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Mapping the potential distribution of the invasive apple snails (*Pomacea canaliculata* and *P. maculata*) in European wetlands and freshwater ecosystems

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imati
Università degli Studi di Milano
efsa European Food Safety Authority

Aim of the study

- Two main goals:

1) Specific: mapping the potential distribution of the invasive apple snails (*Pomacea canaliculata* and *P. maculata*) in European wetlands and freshwater ecosystems

2) General: to show a methodological framework (i) able to define the area of potential establishment on the basis of the physiologically-based approach to population dynamics modelling (ii) that uses the population abundance (whatever defined) as the driver that can better explain the impact (iii) that links the area of potential establishment with the suitable habitats (iv) that makes possible, if available, the implementation of models linking the population abundance with the impact on cultivated plants and/or the environment

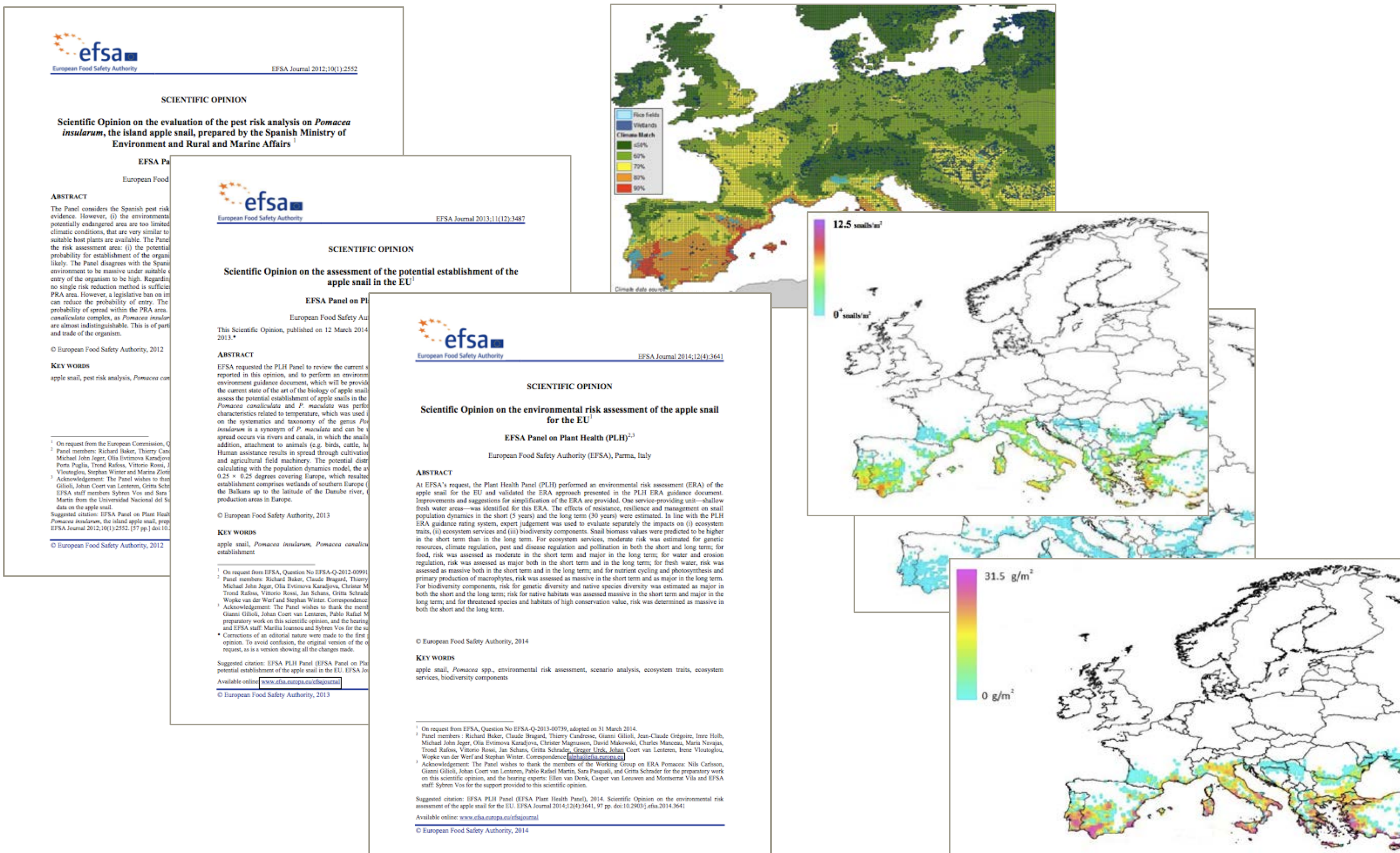
Pest Risk Analysis

EFSA (2012). Scientific Opinion on the evaluation of the pest risk analysis on Pomacea insularum, the island apple snail, prepared by the Spanish Ministry of Environment and Rural and Marine Affairs.

EFSA (2013). Scientific Opinion on the assessment of the potential establishment of the apple snail in the EU.

EFSA (2014). Scientific Opinion on the environmental risk assessment of the apple snail for the EU.

Pest Risk Analysis

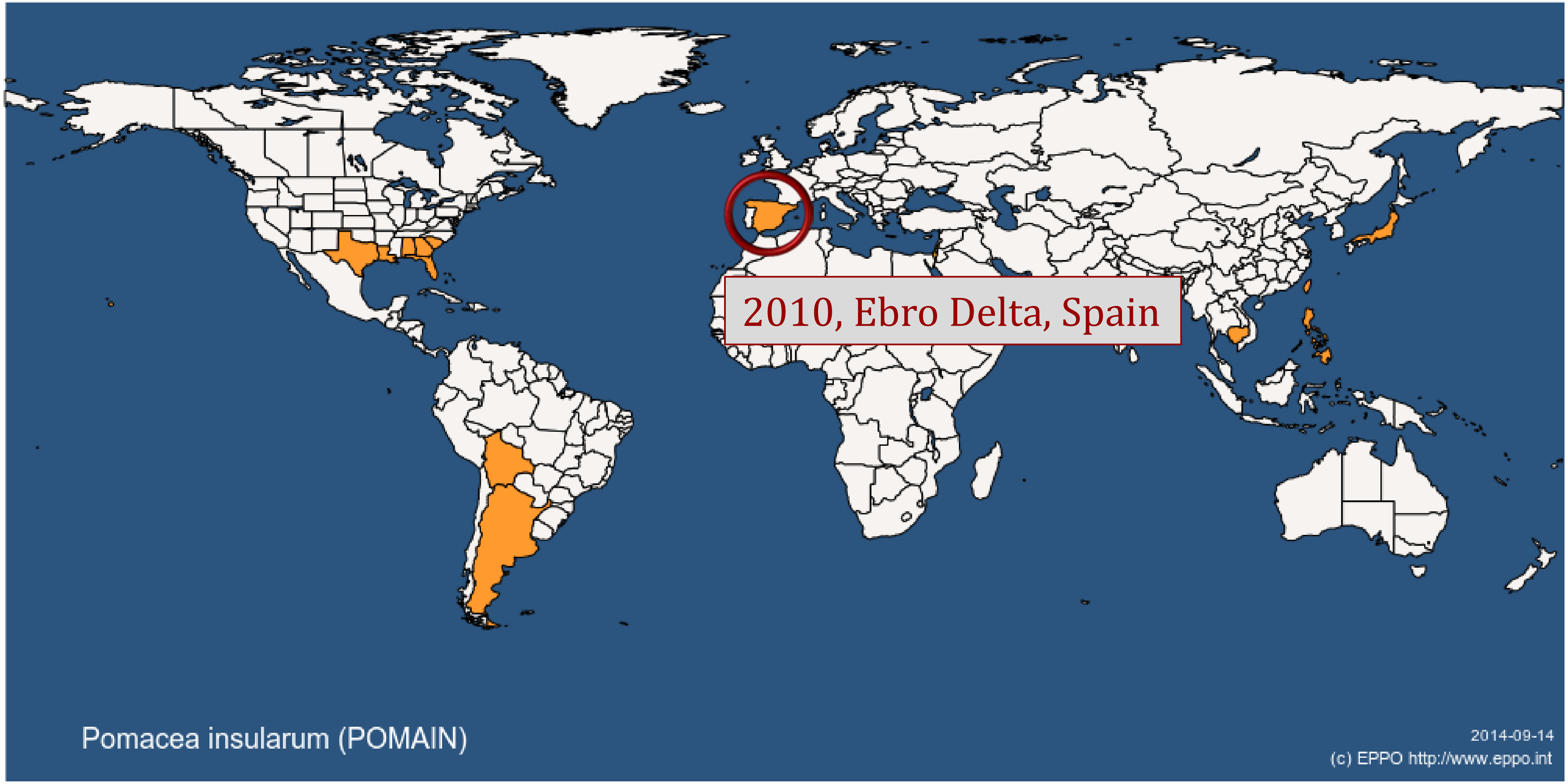


The invasive apple snails (*Pomacea* spp.)

- Originally from South or Central America → Asia, North America, Europe
- Three developmental stages: eggs, juveniles, adults
- Extremely adaptive to environmental conditions in wetlands, freshwater ecosystems and rice paddies
- Extremely polyphagous
- Highly reproductive
- Damaging freshwater macrophytes predominant environments
- One of the 100 World's Worst Invasive Alien Species

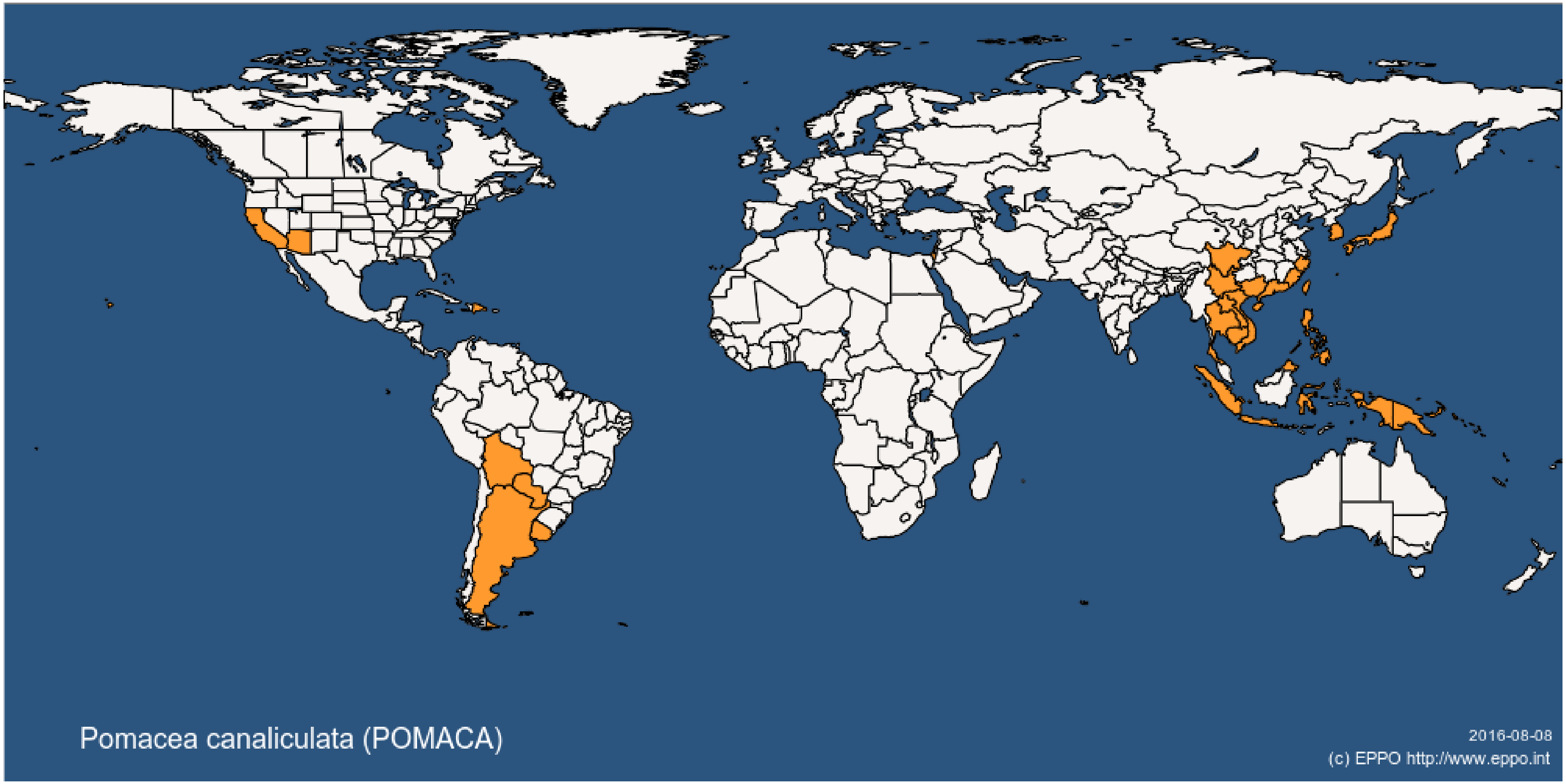
Distribution

P. maculata



Distribution

P. canaliculata



From the potential distribution to the impact

- Density or biomass per unit area of an invasive species is a key predictor of the magnitude of environmental and economic impact in the invaded habitat

- The combination of climatic and habitat variables is a powerful way to model the distributions of invasive species but does not provide us with information about the variability and adaptability of life-history traits, their consequences on population dynamics, nor on how the density of the invader across different geographical scales is distributed.

→ Physiologically-based modelling increases our ability to forecast the spatio-temporal pattern of population dynamics of the same invader within the potential, invasible geographical range

- Provide information about when, and where, risk reducing options and control measures would be most effective considering how they can modify population abundance

An effective approach

- In this study, we use the highly invasive snail *P. canaliculata* as a case study illustrating the potentiality of the physiologically-based demographic modelling approach to describe and forecast population dynamics of an invasive species at different locations.

- The approach followed in this work allows to roughly translate the potential densities into an estimated impact on biodiversity, ecosystem services and local economies (for example agriculture, forestry or fishery) in different areas

- The availability of information on the driver of the environmental impact can support risk management measures, for instance management efforts can be concentrated to “hot spots” (i.e. high density areas) where the negative effects of an invader are likely to be high

Data collections and methods

✧ *The information layer related to the wetlands and other suitable habitats of apple snails should be added to the maps of potential distribution, in order to properly define the area at risk of establishment*

1. *P. canaliculata* biomass data points obtained from the model [juveniles + adults]
2. Data on wetlands and freshwater ecosystems [GIEMS - D15]
3. Data on European protected areas [Natura 2000]

- Interpolation and overlay (QGIS and GRASS)
- Statistics based on biomass ranges of *P. canaliculata* in Europe

1) Model development and biomass data points

- **Temperature-dependent physiologically-based demographic model**

- Water/air temperature dependent development, fecundity and mortality rate functions

- Hourly values of water and air temperature have been simulated for each point of a 0.25 X 0.25 degrees grid based on the daily maximum and minimum air temperature of the 10 closest weather stations of NOAA-GSOD dataset

- The potential snail biomass, defined as the biomass in a given point of the considered grid where a suitable habitat is present at a time t, has been obtained and expressed in g/m^2

- The stochastic model accounts for biological variability and uncertainty

***P. canaliculata* biomass data points**

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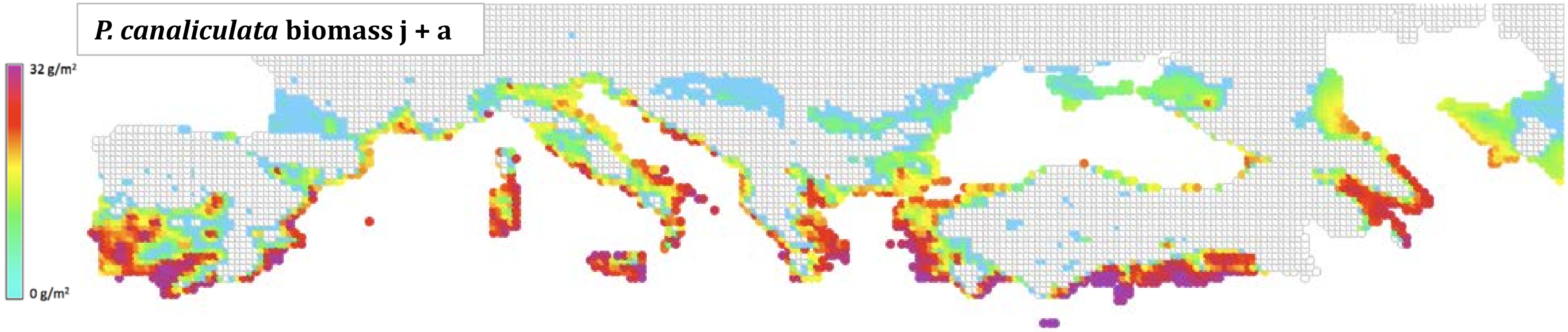
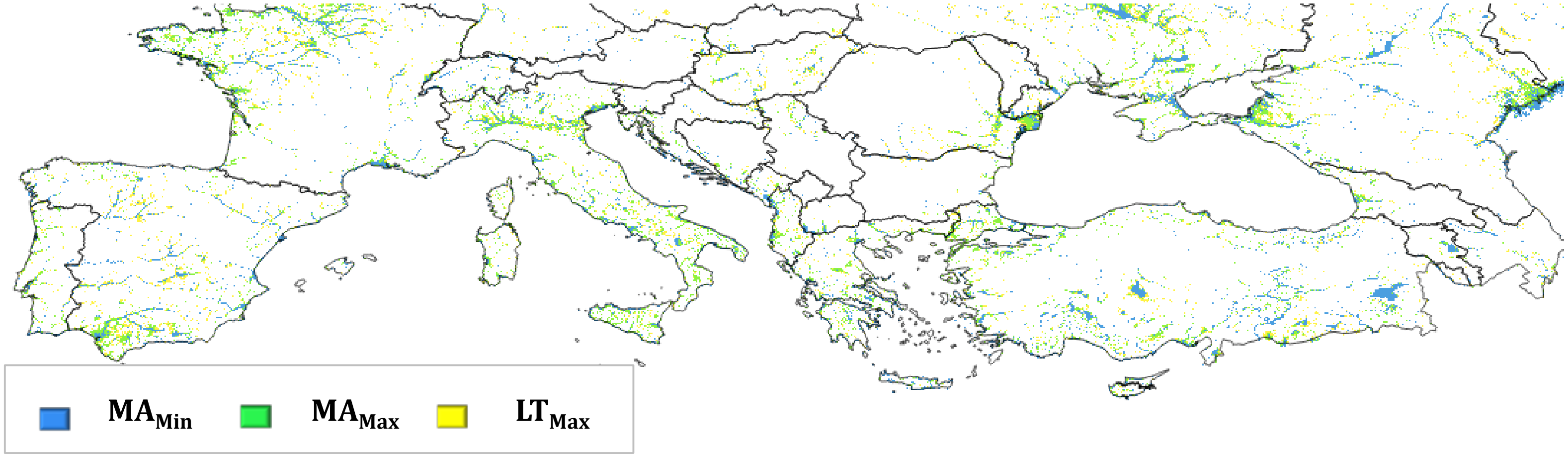


2) Data on wetlands and freshwater ecosystems

- The Global Inundation Extent from Multi-Satellite dataset downscaled to 15 arc-seconds (~ 500 meters at the equator)

- Monthly data on surface water extent over a 12-year time period of observations together with data on wetlands extent from the Global Lakes and Wetlands Database (GLWD)

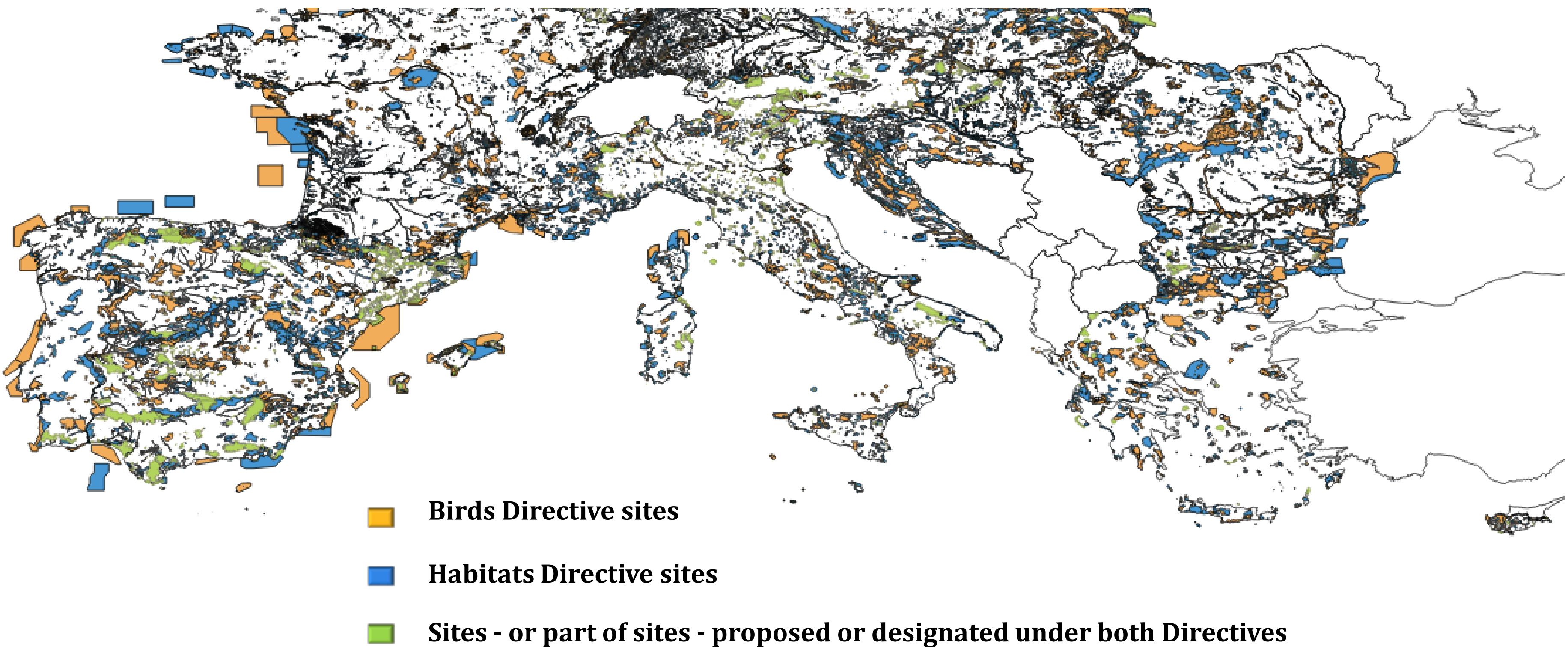
- Three states of global inundation extents: the mean annual minimum (MA_{Min}), the mean annual maximum (MA_{Max}) and the long-term maximum (LT_{Max})



3) Data on European protected areas

- The Natura 2000 database

- Birds Directive and Habitats Directive



Methods for...

- Interpolation and overlay

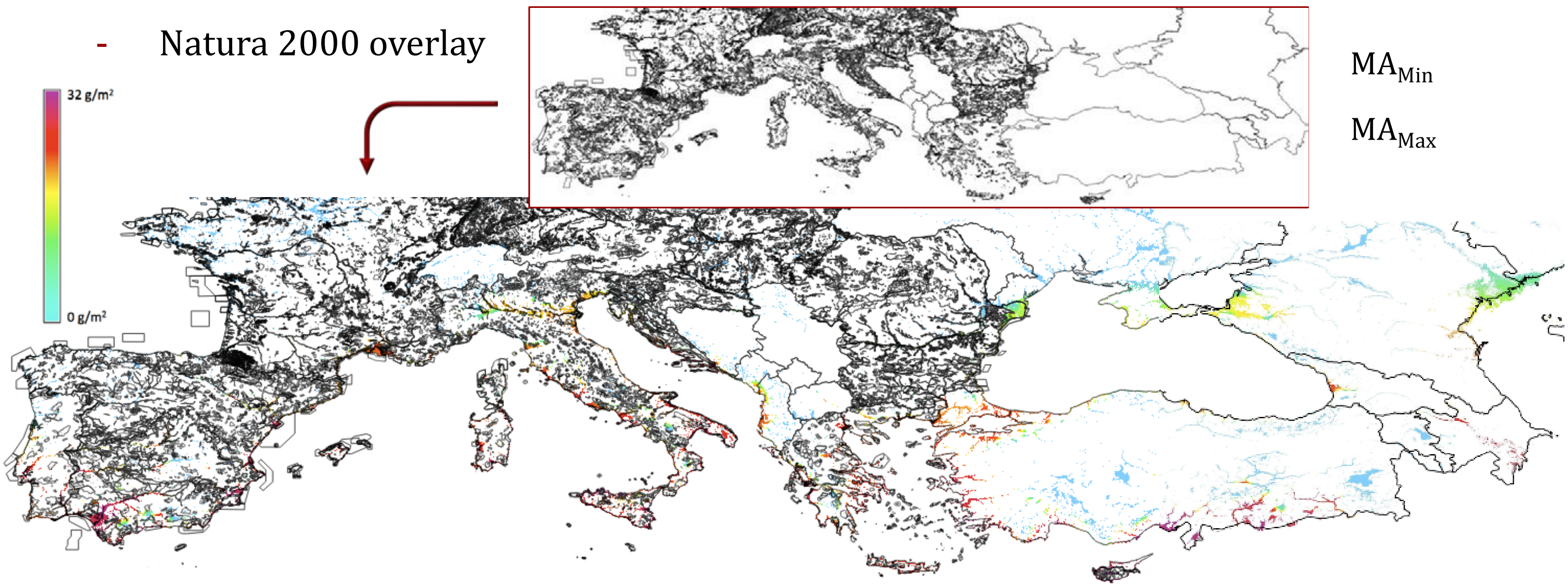
- Regularized Spline with Tension (RST)
- GIEMS mask overlay
- Natura 2000 overlay

v.surf.rst (GRASS)

tension 100

smoothing 0.01

+

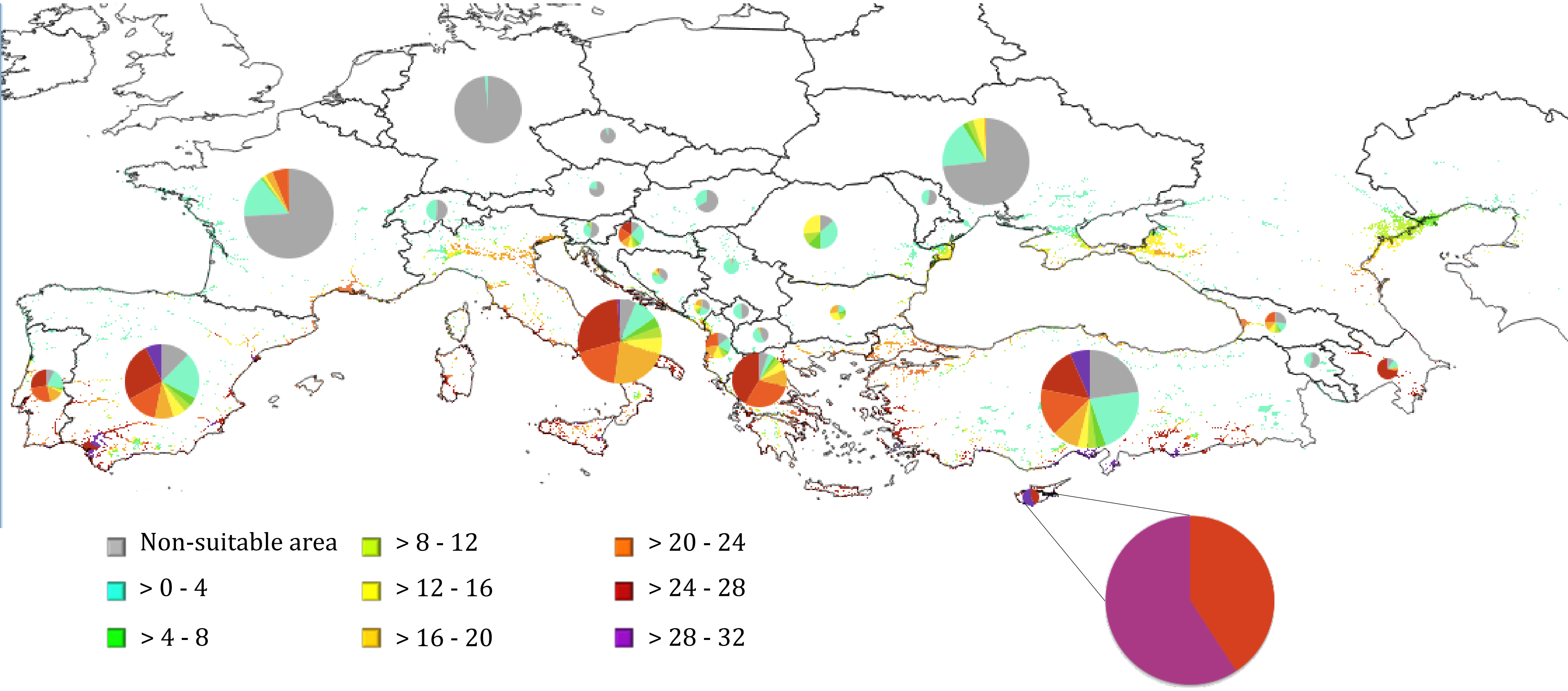


MA_{Min}

MA_{Max}

Results - part 1

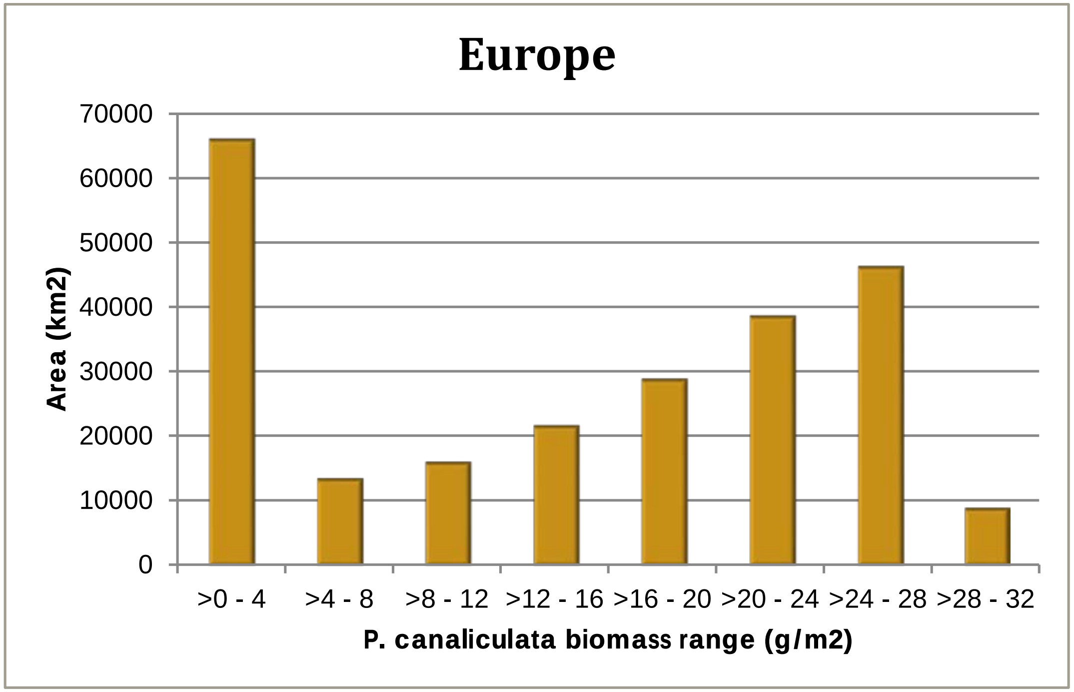
***P. canaliculata* biomass (g/m²) > 0**



Results - part 1

European total surface (Km^2) potentially affected by *P. canaliculata* per biomass sub-range (g/m^2)

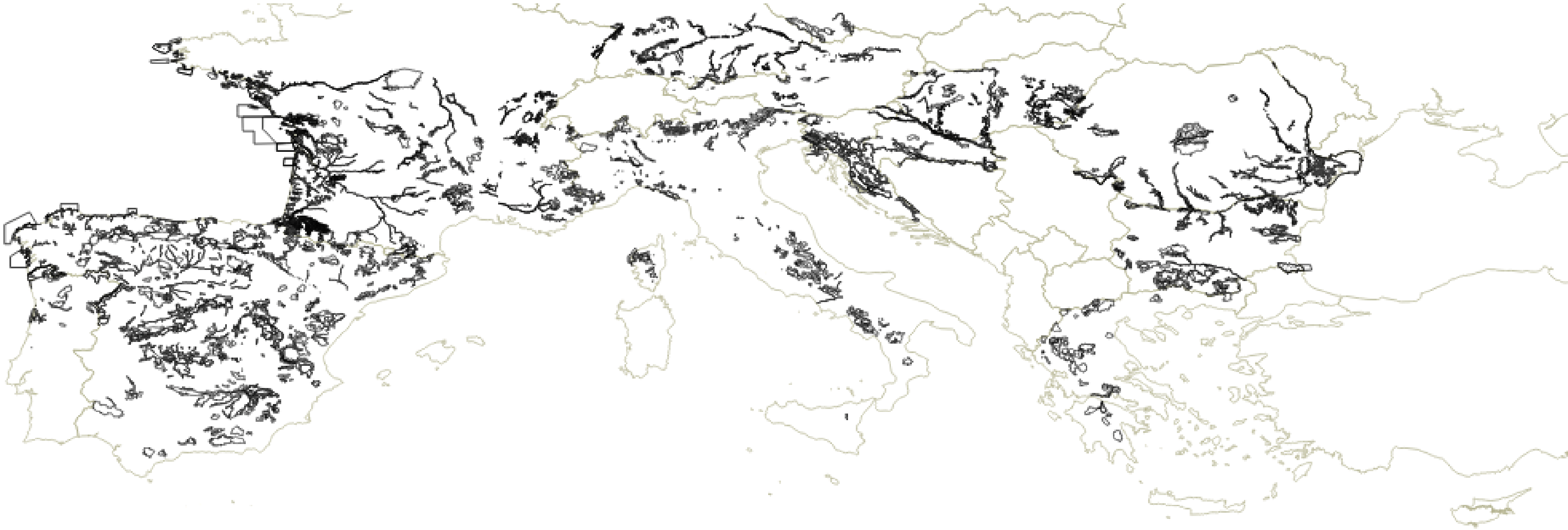
Europe	
P. canaliculata biomass range (g/m^2)	Area (Km^2)
>0 - 4	65801
>4 - 8	13203
>8 - 12	15808
>12 - 16	21480
>16 - 20	28668
>20 - 24	38356
>24 - 28	46044
>28 - 32	8578
TOT.	**237938**



Results - part 2

Natura 2000 areas with *P. canaliculata* biomass (g/m^2) > 0

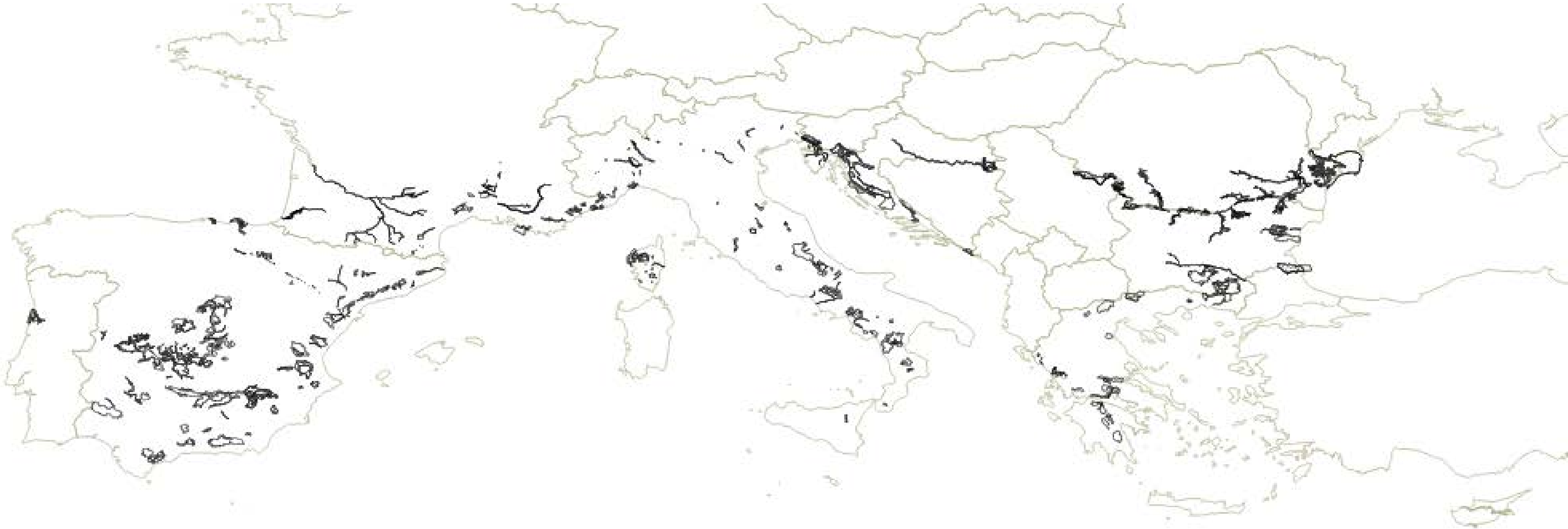
> 0 - 4



Results - part 2

Natura 2000 areas with *P. canaliculata* biomass (g/m²) > 0

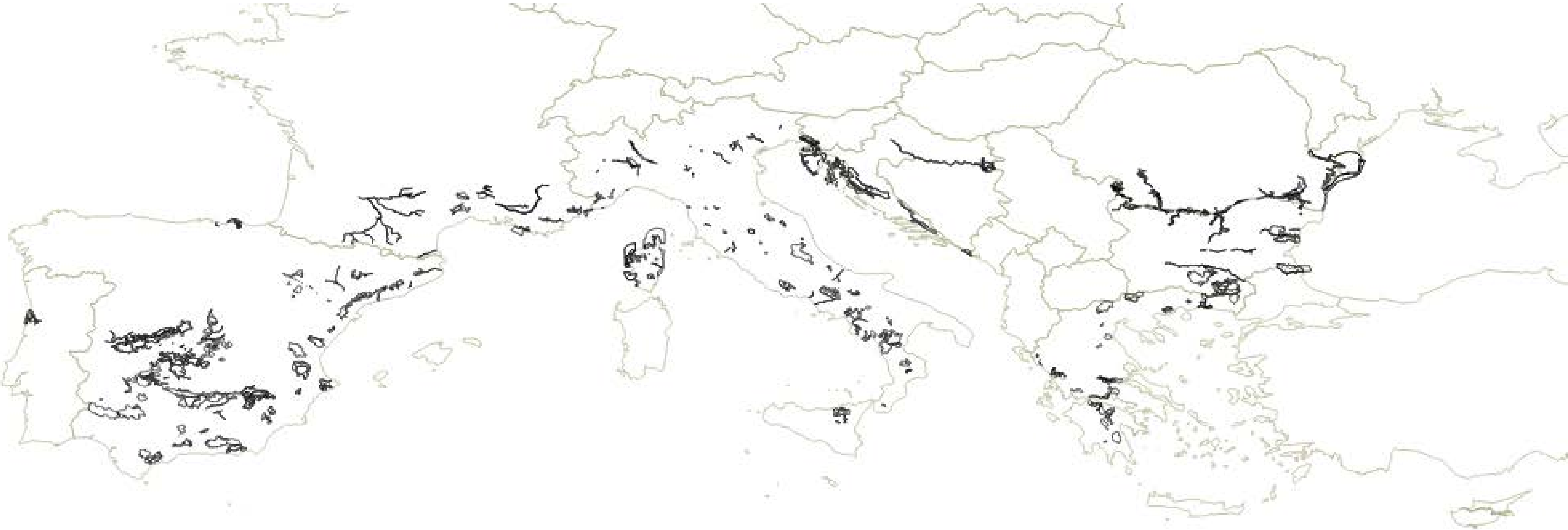
> 4 - 8



Results - part 2

Natura 2000 areas with *P. canaliculata* biomass (g/m²) > 0

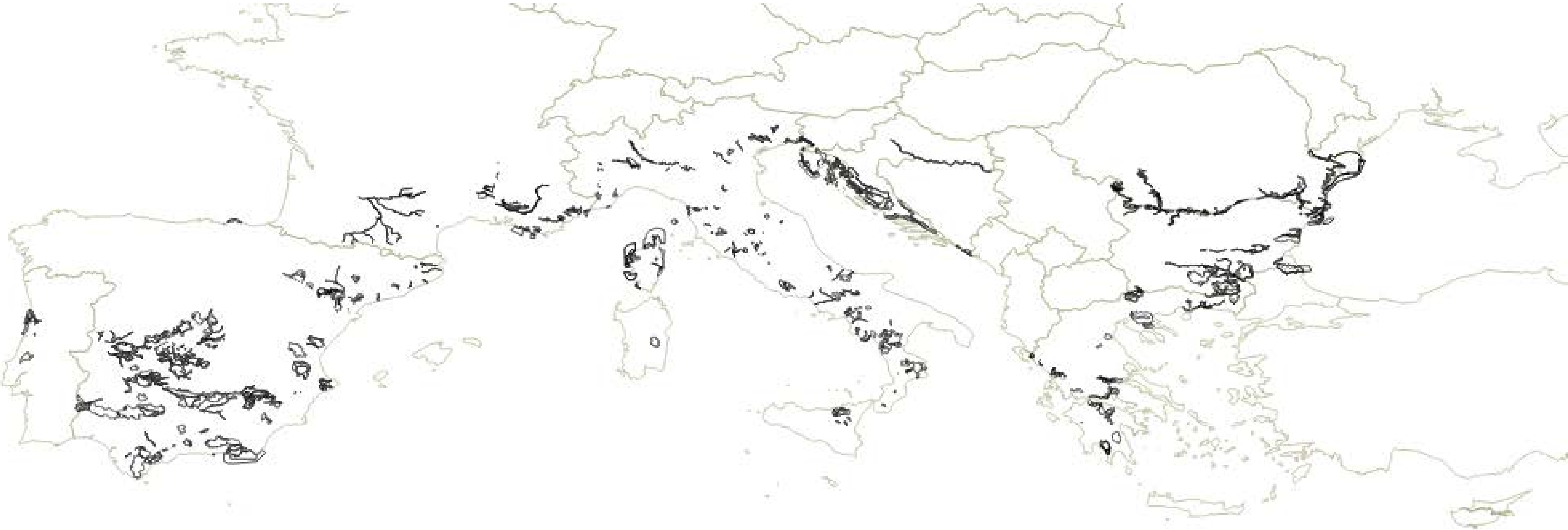
> 8 - 12



Results - part 2

Natura 2000 areas with *P. canaliculata* biomass (g/m^2) > 0

> 12 - 16



Results - part 2

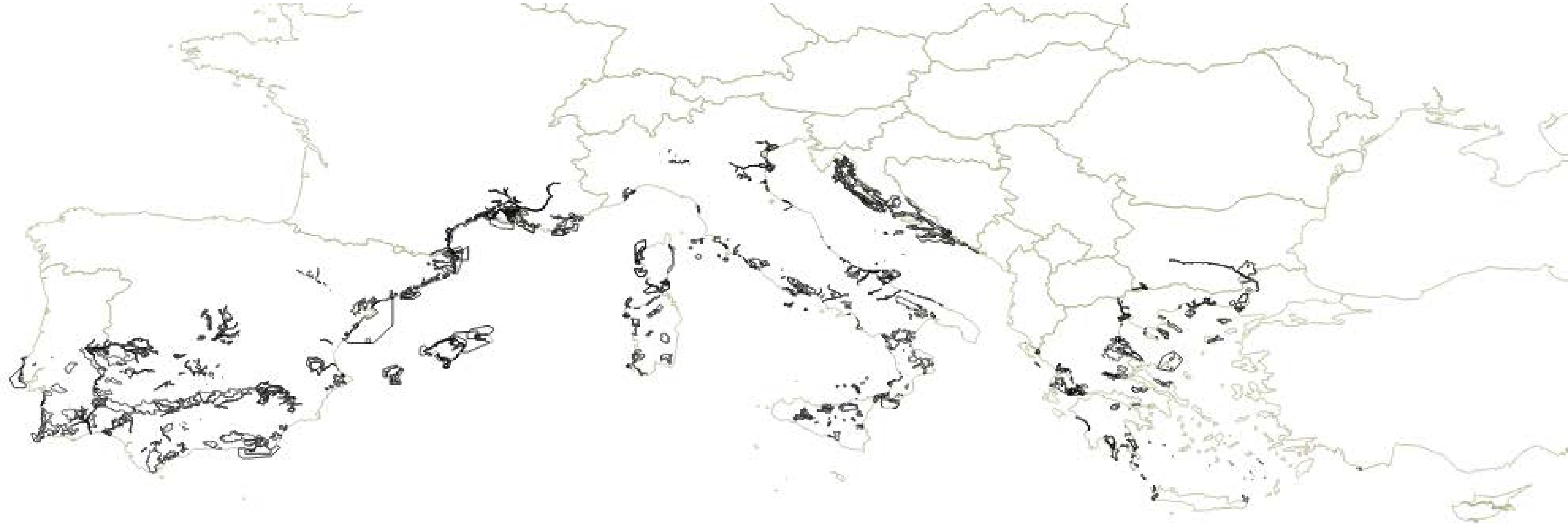
Natura 2000 areas with *P. canaliculata* biomass (g/m^2) > 0

> 16 - 20

Results - part 2

Natura 2000 areas with *P. canaliculata* biomass (g/m^2) > 0

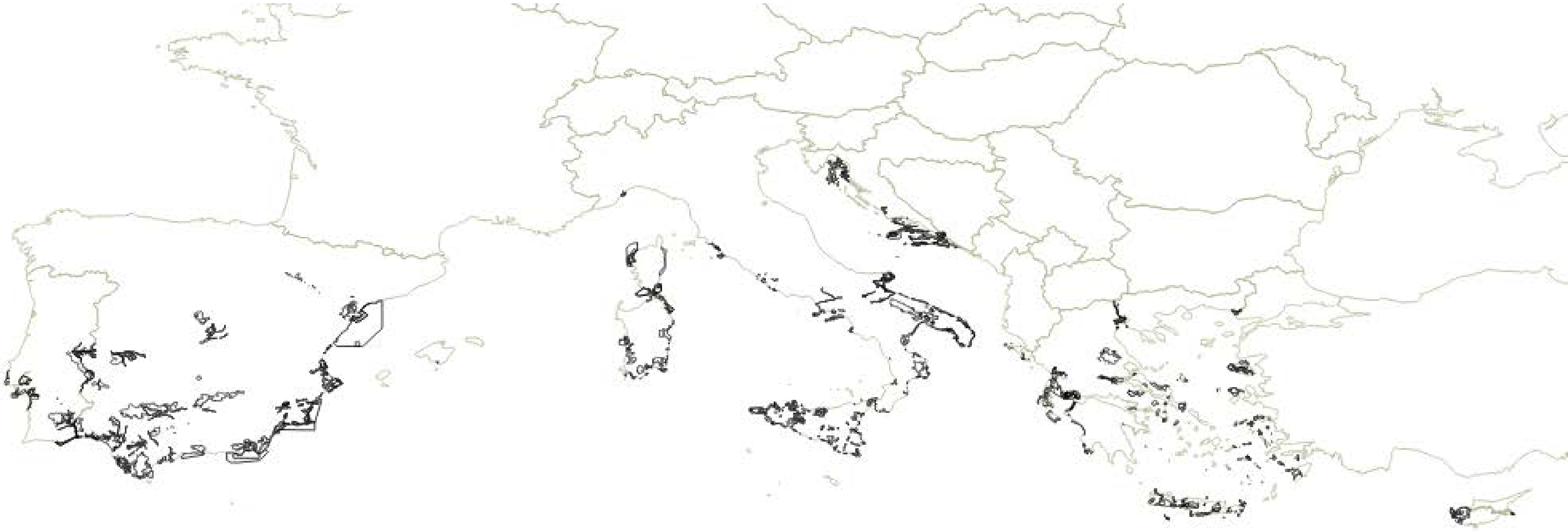
> 20 - 24



Results - part 2

Natura 2000 areas with *P. canaliculata* biomass (g/m^2) > 0

> 24 - 28



Results - part 2

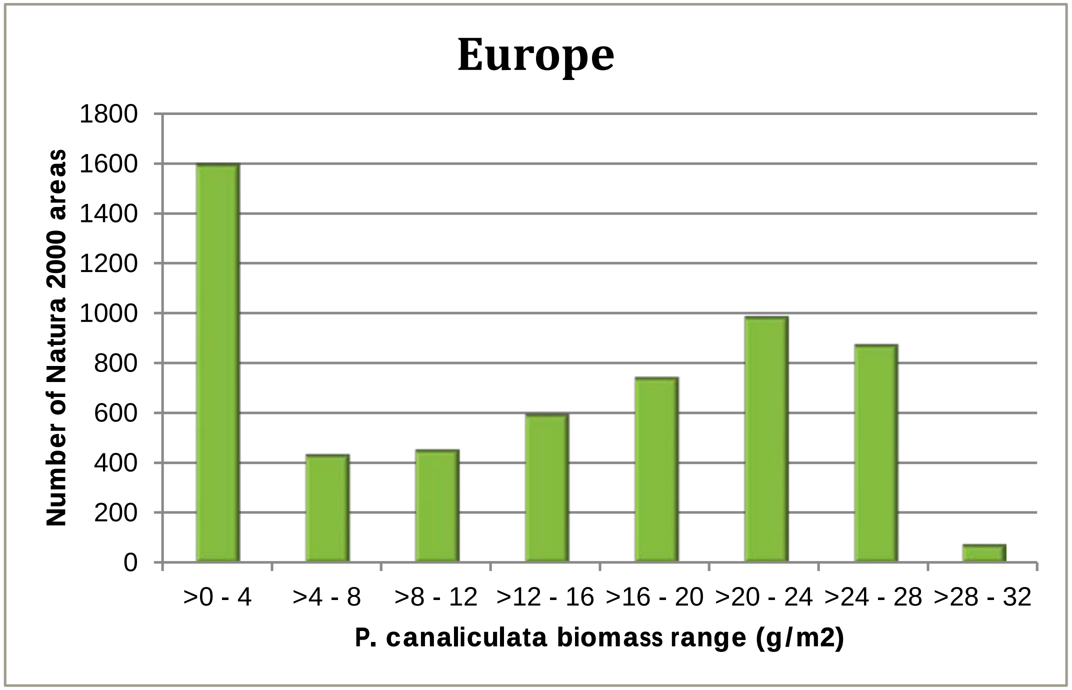
Natura 2000 areas with *P. canaliculata* biomass (g/m^2) > 0

> 28 - 32

Results - part 2

Number of European Natura 2000 areas potentially affected by *P. canaliculata* per biomass sub-range (g/m^2)

Europe	
P. canaliculata biomass range (g/m^2)	Number of Natura 2000 areas
>0 - 4	1596
>4 - 8	435
>8 - 12	455
>12 - 16	597
>16 - 20	743
>20 - 24	986
>24 - 28	874
>28 - 32	72
TOT.	**5758**



Conclusions and final remarks

- Wetlands and freshwater ecosystems have been included and the area (Km^2) potentially affected by *Pomacea* spp. has been extrapolated per country and sub-range

- The number of protected areas under Natura 2000 that could be potentially affected by *Pomacea* spp. have been identified per country and sub-range

↓

Support to risk managers

- WHAT'S NEXT?

Further mapping based on the impacts on ecosystems traits, ecosystems services and biodiversity components, taking into account different scenarios resulting from the influence and variability of resistance, resilience and management

Acknowledgments

The authors wish to thank the producers of the GIEMS-D15 database for the provision of the database.

- Fluet-Chouinard, E., Lehner, B., Rebelo, L.-M., Papa, F., & Hamilton, S. K. (2015). Development of a global inundation map at high spatial resolution from topographic downscaling of coarse-scale remote sensing data. *Remote Sensing of Environment*, *158*, 348–361.

- Prigent, C., Papa, F., Aires, F., Rossow, W. B. & Matthews, E. (2007). Global inundation dynamics inferred from multiple satellite observations, 1993-2000. *Journal of Geophysical Research*, 112(D12107): 1-1.

THANK YOU!