

NaturaSat Wetland

Novel tool for riparian vegetation
monitoring after river branch system restoration



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Introduction

- NaturaSat software was developed with the support of ESA
- Mapping and monitoring of Natura2000 habitats
- Due to the complicated character of plant communities, it was impossible to reach the detailed scale defined by diagnostic plant species composition

Aims

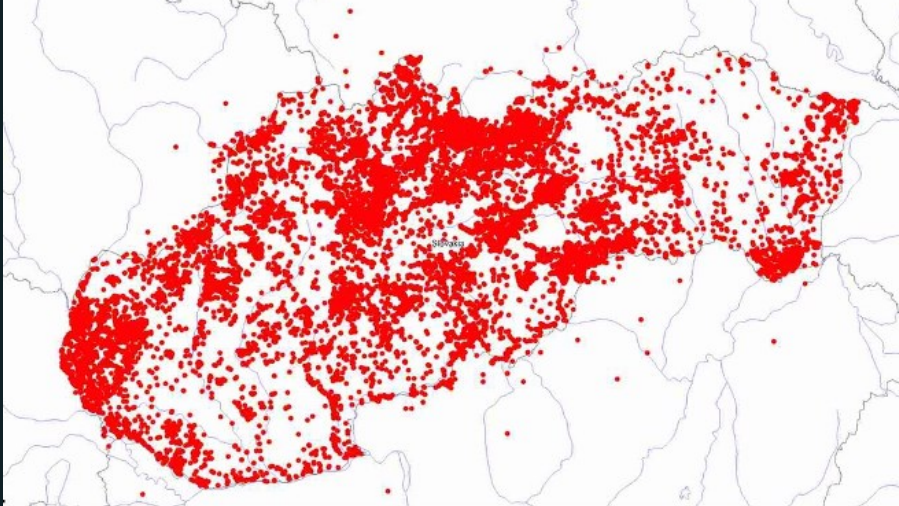
- To show the concept of NaturaSat tools for identifying plant communities using satellite images that break this limitation.
- To present NaturaSat application specialized for wetlands and riparian vegetation
 - Examples from the Danube inland delta
 - Monitoring of habitats of interest within revitalization projects



Introduction

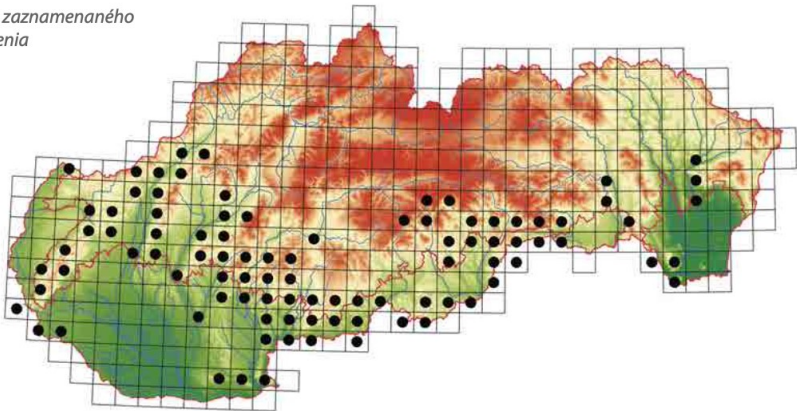


- Slovak Vegetation Database

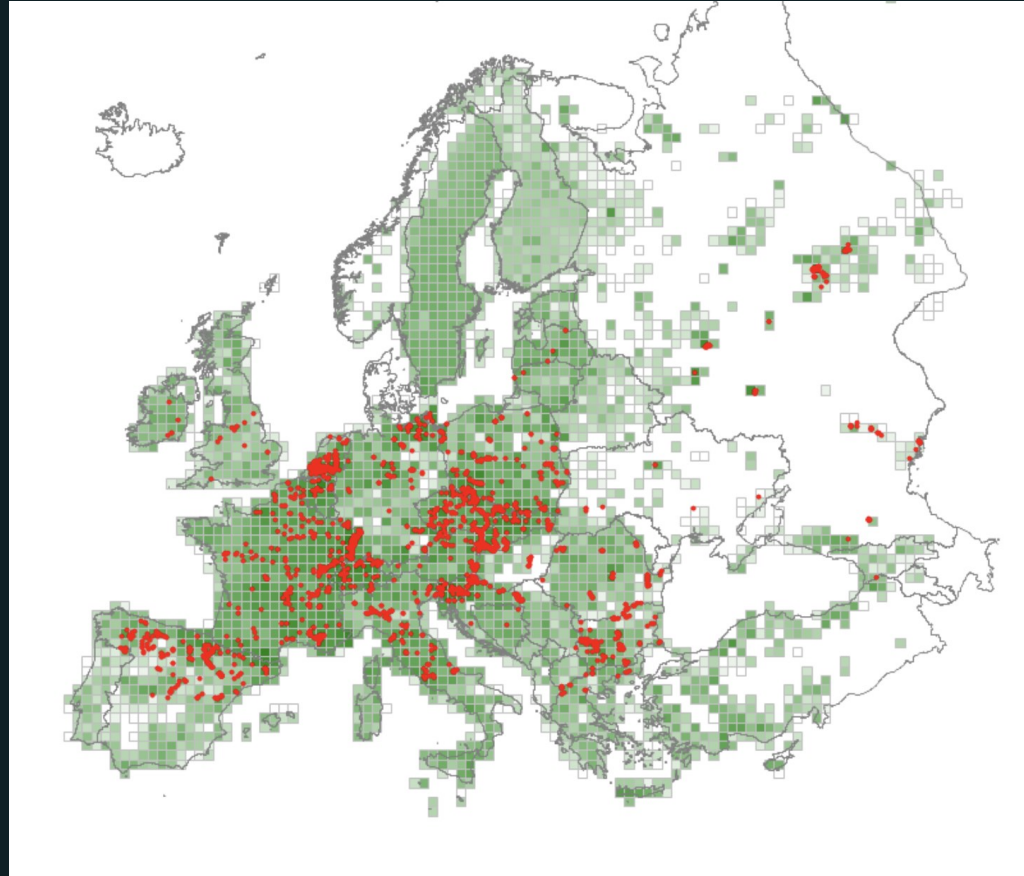


- Catalogue of habitats of Slovakia

Mapa zaznamenaného rozšírenia

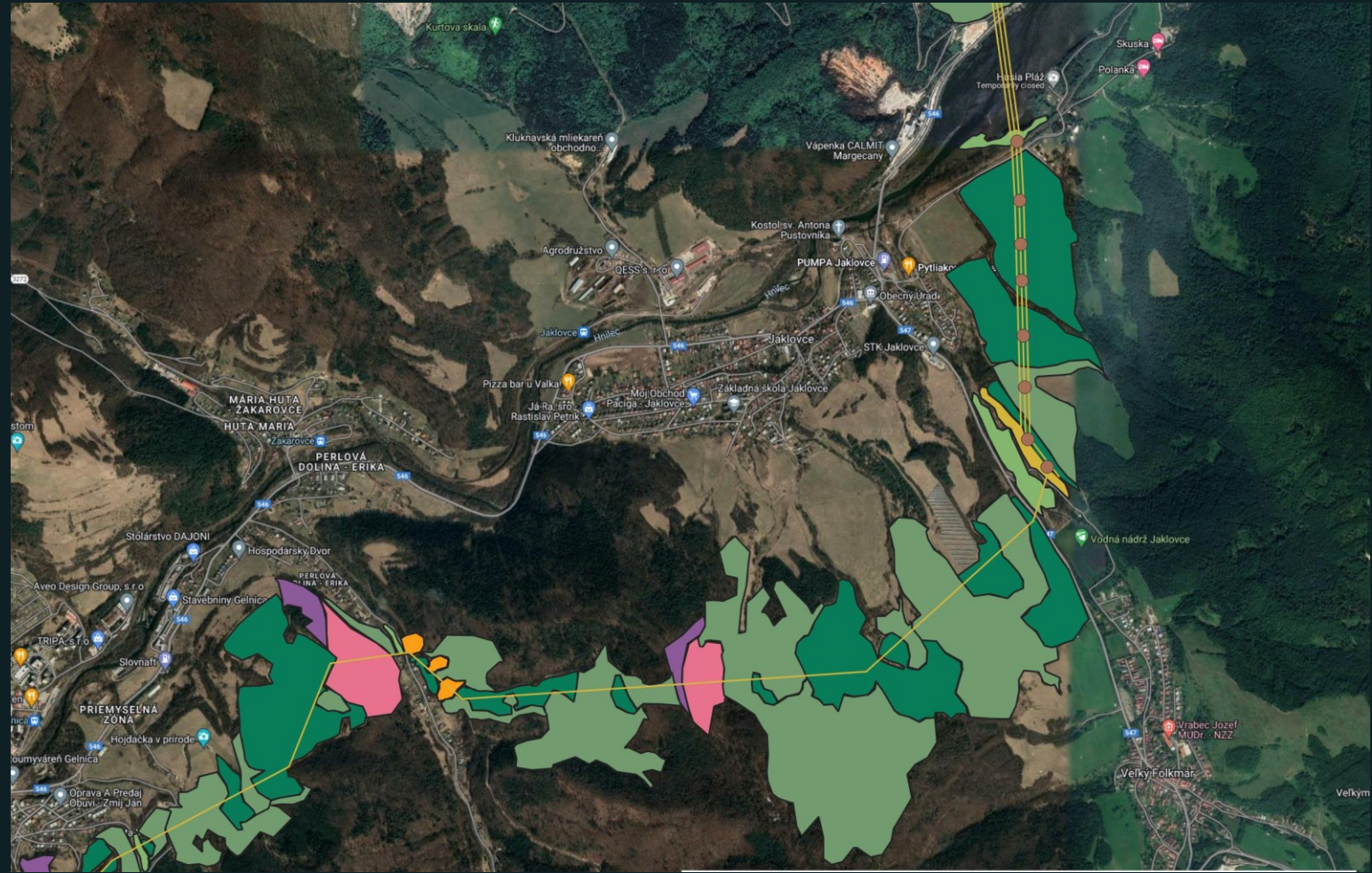


- Point distribution (vegetation databases) or distribution in quadrats
- Habitat distribution modeling - based on geographical and climate data



- FloraVeg

Introduction



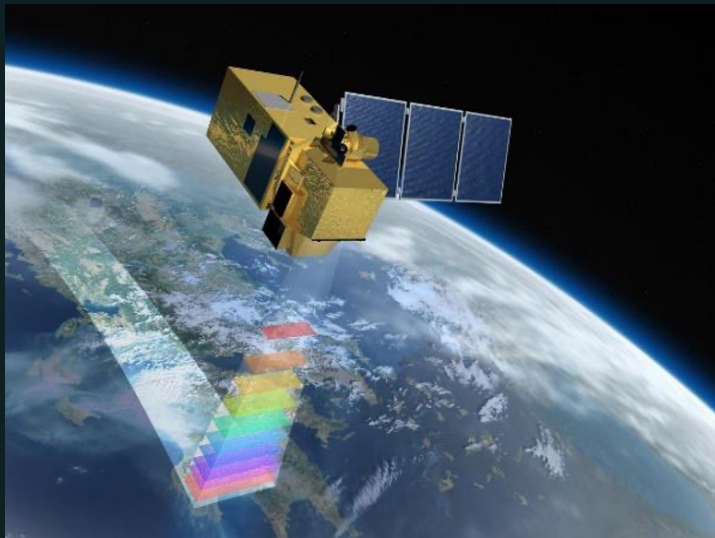
- Polygons - exact areas

Methods - Remote sensing

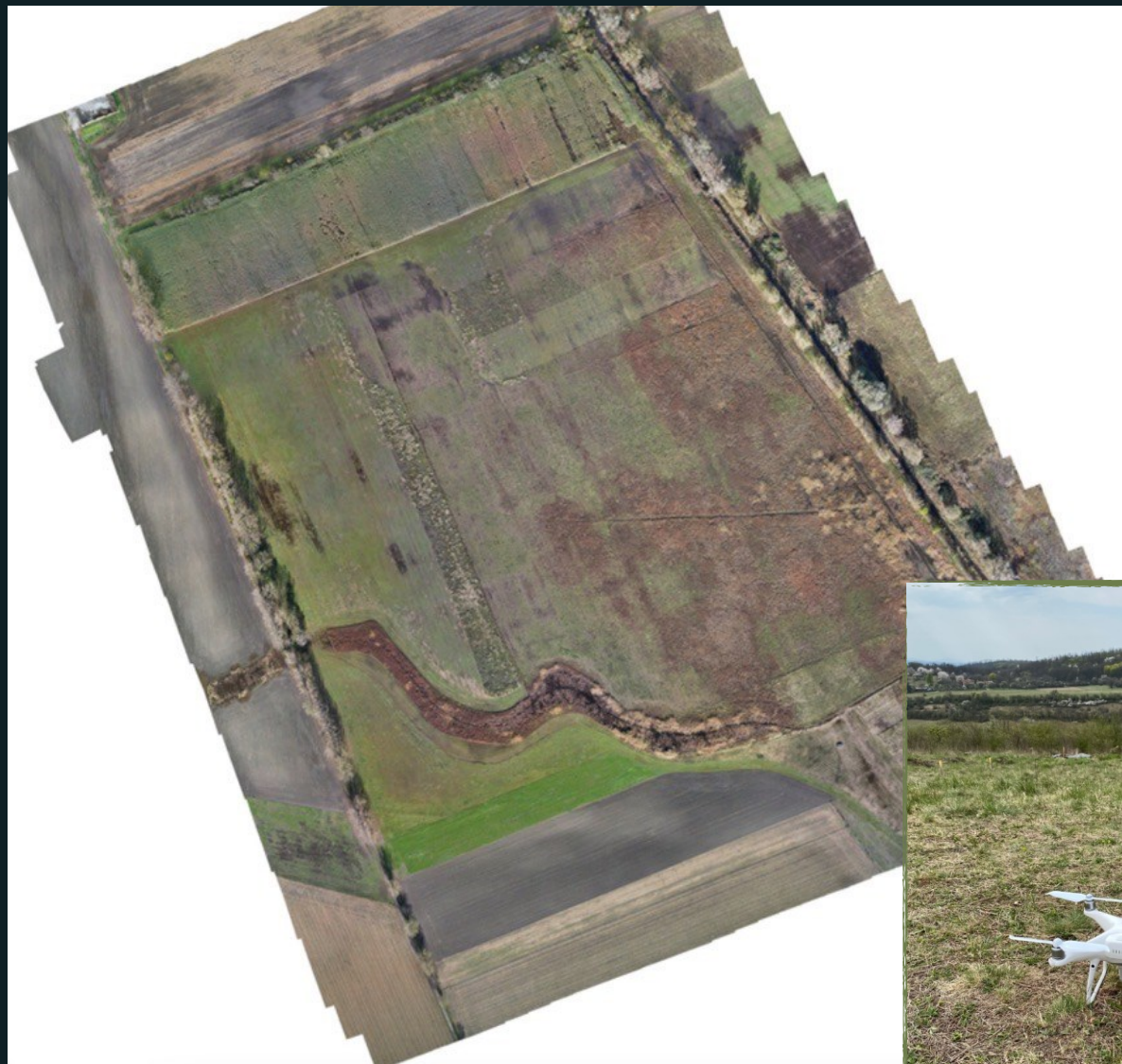


- Remote sensing is one of the essential tools in ecology and nature conservation
- Multispectral and hyperspectral data availability, advanced data processing techniques improve - more profound insights into land cover categories.

- Sentinel-2 data
- 3-4 days regular sampling
- Resolution 10x10 meters



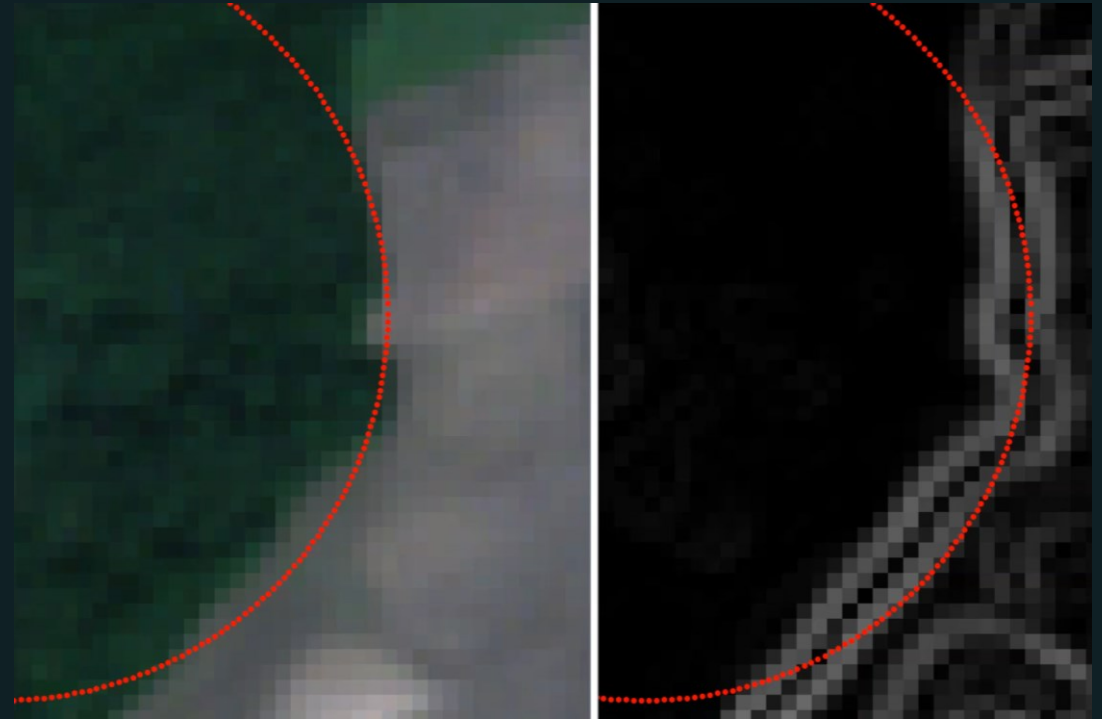
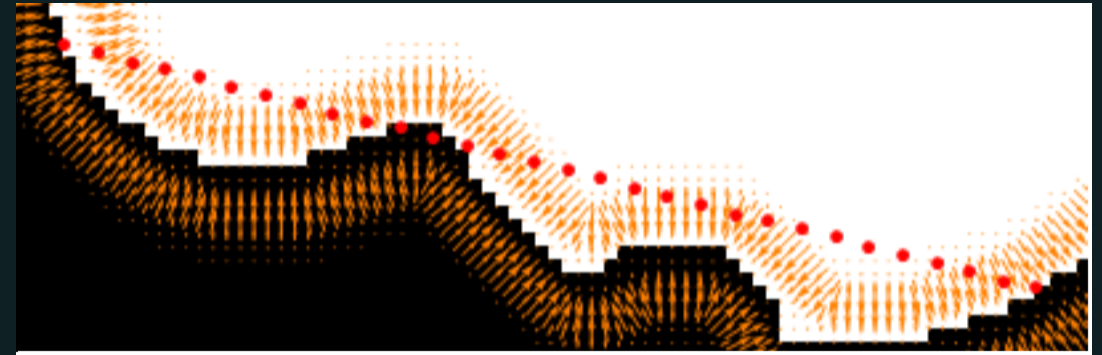
Methods - ortophotomaps and UAV



Methods - Border detection



- The pixel resolution was reached (10x10 meters)



Edge detector



NaturaSat v2.0.0

File View Window Curves Help

Curves explorer

Name	Type
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Data Explorer Curves explorer

Properties

Label	Options
File	
Show type	Multiple channels
Channel	B04-Red
Channel	B03-Green
Channel	B02-Blue
Apply	
Crop histogram	
Bottom crop [%]	0.00
Top crop [%]	2.50
Apply	
Curve style	

Preview map

S2A_MSIL2A_20180910T095031_N0208_R079_T33UXP_20180910T143931

Tools

Filtering

Semi-automatic segmentation

Controls

New Continue

Label	Options
Feature functions	
Feature to show	Edge detector
Show feature	
Update image	
Filtering for edge detector	
Type	Linear
Linear timestep	0.25
Edge detector	
Gradient sensitivity	500.00
Segmentation settings	
Curvature influence	0.30
Initial condition	Gradient-driven
Evolve segment	<input checked="" type="checkbox"/>
Auto stop	<input type="checkbox"/>
Magnet threshold (px)	3

Automatic segmentation

Monitoring

Classification

WGS84: 48.341699, 16.983566, UTM: 646982, 535618133N, Image coordinates 4698.21, 4381.9

Semi-automatic segmentation



NaturaSat v2.0.0

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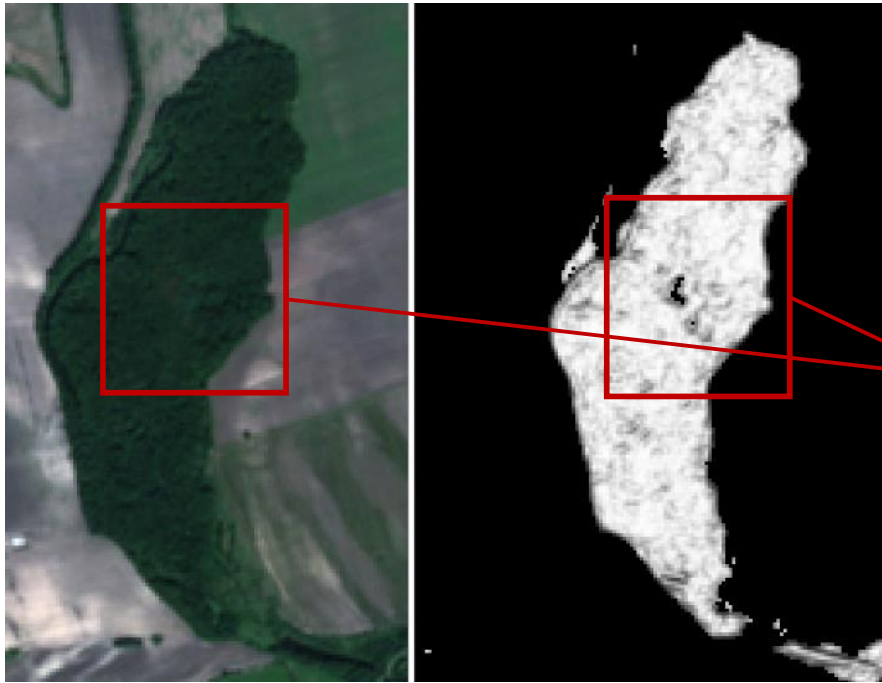
Automatic segmentation

Monitoring

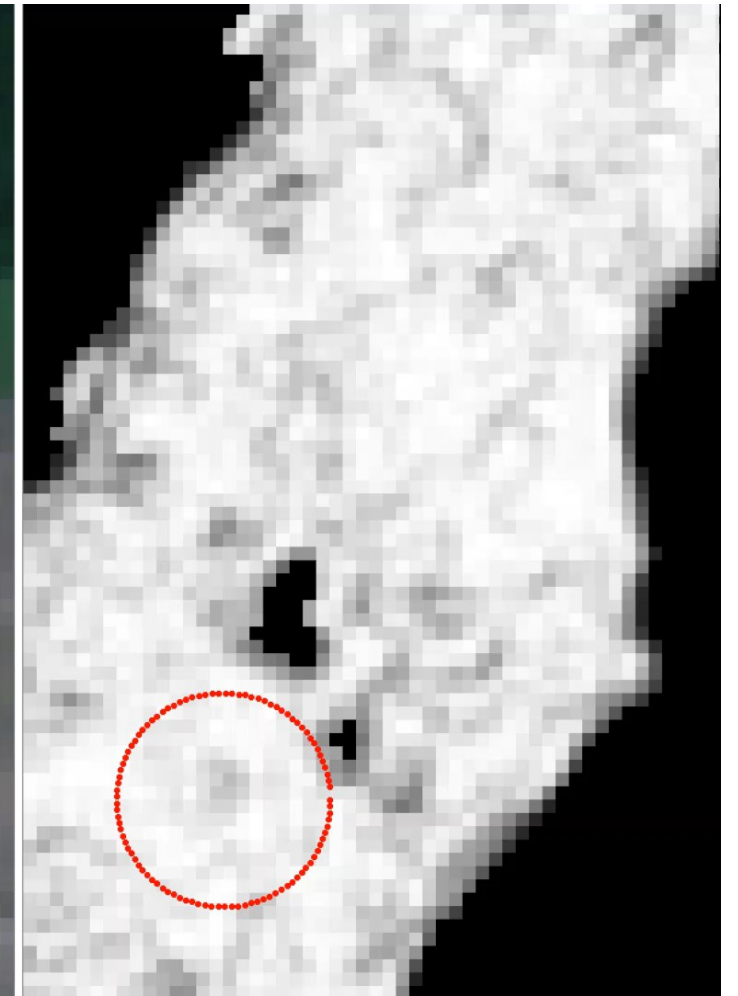
Classification

WGS84: 48.344906, 16.969195, UTM: 645908, 5356510 33N, Image coordinates 4590.82, 4348.94

Automatic segmentation



Original image



Expanding force function

Relevancy map



NaturaSet v2.0.0

File View Window Curves Help

Curves explorer

Name	Type
T33UXP_91E0_bodikyoprotib...	chl
curve_11	chl
T33UXP_91E0_bodikyostrov3...	chl
91E0_bodikyostrov3_final	chl
T33UXP_91E0_bodikyprhrad...	chl
curve_6	chl
T33UXP_91E0_bodikyprhrad...	chl
curve_7	chl
T33UXP_91E0_bodikyprhrad...	chl
curve_8	chl
T33UXP_91E0_bodikyprhrad...	chl

Data Explorer Curves explorer

Properties

Label	Options
File	
Show type	Multiple channels
Channel	B04-Red
Channel	B03-Green
Channel	B02-Blue
Apply	
Crop histogram	
Bottom crop [%]	0.00
Top crop [%]	2.50
Apply	
Curve style	

Preview map

S2A_MSIL2A_20180910T095031_N0208_R079_T33UXP_20180910T143931

Tools

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Semi-automatic segmentation

Automatic segmentation

Monitoring

Classification

Type of classification:

Network: 118x72_westSK_natNet.csv

Classification of area

Size of relevancy maps: 504

Create relevancy maps

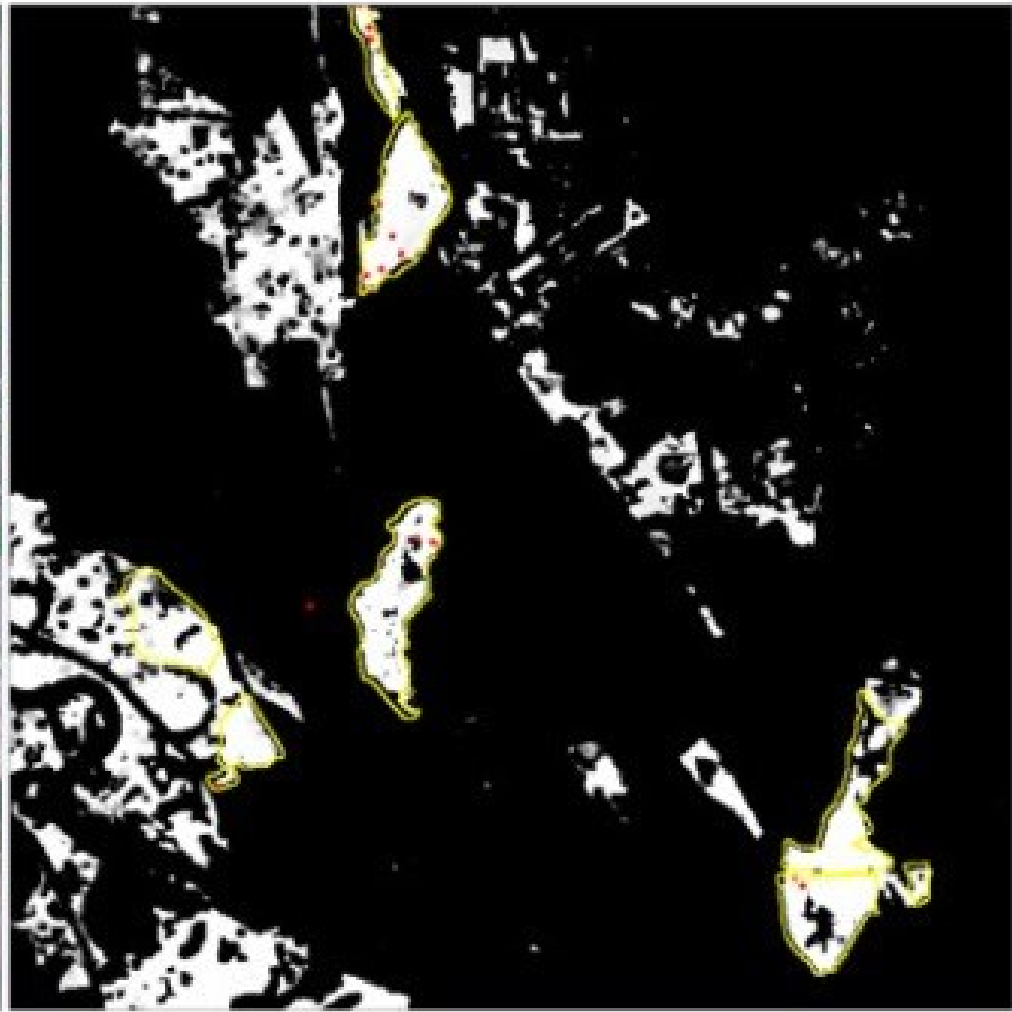
Relevancy map Explorer

Show relevancy map

Map name	Network name
RM91E0_0	118x72_westSK_natNet.csv
RM91F0_0	118x72_westSK_natNet.csv
RM91G0_0	118x72_westSK_natNet.csv
RM91I0_0	118x72_westSK_natNet.csv

WGS84: 47.902251, 17.496162, UTM: 686548, 5308452 33N, Image coordinates 8654_8,9154_8

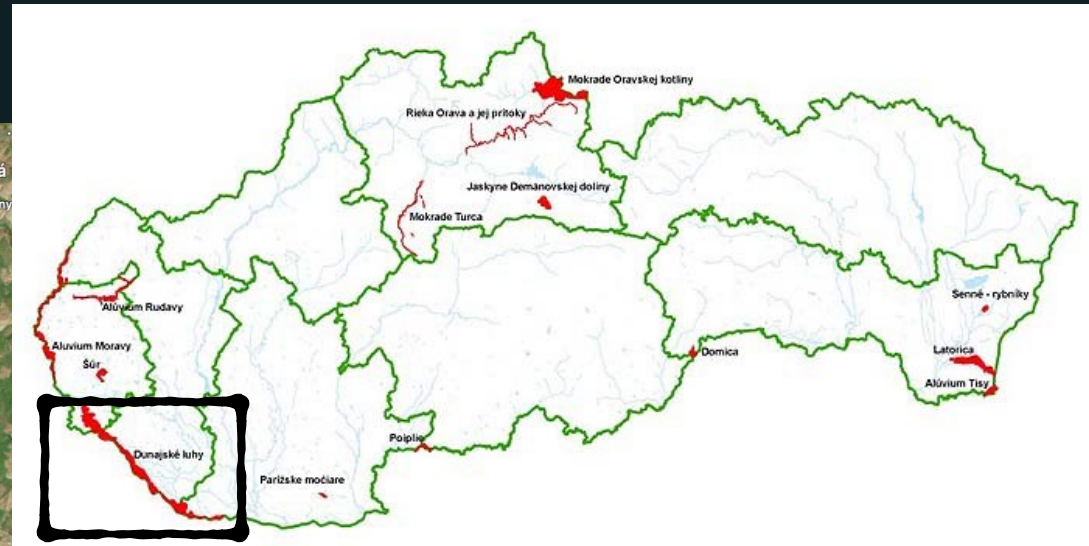
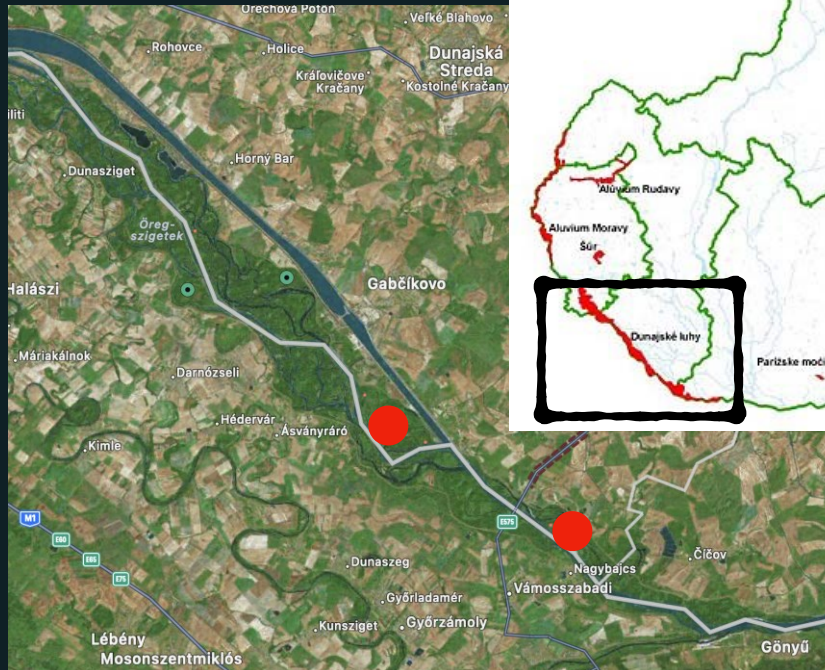
Relevancy map



Danube inland delta



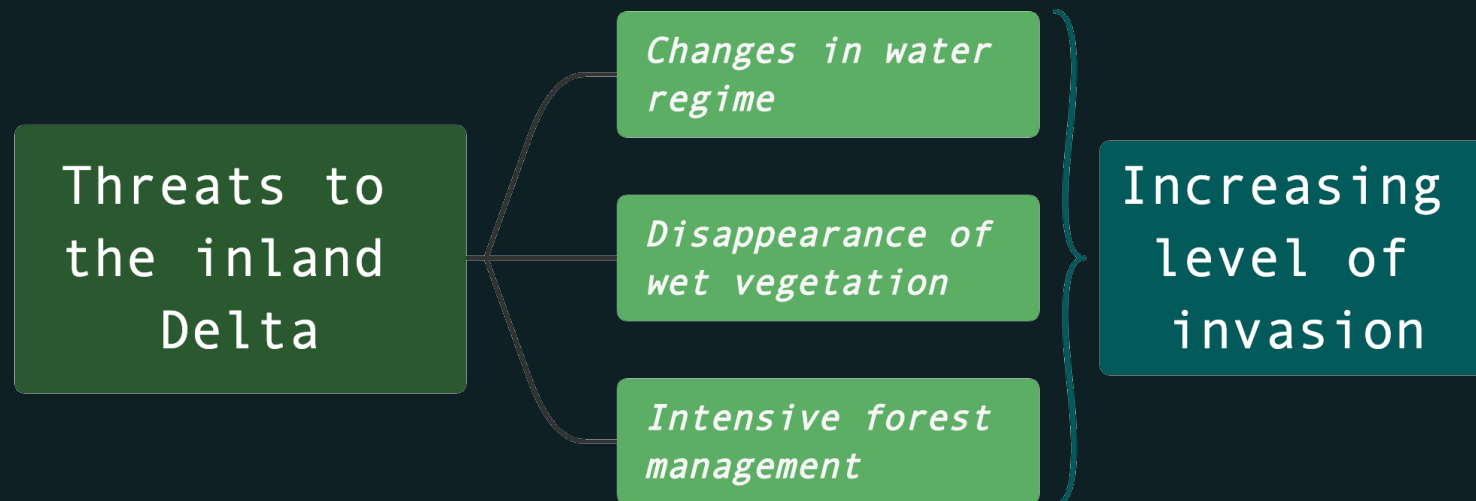
- The site is a part of the Podunajská nížina lowland
- Ramsar site
- The main landscape-forming factor was Danube river that changed its course regularly in the past
- The network of river branches formed the Danube inland delta



Riparian vegetation



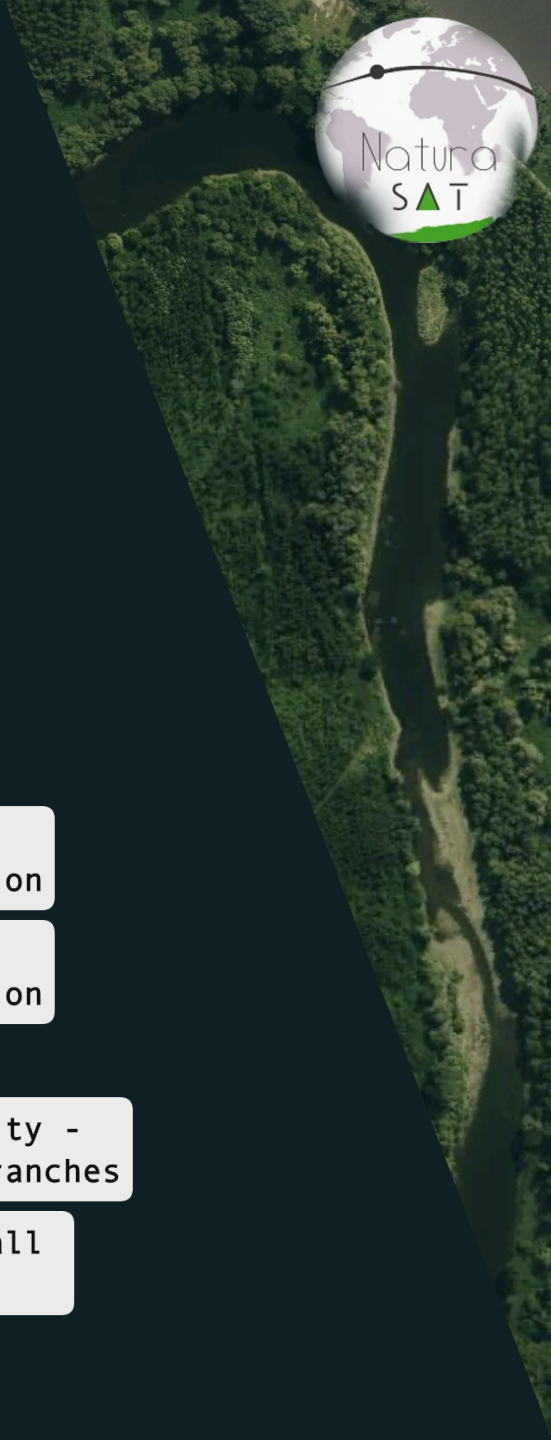
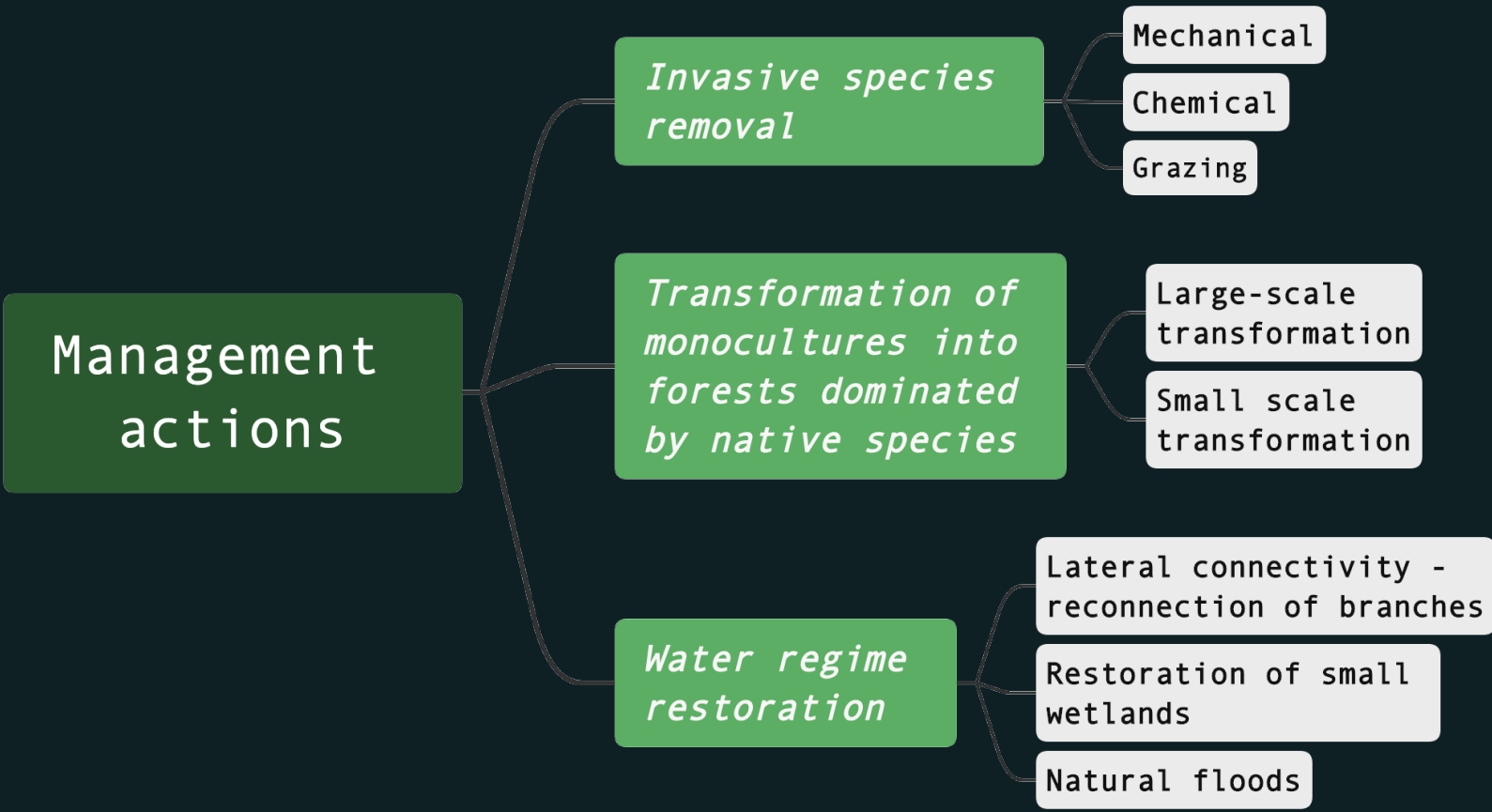
- Alluvial meadows, natural eutrophic lakes, and muddy banks – are among the most threatened habitats in Slovakia due to river regulation, water regime changes, and pressure of invasive species
- Water regime, especially the timing and duration of floodings, is crucial for this habitat's existence





Revitalization projects

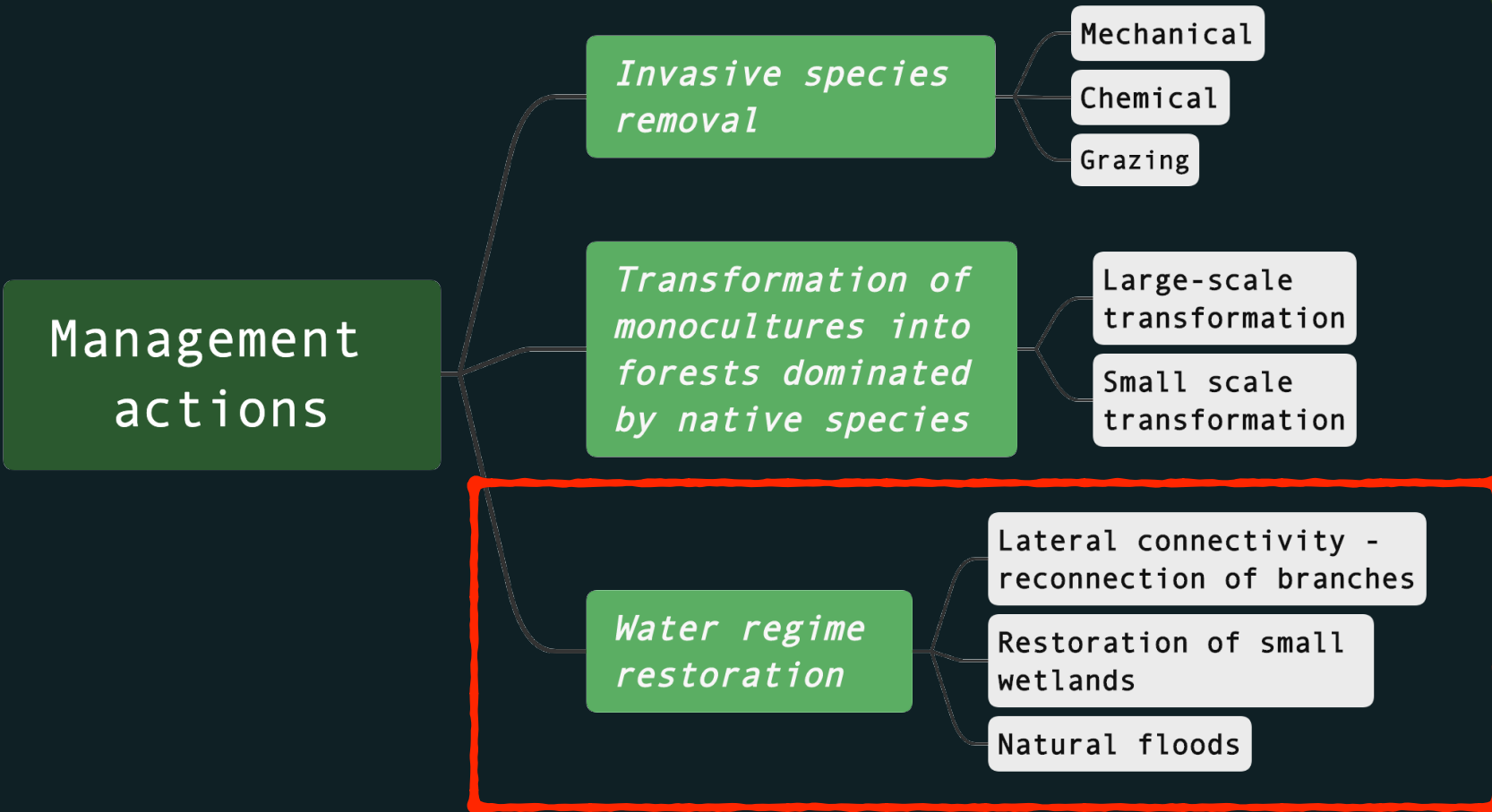
- Restoration and management of Danube floodplain habitats (LIFE14 NAT/SK/001306)
- DLLD - Dynamic Life Lines Danube (LIFE 18 NAT/AT/000733)
- WILDIsland (LIFE20 NAT/AT/000063)





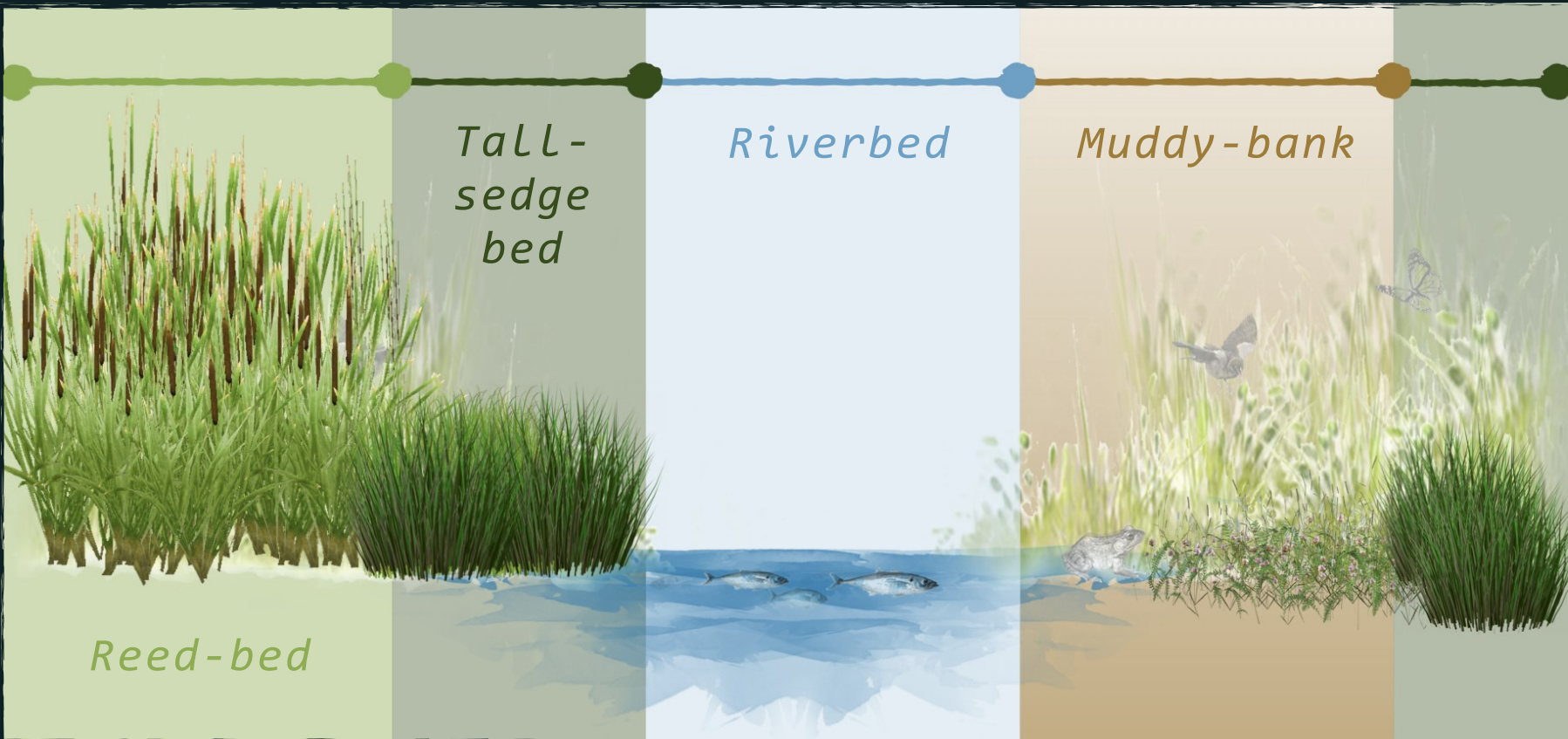
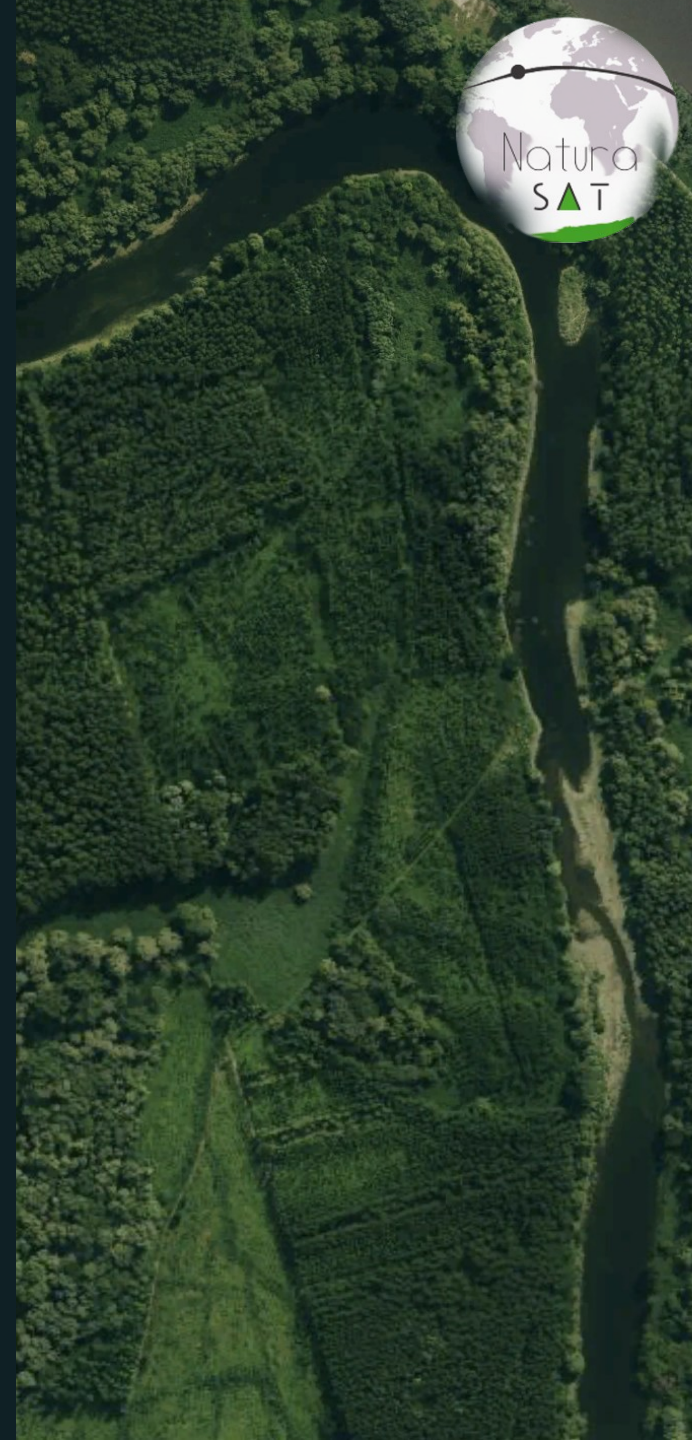
Revitalization projects

- Restoration and management of Danube floodplain habitats (LIFE14 NAT/SK/001306)
- DLLD - Dynamic Life Lines Danube (LIFE 18 NAT/AT/000733)
- WILDIsland (LIFE20 NAT/AT/000063)



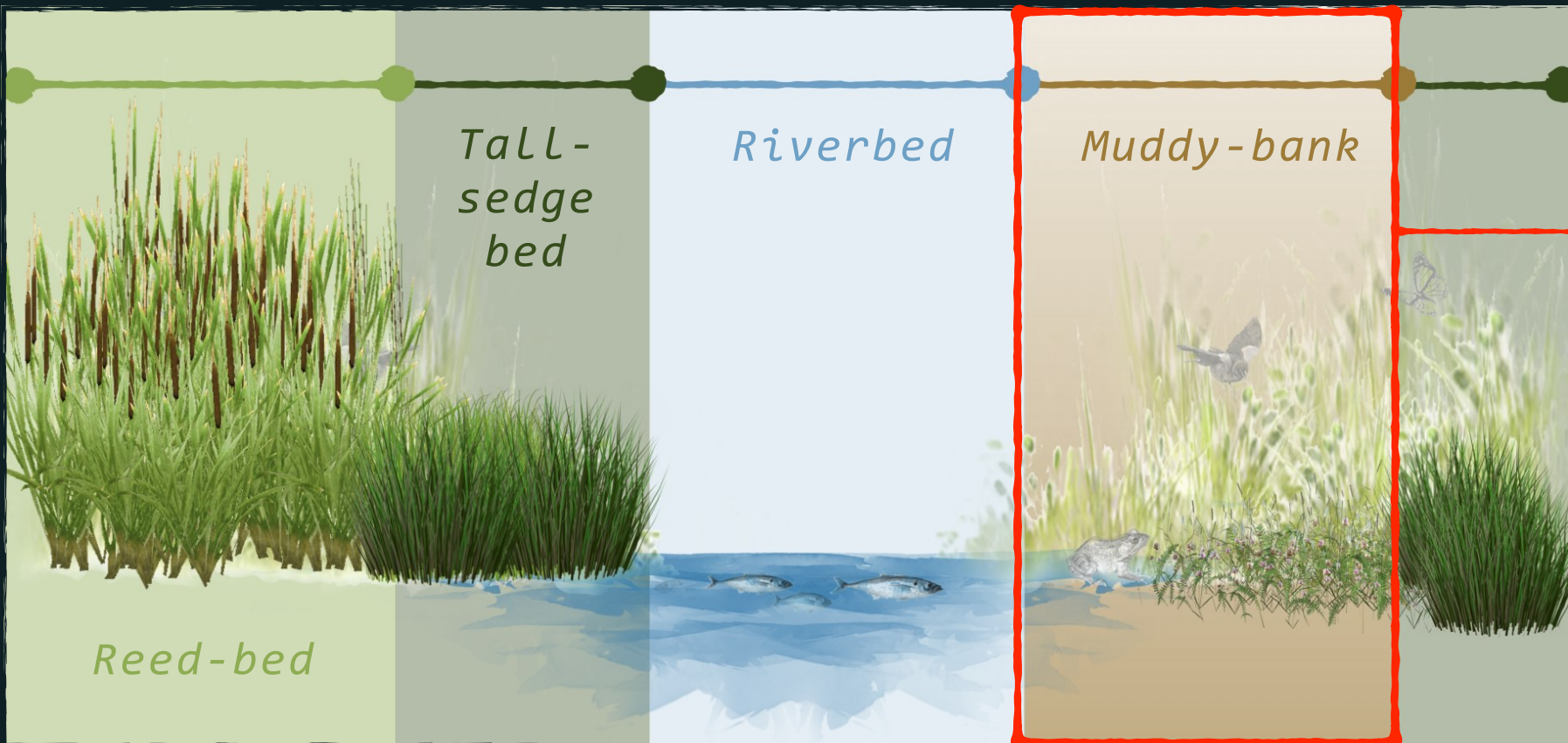
Riparian vegetation and water regime

- Water regime, especially the timing and duration of floodings, is crucial for this habitat's existence
- Muddy-bank vegetation (habitat 3270) - the most dynamic one



Riparian vegetation

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Monitoring methods



- Vegetation monitoring on permanent plots was established on the project sites before and after management activities
- Phytosociological relevés were sampled on invaded alluvial meadows and sedge-beds
 - For the muddy banks habitats and water habitats in oxbows, standard monitoring methods fell short in the assessment of vegetation extent and status
 - Muddy banks were dynamic between sampled years - permanent plots contains different vegetation types in different years



Monitoring methods



- Area monitoring - segmentation of habitat borders in different time (comparing the Hausdorff distance)



- Quality monitoring (within segmented area)

- Normalized Difference vegetation index
- Normalized Difference Water Index (NDWI)
- $NDWI_1 = (Green - NIR) / (Green + NIR)$
- $NDWI_2 = (Green - SWIR) / (Green + SWIR)$
- $NDWI_3 = (NIR - MIR) / (NIR + MIR)$
- Normalized Difference Pond Index $NDPI = (SWIR - Green) / (SWIR + Green)$
- Normalized Difference Turbidity Index (NDTI) $NDTI = (Red - Green) / (Red + Green)$

Habitat monitoring - segmentation



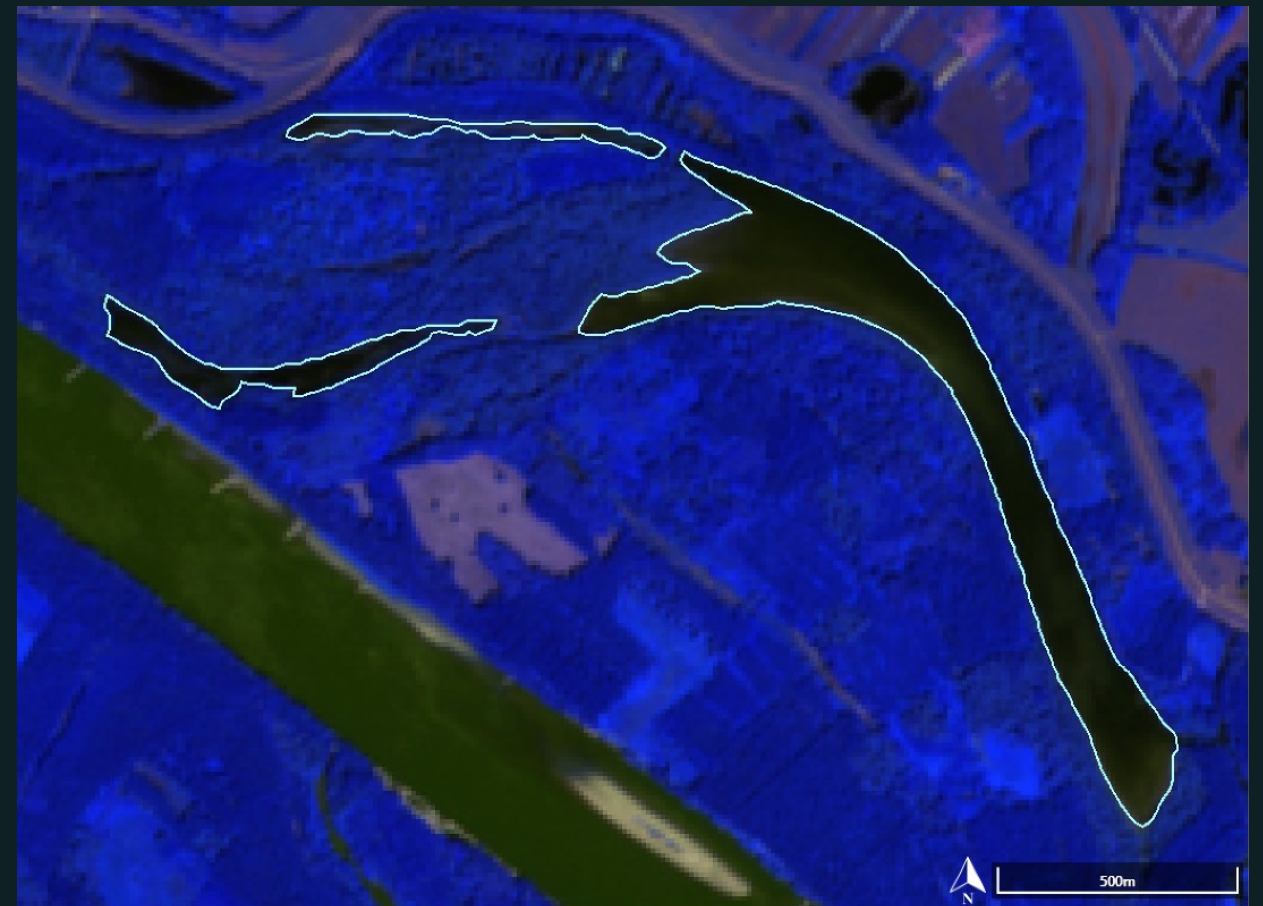
- Oxbow and muddy-bank areas were segmented during the highest water level
- Every available (cloudless) Sentinel-2 data were downloaded for the years 2022 and 2023



Habitat monitoring - segmentation

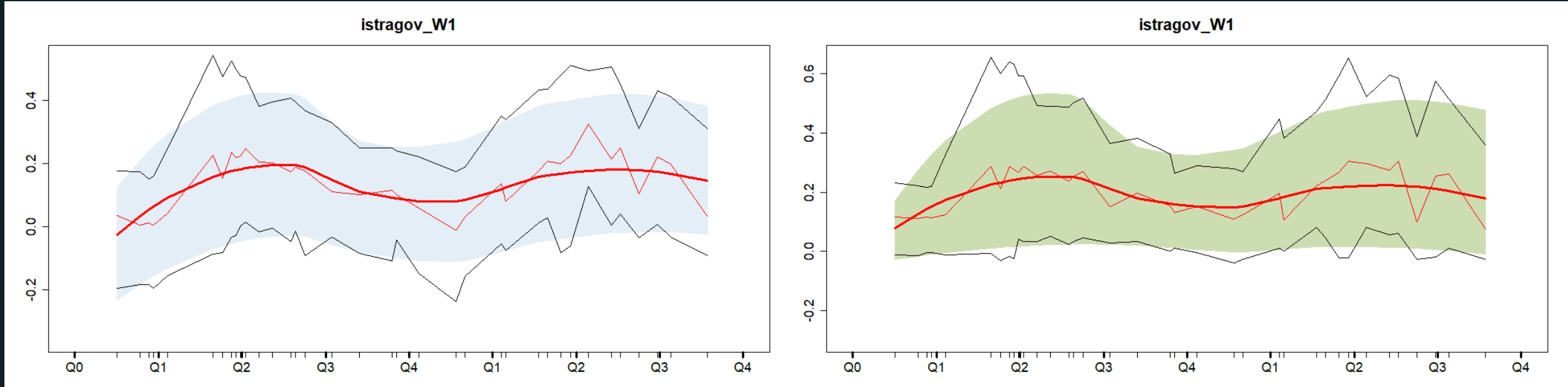


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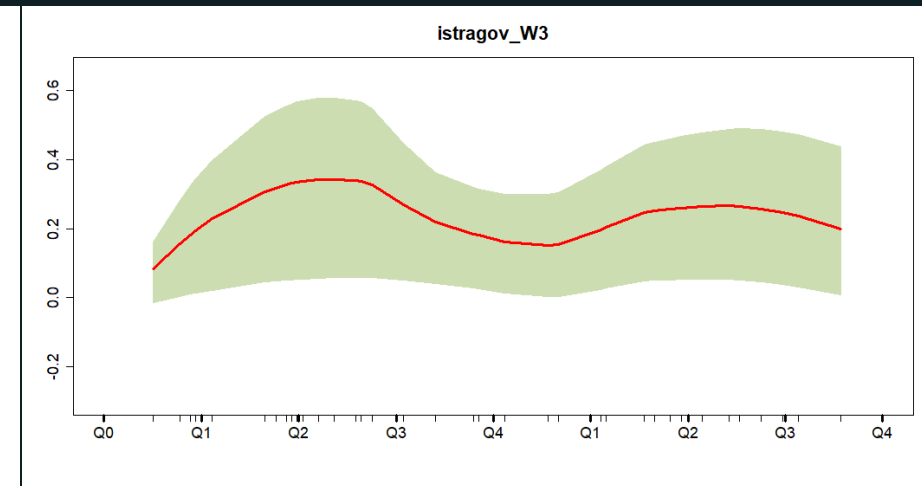
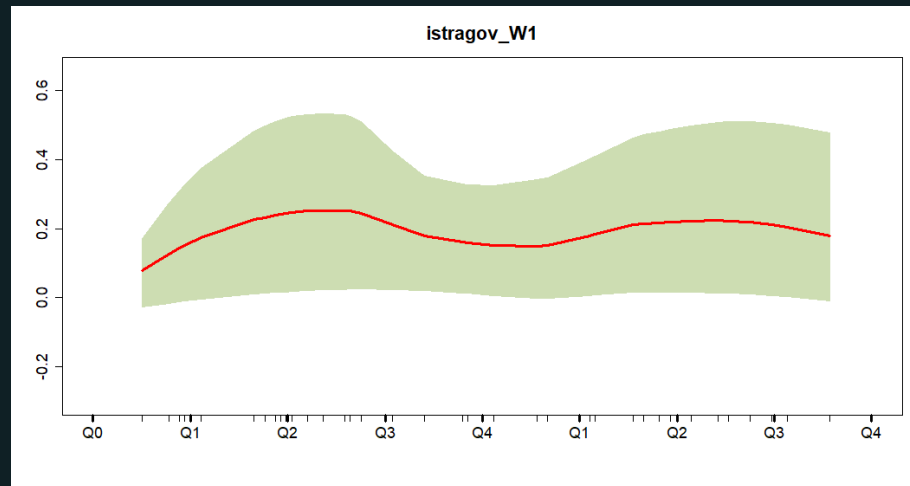
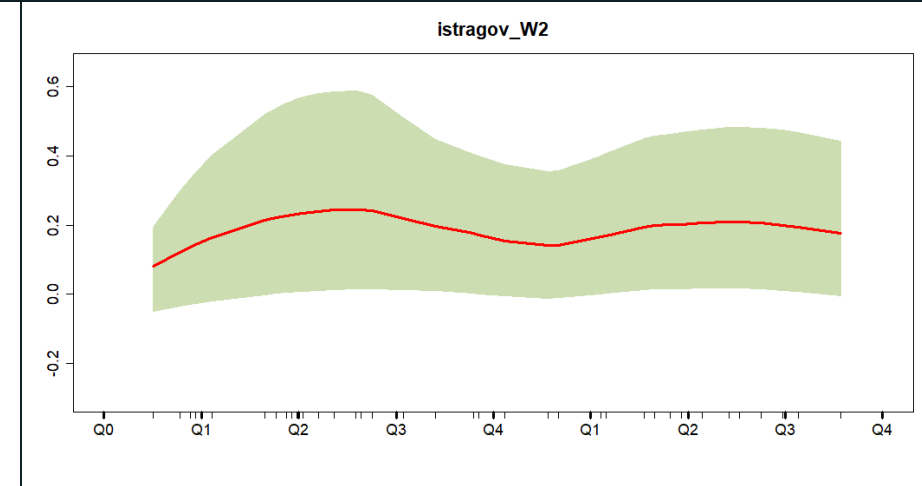
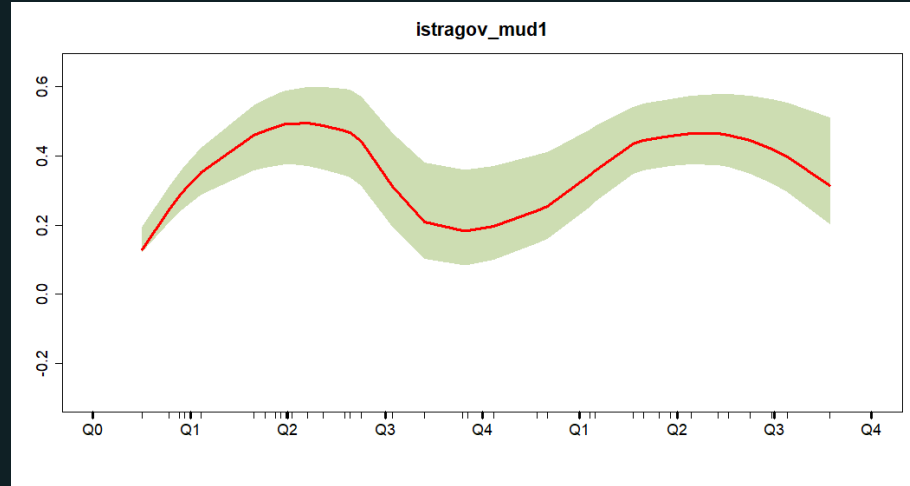


Habitat monitoring – statistics

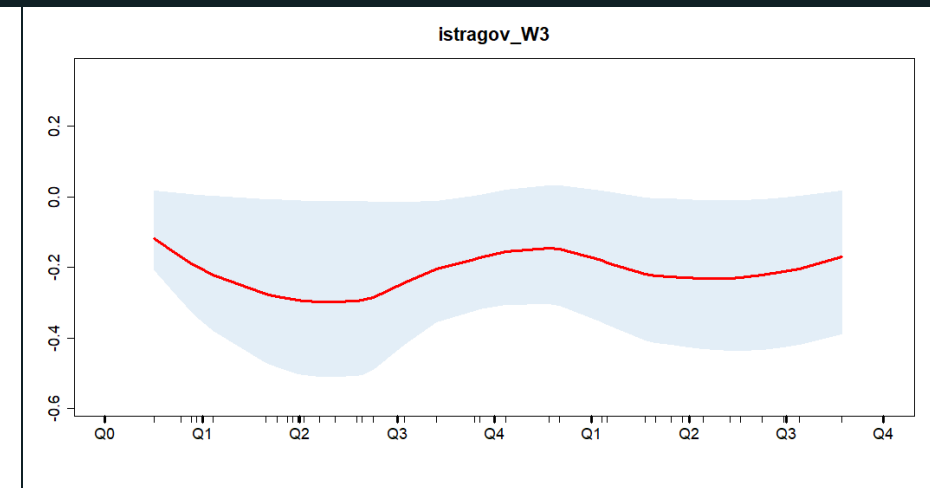
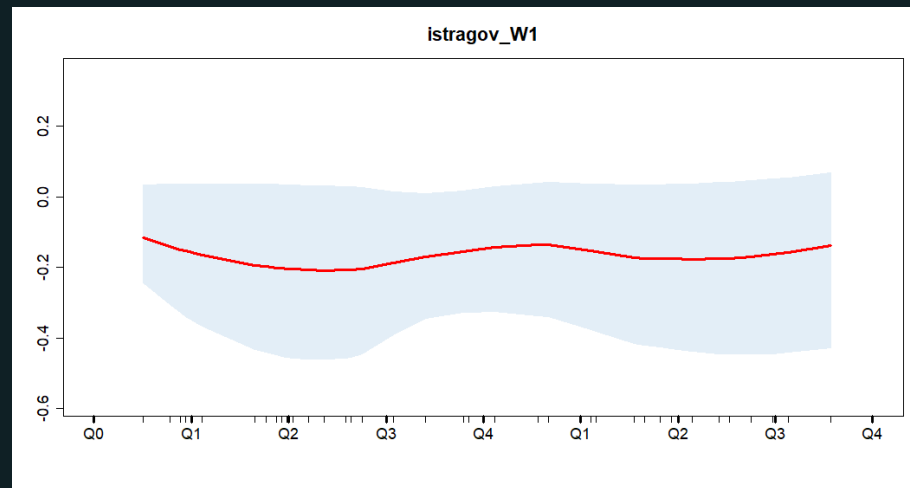
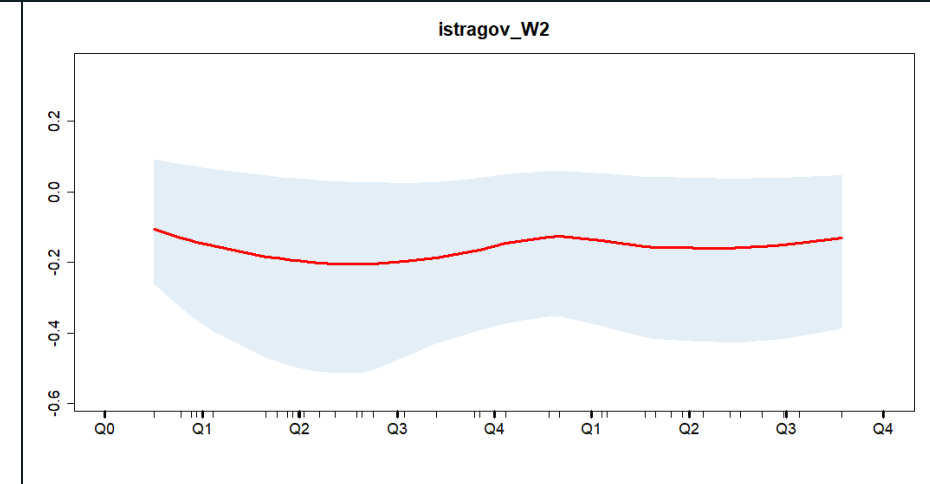
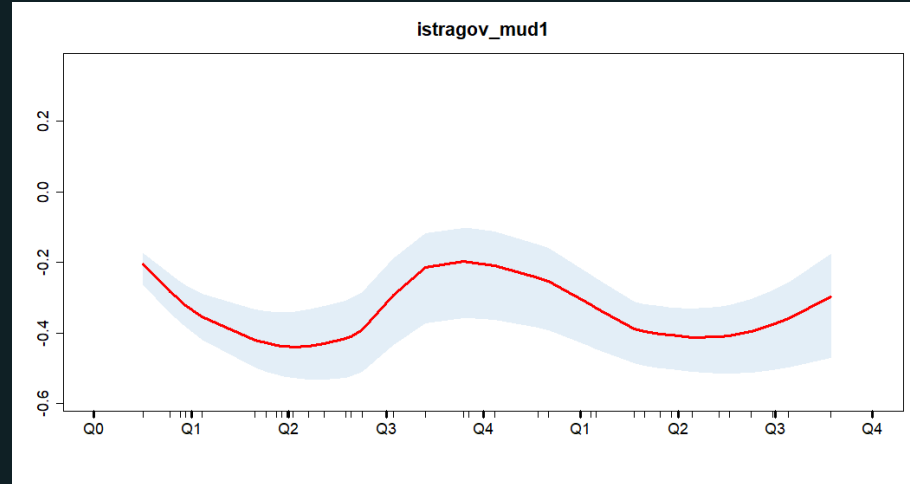
- Minimum, maximum and mean values of indexes were computed and smoothed trend line was visualized (R-software)



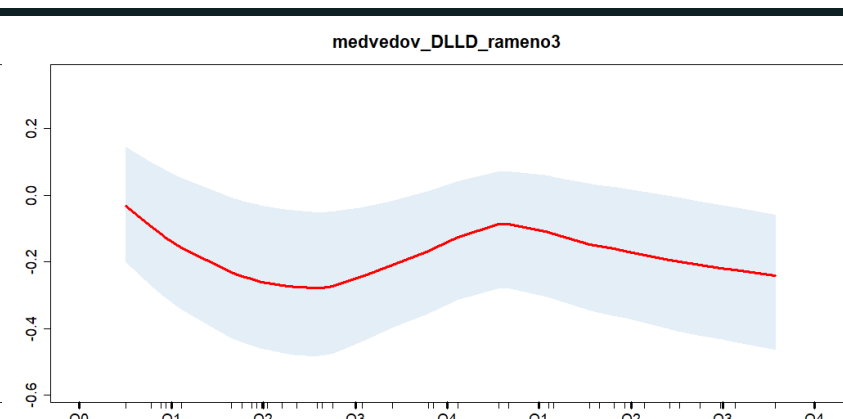
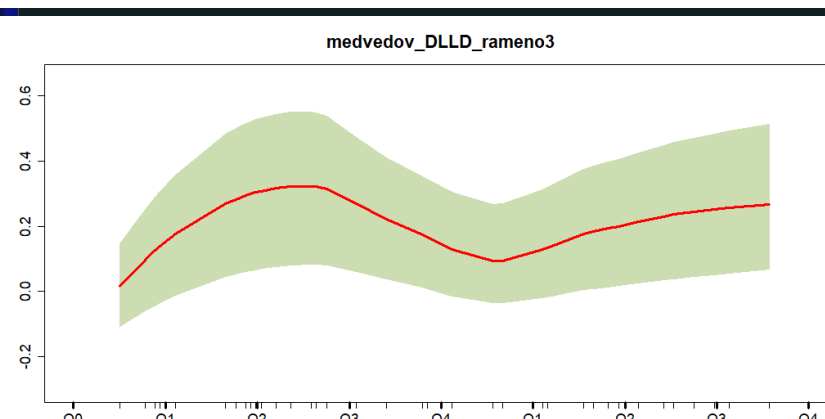
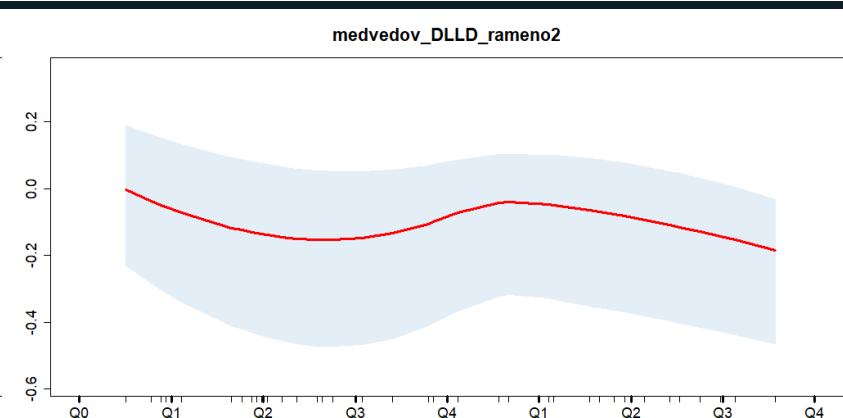
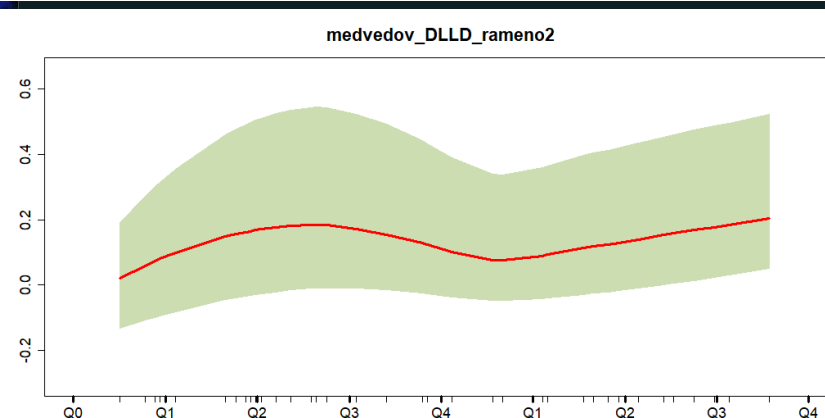
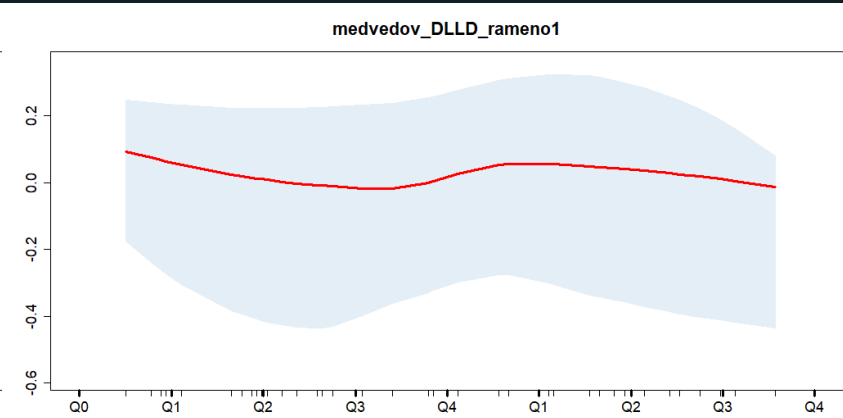
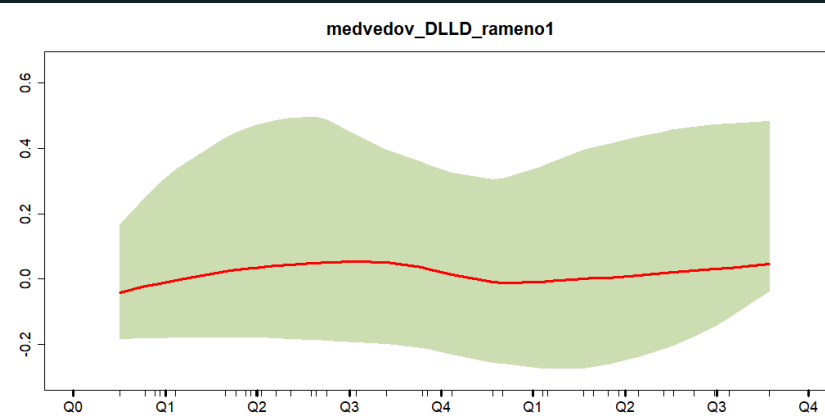
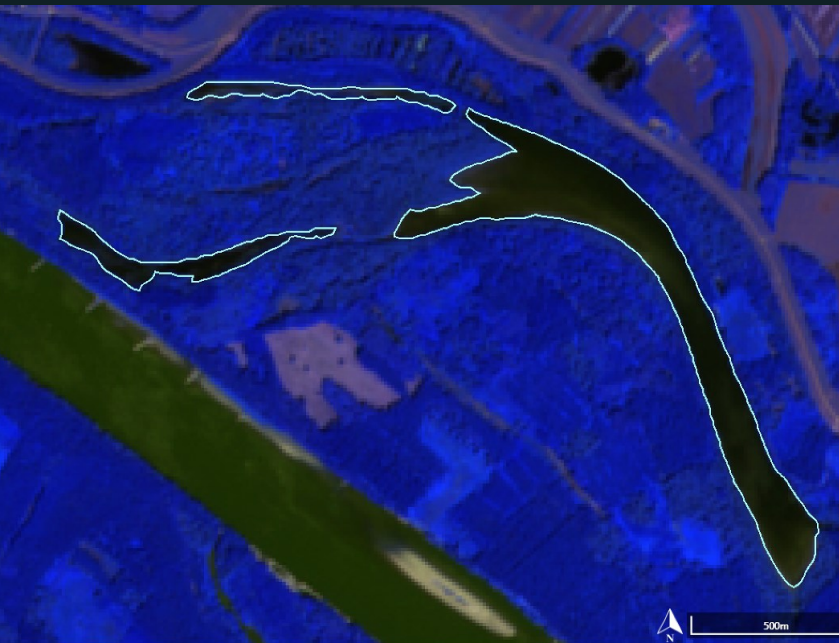
Results - Istragov area NDVI



Results - Istragov area NDWI



Results - Medved'ov area NDVI and NDWI



Conclusion and next steps



- Segmentation methods works with pixel resolution in case of wetland habitats
- Temporal changes in NDVI and NDWI indexes are different for water macrophyte vegetation and muddy banks
- Both years showed similar trends
- The monitoring will continue next years



NaturaSat Wetland

Thank you for your attention!



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