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Reed analysis and classification

Interreg
AUSTRIA–HUNGARY

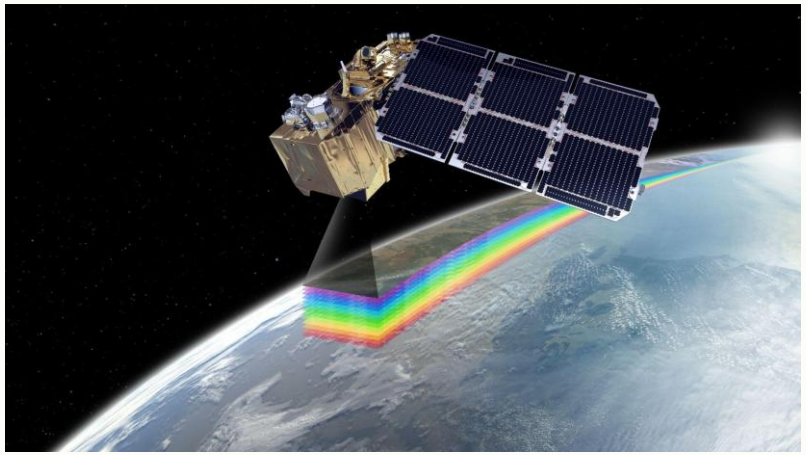
Co-funded by the European Union

NeuBaSe
A GREEN AND RESILIENT BORDER REGION

Data Acquisition

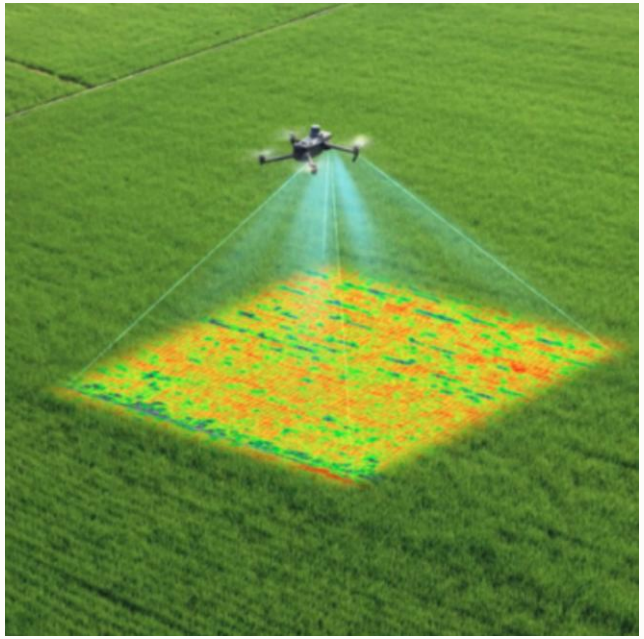
Sentinel-2 Satellite

- Comprehensive observation from the lake
- Continuous spectral data (every 5 days)
- Open source and data since 2017.



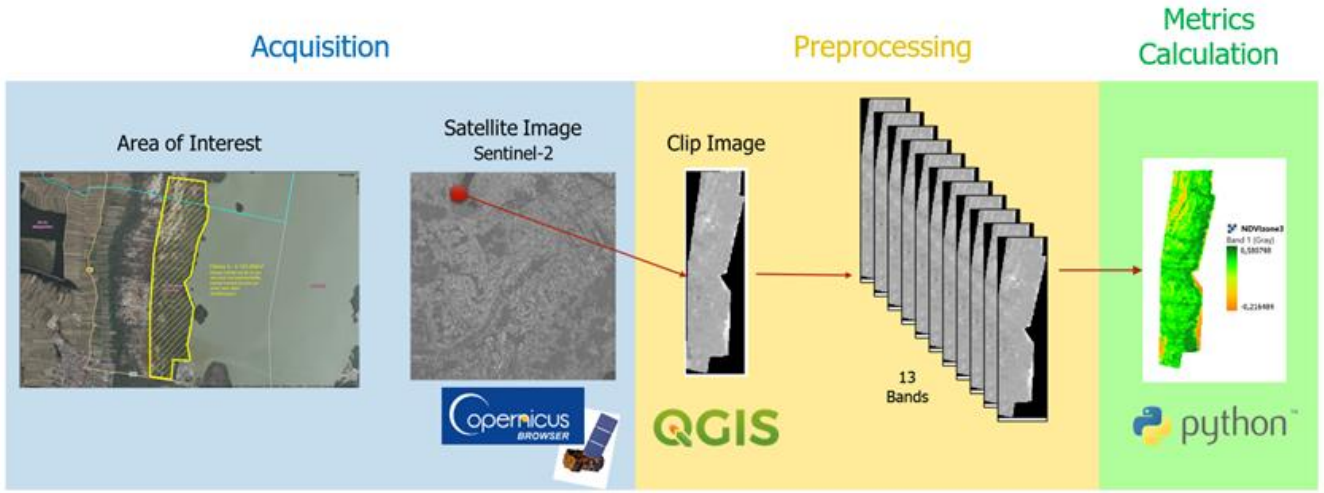
Drone with multispectral camera

- More flexible and detailed recordings for targeted monitoring
- Individual selection of sensors and flight routes

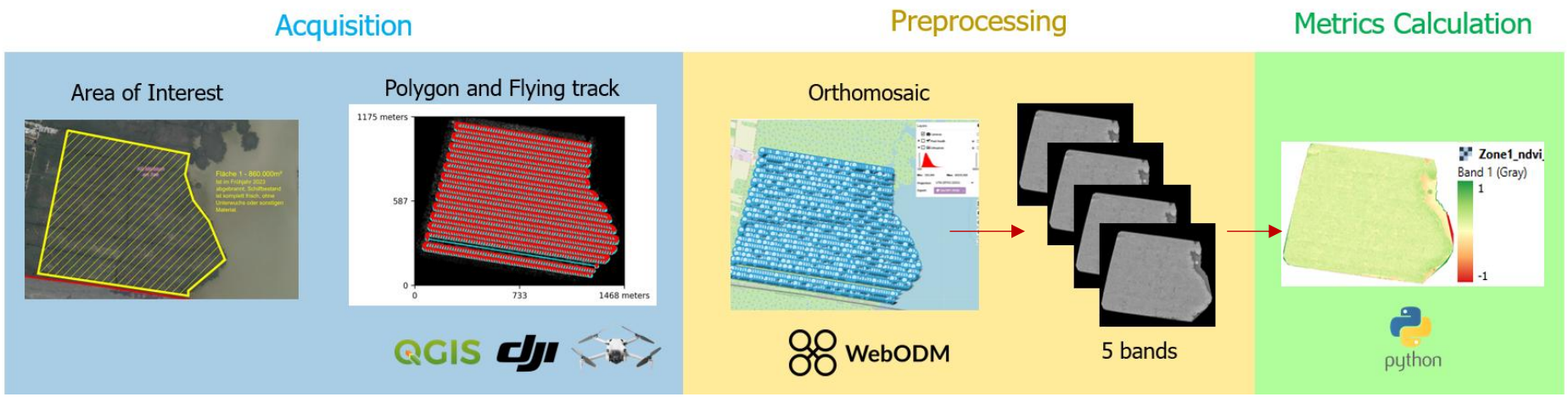


Analytical methods

- **Sentinel-2 Satellite**

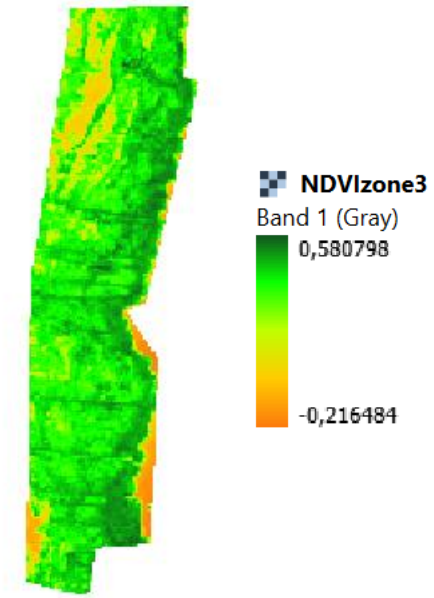


- **Drone**



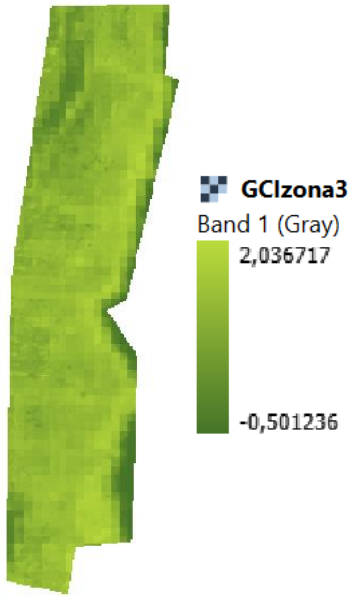
Vegetation metrics

NDVI
(Normalized Difference Vegetation Index)



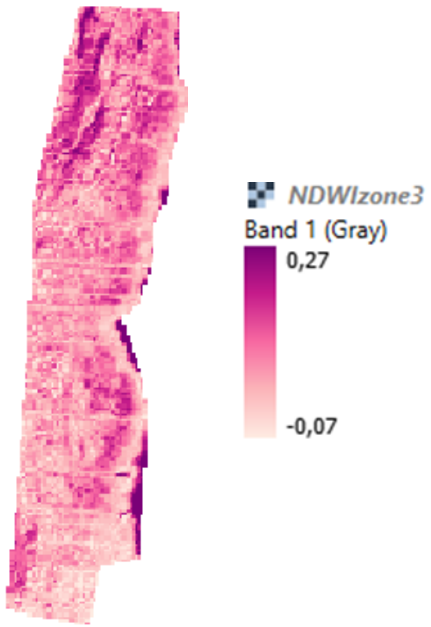
Assesses the condition and the density of the vegetation

GCI
(Green Chlorophyll Index)



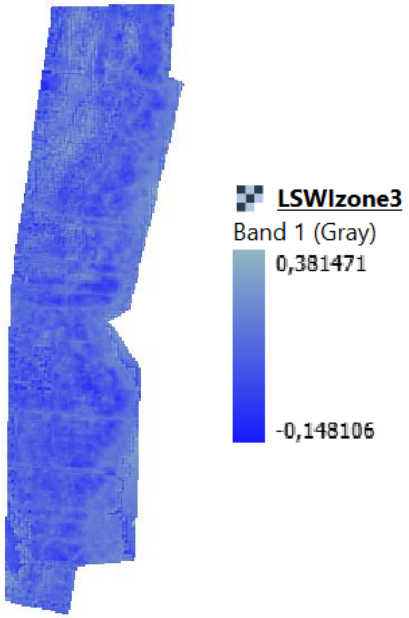
Calculates the condition of the plants, and the chlorophyll content

NDWI
(Normalized Difference Water Index)



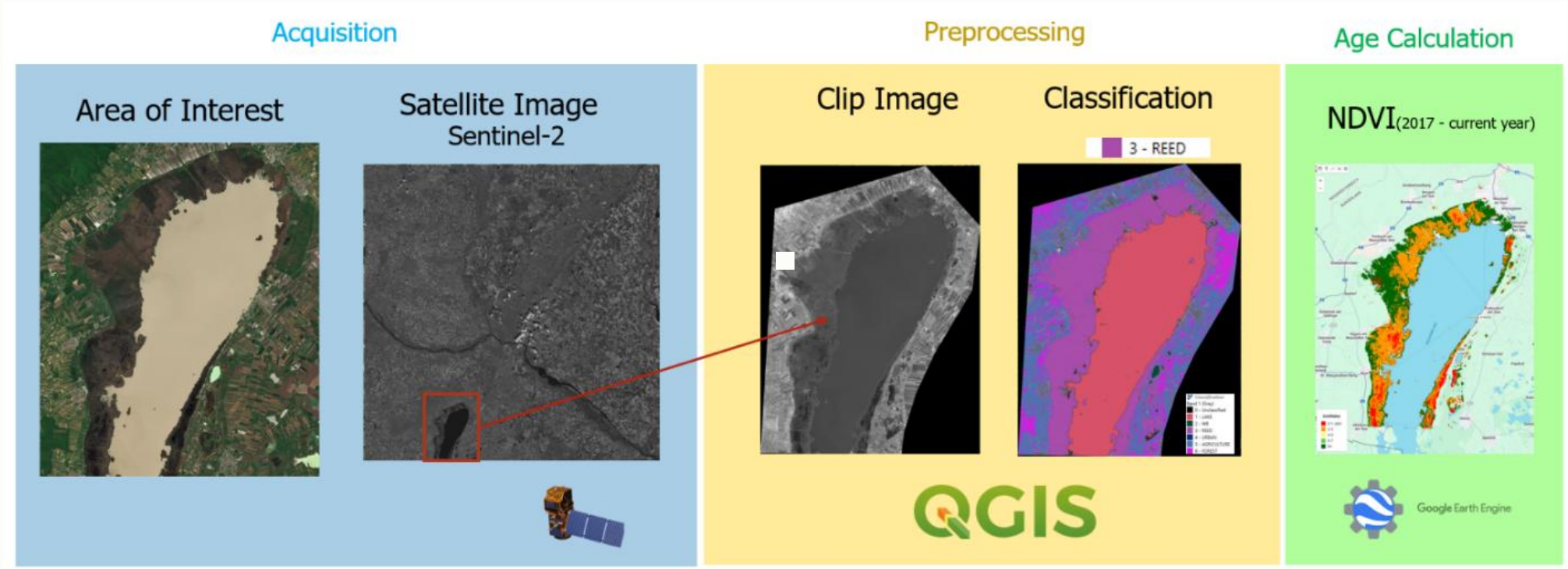
Identification and mapping of water surfaces

LSWI
(Land Surface Water Index)



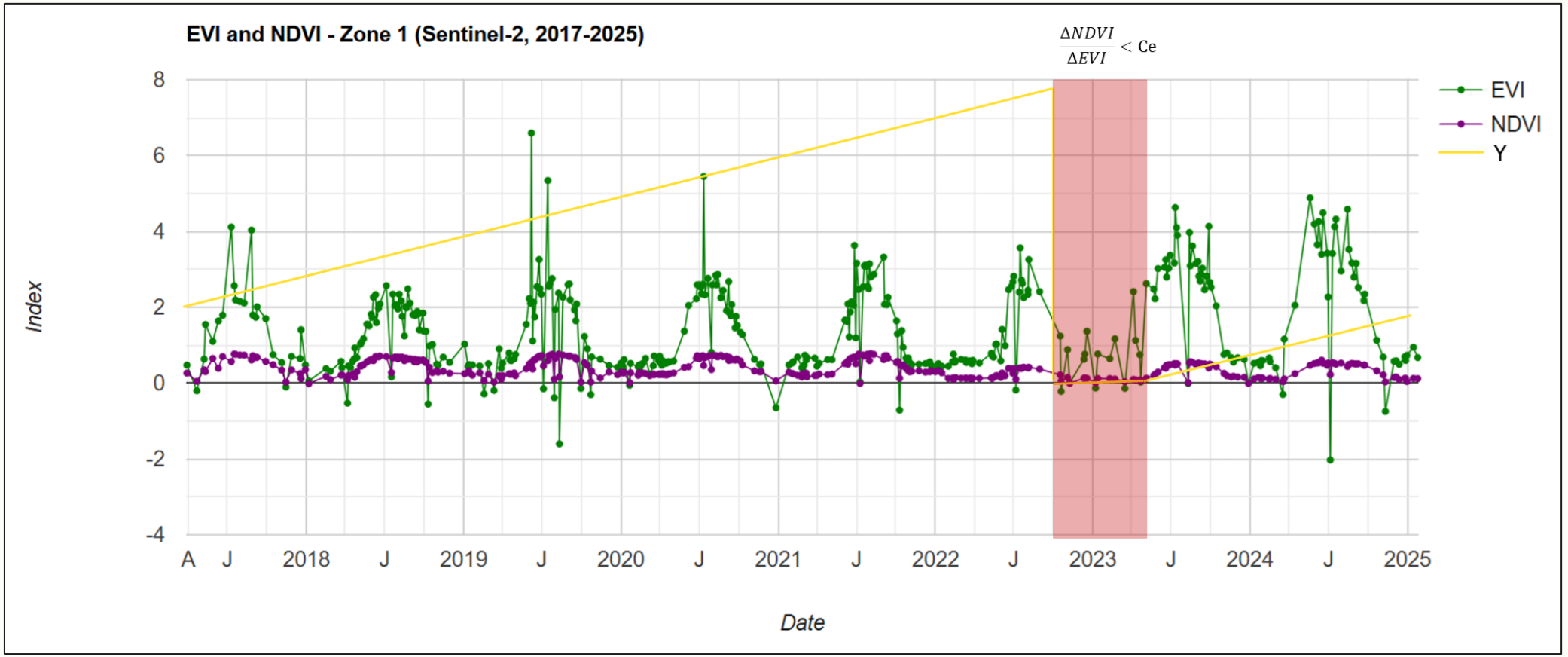
Measures the moisture of the surface and recognizes water stress in plants

Classification Method



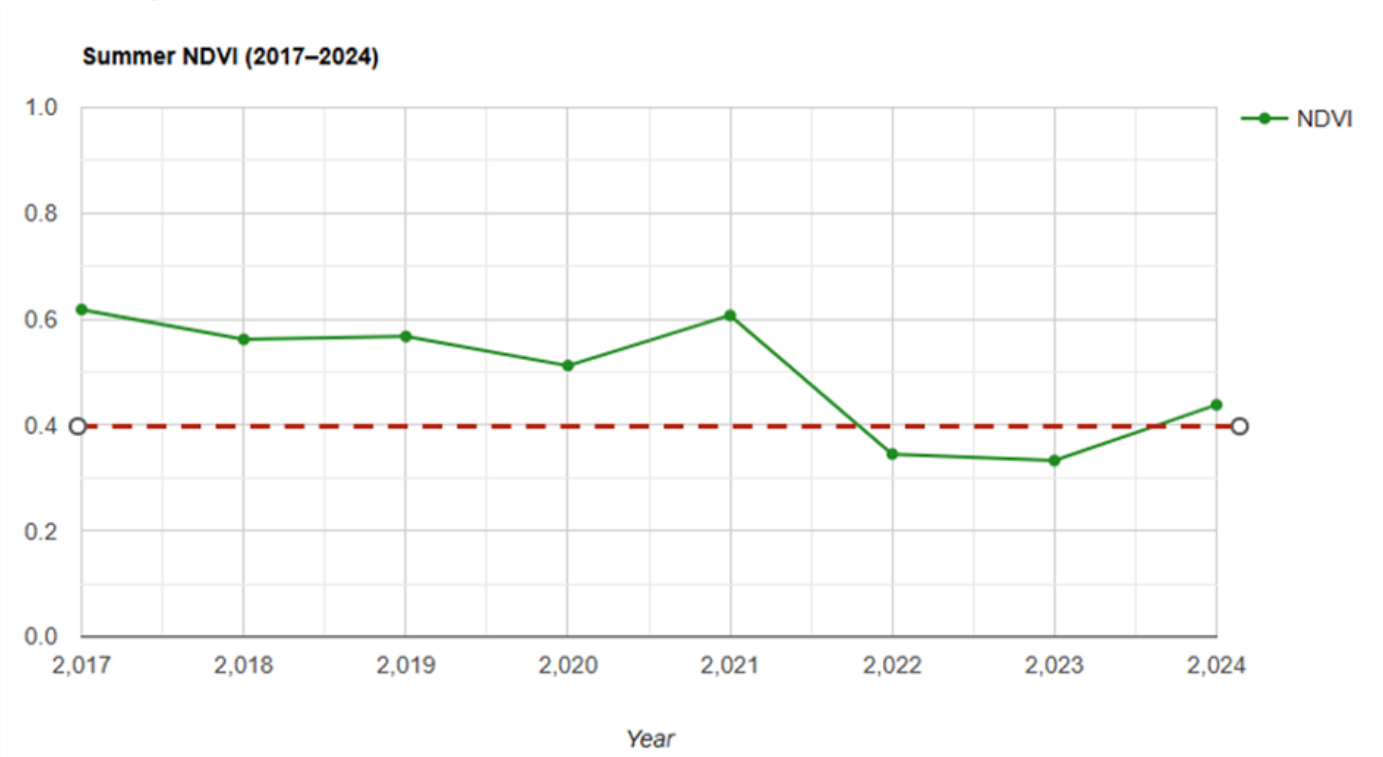
Reed classification

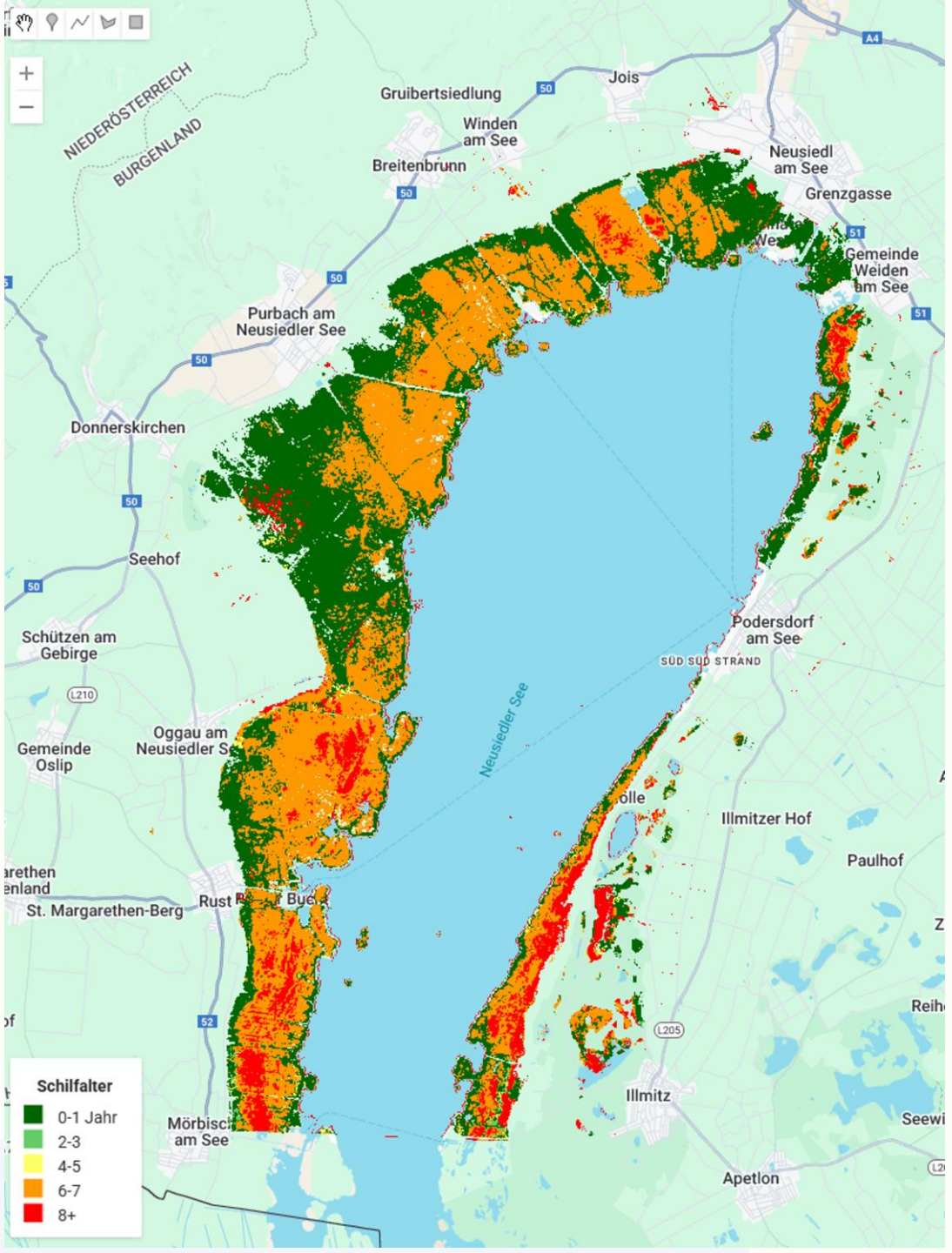
- **Spectral Analysis**
  - Time series / Pattern Recognition



Reed classification

- Age Classification





NeuBaSe

Reed Analysis

Reed management

Ecosystem Balance

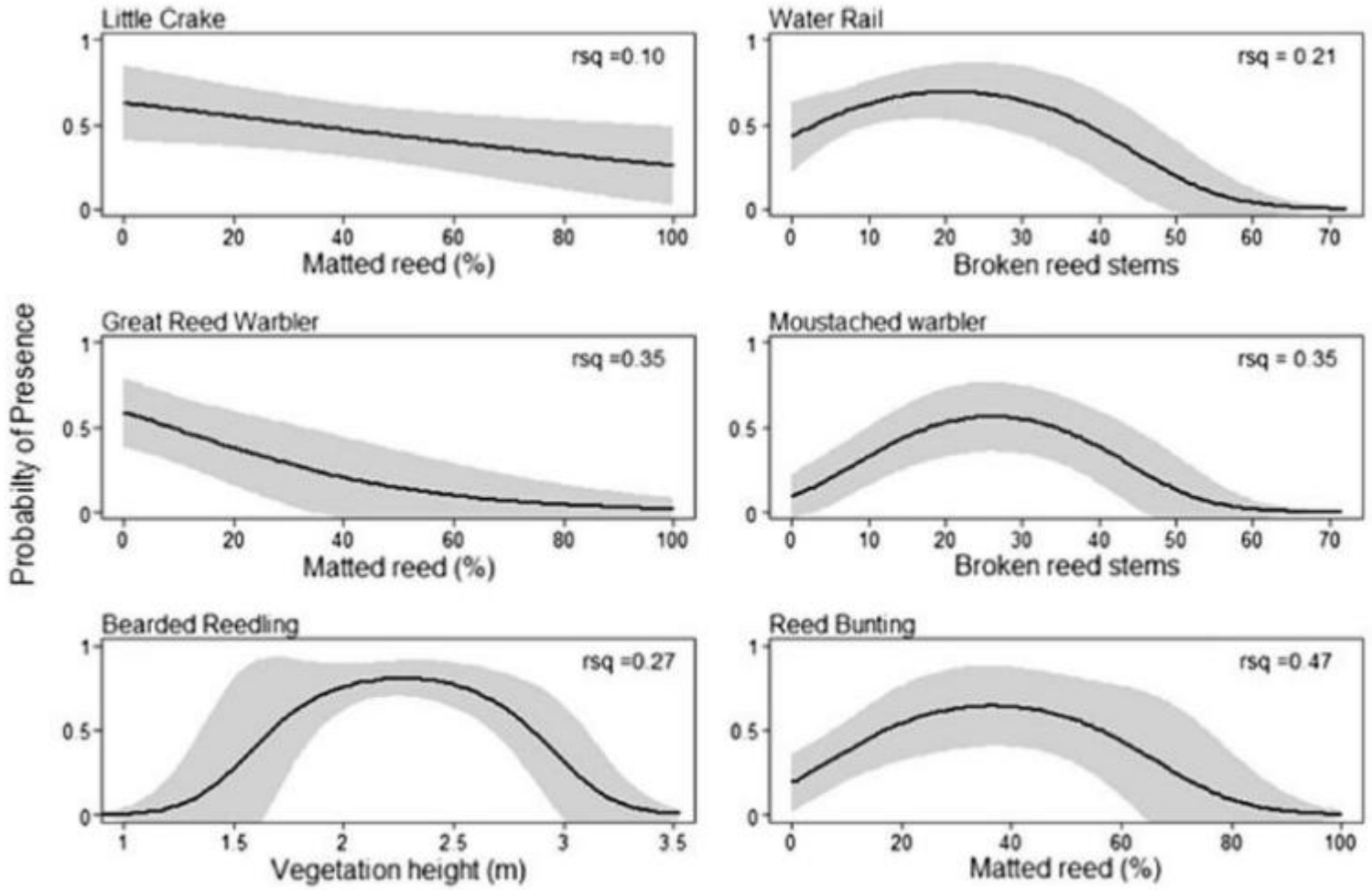


Figure 4. Relationships between bird presence and habitat variables linked to reed die-back. (Nemeth & Dvorak, 2022)

WP3

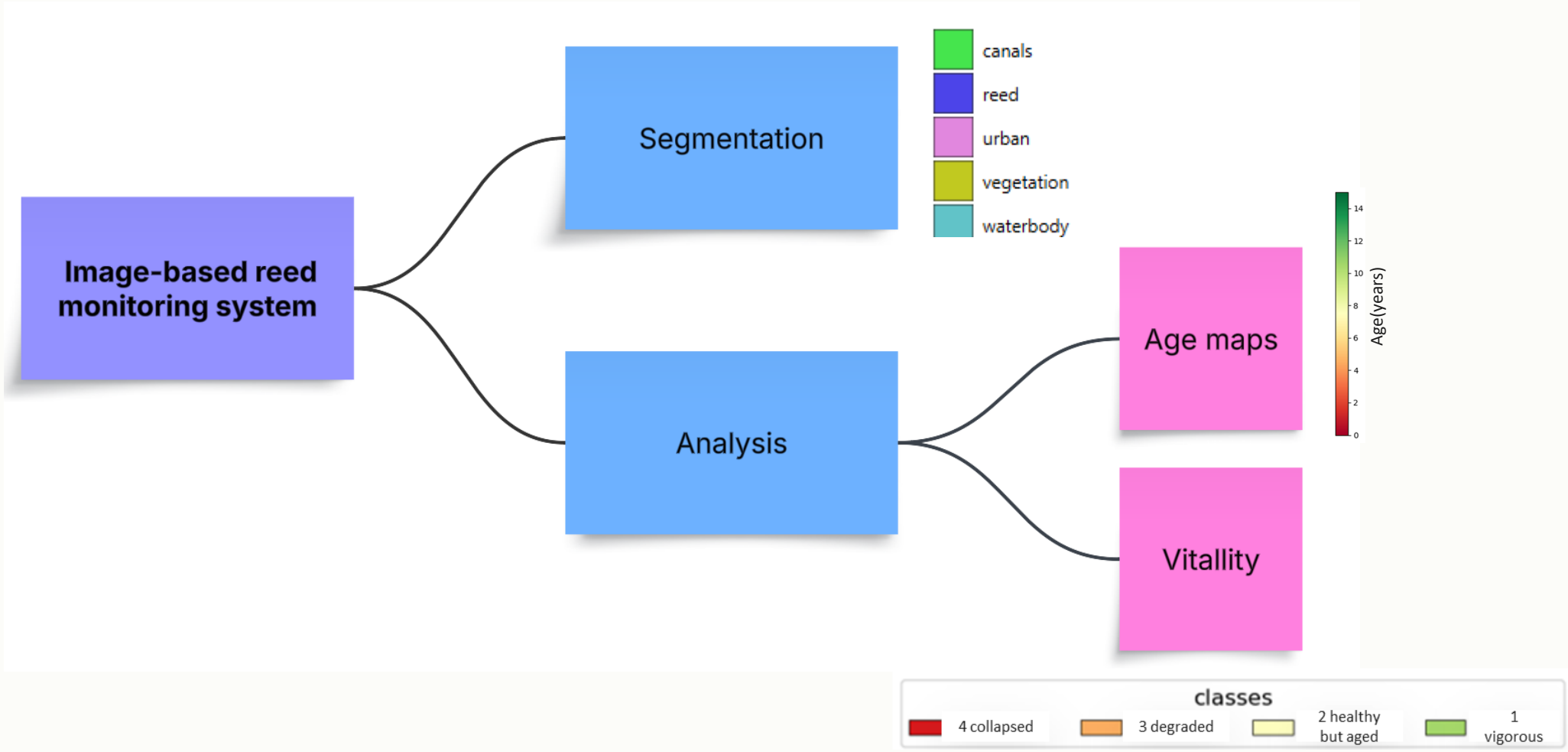
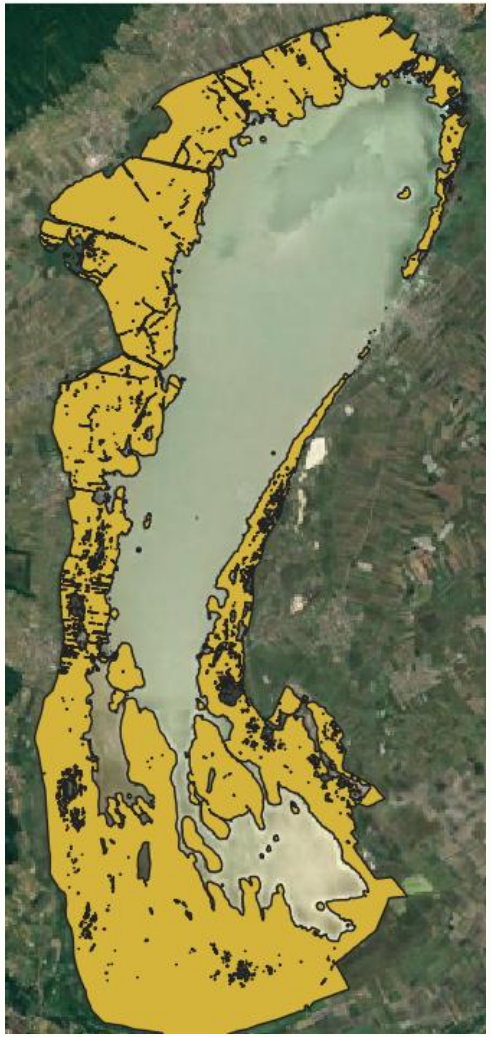


Image-based reed monitoring system
Segmentation
Analysis
canals
reed
urban
vegetation
waterbody
Age maps
Vitallity
Age(years)
0
2
4
6
8
10
12
14
classes
4 collapsed
3 degraded
2 healthy but aged
1 vigorous

Reed Segmentation 2025



```
Count in pixels:):
 4         Vegetation: 428042
 5         Bare soils: 6870
 6              Water: 8089
 7      Unclassified: 5674
 8      Cloud medium: 1
```

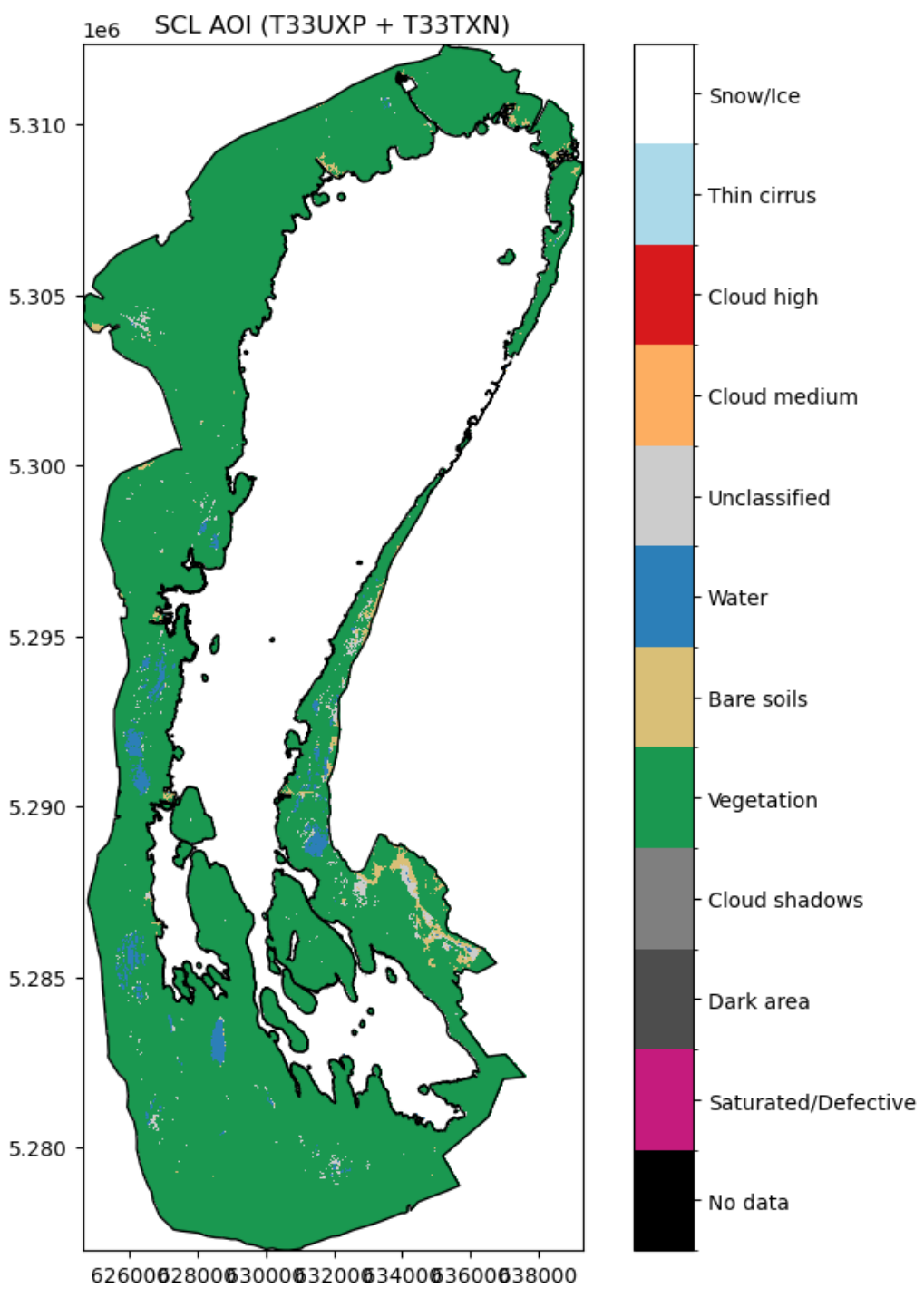
Ortophotos 2022
Geodaten Burgenland

Sentinel 2

NDWI

Water bodies

Brown water



Reed Segmentation2025

Data input

Samples
-Urban
-Canals
-Water
-Vegetation
-Reed

Rasters
Orthophotos 2025
Geodaten Burgenland

Shapefiles
-Wasserfläche AT 2022
-Schilfgrenze AT 2022
-Nádas HU 2017

Preprocessing

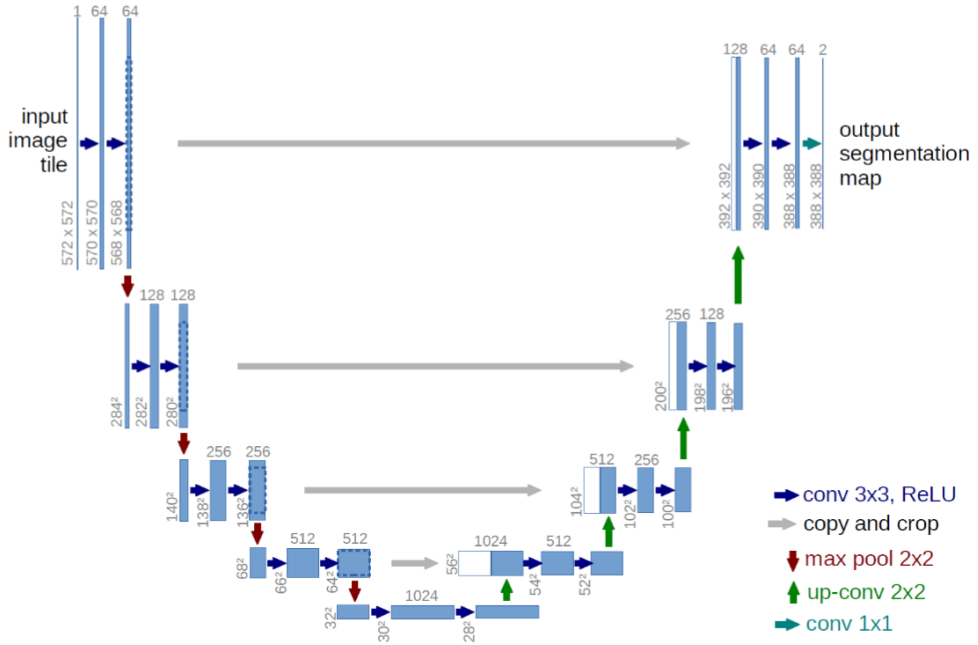
Samples
-Normalization
-Augmentation

Ortophoto
-AOI setting
- Tile cutting

Training tiles
-Samples Annotation

Modeling

1)Training



2)Metrics Evaluation

3)Tile inference

Postprocessing

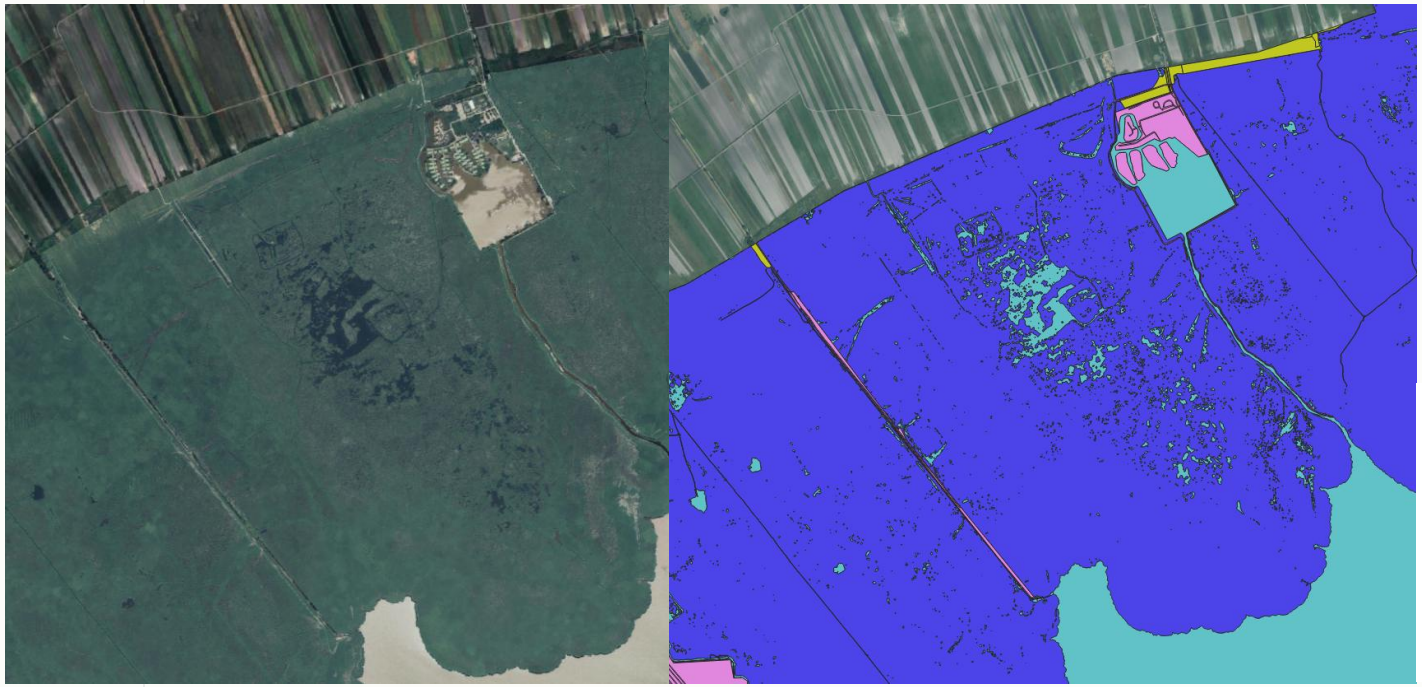
Majority Filter
-Noise reduction

Vectorization

Reed Classification 2025

TRUE CLASS	PREDICTED CLASS			
	Vegetation (1)	Waterbody (2)	Urban (4)	Row Total
Reed (1)	**49.501**	49	450	**50.000**
Waterbody (2)	69	**42.152**	4.069	**46.290**
Urban (3)	355	4.225	**45.420**	**50.000**
Column Total	**49.925**	**46.426**	**49.939**	**146.290**

Class	Precision	Recall	F1-score	Support (pixels)
Vegetation (1)	0,992	0,990	0,991	50.000
Water (2)	0,908	0,911	0,909	46.290
Urban (3)	0,910	0,908	0,909	50.000
Macro avg	**0,936**	**0,936**	**0,936**	**146.290**
Weighted avg	**0,937**	**0,937**	**0,937**	**146.290**
Overall accuracy	—	—	**0,937**	**146.290**



Reed Classification

HARVESTED AREAS

Sentinel 2 – 10 m , 20 m

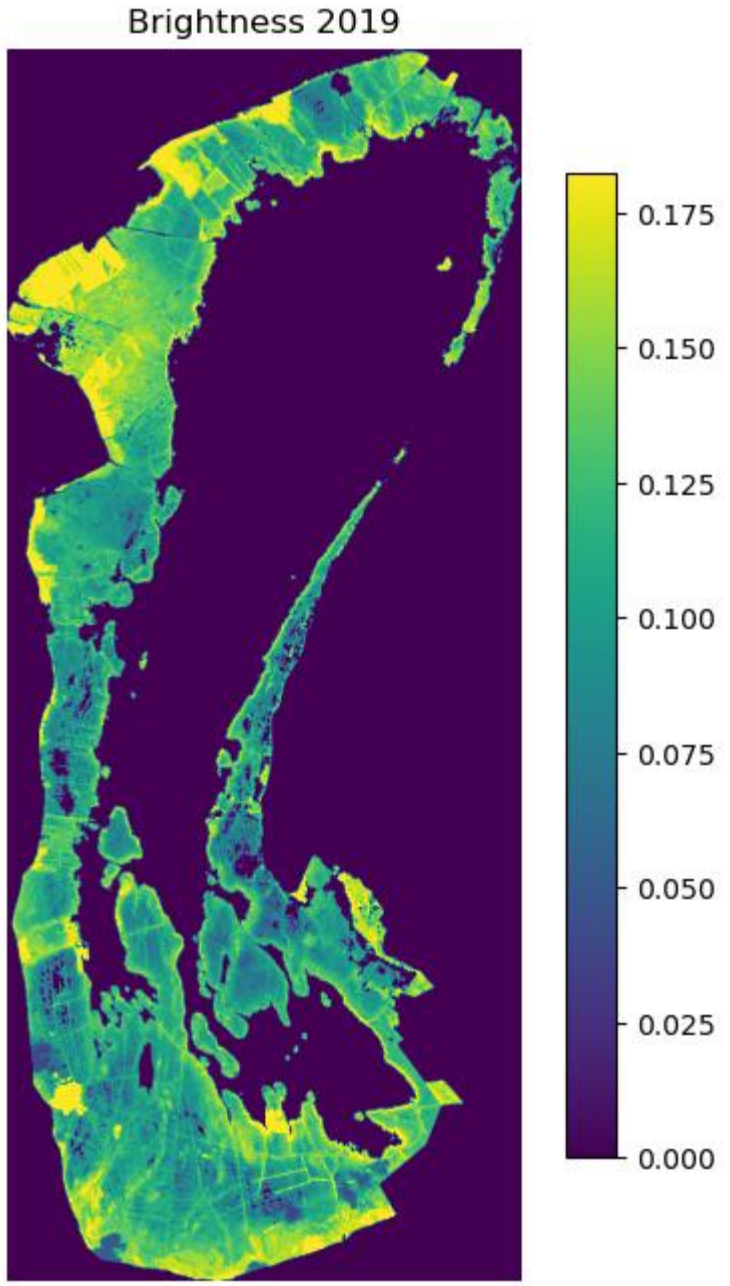
Brightness $\frac{Blue + Green + Red + NIR}{4}$

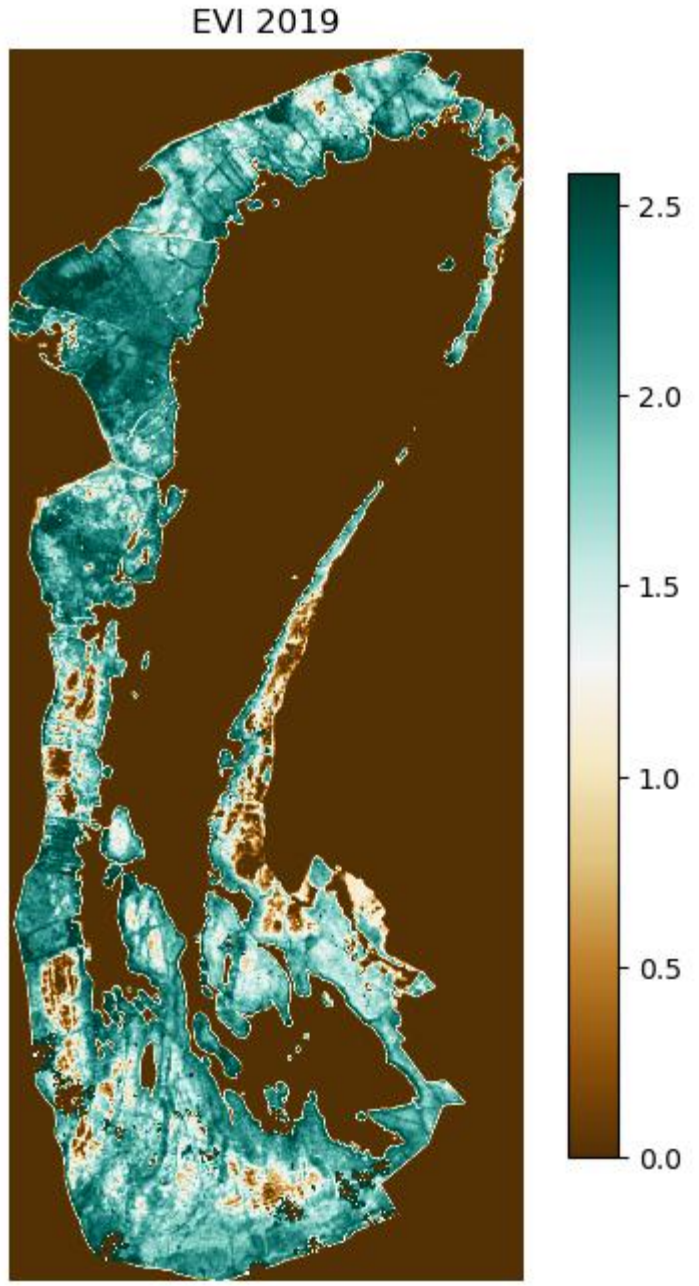
EVI $G\frac{(NIR-Red)}{(NIR * C_1 * Red - C_2 * Blue + L)}$

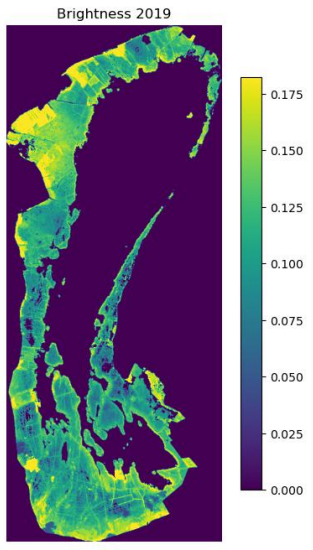
Spring images (April)

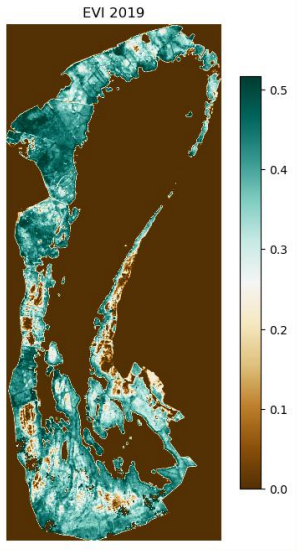
Reed Classification

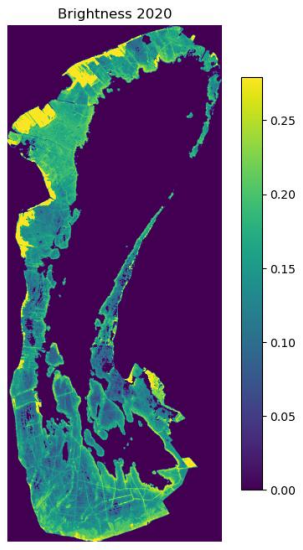
HARVESTED AREAS

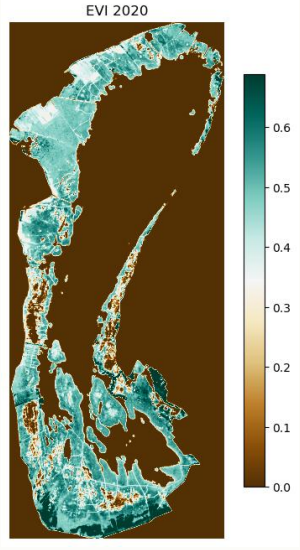


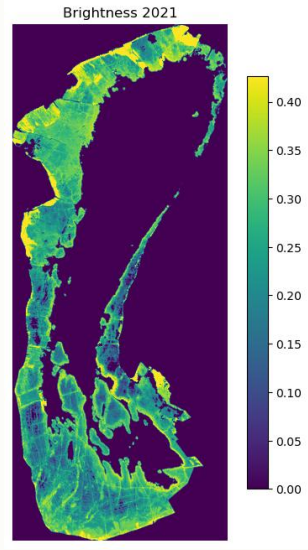


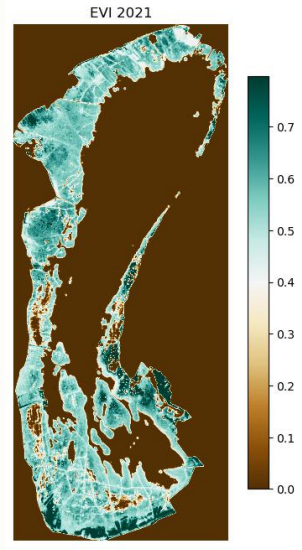

Brightness 2019
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000


EVI 2019
0.5
0.4
0.3
0.2
0.1
0.0


Brightness 2020
0.25
0.20
0.15
0.10
0.05
0.00


EVI 2020
0.6
0.5
0.4
0.3
0.2
0.1
0.0

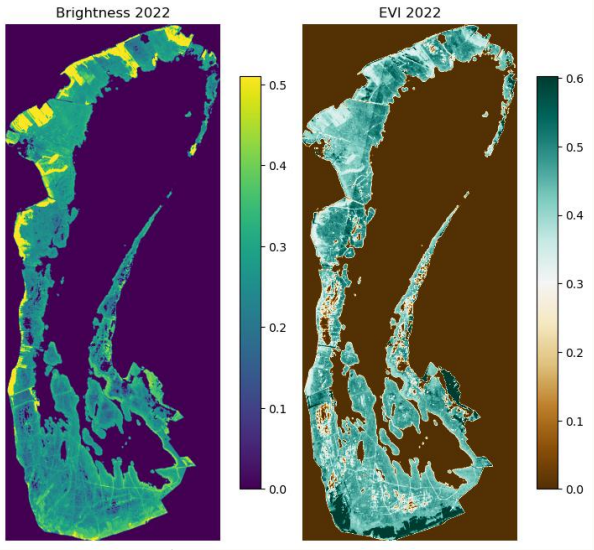

Brightness 2021
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00

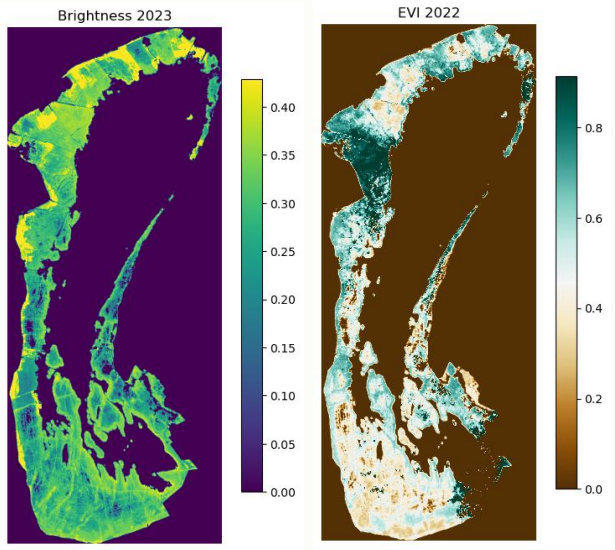

EVI 2021
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0

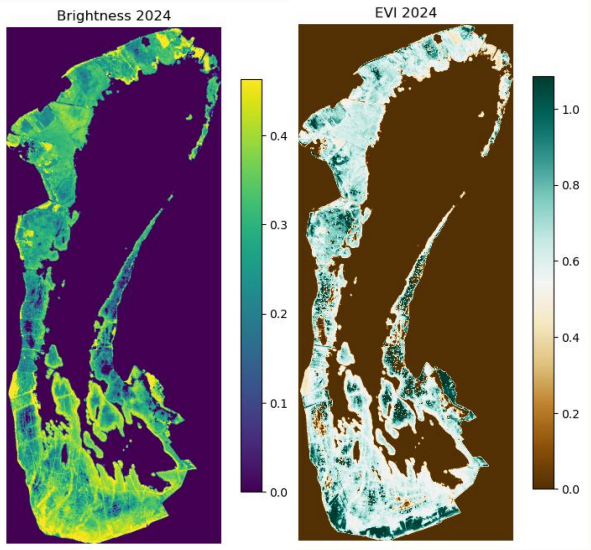

Harvested areas 2019 - 90 percentile

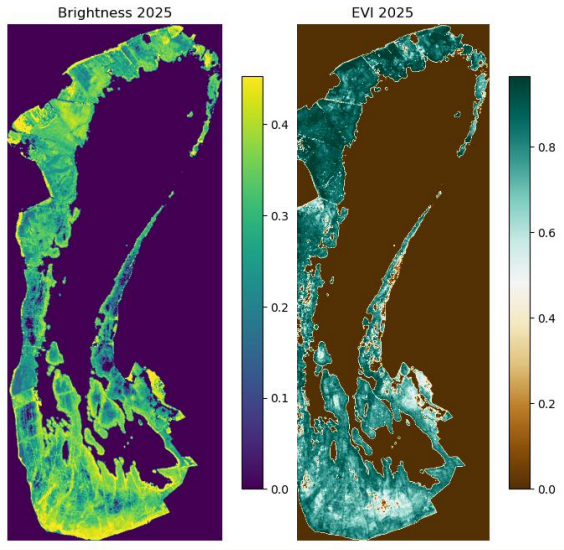

Harvested areas 2020 90 percentile)


Harvested areas 2021 90 percentile


Brightness 2022
EVI 2022


Brightness 2023
EVI 2022


Brightness 2024
EVI 2024


Brightness 2025
EVI 2025


Harvested areas 2022 90 percentile


Harvested areas 2023 90 percentile)


Harvested areas 2024 90 percentile)

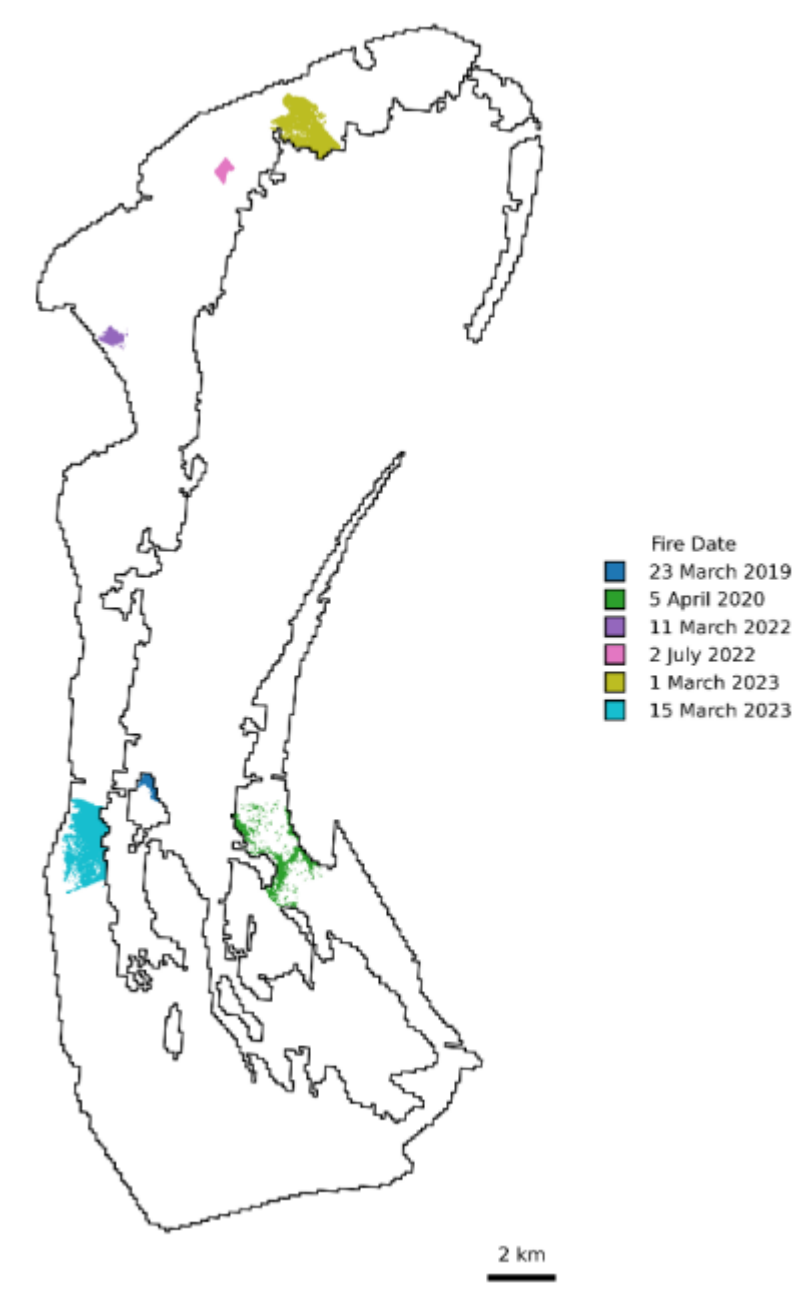

Harvested areas 2025 90 percentile

Reed Classification

BURN AREAS

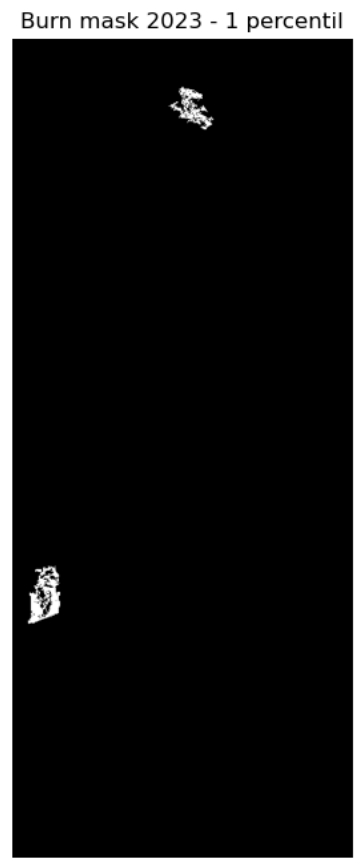
NBR $\frac{NIR-SWIR}{NIR+SWIR}$

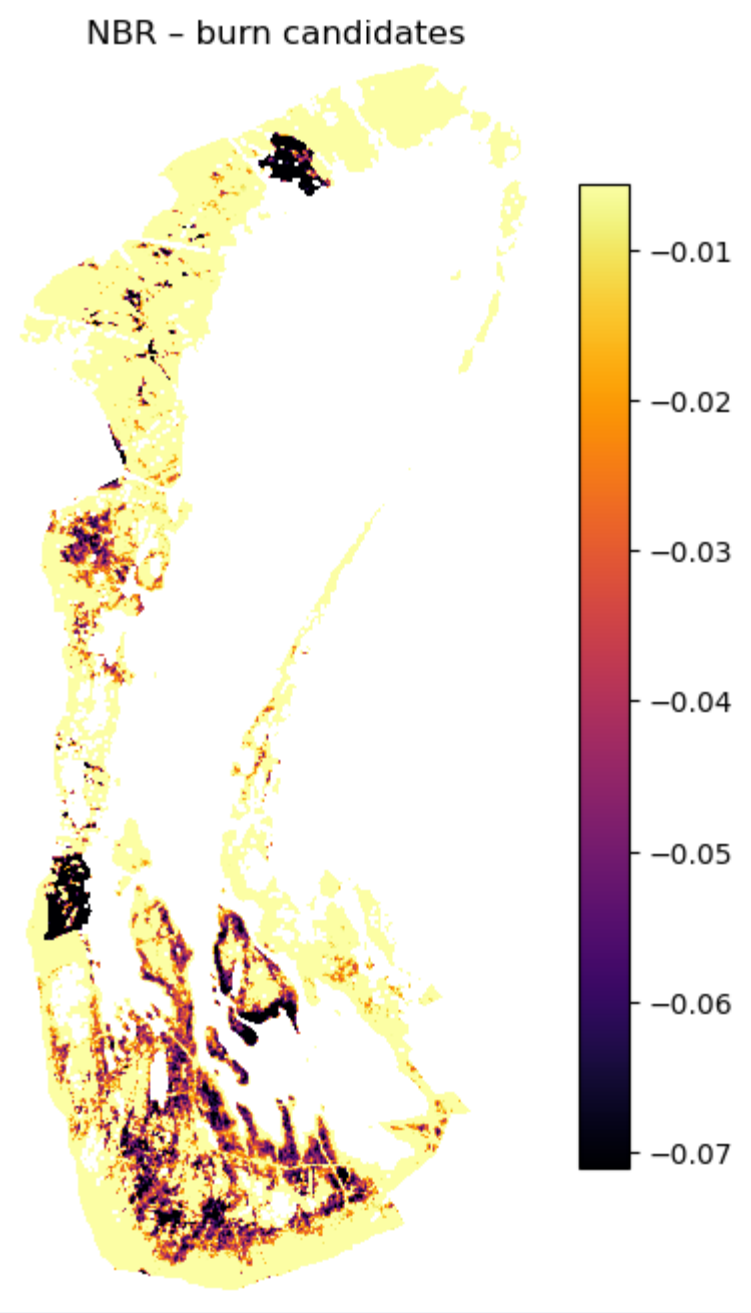
Date	Location	Burnt area of the Mask (ha)
23 July 2019	Southern Island in front of Mörbisch	20.8
5 April 2020	Illmitz	126.7
11 March 2022	Donnerskirchen	27.1
2 July 2022	Purbach	21.5
1st March 2023	Breitennbrunn	184.1
15 March 2023	Mörbisch	227.4



Reed Classification

BURN AREAS





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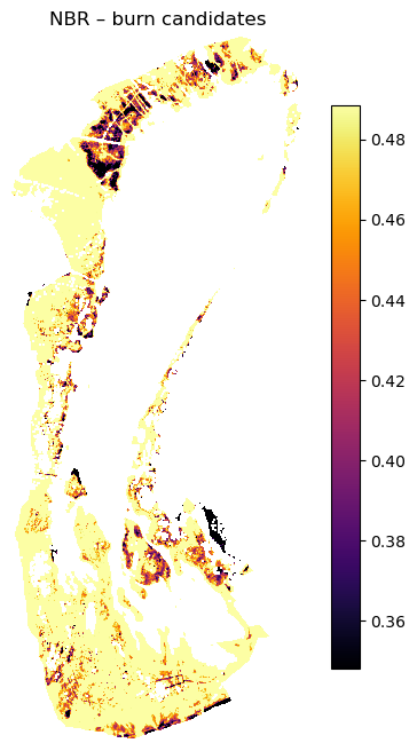

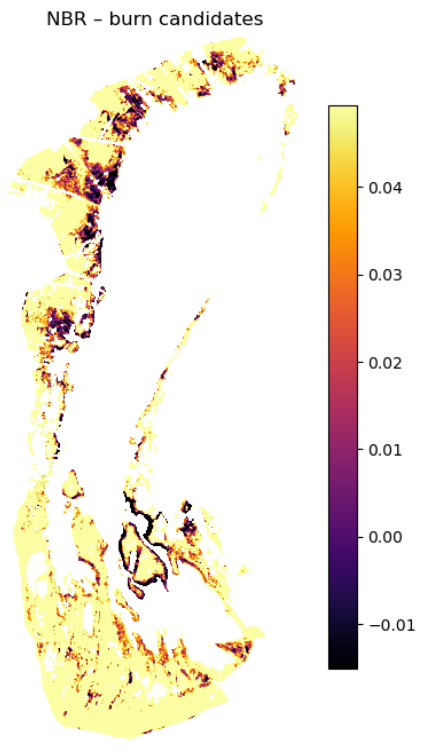

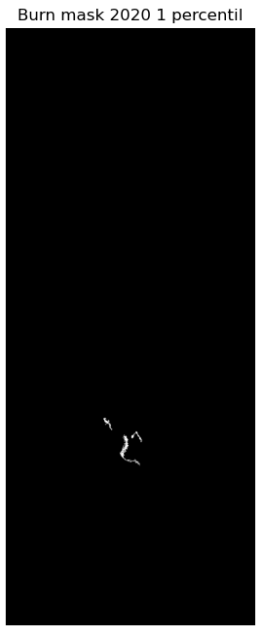

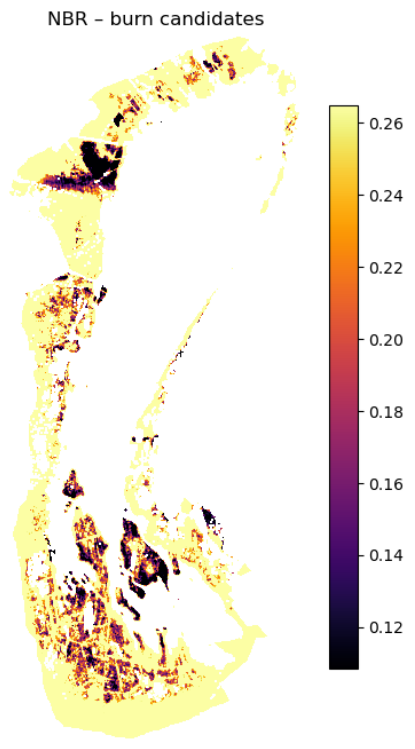

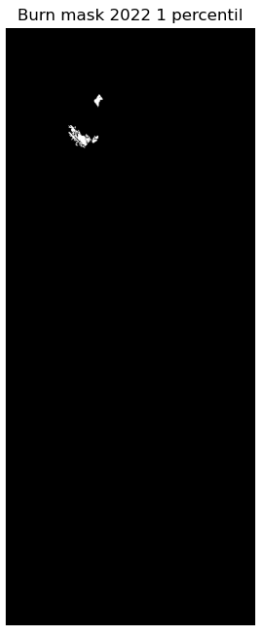

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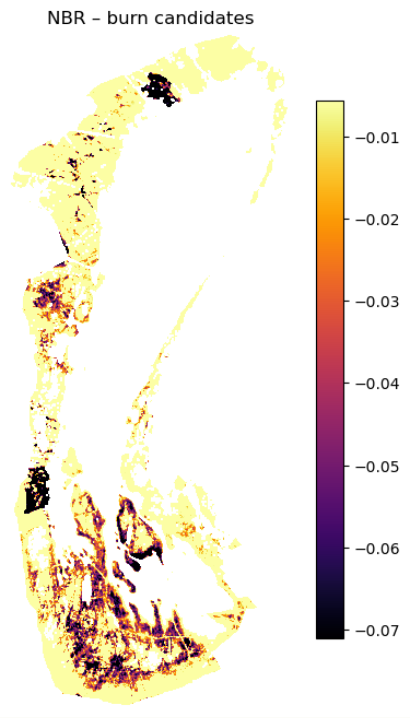

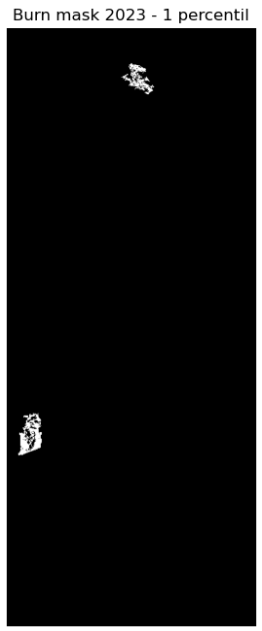

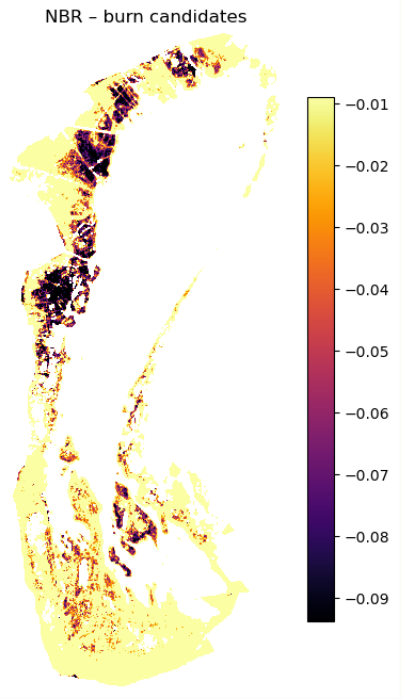

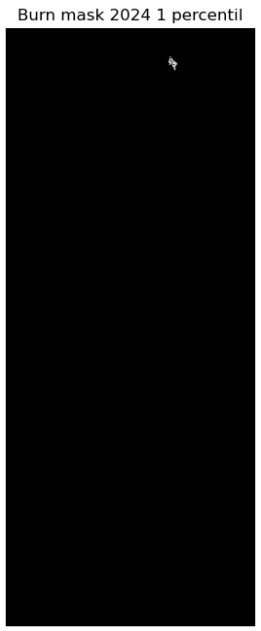

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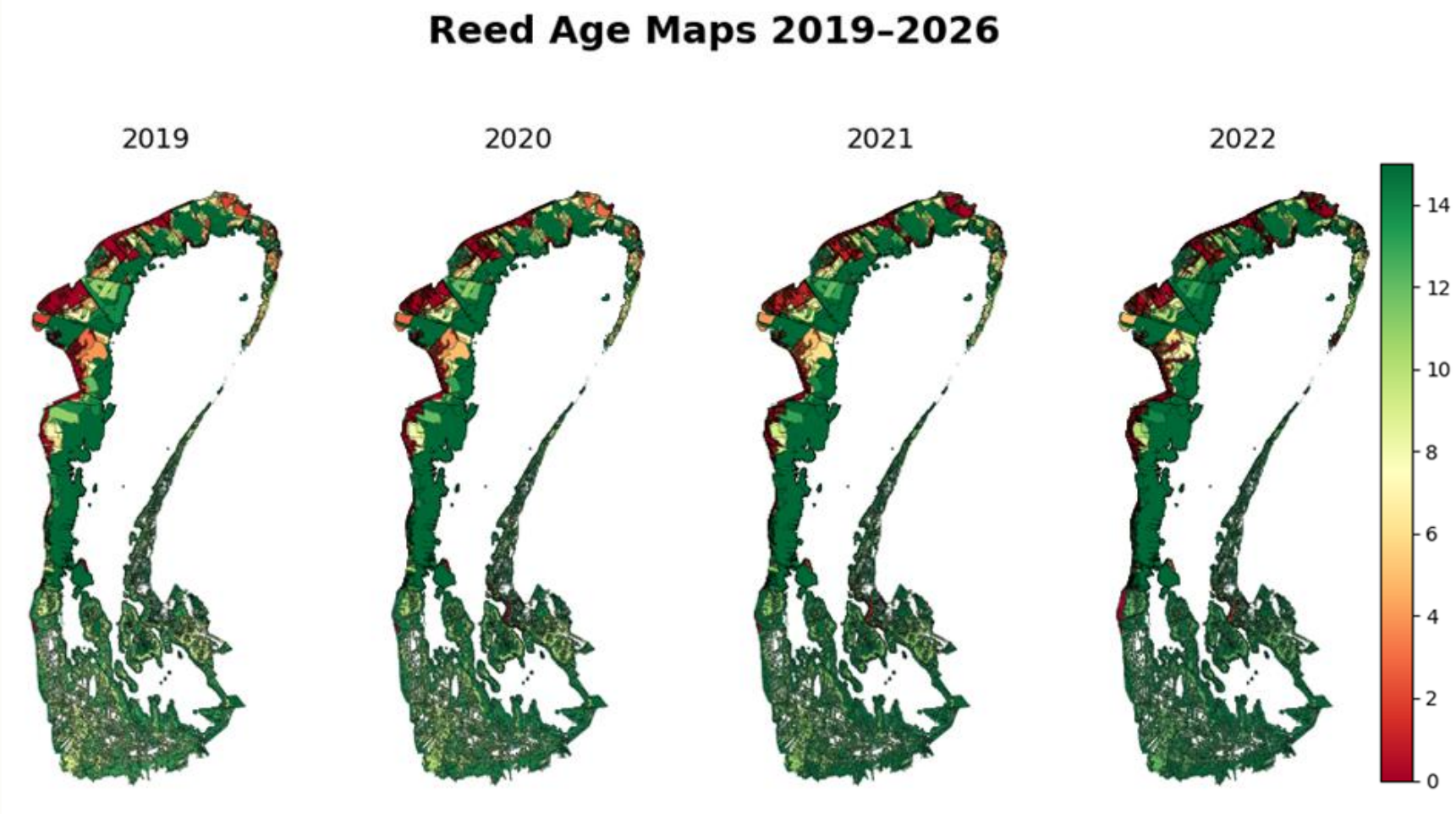
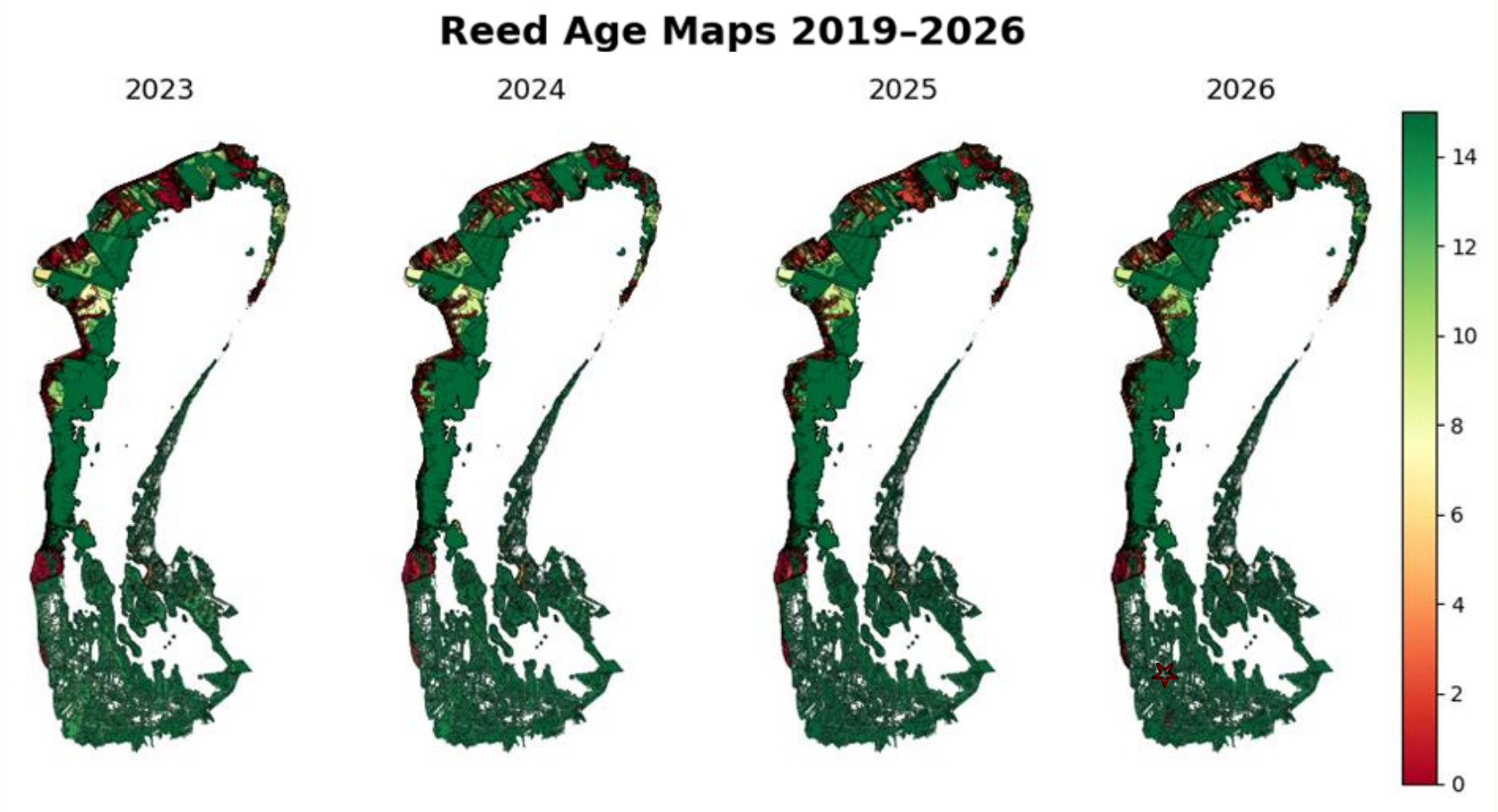


Reed Classification



Reed Classification

CLUSTERING

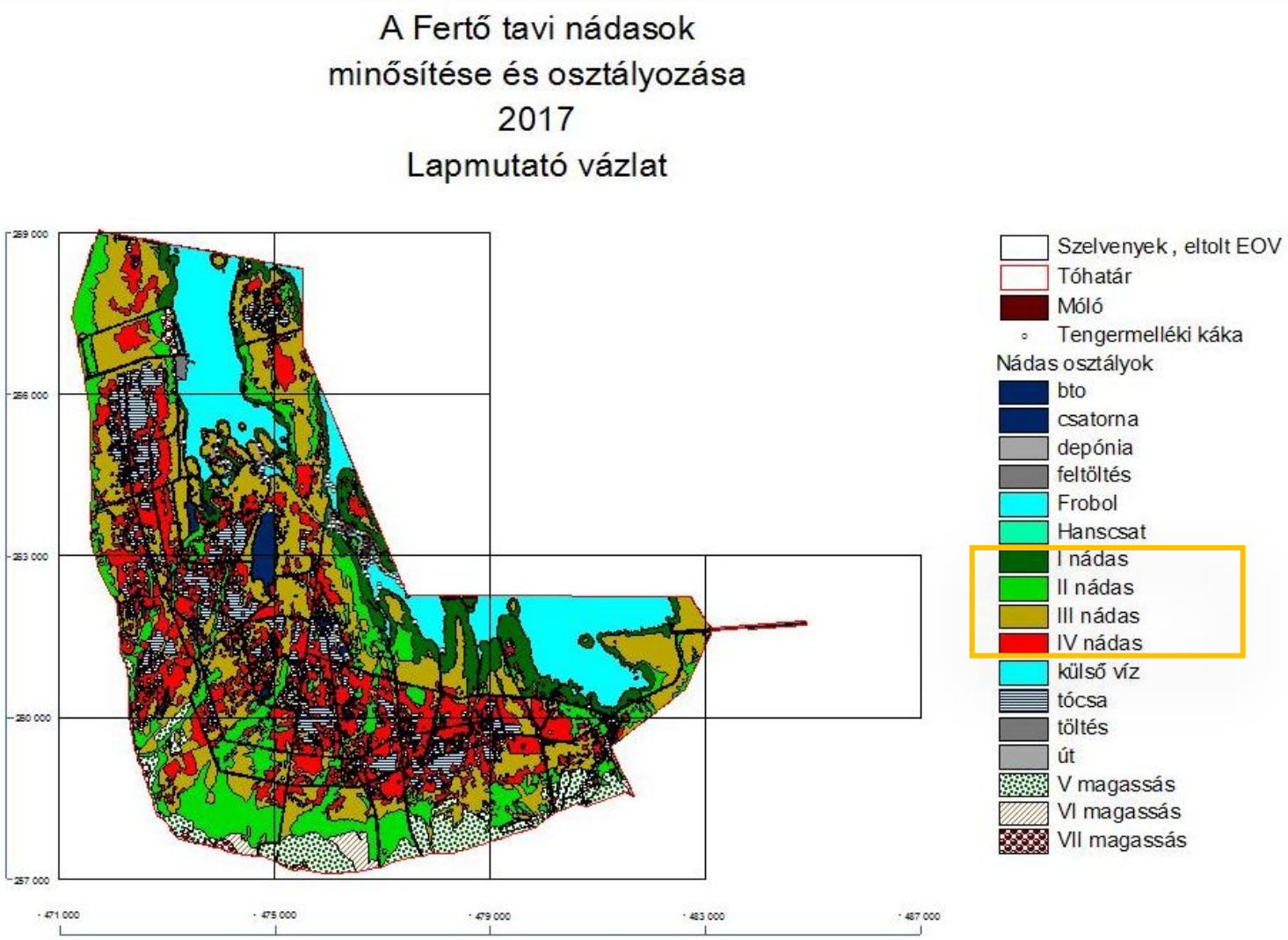
EVI

XGBoost

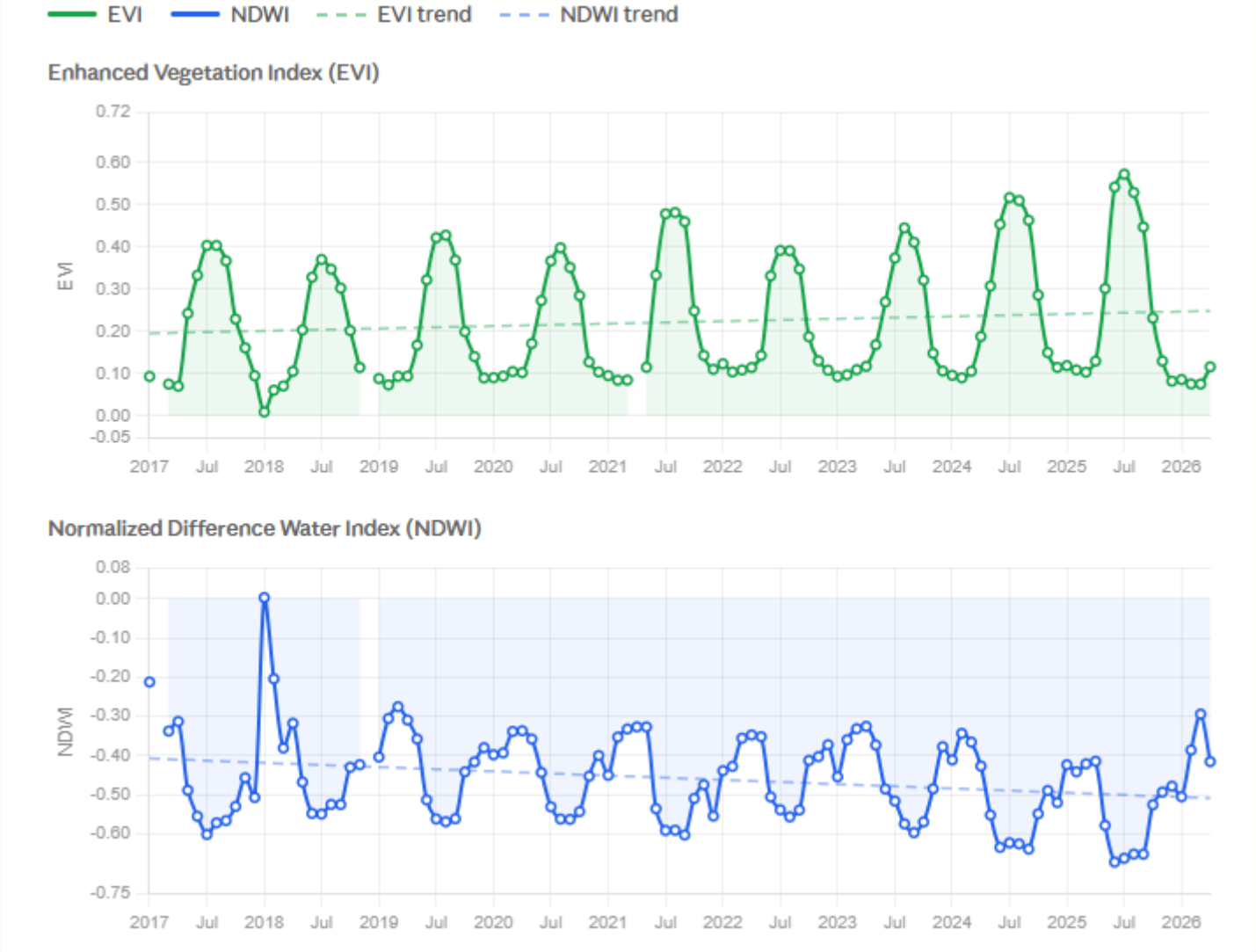
Summer images (July)

Cluster number	Associated Class in Csaplovics et al. (2009)	Typical July EVI Range (p25–p75)	Description
Cluster 4	Class I and II + class III.Aa in the Wulka delta only	**0.50–0.63**	**Vigorous reed** High biomass, tall reed, consistent seasonal productivity.
Cluster 3	class III.A	**0.39–0.50**	**Healthy but aging / mixed reed** Slight senescence or patchiness, possible heterogeneity, still functionally strong.
Cluster 2	class IV.A	**0.27–0.37**	**Structurally degraded reed** Gaps, fragmentation, potential invasion by Typha or other species.
Cluster 1	Class V + brown water	**0.10–0.21**	**Non-productive / collapsed system** Dead reed, mudflat, brownwater areas, post-disturbance, open water encroachment.

Reed Classification



Reed Classification



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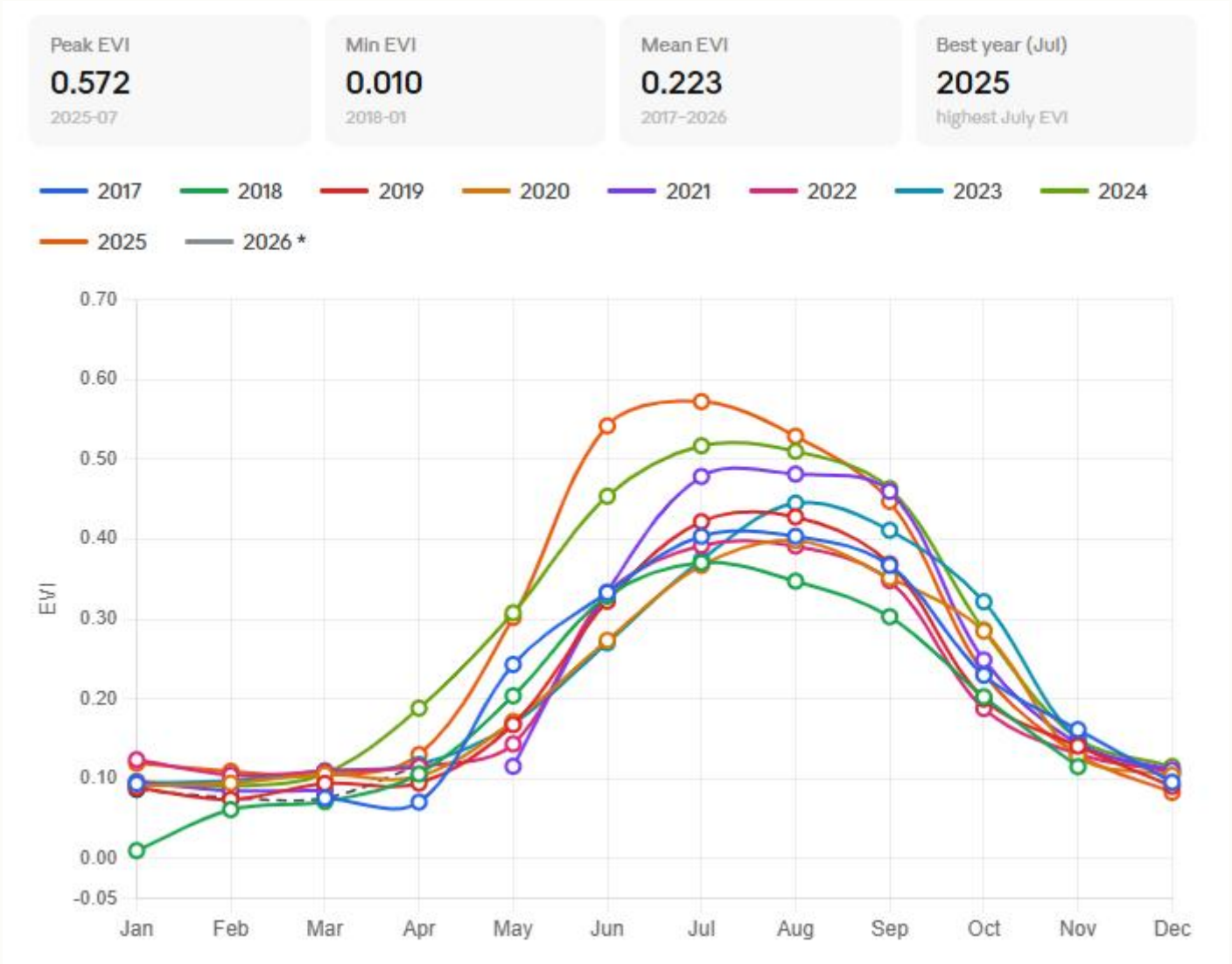
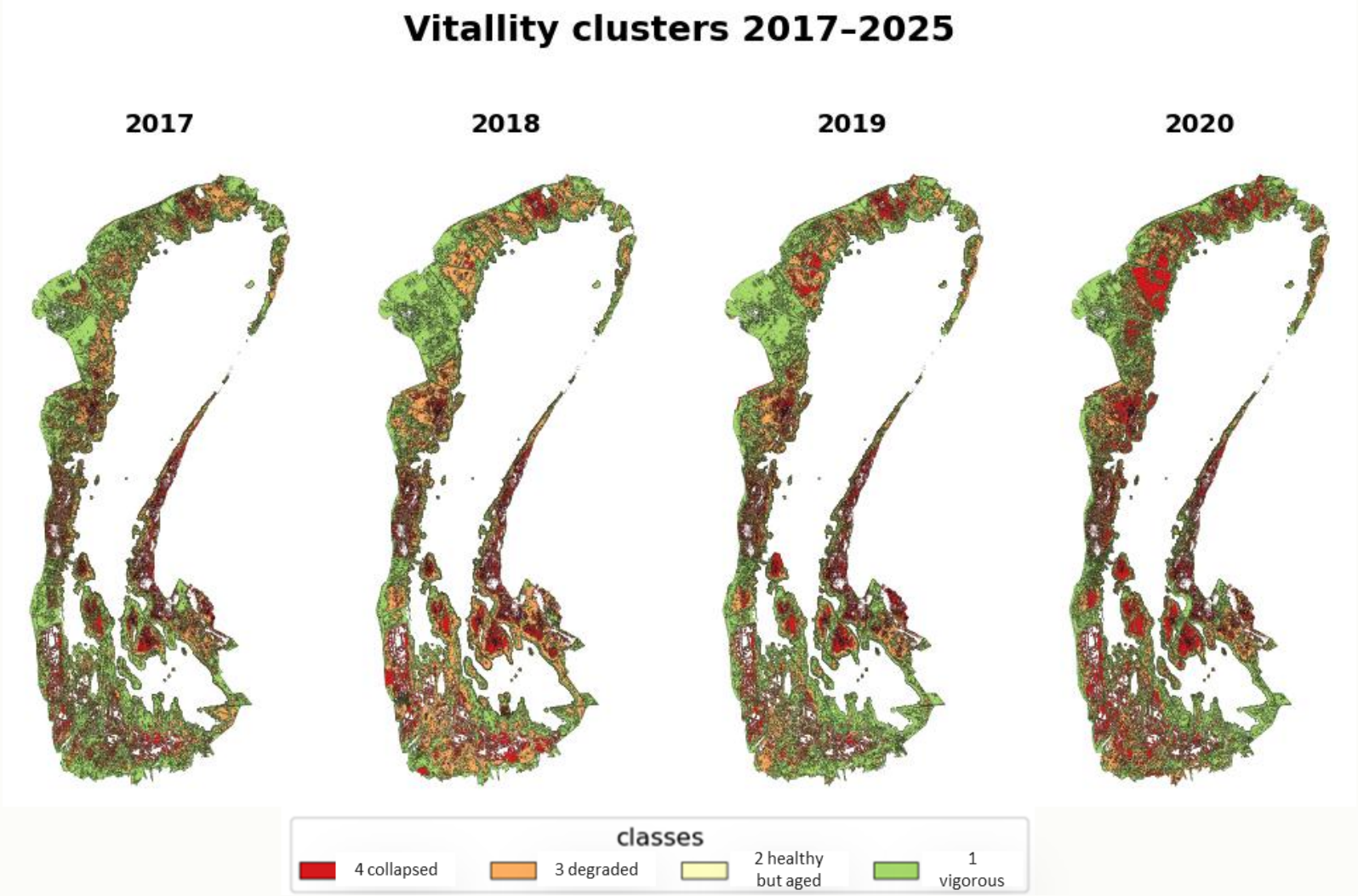
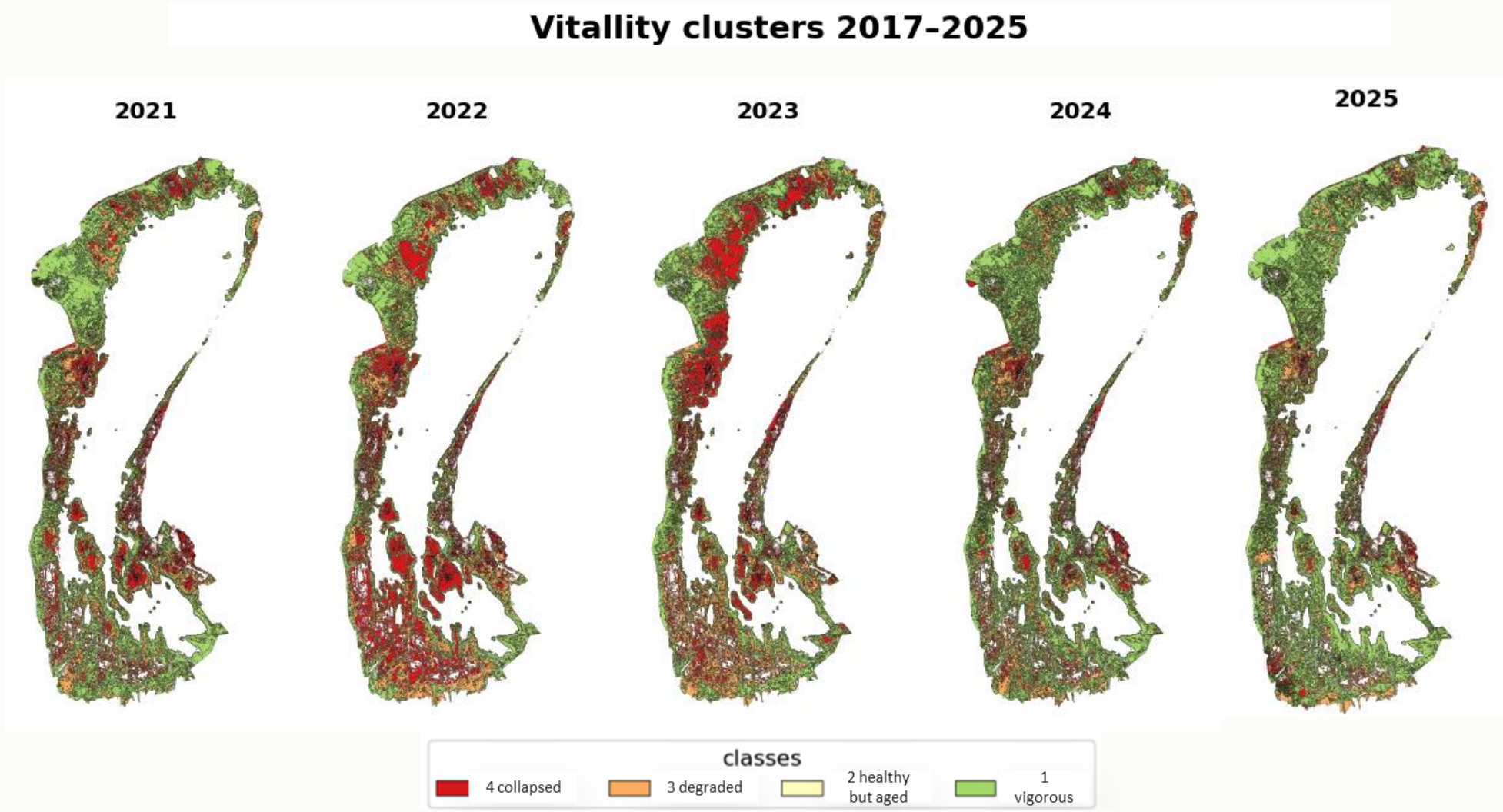


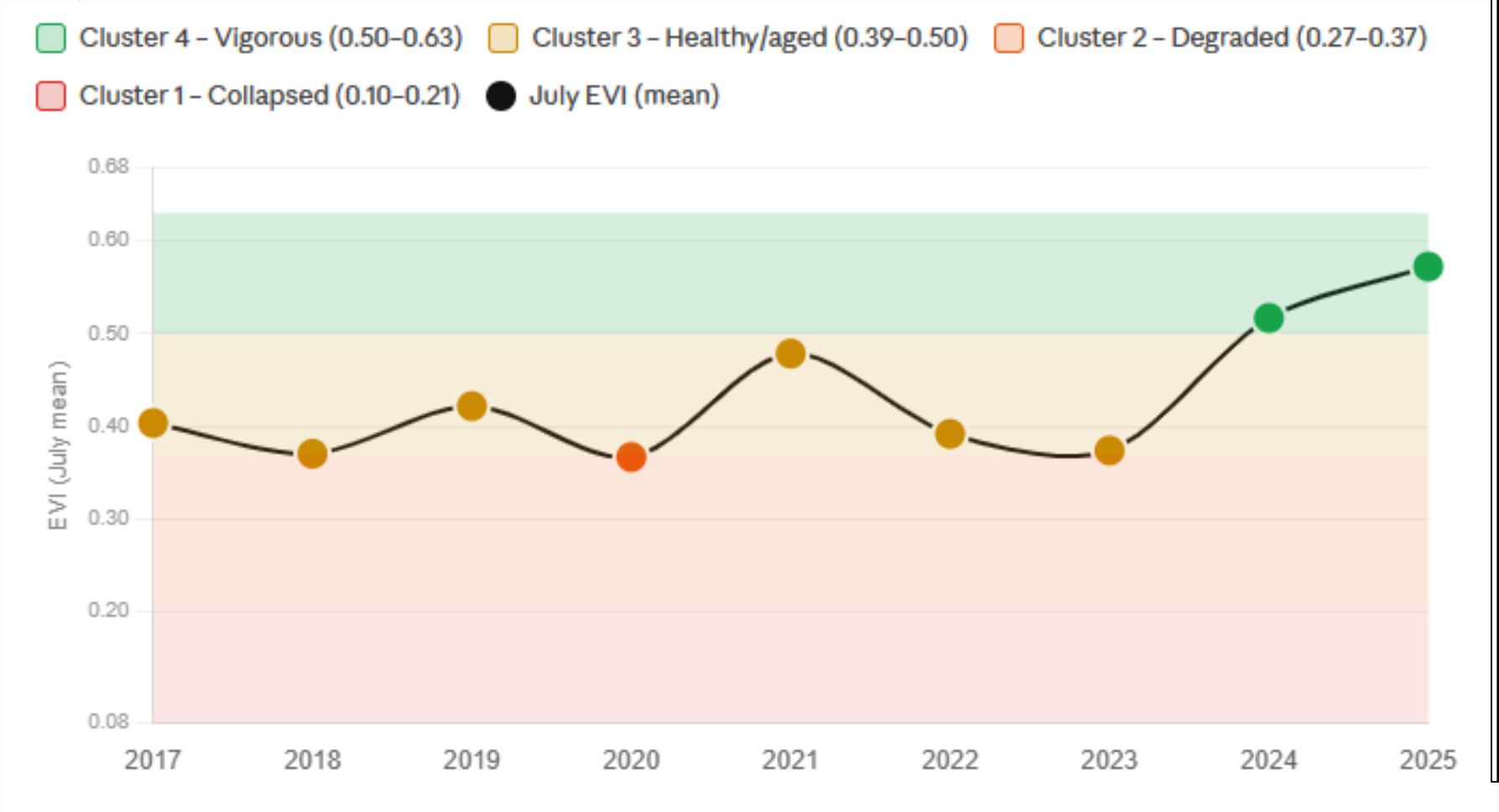
Reed Classification



Reed Classification

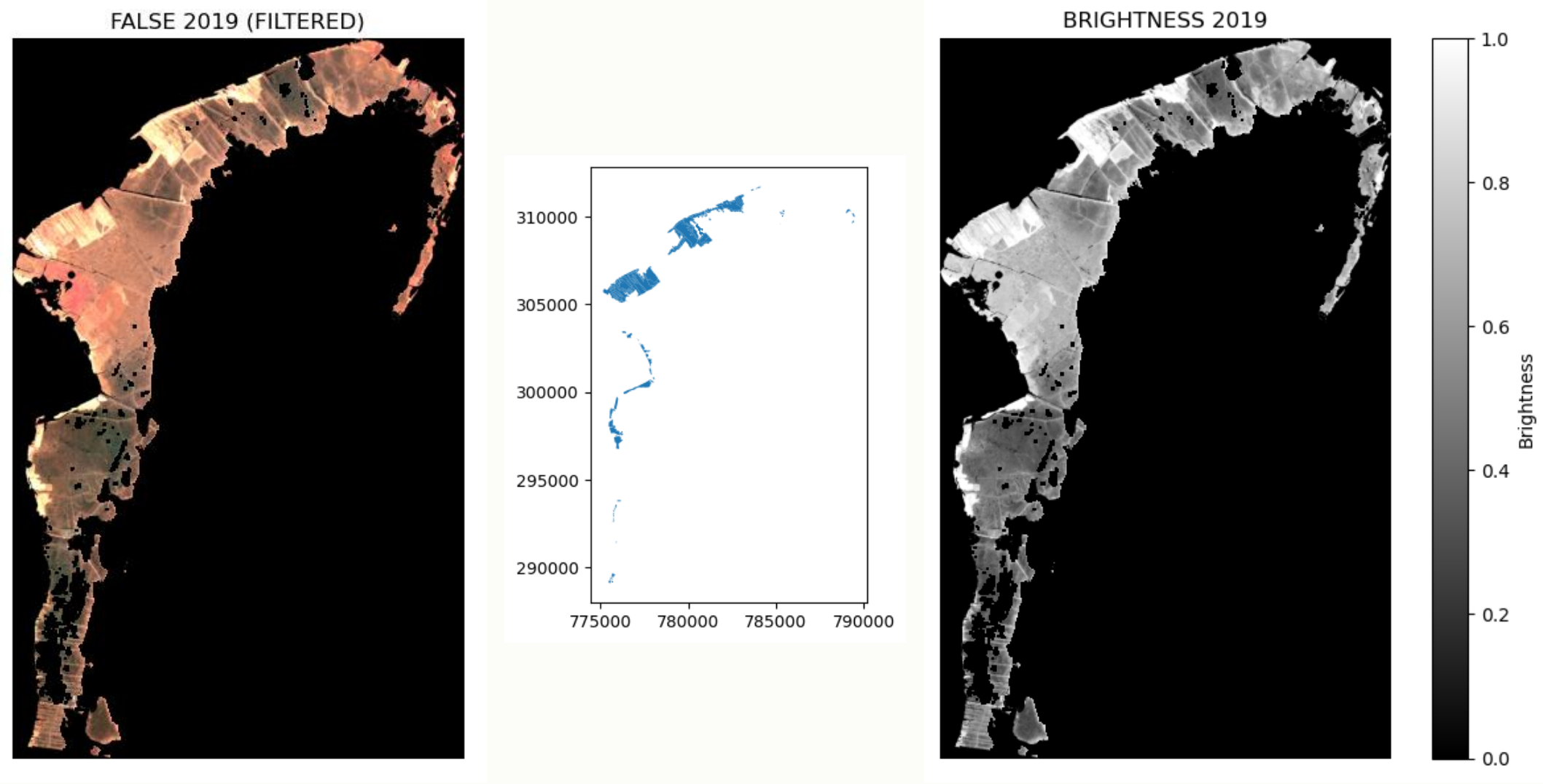


Reed Classification

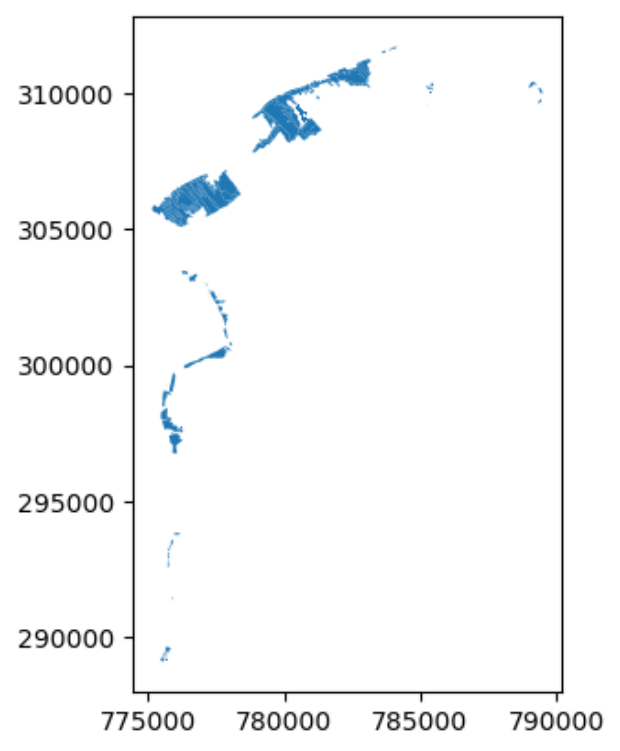


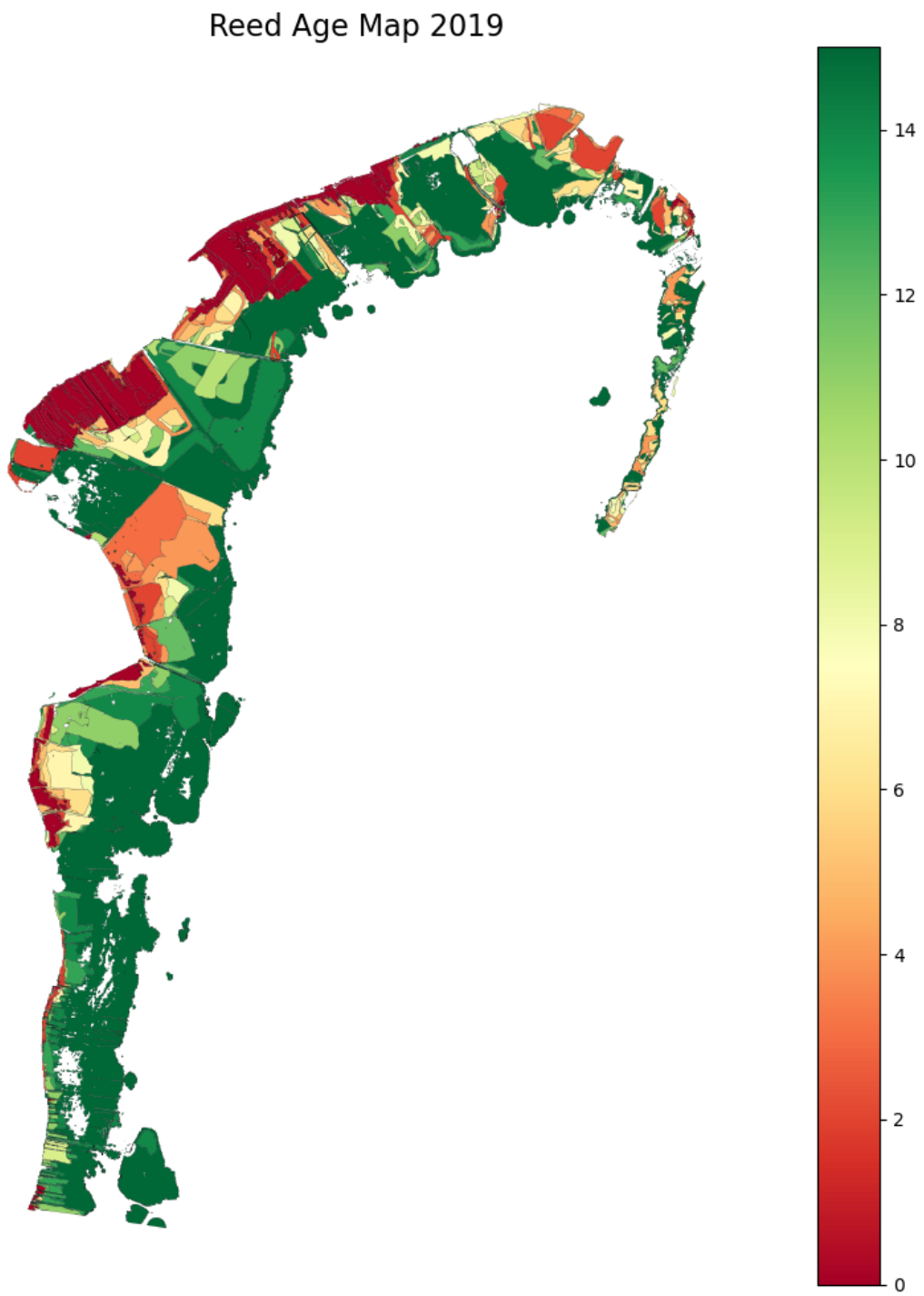
Cluster number	Associated Class in Csaplovics et al. (2009)	Typical July EVI Range (p25–p75)
Cluster 4	Class I and II + class III.Aa in the Wulka delta only	**0.50–0.63**
Cluster 3	class III.A	**0.39–0.50**
Cluster 2	class IV.A	**0.27–0.37**
Cluster 1	Class V + brown water	**0.10–0.21**

Brightness Algorithm



Brightness Algorithm





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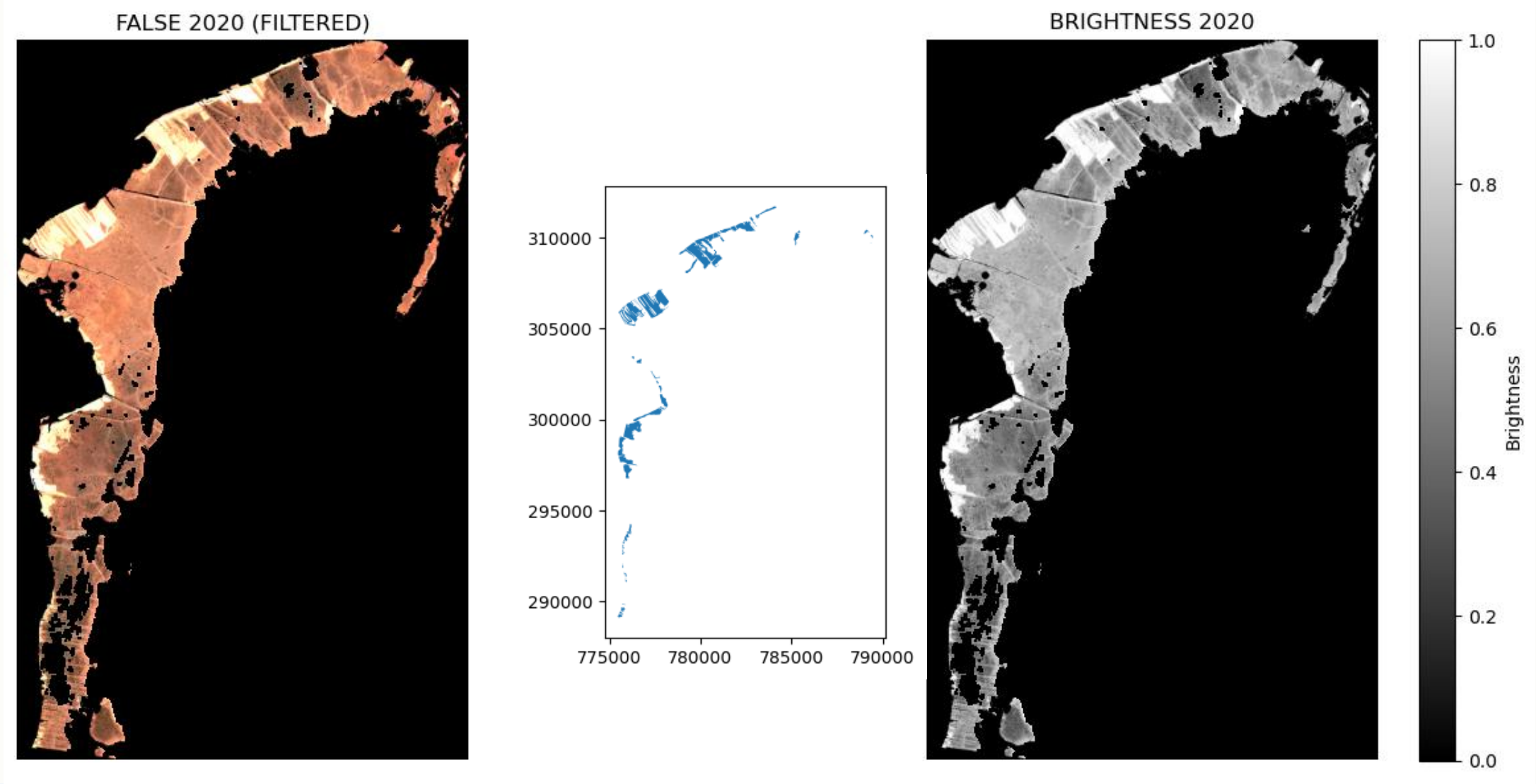

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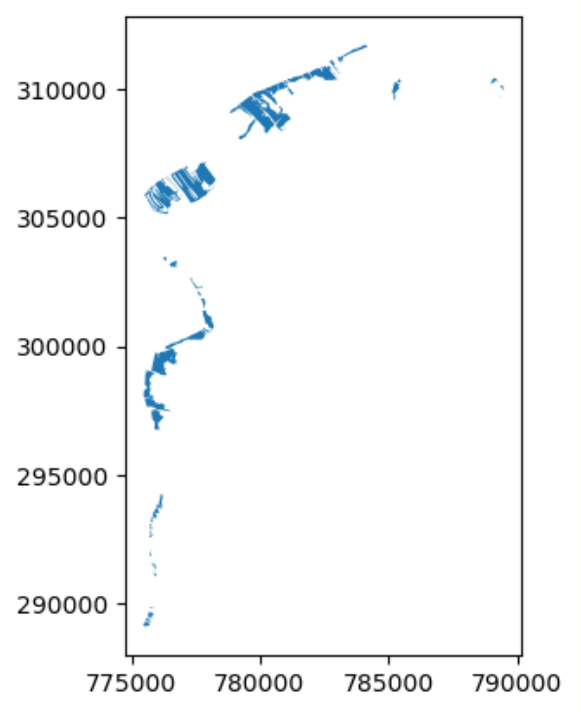
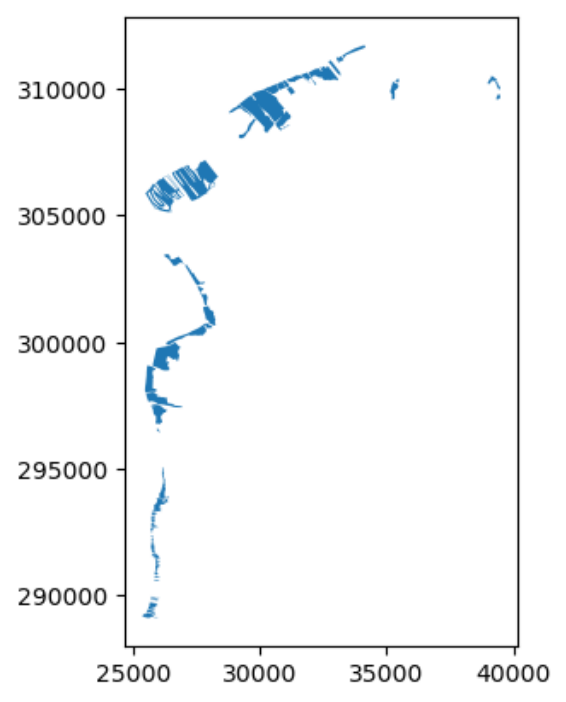
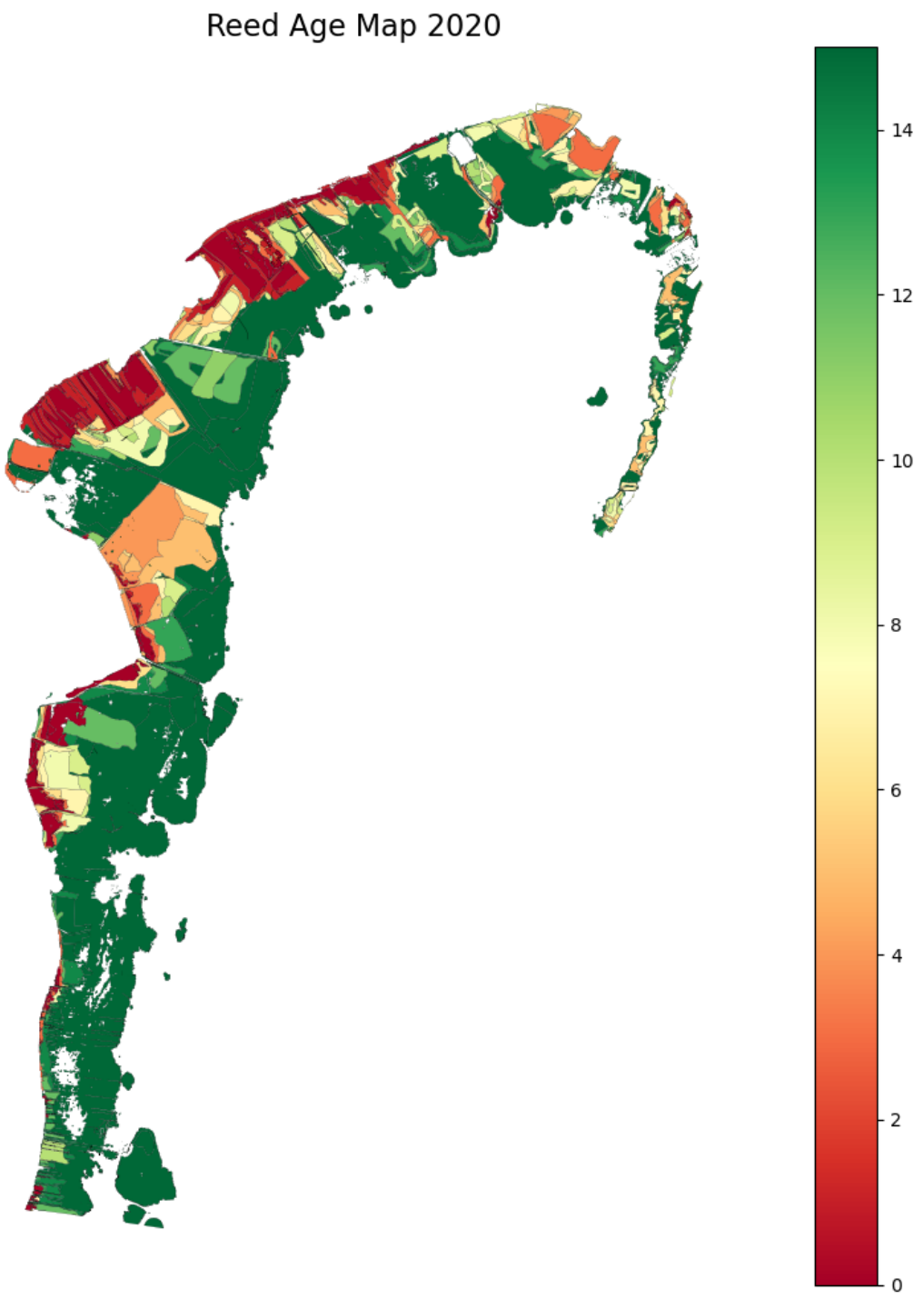


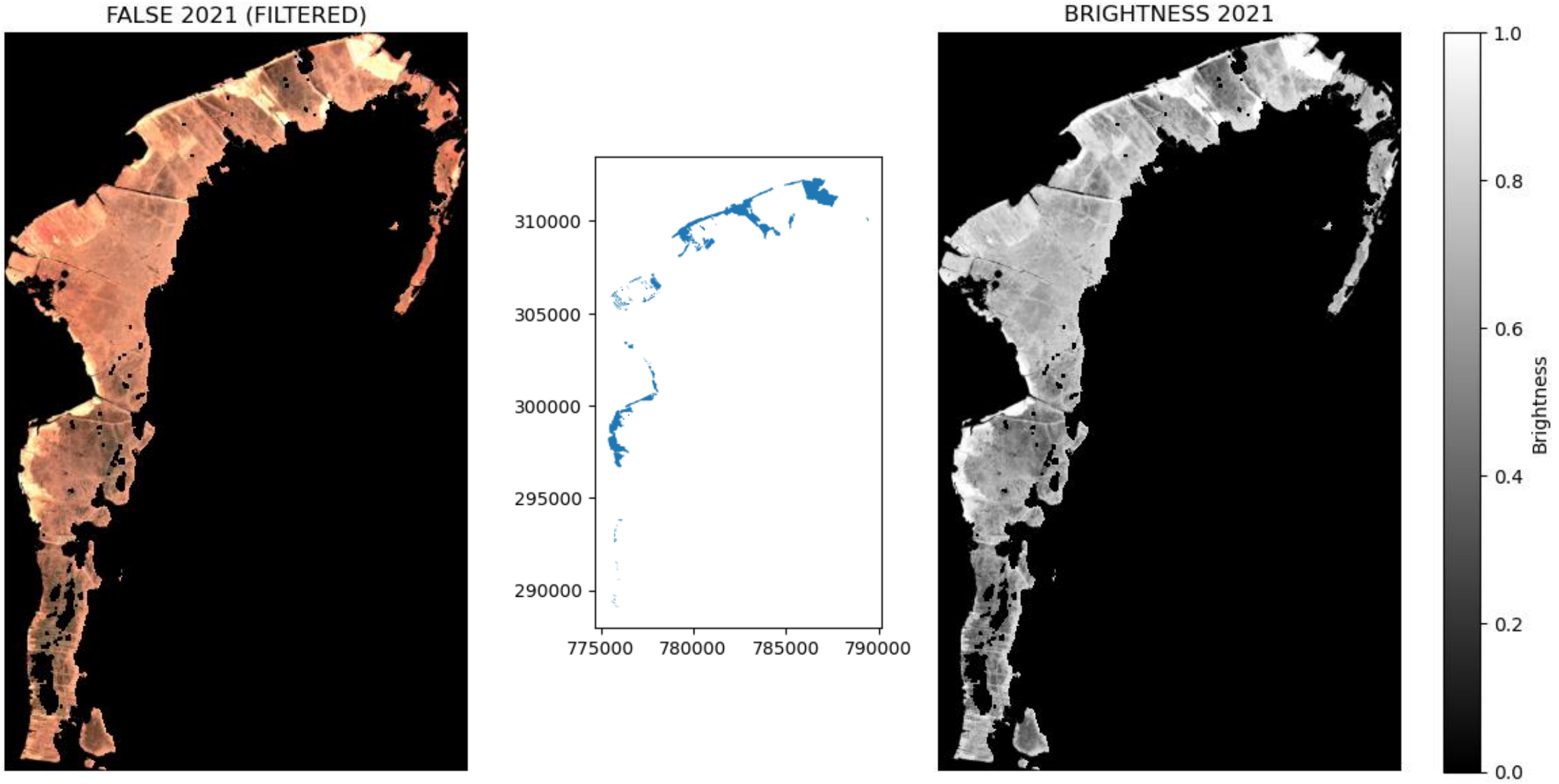
Brightness Algorithm, 2020
CRS: 31259



schilfschnitt2020
CRS: 31256



Brightness Algorithm



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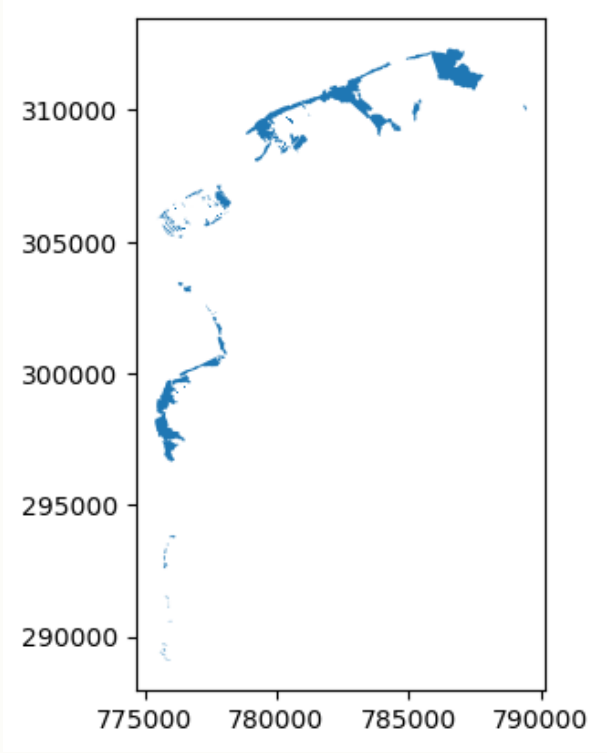

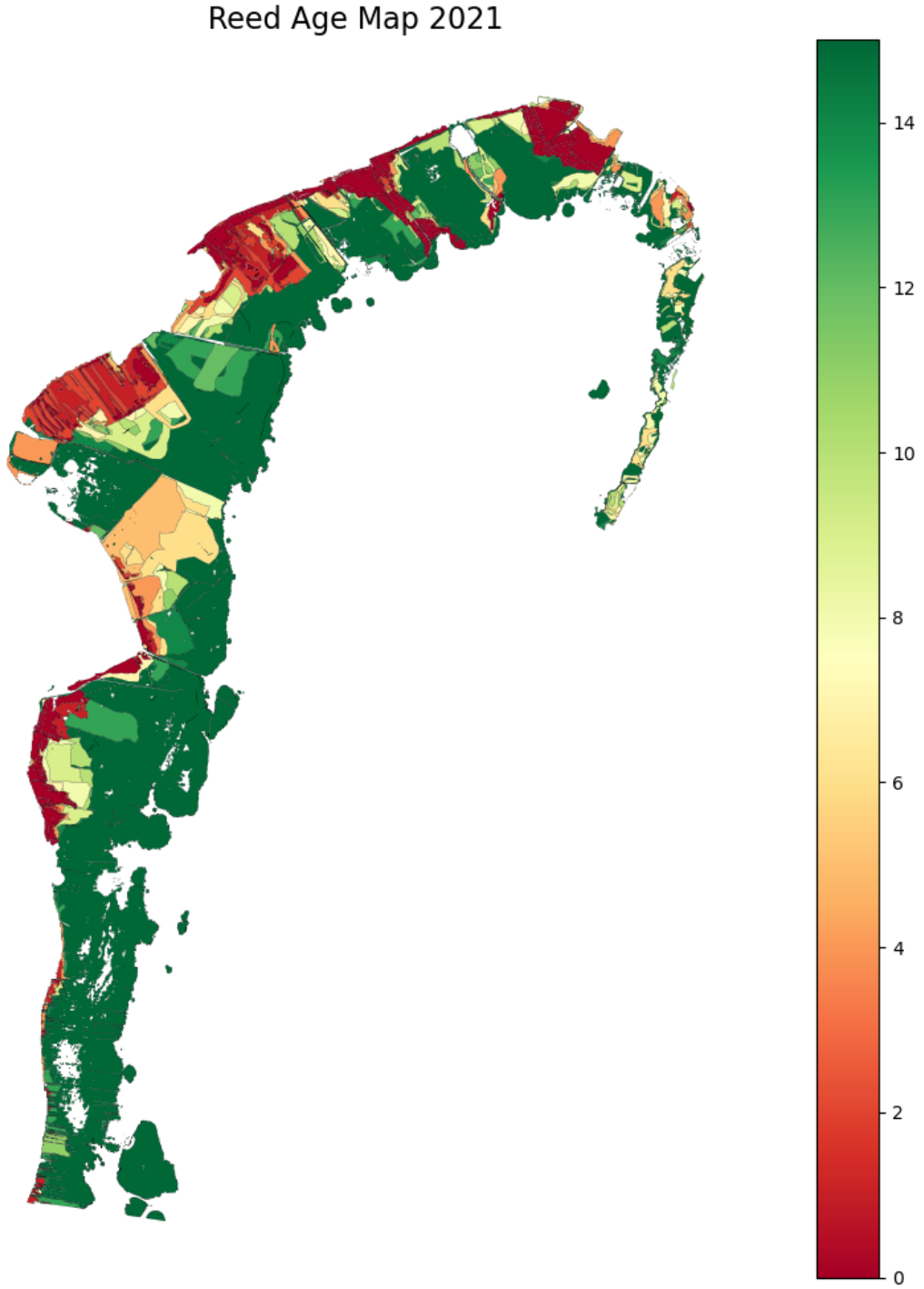

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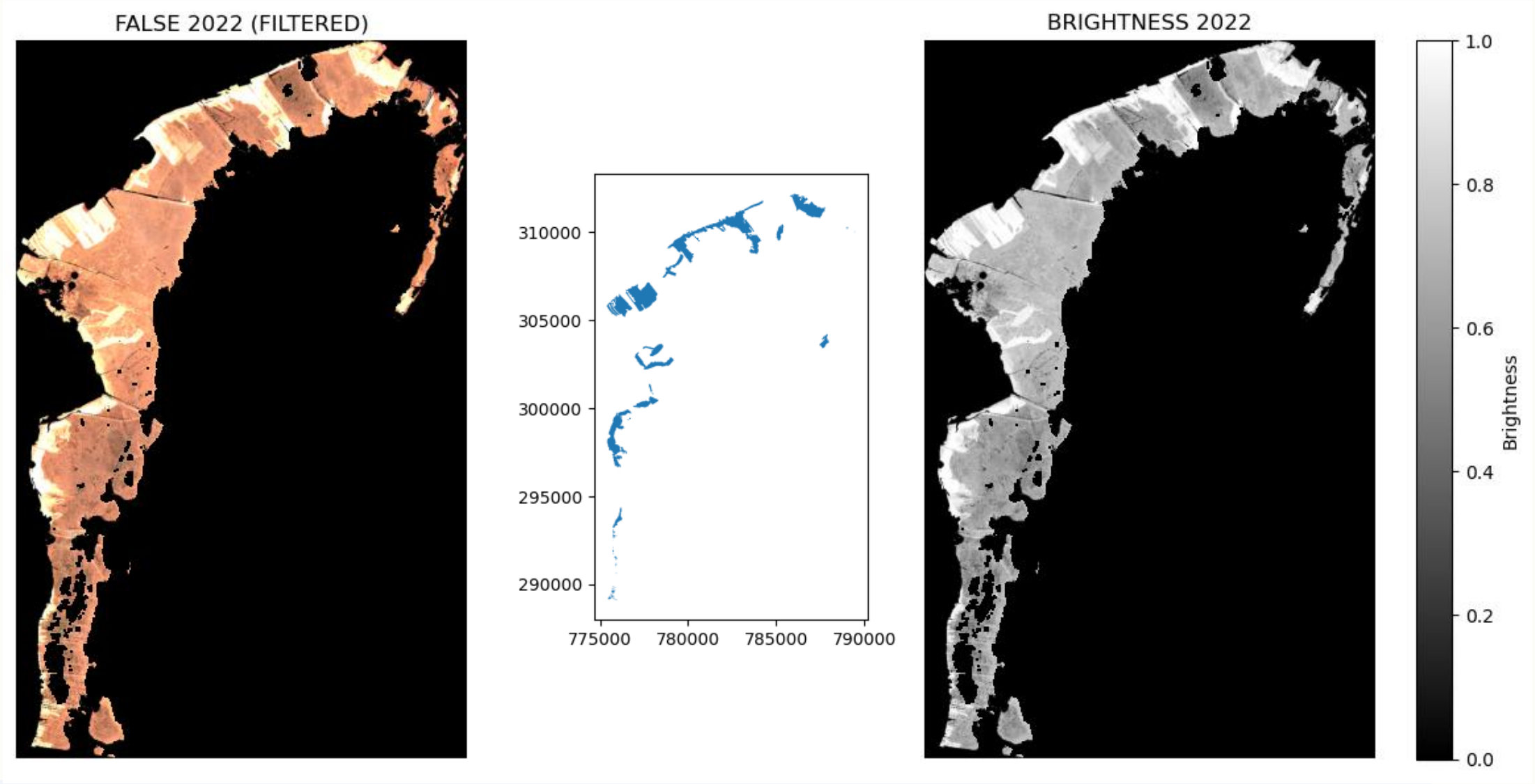

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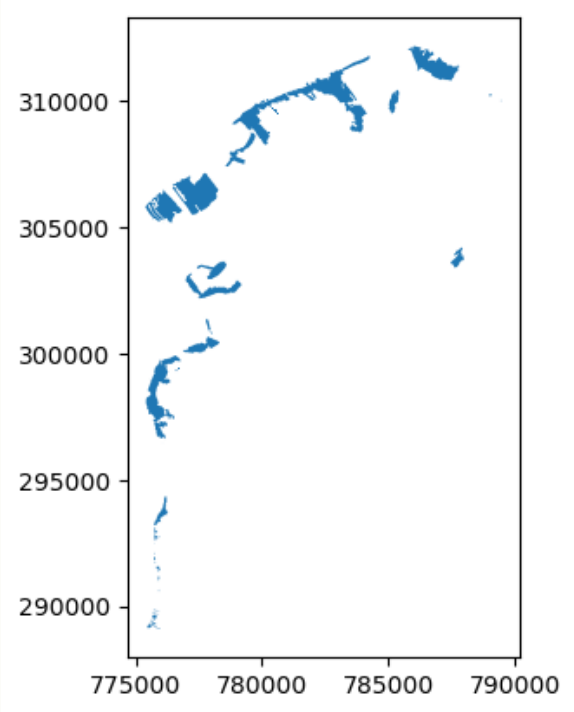

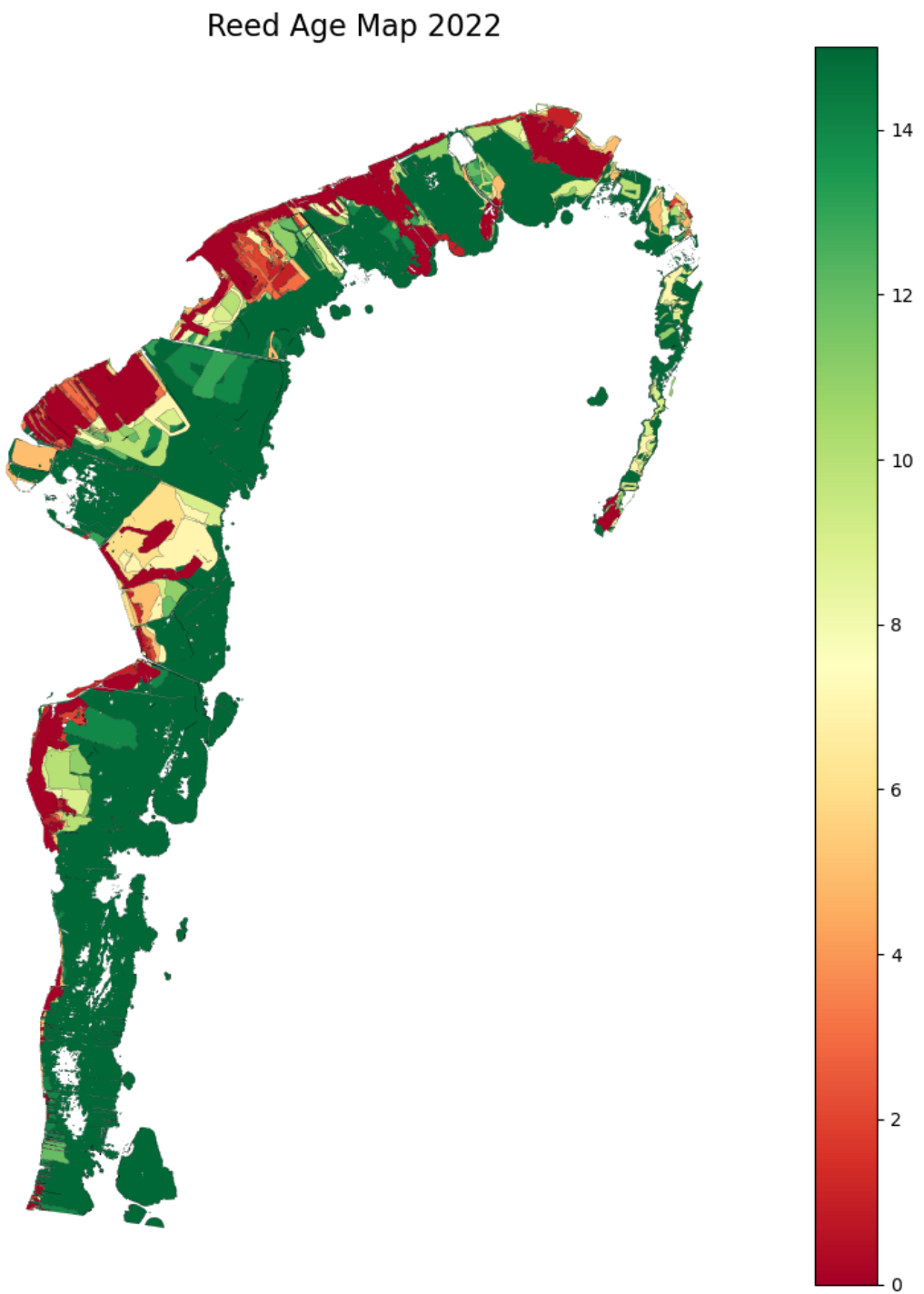

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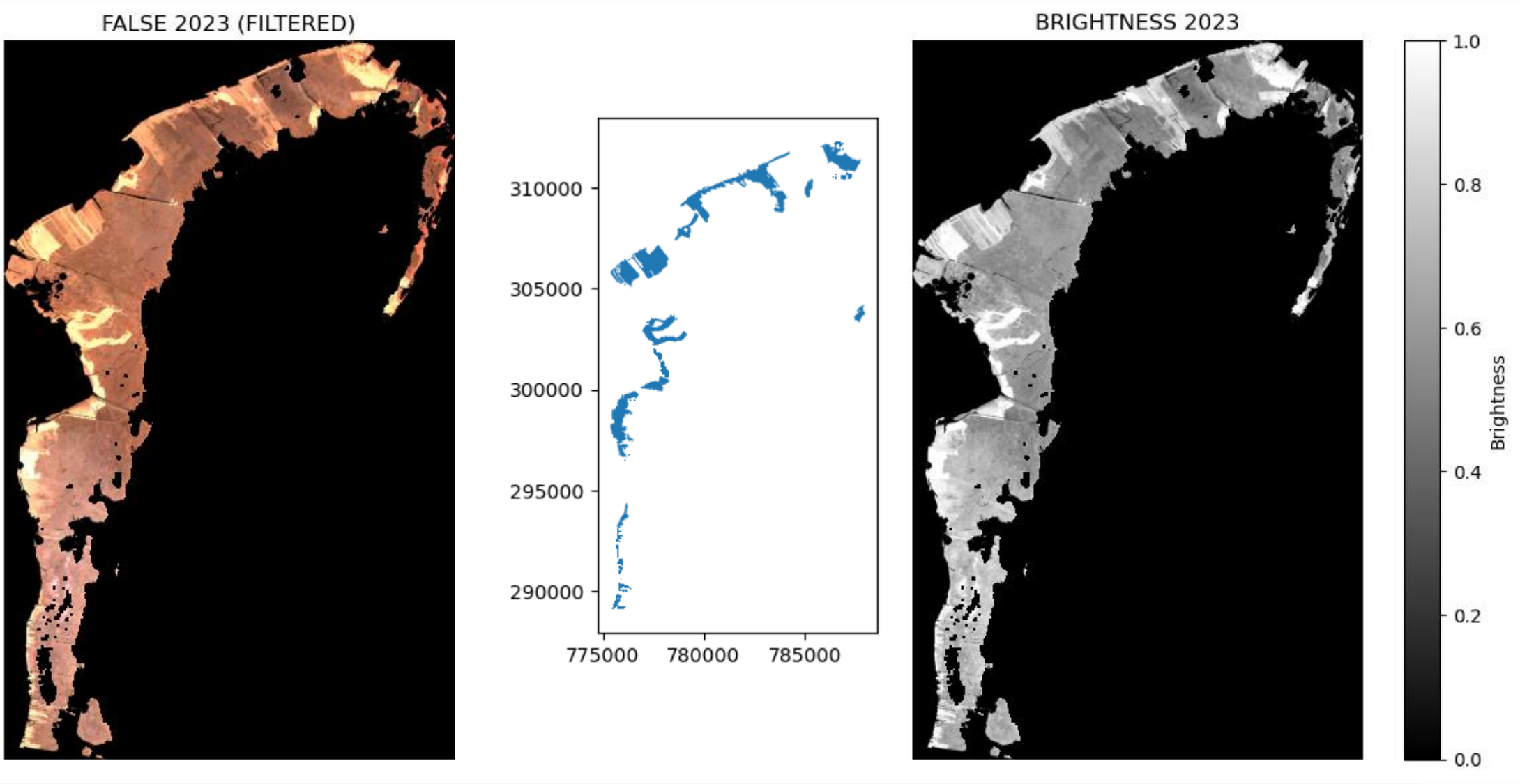

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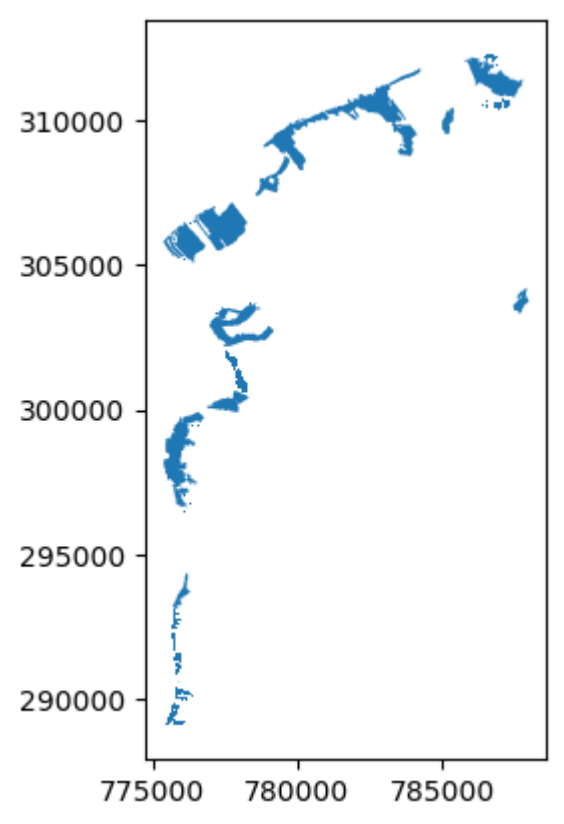

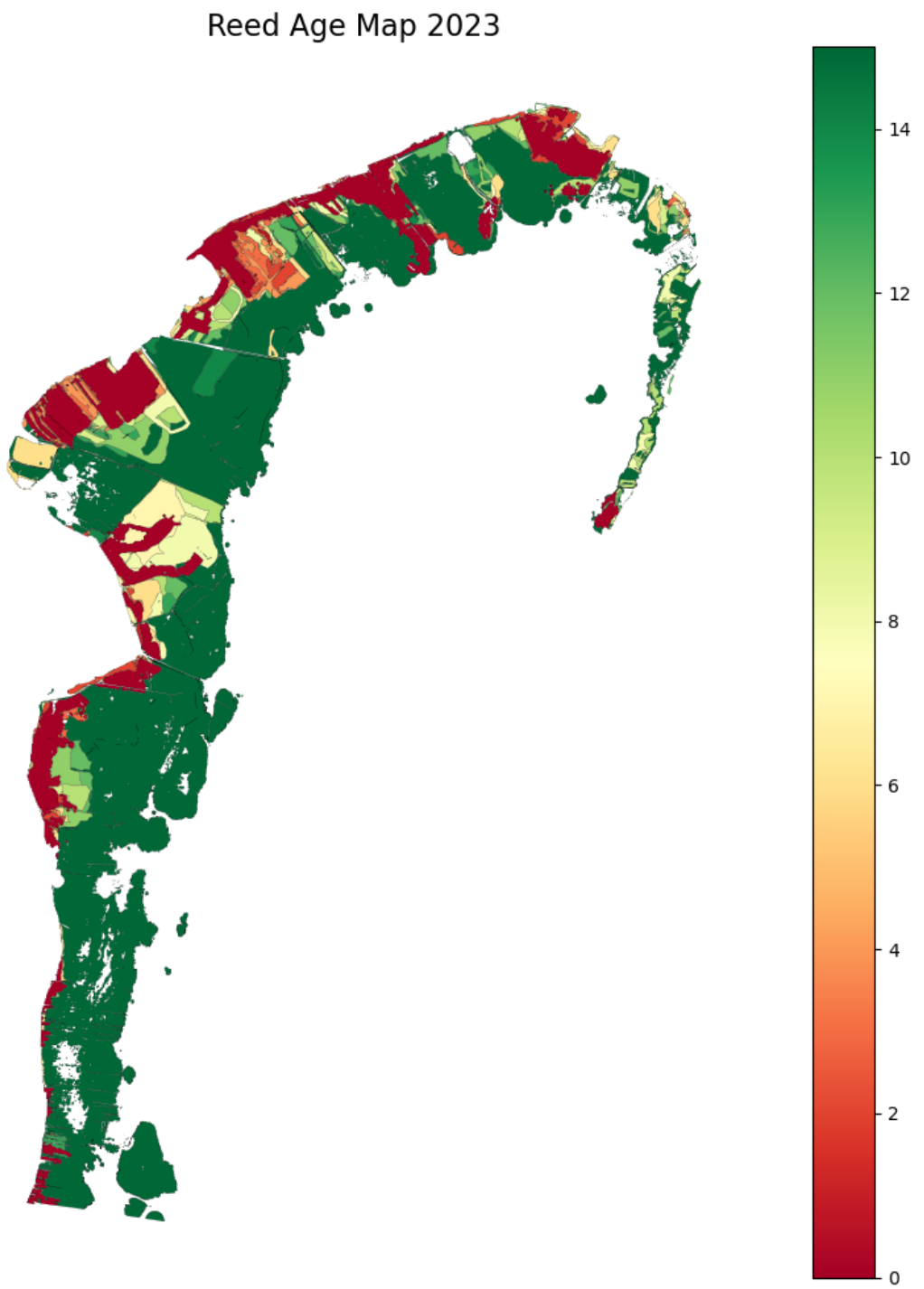

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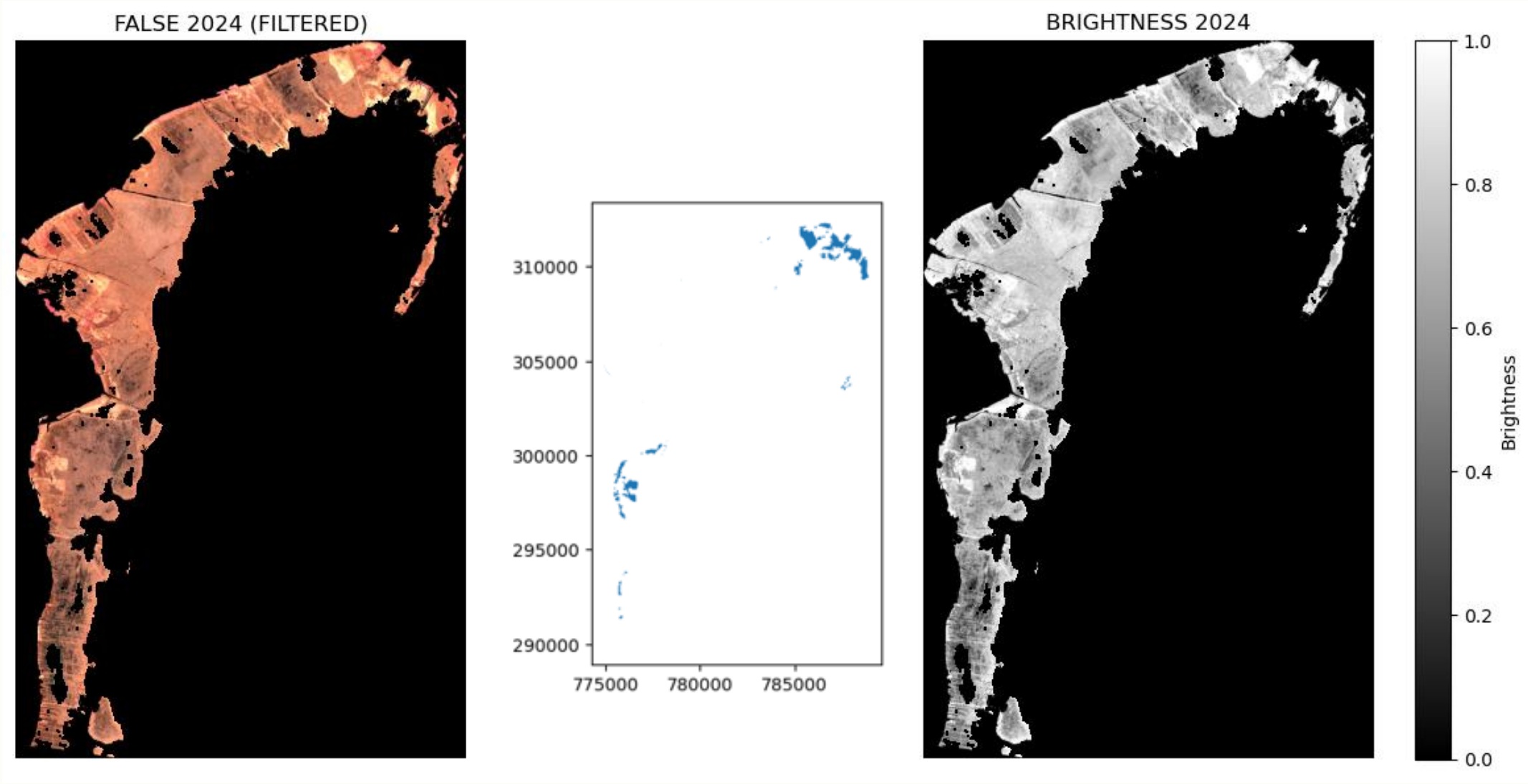
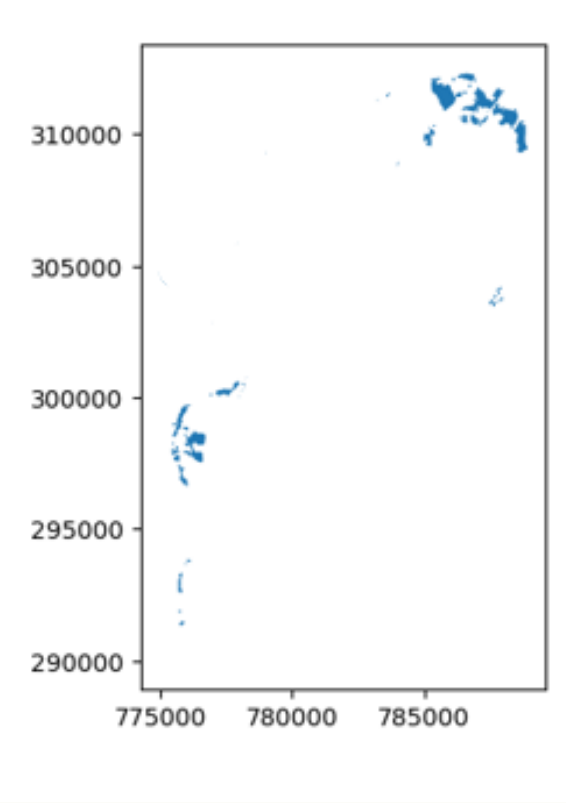
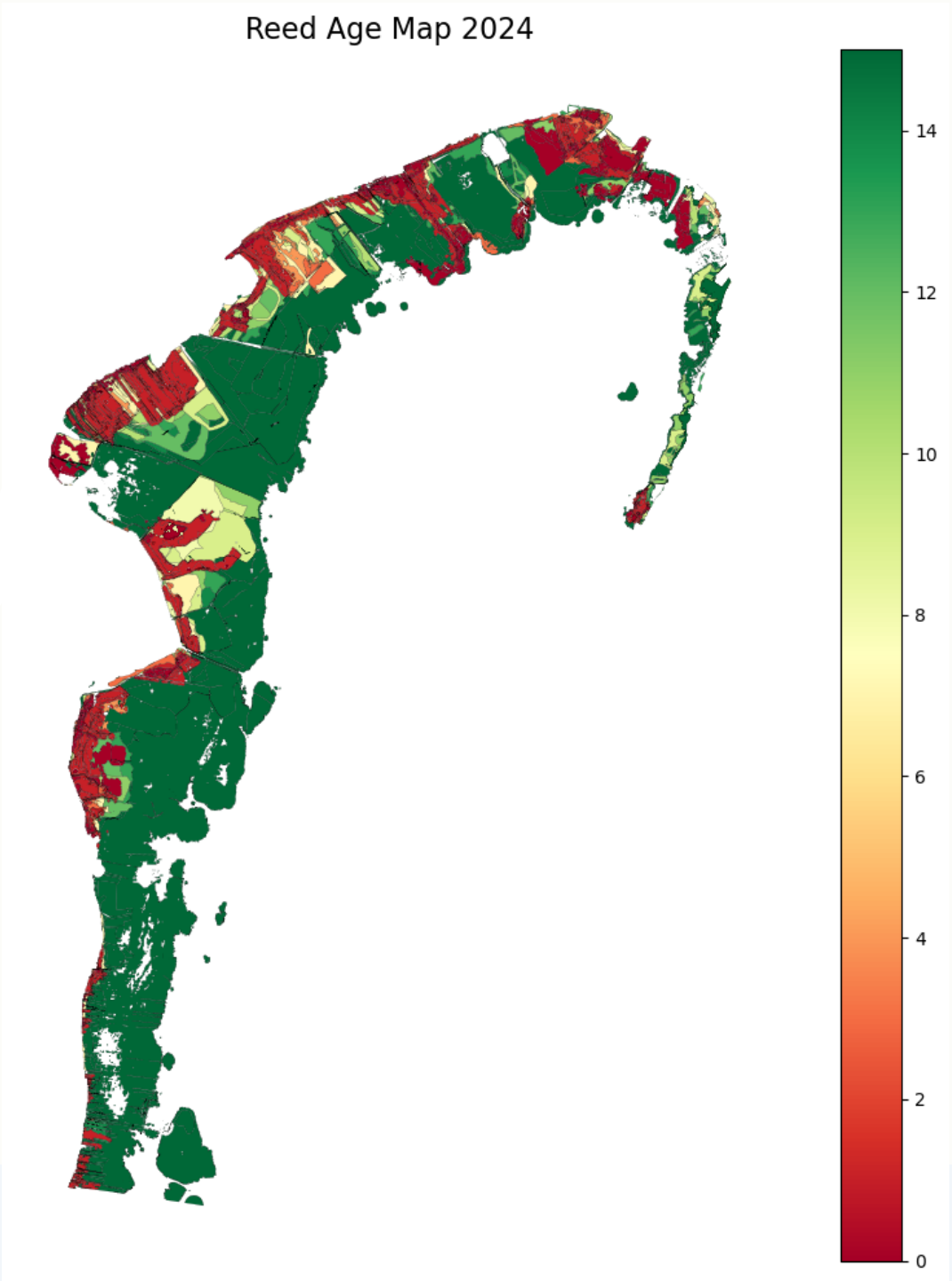


Brightness Algorithm





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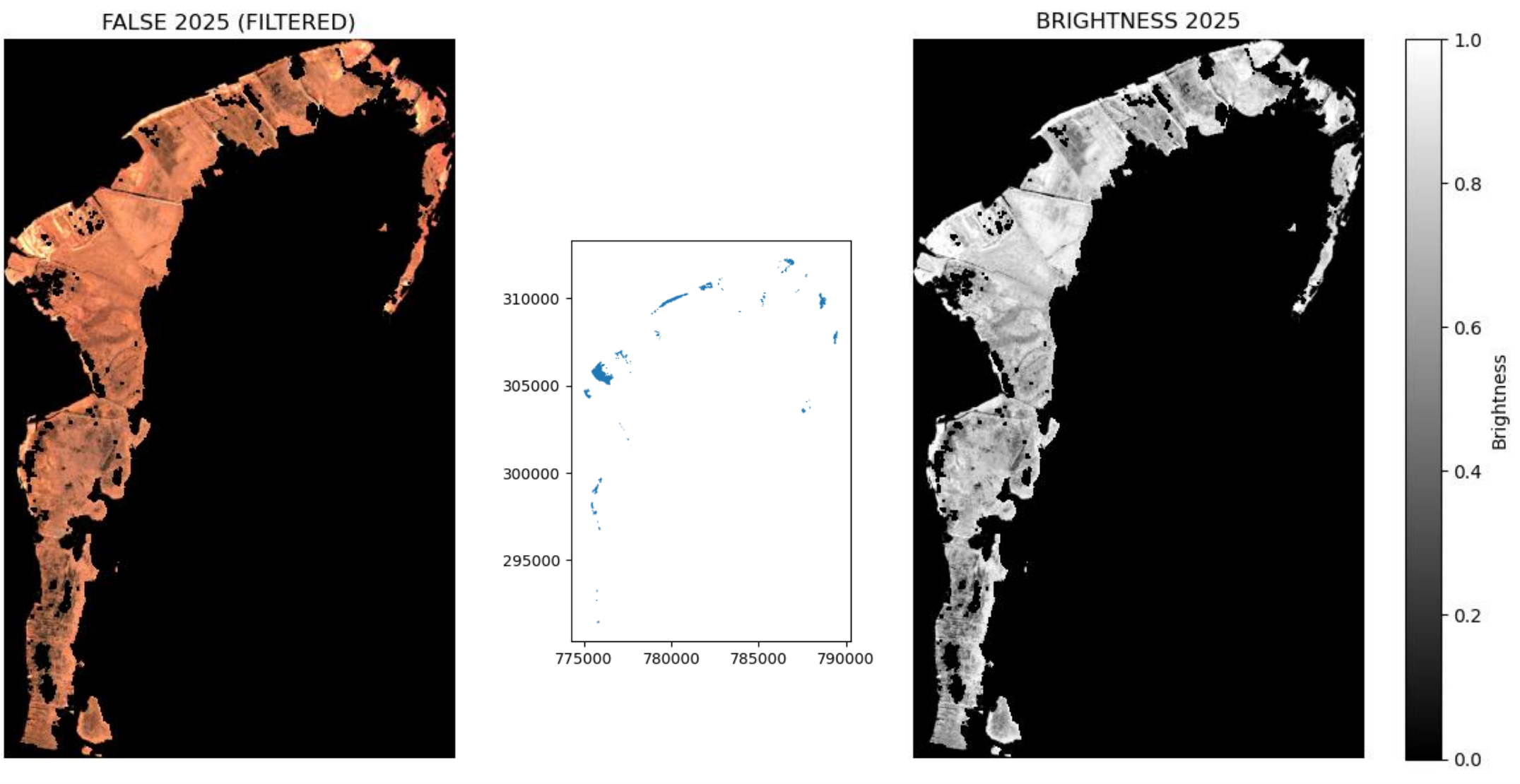

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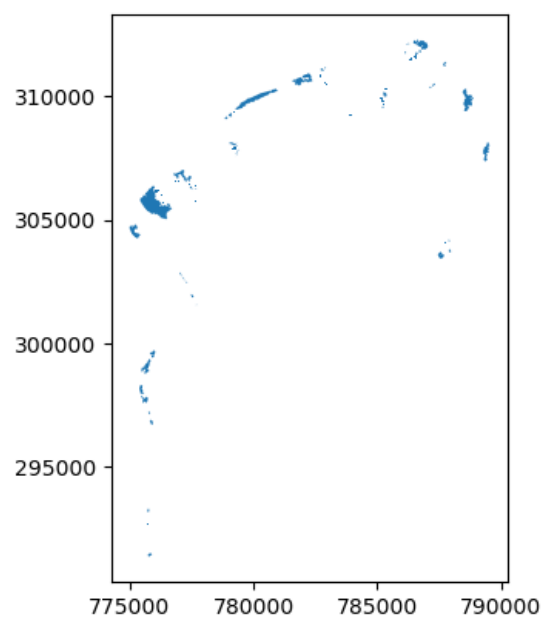
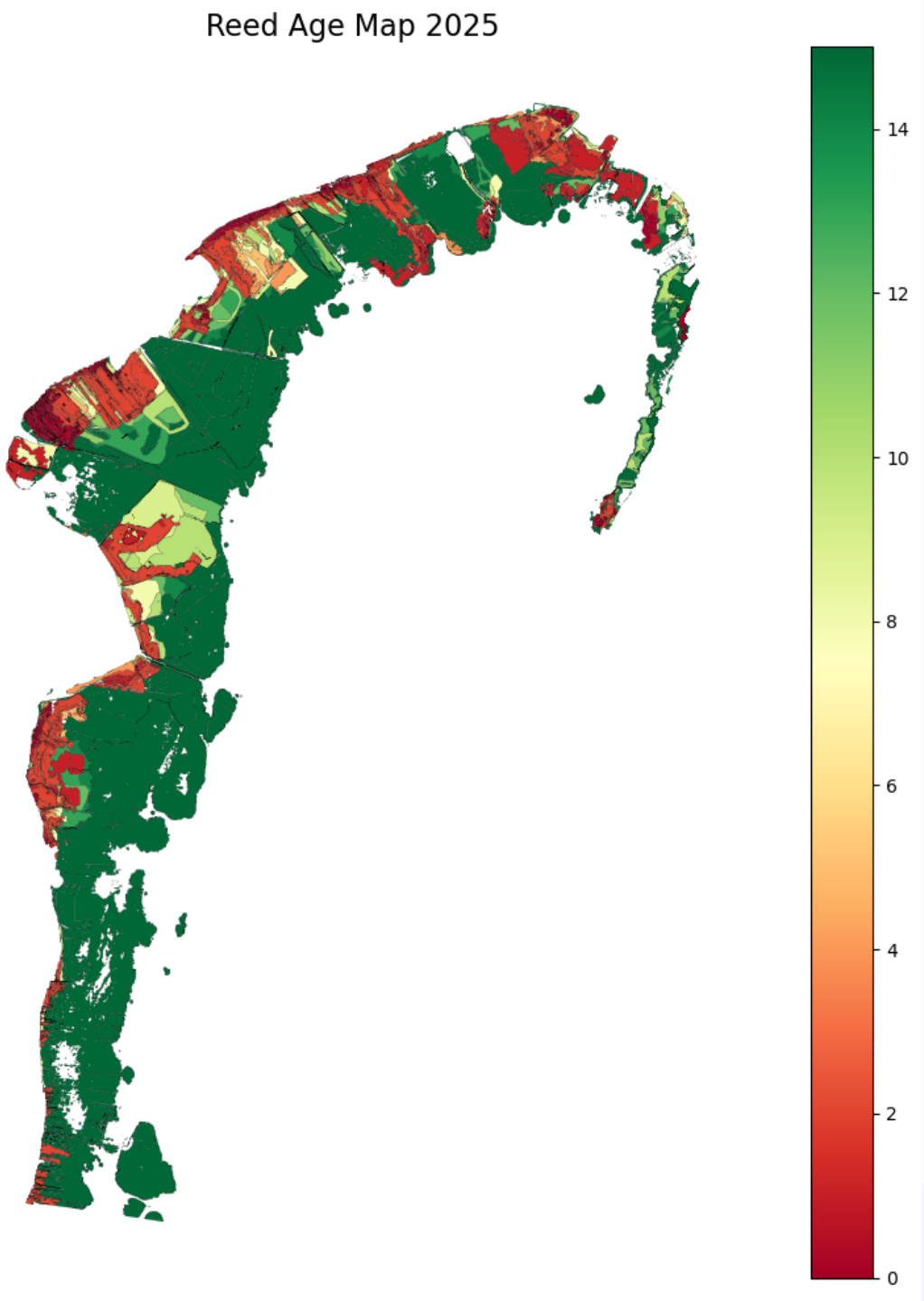
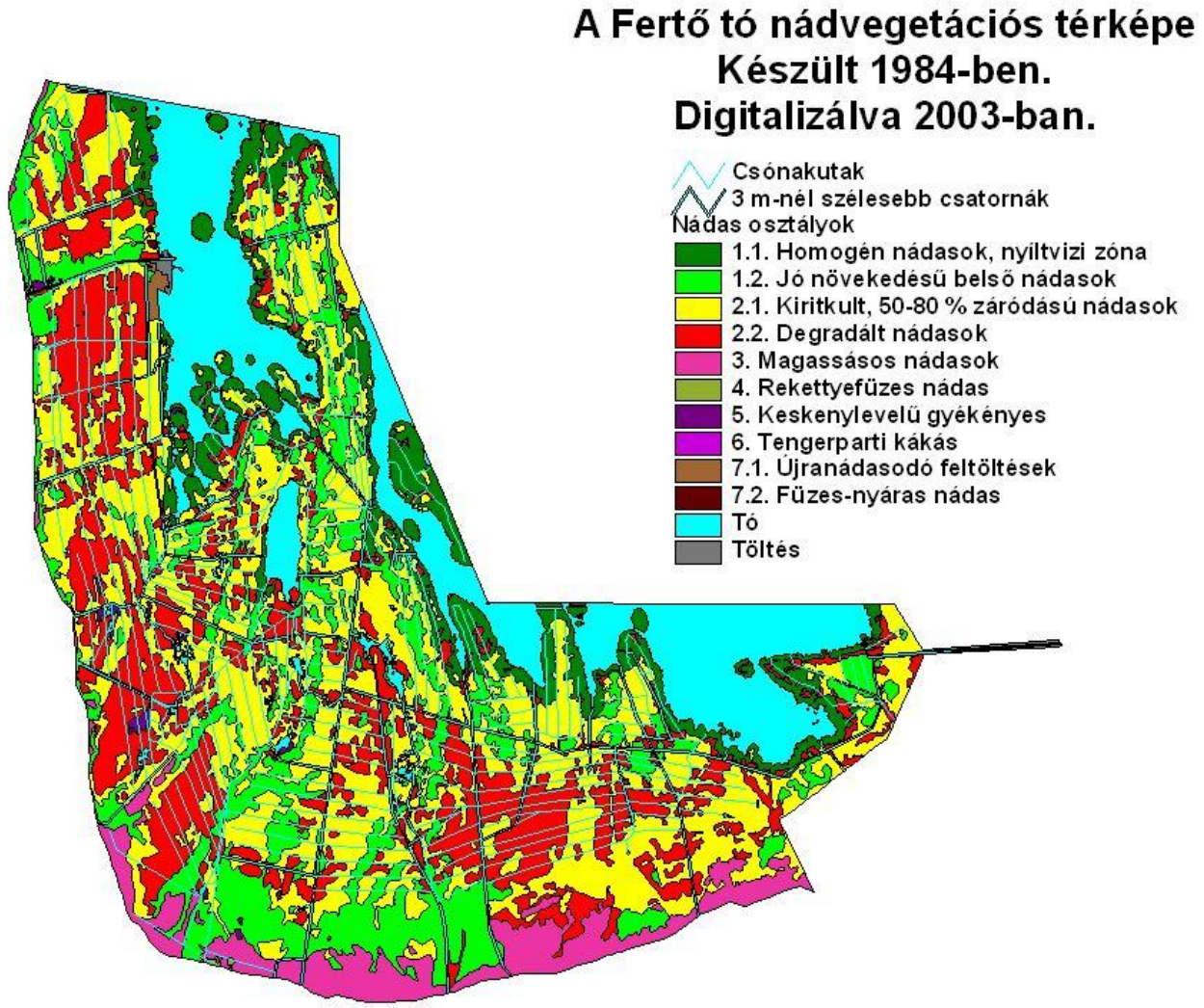




Hungarian Reed Analysis

Year	Main Technology Used	Fieldwork Intensity	Precision Level	Primary Objective
1984	Infrared aerial photography + stereoscopic interpretation	Very high	Medium	Create the **first complete reed-vegetation map** of Lake Fertő
1999	Infrared aerial photography	Medium	Medium–High	Update the reed map; provide a **new baseline** for future comparisons
2007	Digital aerial imagery + GPS mapping + GIS analysis	High	High	Evaluate reed condition; **classify reed quality** into Classes I–V
2017 Technical Study	Drone (UAV) surveys + high-resolution orthophotos + RTK GPS	Very high	Very high	Detailed reed classification (Classes I–VII**); detect degradation, water patches, shrub encroachment**
2017 Map Classification	Orthophotos + GIS polygon classification	Medium	Medium - High	Produce a simplified management-oriented map of reed zones: **shoreline reed, transitional zone, opened reed, open-water reed, sedge/marsh, open water**, protected areas

Hungarian Reed Analysis

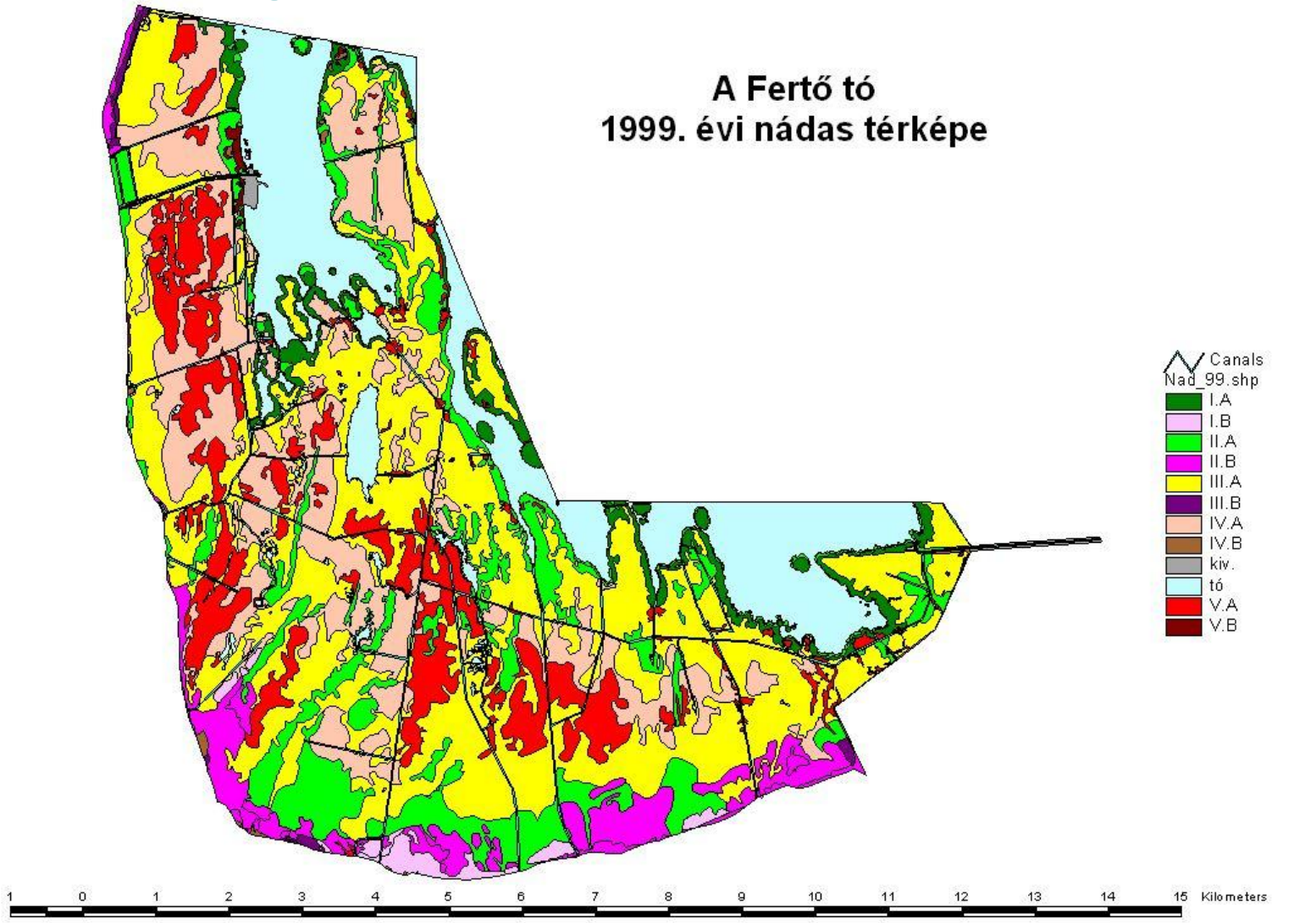


Reed Vegetation Map of Lake Fertő
Created in 1984.
Digitized in 2003.

Boat Routes
Channels wider than 3 meters

1.1. Homogeneous reed stands, open-water zone
1.2. Well-growing inner reed stands
2.1. Thinned reed stands, 50–80% cover
2.2. Degraded reed stands
3. Tall-sedge reed stands
4. Grey willow–reed stands
5. Narrow-leaf cattail stands
6. Seaside bulrush
7.1. Re-reeded fill areas
7.2. Willow–poplar reed stands
Lake
Embankment

Hungarian Reed Analysis



Reed Map of Lake Fertő 1999

Canals

I.A Homogeneous, healthy and dense reed stands

I.B Mixed reed–tall sedge stands, species-rich and natural

II.A Healthy reed stands with slight signs of aging

II.B Mixed stands showing early signs of degradation

III.A Moderately degraded reed stands (partially open)

III.B Mixed tall sedge–reed stands degraded by drying or disturbance

IV.A Strongly degraded reed stands with large open-water patches

IV.B Areas degraded by dredging or filled with sediment

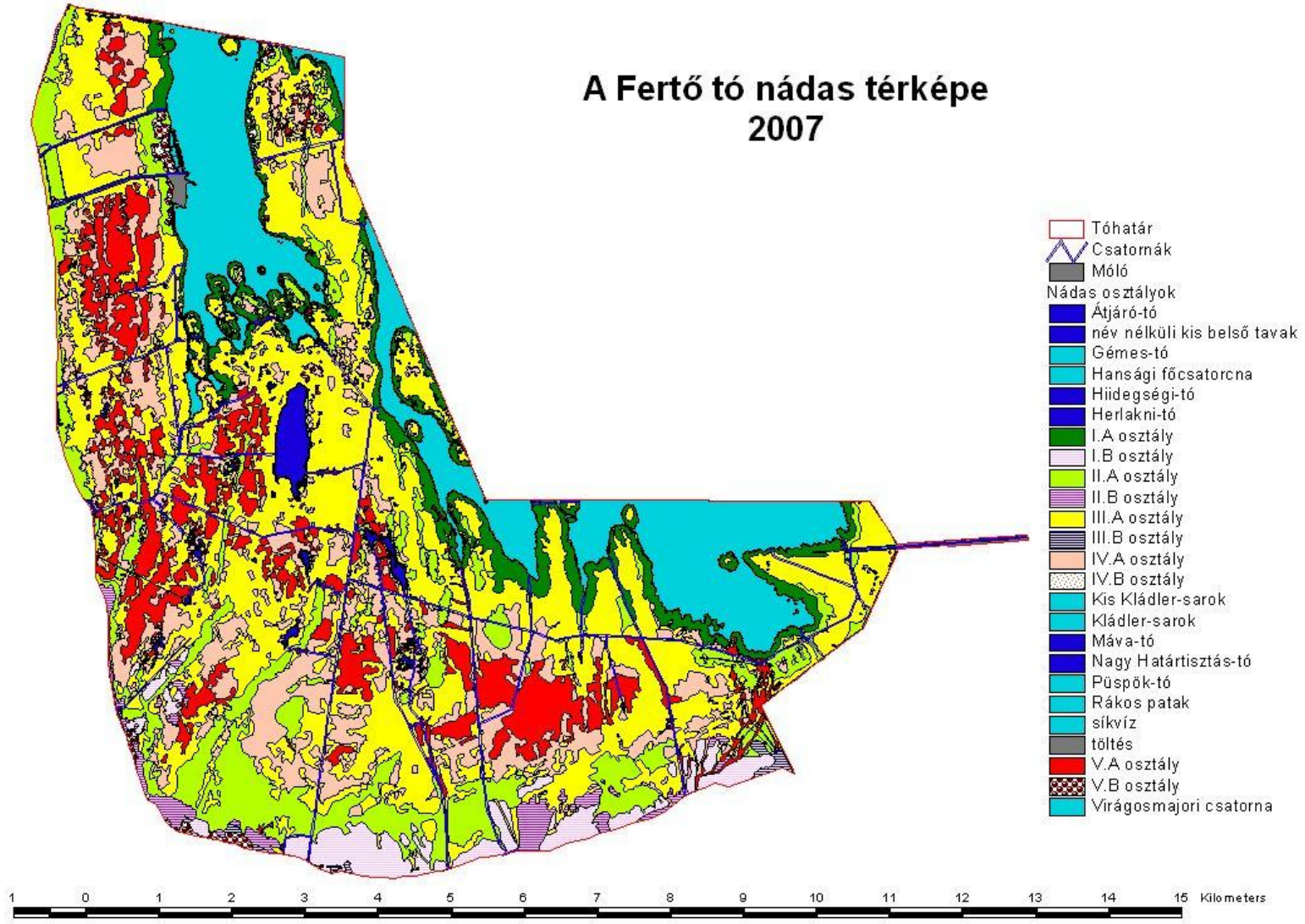
kiv. Excluded / non-vegetation areas (roads, built zones, boat bases)

tó. Open water

V.A Very open stands; reed mostly gone (near-complete dieback)

V.B Severely degraded dry areas with pioneer tree encroachment

Hungarian Reed Analysis



Reed Map of Lake Fertő, 2007

Tóhatár - Lake boundary
Csatornák - Canals
Móló - Pier / jetty

Átjáró-tó - Passage Lake
Név nélküli kis tavak - Unnamed small lakes
Gémes-tó - Gémes Lake
Hansági főcsatorna – Hanság Main Canal
Hidegségi-tó – Hidegség Lake
Herlakni-tó – Herlakni Lake

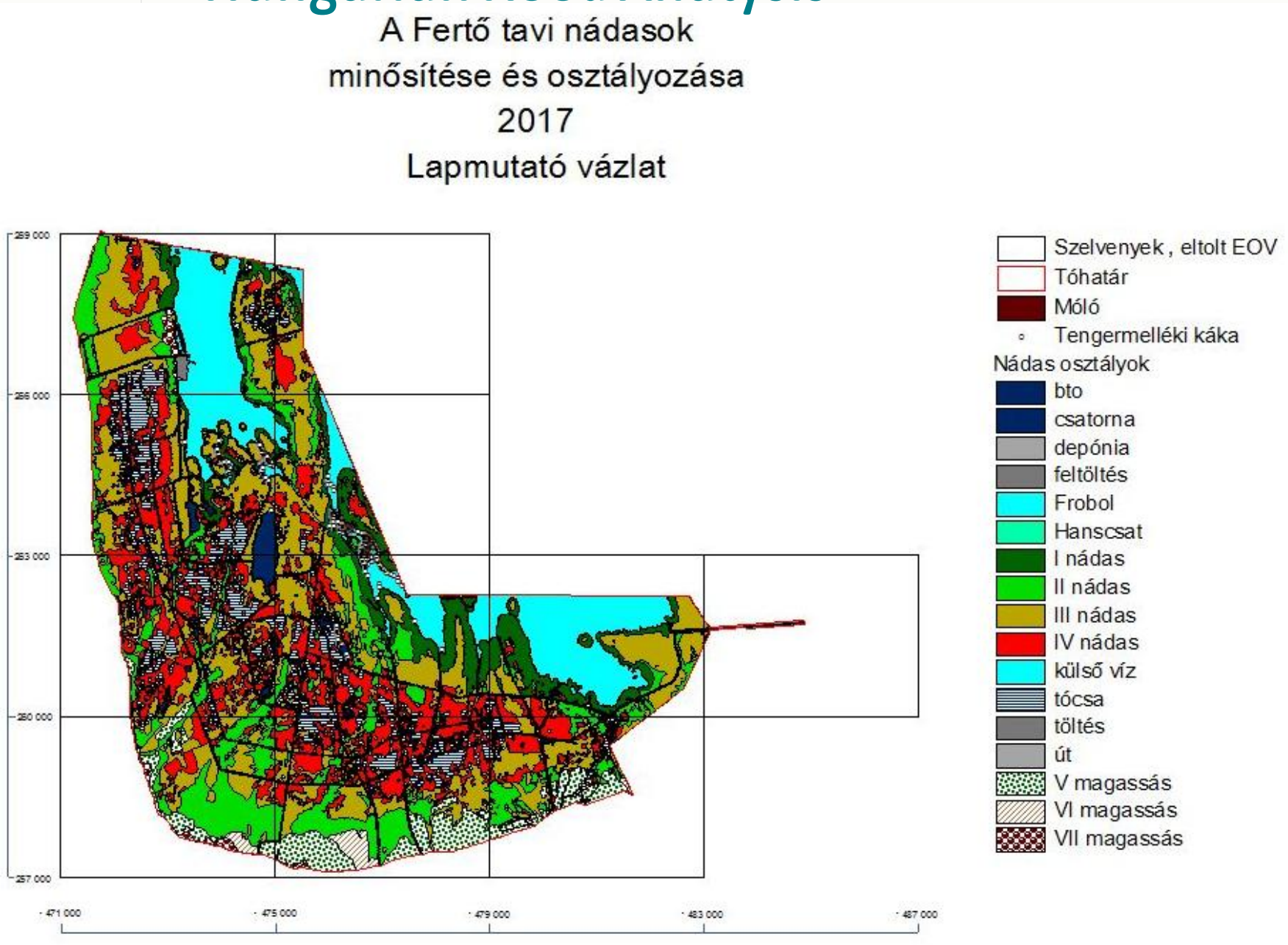
I.A – Homogeneous, dense reed
I.B – Natural sedge meadows
II.A Homogeneous, slightly opening reed
II.B – Sedges with initial weedy invasion
III.A – Thinning, aging reed
III.B – Weedy sedges and disturbed wetlands
IV.A – Strongly degraded reed with patchy water areas
IV.B – Weed-dominated drying zones

Kis Kládler-sarok – Small Kládler Corner
Kládler-sarok – Kládler Corner
Máva-tó – Máva Lake
Püspök-tó – Bishop's Lake
Rákos patak – Rákos Stream
Síkvíz – Open shallow water
Töltés – Embankment

V.A – Collapsing or nearly dead reed beds
V.B – Shrub-invaded, dried-out areas

Virágosmajori csatorna - Virágosmajor Canal

Hungarian Reed Analysis



Classification and Mapping of the Hungarian Reed Beds of Lake Fertő 2017

Szelvények, eltolt EOV - Map grid, shifted Hungarian National Projection
Tóhatár- Lake boundary
Móló - Pier / jetty
Tengermelléki káka - *Sea clubrush* (*Bolboschoenus maritimus*) patches

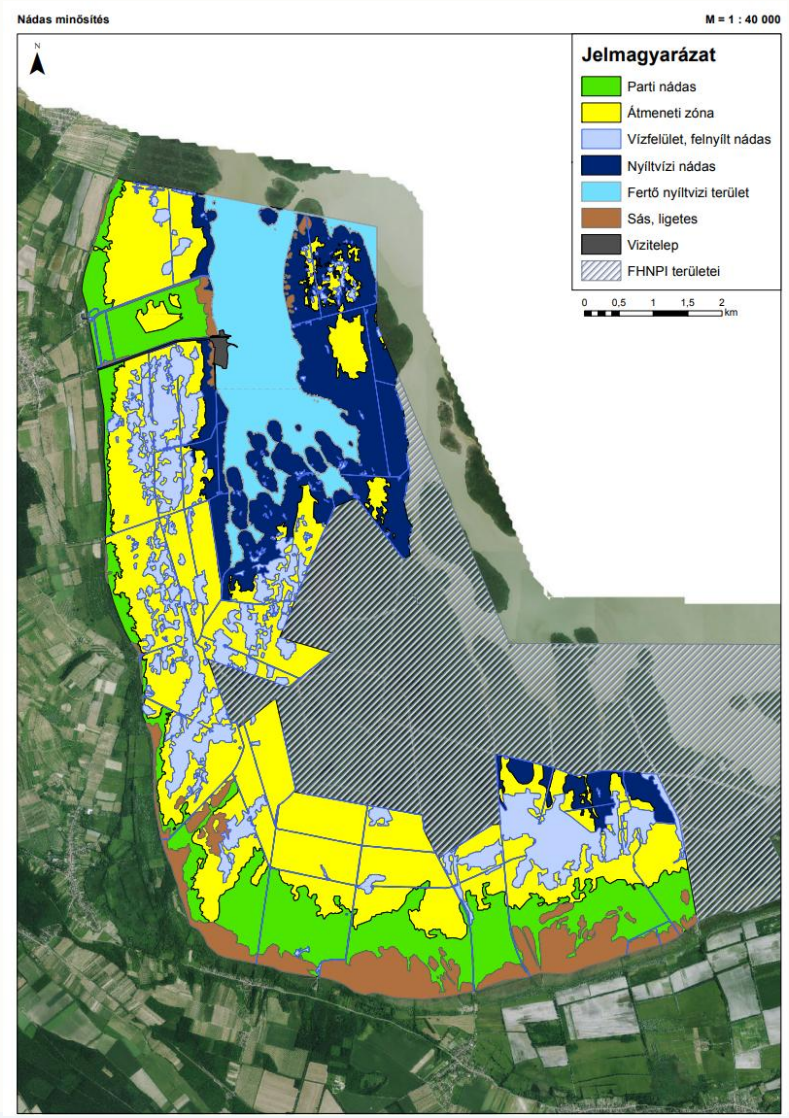
Bto- inner lake
csatorna – canal
Depónia - Spoil heap
Feltöltés - Filled area / artificial fill
Frobol - Bay

I. Nádas - Optimal, healthy reed stands
II. Nádas - Healthy inner or shoreline reed
III. Nádas - Thinning, aging reed stands
IV. Nádas - Heavily degraded reed with large water patches

külső víz – lake water
tócsa - Water patches created by *reed death after harvesting*, with >50% open water.
Töltés – Embankment
Út – road

V. Magassásos - High-diversity sedge meadow / marsh
VI. Magassásos - Tall-sedge marsh dominated by weeds
VII. Magassásos - Heavily weedy, shrub-invaded drying marsh

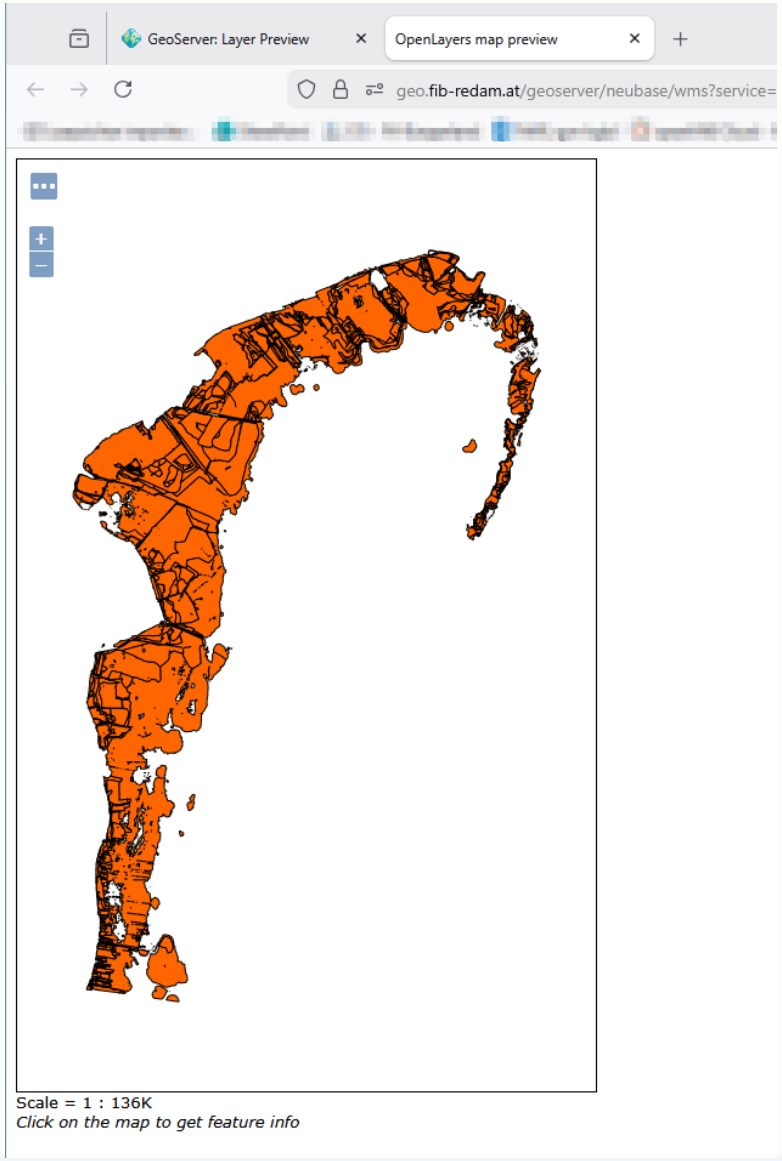
Hungarian Reed Analysis



Map legend

Parti nádas - Shoreline reed belt
Átmeneti zóna - Transitional zone
Vízfelület, felnyílt nádas - Water surface, opened reed areas
Nyíltvízi nádas - Open-water reed belt
Fertő nyíltvízi terület - Open-water area of Lake Fertő
Sás, ligetes - Sedge / marshy patches / clumped vegetation
Vízitelep - Boathouse / water facility area
FHNPI területei - Areas of the Fertő–Hanság National Park

GeoServer



Access:
https://geo.fib-redam.at/geoserver/web/?54

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GeoServer – Key Functions
- Geospatial data storage and distribution layer
- Multi-source data ingestion (PostGIS, Shapefiles, etc.)
- Standards-based data access (OpenLayers, GML, REST APIs)

Scope & Usage
- Preview-level visualization only
- Full visualization via professional GIS tools (e.g. QGIS)

Project Value
- Prototype platform for testing and validating the final data architecture
- Testing interfaces in a safe environment
- Foundation for geospatial expertise development within the project

Neubase

Neusiedler See – Fertő tó – A data platform for optical and bathymetry survey for reed classification and sediment transport modelling

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