Modelling land use for global biodiversity assessments
Discrete allocation at 10 arc-seconds

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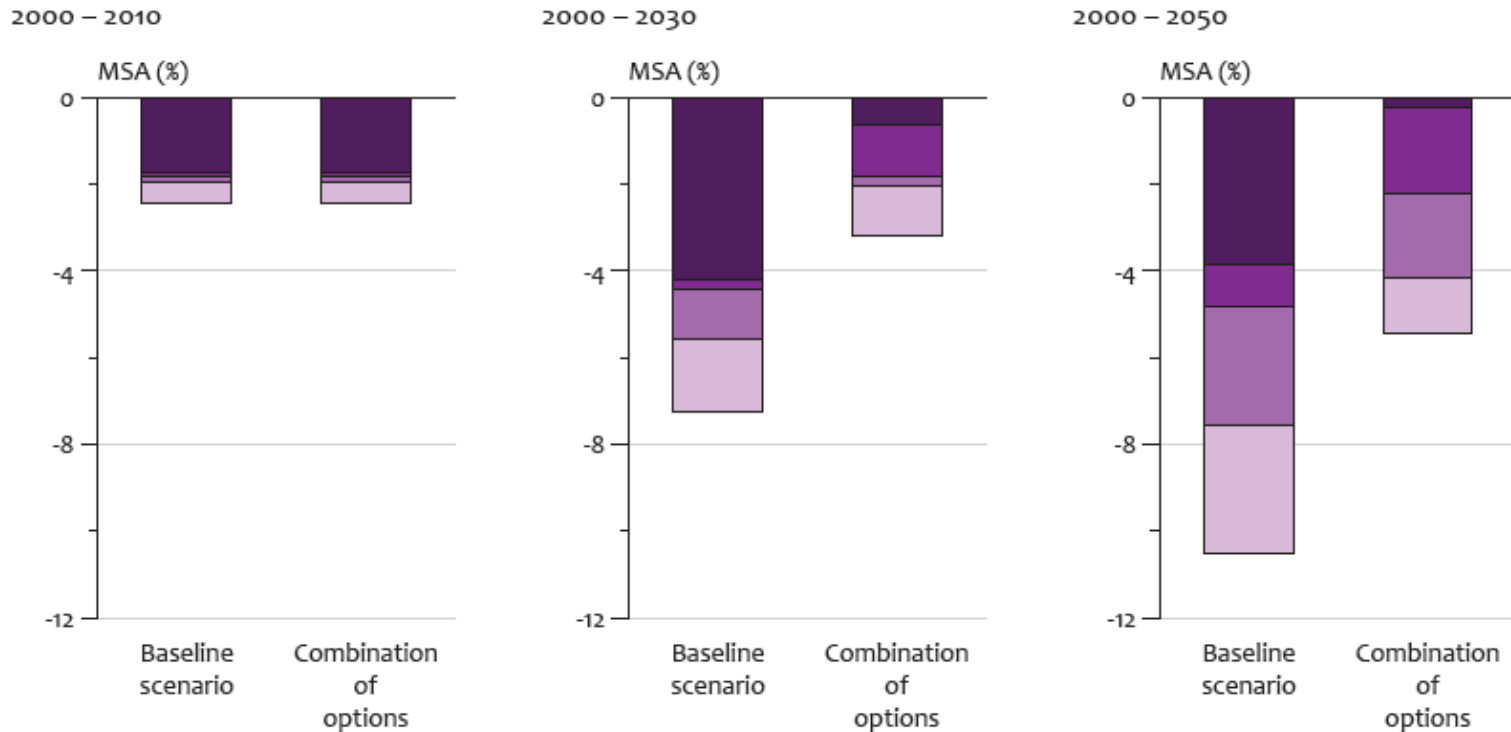Zoran Steinmann
Aafke Schipper

Radboud University

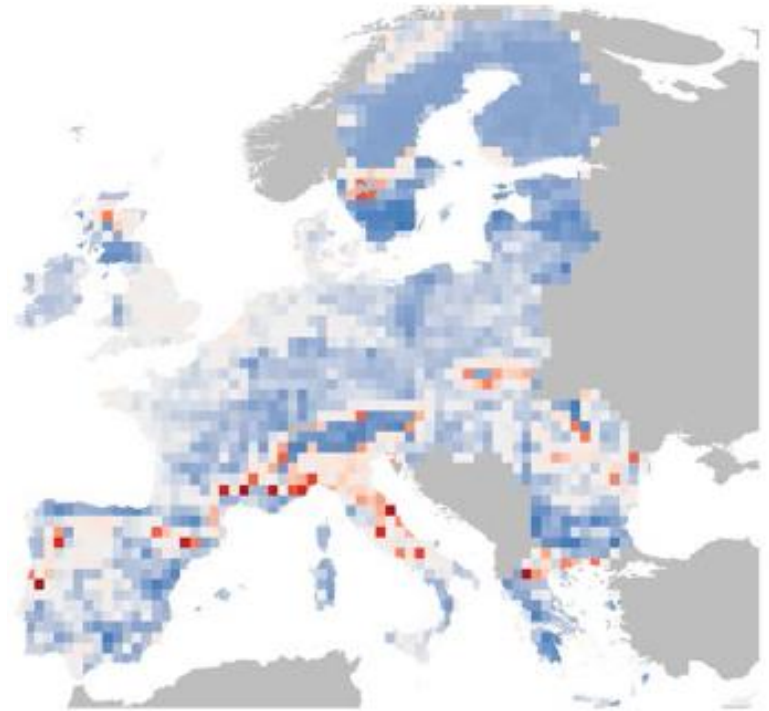PBL Netherlands Environmental Assessment Agency
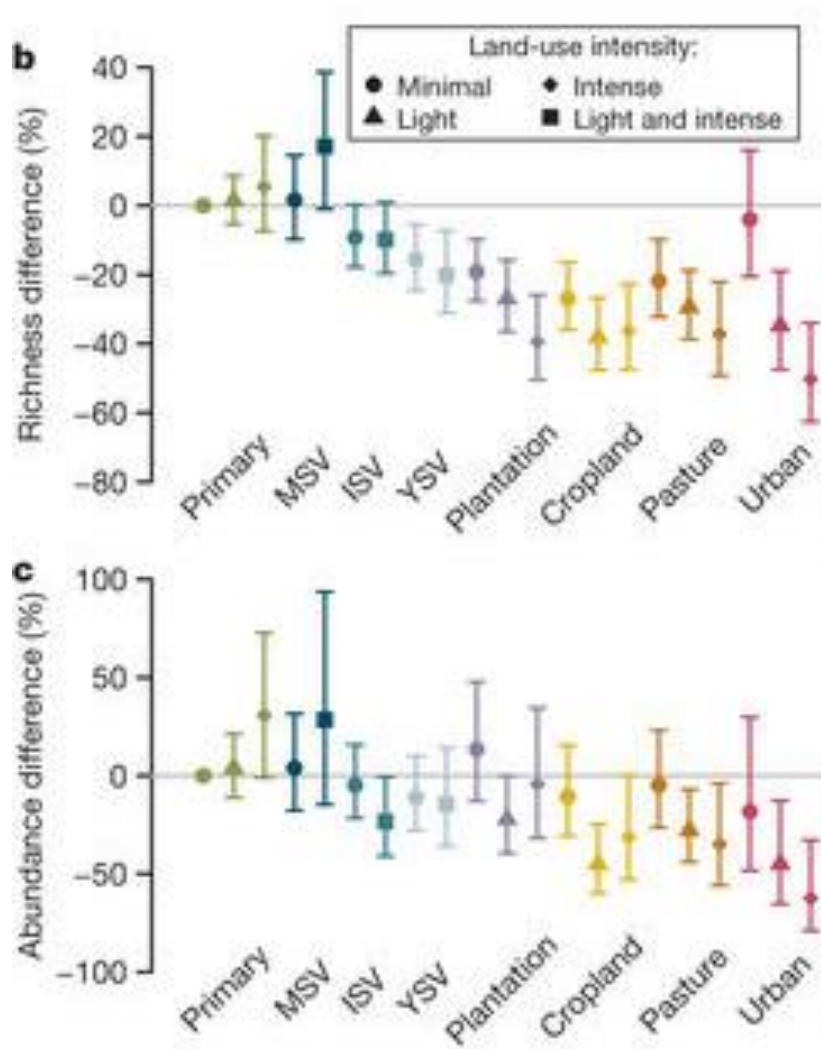
GLoBio4
Modelling human impacts on biodiversity

ARIS

Land use, habitat loss and biodiversity

Figure S.3 — Pressures driving global biodiversity loss

Land use, habitat loss and biodiversity

Newbold et al. 2015 Nature 520:45-50

Gerstner et al. 2017 Div Distr 23:1193-1203

Global land use models

	Resolution
Hasegawa et al. 2016	~ 50 km
Alkemade et al. 2009 (GLOBIO3)	~ 50 km
Hurtt et al. in prep.	~ 25 km
Klein Goldewijk et al. 2011	~ 9 km
Van Asselen and Verburg 2012	~ 9 km
Seto et al. 2012	~ 5 km
Robinson et al. 2014	~ 1 km
Hoskins et al. 2016	~ 1 km

However, the production of the 2005 layers relied on accessing 1024 GB of RAM, spread between 17 compute nodes, ==run for almost a month.== To repeat this process iteratively for numerous future time steps would require major improvements in computational power or efficiency to be completed within a reasonable timeframe.
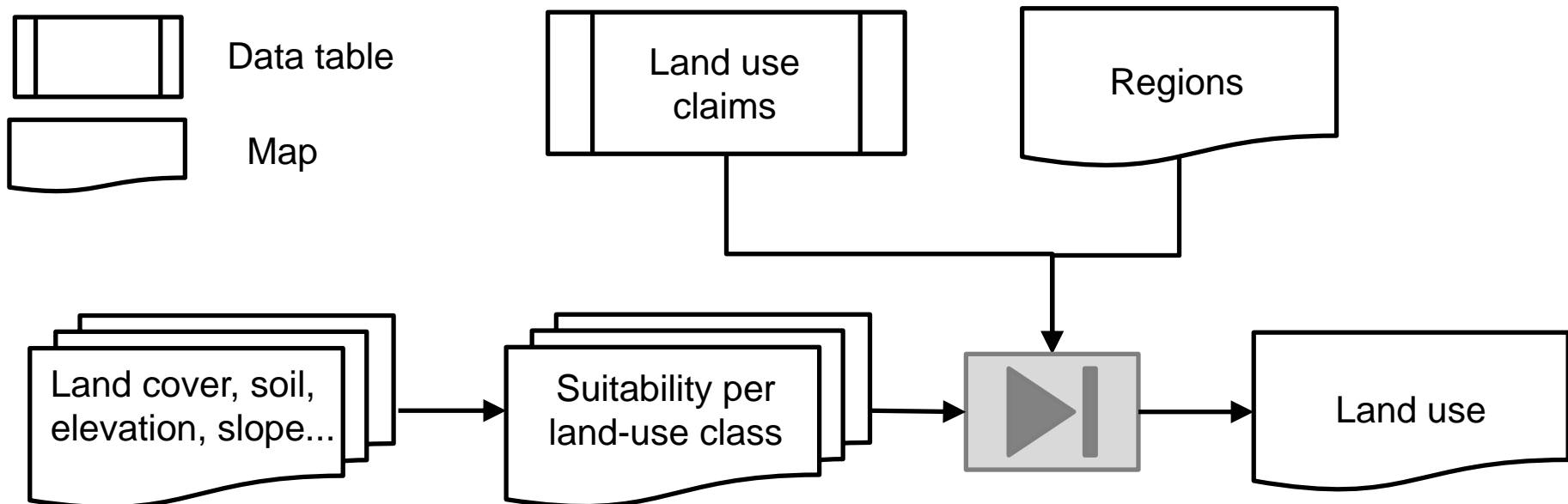
GLOBIO 4 land-use allocation routine

Wish list

- Global extent

- High resolution

- Discrete allocation

- Land use + intensity (following GLOBIO and PREDICTS)

- Connection to PBL's IMAGE model

- Reasonable run-time

GLOBIO 4 land-use allocation routine

General idea

- Regional land-use 'claims' (socio-economic drivers)
- Local allocation (mainly physiographic variables)
- User-defined allocation order
   (urban > cropland > pasture > forestry)

Cropland suitability modelling

ESA CCI land cover maps (1992-2015)

Cropland suitability modelling

ESA CCI land cover maps (1992-2015)

Cropland suitability modelling

Procedure

- Relate cells converted to cropland to covariates
- Covariates: previous land cover, climate, distance to roads, slope, elevation, soil properties, ...
- Four cropland types + overall
- Model per IMAGE region
- Logistic regression, AIC-based variable selection
- Model fitting and cross-validation: 2003-2013
- Model testing (hind-casting): 1992-2002
- Model evaluation based on AUC, TSS and Moran's I

Cropland suitability modelling

Results

Model goodness of fit based on back-casting

Rainfed crops

Annual mean temperature
Soil pH
Elevation
Annual precipitation
Soil available water capacity
Soil silt content
Soil cation exchange capacity
Distance from urban areas
Topographical Wetness Index
Temperature seasonality

0.0 0.2 0.4 0.6 0.8 1.0

Irrigated crops

Soil sand content
Annual mean temperature
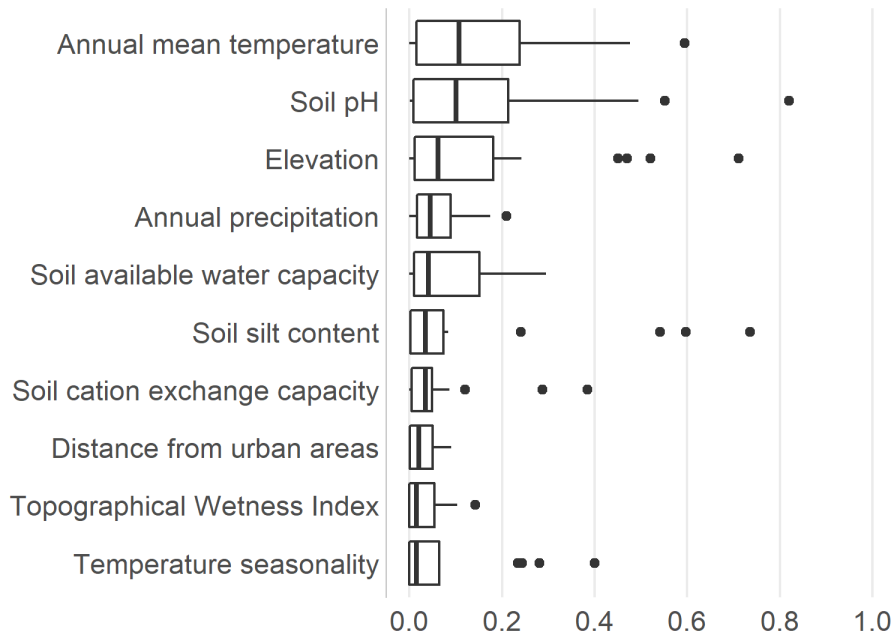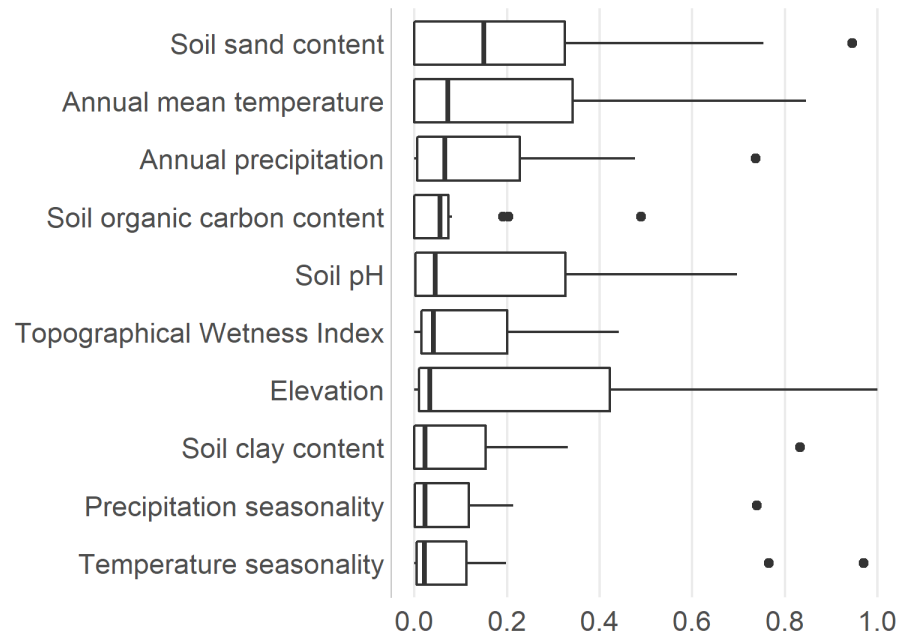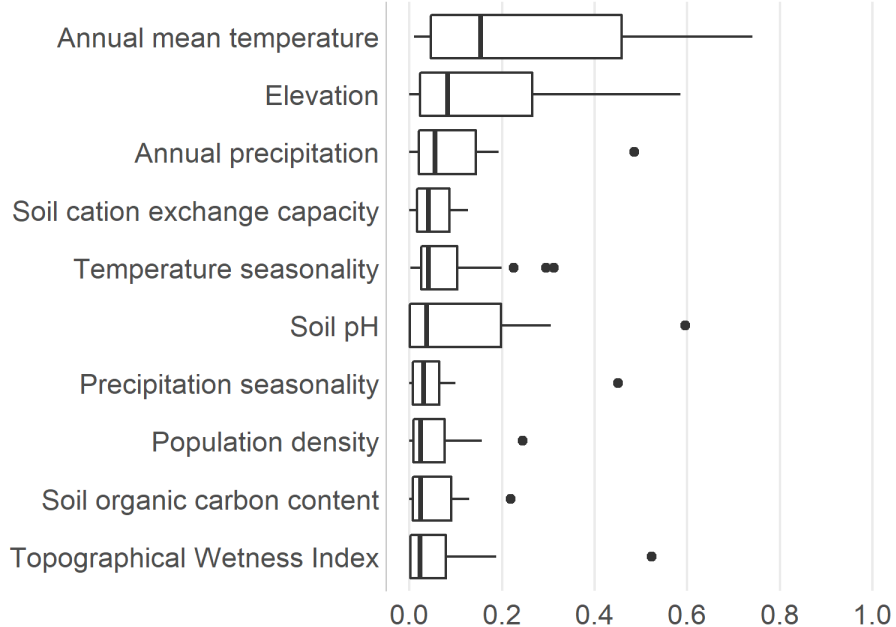Annual precipitation
Soil organic carbon content
Soil pH
Topographical Wetness Index
Elevation
Soil clay content
Precipitation seasonality
Temperature seasonality

0.0 0.2 0.4 0.6 0.8 1.0

Mosaic crops - <50% vegetation

Annual mean temperature
Elevation
Annual precipitation
Soil cation exchange capacity
Temperature seasonality
Soil pH
Precipitation seasonality
Population density
Soil organic carbon content
Topographical Wetness Index

0.0 0.2 0.4 0.6 0.8 1.0

Mosaic crops - >50% vegetation

Annual mean temperature
Elevation
Annual precipitation
Soil pH
Soil clay content
Temperature seasonality
Population density
Precipitation seasonality
Soil organic carbon content
Soil available water capacity

0.0 0.2 0.4 0.6 0.8 1.0

Cropland suitability modelling

Results

Rainfed crops - suitability for conversion

Value	
	0.0
	0.2
	0.4
	0.6
	0.8

0   500   1000   1500 km
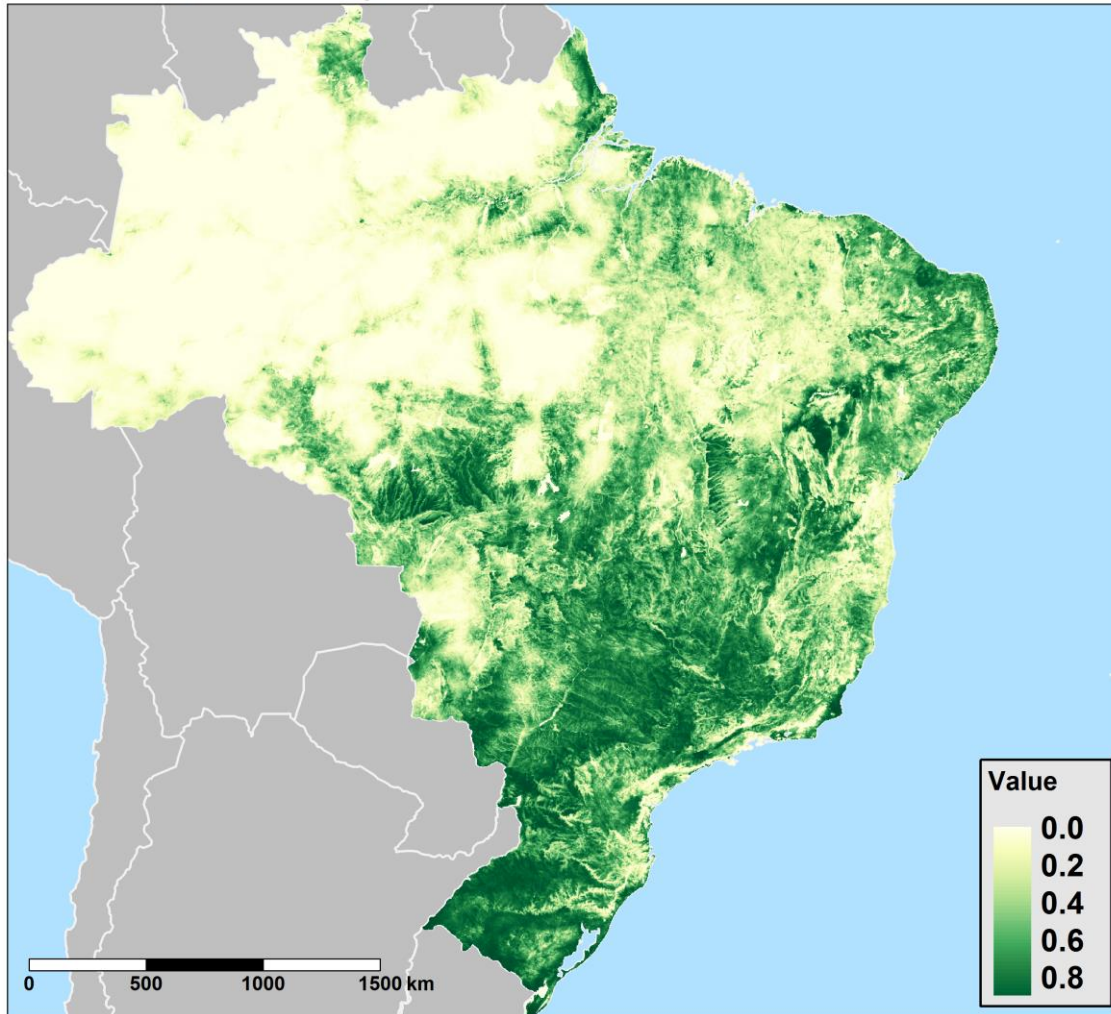
Further suitability modelling

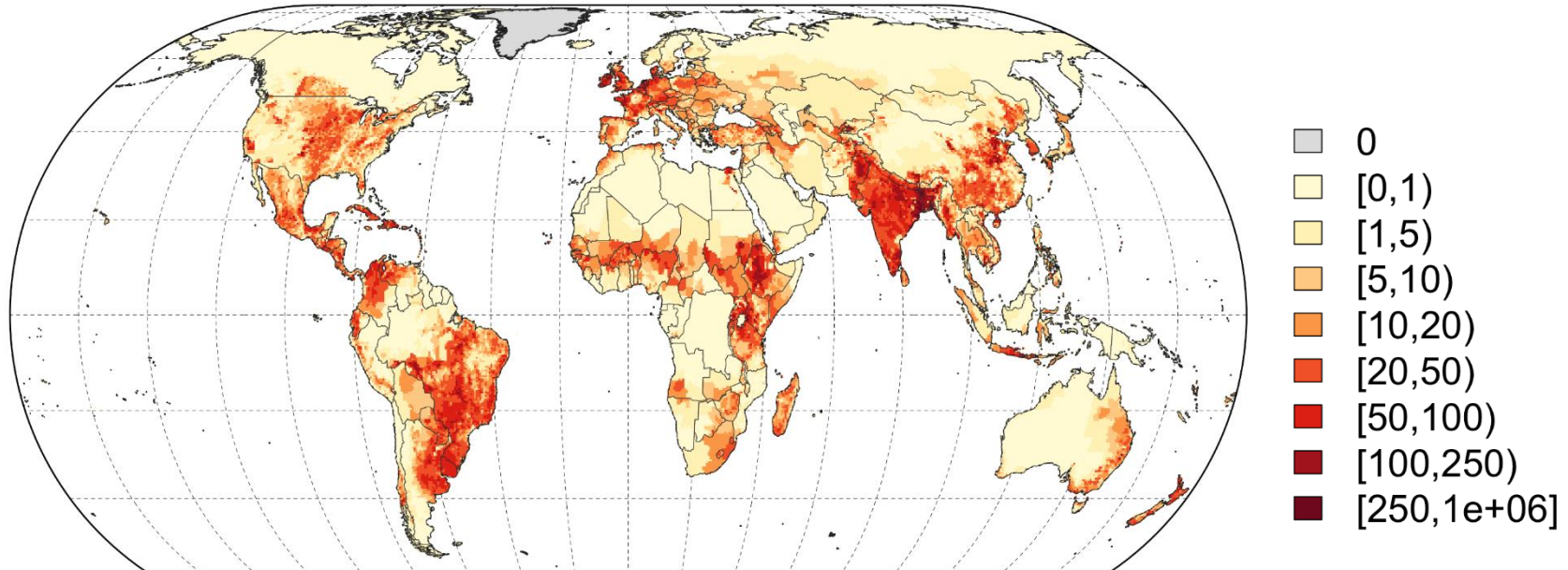**Urban**

Approach similar to cropland

Further suitability modelling

Urban

Approach similar to cropland

Pasture

Based on FAO livestock allocation procedure

cattle density (animals per km²; GLW 3)

Robinson et al. 2014 PloS ONE

Further suitability modelling

Urban

Approach similar to cropland

Pasture

Based on FAO livestock allocation procedure

Forestry

Based on altitude and accessibility (roads)

Pilot study

- IPBES global assessment
- Cropland + urban suitability based on distance
- Claims of cropland, urban, pasture, rangeland and forestry from LUH data
- Cropland intensity added based on N application

GLOBIO 4 land-use allocation routine

Land use 2050 SSP1 RCP2.6

*10 arcsecond resolution - first draft results*

GLoBio4
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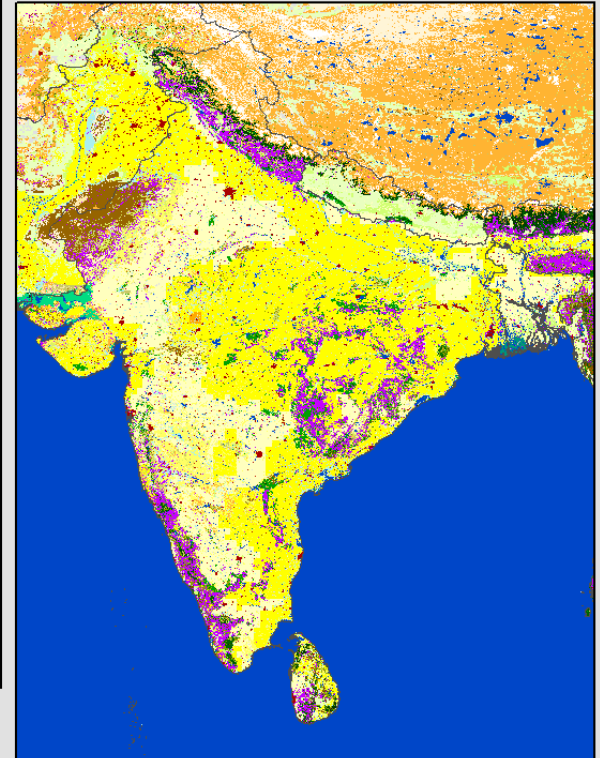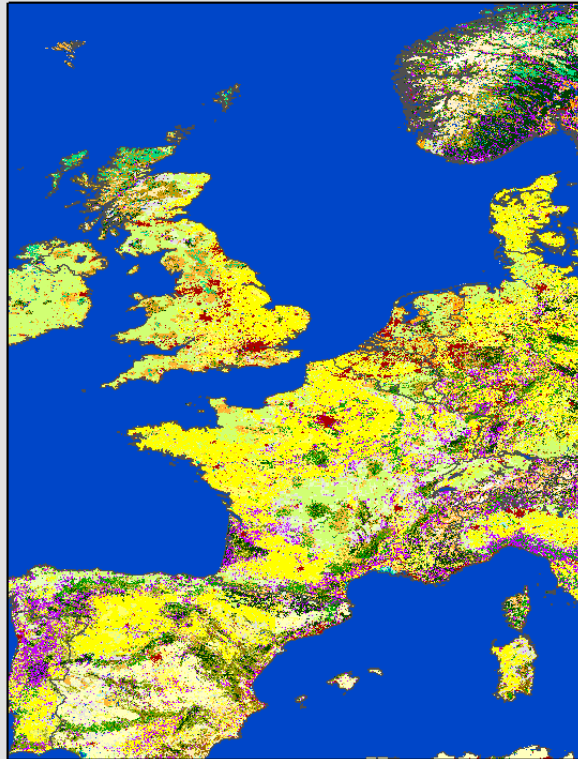
Legend

1 Urban	10 ESA classes	40	70	82	121	151	180	210	
3 Pasture	11	50	71	90	122	152	190	220	
4 Rangeland	12	60	72	100	130	153	200	230 Low intensity cropland	
5 Forestry	20	61	80	110	140	160	201	231 Medium intensity cropland	
7 Undefined	30	62	81	120	150	170	202	232 High intensity cropland	

Biodiversity modelling with GLOBIO
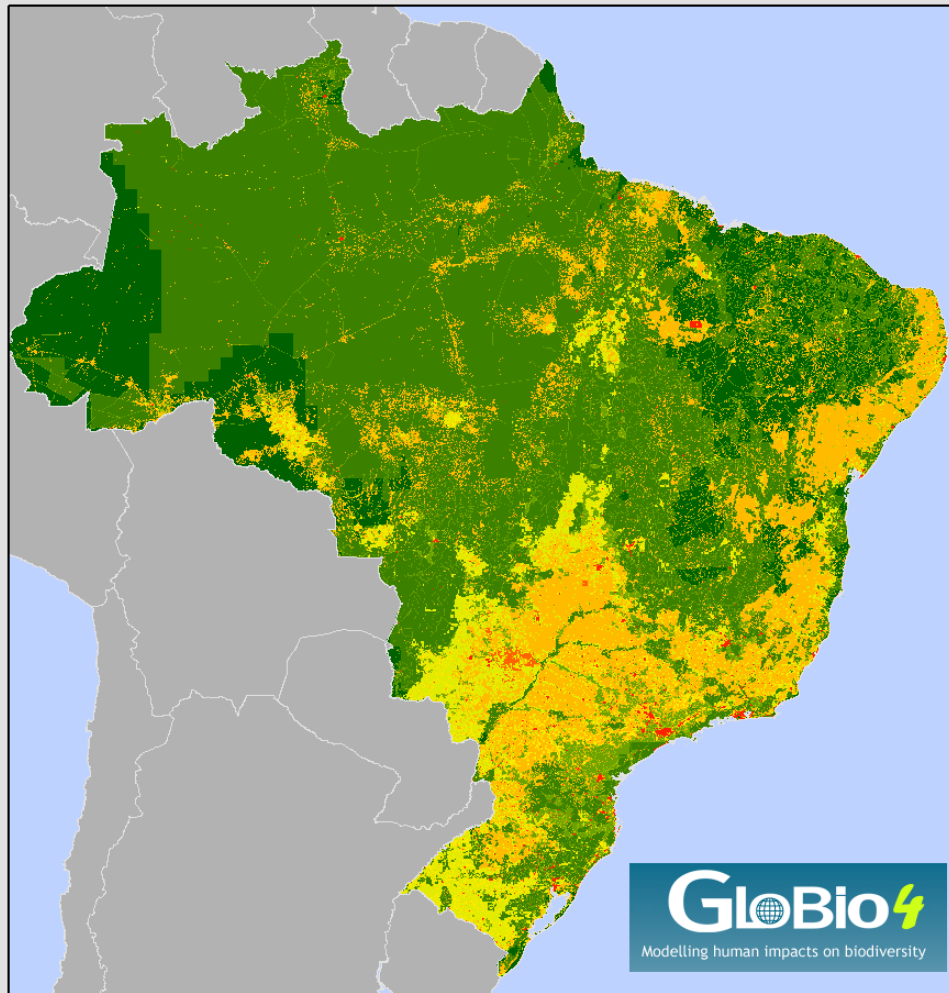
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Wish list

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✔ Connection to PBL's IMAGE model

✔ Reasonable run-time

Outlook

- Finalize suitability layers
- Improve intensity modelling
- Incorporate changes in natural vegetation
- Go probabilistic