
A Decade of Satellite-Based Vegetation Monitoring in Kopački Rit Nature Park

Asst. Prof. Dorijan Radočaj

Faculty of Agrobiotechnical Sciences Osijek,
Josip Juraj Strossmayer University of Osijek

Introduction

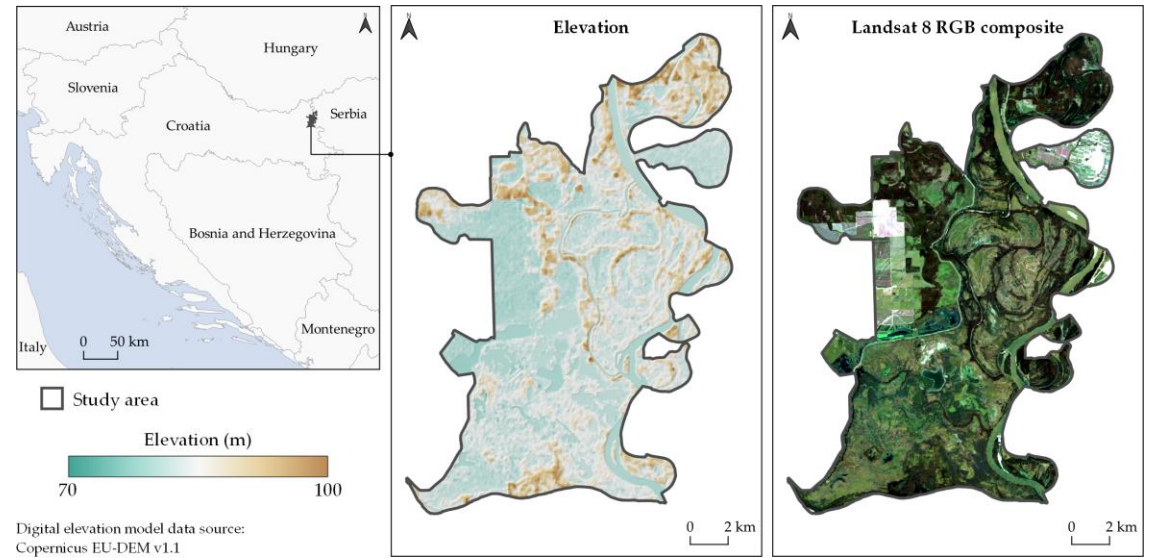
- Vegetation is a key indicator of **ecosystem health and biodiversity**, and detecting change within protected wetlands is critical for conservation and management.
- Landsat missions provide long-term, freely available multispectral imagery (since 1972), enabling **phenology analysis** of seasonal vegetation dynamics over multi-year periods.
- The **normalized difference vegetation index (NDVI)** remains the preferred index for phenology analysis due to its standardized $[-1,1]$ range and strong link to vegetation health.
 - sensitive to chlorophyll content and canopy structure, capturing green-up and senescence phases

Research gap & objective

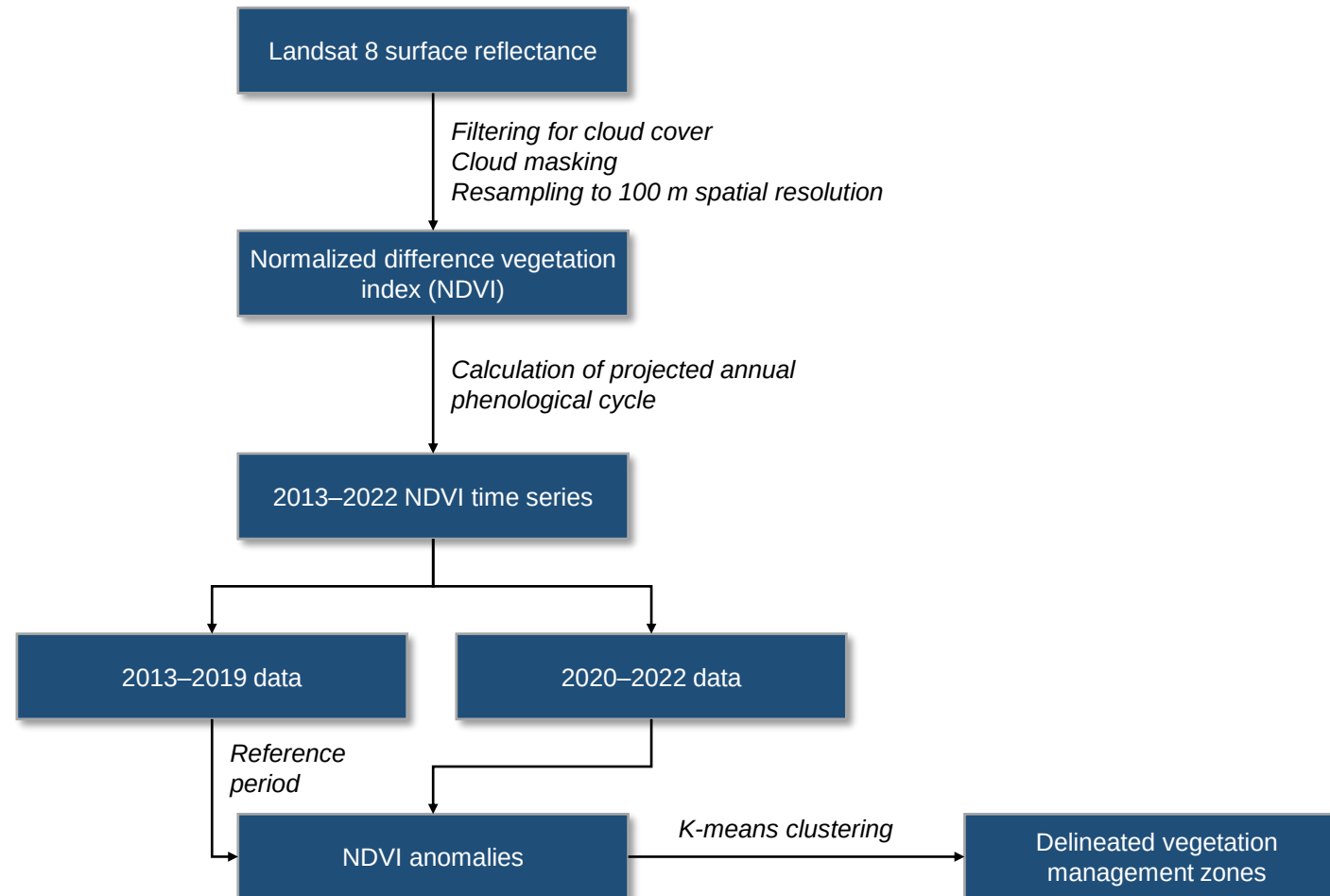
- Previous studies evaluated vegetation indices for phenology analysis, but a **research gap** remained in methods that both detect vegetation changes and establish geospatial management zones.
- **Objective:** propose a straightforward, robust method to detect vegetation changes using Landsat 8 imagery for a **10-year phenology analysis (2013–2022)** of Nature Park Kopački rit, Croatia.
- Main components of the proposed method:
 - phenology analysis and NDVI anomaly detection
 - unsupervised k-means classification of vegetation management zones

Study area – Nature Park Kopački rit

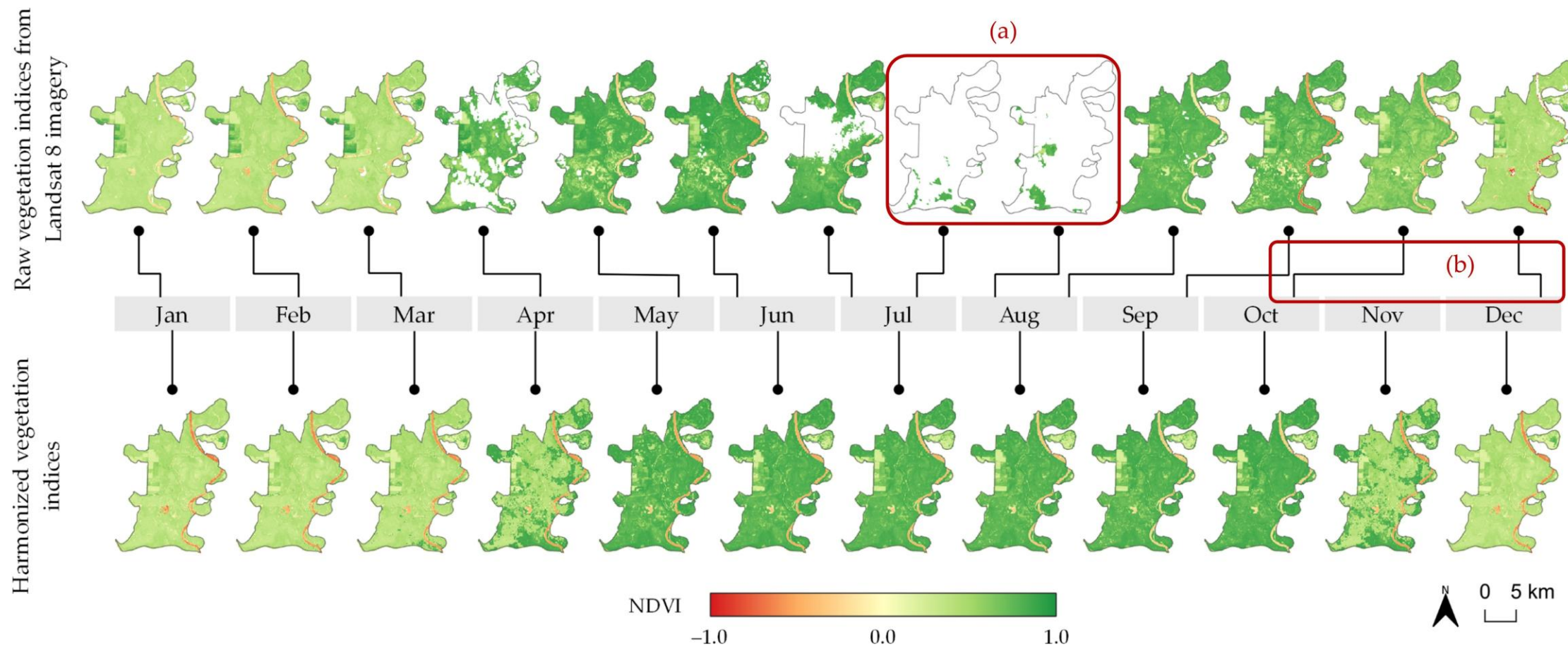
- **177 km²** of ecologically diverse wetland along the Danube River in eastern Croatia
- Dominant vegetation: floodplain forests of white willow, elevated forests of black poplar and pedunculate oak, and aquatic vegetation (duckweed, water lilies, bulrushes)



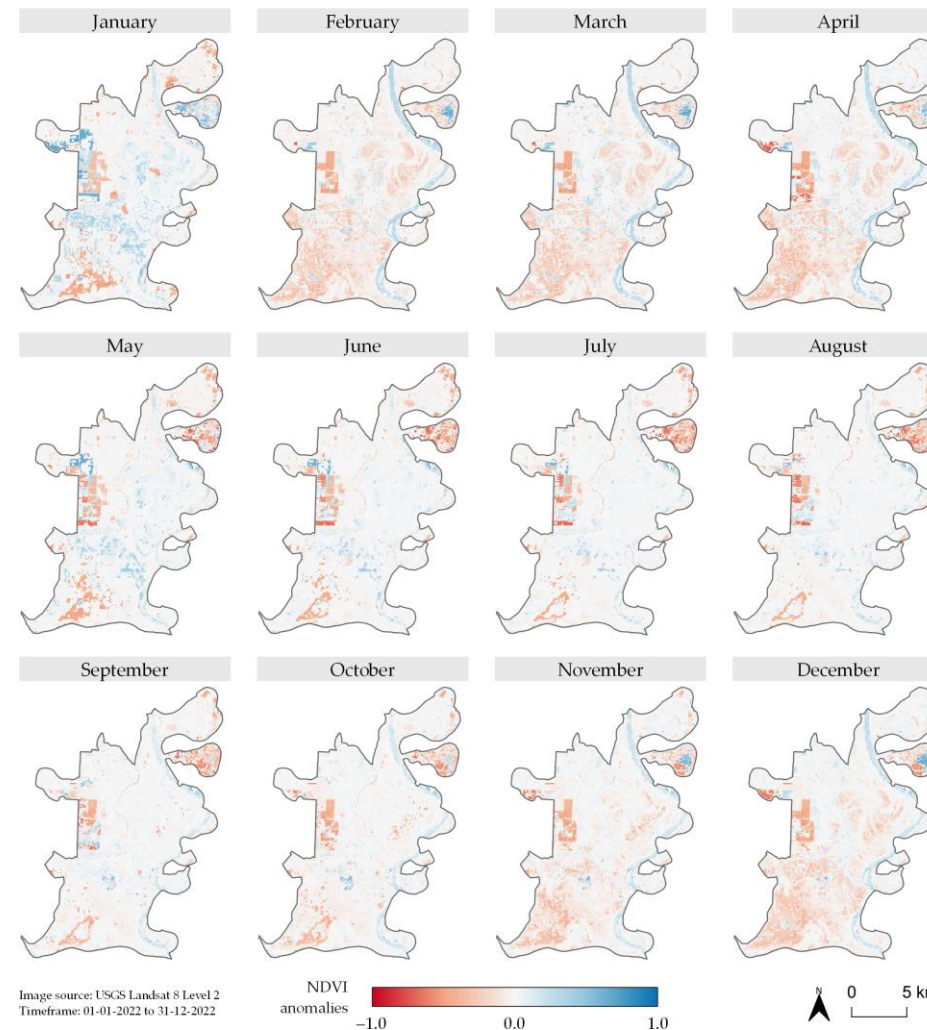
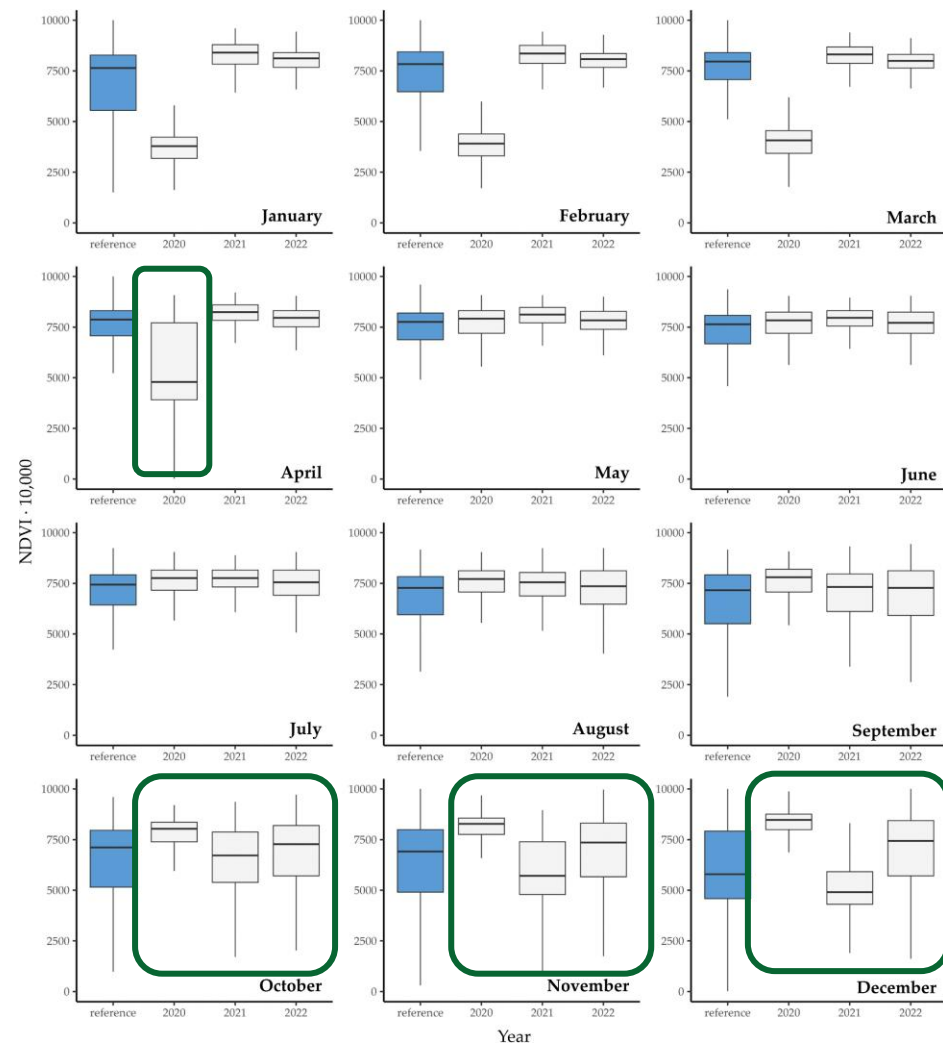
Data & methods overview



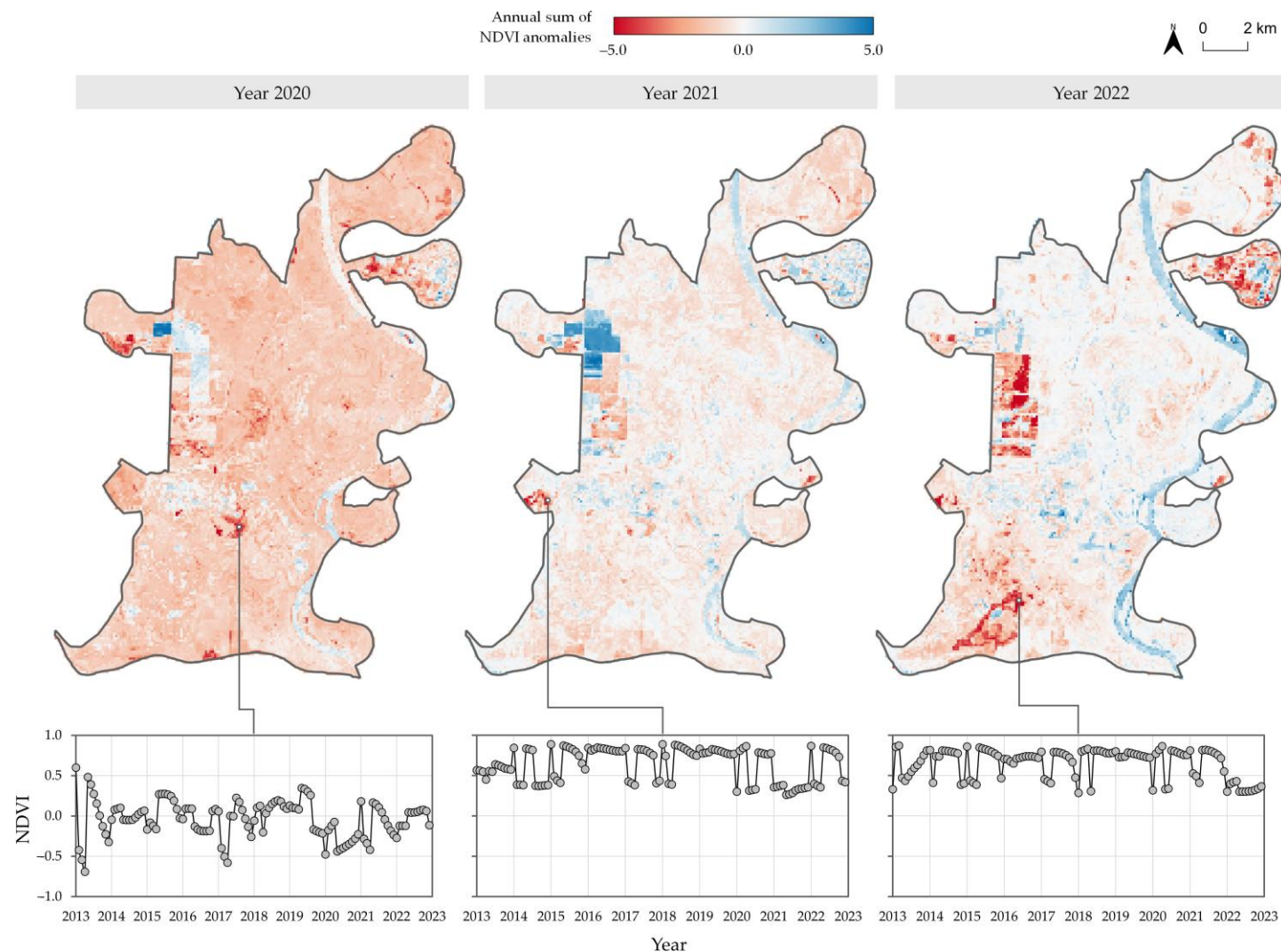
Phenology analysis



Results: monthly NDVI distribution shifts

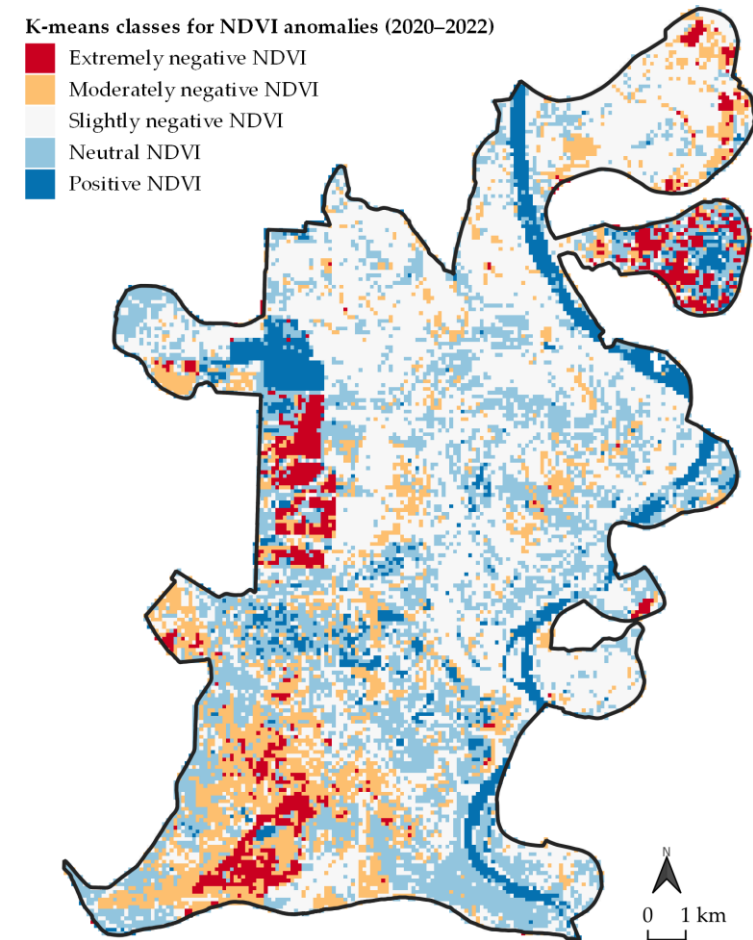


Results: NDVI anomalies, 2020–2022



Results: vegetation management zones

- Five k-means classes ranged from **extremely negative to positive** NDVI anomalies
- Three negative classes covered **64.1%** of the study area
- Extremely negative anomalies increased sharply from 2020 to 2022
- Positive anomalies concentrated in arable cropland and water bodies, reflecting crop rotation rather than degradation



NDVI anomaly classes & area coverage

Class	Annual sum 2020	Annual sum 2021	Annual sum 2022	Average	Area (%)
Extremely negative NDVI	-13,598	-8,770	-34,921	-19,097	4.9%
Moderately negative NDVI	-17,768	-7,965	-10,917	-12,217	15.2%
Slightly negative NDVI	-14,916	-4,606	-77	-6,533	44.0%
Neutral NDVI	-8,599	1,355	-687	-2,643	28.3%
Positive NDVI	3,273	15,527	15,908	11,569	7.5%

Practical value & recommendations

- Classified maps can be used by **Nature Park management** for monitoring, **ecologists** for research, and **policymakers** for informed decision-making
- Areas with the highest and lowest NDVI anomalies should be prioritized for **comprehensive field observation** to determine environmental or anthropogenic causes
- This approach significantly reduces the need for extensive fieldwork, letting biologists focus effort on areas with detected abnormal vegetation activity

Limitations & future work

- Months with little or no cloud-free data can bias NDVI calculations; **ground-truthing** remains difficult due to accessibility
- **Climate data** (temperature, precipitation, soil moisture) was not yet integrated, though it could clarify natural vs. anthropogenic drivers
- Higher-resolution imagery (**Sentinel-2, 10 m; PlanetScope, 3 m**) and longer study periods combining earlier Landsat missions would sharpen detection of smaller-scale changes

Acknowledgements

- This research was supported by the **Tech4All program**, under project “Wetland and wildlife monitoring using technology and acoustics” (**WatchOut**)
- Published in: Radočaj, D., Plaščak, I., Jurišić, M., Majić, I., Ozimec, S., Sarajlić, A., & Rožac, V. (2024). Phenology Analysis for Detection of Vegetation Changes Based on Landsat 8 Images in Nature Park Kopački rit, Croatia. *Geographica Pannonica*, 28(4), 238–249.
 - <https://doi.org/10.5937/gp28-50802>



Josip Juraj Strossmayer
University of Osijek
Faculty of
Agrobiotechnical
Sciences Osijek



KOPAČKI
RIT
Park prirode
Nature Park



Thank you for your
attention!