Supplementary Information for

Biodiversity side-effects of carbon-focused reforestation under Paris-aligned transition pathways

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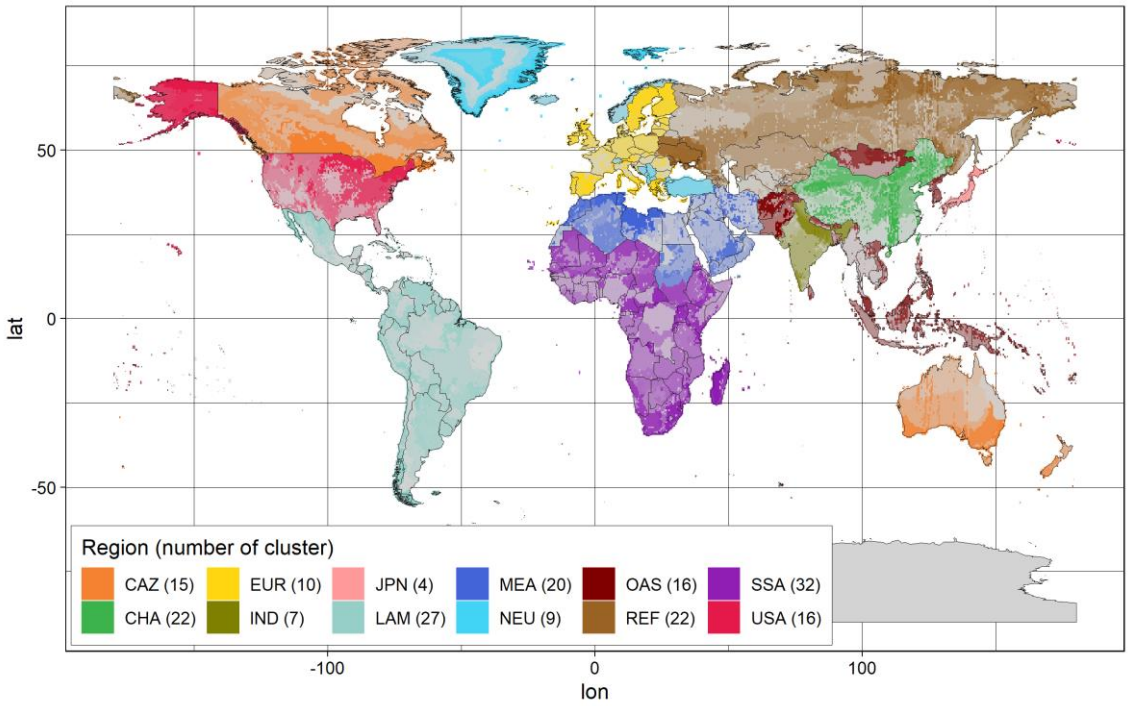
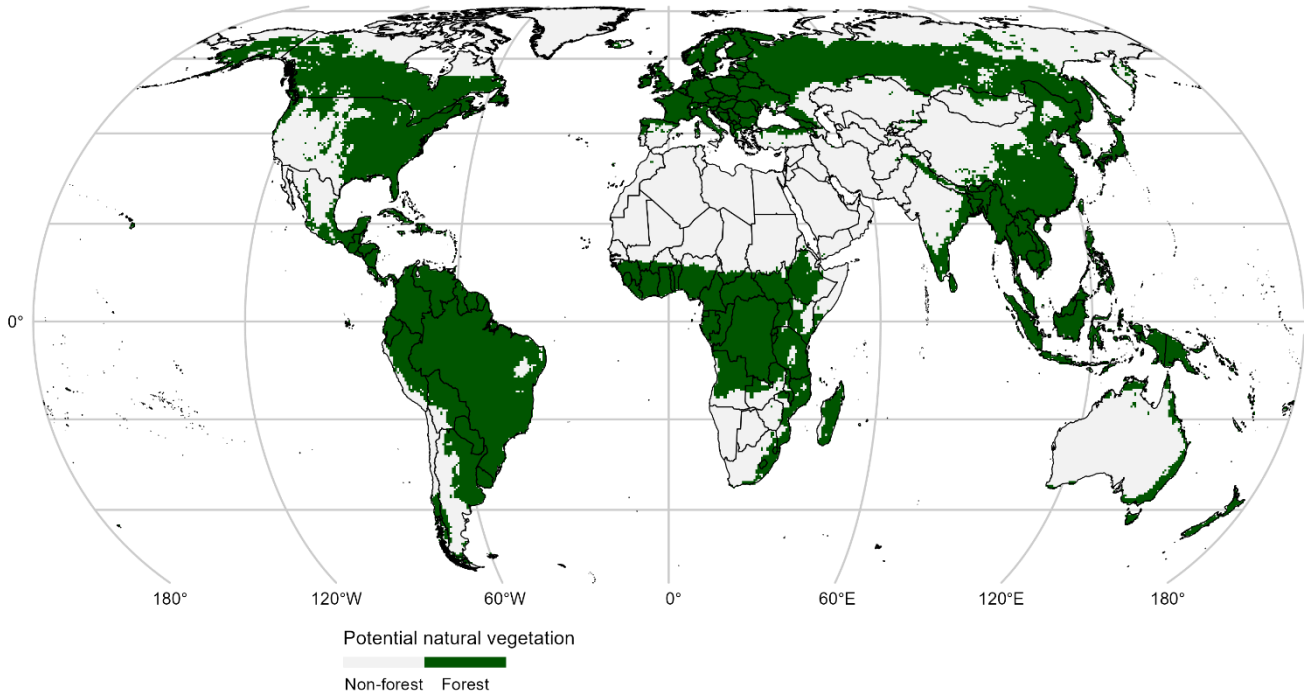
Supplementary Data



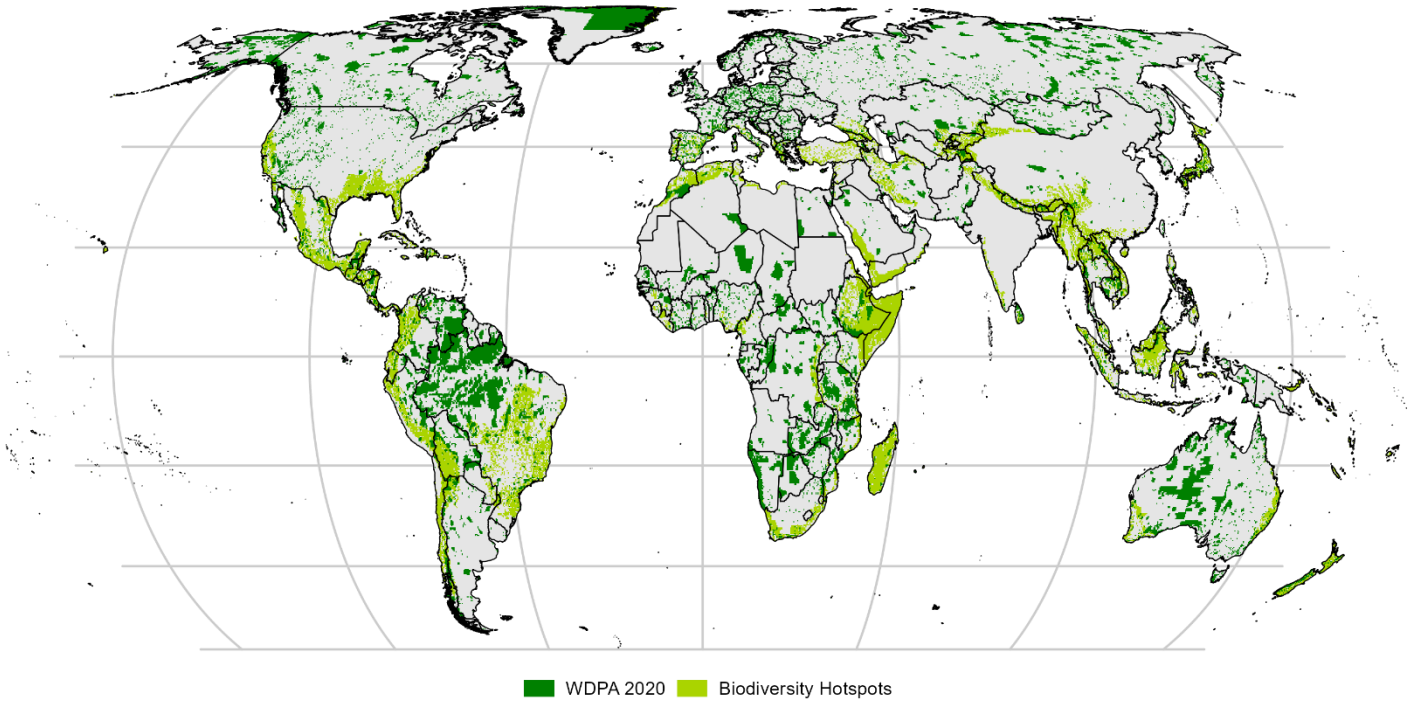
Supplementary Figure 1: REMIND-MAgPIE world regions and spatial clusters in MAgPIE (number in brackets). The MAgPIE model combines a more detailed level of spatial clusters[1] with the multiregional setup of REMIND-MAgPIE. Processes such as land competition are modelled at the cluster level and depend on biophysical information at 0.5° spatial resolution, such as cropland suitability, crop yield potential, irrigation water requirements, and proximity to urban markets. Due to computational constraints, inputs at 0.5° resolution are aggregated to the cluster level using a k-means clustering algorithm[2].

Supplementary Table 1: ISO3 codes of countries grouped to REMIND-MAgPIE world regions

REMIND-MAgPIE region	ISO3 country codes
CAZ	AUS, CAN, HMD, NZL, SPM
CHA	CHN, HKG, MAC, TWN
EUR	ALA, AUT, BEL, BGR, CYP, CZE, DEU, DNK, ESP, EST, FIN, FRA, FRO, GBR, GGY, GIB, GRC, HRV, HUN, IMN, IRL, ITA, JEY, LTU, LUX, LVA, MLT, NLD, POL, PRT, ROU, SVK, SVN, SWE
IND	IND
JPN	JPN
LAM	ABW, AIA, ARG, ATA, ATG, BES, BHS, BLM, BLZ, BMU, BOL, BRA, BRB, BVT, CHL, COL, CRI, CUB, CUW, CYM, DMA, DOM, ECU, FLK, GLP, GRD, GTM, GUF, GUY, HND, HTI, JAM, KNA, LCA, MAF, MEX, MSR, MTQ, NIC, PAN, PER, PRI, PRY, SGS, SLV, SUR, SXM, TCA, TTO, URY, VCT, VEN, VGB, VIR
MEA	ARE, BHR, DZA, EGY, ESH, IRN, IRQ, ISR, JOR, KWT, LBN, LBY, MAR, OMN, PSE, QAT, SAU, SDN, SYR, TUN, YEM
NEU	ALB, AND, BIH, CHE, GRL, ISL, LIE, MCO, MKD, MNE, NOR, SJM, SMR, SRB, TUR, VAT
OAS	AFG, ASM, ATF, BGD, BRN, BTN, CCK, COK, CXR, FJI, FSM, GUM, IDN, IOT, KHM, KIR, KOR, LAO, LKA, MDV, MHL, MMR, MNG, MNP, MYS, NCL, NFK, NIU, NPL, NRU, PAK, PCN, PHL, PLW, PNG, PRK, PYF, SGP, SLB, THA, TKL, TLS, TON, TUV, UMI, VNM, VUT, WLF, WSM
REF	ARM, AZE, BLR, GEO, KAZ, KGZ, MDA, RUS, TJK, TKM, UKR, UZB
SSA	AGO, BDI, BEN, BFA, BWA, CAF, CIV, CMR, COD, COG, COM, CPV, DJI, ERI, ETH, GAB, GHA, GIN, GMB, GNB, GNQ, KEN, LBR, LSO, MDG, MLI, MOZ, MRT, MUS, MWI, MYT, NAM, NER, NGA, REU, RWA, SEN, SHN, SLE, SOM, SSD, STP, SWZ, SYC, TCD, TGO, TZA, UGA, ZAF, ZMB, ZWE
USA	USA



Supplementary Figure 2: Potential natural vegetation based on LPmL carbon densities at 0.5° × 0.5°. Grid cells with an estimated potential carbon density >20 tC ha^{-1} were classified as suitable for forest growth[3].



Supplementary Figure 3: Baseline protected area and simulated enlargement of protected areas in biodiversity hotspots. The protected area baseline was taken from the WDPA Database[4] and held constant after 2020.

Supplementary Table 2: Relation between habitats (level 1) based on the IUCN classification scheme and ESA CCI land cover classes. The table was derived using the habitat-land cover model by Lumbierres et al.[5] (see Methods) choosing the strongest association threshold for each habitat group.

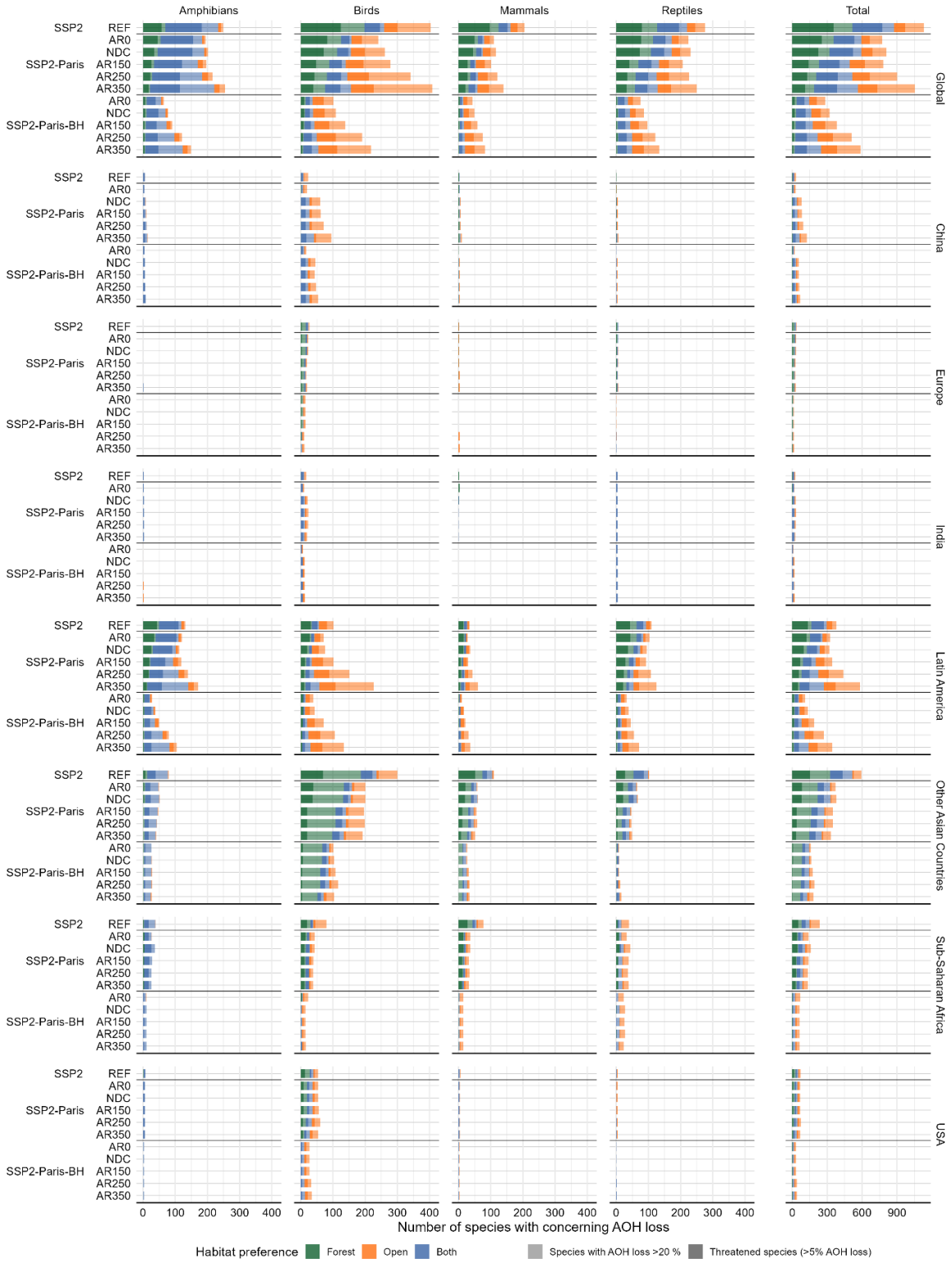
IUCN code	Habitat description	ESA CCI code	ESA CCI habitat description	Habitat type
1	Forest	50	Tree cover, broadleaved, evergreen, closed to open (>15%)	Forest
1	Forest	60	Tree cover, broadleaved, deciduous, closed to open (>15%)	Forest
1	Forest	61	Tree cover, broadleaved, deciduous, closed (>40%)	Forest
1	Forest	62	Tree cover, broadleaved, deciduous, open (15-40%)	Forest
1	Forest	70	Tree cover, needleleaved, evergreen, closed to open (>15%)	Forest
1	Forest	71	Tree cover, needleleaved, evergreen, closed (>40%)	Forest
1	Forest	72	Tree cover, needleleaved, evergreen, open (15-40%)	Forest
1	Forest	90	Tree cover, mixed leaf type (broadleaved and needleleaved)	Forest
1	Forest	160	Tree cover, flooded, fresh or brakish water	Forest
2	Savanna	120	Shrubland	Open
2	Savanna	121	Evergreen shrubland	Open
2	Savanna	122	Deciduous shrubland	Open
3	Shrubland	120	Shrubland	Open
3	Shrubland	121	Evergreen shrubland	Open
3	Shrubland	122	Deciduous shrubland	Open
3	Shrubland	150	Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	Open
3	Shrubland	152	Sparse shrub (<15%)	Open
3	Shrubland	153	Sparse herbaceous cover (<15%)	Open
3	Shrubland	200	Bare areas	Open
3	Shrubland	201	Consolidated bare areas	Open
3	Shrubland	202	Unconsolidated bare areas	Open
4	Grassland	130	Grassland	Open
4	Grassland	140	Lichens and mosses	Open
4	Grassland	150	Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	Open

4	Grassland	152	Sparse shrub (<15%)	Open
4	Grassland	153	Sparse herbaceous cover (<15%)	Open
5	Wetlands	20	Cropland, irrigated or post-flooding	Open
5	Wetlands	80	Tree cover, needleleaved, deciduous, closed to open (>15%)	Forest
5	Wetlands	81	Tree cover, needleleaved, deciduous, closed (>40%)	Forest
5	Wetlands	82	Tree cover, needleleaved, deciduous, open (15-40%)	Forest
5	Wetlands	160	Tree cover, flooded, fresh or brakish water	Forest
5	Wetlands	170	Tree cover, flooded, saline water	Forest
5	Wetlands	180	Shrub or herbaceous cover, flooded, fresh/saline/brakish water	Open
5	Wetlands	210	Water bodies	NA
6	Rocky areas	70	Tree cover, needleleaved, evergreen, closed to open (>15%)	Forest
6	Rocky areas	71	Tree cover, needleleaved, evergreen, closed (>40%)	Forest
6	Rocky areas	72	Tree cover, needleleaved, evergreen, open (15-40%)	Forest
6	Rocky areas	130	Grassland	Open
6	Rocky areas	150	Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	Open
6	Rocky areas	152	Sparse shrub (<15%)	Open
6	Rocky areas	153	Sparse herbaceous cover (<15%)	Open
6	Rocky areas	200	Bare areas	Open
6	Rocky areas	201	Consolidated bare areas	Open
6	Rocky areas	202	Unconsolidated bare areas	Open
8	Desert	150	Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	Open
8	Desert	152	Sparse shrub (<15%)	Open
8	Desert	153	Sparse herbaceous cover (<15%)	Open
8	Desert	200	Bare areas	Open
8	Desert	201	Consolidated bare areas	Open
8	Desert	202	Unconsolidated bare areas	Open

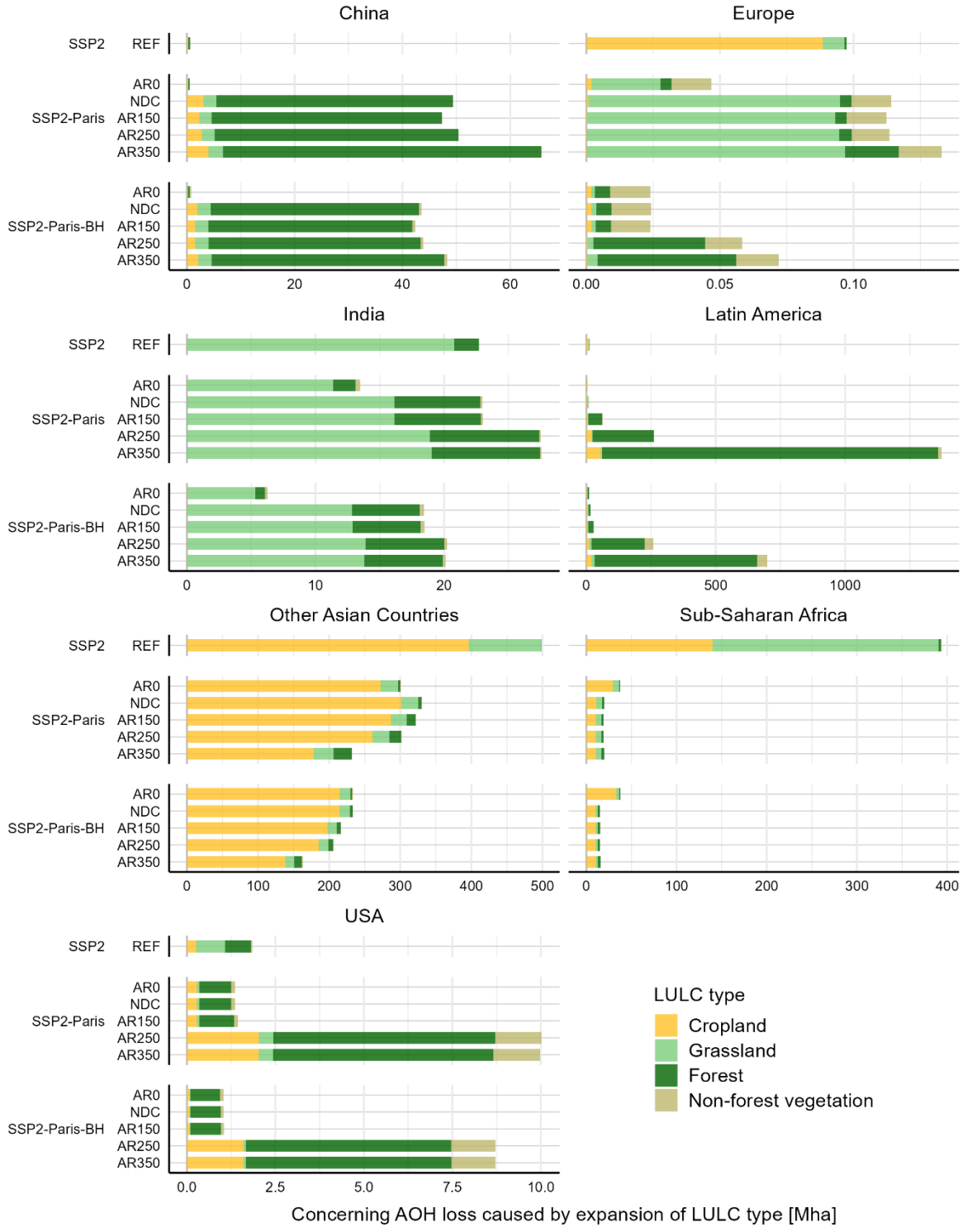
9	Marine Neretic	NA	NA	NA
10	Marine Oceanic	NA	NA	NA
12	Marine Intertidal	NA	NA	NA
13	Marine Coastal/Supratidal	NA	NA	NA
14.1 & 14.2	Artificial arable and pasture land	11	Cropland, rainfed, Herbaceous cover	Open
14.1 & 14.2	Artificial arable and pasture land	20	Cropland, irrigated or post-flooding	Open
14.1 & 14.2	Artificial arable and pasture land	190	Urban areas	NA
14.3 & 14.6	Artificial degraded forest and plantation	12	Cropland, rainfed, Tree or shrub cover	Open
14.3 & 14.6	Artificial degraded forest and plantation	20	Cropland, irrigated or post-flooding	Open
14.3 & 14.6	Artificial degraded forest and plantation	190	Urban areas	NA
14.4 & 14.5	Artificial urban areas and rural gardens	190	Urban areas	NA
15	Artificial/Aquatic	20	Cropland, irrigated or post-flooding	Open
15	Artificial/Aquatic	160	Tree cover, flooded, fresh or brakish water	Forest
15	Artificial/Aquatic	170	Tree cover, flooded, saline water	Forest
15	Artificial/Aquatic	180	Shrub or herbaceous cover, flooded, fresh/saline/brakish water	Open
15	Artificial/Aquatic	190	Urban areas	NA
15	Artificial/Aquatic	210	Water bodies	NA
16	Introduced vegetation	NA	NA	NA
17	Other	NA	NA	NA
18	Unknown	NA	NA	NA
9.8.1	Outer Reef Channel	NA	NA	NA
9.8.3	Foreslope (Outer Reef Slope)	NA	NA	NA
9.8.4	Lagoon	NA	NA	NA
9.8.5	Inter-Reef Soft Substrate	NA	NA	NA
9.8.6	Inter-Reef Rubble Substrate	NA	NA	NA

Supplementary Results

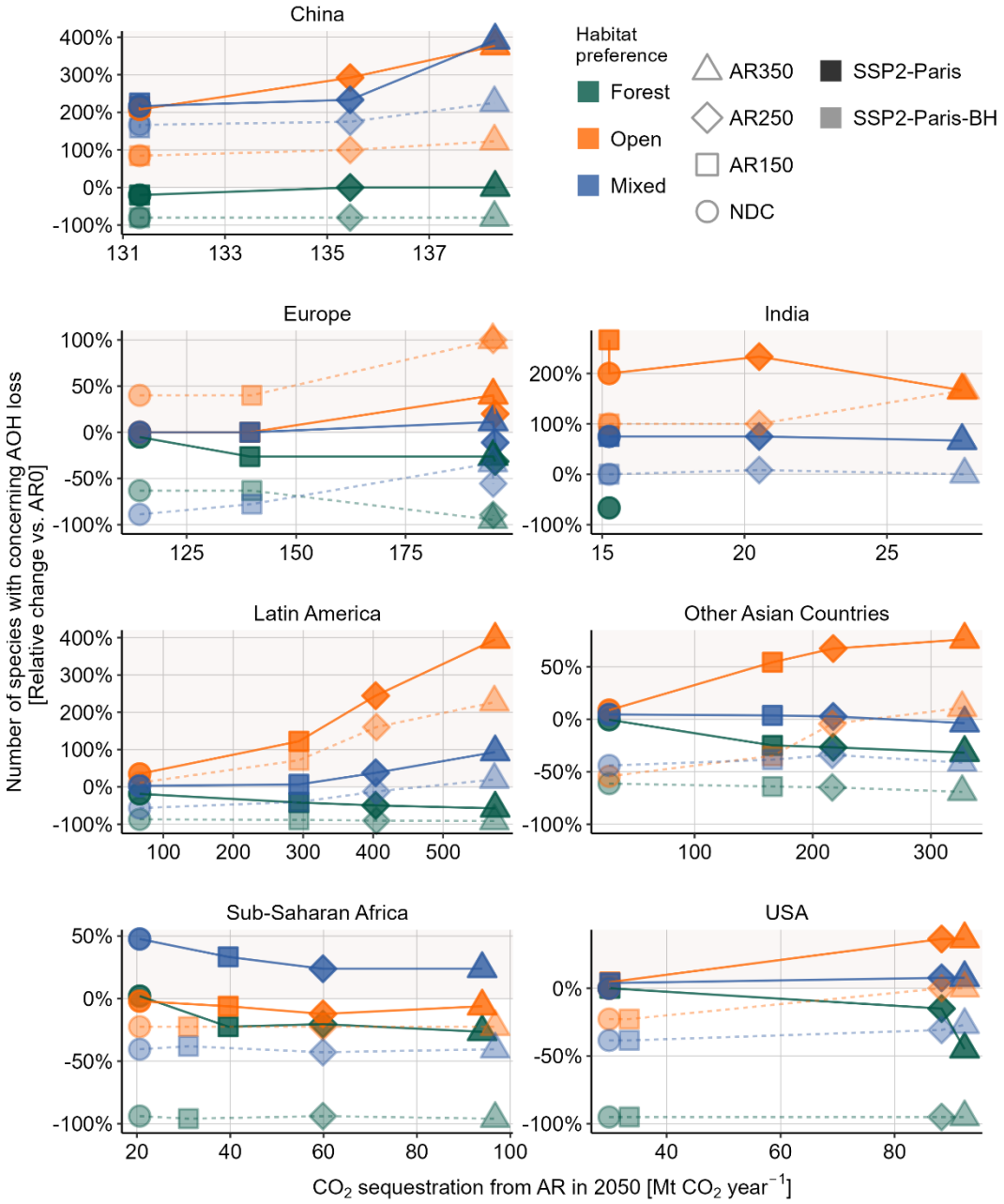
Main Scenarios



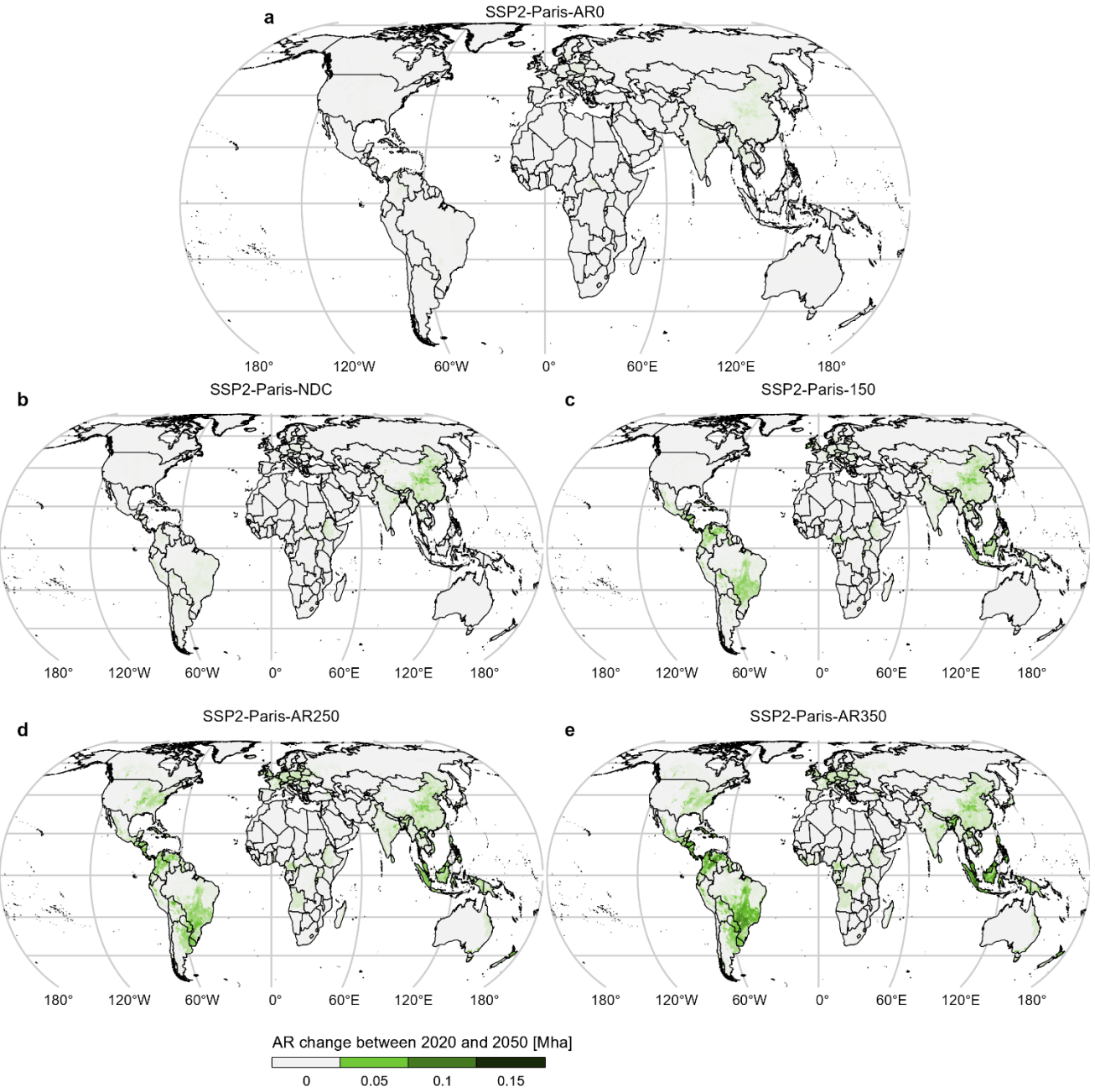
Supplementary Figure 4: Number of species with concerning AOH loss by 2050 and their habitat preference across world regions. The regions correspond to the REMIND-MAgPIE regions China (CHA), India (IND), Latin America (LAM), other Asia (OAS), Sub-Saharan Africa (SSA), and United States (USA). European Union (EUR) and non-EU member (NEU) states were grouped to Europe for this figure. Japan (JPN), Middle East and Northern Africa (MEA) and reforming economies of the former Soviet Union (REF) are not shown.



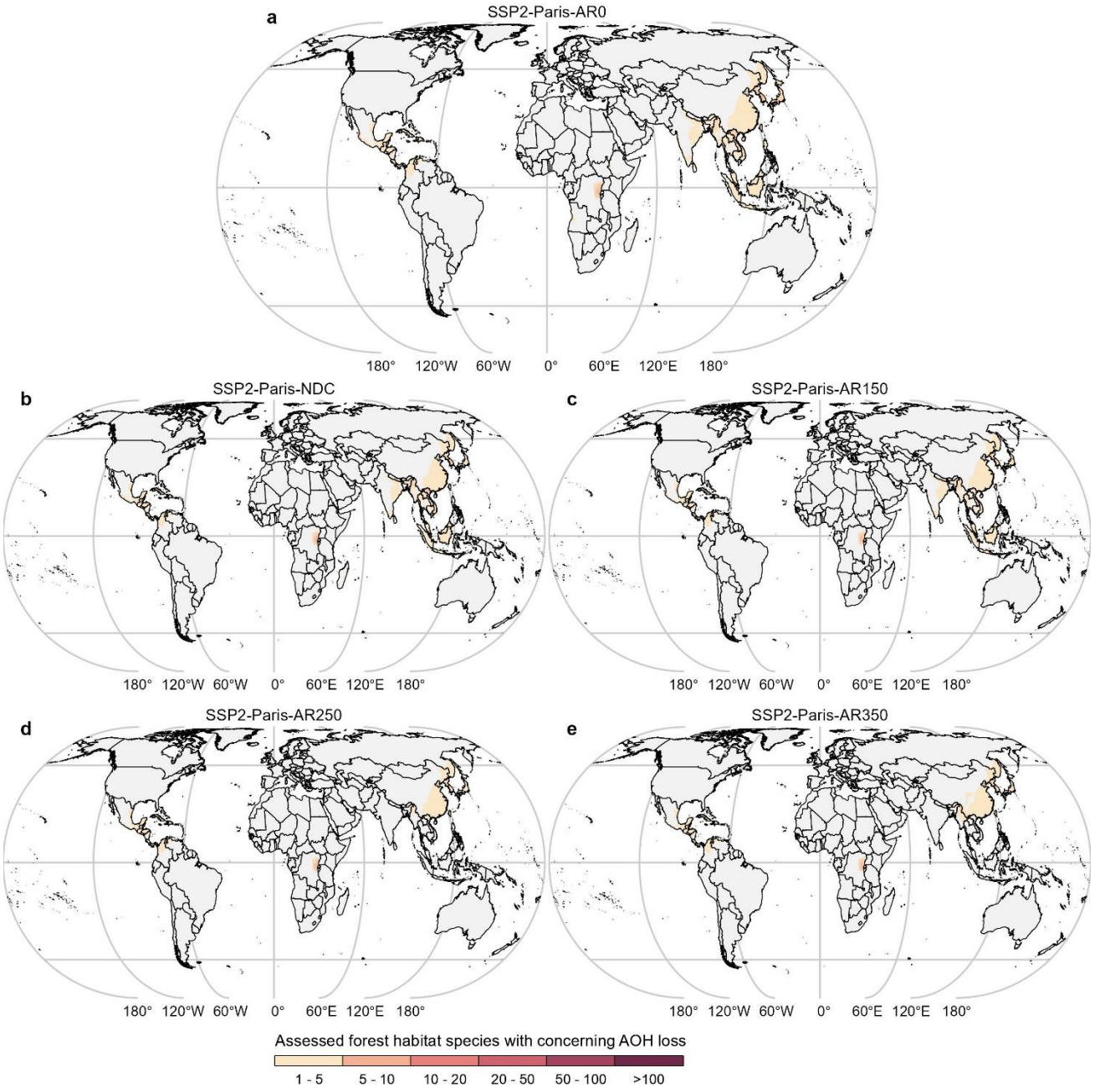
Supplementary Figure 5: Sum of concerning habitat loss from 2020 to 2050 caused by the expansion of aggregated land-use/land-cover (LULC) types across different world regions. The regions correspond to the REMIND-MAgPIE regions China (CHA), India (IND), Latin America (LAM), other Asia (OAS), Sub-Saharan Africa (SSA), and United States (USA). European Union (EUR) and non-EU member (NEU) states were grouped to Europe for this figure. Japan (JPN), Middle East and Northern Africa (MEA) and reforming economies of the former Soviet Union (REF) are not shown.



Supplementary Figure 6: CO2-sequestration and relative change in the number of species with concerning habitat loss across AR scenarios and different world regions. The regions correspond to the REMIND-MAgPIE regions China (CHA), India (IND), Latin America (LAM), other Asia (OAS), Sub-Saharan Africa (SSA), and United States (USA). European Union (EUR) and non-EU member (NEU) states were grouped to Europe for this figure. Japan (JPN), Middle East and Northern Africa (MEA) and reforming economies of the former Soviet Union (REF) are not shown.



Supplementary Figure 7: Projected change in afforestation/reforestation (AR) area between 2020 and 2050 across different scales of AR deployment.



Supplementary Figure 8: Number of forest habitat species with concerning habitat loss in 2050 across modelled AR scenarios. The colour shading signifies the numberoverlapping range polygons of forest habitat vertebrate species affected by concerning habitat loss across modelled scenarios of AR deployment (**a-e**). Country polygons were adapted from World Bank Official Boundaries[6] under a Creative Commons license CC BY 4.0.

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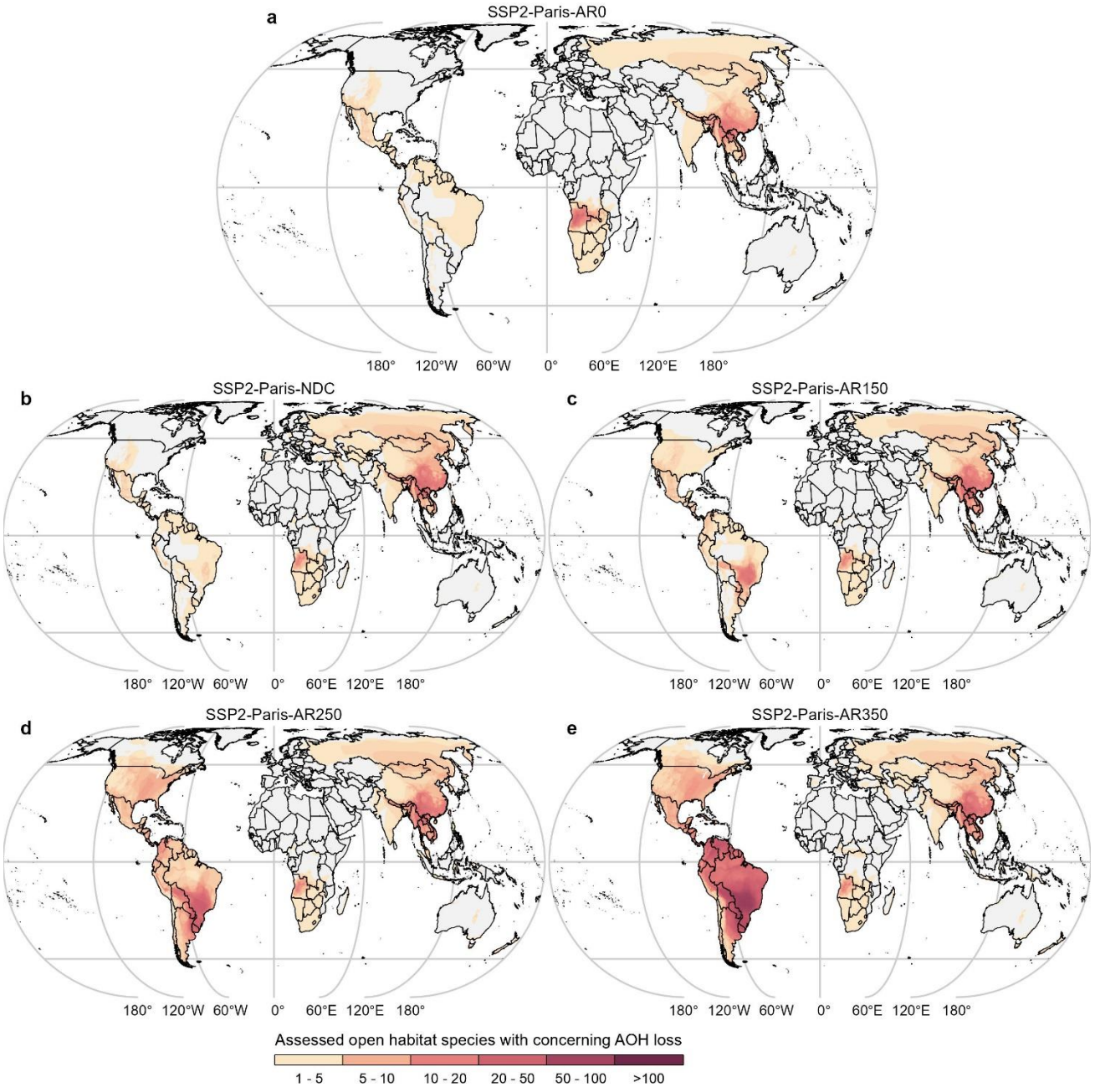
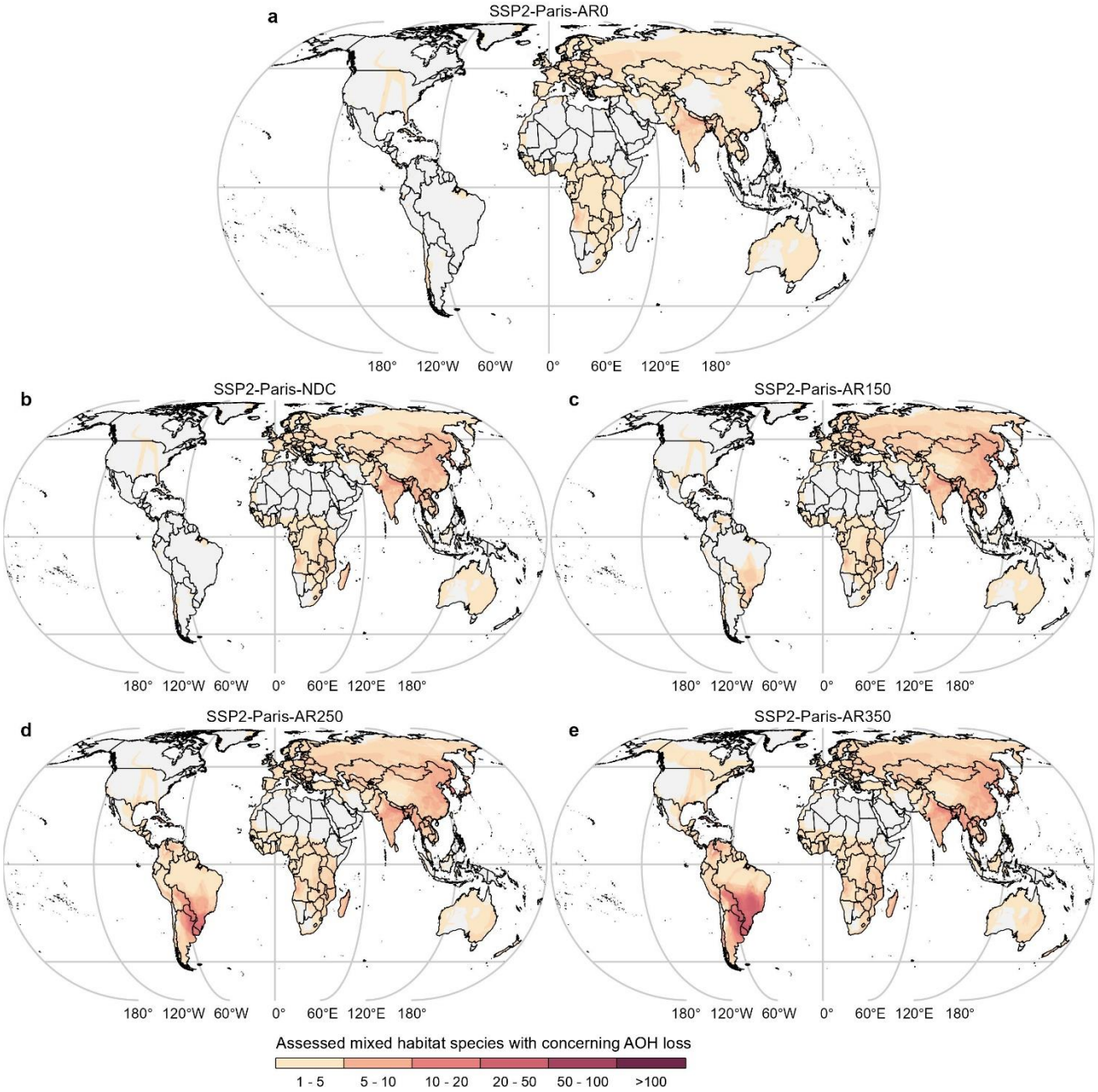
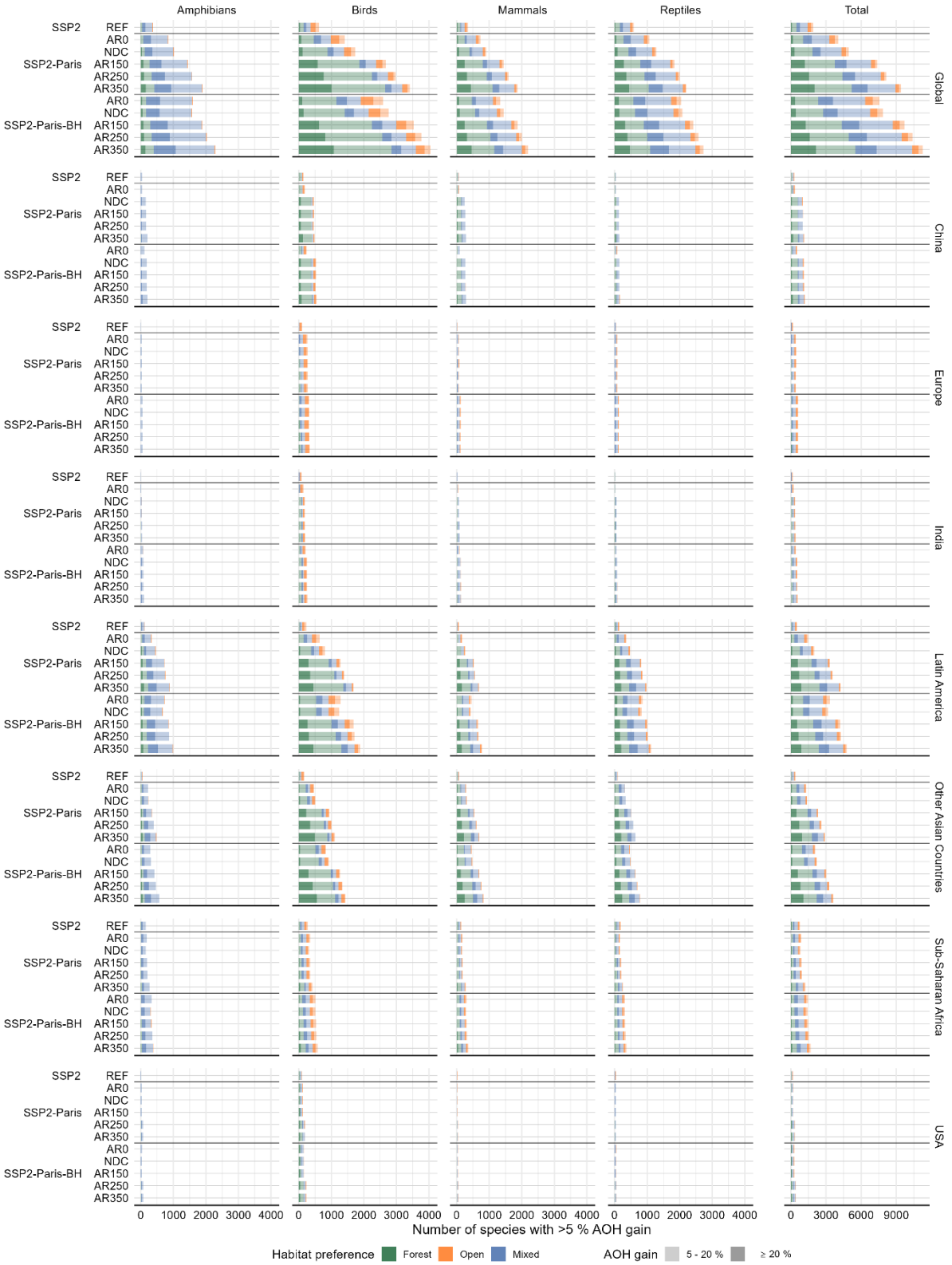


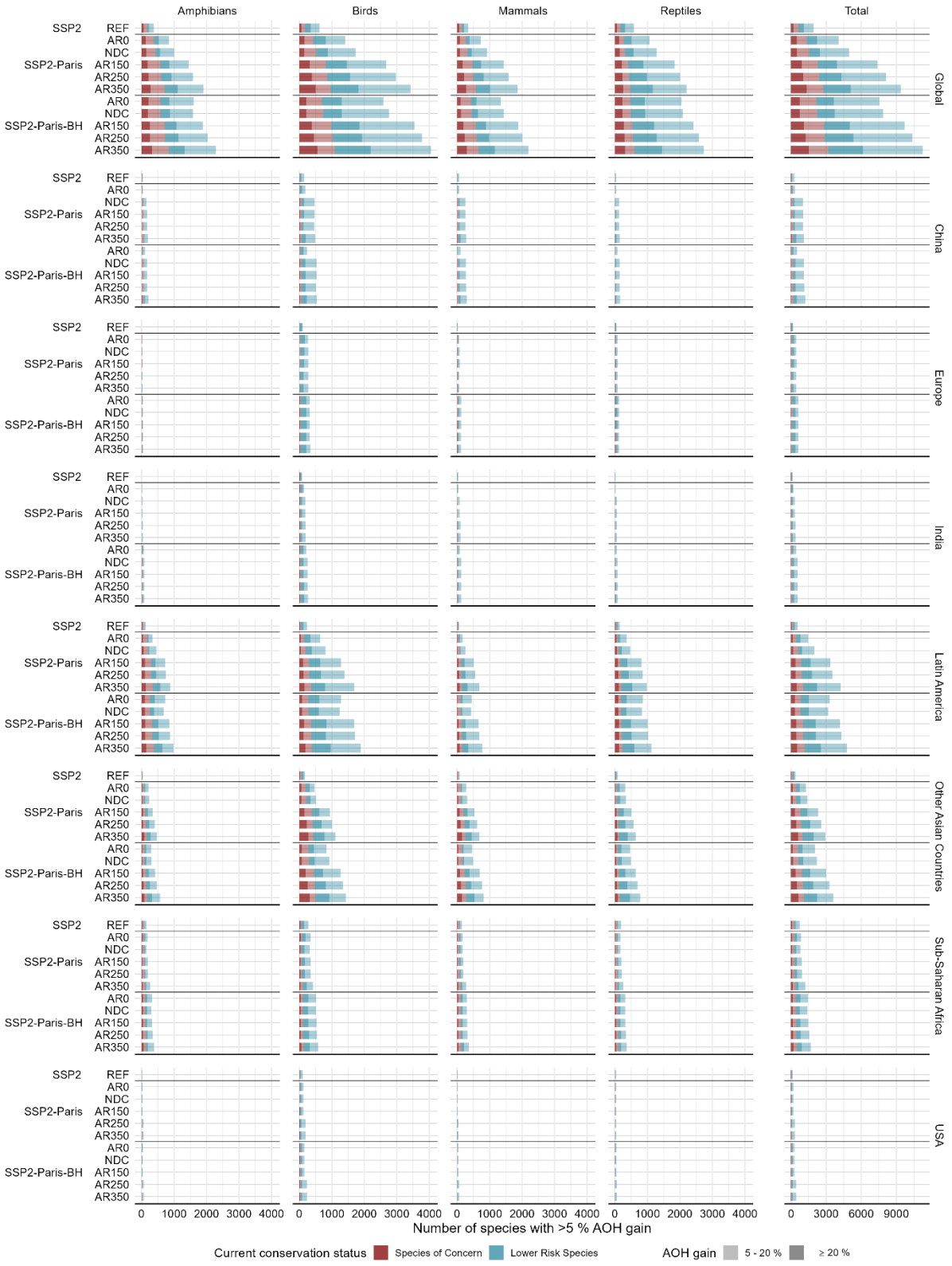
Supplementary Figure 9: Number of open habitat species with concerning habitat loss in 2050 across modelled AR scenarios. The colour shading signifies the numberoverlapping range polygons of open habitat vertebrate species affected by concerning habitat loss across modelled scenarios of AR deployment (**a-e**). Country polygons were adapted from World Bank Official Boundaries[6] under a Creative Commons license CC BY 4.0.



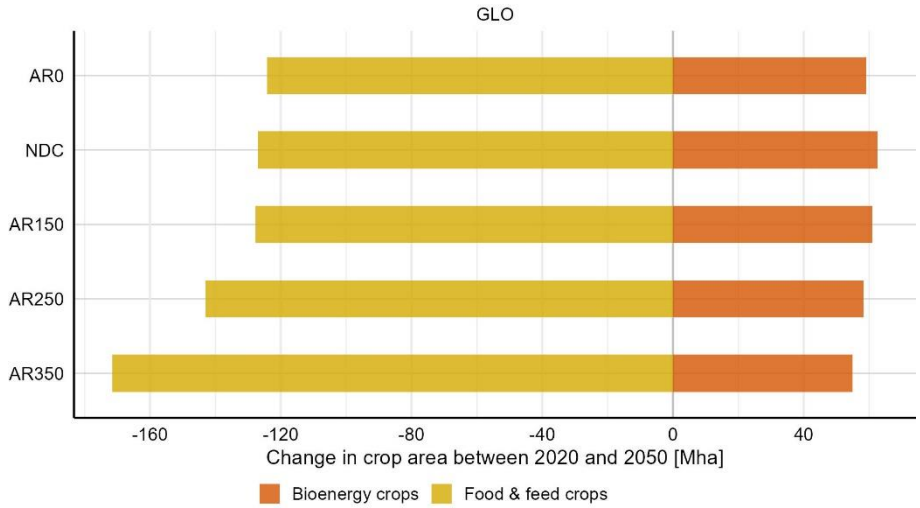
Supplementary Figure 10: Number of mixed habitat species with concerning habitat loss in 2050 across modelled AR scenarios. The colour shading signifies the number overlapping range polygons of mixed habitat vertebrate species affected by concerning habitat loss across modelled scenarios of AR deployment (**a-e**). Country polygons were adapted from World Bank Official Boundaries[6] under a Creative Commons license CC BY 4.0.



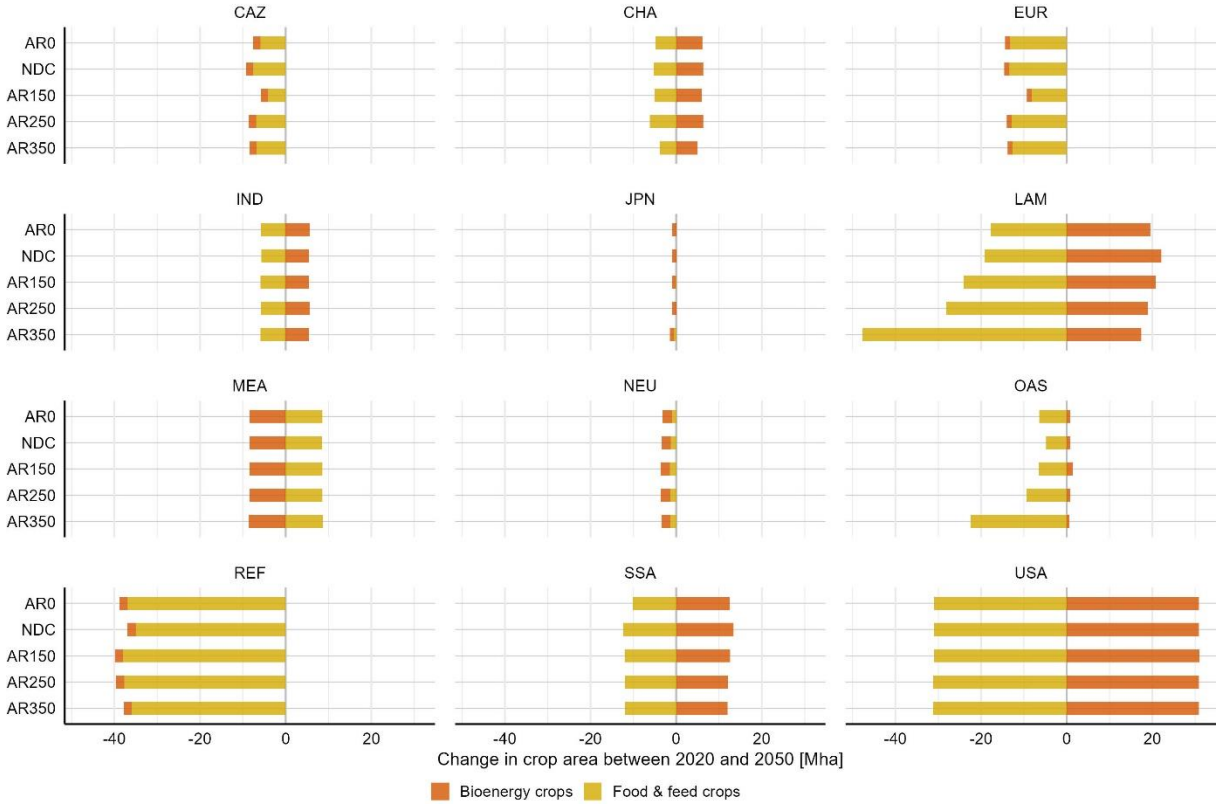
Supplementary Figure 11: Number of species with >5 % AOH gain by 2050 and their habitat preference across world regions. The regions correspond to the REMIND-MAgPIE regions China (CHA), India (IND), Latin America (LAM), other Asia (OAS), Sub-Saharan Africa (SSA), and United States (USA). European Union (EUR) and non-EU member (NEU) states were grouped to Europe for this figure. Japan (JPN), Middle East and Northern Africa (MEA) and reforming economies of the former Soviet Union (REF) are not shown.



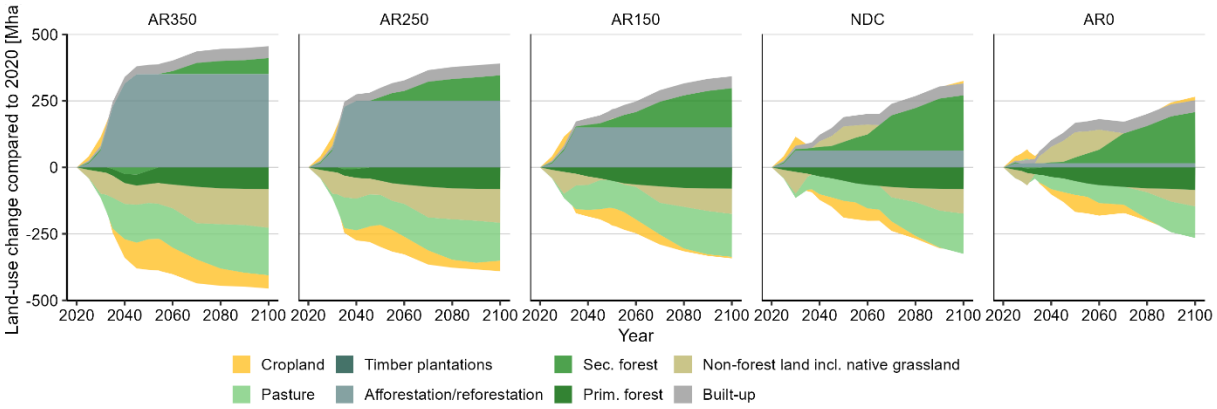
Supplementary Figure 12: Number of species with >5 % AOH gain by 2050 and their current conservation status across world regions. The regions correspond to the REMIND-MAgPIE regions China (CHA), India (IND), Latin America (LAM), other Asia (OAS), Sub-Saharan Africa (SSA), and United States (USA). European Union (EUR) and non-EU member (NEU) states were grouped to Europe for this figure. Japan (JPN), Middle East and Northern Africa (MEA) and reforming economies of the former Soviet Union (REF) are not shown.



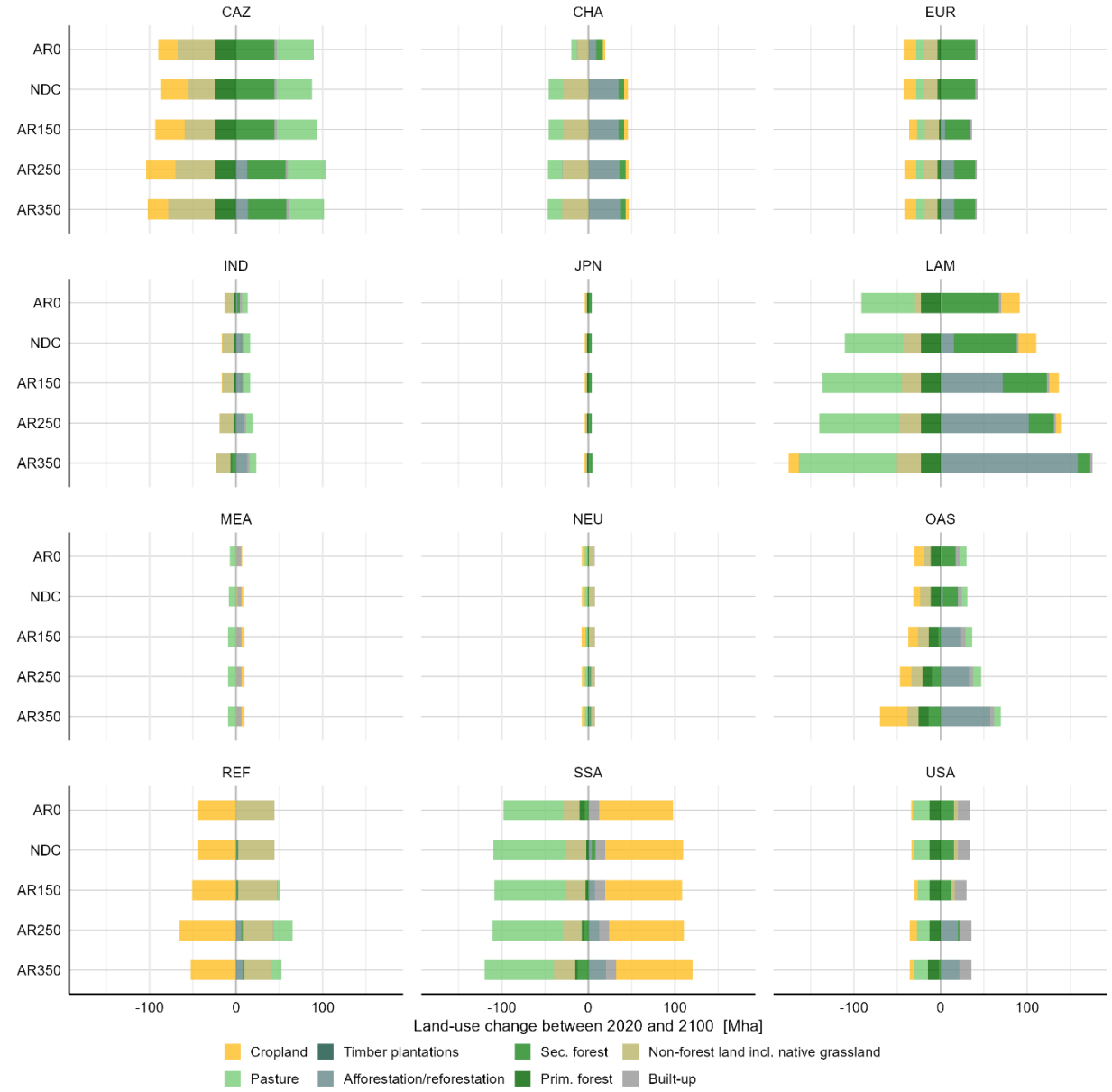
Supplementary Figure 13: Projected change in global crop area of bioenergy, and food and feed crops.



Supplementary Figure 14: Projected change in regional crop area of bioenergy, and food and feed crops. CAZ: Canada, Australia and New Zealand; CHA: China; EUR: European Union; IND: India; JPN: Japan; LAM: Latin America; MEA: Middle East and Northern Africa; NEU: non-EU member states; OAS: other Asia; REF: reforming countries; SSA: Sub-Saharan Africa; USA: United States.



Supplementary Figure 16: Global land use dynamics between 2020 and 2050 of primary land types



Supplementary Figure 15: Regional land use dynamics between 2020 and 2050 of primary land types. CAZ: Canada, Australia and New Zealand; CHA: China; EUR: European Union; IND: India; JPN: Japan; LAM: Latin America; MEA: Middle East and Northern Africa; NEU: non-EU member states; OAS: other Asia; REF: reforming countries; SSA: Sub-Saharan Africa; USA: United States.

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