Prague, 26.05.2025

Classification of Orchard Meadows based on Phenological Characteristics

Jana Metzger, Paul Joseph, Dr. Maike Petersen,
Prof. Dr. Alexander Siegmund

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Institute of Geography and Geocommunication | Research Group for Earth Observation – ʳgeo

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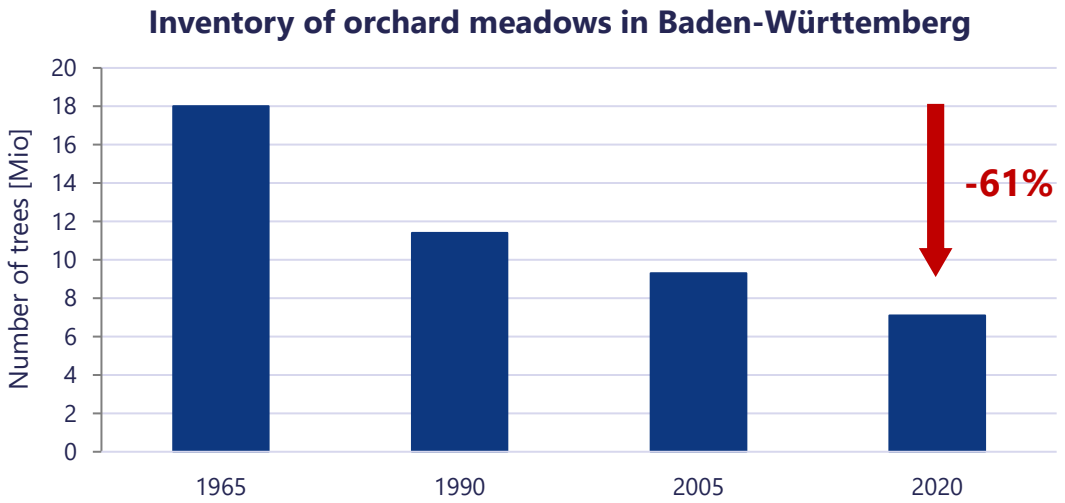
What are Orchard Meadows?

Endangerment of Orchard Meadows



MLR, 2009 & LUBW 2020

Reasons:

- Land use change
- Intensification of agriculture
- Lack of care and management

Research work

Main objective of my master‘s thesis:
Successfully classify (well-maintained and poorly maintained) orchard meadows to facilitate maintenance.

Well-maintained

Poorly maintained

Outline

Part I: Research Framework

1. Key Questions
2. State of Research and Research Gap
3. Which Orchard Meadows are analyzed?
4. Methodical Approach

Part II: First Results

5. Comparison of different Indices
6. Comparison of different Land Use Types
7. Initial Findings

Part III: Outlook

8. Further Research and Potential Challenges

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Part I: Research Framework

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Key Questions

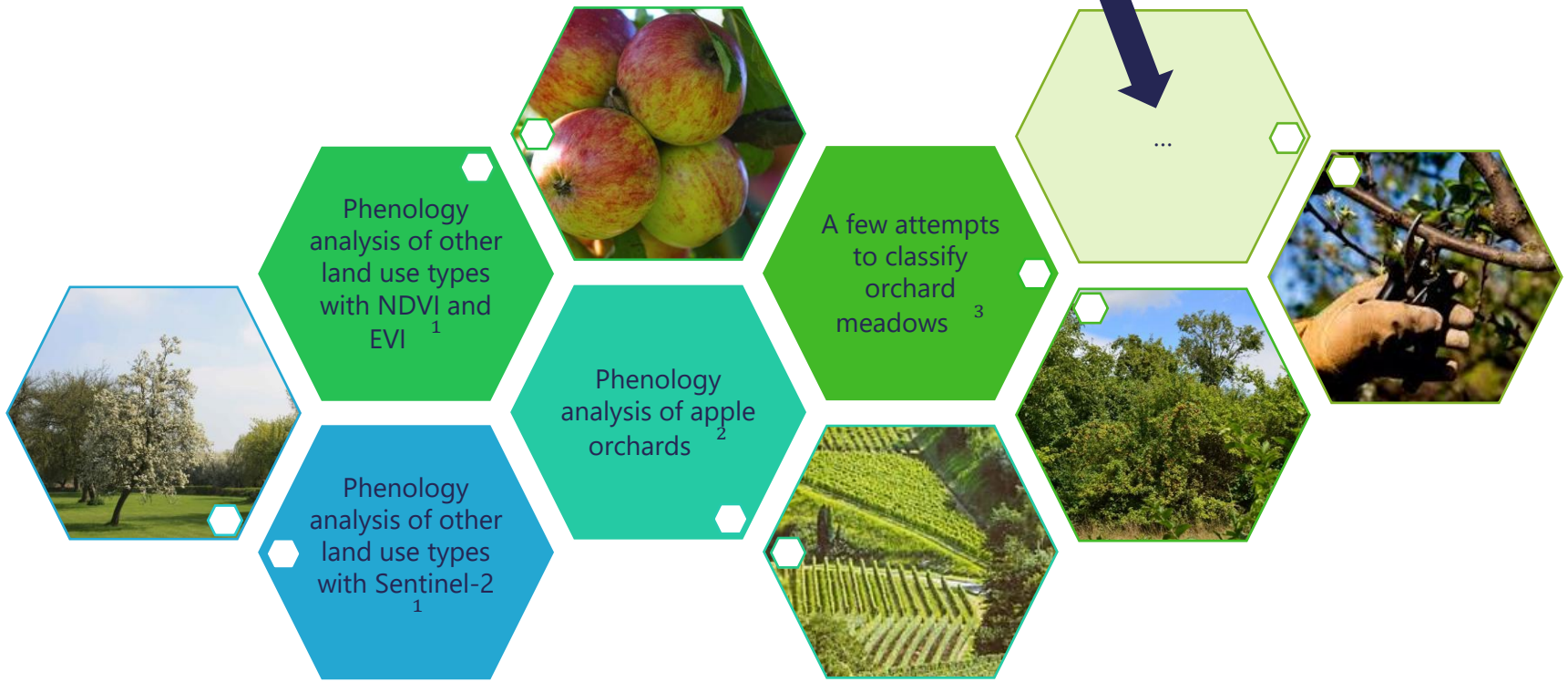
1. Which **indices** most clearly show the phenological annual cycle of orchard meadows?

2. To what extent do the phenological annual cycles of orchard meadows **differ from other forms of land use**?

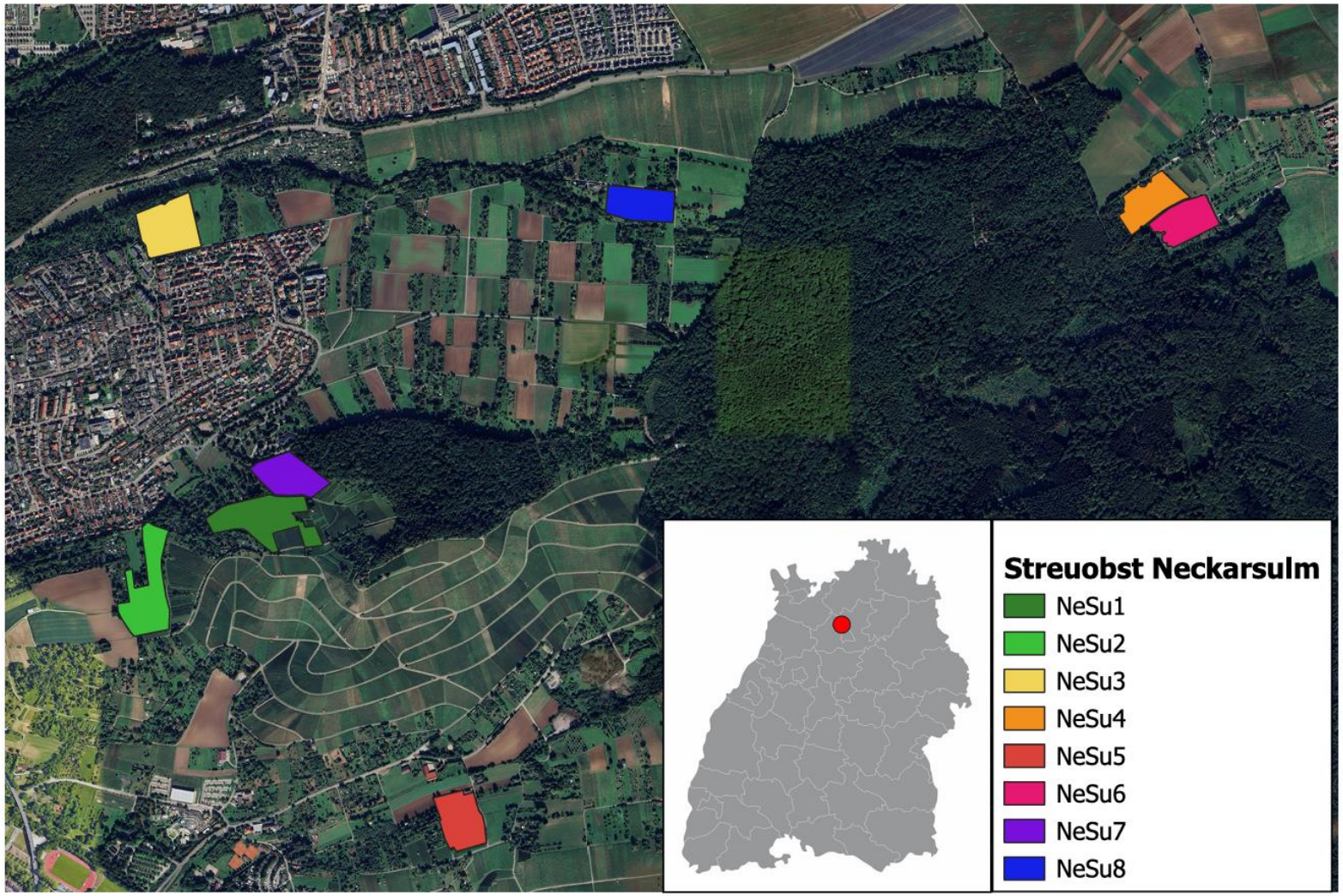
3. How well can **well-maintained and poorly maintained** orchard meadows be classified on the basis of phenology?

State of Research and Research Gap

…and no attempts to classify poorly maintained orchard meadows.



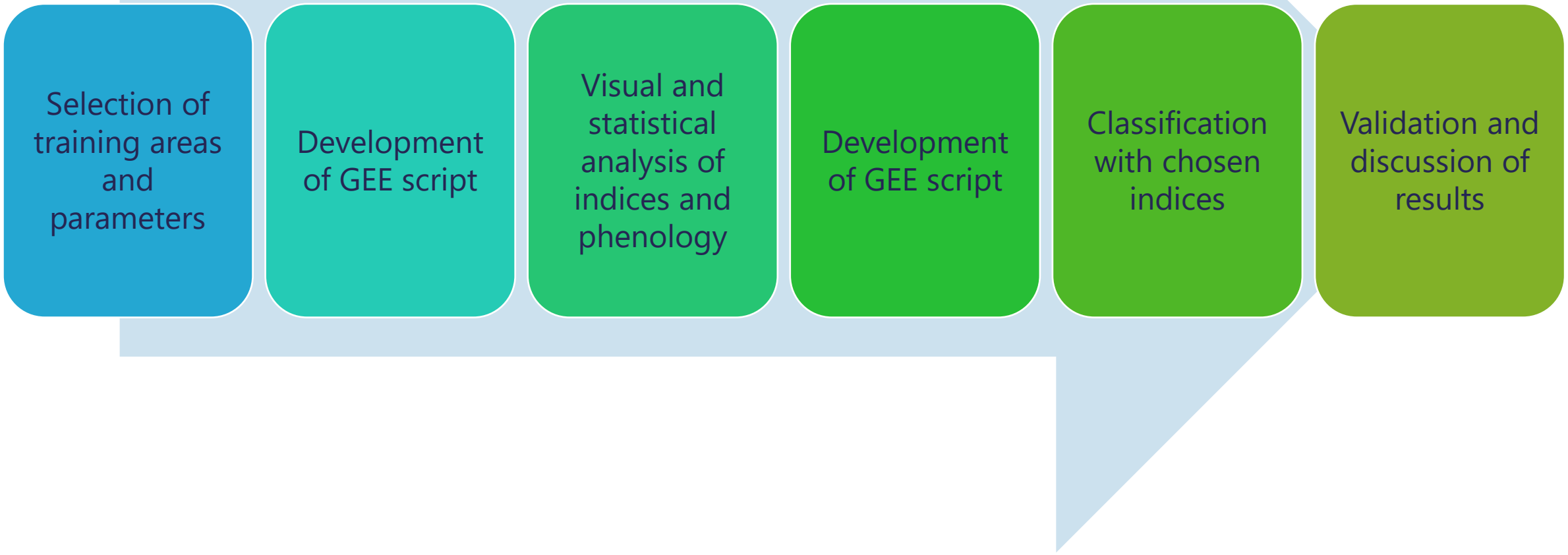
Which Orchard Meadows are analyzed?



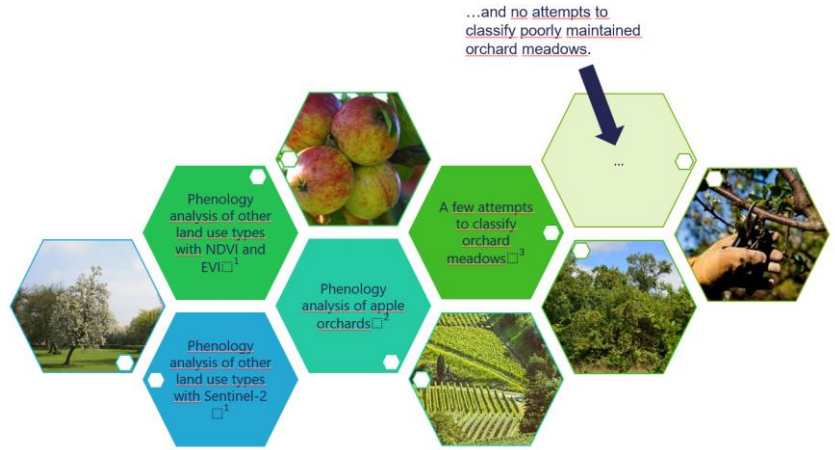
Jana Metzger, 26.09.2025, EPSG 25832,
Base Map Google Earth, Streuobstflächen
aus diversen Kartierungen

- **Training data** of mappings in Baden-Württemberg (Neckarsulm, Bad Schönborn, Tübingen and Naturpark Neckar-Odenwald)
- Min. **2 ha**
- So far very **well-maintained orchard meadows** because they are known

Methodical Approach



Methodical Approach



Selection of Parameters

- **Satellite images:** Sentinel-2, räumliche Auflösung 10m x 10m
- **Cloud Masking:** 10 %
- **Temporal Resolution:** Monthly data from April to August
- **Classification Algorithm:** Random Forest, object-based
- **Potential Indices:** NDVI, EVI, NDRE, Red Edge 1 and SAVI (Median)
- **Statistical Variables:** Min, Max, Difference Max Min, Integral and DOY Max,…

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Part II: First Results

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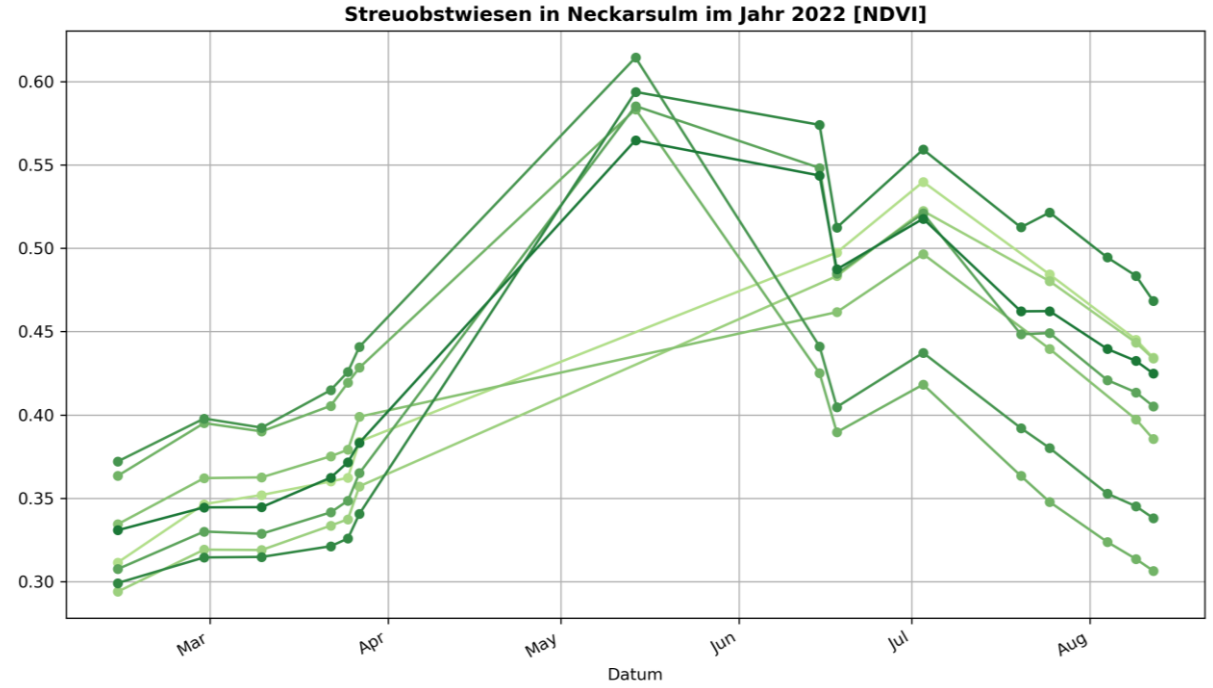
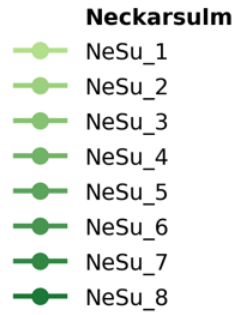
Comparison of different Indices

NDVI

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{Rot}}{\mathrm{NIR} + \mathrm{Rot}}$$

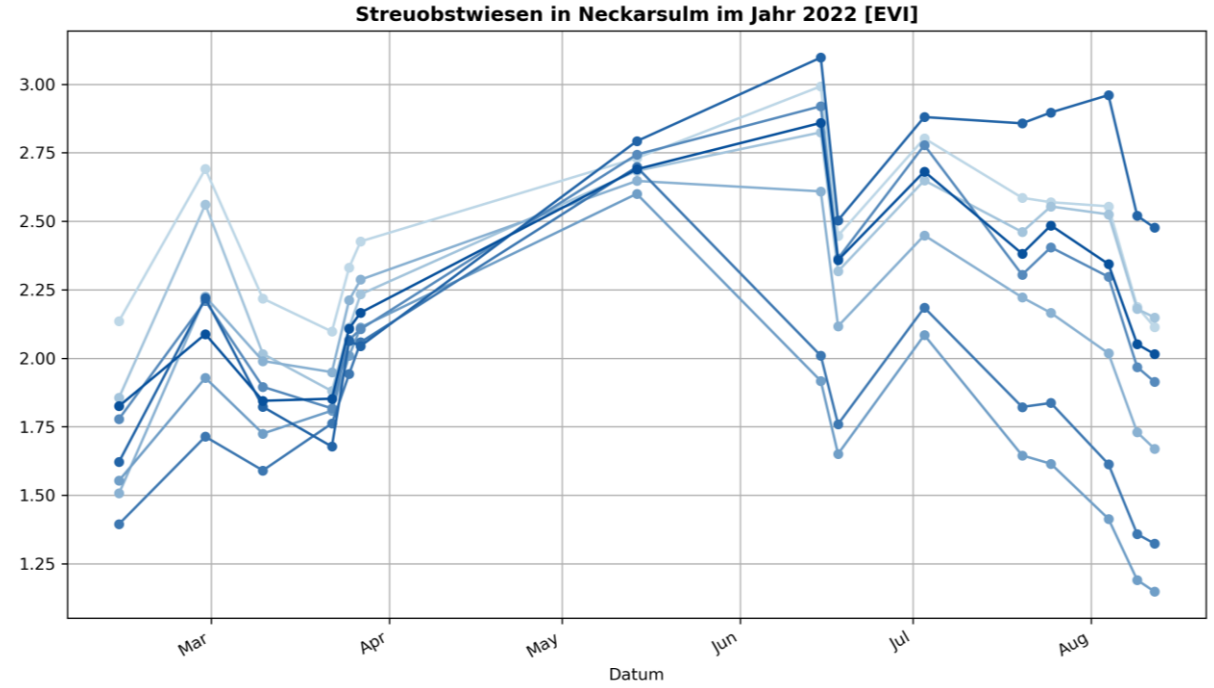


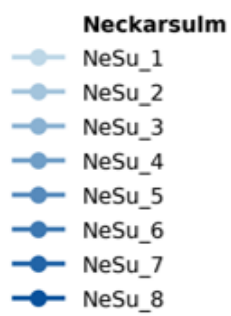


- NDVI sensitive to chlorophyll

EVI

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

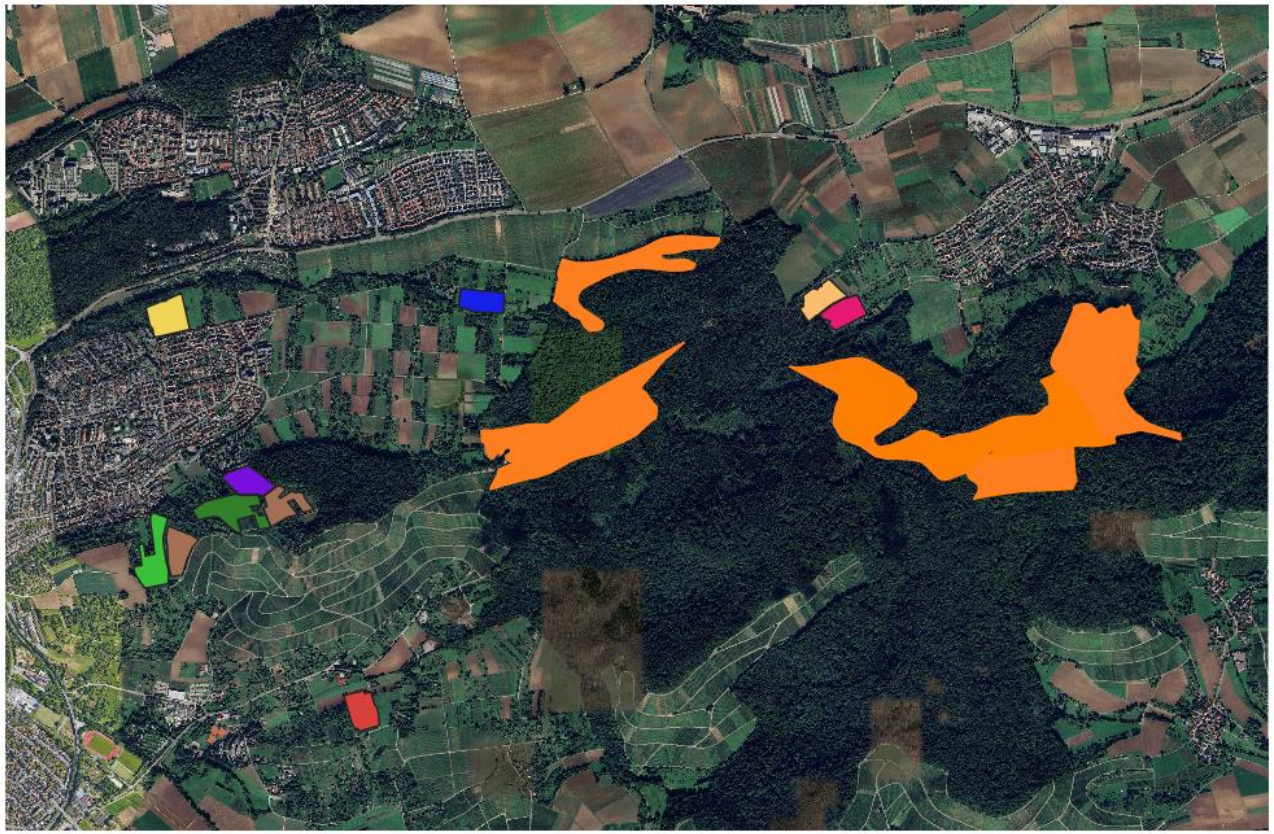




- EVI more responsive to canopy structural variations
- Improved sensitivity for high biomass

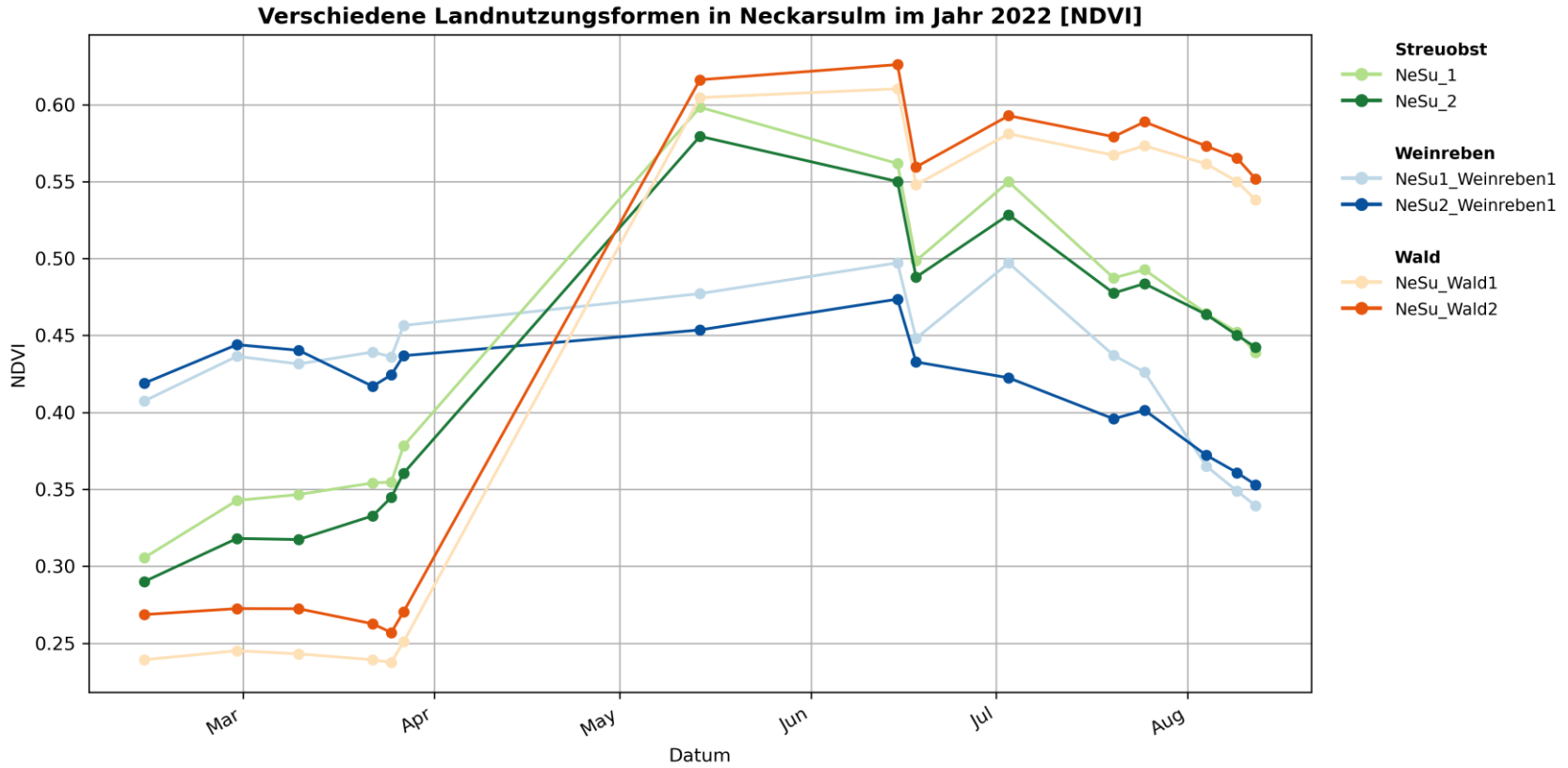
Comparison of different Land Use Types

Streuobstwiesen, Weinreben und Laubwald in Neckarsulm



Jana Metzger, 27.09.2025, EPSG 25832
Streuobstwiesen aus diversen Kartierungen, Wald und Wein von Vektorlayer Landnutzung von Geoportal Baden-Württemberg,
Basemap Google Satellite

Comparison of different Land Use Types



Kategorie	Fläche	Jahr	Index	Integral	Integral_Feb_Mar	Integral_Jul_Aug	Differenz_Max_Min	DOY_Max	Max_Wert
Streuobst	NeSu_1	2022	NDVI	98,52	14,31	19,68	0,29	134,00	0,60
Streuobst	NeSu_2	2022	NDVI	94,76	13,36	19,31	0,29	134,00	0,58
Weinreben	NeSu1_Weinreben1	2022	NDVI	96,16	18,10	16,87	0,23	166,00	0,57
Weinreben	NeSu2_Weinreben1	2022	NDVI	94,07	18,16	15,72	0,31	166,00	0,66
Wald	NeSu_Wald1	2022	NDVI	94,63	10,17	22,70	0,37	166,00	0,61
Wald	NeSu_Wald2	2022	NDVI	98,76	11,30	23,21	0,37	166,00	0,63

Comparison of different Land Use Types

NDVI $$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{Rot}}{\mathrm{NIR} + \mathrm{Rot}}$$

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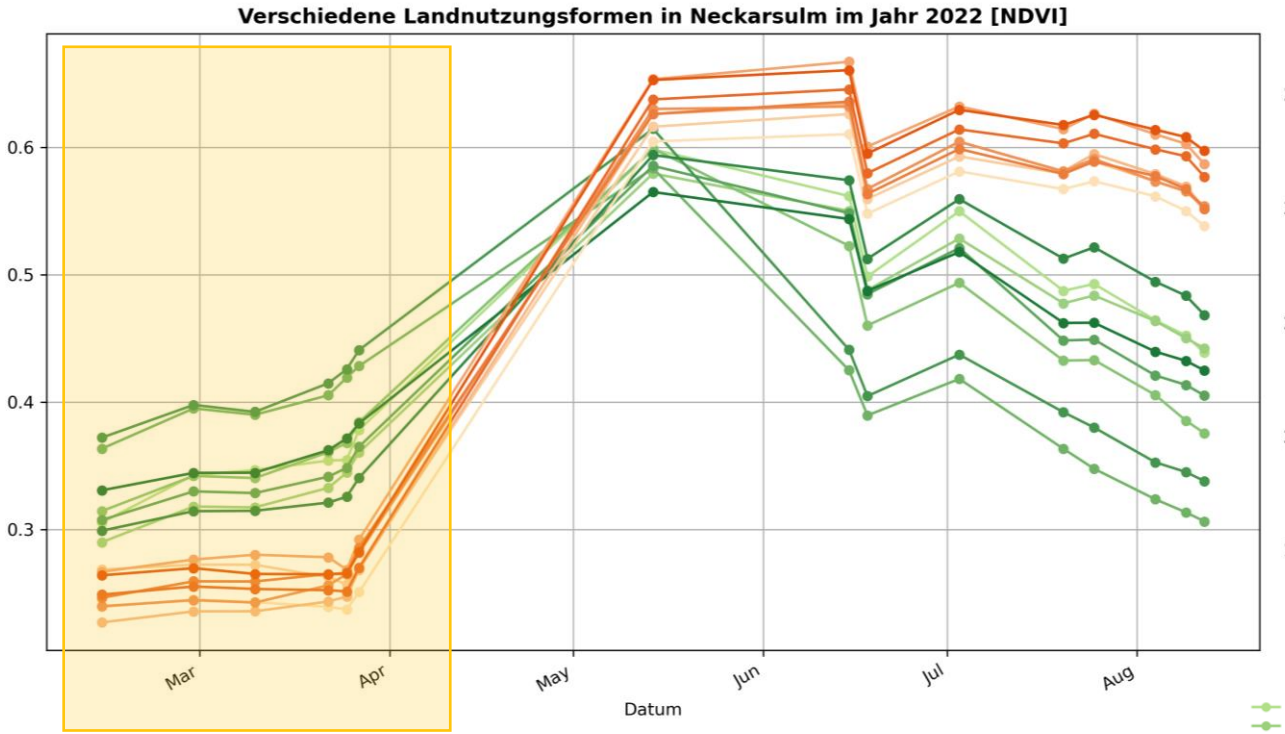
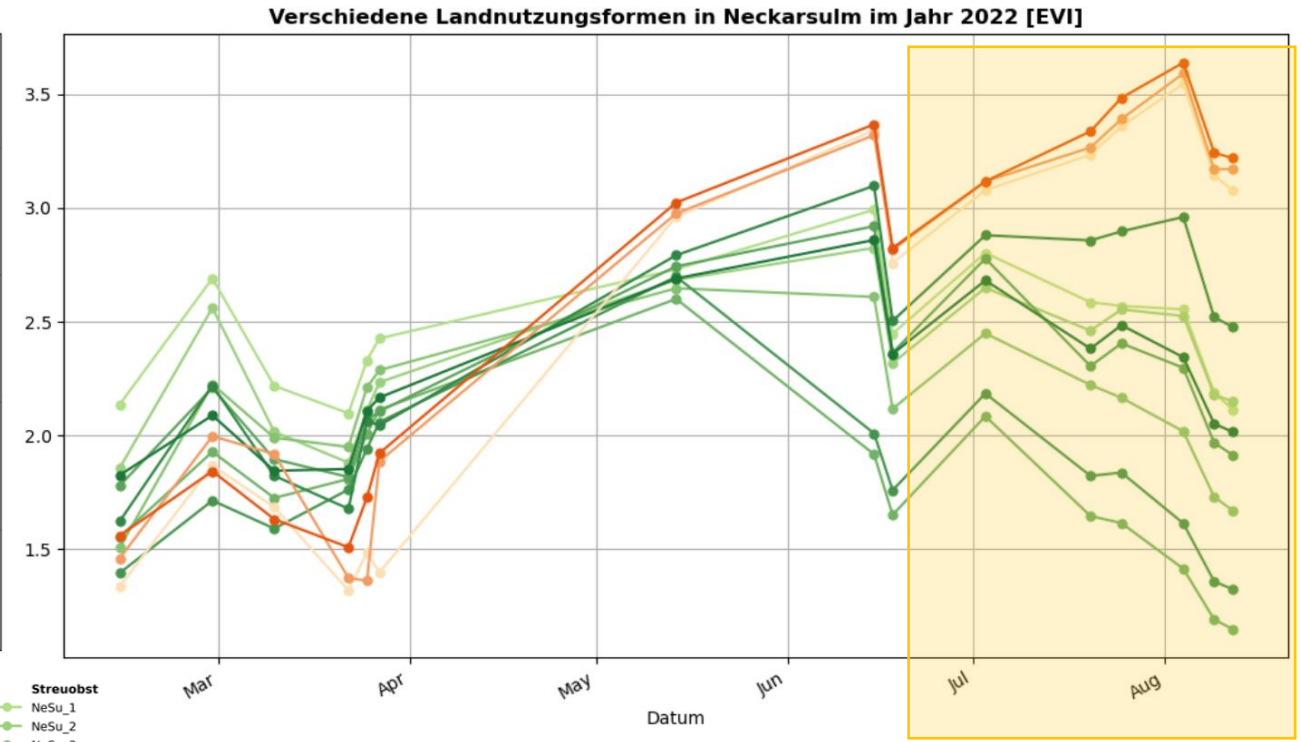
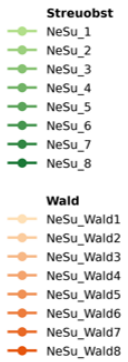




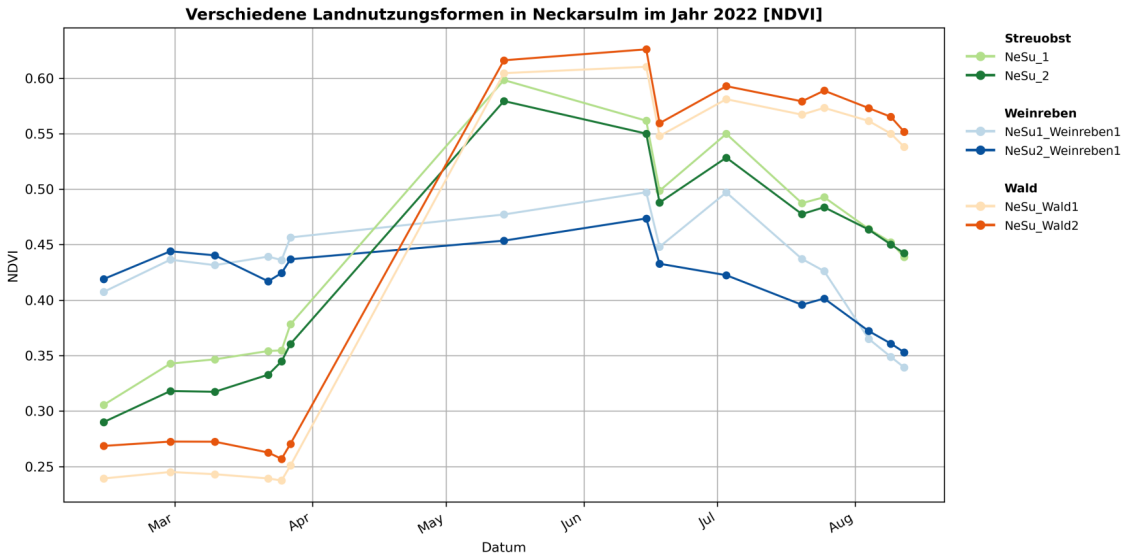


- NDVI sensitive to chlorophyll

- EVI more responsive to canopy structural variations
- Improved sensitivity for high biomass

Initial Findings

Comparison of different Indices



- **NDVI** → seems to reflect the differences most clearly, especially before and after the flowering phase
- **EVI** → could be considered to show differences after the flowering phase more clearly
- **NDRE** → does not clearly highlight differences
- **Red Edge 1** → too many irregularities → not suitable

Comparison of different Land Use Types

- Well-maintained orchard meadows start at a higher NDVI than deciduous forests
- Max-NDVI of orchard meadows is earlier than of deciduous forests and vineyards
- NDVI-Integral between July and August is lower of orchard meadows than of deciduous forests

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Part III: Outlook

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Outlook – It remains exciting…

Further Research and Potential Challenges

Spectral/ structural heterogenity
- Mowed/ unmowed
- Varying tree density
- Maintained/ not maintained

Confusion with other land cover types
- Seasonality of deciduous forests is very similar
- Selecting significant parameters within a small timeframe

Model training
- Selecting significant indices and statistic parameters
- Balanced training samples
- Training data hast to be accurate

Transferability
- Different locations have different micro-climatic conditions
- Phenological timing can shift between years

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Thank you!

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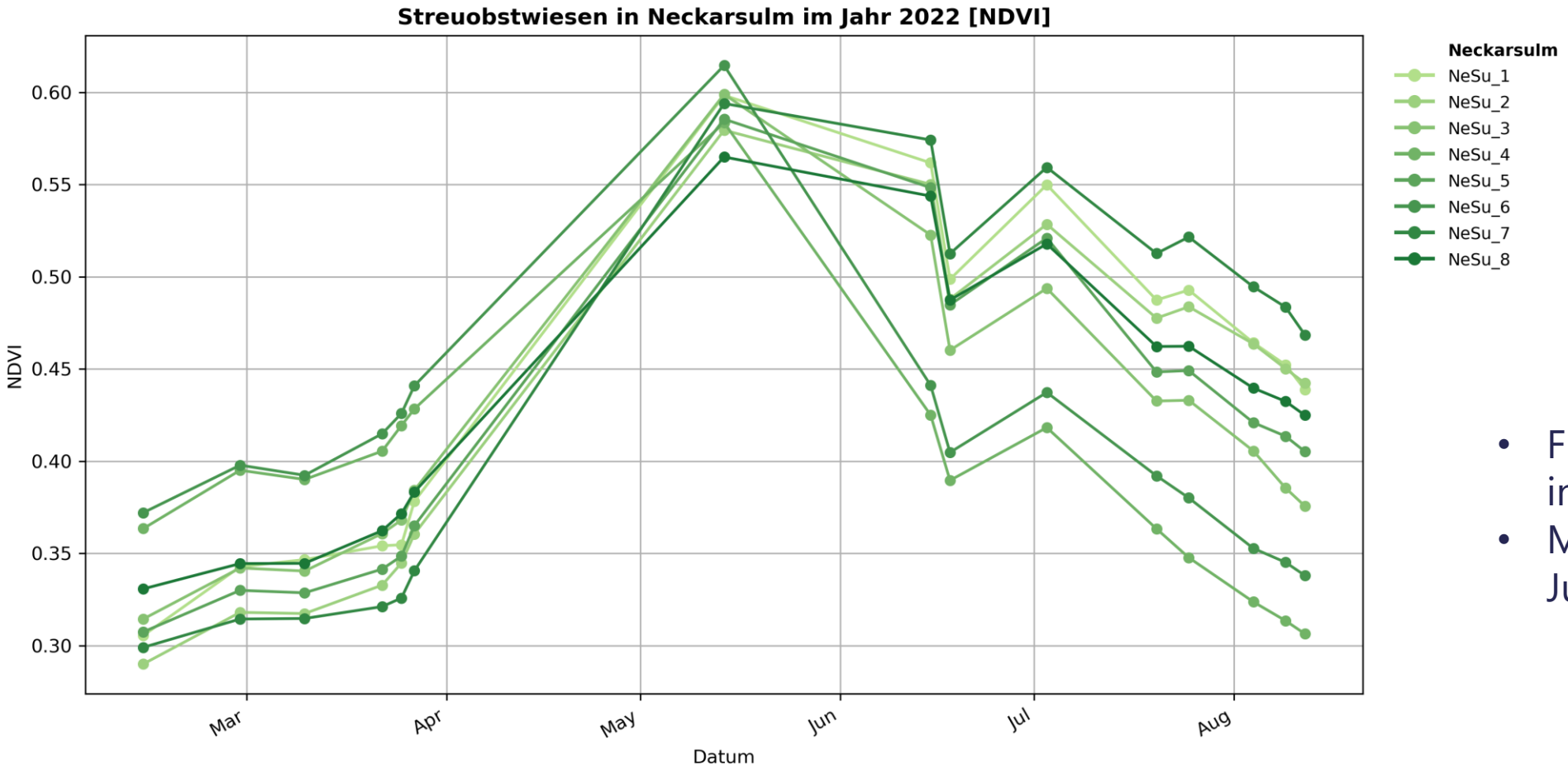
Comparison of different Land Use Types



- Flowering phase starts in late March
- Mowing usually in June, then follow-up

NDRE

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EVI

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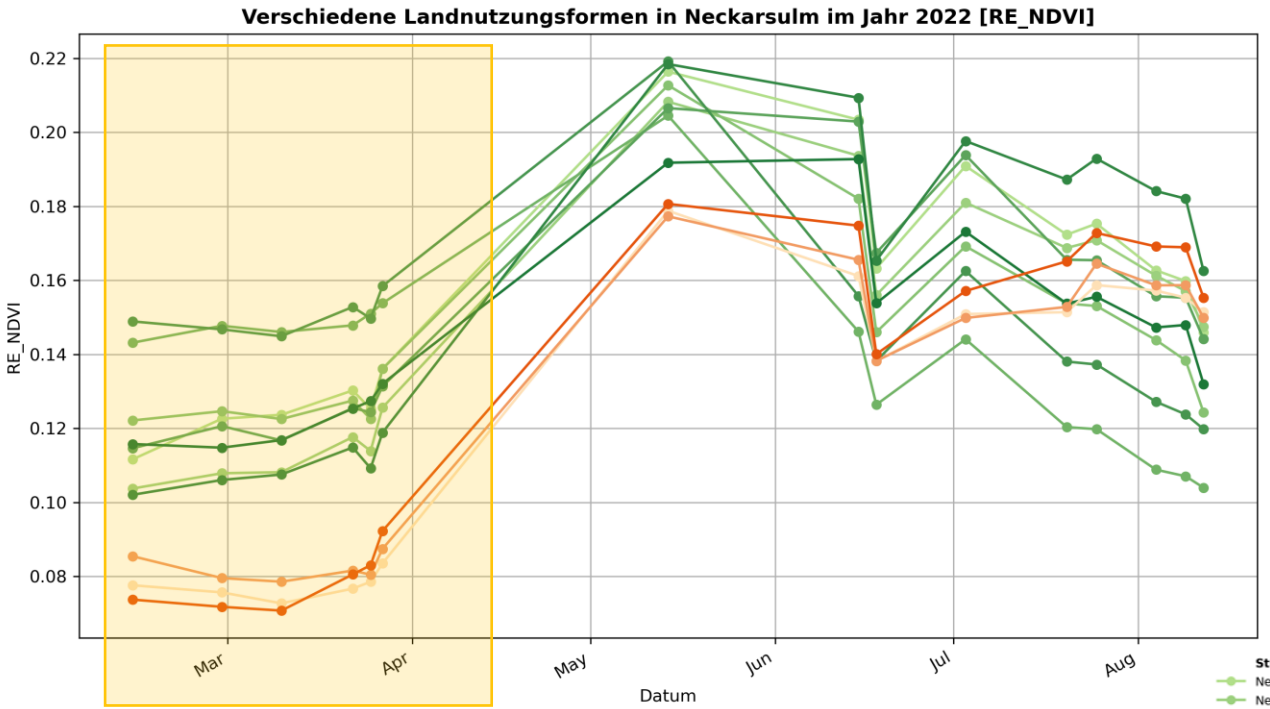

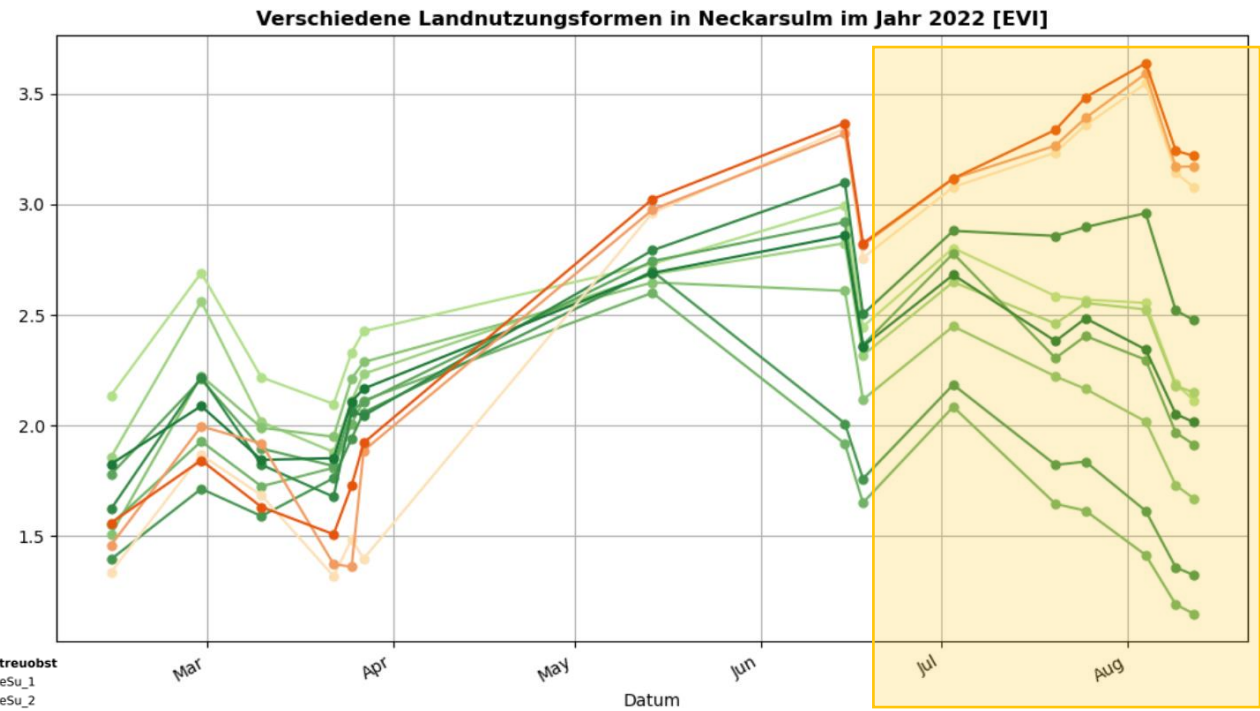

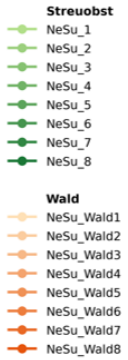

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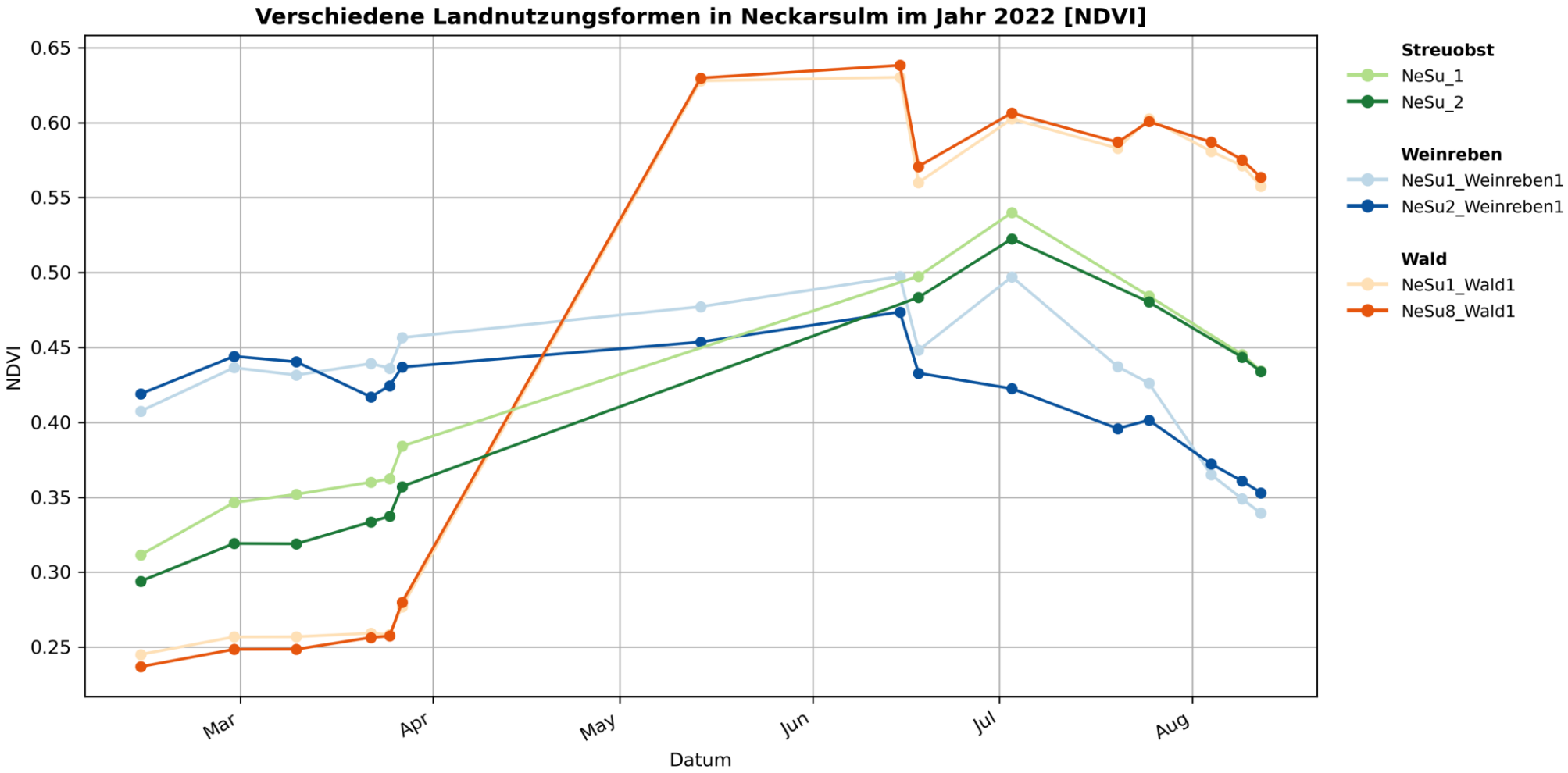

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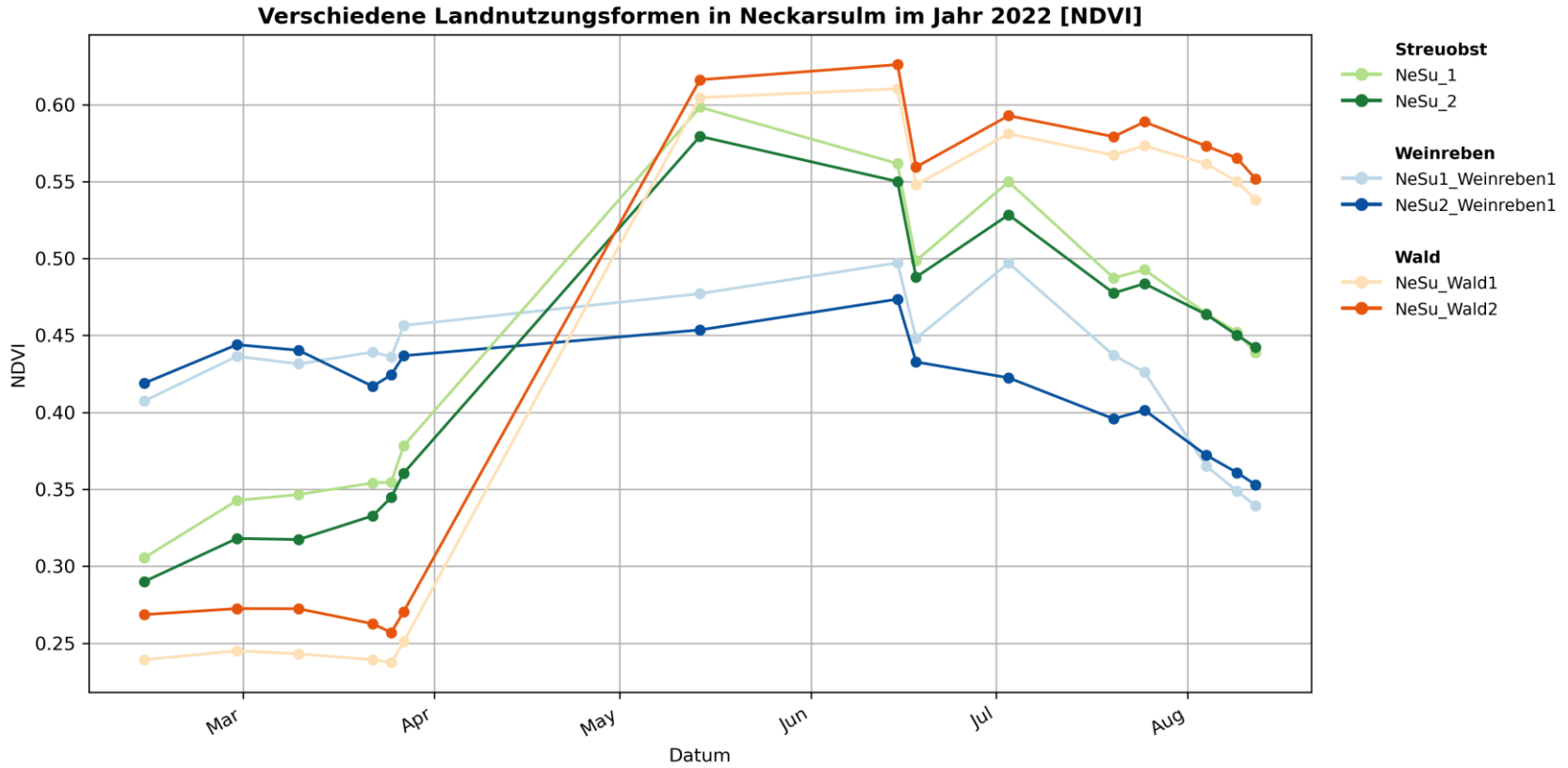

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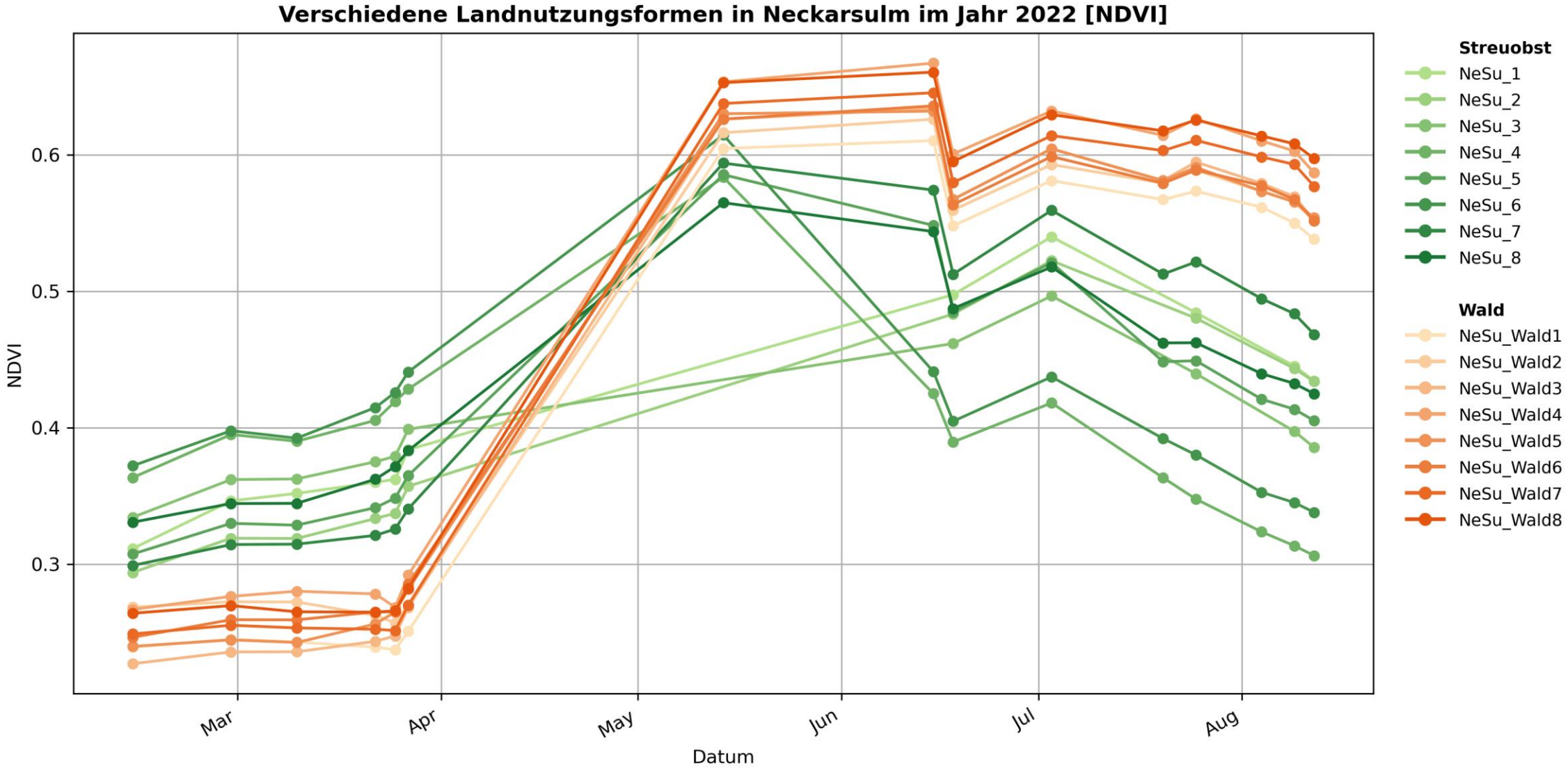
Verschiedene Landnutzungsformen in Neckarsulm im Jahr 2022 [NDVI]
NDVI
0.6
0.5
0.4
0.3
Mar
Apr
May
Jun
Jul
Aug
Datum
Streuobst
NeSu_1
NeSu_2
NeSu_3
NeSu_4
NeSu_5
NeSu_6
NeSu_7
NeSu_8
Wald
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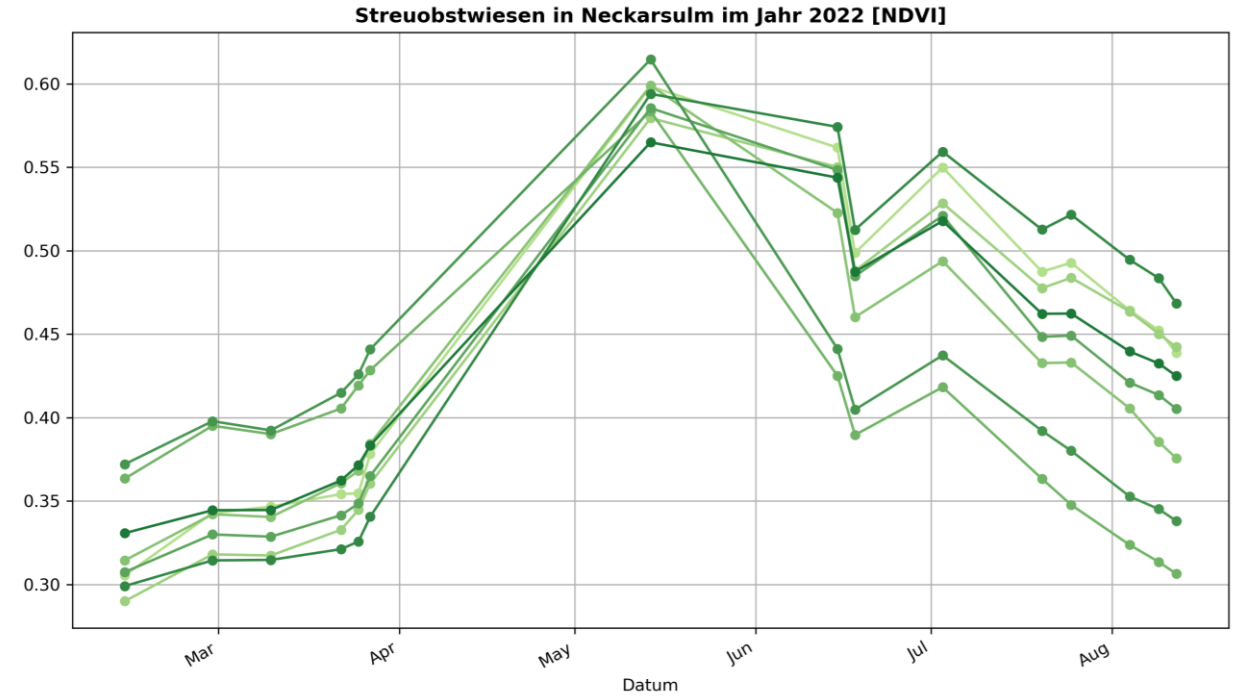

- NDVI sensitive to chlorophyll

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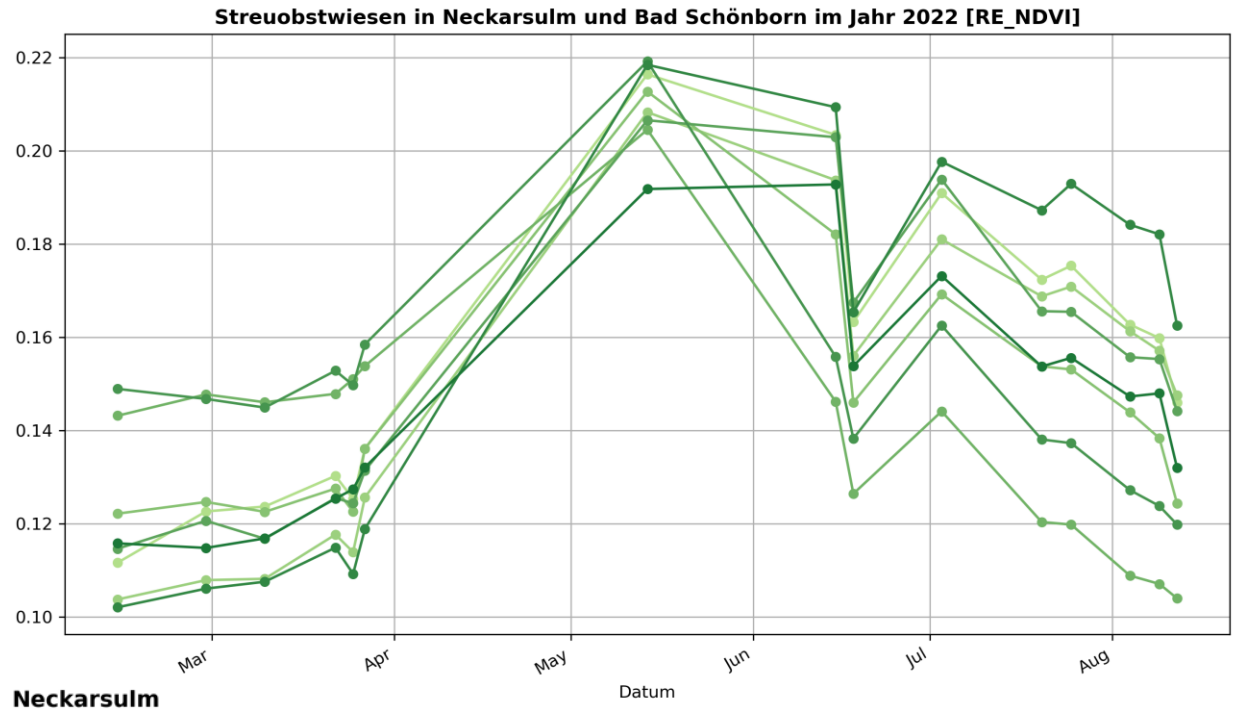

- NDRE more sensitive to chlorophyll in higher concentrations

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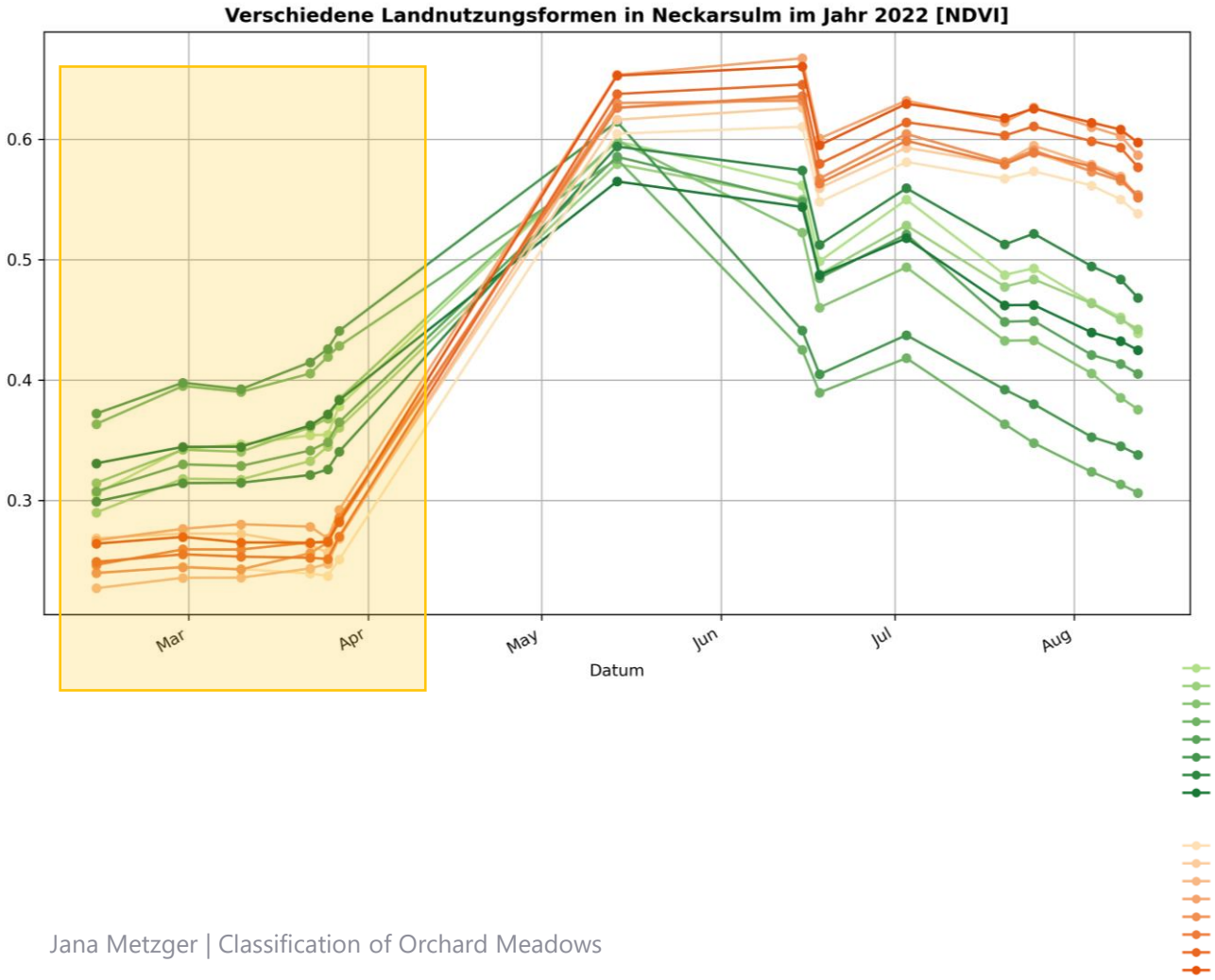

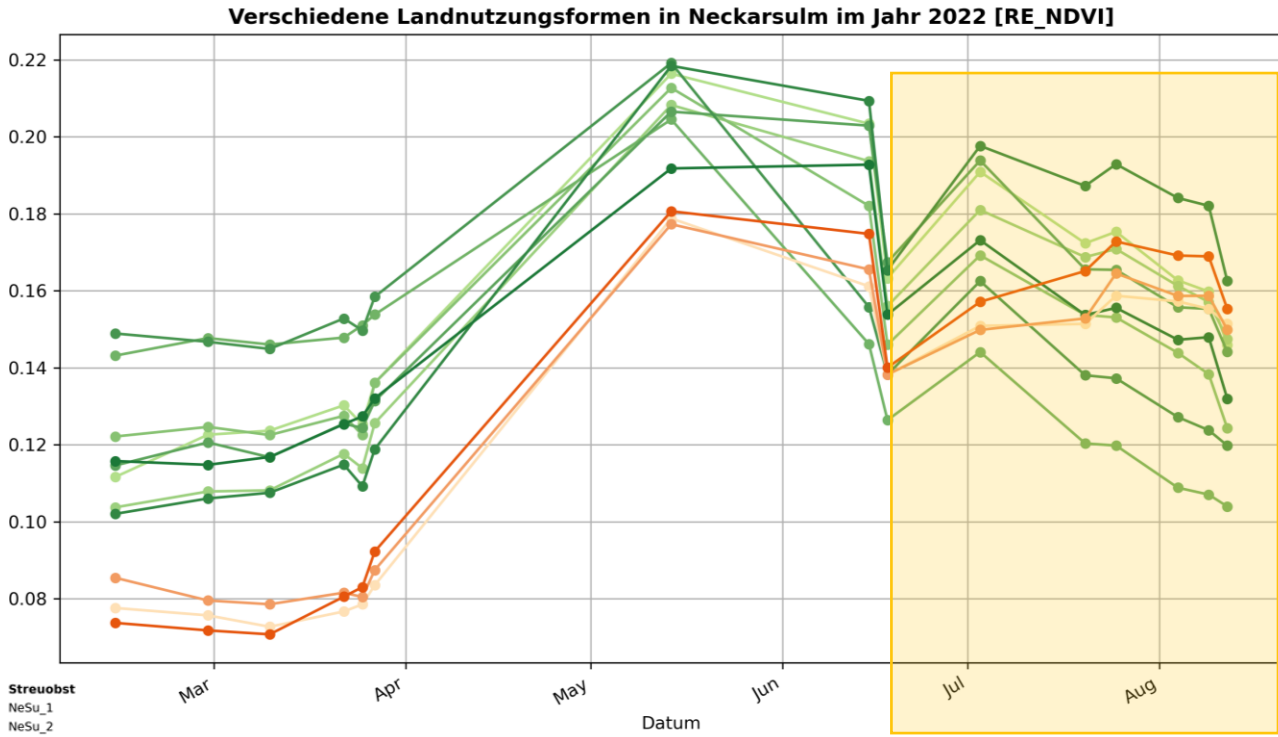

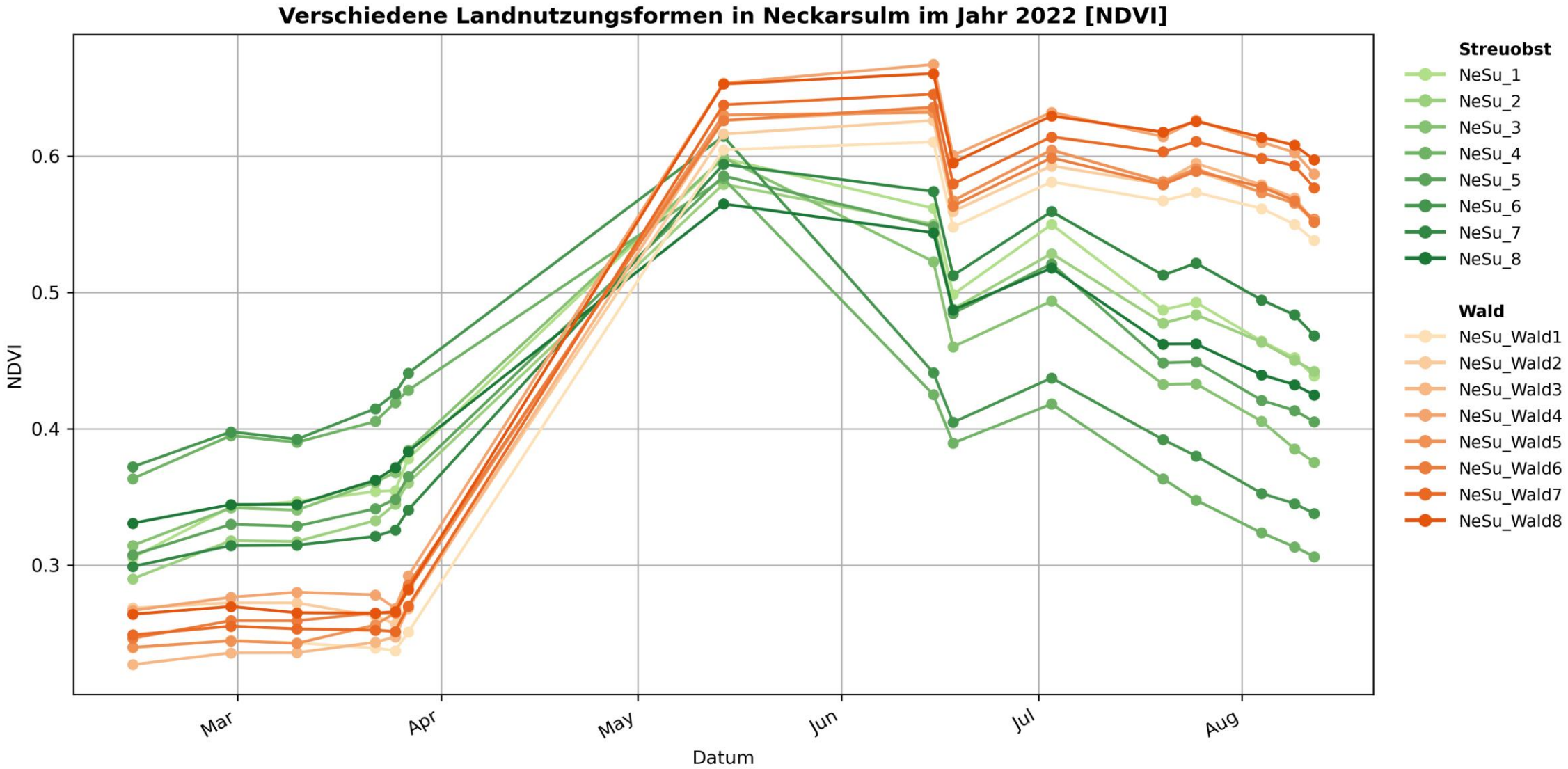
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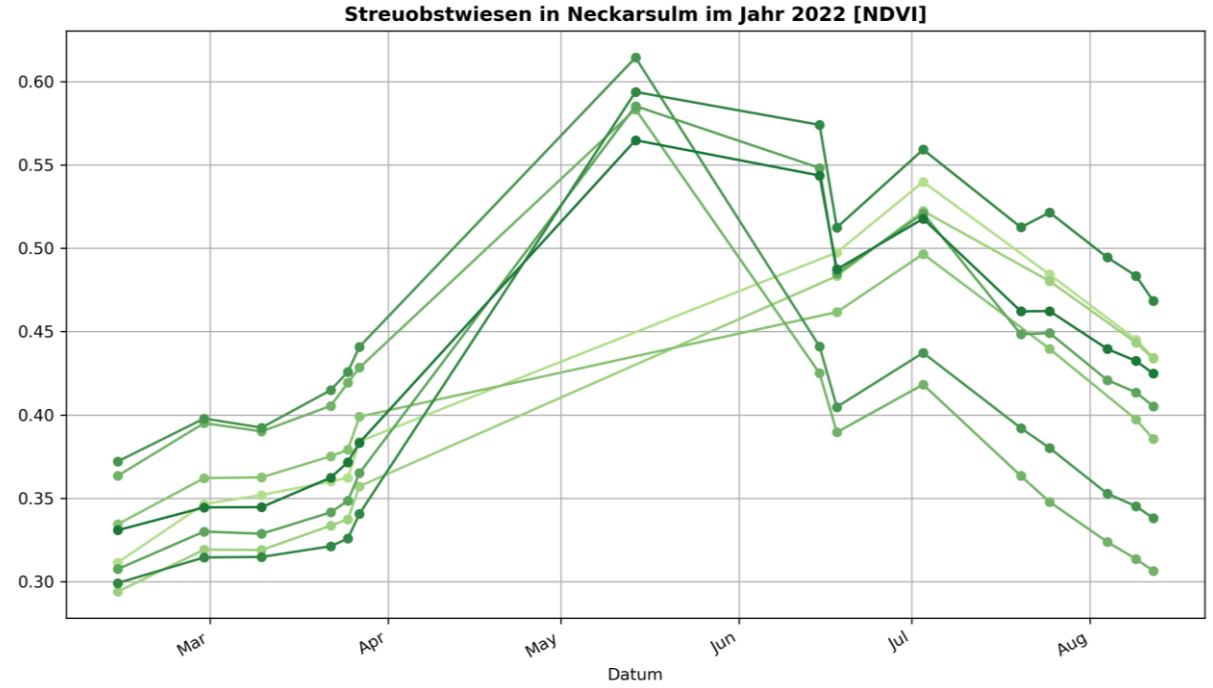

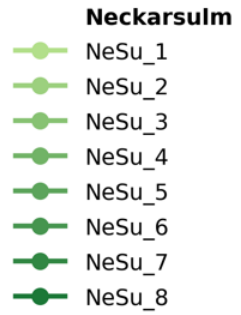

- NDVI sensitive to chlorophyll

EVI

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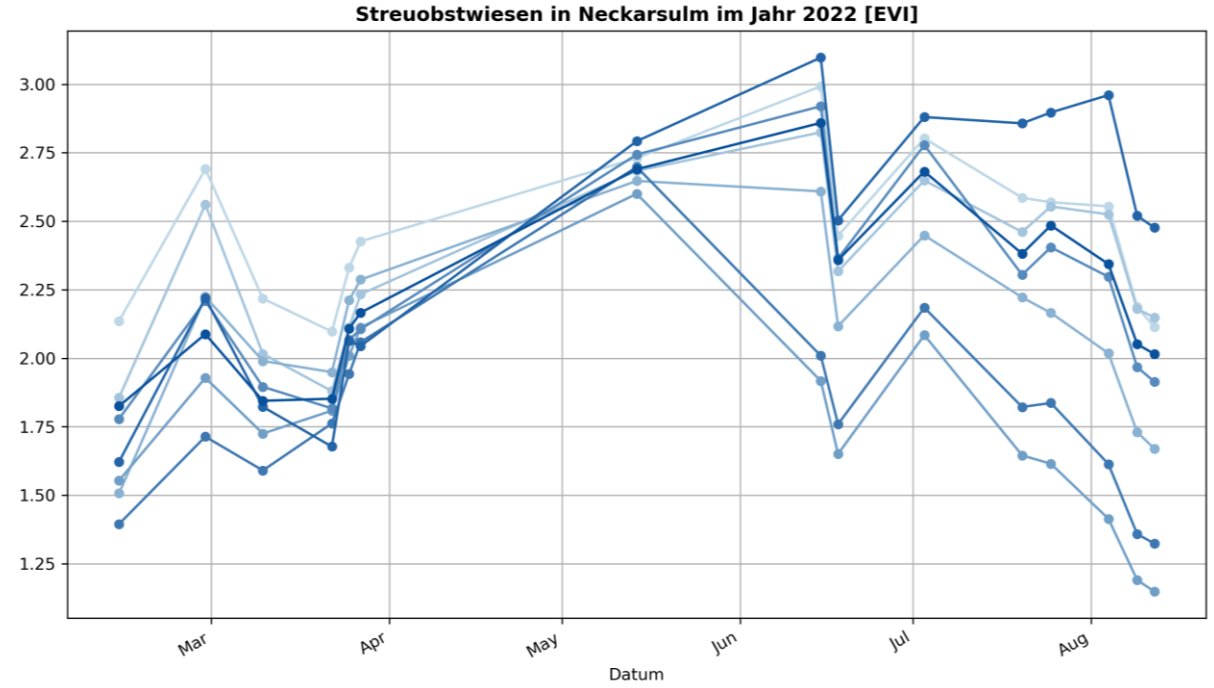

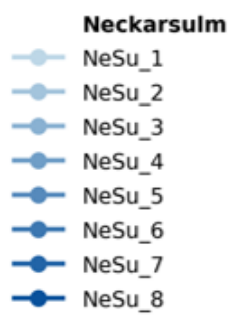

- EVI more responsive to canopy structural variations
- Improved sensitivity for high biomass