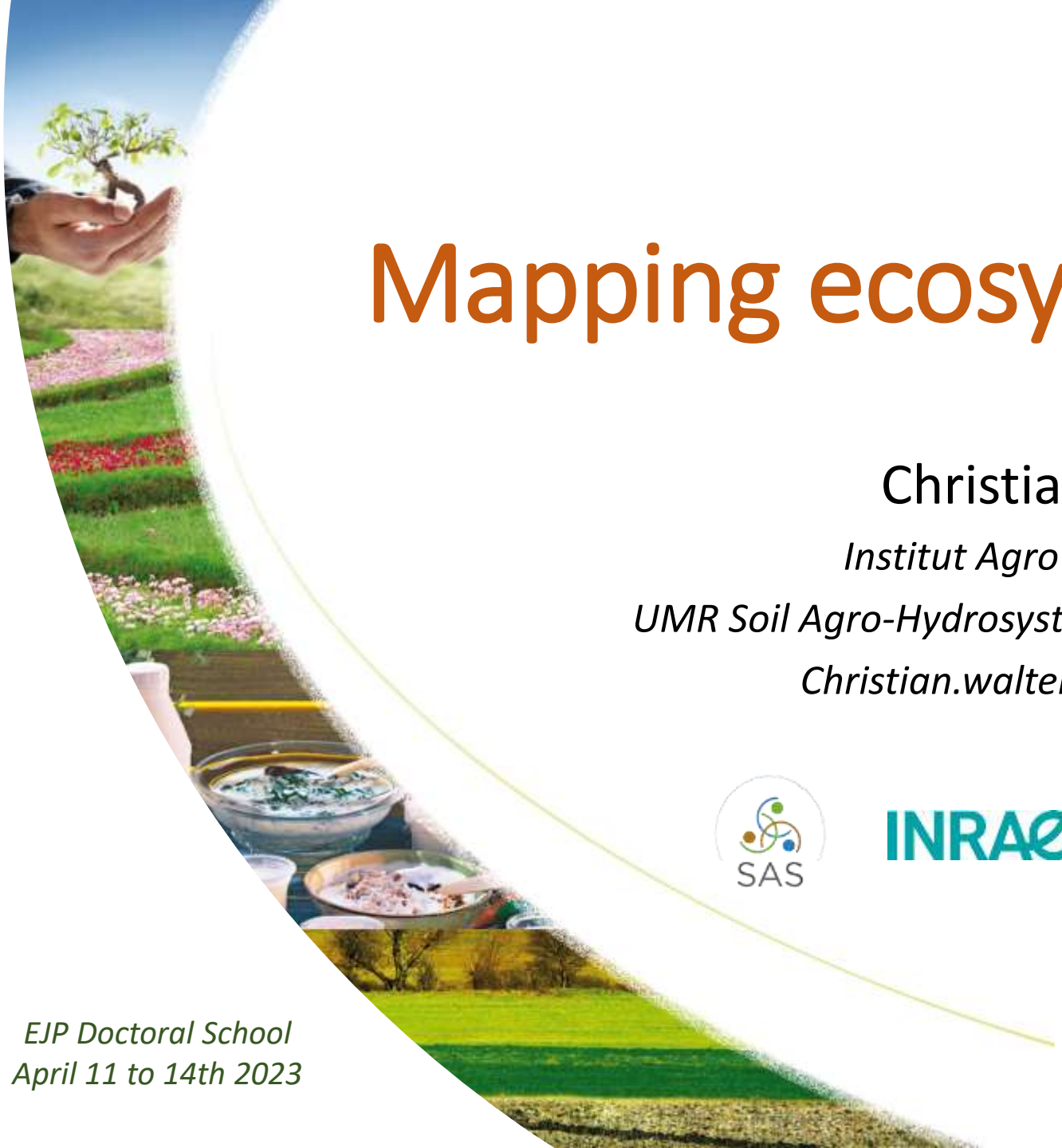

Mapping ecosystem services

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EJP Doctoral School
April 11 to 14th 2023

Introduction

(source: EPA, 2018)

- **Ecosystem services (ES) as a concept to increase people's awareness on the contribution of nature to human well-being**
- **ES also as a tool for policy and decision-making from global to local levels.**
  - Sustainable management of natural resources
  - Environmental protection
  - Nature conservation and restoration
  - Territorial and landscape planning
  - Nature-based solutions
  - Climate change mitigation
  - Disaster risk reduction

-> need for ES assessment maps

Outline

1. Interest and risk of ES mapping
2. Early experiences of “ES-like” concepts mapping
3. The MAES program: Mapping and Assessment of Ecosystems and their services
4. Discussion on scientific papers:
   - Kandziora et al. 2013 – Mapping provisioning ecosystem services…
   - Baro et al. 2016 – Mapping ecosystem service capacity, flow and demand…

Interest of *Ecosystem services* mapping?

- **ES maps to test and evaluate ES assessment procedures**
  - Taking account the spatial variability of the ES drivers
  - Sensitivity of ES assessment to spatial variability

- **ES maps as a tool to bring ES into practical application**
  - Efficiently communicate complex spatial information, raising awareness
  - Mandatory instruments for planning and protection
  - Portray trade-offs and synergies
  - Enable budgets for ES supply and demand at different spatio-temporal scales

Risk linked to ES mapping

1. Risks linked to the mapping process

- Ambiguity on the concepts
- Over_simplification of ES assessment based on existing spatial data *(See the biophysical realism gap in ES mapping, S. Lavorel et al., 2017)*
- Uncertainty of the maps

2. Risks linked to the mapping finality

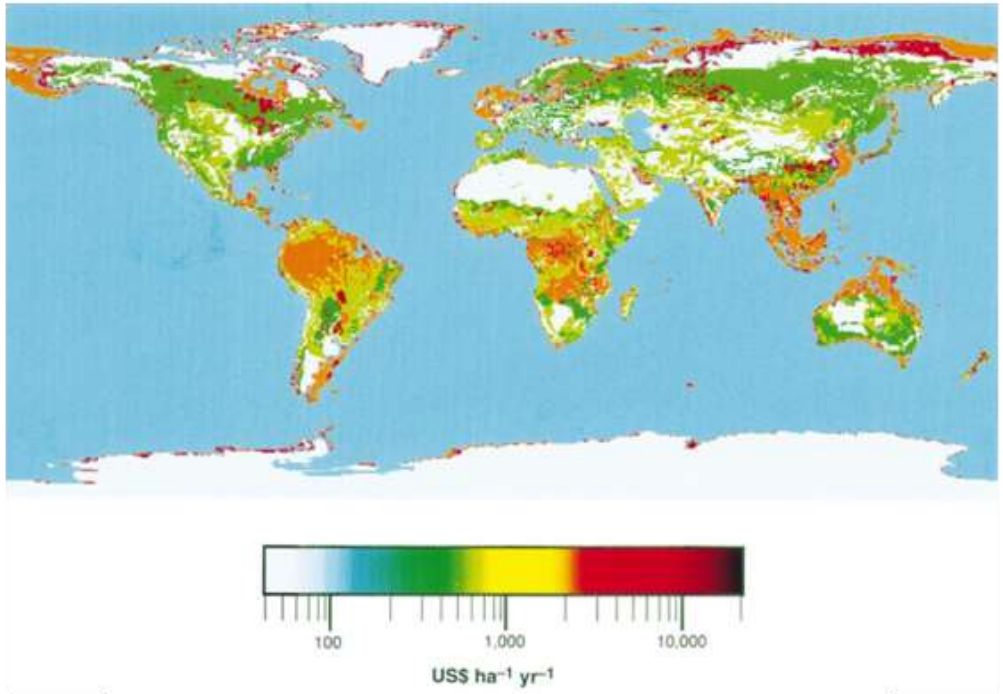
ES maps enhance further exploitation (commodification, privatization) of natural resources

(See *Maris V. 2014, Nature for sale ; Ed. Quae*)

3. A priori responses

- Develop research in ES mapping
- Stop the mapping process when uncertainty too high
- Produce well documented maps with explanations of procedures and uncertainties

Global map of values of estimated ecosystem services in 1997.

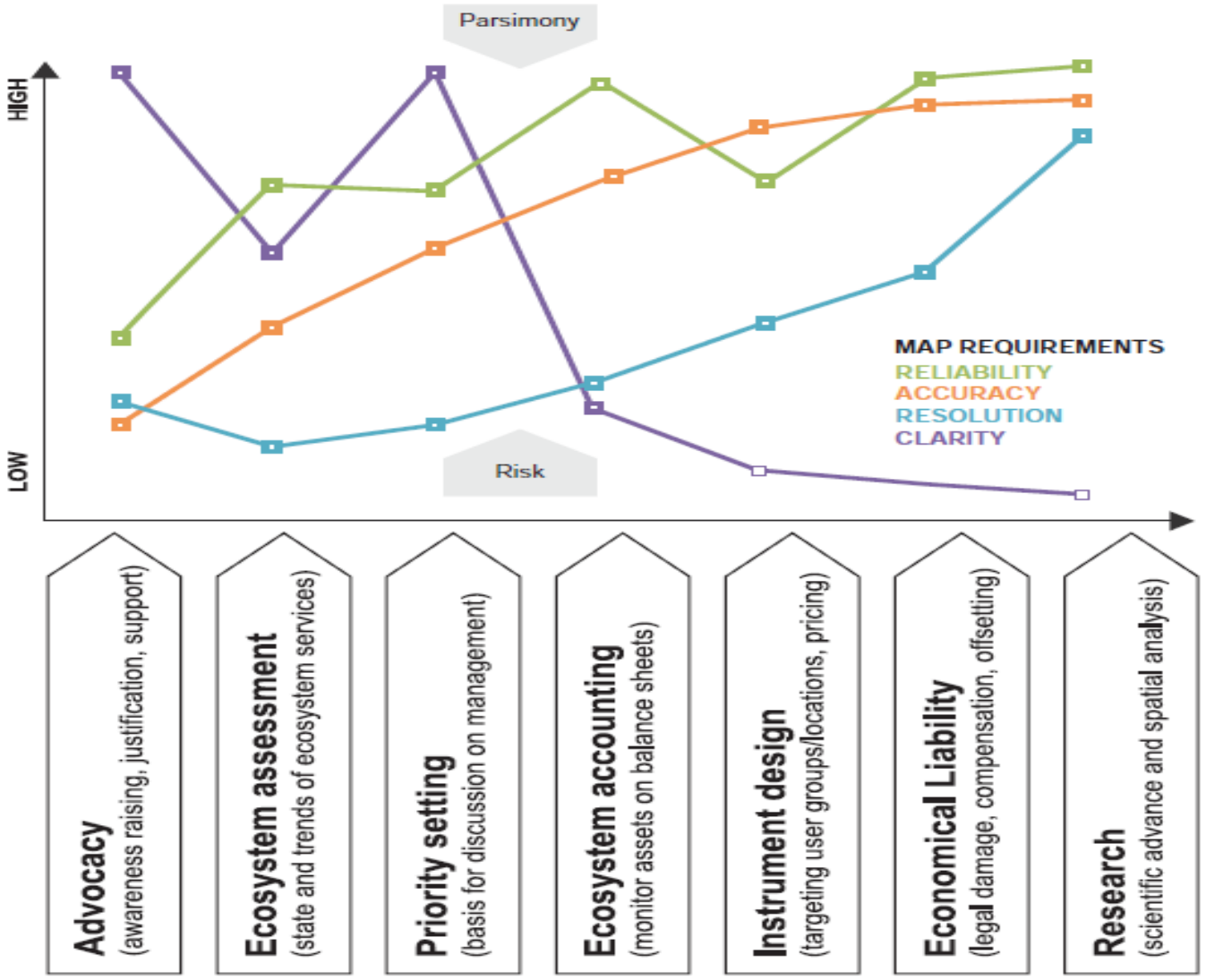


Source: Costanza et al., 1997.

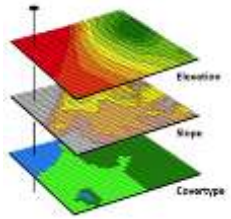
ES mapping related to mapping objective

Purpose of ES mapping should influence the quality requirements of the mapping procedure

(Jacobs et al., 2017)



The main steps of ES mapping



Spatial information: existing or new

- Objectives of the study
- Expected accuracy

1

2

Choice of ES indicators

ES quantification

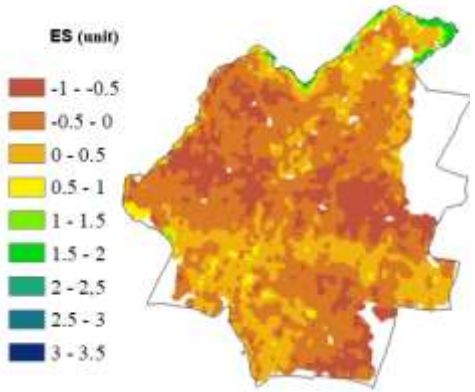
Direct measurements of ES

Biophysical modelling

Proxies

Survey and participatory ap.

ES indicator map



3

+ uncertainty assessment

4: interaction with end-user

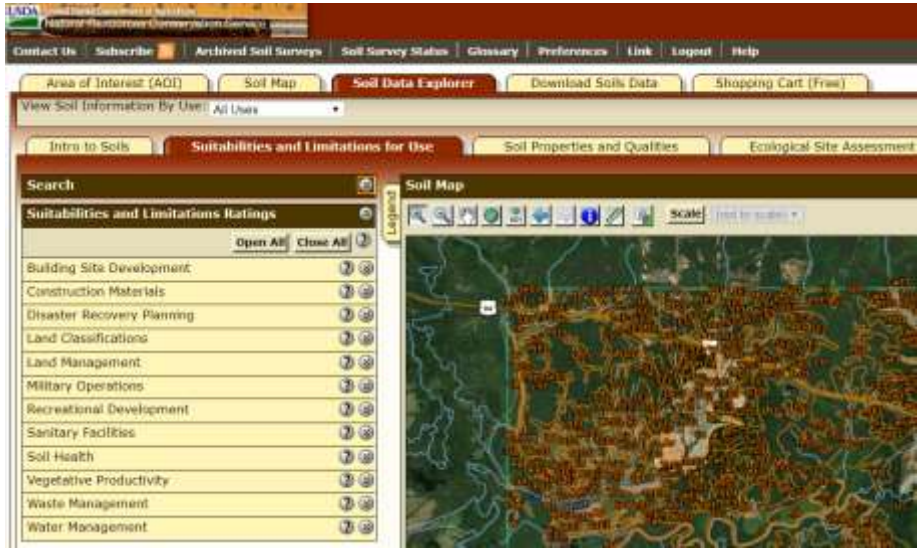
Early experiences of « ES-like » mapping

Early experiences of « ES-like » mapping

- **Canada Land Inventory (1960-1971)**
  - A federal survey of land capability
  - 2.6 million km² (25 % of Canada)

- **France: CDTA maps of agricultural land (1981-1987)**
  - Aim: « Protecting agricultural land, fixing loans, planning land improvement »
  - 10 % of France at 1:50 000 scale

- **USA: Suitabilities and limitations ratings derived from soil survey (NRCS)**
  - 90 % of US area at 1:63 000 scale
  - https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

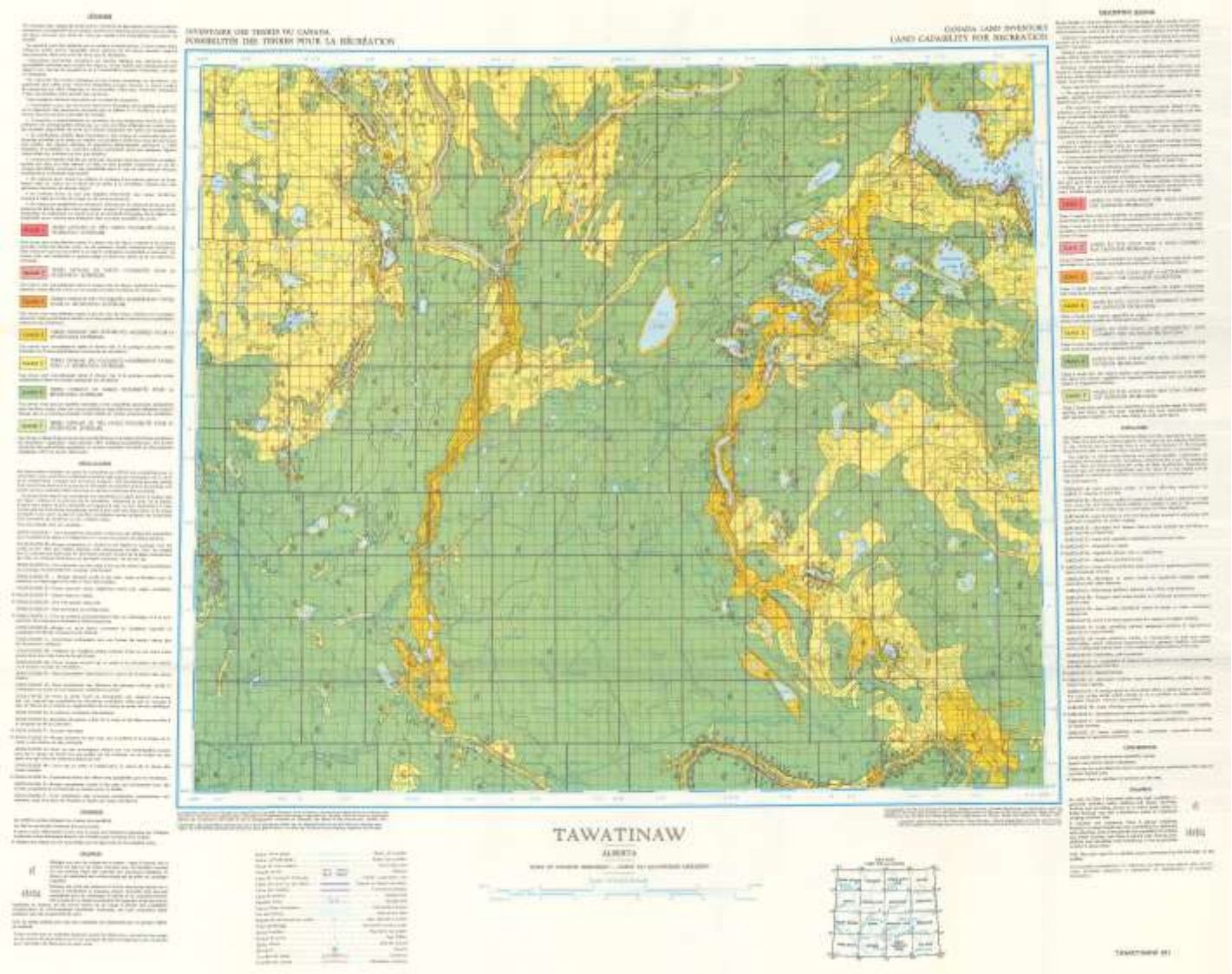


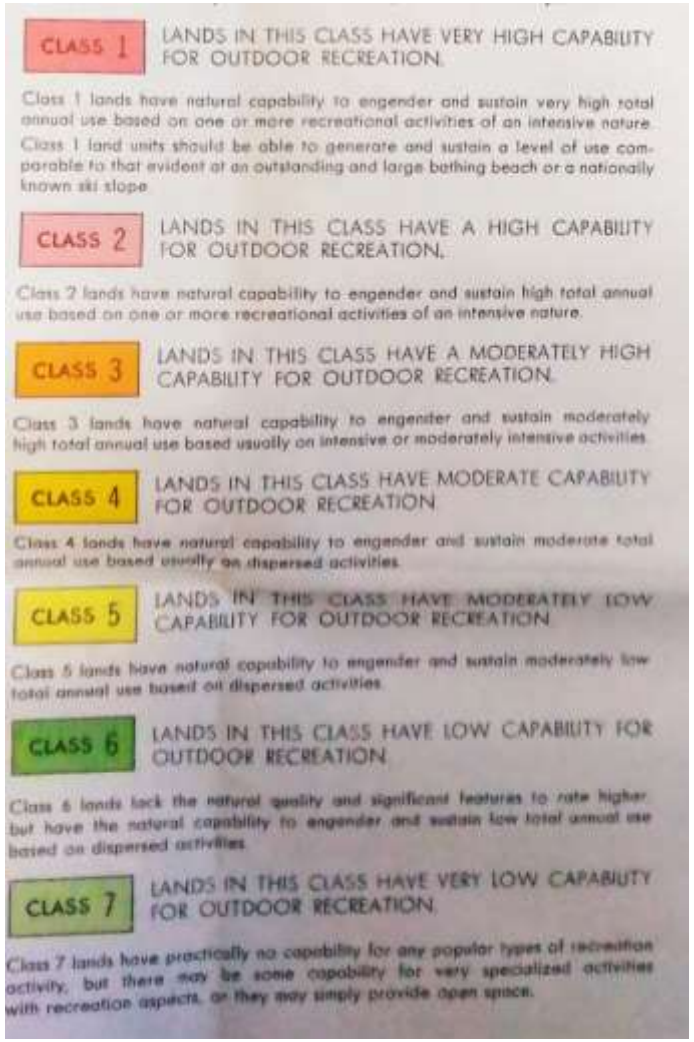
Early experiences of ES mapping

- **Canada Land inventory – scale : 1:250,000**

Early experiences (2): Canada Land Inventory

- **Land capability for outdoor recreation**





Available for whole Canada: 195 sheets

http://sis.agr.gc.ca/cansis/publications/maps/cli/250k/rec/index.html

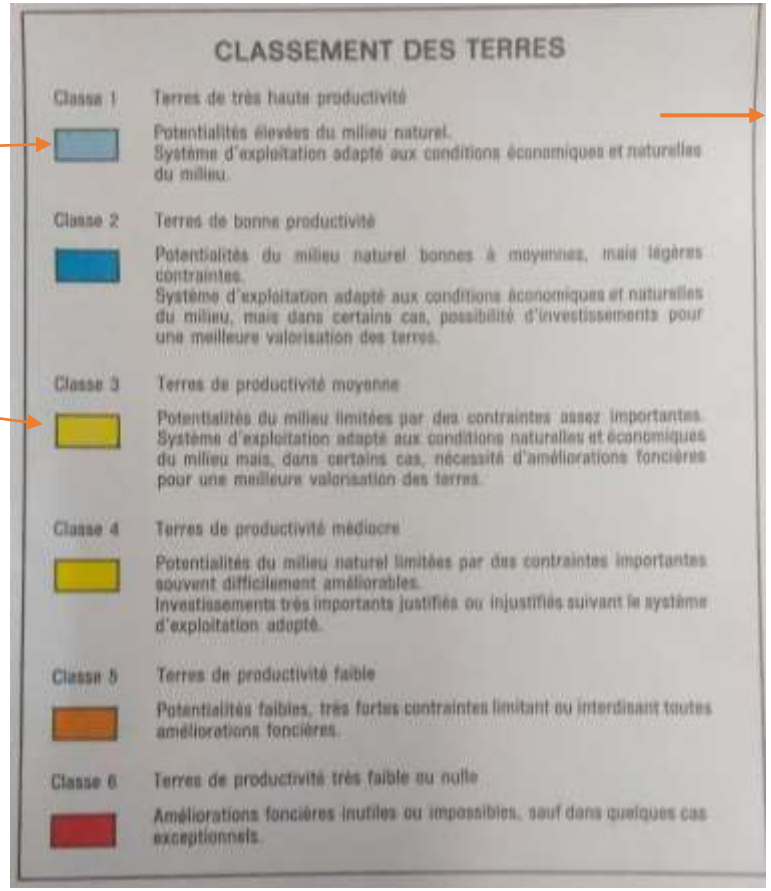
Early experiences (3): Canada Land Inventory

- **A program started in 1961 and ended in the early 1990**
- **Over one million copies of maps were printed**
- **Still available on Cansis website: http://sis.agr.gc.ca/cansis**

"Although the information is old, and better information is available for some areas, the interpretations are still largely valid, and many jurisdictions still use them for land use planning purposes."
(Government of Canada, 2023)

Early experiences of ES mapping (4)

- **France: Departmental map of agricultural land**



Class 1: very high productivity land

- High productivity potential enabled by soil and climate
- Production system adapted to economical and environmental conditions

Class 3: medium productivity land

- Existing constraints to productivity
- Need for land improvement (drainage, land consolidation…) in some cases

Early experiences : Departmental map of agricultural land (5)

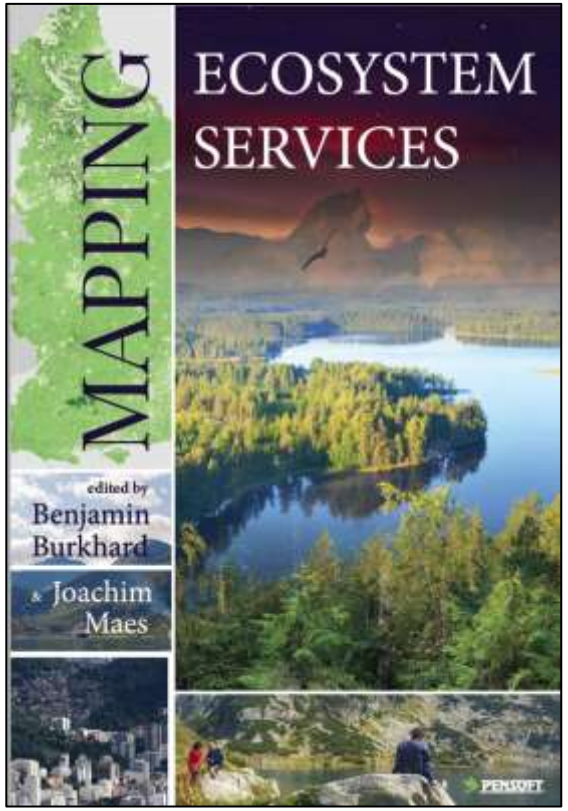
- A land capability concept integrating natural constraints and socio-economical conditions of the agricultural production:
  - Publication of 133 sheets at 1:50,000 scale: 10 % of France
  - A monofactorial approach: agricultural productivity as unique service
  - Strong heterogeneity between maps (data availability, assessment methodology)
- Only available in paper format maps today

-> a failure, but maps would today be useful to protect agricultural land against urban sprawling

The MAES and JRC approaches for Europe

MAES : Mapping and Assessment of Ecosystems and their services

JRC : Joint Research Centre



Burkhard B, Maes J (Eds.) (2017) Mapping Ecosystem Services. Pensoft Publishers, Sofia,

https://ab.pensoft.net/article/12837/download/pdf/

Vallecillo et al, (2022) - EU-wide methodology to map and assess ecosystem condition, EUR 31226 EN, Publications Office of the European Union, doi:10.2760/13048

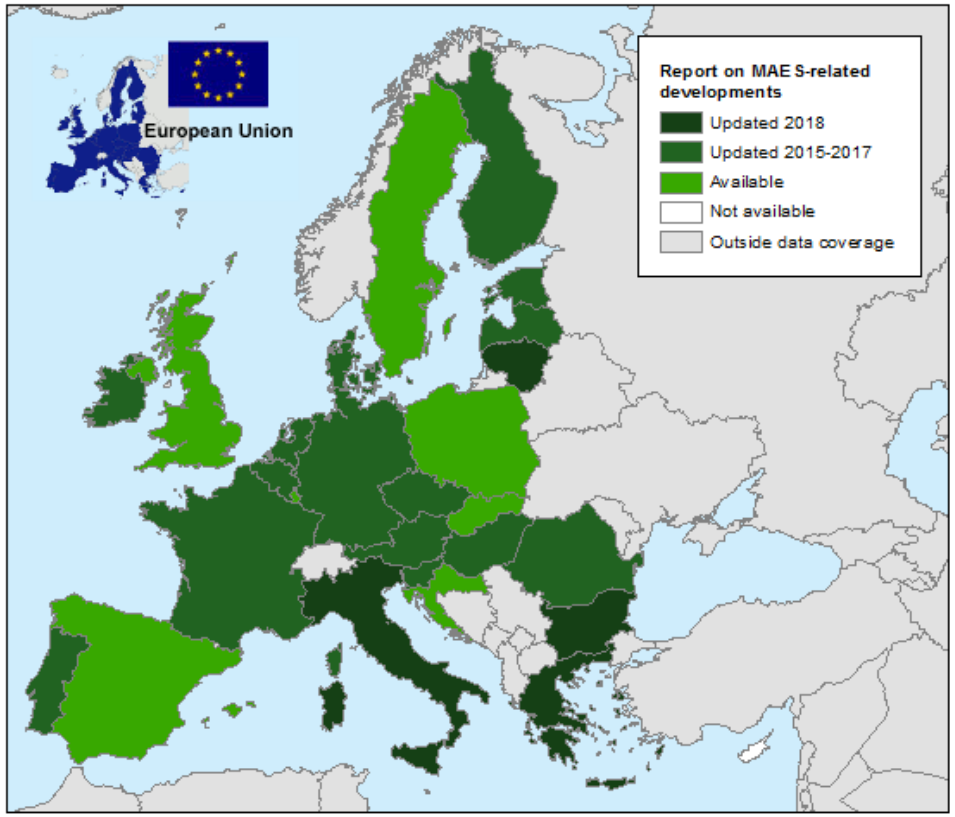
The MAES program (1)

- **MAES initiated in 2011 by the EU biodiversity strategy:**
  - "halt the loss of biodiversity and ecosystem services in the EU and help stop global biodiversity loss by 2020"
- **Action 5 of the strategy:** improve knowledge of ecosystems and their services in the EU

" Member States, with the assistance of the Commission, will map and assess the state of ecosystems and their services in their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020."

The MAES program (2)

- **A common framework of ES assessment and a common classification of ES**
- **Methodological work by European agencies**
  - 5 reports from 2012 to 2017: (1) framework, (2) ES indicators, (3) Ecosystem conditions, (4) urban ecosystems, (5) final framework
- **a typology of ecosystems in three major types: terrestrial, freshwater and marine environment**
- **Common classification of ecosystem services: CICES classification v5.1**
  - https://cices.eu/
- **The member states are in charge of the detailed methodology and final mapping**
  - https://biodiversity.europa.eu/countries/



The CICES Classification (1)

- **Intended as a reference classification of final ecosystem services: contribution that ecosystems make to human well-being.**
- **3 major sections of ES:**
  - Provisioning
    - Nutritional material, non-nutritional material, energetic outputs, abiotic outputs
  - Regulation and maintenance
    - Transformation of biochemical or physical inputs to ecosystem
    - Regulation of physical, chemical and biological conditions
  - Cultural
    - All the non-material outputs of ecosystems (biotic and abiotic) that affect physical and mental states of people

Indicators of Ecosystem services

- **A proposal of ES indicators for:**
  - Forest services
  - Cropland and grassland services
  - Freshwater services

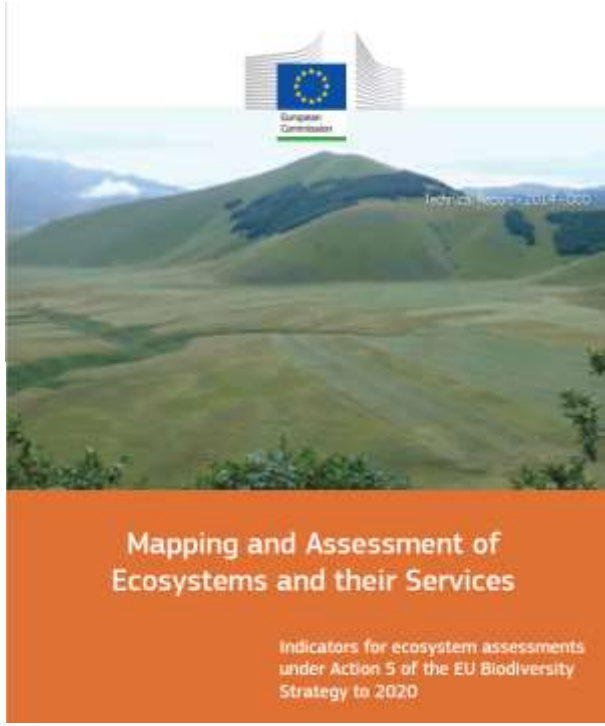


Table 8. Indicators for provisioning services delivered by agro-ecosystems.

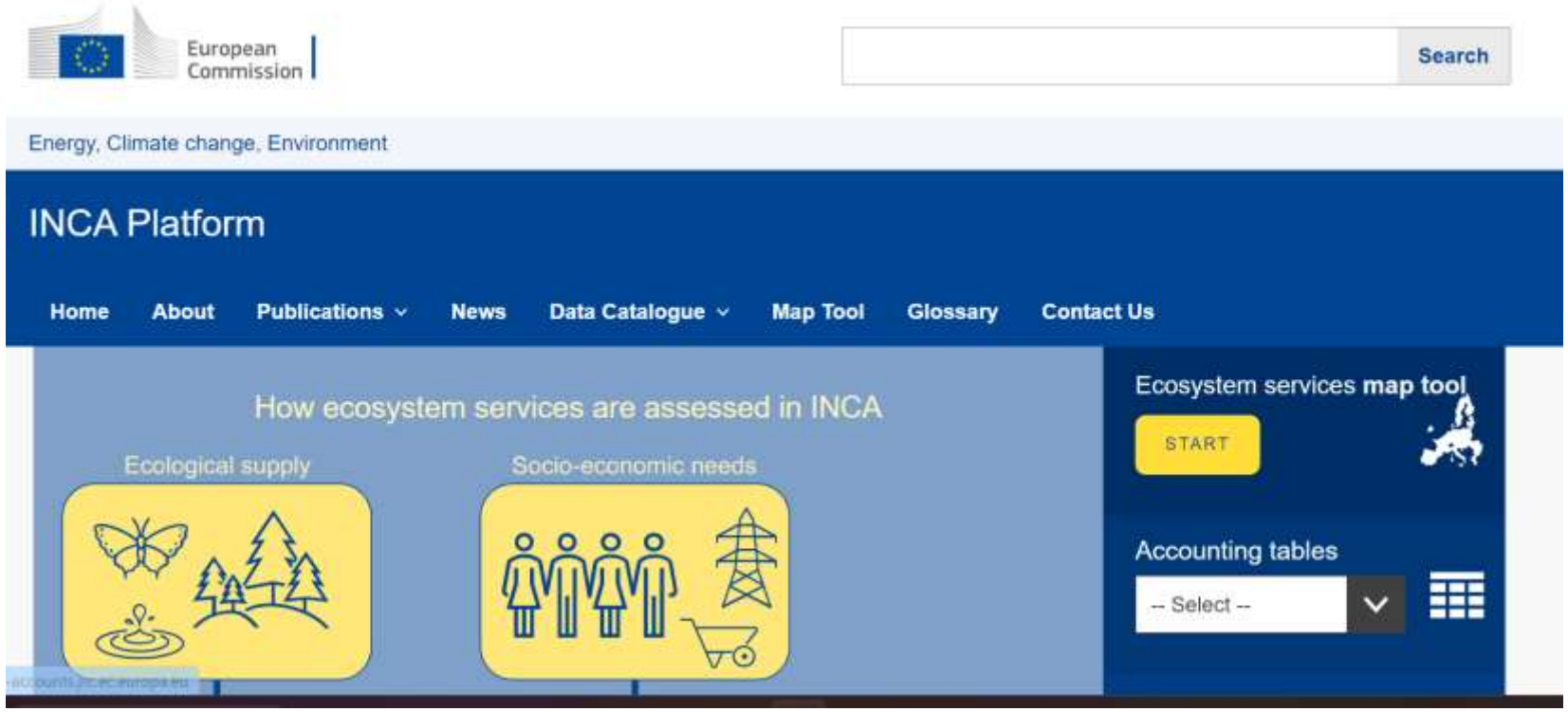
Division	Group	Class	Cropland	Grassland
Nutrition	Biomass	Cultivated crops	• Yields of food and feed crops (ton/ha; ton dry matter/ha; MJ/ha) • Food and feed crop area (ha)	• Yields (ton/ha; ton dry matter/ha; MJ/ha) • Grassland area (ha)
		Reared animals and their outputs	• Livestock data (LU/ha, Ton/yr/region)	
		Wild plants, algae and their outputs		
		Wild animals and their outputs	• Wild game bag data (merged with forest ecosystems) • Wild game population estimates	
		Plants and algae from in-situ aquaculture		
		Animals from in-situ aquaculture		
	Water	Surface water for drinking	• High Nature Value farmland	
		Ground water for drinking	• Areas important for groundwater abstraction in agro ecosystems	

Global Datasets to mapping ES

Ecosystem service	Global dataset	Resolution	URL
Food production	Land Cover	250 m	http://www.eea.europa.eu/data-and-maps/data/global-land-cover-250m
	Land Use Systems	8 km	http://www.fao.org/geonetwork/srv/en/metadata.show?id=37139
	Net Primary Productivity	10 km	http://neo.sci.gsfc.nasa.gov/view.php?-datasetId=MOD17A2_M_PSN
	Global Livestock Densities	5 km	http://www.fao.org/ag/againfo/resources/en/glw/GLW_dens.html
Fresh water	FAO Global Water Database (AQUASTAT)	Country	http://www.fao.org/nr/water/aquastat/main/index.stm
Timber harvesting	Global Tree Cover Loss	30 m	http://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.2.html
Carbon sequestration	Global Biomass Carbon	1 km	http://cdiac.ornl.gov/epubs/ndp/global_carbon/carbon_documentation.html

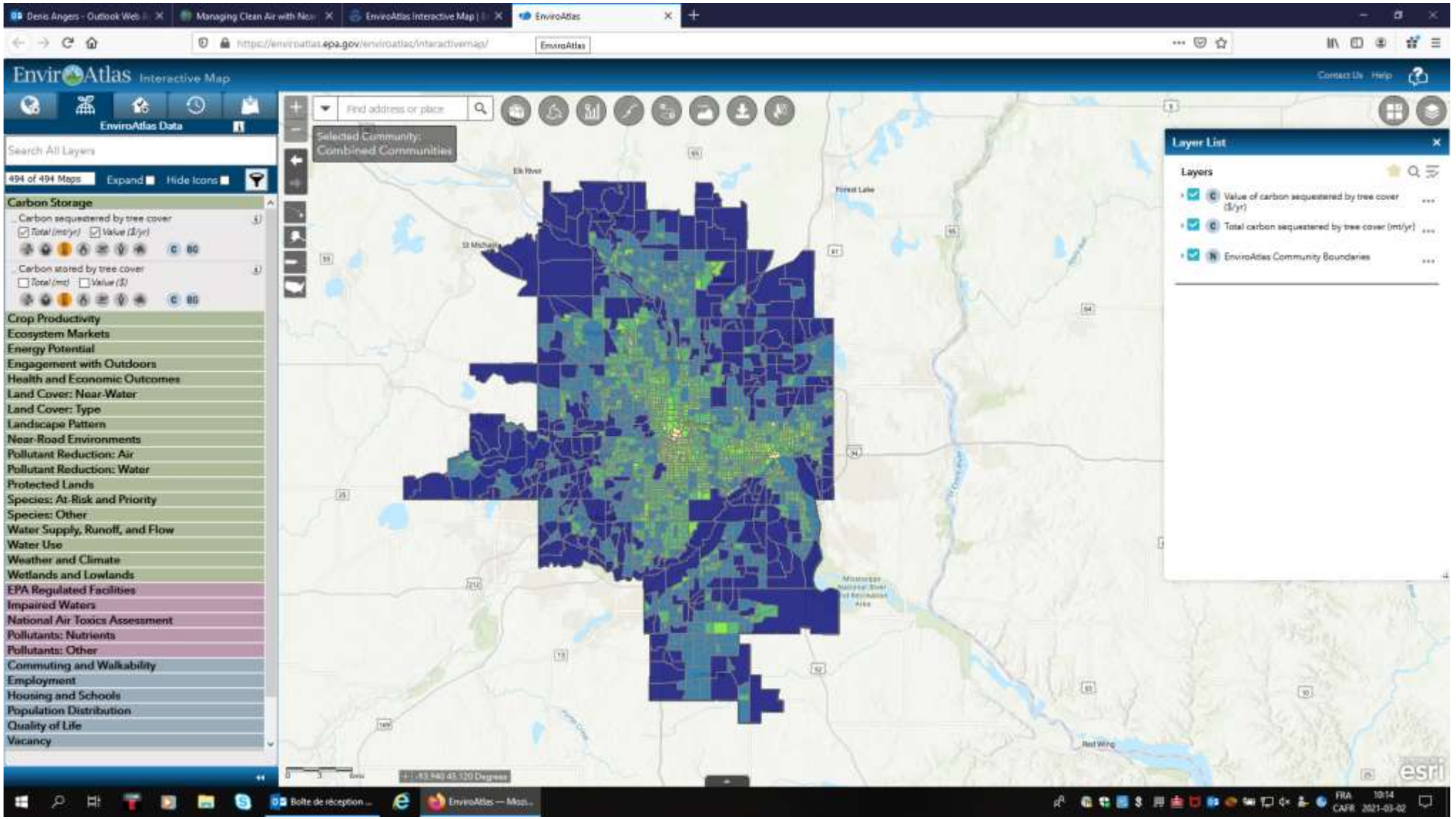
Where are we today?
The INCA ES mapping platform for Europe

- **https://ecosystem-accounts.jrc.ec.europa.eu/**

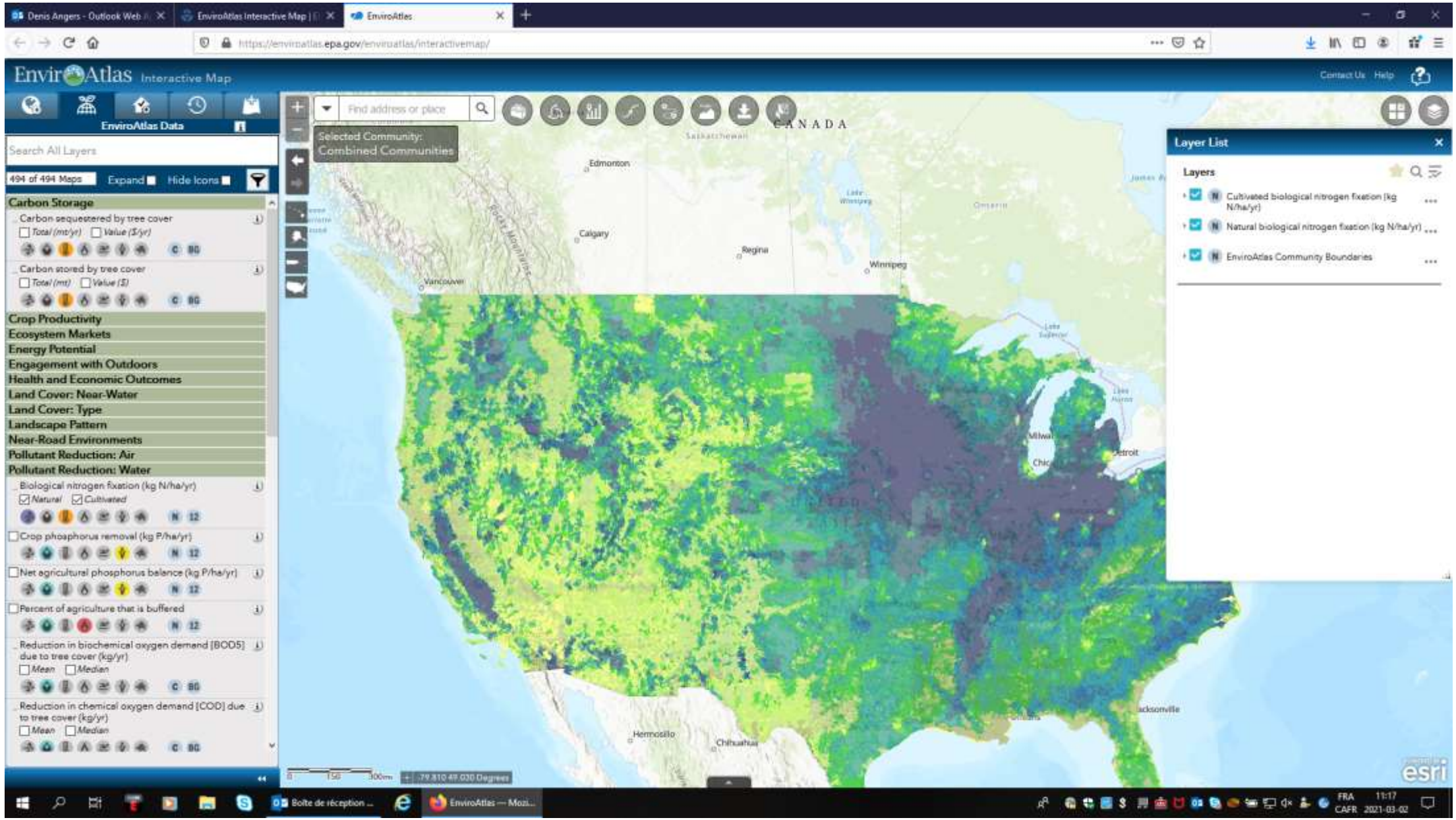


Conclusion

- ES maps are intended to help decision-making, but are still complex to establish and their validity must often be questioned
- Poor maps should not lead to wrong decisions
- MAES framework is as a solid reference but should not be considered as a definitive methodology of ES assessment
- Recent progress in information availability and processing, but still research needed for harmonized ES quantification and uncertainty assessment
- See also the US experience of ES mapping (Enviroatlas, US EPA):
  - https://enviroatlas.epa.gov/enviroatlas/interactivemap/



https://www.epa.gov/enviroatlas/enviroatlas-interactive-map



https://www.epa.gov/enviroatlas/enviroatlas-interactive-map

Discussion on examples of ES mapping studies

Mapping provisioning ecosystem services at the local scale… (Kandziora et al., 2013)

Ecosystem Services

Mapping provisioning ecosystem services at the local scale using data of varying spatial and temporal resolution

Marion Kandziora*, Benjamin Burkhard, Felix Müller

Kandziora et al., 2013

- **Ecosystem services considered:**

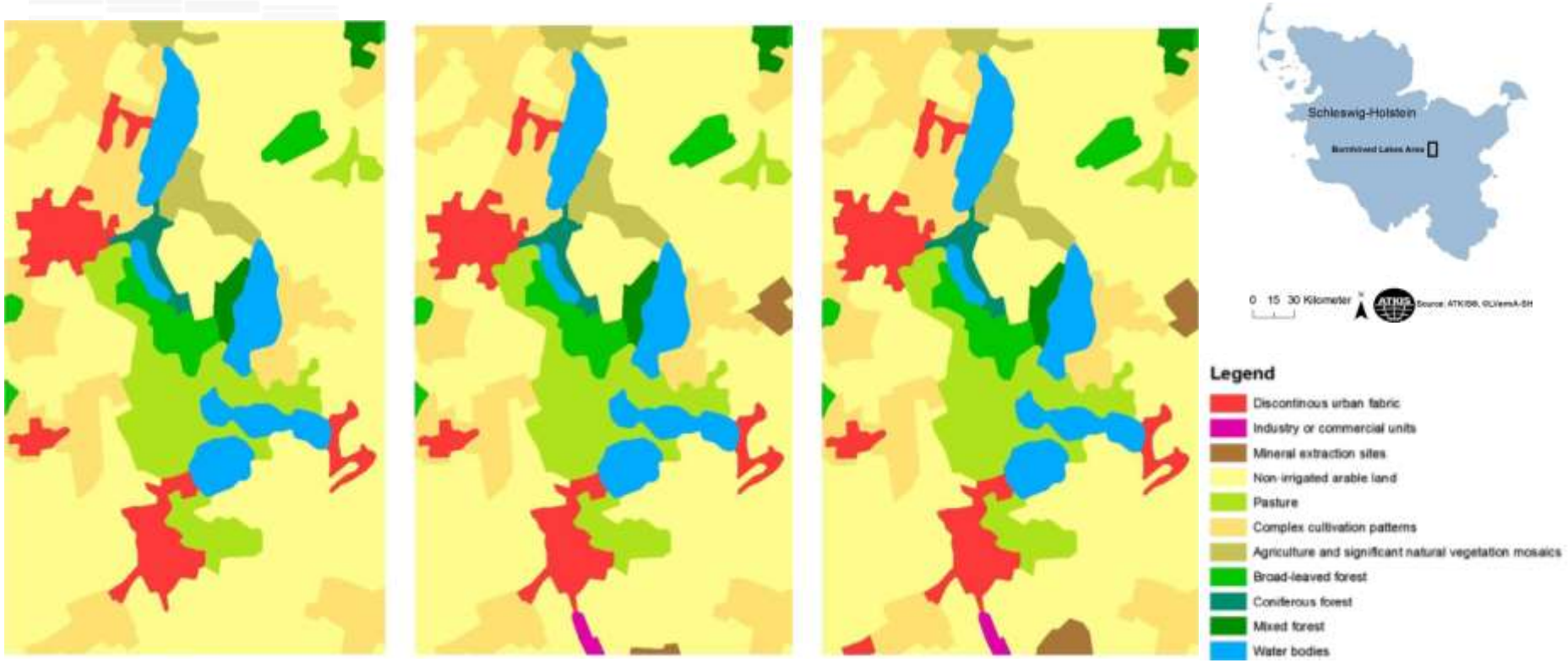
  Provisioning ES: capacity for crop supply or fodder supply

- **Aim of the study:**

Influence of spatial and temporal resolution of input data on local ES assessment

- **Assessment methodology of ES**
  - Multiple input spatial data sets
  - Proxy based assessment
  - Statistical data
- **Mapping of ecosystem services**
  - Mean value per land use or land cover class
  - Local scale (northern Germany - 60km^2)

Corine Land Cover as basis of ES mapping ?

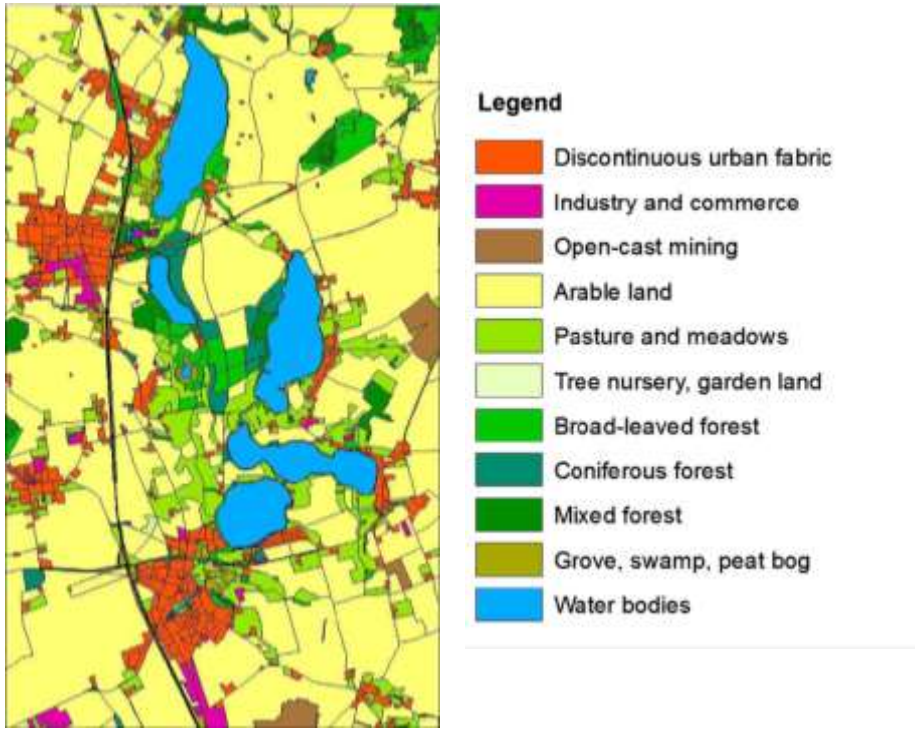


1990 2000 2006

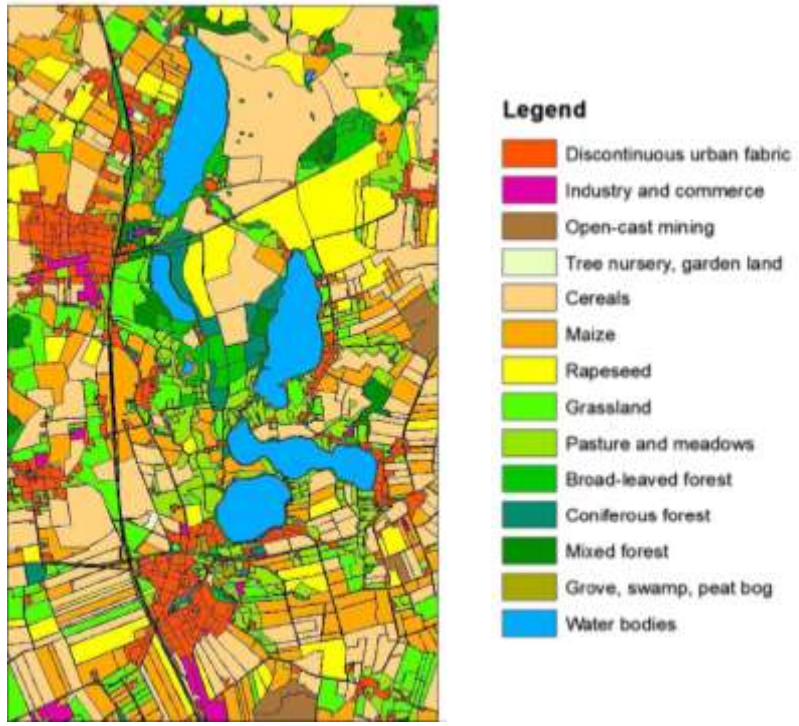
Kandziora et al., 2013

Very broad land cover classes, but freely available and existing at different dates

More detailed information: cartographic information systems and remote sensing



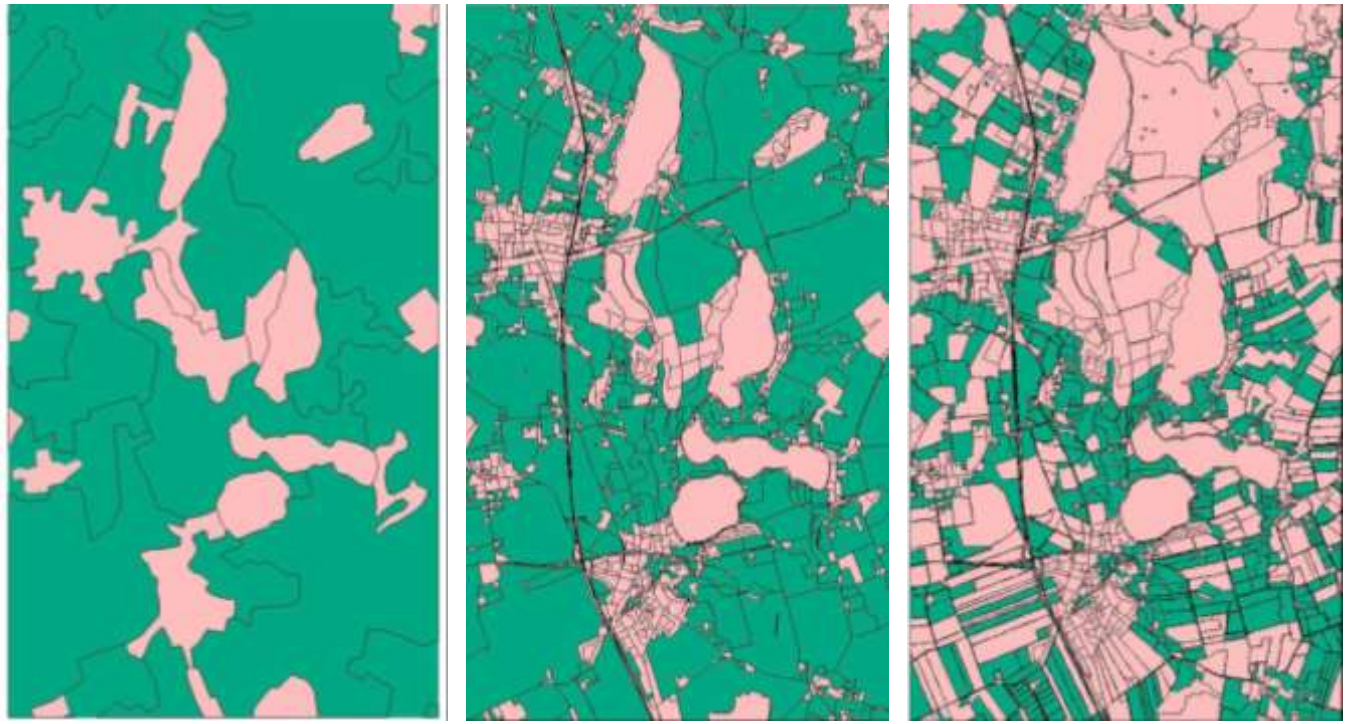
ATKIS - 2010



ATKIS + InVeKoS + Landsat classification - 2010

Kandziora et al., 2013

Results (1): Mapping ES capacity for crop production depending on the information source



CORINE - Minimum mapping unit 25ha - 2006

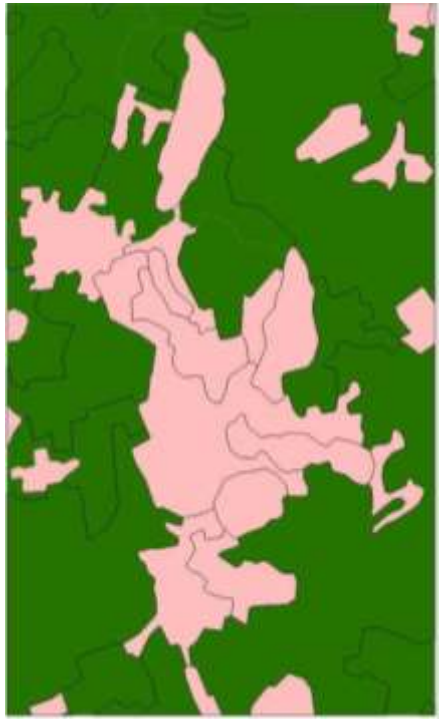
ATKIS – 1:5000 2010

ATKIS – 1:5000 combined with landsat classification and InVeKos - 2010

Kandziora et al., 2013

Strong differences between ES capacity maps depending on spatial resolution of input data

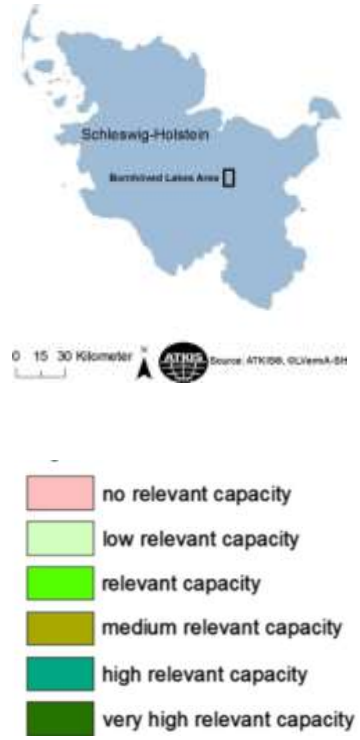
Results (2): Mapping ES capacity for crop production depending on the information source



CORINE - Minimum mapping unit 25ha- 2006

ATKIS – 1:5000 2010

ATKIS – 1:5000 combined with landsat classification and InVeKos - 2010



Kandziora et al., 2013

Questions on this paper

- **Are statistics of annual average yields good indicators of provisioning ES ?**
- **Is the uncertainty associated to the ES maps known ?**
- **How can we improve the assessment?**

Mapping ecosystem service capacity, flow and demand for landscape and urban planning (Baro et al, 2017)

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Regular research paper

Mapping ecosystem service capacity, flow and demand for landscape and urban planning: A case study in the Barcelona metropolitan region

Francesc Baró, Ignacio Palomo, Grazia Zulian, Pilar Vizcaino, Dagmar Haase, Erik Gómez-Baggethun

ARTICLE INFO

ABSTRACT

1. Introduction

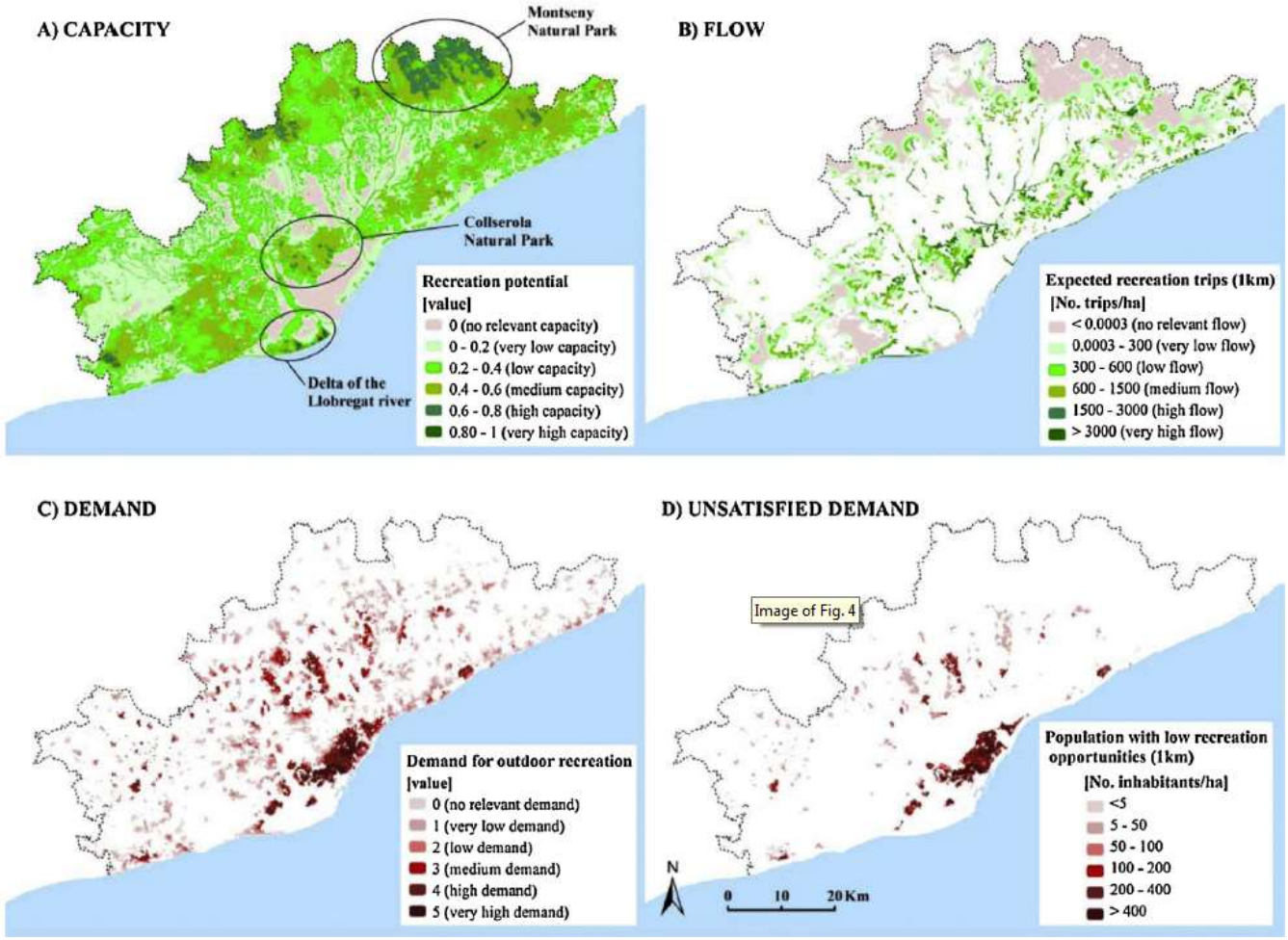
Baro et al., 2016

- **Ecosystem Services considered**
  - *Regulation ES: air purification*
  - *Cultural ES : Outdoor recreation*
- **Aim of the study:**

  compare ES capacity, flow and demand in the Barcelona Metropolitan area
- **Assessment methodology**
  - Distinction between ES capacity, flow and demand
  - Proxy-based and process-based assessment (ESTIMAP)
  - Expert knowledge – Population analysis
- **Mapping of ecosystem services**
  - Composite-based mapping procedure
  - Regional scale (3244 km^2)

Maps of ES outdoor recreation

Cultural ES outdoor recreation

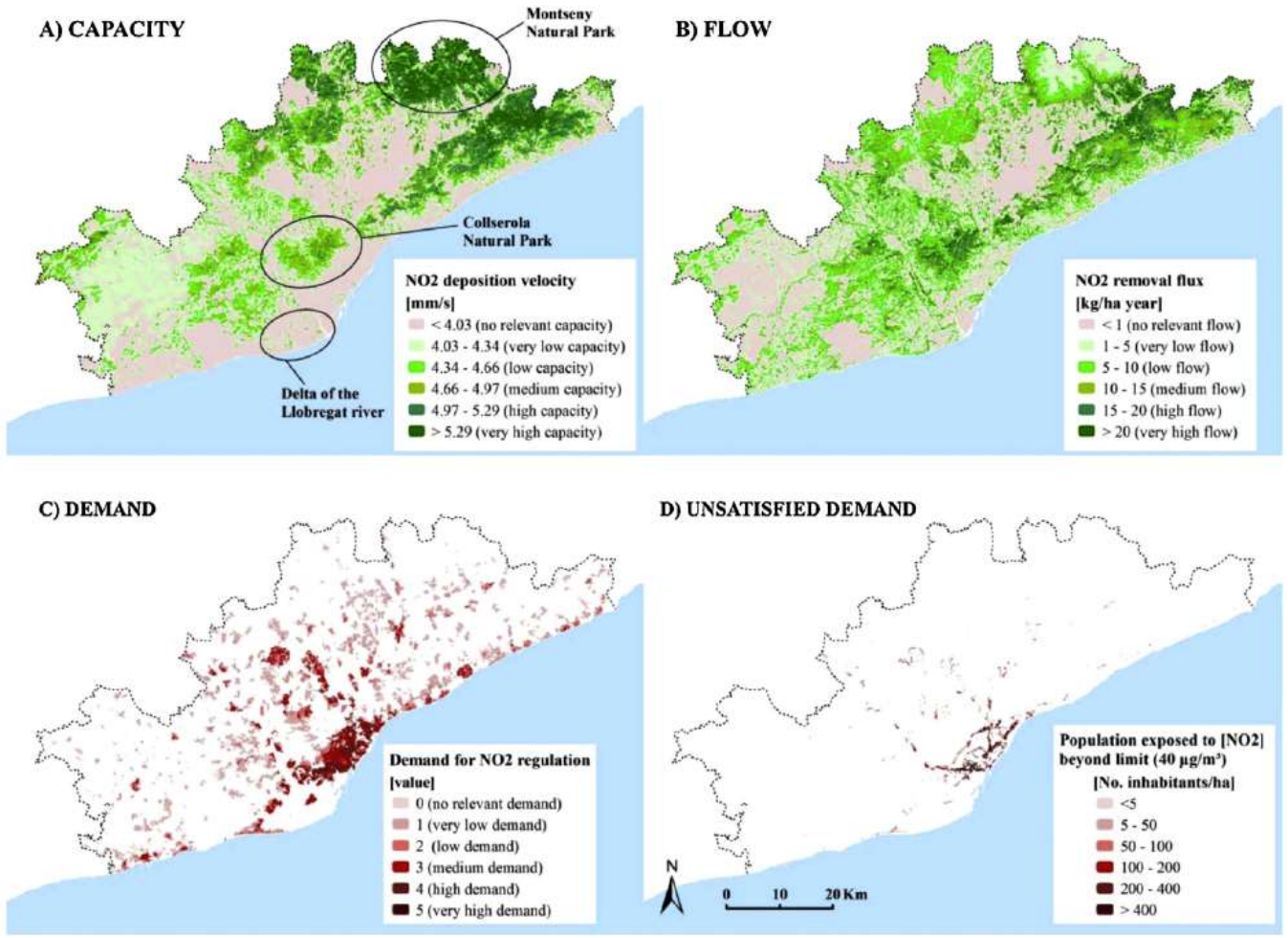


Outdoor recreation:

- **Capacity**: human influence x protected areas x water bodies
- **Flow**: distance analysis
- **Demand**: population density to distance to recreational sites

Baro et al., 2016

Maps of air purification ES



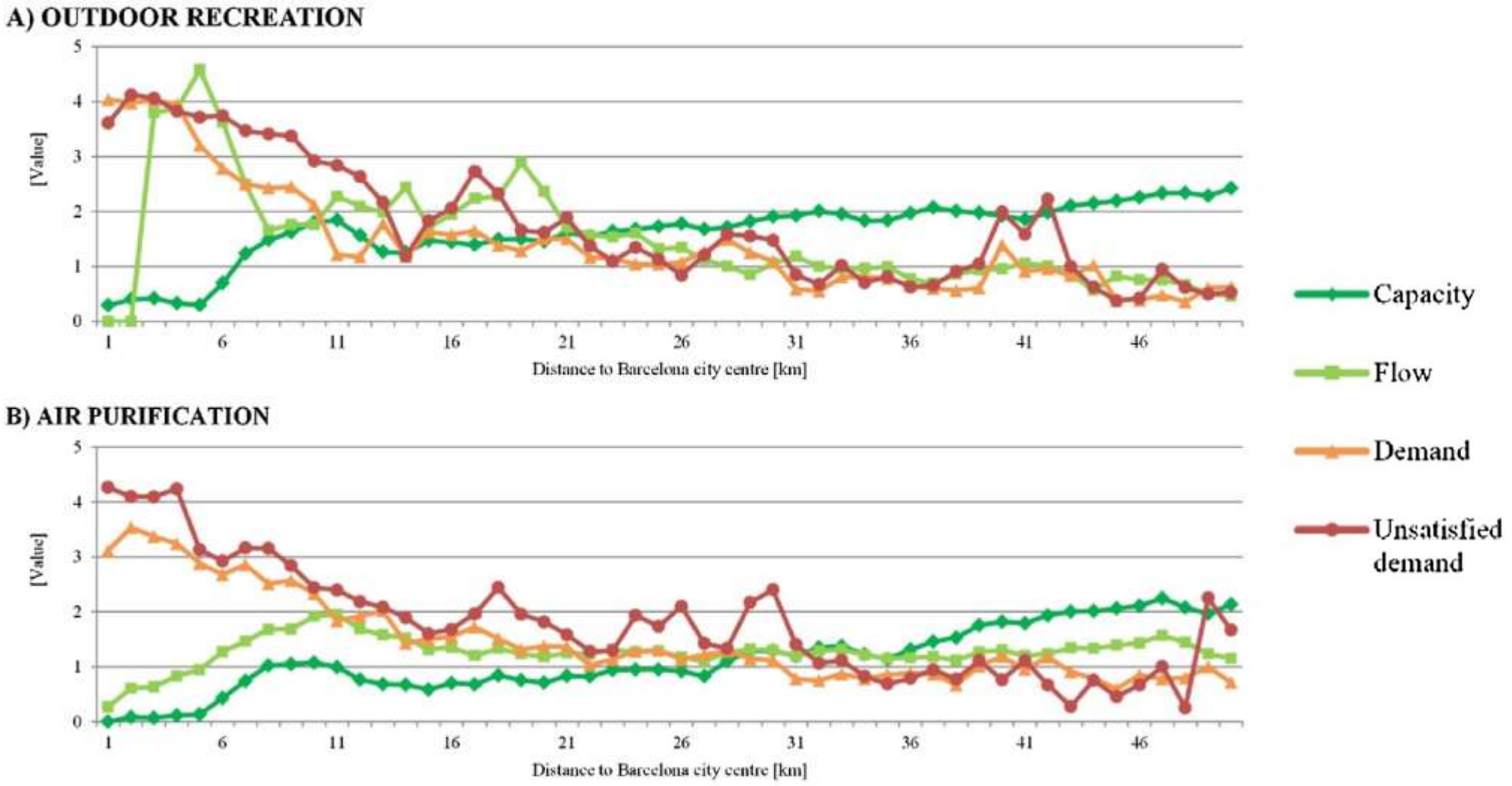
Abatement of N2O air pollution by vegetation

Multi component assessment :

- **« Capacity »** : NO2 dry deposition velocity
- **« Flow »:** Modeled NO2 removal by vegetation
- **« Demand »:** population density and exposure to NO2 concentrations

Baro et al., 2016

Comparison of the ES capacity, flow and demand



Questions on this study

- **Indicators of capacity, flow and demand?**
- **Can we compare easily ES capacity, flow and demand ?**
- **How to improve the approach ?**