disruptions across pathways: the rate of self-sufficiency and diversity of production and trade. Together they highlight the gaps between national production and demand and the degree to which we rely on a narrow range of goods for our crop production system and trade.

Self-Sufficiency

Argentina has long been self-sufficient in food production, with an estimated 40% of total of food produced exported annually. For example, the exported value of food products of 2010 was around 80 billion USD (MINAGRO, 2016).

Under the Current Trends Pathway, we project that Argentina would be self-sufficient in virtually all product groups in 2050, with self-sufficiency by product group slightly increasing for the majority of products from 2010 – 2050 (Figure 9). The product groups where the country depends the most on imports to satisfy internal consumption are nuts, for which no noticeable changes are observed between 2010 and 2050. In the Sustainable Pathway we project that Argentina would still remain self-sufficient, but that these levels would decrease between 2010 and 2050 for most products. Nevertheless, no additional groups fall below the level of self-sufficiency due to lower production or increased consumption.

Figure 9 | Self-sufficiency per product group in 2010 and 2050



Note. In this figure, self-sufficiency is expressed as the ratio of total internal production over total internal demand. A country is self-sufficient in a product when the ratio is equal to 1, a net exporter when higher than 1, and a net importer when lower than 1. The discontinuous lines on the right side of this figure, as appear for cereals and oilseeds and vegetable oils, indicate a high level of self-sufficiency in these categories.

Diversity

The Herfindahl-Hirschman Index (HHI) measures the degree of market competition using the number of firms and the market shares of each firm in a given market. We apply this index to measure the diversity/concentration of:

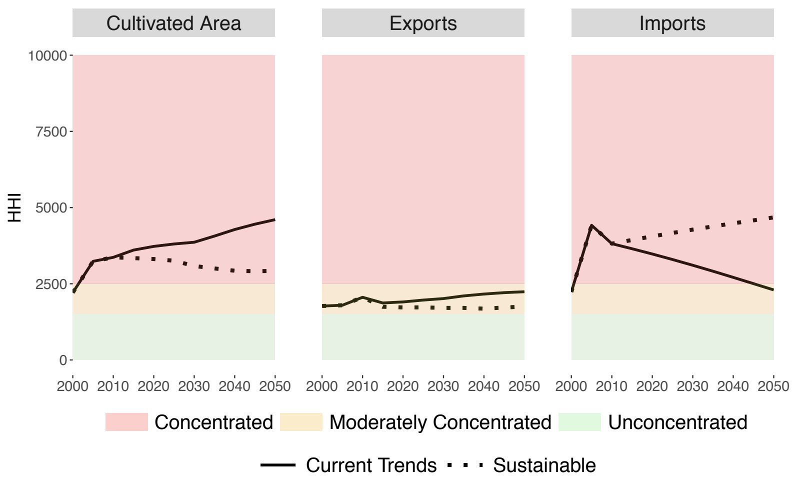
- **Cultivated area:** where concentration refers to cultivated area that is dominated by a few crops covering large shares of the total cultivated area, and diversity refers to cultivated area that is characterized by many crops with equivalent shares of the total cultivated area.
- **Exports and imports:** where concentration refers to a situation in which a few commodities represent a large share of total exported and imported quantities, and diversity refers to a situation in which many commodities account for significant shares of total exported and imported quantities.

We use the same thresholds as defined by the U.S. Department of Justice and Federal Trade Commission (2010, section 5.3): diverse under 1,500, moderate concentration between 1,500 and 2,500, and high concentration above 2,500.

In 2010, Argentina's imports and exports of food products were diverse. The values of the HHI Index were 818 for the export and 226 for the import market (calculated from trade values of main products for that year according to Hausmann et al., 2011). These values were obtained from official import and export records, which differ compared to our calculations (HHI values of 2,056 and 3,818, respectively). In addition, we found a HHI Index of 3,366 for the planted crop area in 2010, which is not at all diverse. This is unsurprising given that 60% of the crop area is planted with soybean and more than 95% of cultivated area is covered by only seven crops (MAGyP, 2020).

Under the Current Trends Pathway, we project a mild increase in the concentration of crop exports and a decrease in that of imports over the period 2010 to 2050. The difference in the 2010 values found in the literature and our results is due to the number and categories of food products considered and should be checked more carefully in future reports. Regarding the concentration in the range of crops planted between 2010 and 2050, the trend shows a marked increase in the HHI index. This indicates lower levels of diversity across the national production system. In contrast, under the Sustainable Pathway, we project a comparatively lower concentration of crop exports, fairly stable during the whole period, but a relatively higher concentration of imports towards 2050 (Figure 10). This is explained by a less ambitious export target and a higher dependency on imports in this pathway, and the fact that only two or three of the most relevant products are used to implement import-export scenarios.

Figure 10 | Evolution of the diversification of the cropland area, crop imports, and crop exports using the Herfindahl-Hirschman Index (HHI)



Discussion and Recommendations

The pathways presented in this chapter can be summarized as "compromises between development and environmental objectives", with each slightly leaning in favor of one or the other. In both, land-use changes by 2050 are moderate. In both pathways, greenhouse gas emissions increase at first, disappear from deforestation after 2030 and reach levels similar to those in 2000 by midcentury. Moreover, emissions from crops, livestock, and land-use change would account for only 2.5% of the targeted 4 Gt CO_2e from crops and livestock and negative and zero from land use changes by 2050, which all FABLE country teams aim to achieve collectively. Finally, under these pathways, Argentina would achieve zero net deforestation by 2030, which also contributes to the zero-net -emissions target from land-use change.

To achieve these climate goals, it is necessary to halt the expansion of the current crop area (which should, in fact, decrease slightly), increase productivity, diversify production, minimize emissions from agriculture (including transport logistics), and expand the area of biodiversity protection, biomass carbon stocks and water retention. Our ongoing Nature Map prioritization studies (Annex 5) show that expanding protected areas to 30% could conserve more than 75% carbon in biomass, almost 90% of endemic species, and more than 81% of pure water sources. However, if this expansion were to take place without considering crop distribution, around 12% of crop-producing areas would be lost. This tradeoff would lead to production losses of around 7.6 Mt/year, provided crops are not relocated and yields remain at their 2017 and 2018 levels (Table 4). However, these results were obtained without applying constraints to the expansion of protected areas within the most productive zones. Preliminary results from the Nature Map Argentina indicate that this overlap could be strongly reduced without significantly affecting the fulfillment of conservation targets.

Table 4 | Production loss of main crops due to protecting 30% of key natural areas as compared to 2017 and 2018

	Production Loss (t/year)	Production value in 2017/2018 (t/year)	Percentage of loss (%)
Rice	173,801	1,367,968	12.7%
Oat	12,243	491,713	2.5%
Barley	52,624	3,741,158	1.4%
Rye	2,033	86,098	2.4%
Sunflower	180,647	3,537,545	5.1%
Corn	2,952,293	43,462,323	6.8%
Peanut	57,849	921,231	6.3%
Soybean	2,434,654	37,787,927	6.4%
Sorghum	177,768	1,563,445	11.4%
Wheat	796,096	18,518,045	4.3%
Sugarcane	796,095	17,760,997	4.3%
Total	**7,636,101**	**129,238,450**	**6.1%**

Regarding the principal trade-offs between competing uses of land, we found no significant compromises between conservation goals and food provision. Similarly, there are no visible trade-offs in terms of food security as Argentina can easily cover the dietary requirements of its population (Feeney & MacClay, 2016). In other words, there are no biophysical limits to produce healthy food in a sustainable way. Rather, the main trade-off would be between sustainability and an export policy that primarily sells a single commodity (e.g. soybean and its byproducts) to very few importing countries.

This relates to the important issue of "spillover effects", understood here as the effects of the decisions taken in one country on other countries, which needs further attention. For example, the positive (i.e. income and job creation) and negative effects (i.e. deforestation, pollution, GHG emissions, population displacement, and biodiversity loss) of China´s and the European Union's imports from Argentina (Hoff et al., 2019). When richer countries buy food abroad for their internal consumption to make progress towards achieving the SDGs and spare land within their own territories, this creates spillover effects on producing countries.

In regard to the key limitations of this analysis, the FABLE Calculator currently has its limits as a tool for territorial environmental planning given that it is not spatially explicit, as it is not currently possible to define priority areas. With Nature Map Argentina we are moving to bridge this gap. Similarly, we have not yet explicitly considered the supply of food from small and medium producers of fruits and vegetables in our pathways. Family farming and agroecology, as well as small peri-urban vegetable crops, are important contributors to Argentina's food security. Therefore, these aspects will be particularly important to explore in the future given that the Ministry of the Environment and Sustainable Development of Argentina now lists reducing the prevalence of monocultures and increasing agroecological production among its highest priorities. Finally, food distribution is not properly accounted for in this assessment. Our results show a plentiful supply of food, which means that hunger is the results of its unequal distribution. This raises the need for a specific indicator to address this problem, such as, for example, one that "corrects" the food supply by its unequal distribution.

To overcome these limitations, our next steps include integrating the Nature Map and the FABLE tools to prioritize areas for conservation and food production. We are working on the construction of an Environmental Territorial Planning Map of Argentina using Nature Map and the FABLE Calculator with the Ministry of Environment and Sustainable Development, which will directly inform the implementation of sustainable policies. In parallel, we will continue the participation in the ongoing Strategic Partnerships for the Implementation of the Paris Agreement (SPIPA) Project, which aims at the development of Argentina's LT-LEDS for reducing GHG emissions by 2050. To this end, we also intend to include mitigation measures in our modeling.

Annex 1. List of changes made to the model to adapt it to the national context

No significant changes have been made to the Argentinian FABLE Calculator. However, in order to comply with Argentina's method for measuring national GHG emissions, we added a method that allowed us to estimate emissions in line national calculations (results not showed in this report). The only substantial differences between these calculations relates to forests (the Argentinian NDCs consider forests as net emitters of GHG). In addition, in certain cases we replaced the default FAO data when more accurate or more recent data were available. Finally, we modified the Bonn Challenge scenario to account for stakeholder input; an increase from 1 Mha to 2 Mha in Current Trends Pathway and an additional scenario targeting 4 Mha in the Sustainable Pathway.

Annex 2. Underlying assumptions and justification for each pathway in the FABLE Calculator

POPULATION Population projection (million inhabitants)	
Current Trends Pathway	**Sustainable Pathway**
Population is expected to increase by 33% between 2015 and 2050 from 43 million inhabitants to 57 million. Based on combined extrapolations from INDEC (2019) and Baumann Fonay & Cohan (2018). (SSP3 scenario selected)	

LAND Constraints on agricultural expansion	
Current Trends Pathway	**Sustainable Pathway**
We assume that deforestation will be halted beyond 2030. We made our choice based on the existence of a new law that establishes forest protection (MJyDH, 2007). (NoDefor 2030 scenario selected)	We assume no productive land expansion beyond 2010. We made our choice based on the preferences declared by most stakeholders during the meetings for the SPIPA Project (INTA, 2020). (NoExpansion scenario selected)
LAND Afforestation or reforestation target (Mha)	
We assume new afforested area to reach 2 Mha by 2050, based on a more ambitious target than the Bonn Challenge commitment. Argentina's national commitment is to restore 1 Mha by 2030 (Bonn Challenge, 2019).	We assume new afforested area will reach 4 Mha by 2050, based on the preferences declared by some of the stakeholders during the meetings for the SPIPA Project (INTA, 2020).

BIODIVERSITY Protected areas (1000 ha or % of total land)	
Current Trends Pathway	**Sustainable Pathway**
We used the by-default assumption in the FABLE Calculator which is that in the ecoregions where current level of protection is between 5% and 17%, the natural land area under protection increases up to 17% of the ecoregion total natural land area by 2050.	

PRODUCTION Crop productivity for the key crops in the country (in t/ha)

Current Trends Pathway	Sustainable Pathway

We assume that between 2015 and 2050 crop productivity increases:

- from 8 t/ha to 21 t/ha for corn
- from 3 t/ha to 5.6 t/ha for soybean
- from 3.7 t/ha to 10.4 t/ha for wheat

These assumptions are based on estimated yield gaps in Argentina, which stand at 100% for corn, 140% for wheat, and 130% for soybean (Global Yield Gap Atlas, 2019). Although we assumed productivity to be the same across pathways, some minor differences could appear due to the two different climate change scenarios.

PRODUCTION Livestock productivity for the key livestock products in the country (in kg/TLU)

We assume that between 2015 and 2050, productivity increases:

- from 76 kg/TLU to 90 kg/TLU for beef
- from 5.9 t/TLU to 6.9 t/TLU for cow milk

The estimated yield gap in Argentina is 54% for cow-calf and 60% for finishing (Rearte, 2010).

PRODUCTION Pasture stocking rate (in number of animal heads or animal units/ha pasture)

The average livestock stocking density remains constant at 0.32 TLU/ha of pastureland between 2015 and 2050. This is a conservative assumption. (Rearte, 2010) estimates that it could increase by 15-20% with better management of forage resources only, but increasing stocking rate elevates the number of heads, thus elevating GHG emissions, and that is an issue among stakeholders (INTA, 2020).

PRODUCTION Post-harvest losses

Argentina wastes 16 Mt/year of food (Roulet, N, 2018, unpublished data). In order to release pressure on land and resources, loses were reduced by half. Based on discussions with stakeholders during the SPIPA Project (INTA, 2020).

TRADE Share of consumption which is imported for key imported products (%)

Current Trends Pathway	Sustainable Pathway
The share of total consumption which is imported decreases: • from 72% in 2010 to 36% in 2050 for bananas. The share of total consumption which is imported remains constant at 2010 level for the other products.	The share of total consumption which is imported increases: • from 72% in 2010 to 100% in 2050 for bananas. The share of total consumption which is imported remains constant at 2010 level for the other products.

TRADE Evolution of exports for key exported products (Mt)

Current Trends Pathway	Sustainable Pathway
The exported quantity increases: • from 17 Mt in 2010 to 71 Mt in 2050 for corn • from 13 Mt in 2010 to 54 Mt in 2050 for soybean • from 5 Mt in 2010 to 20 Mt in 2050 for soy oil • from 0.16 Mt in 2010 to 0.48 Mt in 2050 for milk The exported quantity remains constant at 2010 level for the other commodities.	The exported quantity increases: • from 17 Mt in 2010 to 36 Mt in 2050 for corn • from 13 Mt in 2010 to 27 Mt in 2050 for soybean • from 5 Mt in 2010 to 10 Mt in 2050 for soy oil • from 0.16 Mt in 2010 to 0.32 Mt in 2050 for milk The exported quantity remains constant at 2010 level for the other commodities.

Argentina

FOOD Average dietary composition (daily kcal per commodity group or % of intake per commodity group)

Current Trends Pathway	Sustainable Pathway
By 2030, the average daily calorie consumption per capita is 2,900 kcal and comes mainly from cereals, sugar and red meat, with animal products representing 32% of the total calorie intake. We assume no significant dietary changes in either pathway between 2020 and 2050, except that we assume the consumption of eggs and poultry will increase while cereals, sugar, and oils consumption will decrease. For this analysis, we prioritized the discussion of environmental concerns rather than food security issues (in part due to Argentina's "overproduction" of food – this points to the importance of food distribution, which is not yet considered in the modelling efforts). In the following stages, we will be contacting expert and stakeholder groups regarding these issues.	

FOOD Share of food consumption which is wasted at household level (%)

Between 2015 and 2050, the share of final household consumption which is wasted remains stable at 10%.	Argentina wastes 16 Mt/year of food (Roulet, N, 2018, unpublished data). In order to account for feasible improvements, we selected the scenario *Reduced*, in which household food consumption is reduced by half by 2050.

BIOFUELS Targets on biofuel and/or other bioenergy use (Mt)

Current Trends Pathway	Sustainable Pathway
Both in the Current Trends and Sustainable pathways, the OECD_AGLINK Scenario was assumed, which corresponds to maintaining projections until 2028, and then stable values. This represents an initial demand for the following products: sugarcane (3.4 Mt), soyoil (1.8 Mt), and other minimal contributions from corn and rice.	

CLIMATE CHANGE Crop model and climate change scenario

Current Trends Pathway	Sustainable Pathway
By 2100, global GHG concentration leads to a radiative forcing level of 6 W/m2 (RCP 6.0). Impacts of climate change on crop yields are computed by the crop model GEPIC using climate projections from the climate model HadGEM2-E without CO_2 fertilization effect.	By 2100, global GHG concentration leads to a radiative forcing level of 2.6 W/m2 (RCP 2.6). Impacts of climate change on crop yields are computed by the crop model GEPIC using climate projections from the climate model HadGEM2-E without CO_2 fertilization effect.

Annex 3. Correspondence between original ESA CCI land cover classes and aggregated land cover classes displayed on Map 1

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)

Annex 4. Overview of biodiversity indicators for the current state at the ecoregion level[4]

Table 3 | Overview of biodiversity indicators for the current state at the ecoregion level[3]

	Ecoregion	Area (1,000 ha)	Protected Area (%)	Share of Land where Natural Processes Predominate (%)	Share of Land where Natural Processes Predominate that is Protected (%)	Share of Land where Natural Processes Predominate that is Unprotected (%)	Cropland (1,000 ha)	Share of Cropland with >10% Natural Vegetation within 1km² (%)
439	Alto Paraná Atlantic Forests	2,263.5	9.9	51.9	17.4	82.6	39.3	97.6
440	Araucaria Moist Forests	463.1	10.4	73.4	13.3	86.7	5.0	92.9
587	Central Andean Dry Puna	3,011.9	36.0	88.4	37.9	62.1	0.5	100.0
588	Central Andean Puna	8,749.8	26.0	72.8	28.3	71.7	62.0	88.2
569	Dry Chaco	49,102.3	5.1	25.8	16.5	83.5	8,034.4	46.1
575	Espinal	29,922.7	1.7	6.7	9.1	90.9	14,645.3	27.0
592	High Monte	11,698.6	12.9	68.0	13.7	86.3	108.2	76.1
571	Humid Chaco	16,228.4	10.1	23.2	24.4	75.6	3,051.6	64.5
576	Humid Pampas	39,904.8	3.0	6.8	10.6	89.4	30,050.7	29.4
577	Low Monte	35,411.7	5.4	29.6	11.7	88.3	940.6	55.5

4 The share of land within protected areas and the share of land where natural processes predominate are percentages of the total ecoregion area (counting only the parts of the ecoregion that fall within national boundaries). The shares of land where natural processes predominate that are protected or unprotected are percentages of the total land where natural processes predominate within the ecoregion. The share of cropland with at least 10% natural vegetation is a percentage of total cropland area within the ecoregion.

	Ecoregion	Area (1,000 ha)	Protected Area (%)	Share of Land where Natural Processes Predominate (%)	Share of Land where Natural Processes Predominate that is Protected (%)	Share of Land where Natural Processes Predominate that is Unprotected (%)	Cropland (1,000 ha)	Share of Cropland with >10% Natural Vegetation within 1km^2 (%)
561	Magellanic Subpolar Forests	2,842.3	36.2	88.0	39.4	60.6	77.4	91.1
585	Paraná Flooded Savanna	3,714.6	34.5	31.4	41.3	58.7	254.7	66.3
578	Patagonian Steppe	53,542.8	6.3	64.2	9.4	90.6	247.7	87.2
0	Rock and Ice	124.0	99.0	100.0	99.0	1.0	0.5	51.8
595	Southern Andean Steppe	9,485.4	26.2	92.2	27.7	72.3	23.1	78.4
504	Southern Andean Yungas	4,765.0	9.2	48.5	17.6	82.4	479.0	67.2
586	Southern Cone Mesopotamian savanna	2,683.9	1.6	17.2	7.3	92.7	327.6	80.7
574	Uruguayan Savanna	24.0	0.6	32.9	1.0	99.0	0.8	94.8
563	Valdivian Temperate Torests	4,467.7	37.4	92.4	40.1	59.9	194.1	89.0

Source. countries - GADM v3.6; ecoregions Dinerstein et al. (2017); cropland, natural and semi-natural vegetation – ESA CCI land cover 2015 (ESA, 2017); protected areas – UNEP-WCMC and IUCN (2020); natural processes predominate comprises key biodiversity areas – BirdLife International 2019, intact forest landscapes in 2016 – Potapov et al. (2016), and low impact areas – Jacobson et al. (2019)

Annex 5. Application of Nature Map in Argentina

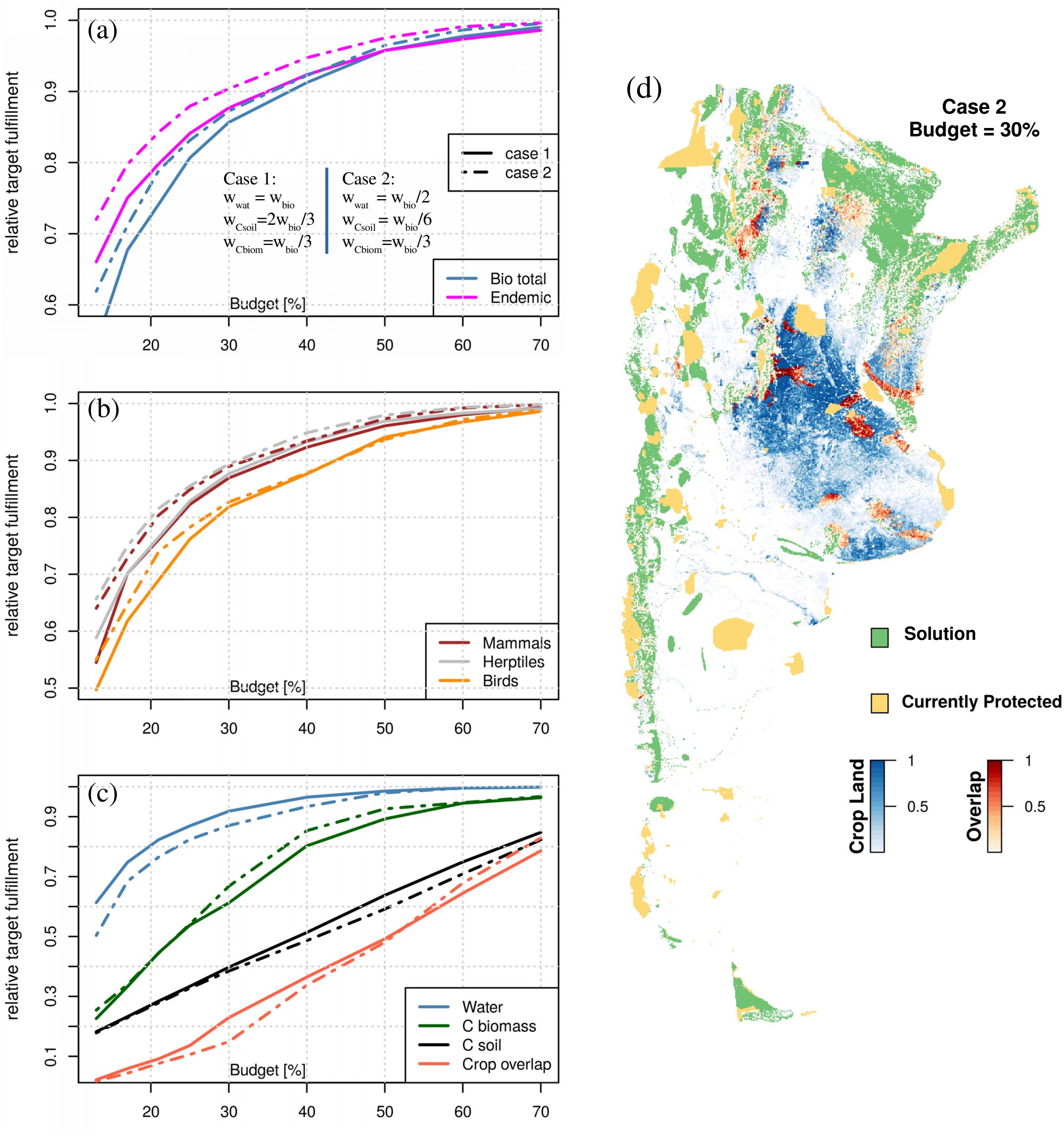
The Nature Map project (IIASA, IIS, UNEP-WCMC and SDSN, 2020) is an international effort to produce integrated maps of terrestrial areas of significance for conservation and restoration of biodiversity, carbon storage, water provision, and other ecosystem services. In Argentina, we are currently mapping habitats of endemic and non-endemic species, vulnerable soil and plant carbon, and potential sources of clean water provision. The aim is to build a map that combines each of these features and prioritizes them for conservation through a spatial optimization algorithm. To do so, we map the entire country by planning units of either protected or unprotected areas. Within the bounds of an overall "budget" that limits the maximum extent of protected areas, we then prioritize these units by identifying those which maximize the relative target fulfillment of each feature.

For this preliminary study, we considered 359 endangered species that are present in 17 biomes in Argentina. We set a target to preserve 80% to 100% of their original distribution ranges, depending on their IUCN endangerment category, including endemism into the prioritization. Furthermore, we set the target to preserve 100% of vulnerable (prone to loss) soil and biomass carbon and freshwater supply to downstream beneficiaries.

The variables were then charted against the protection budgets (from 0 to 100% of the country area) needed to reach the desired targets, considering different relative weights (Figure 11a-c). A preliminary solution is presented in Figure 11d: a map of the optimal way to preserve biodiversity, water, and carbon with a total given budget of 30% of the area (green areas, in addition to the already preserved yellow ones). This would result in the conservation of more than 75% of the carbon in biomass, almost 90% of endemic species, and more than 81% of potential clean water provision. Since soil carbon is distributed more evenly than the other variables, only around 30% of it can be protected. The areas in red correspond to the overlap of the proposed protected areas with the current cropland distribution, which account for around a 10% loss of some of the most productive areas. Considering current crop distribution and productivity, this could mean a loss of near 7.6 Mt of grain, around 6% of 2017-2018 value.

The preliminary Nature Map Argentina results show that potentially contrasting objectives can be achieved jointly through the use of prioritization models designed to answer how much area is needed for successful conservation of natural resources (and where protected areas should be located). The 30% budget solution is not entirely satisfactory due to the overlap of conservation and crop production. Future optimizations should be carried out applying additional constraints to protecting croplands and other productive areas, or even attempting to achieve both food production targets and environmental targets by allocating cropland, grazing and conservation areas at the same time, to better address this trade-off.

Figure 11 | Prioritization analysis



Notes. Calculation of the relative target fulfillment for different sets of features, as a function of the allowed budget: (a) mean biodiversity (total and endemic), (b) mammals, reptiles and birds, and (c) water and carbon, both in soil and in biomass. In addition, the overlap with current cropland areas is shown in panel (c) (relative to total cropland). Two cases using different weights for water and carbon are shown (see panel (a)). The resulting map for case 2 for budget 30% is shown in (d).

Units

°C – degree Celsius

% – percentage

/yr – per year

cap – per capita

CO_2 – carbon dioxide

CO_2e – greenhouse gas expressed in carbon dioxide equivalent in terms of their global warming potentials

g – gram

GHG – greenhouse gas

Gt – gigatons

ha – hectare

kcal – kilocalories

kg – kilogram

km^2 – square kilometer

km^3 – cubic kilometers

m – meter

Mha – million hectares

Mm^3 – million cubic meters

Mt – million tons

t – tonne

TLU – Tropical Livestock Unit is a standard unit of measurement equivalent to 250 kg, the weight of a standard cow

t/ha – tonne per hectare, measured as the production divided by the planted area by crop by year

t/TLU, kg/TLU, t/head, kg/head- tonne per TLU, kilogram per TLU, tonne per head, kilogram per head, measured as the production per year divided by the total herd number per animal type per year, including both productive and non-productive animals

USD – United States Dollar

W/m^2 – watt per square meter

yr – year

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