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# Land of opportunities: Aligning organic farming and conservation targets in Europe


**Luisa Gensch**

Uwe A. Schneider, Kerstin Jantke, Livia Rasche

University of Hamburg, Max Planck Institute for Meteorology


This presentation participates in OSPP

Outstanding Student & PhD candidate Presentation contest

# NEGATIVE EFFECTS OF INTENSIVE AGRICULTURE ON BIODIVERSITY, SOIL HEALTH AND ENVIRONMENT

https://medium.com/remote-sensing-in-agriculture/is-sustainable-industrial-farming-a-reality-5ba0966ab11d

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Deutsche Akademie der Naturforscher Leopoldina e.V. (2024). Zukunftswerkstatt Landwende: Wie wollen wir leben? Unsere Vision.

# MODELING APPROACH TO INTEGRATE LAND USE CONFLICTS

## Research questions

- How can we allocate land optimally?
- How does the fulfillment of both targets impact economic factors?
- How large are land use conflicts?

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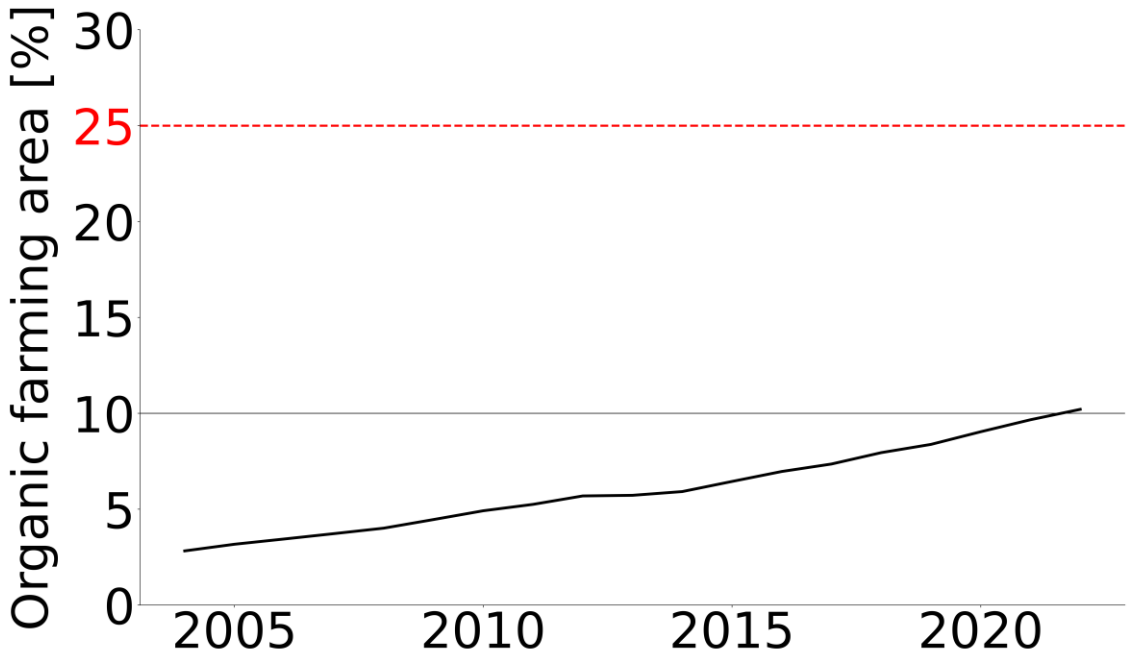
# LAND USE CONFLICTS ARE INCREASING

- intensive agricultural practices have taken a toll on biodiversity, soil health and the environment (Foley et al., 2011)
- The European Green Deal aims to counteract these issues with two ambitious targets by 2030:

1) the protection of 30% of the EU's land area, and the strict protection of 10%
2) the expansion of organic farming to a share of 25% of agricultural land




Growth of organic agriculture in the European Union.

**Research questions:** How can we allocate land optimally?

How do the targets influence each other?

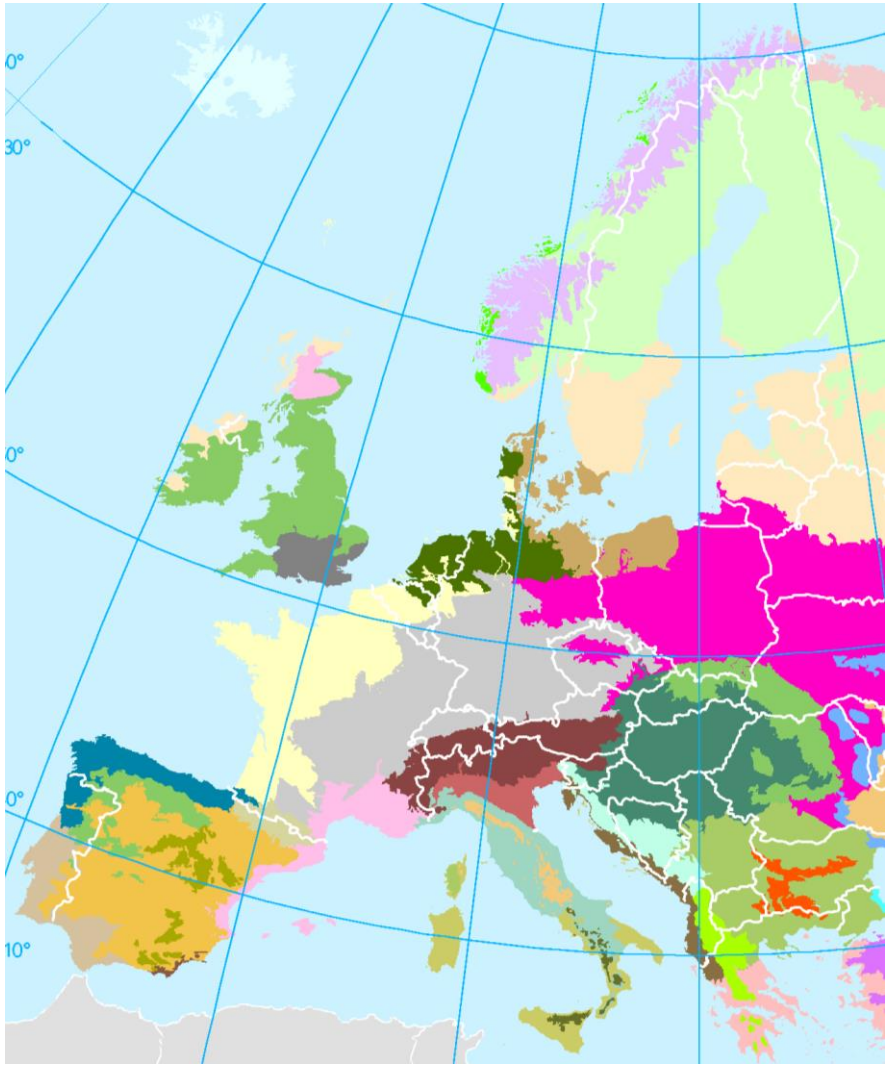
# OBJECTIVES OF LAND USE MUST BE CONSIDERED SIMULTANEOUSLY

- **Optimal expansion of protected areas for nature conservation has been studied** (Kukkala et al., 2016; Mueller et al., 2018; Mueller et al., 2020; Ricci et al., 2023)
- **Cazzolla Gatti et al. (2023) studied the 10% strict protection target and found that not enough land is available of low population density and agricultural activity**
- **essential to also consider other objectives of land use (change)** (Young et al., 2005)

# METHODS AND DATA

- **build a partial equilibrium model that optimizes land use decisions**
- **fulfills the 25% organic farming and 10% strict protected area targets under cost minimization**
- **uses ecoregions as ecological representation**

Overview of scenario analysis | Overview of system | Equations



https://www.eea.europa.eu/ds_resolveuid/88446B44-F911-4C6A-83DE-52D7504C38C0.

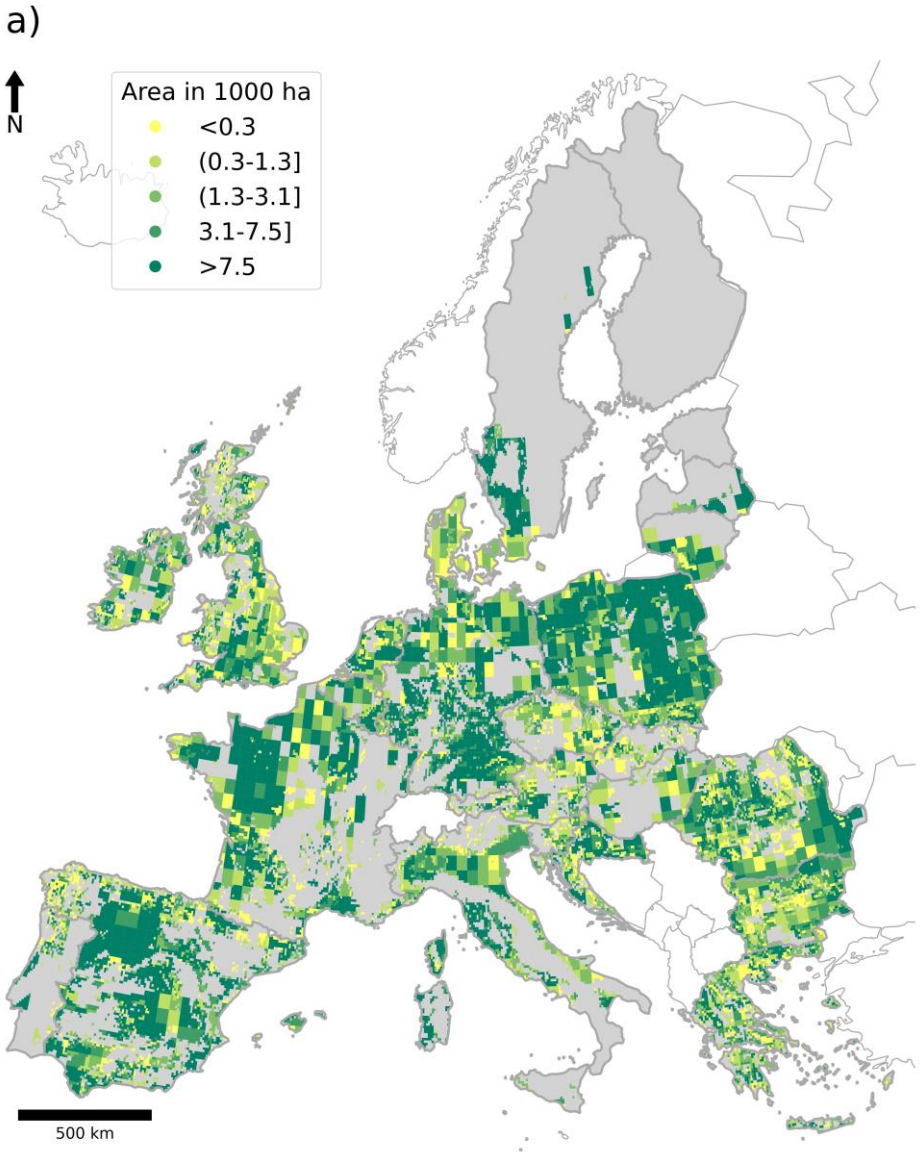
# RESULTS

Spatial distribution of land

Economic impacts

Ecoregion representation

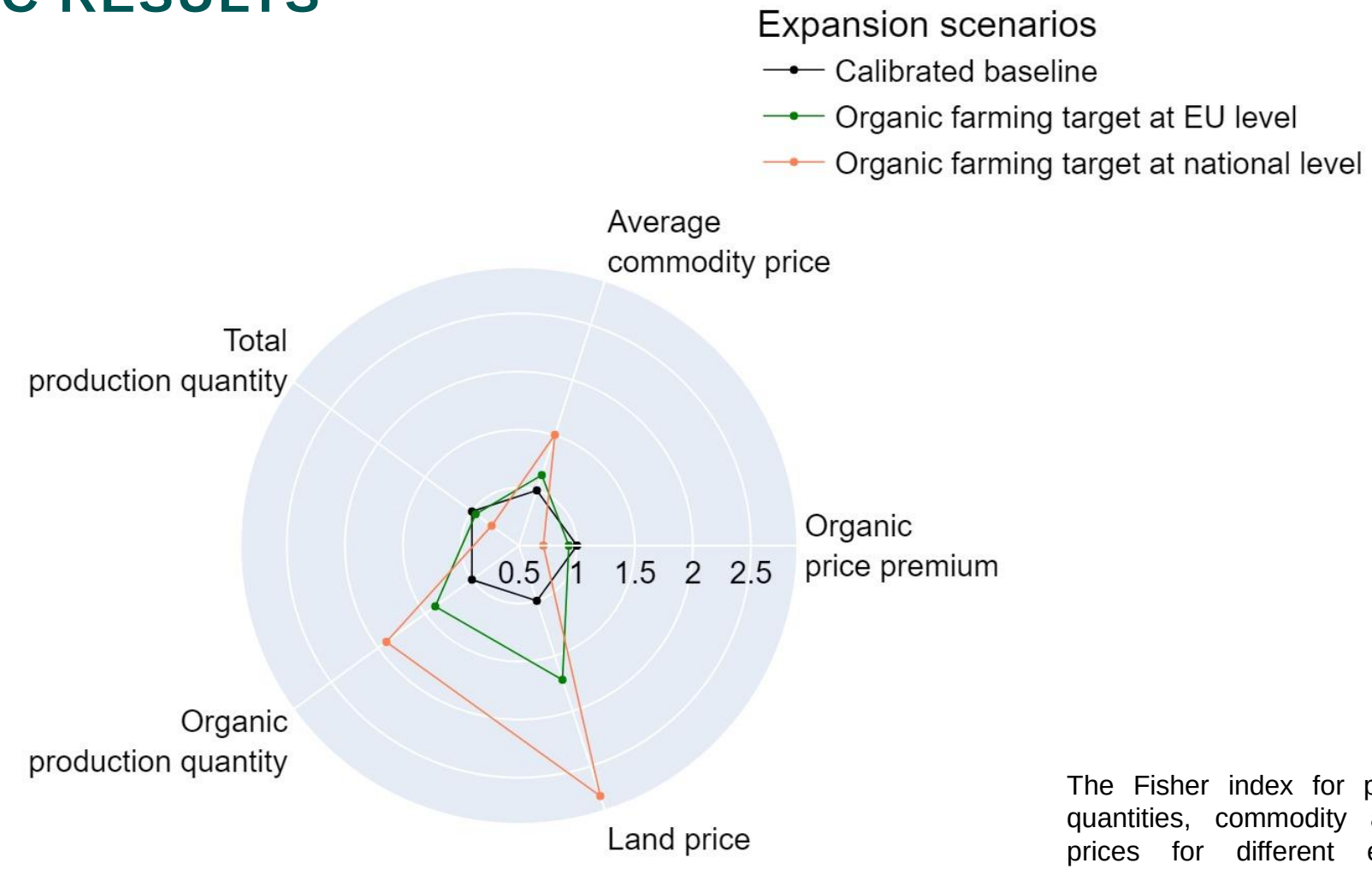
# STRICTLY PROTECTED AREA UNEVENLY DISTRIBUTED




The additionally designated strictly protected area in 1000 ha at the EU level.

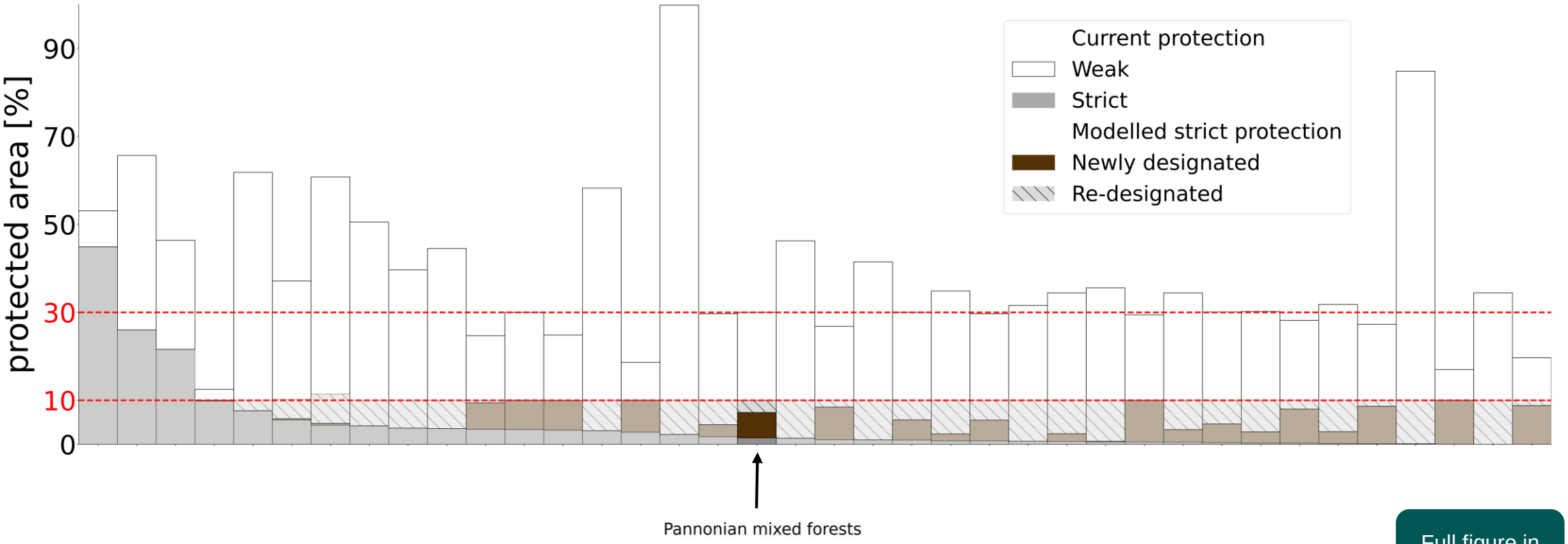
Full figure in appendix

# ECONOMIC RESULTS




The Fisher index for production quantities, commodity and land prices for different expansion scenarios. The calibrated baseline has a value of 1 for all indices.

# HALF OF PROTECTED AREA CAN COME FROM RE-DESIGNATION




Full figure in appendix

The share of already weakly and strictly protected area and the additionally needed and re-designated protected area for each ecoregion of the EU (scenarios at the national level).

# CONCLUDING REMARKS

- **Spatial designation of strictly protected areas should be taken with caution, (should consider biodiversity needs and connectivity)**
- **less than 1% of cropland needed for the strict protection target; both targets can be fulfilled without major conflicts over cropland use**
- **Commodity prices could increase by up to 50% for consumers**
- **Expansion and proper management of existing protected areas is crucial**
- **Supportive policy instruments needed to ensure acceptance and demand for organic products and reduce environmental leakage**

# REFERENCES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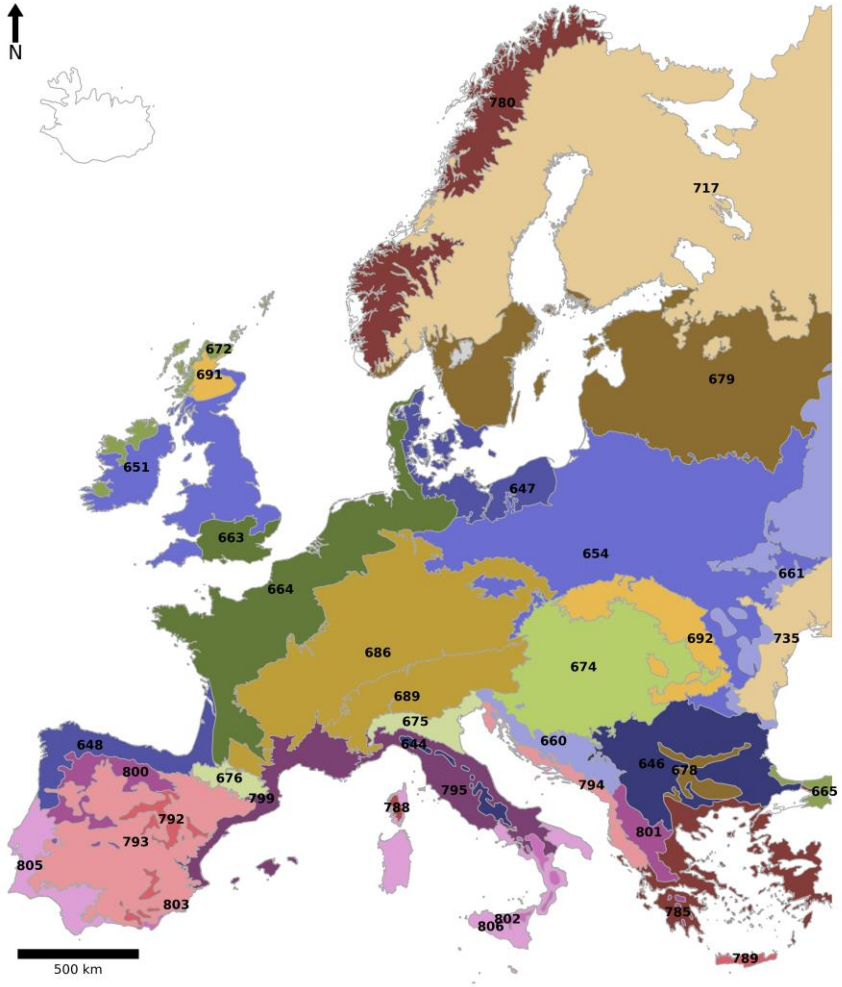
# APPENDIX

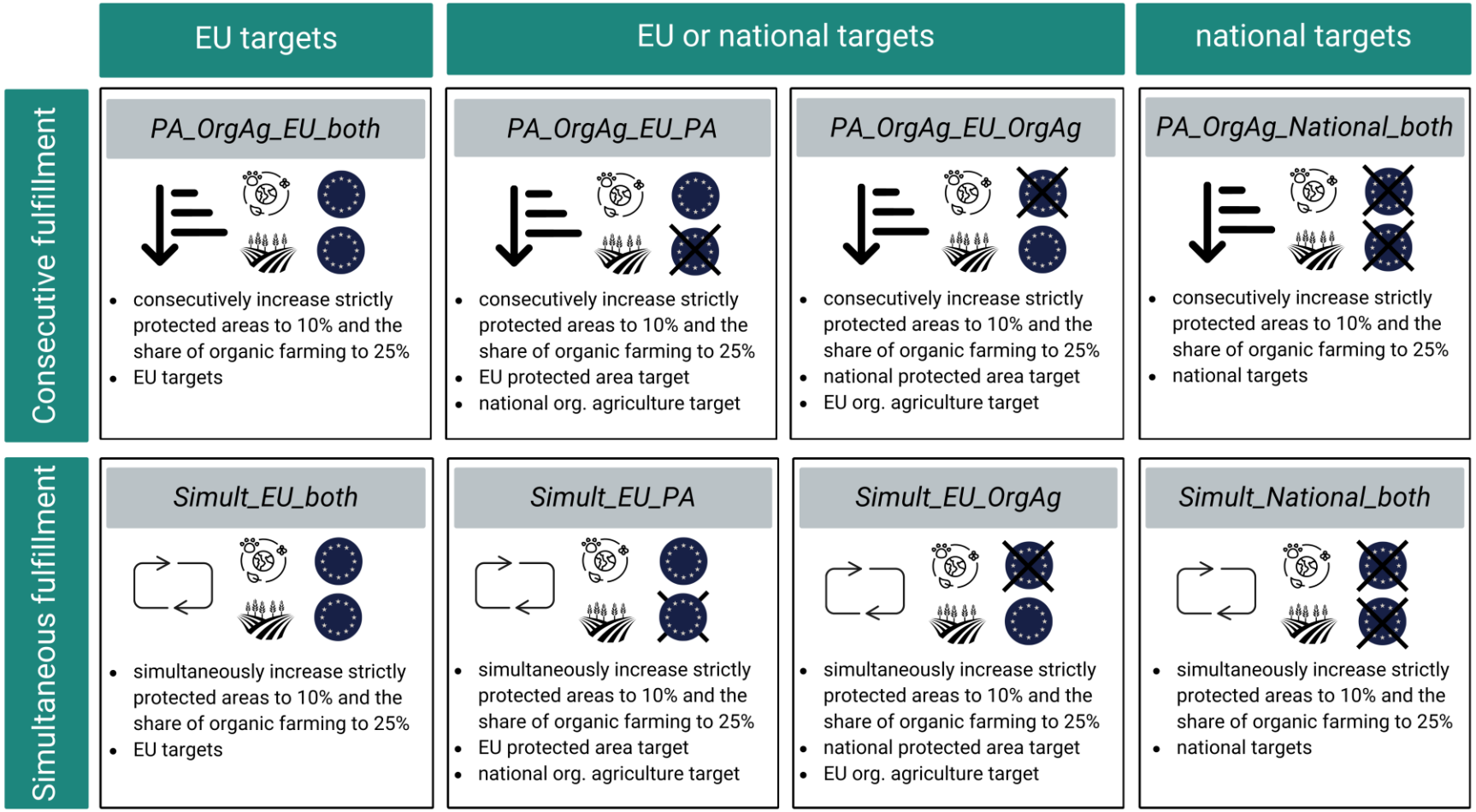
# ECOREGIONS




644: Appenine deciduous montane forests
646: Balkan mixed forests
647: Baltic mixed forests
648: Cantabrian mixed forests
651: Celtic broadleaf forests
654: Central European mixed forests
660: Dinaric Mountains mixed forests
661: East European forest steppe
663: English Lowlands beech forests
664: European Atlantic mixed forests
665: Euxine-Colchic broadleaf forests
672: North Atlantic moist mixed forests
674: Pannonian mixed forests
675: Po Basin mixed forests
676: Pyrenees conifer and mixed forests
678: Rodope montane mixed forests
679: Sarmatic mixed forests
686: Western European broadleaf forests
689: Alps conifer and mixed forests
691: Caledon conifer forests
692: Carpathian montane forests
717: Scandinavian and Russian taiga
735: Pontic steppe
780: Scandinavian Montane Birch forest and grasslands
785: Aegean and Western Turkey sclerophyllous and mixed forests
788: Corsican montane broadleaf and mixed forests
789: Crete Mediterranean forests
792: Iberian conifer forests
793: Iberian sclerophyllous and semi-deciduous forests
794: Illyrian deciduous forests
795: Italian sclerophyllous and semi-deciduous forests
799: Northeast Spain and Southern France Mediterranean forests
800: Northwest Iberian montane forests
801: Pindus Mountains mixed forests
802: South Apennine mixed montane forests
803: Southeast Iberian shrubs and woodlands
805: Southwest Iberian Mediterranean sclerophyllous and mixed forests
806: Tyrrhenian-Adriatic sclerophyllous and mixed forests

A map of the 38 ecoregions within the EU we consider in our anaylsis. Data taken from the Ecoregions 2017 Resolve map (Dinerstein et al., 2017).

# SCENARIO ANALYSIS OF EU OR NATIONAL TARGETS




Overview of the six expansion scenarios that fulfill both targets of 10% strict protection and 25% organic agriculture either simultaneously or successively and either as EU-wide or national targets.

## Base model

$$\max\left(\sum_{s,c}\int_0^{L_{s,c}} \alpha_{s,c}\cdot Q_{s,c}^{\frac{1}{\epsilon_{s,c}}}\mathrm{d}Q_{s,c} - \sum_{s,c,m} c_{s,c,m}\cdot A_{s,c,m}\right)$$

$$s.t. \quad \sum_{c,m} A_{s,c,m} \le a_s \qquad \forall s$$

$$\sum_m A_{s,c,m} = \sum_t m_{s,c,t}\cdot M_{s,t} \qquad \forall c,s$$

$$\sum_m A_{s,c,m} \le \beta_c \cdot \sum_{c,m} A_{s,c,m} \qquad \forall s,c$$

$$\sum_{c,m} y_{s,c,m}\cdot A_{s,c,m} = L_{s,c} \qquad \forall s,c$$

## Organic farming expansion

$$A_{s,c,org} \ge r \cdot \sum_m A_{s,c,m} \qquad \forall s,c$$

## Protected area expansion

$$P_{s,e} \le u_{s,e} \qquad \forall s,e$$

$$P_{s,e}^{\text{new}} + P_{s,e}^{\text{re-designate}} + p_e \ge \left(u_{s,e} + p_{s,e}\right)\cdot t_e \qquad \forall s,e$$

$$\sum_e P_{s,e}^{\text{arable}} + \sum_{c,m} A_{s,c,m} \le a_s \qquad \forall e,c,m$$

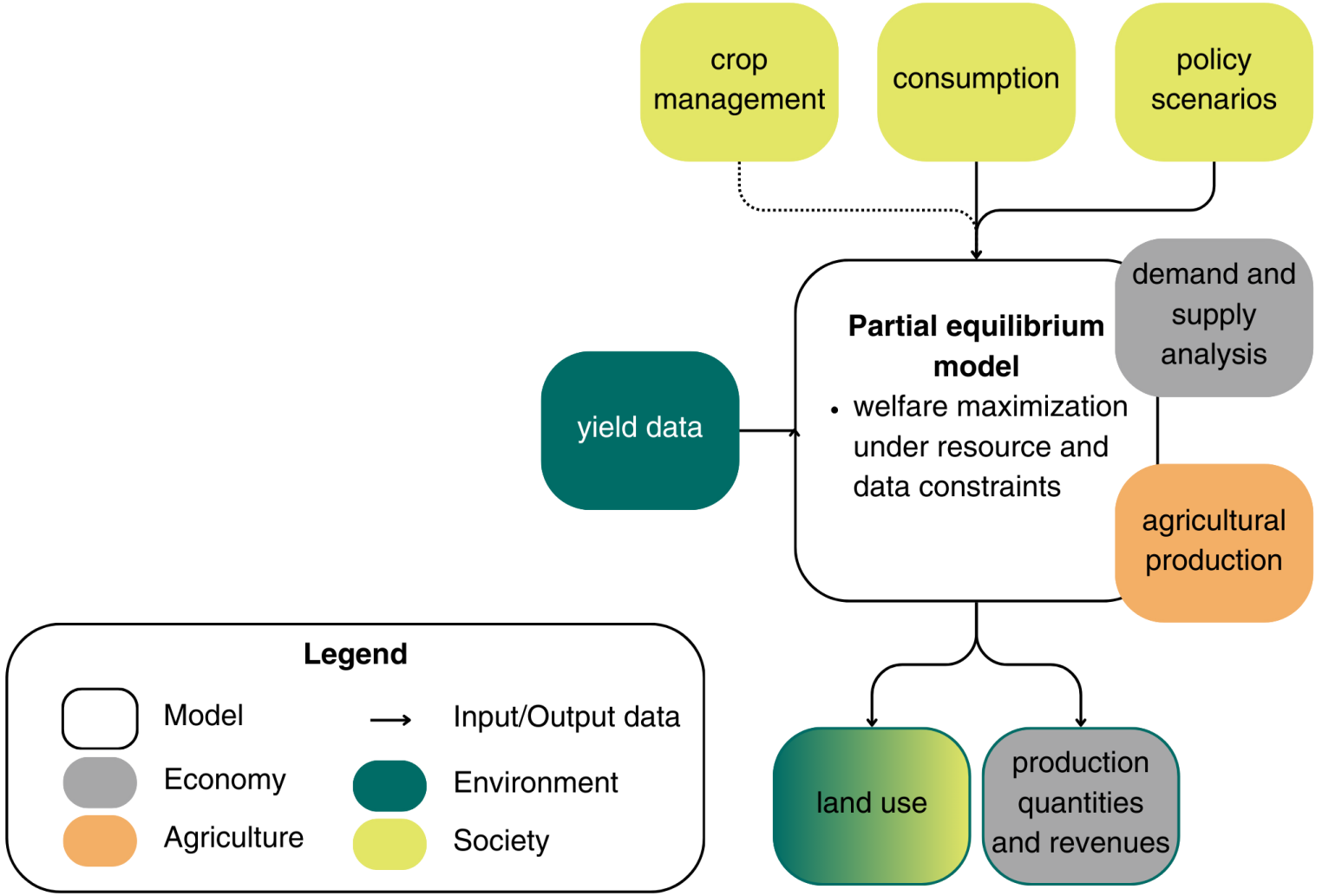
$$\sum_s P_{s,e}^{\text{arable}} - B\cdot\sum_s u_{s,e}^{\text{arable}} \le 0 \qquad \forall e$$

$$\sum_s P_{s,e}^{\text{natural}} - B\cdot\sum_s u_{s,e}^{\text{natural}} \ge 0 \qquad \forall e$$

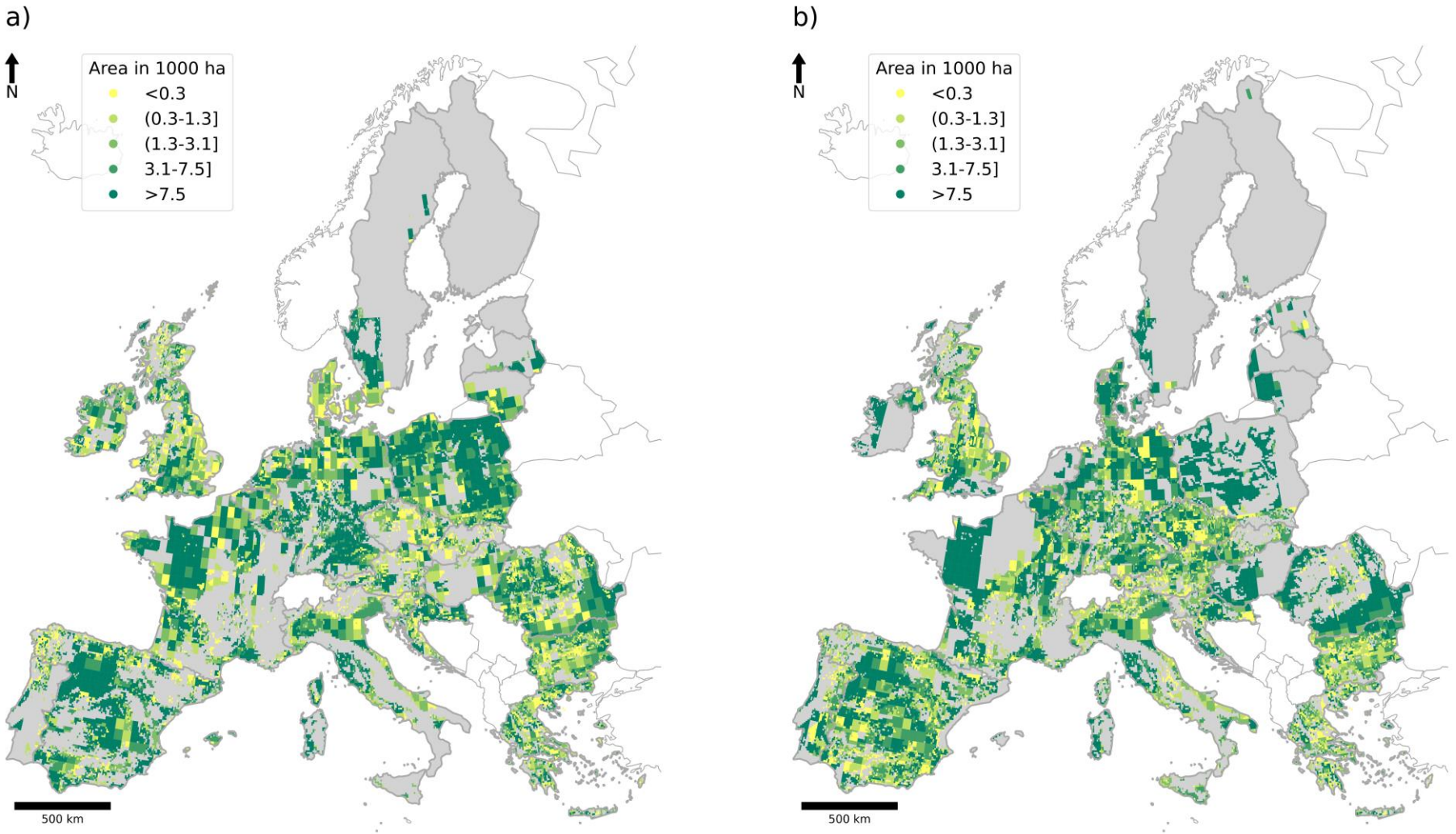
# MODELING PARAMETERS

| | Symbol | Domain | Unit | Description |
|---|---|---|---|---|
| **Variable** | Q | s,c | 1000 tons | Production quantities |
| | A | s,c,m | 1000 ha | Crop management area allocation |
| | M | s,t | - | Scalar indicating to what proportion each parameter is used in the linear combination |
| | L | s,c | 1000 tons | Modeled production quantities |
| | P | s,e | 1000 ha | Protected area |
| | B | - | - | Binary variable to ensure natural land use before agricultural land use |
| **Parameter** | α | s,c | | Scaling factor between quantity and price |
| | ε | s,c | | Price elasticity of demand |
| | c | s,c,m | | Estimated cost parameter |
| | a | s | | Observed cropland area |
| | m | s,c,t | | Observed production quantities |
| | β | c | | Maximum share of total cropland area in each HRU |
| | y | s,c,m | | Exogenously simulated yield outputs |
| | r | - | | Share of organic to total cropland |
| | u | s,e | | Observed unprotected area |
| | t | e | | Target share of strictly protected area |
| | p | e | | Observed strictly protected area |
| **Index** | s | | | Country |
| | c | | | Crop product |
| | m | | | Crop management technology |
| | t | | | Year |
| | e | | | Ecoregion |

# SYSTEM OVERVIEW

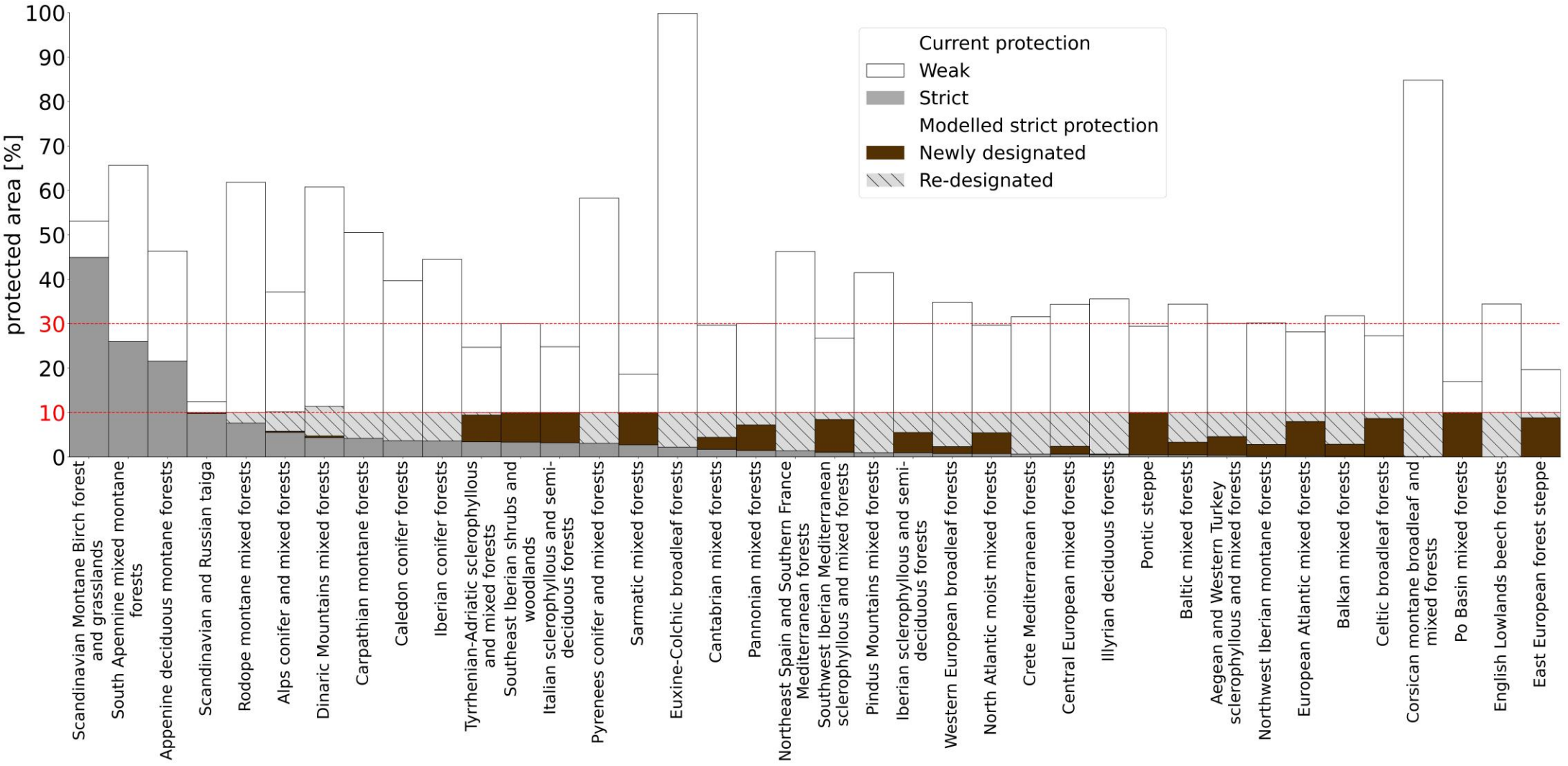


# NEWLY STRICTLY PROTECTED AREA




Additional strictly protected area in 1000 ha needed for the a) 10% strictly protected area target at the EU level (scenario *PA_OrgAg_EU_both*) and b) the 10% strictly protected area target at the national level (scenario *PA_OrgAg_EU_OrgAg*).

# HALF OF PROTECTED AREA CAN COME FROM RE-DESIGNATION




The share of already weakly and strictly protected area and the additionally needed and re-designated protected area for each ecoregion of the EU.