Combining earth observation and other data sets for different analytical uses

Kremena Gocheva, PhD researcher, Institute of Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences

Workshop of the GEO Initiative on Earth Observation for Ecosystem Accounting

27 - 29 March 2017, European Environment Agency, Copenhagen

Background

- Area: 110 912 sq. km.
- Mammal species: 94
- Bird species: 383
- Reptile species 36
- Amphibia species 16
- Fish species: 207 (marine and freshwater)
- Insects and other invertebrates: about 27 000
- Vascular plant species: 3 500 to 3 750
- Non vascular plant species and fungi: 6 500
- Forested area: **30%** of total

MAES process in BG: Timeline

2014

- First mapping as part of PAF
- A map based on existing data was created and need for more work identified
- Funded by OP Environment

2017

- A methodological framework to befinalized (MetEcoSMapproject)
- Mapping and biophysical assessment outside NATURA2000by mid-2017
- Funded by Financial Mechanism of the European Economic Area (EEA FM) 2009-2014

2018-2019

- Methodology for monetary assessment of ecosystem services – development and implementation
- Possible funding by EEA 2014-2021 and OP Environment 2014-2020 (within NATURA)

2020

- Incorporation into national accounts
- Funding depends onvarious financialsources’ planning and programming

MAES process in BG: Organization of work in BG03 MAES related projects

MetEcoSMap

- Methodology for mapping exercise
- Resolving issues during mapping
- Fine-tuning mapping methodology
- Completing the framework

- IBER-BAS is partner in charge of most of the framework

7 mapping projects

- Mapping and assessment of nine ecosystems condition by type
- Mapping and biophysical assessment of ecosystem services
- IBER-BAS is promoter of four projects and maps five ecosystem types (Rivers and lakes, Marine, Wetlands, Grassland, Sparcely Vegetated)

IBBIS

- New module for ecosystem services at the Bulgarian Biodiversity Information System (BBIS)
- Collect and display mapping data for the nine ecosystem types

- IBER-BAS is a partner

National Methodological framework

Introduction

Context: international, EU and national efforts; definitions and terms

9 mapping and assessment methodologies

Baseline 2016: Mapping and assessment of ecosystems condition & services

On-the-spot verification guide

Verifying the mapping methodologies for several ecosystems at once, in one place

Monitoring guide

Methods, frequency of monitoring, annual planning, capacity building

The road ahead

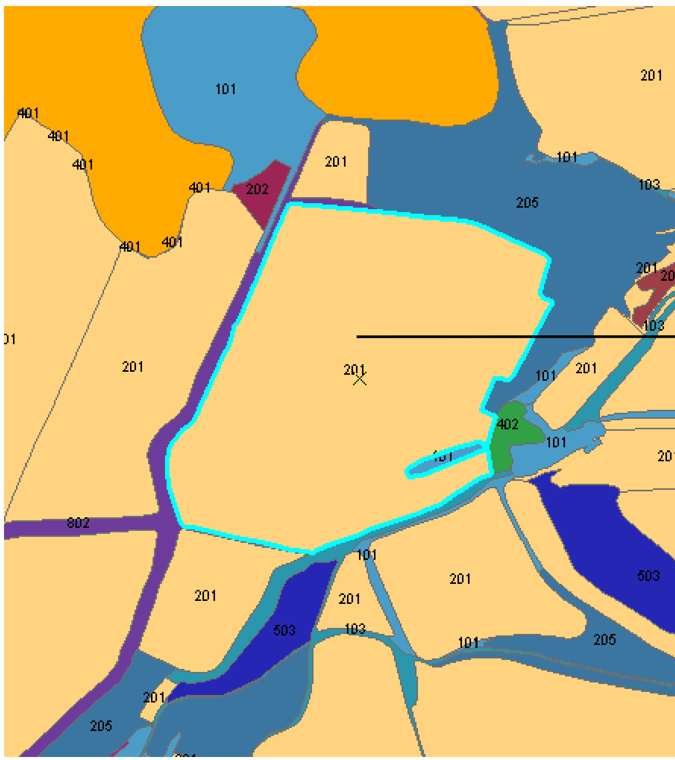
Connection to Monetary valuation and Natural Capital Accounting

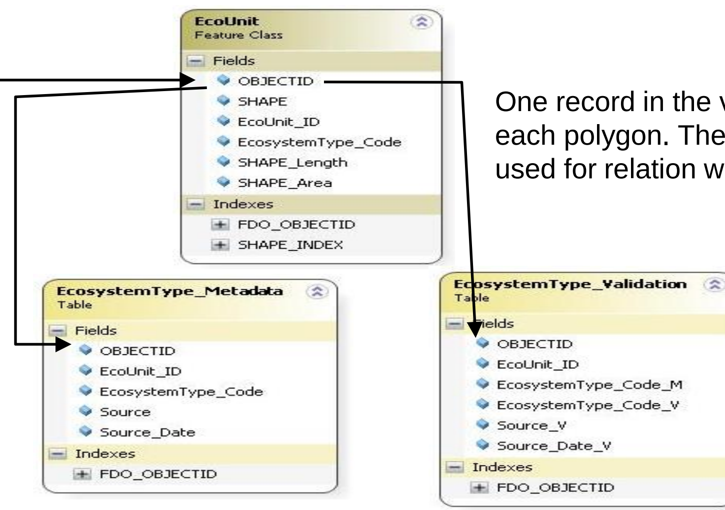
Implementing the methodologies' mapping part

Each polygon represents one ecosystem type at level 3

Step 1: Collecting data for ecosystem condition parameters (methodologies contain typical border parameters and available data on each)

Step 2: Assessment based on available data: calculate for each polygon, fill database (uniform between ecosystem types)





One record in the vector dataset for each polygon. The ID of the polygon used for relation with metadata.

Description of the data sources used for type determination.

Resulting table from validation.

Implementing the methodologies' assessment part

Step 3: Fill in 0-5 scores for each parameter or for each ecosystem service, for example:

- ecosystem condition parameter:

Parameter	Unit	Methodology	Assessment scale				
			Score 1 (bad)	Score 2 (poor)	Score 3 (moderate)	Score 4 (good)	Score 5 (very good)
Plant Diversity	**%**	**Statistic**	**0-20**	**20-40**	**40-60**	**60-80**	**80-100**

- ecosystem service parameter:

Parameter	Unit	Methodology	Assessment scale					
			Score 0	Score 1 (bad)	Score 2 (poor)	Score 3 (moderate)	Score 4 (good)	Score 5 (very good)
Crop Yield	**t/ha**	**Statistic**	**No relevant**	**0-1.0**	**>1-1.5**	**>1.5-2.0**	**>2-3.0**	**>3**

Step 4: For condition, calculate Performance index **IP** for the polygon's ecosystem condition and enter into database: **IP=Σni/Σni(max),**

where: Σni – sum of parameter assessment scores; Σni(max) – sum of the maximum of parameter assessment scores (i.e. n *5); IP – a real number with values between 0 and 1

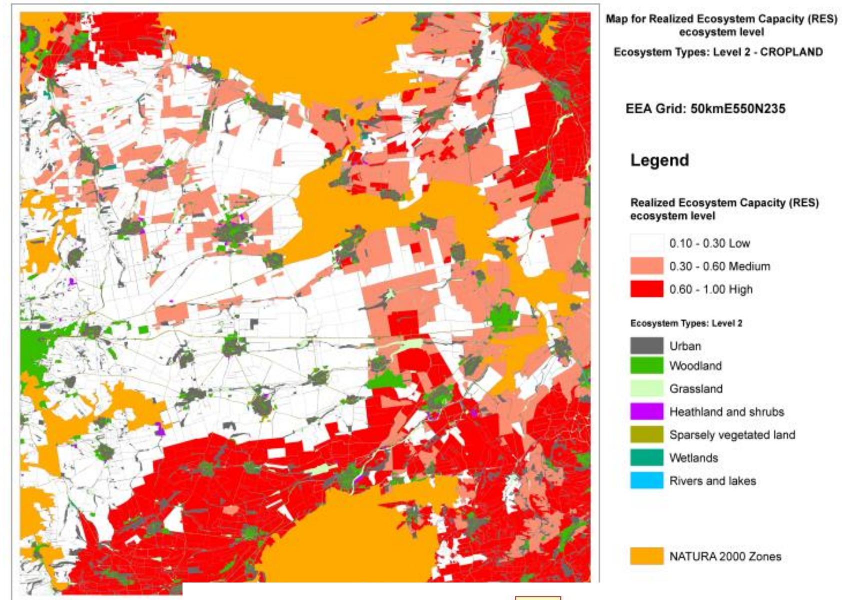
- For services, calculate MEAN value for Real (expert assessed) Ecosystem service Capacity (**RESsC)** for the polygon's ecosystem services and enter into database: MEAN (**RESsC) = Σni/Σni(max),**

where **Σni** – sum of parameter assessment scores (**RESsC**); **Σni**(max) – sum of the maximum of parameter assessment scores (i.e. n *5); MEAN(RESsC) – a real number with values between 0 and 1

Combining the condition / service polygons to maps:

Step 5: Preparation of Digital Maps for ES types at level 3

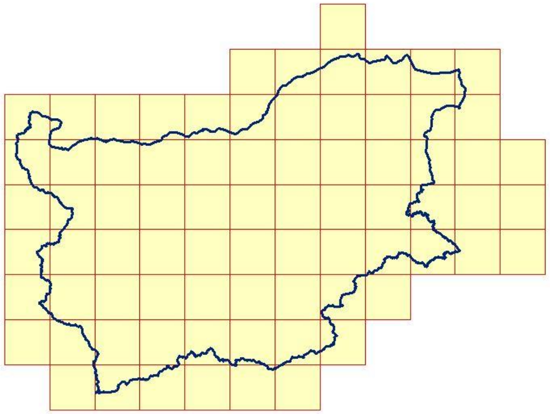
- GIS compatible vector format - geospatial standards of OGC and INSPIRE;
- One complete coverage in a single layer;
- Cartographic projection: ETRS89-LAEA;
- Scale between 1:10 000 and 1:25 000;
- All other details – provided in the methodology



Step 6: Generation of metadata

Step 7: Putting the puzzle together:

- Color coding: comply with common EU standards;
- Scale 1:125 000 size A2
- 77 map sheets based on EEA reference grid
- Specific color scheme for each ecosystem type
- Uniform map template for all mapping projects



Data used for mapping and assessment

- Differ by ecosystem type, from all national and international sources available. Example cropland:
  - Database– State Fund"Agriculture" – Land and Parcel Information System /LPIS/ and Integrated Administration and Control System /IACS/.
  - Database– State Fund"Agriculture" – State Digital Orthophoto map.
  - MoAF – Agrostatistic – BANSIK – statistical survey, Farm Structure survey, Annual bulletin.
  - National Statistical Institute
  - MOEW – ExEA – JICA project, National Database for Biodiversity, National Soil Monitoring Network.
  - EUROSTAT – LUCAS project - **L**and **U**se/**C**over **A**rea frame statistical **S**urvey.
  - GMES - Global Monitoring for Environment and Security
  - Master Plans, Site Development plans, State Cadastre.
  - National Concept for Spatial Development 2013-2025.
  - EEA – CORINE – Land Cover.
  - JRC - ESTIMAP -Polliniation services model, MetEcoSMap - NINA/IBER project.
  - JRC - Soil maps and their properties.
- All methodologies available in sub-menus from this main page: http://bg03.moew.government.bg/node/296

Problems in using EO data and tasks to solve (1)

Tzraklevtsi Wet Meadows: up to 20 m wide

Example:
Capture this known and valuable wetland surrounded by cropland within a Corine Landcover pixel?

- Data scales: different resolutions of EO sources
  - Ortophoto detailed but provides one-time view
  - Satellite data less detailed but contains long time series
  - Satellite resolution varies over time
- To unite both worlds, a model is needed that:
  - recognizes patterns (i.e. discards clouds)
  - matches images of different scales

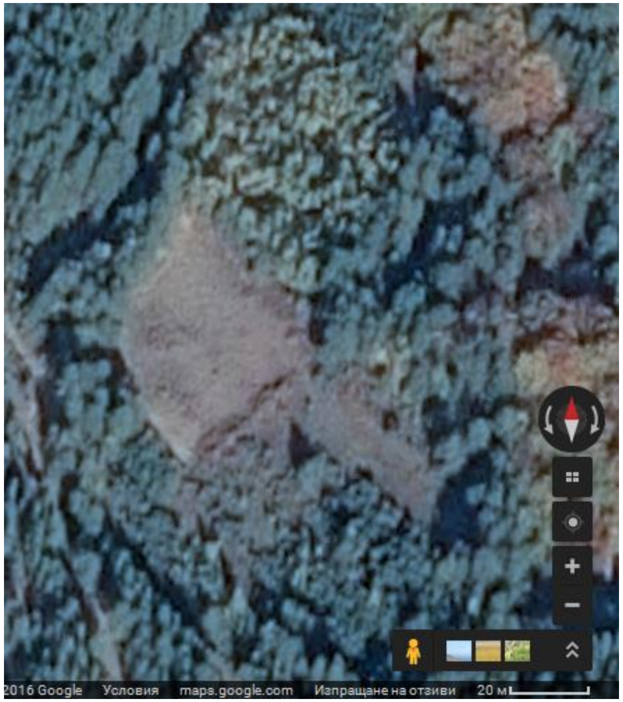
Problems in using EO data and tasks to solve (2)

- Establishing and naming the ground truth:
  - EU classification systems cannot be too detailed while ecosystems can be small
  - The same ES type performs differently according to local conditions
  - The same area is named in different ways (i.e. “river ecosystem” and “water body” may refer to the same object)
  - An ecosystem or water body can have different properties (i.e. Biotic diversity, Environmental status)

- Need for models providing precise pattern recognition and hierarchical labeling according to several classifications

A clearing in the Rhodopi mountain, about 40x80 m, unexplored

Example: Identifying such small ecosystems without manual GIS work



Problems in using EO data and tasks to solve (3)

- Capture trends and salient features within or between ecosystem type maps:
  - Subtype transition boundaries (transition from bog to fen wetland)
  - A fragmented ecosystem whose parts are within another ecosystem (wetlands among cropland, forest clearings, …) can be bigger and more resilient than estimated but remain unnoticed and be destroyed
  - Filter out seasonal change in ecosystems (NDVI, snow covers, phenotypic specifics) and predict trends
- To solve all discussed challenges, a set of models is needed that may include:
  - Statistical and other modelling methods (i.e. decision trees), tolerant to incomplete data
  - Convolutional neural networks to predict missing data in the large scale maps
  - One-shot or zero-shot learning neural network with semantic embeddings to find relations between data and perform automated semantic multi-label mapping
  - Suitable neural networks, such as GRNN, to predict multi-parameter, spatio-temporal development trends

Combining datasets

- Current approach:
  - a lot of experts' manual work to align data formats, identify differences and overlaps
  - based on expert experience and judgement
  - use of many data types, i.e. habitats and WFD data, to estimate condition
  - not always a clear connection between ES condition and services, and understanding of causality
  - iterative improvements

Example of systematization: interpretation keys

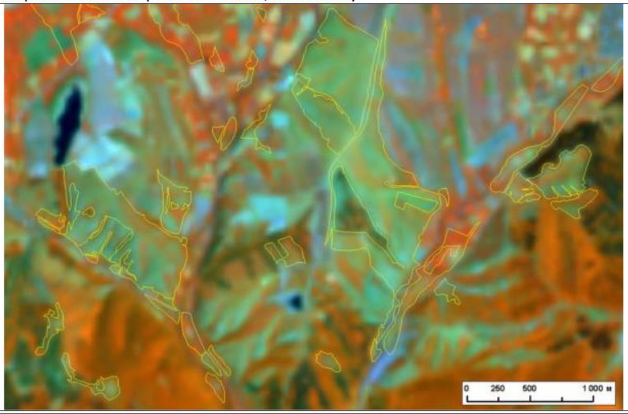
Теренни снимки на типа

Низинни мезофилни тревни екосистеми

Ортофото изображение на подтип Низинни мезофилни тревни екосистеми: общ изглед – южно от град Златица

Спътникови изображения

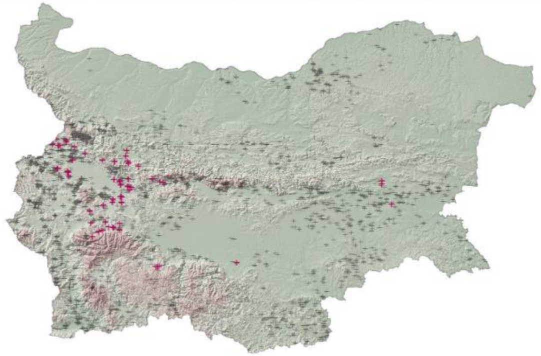
Вегетационен сезон: май (спътник Landsat 8, 30м. пиксел)



Надморска височина: от 2 до 2532 м.н.в., средно 804 м.н.в

0-1700 – 100%

Райони на основно разпределение според налични in-situ данни (Източник: ИБЕИ-БАН)



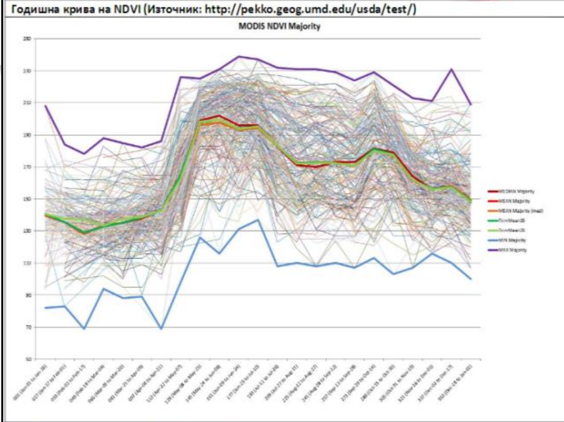
Климатични характеристики (Източник: WorldClim)

Средногодишна температура	Средногодишни валежи	Минимална температура	Максимална температура

Биогеографски региони (съгласно Директива 92/43)

Континентален – 100%

Годишна крива на NDVI (Източник: http://pekko.geog.umd.edu/usda/test/)



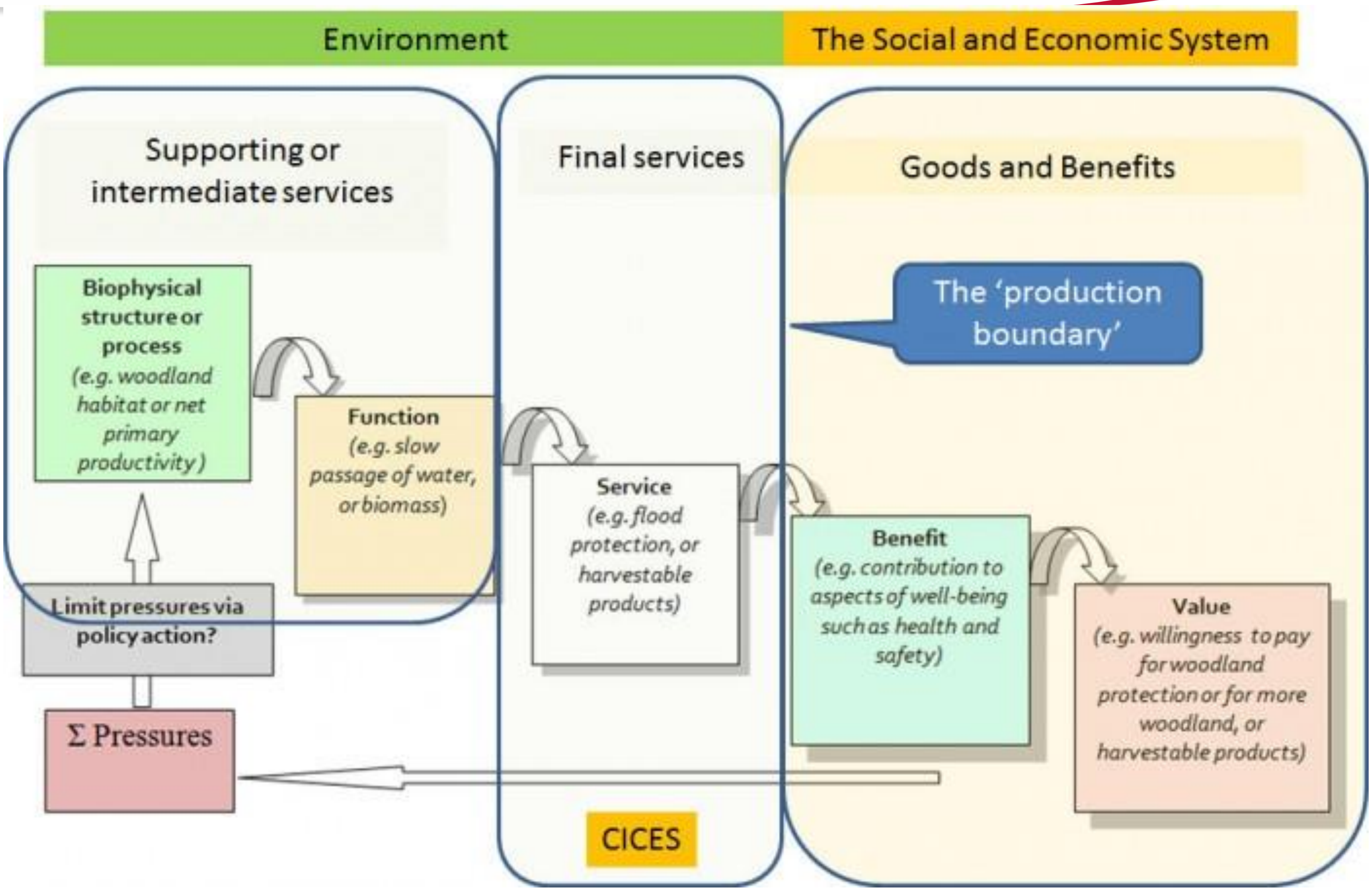
NDVI през май, юни, юли (Източник: Landsat 8)

NDVI май			NDVI юни			NDVI юли		
Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
0.10	0.85	0.70	0.05	0.86	0.64	0.07	0.84	0.66

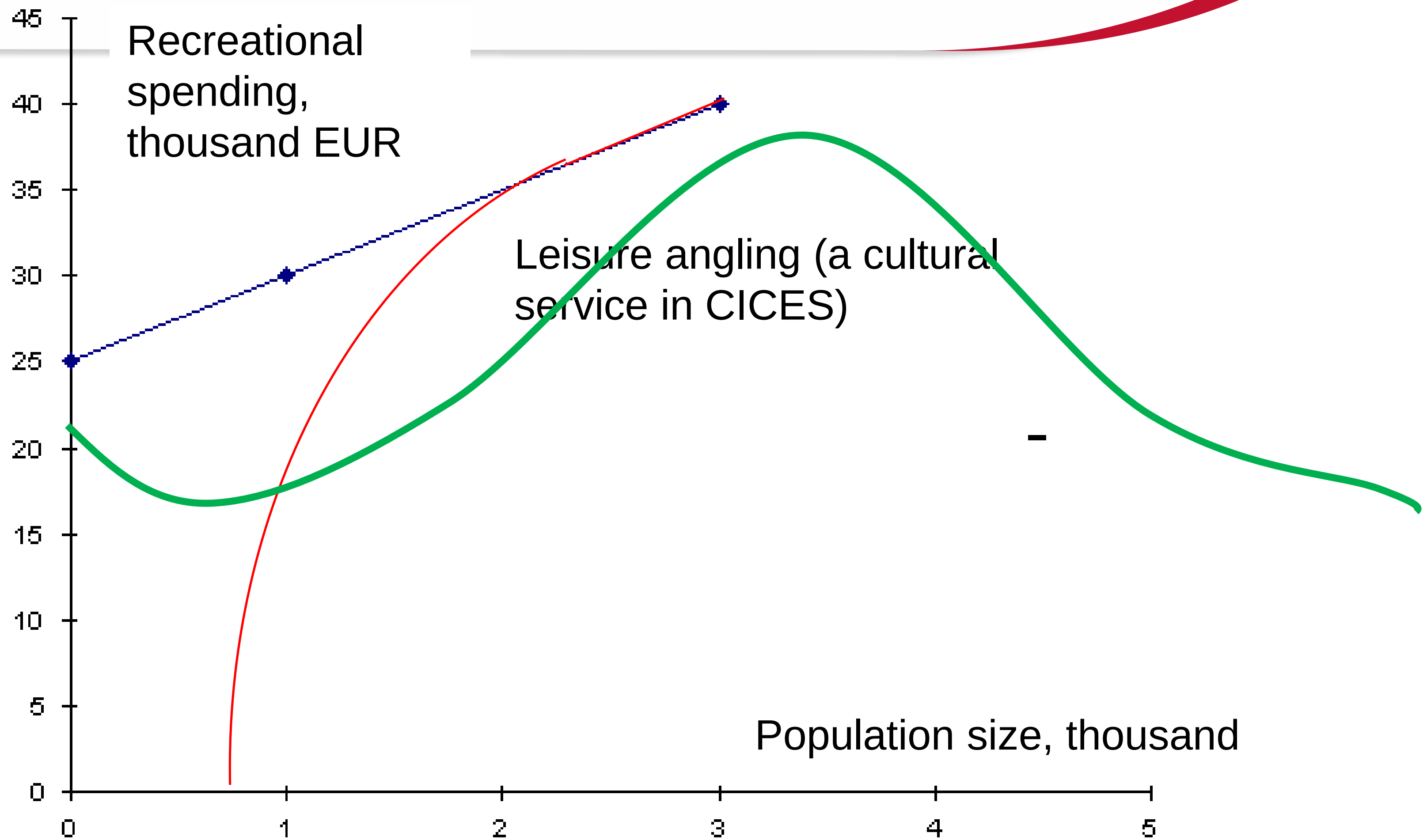
Биологични характеристики
Основни растителни видове:
Arrhenatherum elatius, Dactyilis glomerata, Poa pratensis, P. sylvicola, Alopecurus pratensis, Festuca pratensis, F. rubra agg., Agrostis capillaris, Anthoxanthum odoratum, Cynosurus cristatus, Ranunculus acris, Trisetum flavescens и др.
Проективно покритие на растителността:
от 70% до 100%
Основни видове дребни храстчета или храсти в тревните съобщества:
Rosa canina, Crataegus monogyna, Prunus spp.
Допустимост на наличие на мозайка с дребни храстчета и храсти в проценти:
20%
Почвени типове:
Черноземи (Chernozems), Канелени почви (Chromiccambisols), Алувиално-ливадни почви (Humofluvisols)
Допустимост на наличие на каменни излази на повърхността на почвата:
0%

Source: the grassland mapping project, http://grasslands-ecoservices-bg.eu/

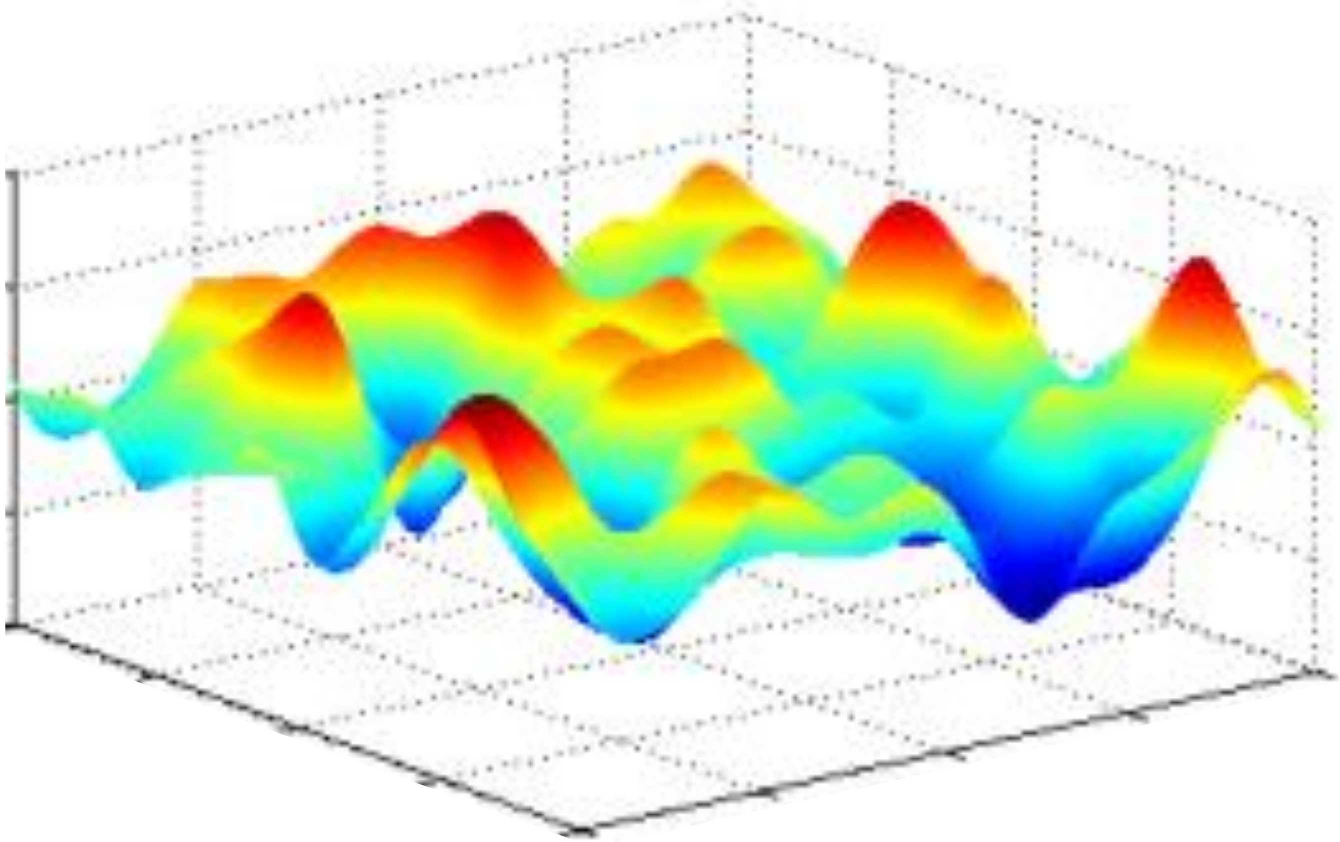
A key conceptual challenge: ESS production functions



Socio-ecological systems, populations and ESS production functions



Socio-ecological systems, populations and ESS production functions

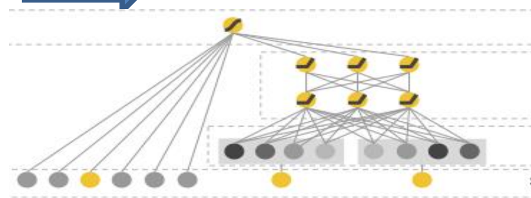


The way to go for the data-poor (1)

1. Train a set of models:

Labels: available metadata from all sources, such as mapping metadata , the new Bulgarian Nature Index, monitoring of species, habitats, soils, air, water; geographic data on elevation and slope, statistics on dempgraphy, ESS production and use

Images from EO, at different scales and by different methods, i.e. NDVI, MODIS, drone images, LIDAR point clouds



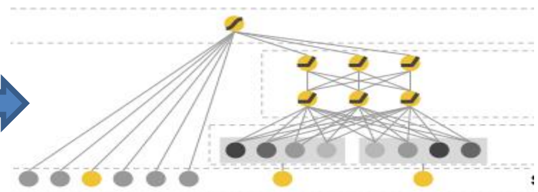
Match data to adopted classifications:

Dry grassland

Sub-Mediterranean subtype

Condition: excellent (5)
Fodder yield 50 kg/ha
Value: BGN 400 ha/a
Bulgarian Nature Index value 0,91

2. Fill gaps, classify new images, forecast:



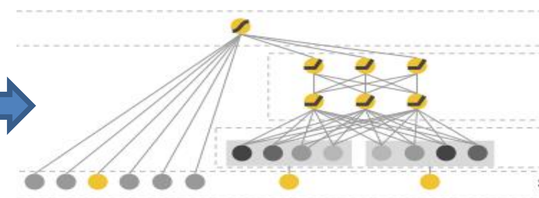
Mesic grassland

Mesic lowland subtype

Conditon: good (4)
Fodder yield 70 kg/ha
Value BGN 560 ha/a
Bulgarian Nature Index 0,58

The way to go for the data poor (2)

3. Run trade-off scenarios



5-years scenarios:

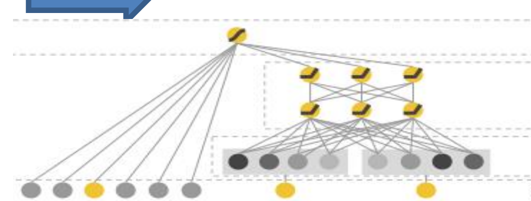
Mowing and sale: condition becomes 2,83, BNI - 0,12, Yield -30%

Grazing: condition becomes 4,24, BNI - 0,67, Yield +5%

4. Re-calibrate the models as new data arrives

Labels: available metadata from all sources, old and new

New images from EO, at different scales and by different methods, old and new



Improved classifications as revised by monitoring of trends

Thank you!

For questions and comments:
kremena.gocheva@gmail.com