Supplementary material to:
“We need biosphere stewardship that protects carbon sinks and builds resilience”

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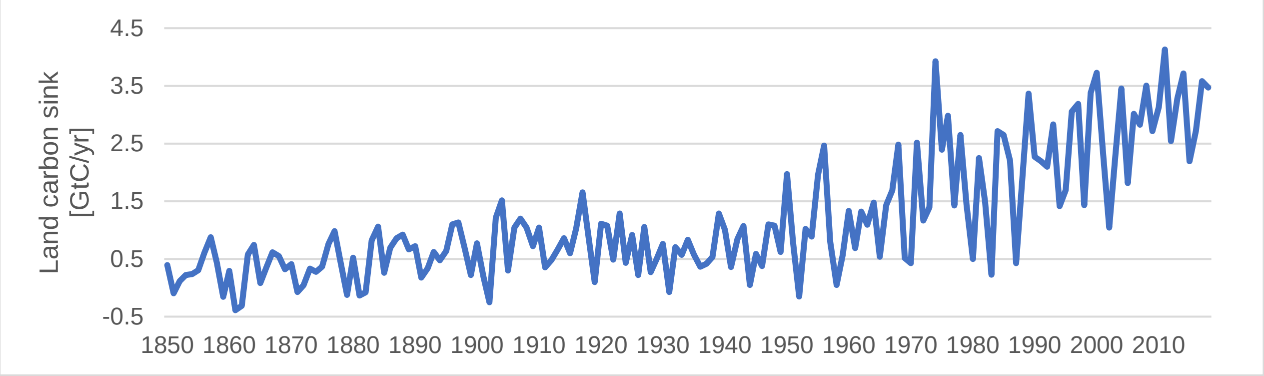

Supplementary Figure 1: Interannual variability of the land carbon sink taken from the Global Carbon Project 2019 (1). Lower interannual variability of up to 1.5 GtC/yr characterized the years 1850-1950 while variability between years almost doubled after 1950.

Data used for Figure 1

Supplementary Table 1: Carbon sinks and stocks in major biomes

Biome or climate zone	**Region**	**Sink strength [tC/ha/yr]**	**Total sink [GtC/yr]**	**Carbon stock [GtC]**	**Loss rate [%]**
Tropical forest				309 (3)	0.45-0.58 (3)
	pan-tropical		-1.2 (2)		
	Amazon	-0.4 (4)	-0.5 (4)	151 (3, 5)	
	Africa	-0.7 (4)	-0.5 (4)	77 (3, 5)	
	SE Asia	-0.4 (6)	-0.1 (2)	80 (3, 5)	
Temperate forest		-0.3 (7)	-0.7 (2)	199 (3)	0.3 (3)
Boreal forest		-0.2(8)	-0.5 (2, 8)	283 (3)	0.2 (3)
Tropical grassland		-0.1 (7)	-0.4 (7)	30 (3)	0.1 (3)
Temperate grassland		-0.1 (7)	-0.2 (7)	39 (3)	0.1 (3)
Peatland	All		-0.1 (9)	220 (3)	
	boreal/temperate	-0.2 (10)	-0.1 (9, 11)		0.0 (3)
	Tropical	-0.5 (9)	-0.03 (9)		0.6 (3)
Permafrost			0.6 (12)	1700 (1)	
Mangroves, seagrass, marshes			-0.2 (13)	11 (14)	0.1 (3)
Ocean			-2.5 (1)	38000 (1)	

Calculation of carbon stocks in major biomes (Figure 1B)

Data sources

- vegetation carbon stocks from Spawn et al. (15)
- soil carbon stocks from Sanderman et al. (16)
- biome classification from Dinerstein et al. (17)
- current land use from HYDE3.2.1 (18)
- low impact areas (LIA) map from Jacobson et al. (19)
- global human modification (GHM) map from Kennedy et al. (20)

Carbon stock calculation

- for each major biomes we calculated total vegetation and soil carbon stocks in natural ecosystems
- we used three different options to map ecosystems that have largely remained in their natural state based on:
  - HYDE: areas not classified as cropland or grazing land
    - $C_{biome} = C\_stocks_{veg+soil} * \left(area_{tot} - area_{crop+grazing}\right)$
  - LIA: areas classified as low impact areas
    - $C_{biome} = C\_stocks_{veg+soil} * area_{lia}$
  - GHM: areas with a GHM index less or equal to 0.1
    - $C_{biome} = C\_stocks_{veg+soil} * area_{ghm \leq 0.1}$

Calculation of unmodified shares of major biomes (Figure 1B)

- We calculated the areas of each major biome from (17) with a GHM values of less or equal to 0.1 (20) and then calculated the share of these areas in the total area of each biome.

MAGICC scenario settings

Supplementary Table 2: MAGICC scenario overview.

	Value	Explanation
Emission scenario	RCP2.6	
Simulation timeframe	1850-2100	
Scenario timeframe	1850-2100	MAGICC does not allow changing model parameters during a simulation so we can only run full 1850-2100 simulations with alternative model settings. E.g., it's impossible to simulate the loss of land carbon sinks after 2020.
CO_2 fertilization	On or off	We turn off CO_2 fertilization in the "biosphere loss" scenario". This means that vegetation does can no longer benefit from the increasing CO_2 content through higher photosynthesis rates and water use efficiency. This has a twofold effect: no acceleration in carbon sequestration rates and no increased drought tolerance.
Vegetation regrowth	Standard or reduced	In the "biosphere loss" scenario we assume that vegetation is not able to regrow as fast as in the standard simulation "Paris goal". This assumes that land is either constantly used after deforestation/conversion or highly degraded. Therefore, carbon stocks in vegetation and soils are not able to build up again.
Climate sensitivity	3°	MAGICC applies a climate sensitivity of 3° as the default.
Restoration scenario	2.4 GtC/yr between 2020 and 2029, 4.6 GtC/yr from 2030	Here we use estimates based on Griscom et al. (21), and aligned with the mid-point of estimates by Girardin et al. (22), that maximum NCS mitigation constrained to cost-feasible levels to limit warming well below 2°C sums to a total of 4.6 GtC additional carbon sequestration per year by 2030. For the decade 2020-2029 we assume a linear increase with an average value of 2.3 GtC/yr. We add this flux to the land use emissions input for MAGICC assuming these are additional efforts in the land sector. In this case we can add this additional mitigation flux from 2020 onwards because land use change carbon fluxes come from an external input file that defines these fluxes as decadal values.

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