Grassland management change over 25 years: A landscape analysis using remote sensing

Habitat changes over time can be an important factor for insect decline.

These changes can be characterized using remote sensing.

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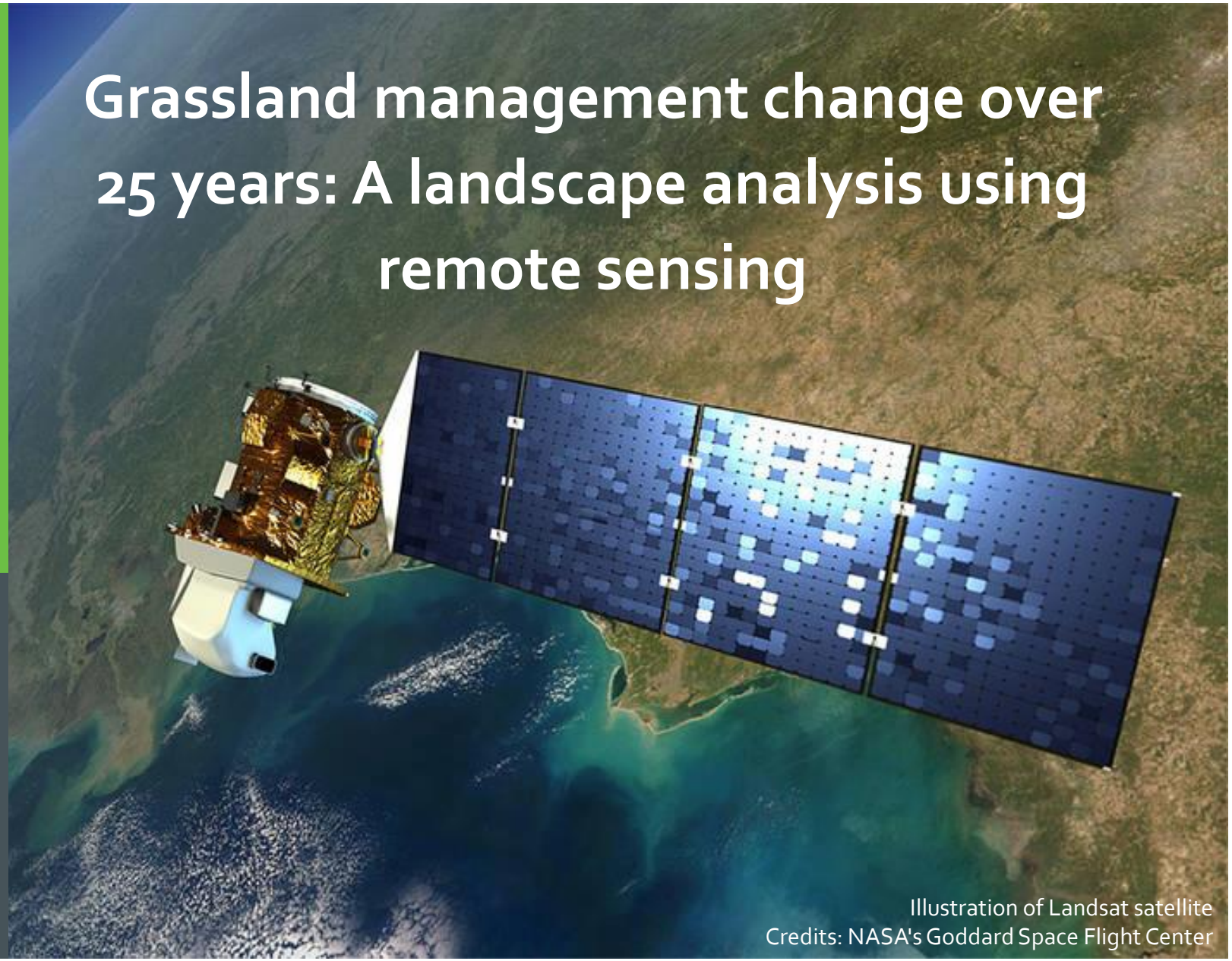


Illustration of Landsat satellite
Credits: NASA's Goddard Space Flight Center

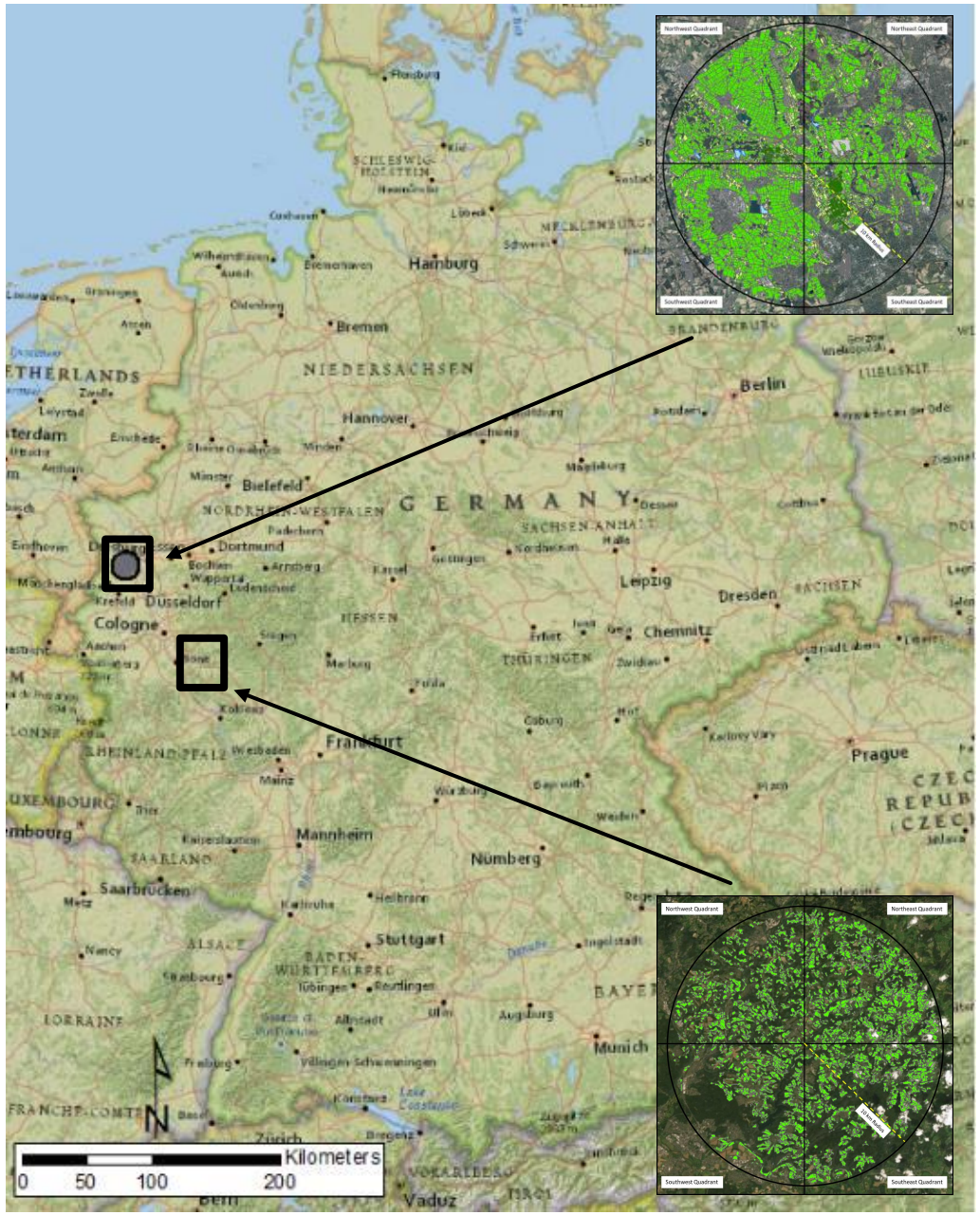
INTRODUCTION

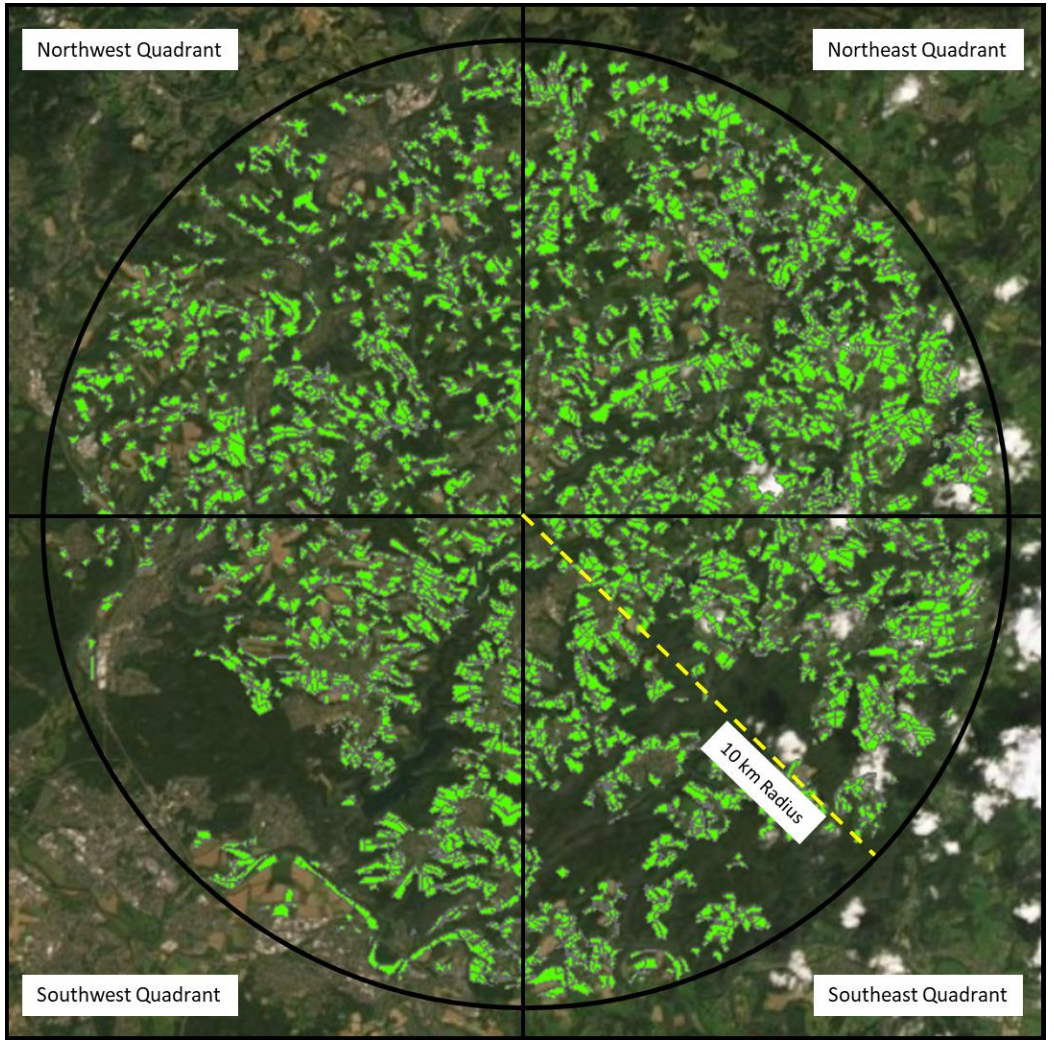
- Complexity of natural biosystems over time make understanding the relevant factors difficult to achieve
- Key drivers in this trend span a variety of influences at the landscape scale, including changes in habitat brought about by anthropogenic activity (e.g., urbanization, agriculture, and cultural behavior)
- Characterizing change in landscape over time can provide one piece to the larger puzzle of insect decline
- Novel remote sensing methods to capture landscape-level changes in grassland management over a 25-year period

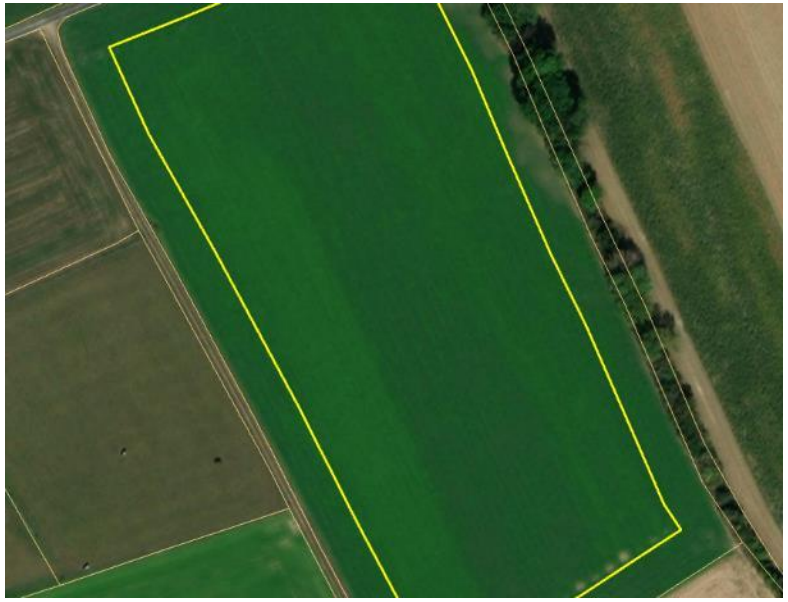
GRASSLAND

- A variety of grassland types within landscapes
- Provide abundant habitat
- Reported reductions of insect biomass over time (e.g., Hallmann et al. 2017)
- Examine landscape-level changes in grassland extent and management over a 25-year period

Study areas:
Krefeld and Wahnbachtal, Germany



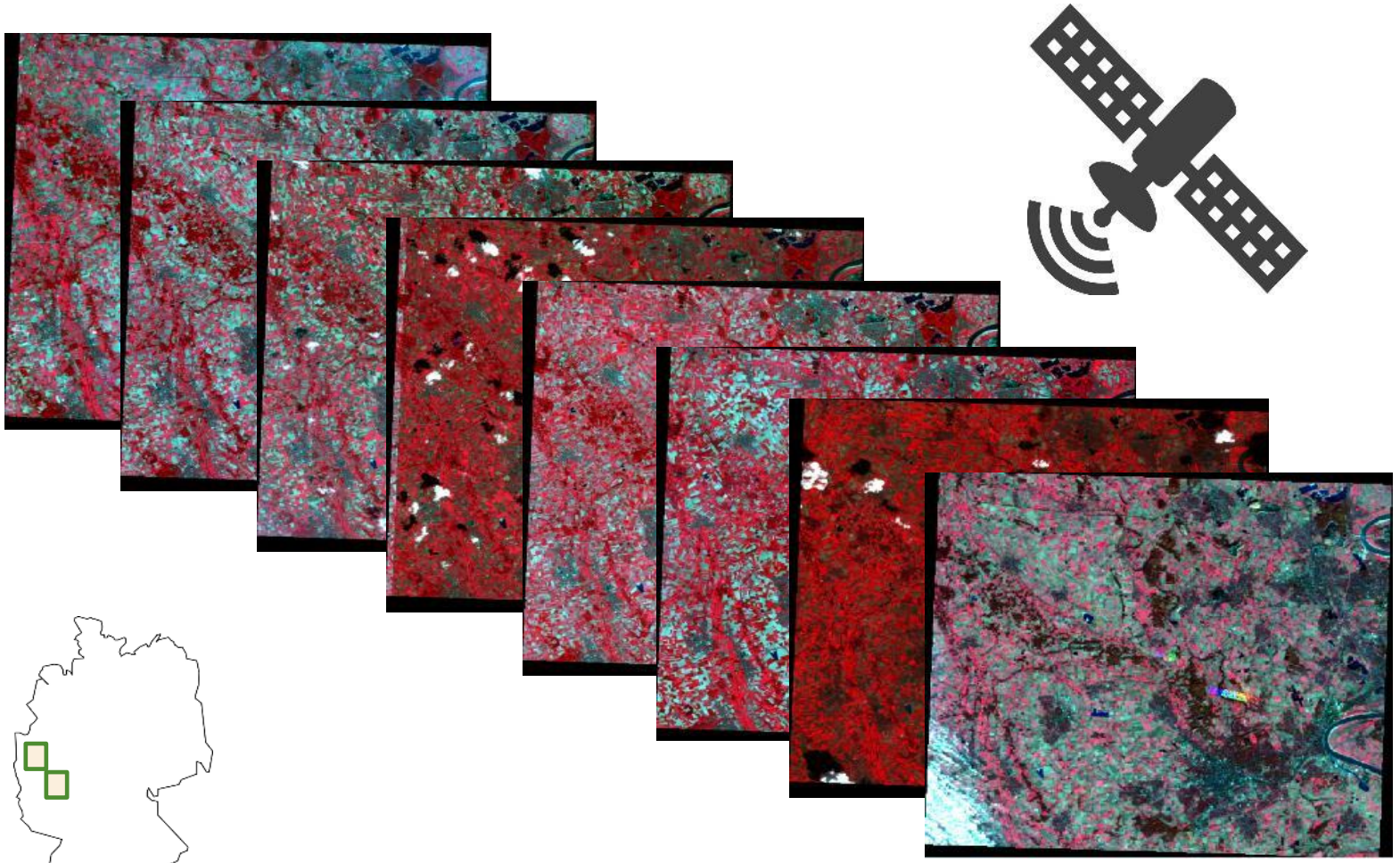




GRASSLAND POLYGONS

- Encompasses a variety of grassland uses
  - Pasture, natural, managed
- Suitability assessment
- Field boundaries shrunk to reduce occurrence of mixed pixels
- 818 final grassland polygons used for temporal analysis

Availability of historical information



Krefeld:
166 images from 1989-2013

Wahnbachtal
266 images from 1989-2015

Development of consistent grassland data over 25 years

Acquisition and quality review

Quantitative and visual quality review

>1700 images

Image Normalization

Suitable for temporal analysis

Cloud Masking

Clouds

Shadow

Haze

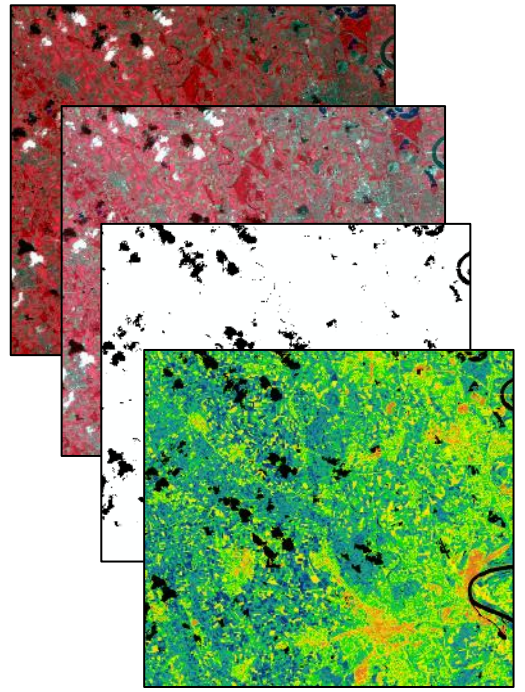
Vegetation Indices

Grassland biomass

166 images + 266 images

Temporal composite

25-year composite "layerstack"



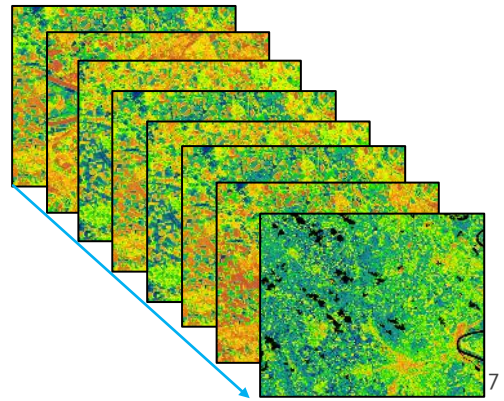


Image normalization

- Satellite images are subject to atmospheric conditions at the time of acquisition

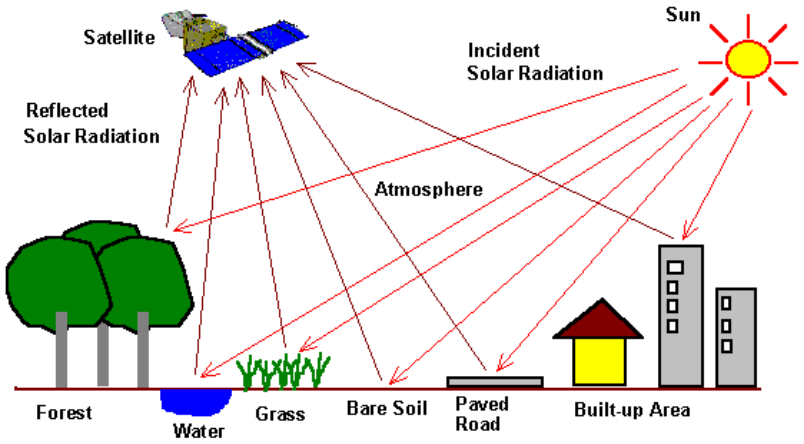
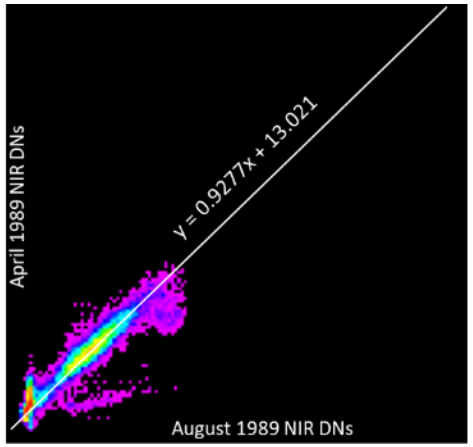
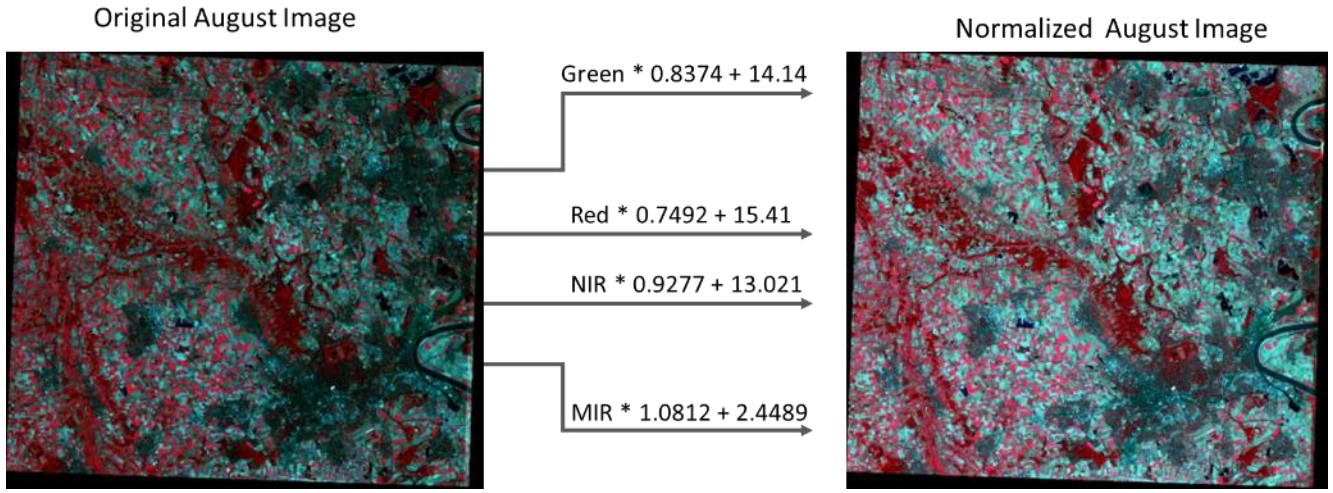


Image from https://crisp.nus.edu.sg/~research/tutorial/optical.htm

- Normalize two images using features with unchanging reflectance between them



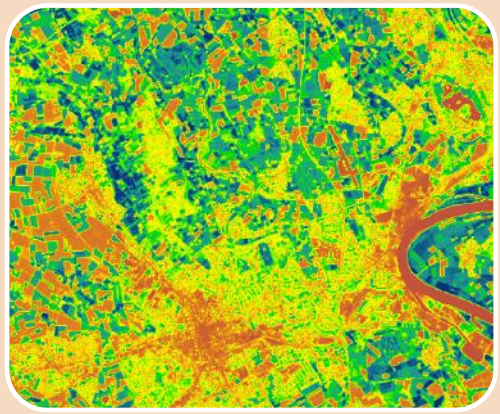
Static Feature Space Plot - NIR

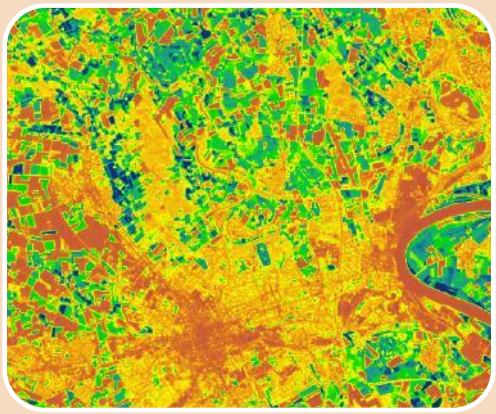


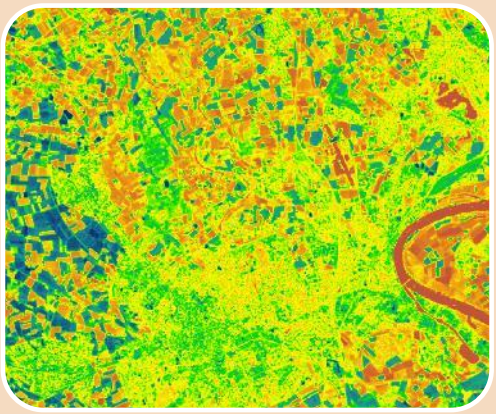
- Applied between years (using April image) and within years
- Needed for characterization of change over time between images

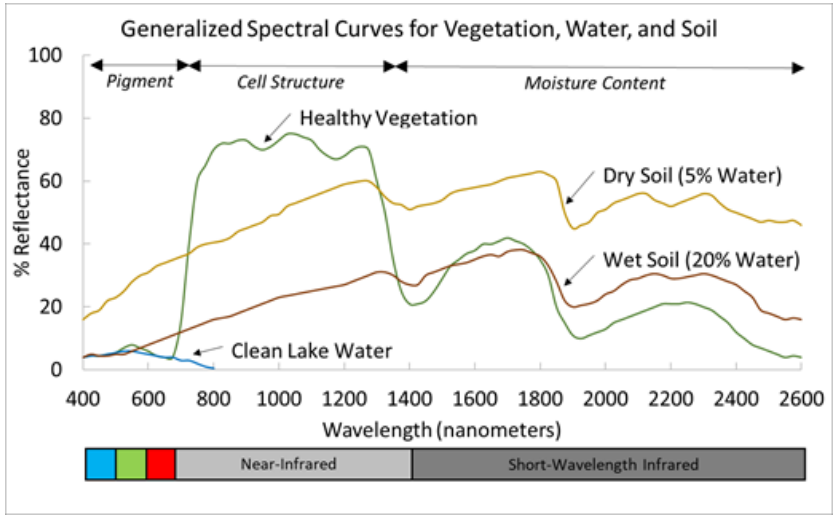
Vegetation characterization

High Low









NDVI - Normalized Difference Vegetation Index

- Most commonly used for vegetation
- Red and near infrared wavelengths
- Higher values indicate greater biomass

MSI - Moisture Stress Index

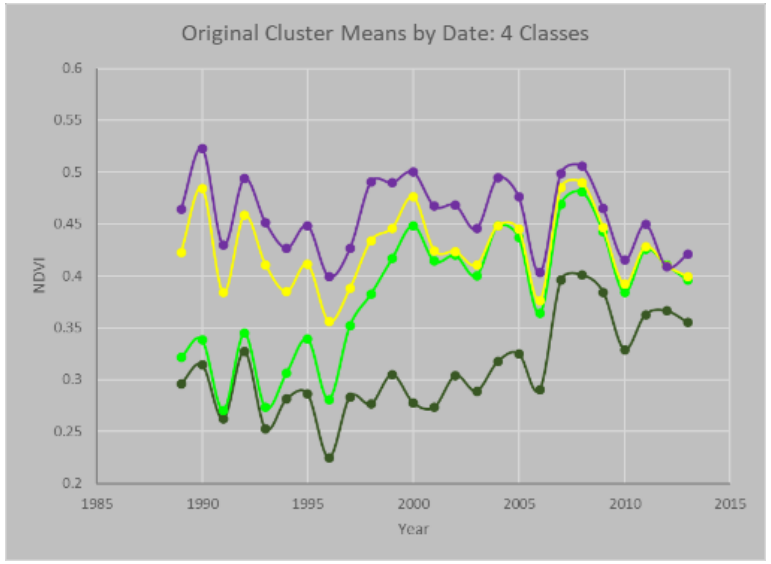
- Incorporates middle infrared information
- Higher values indicate water stress

TVI – Transformed Vegetation Index

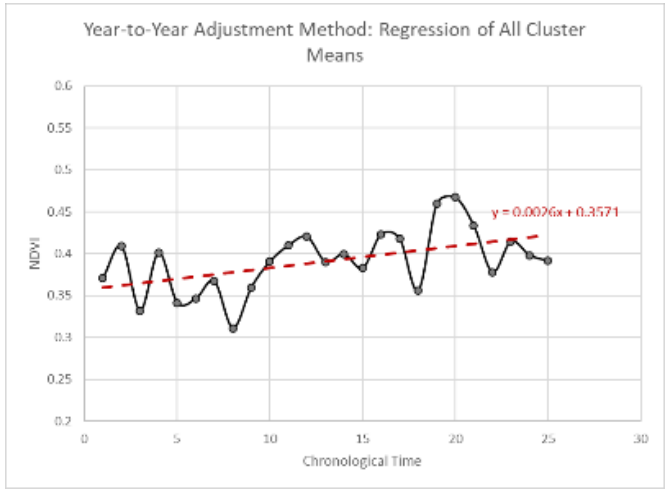
- Assess biomass and LAI / chlorophyll
- Less likely to saturate when assessing higher levels of biomass
- Higher values indicate greater biomass

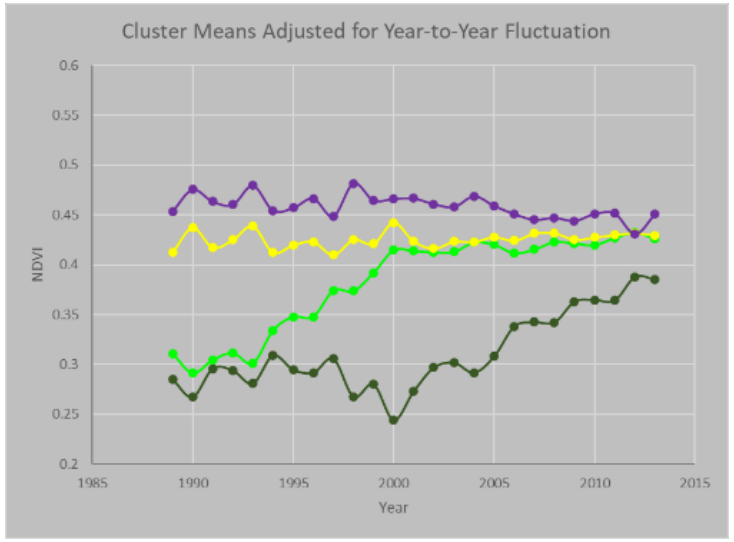
Clustering similar grassland polygons (Krefeld)

- Identify distinct groups of grassland polygons that are spectrally and temporally similar
- K-Means Minimum Distance to the Mean algorithm
- Resulting in four separable clusters (Krefeld)
- Normalized year to year variability to remove overall variation applicable to all clusters



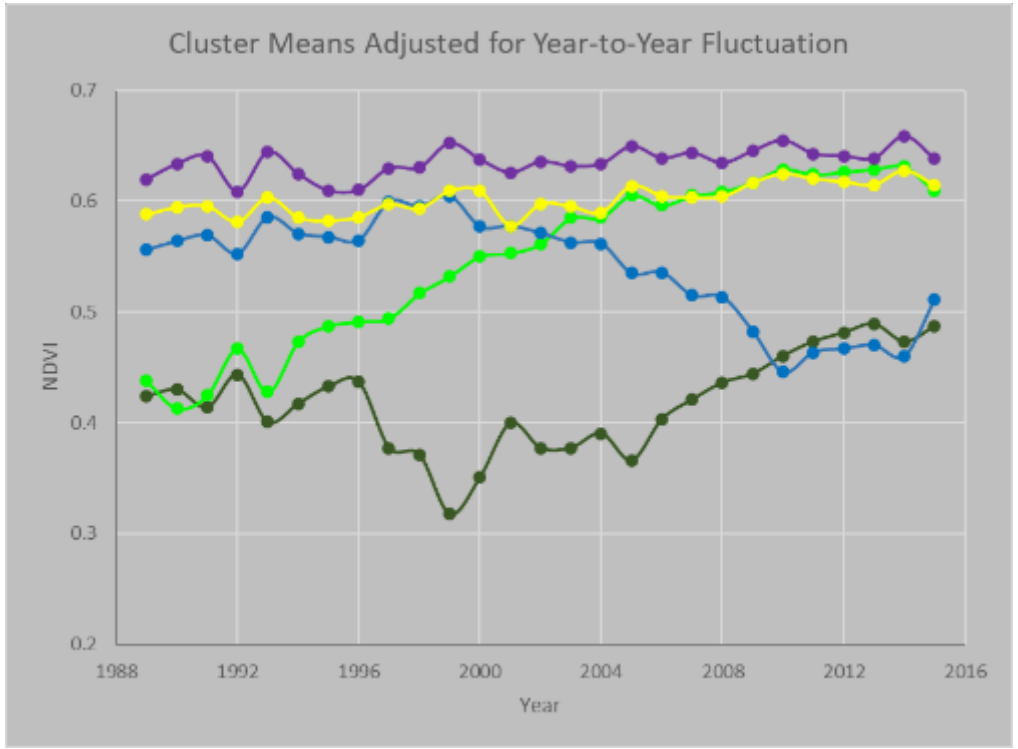
	Total Sampled Acres	Percent of Sampled Acres
Class1	636	15.5%
Class2	694	17.0%
Class3	992	24.2%
Class4	1769	43.2%





Grassland clusters (Wahnbachtal)

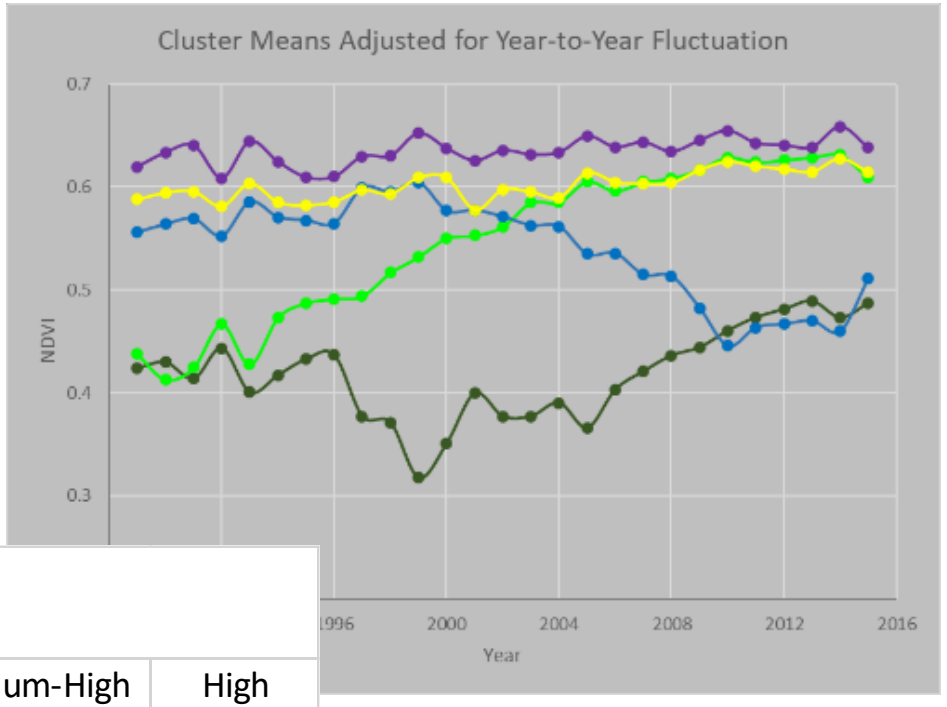
- Five clusters identified in Wahnbachtal
- Similar 'increasing' clusters, but addition of a cluster with decreasing NDVI
- Different behavior in different locations



Cluster comparisons with different Vegetation Indices

- How many grassland polygons fell in the same cluster (grey shading) when comparing 2 indices
- All three vegetation indices (NDVI, MSI, TVI) produce similar cluster groups
- (All index combinations not shown)

Wahnbachtal



			NDVI Values (Biomass)				
			Low	Medium-Low	Medium	Medium-High	High
		Class #	*1*	*2*	*3*	*4*	*5*
MSI Values (Moisture Stress)	Low	*1*	0	0	3	154	**457**
	Medium-Low	*2*	2	16	4	**337**	140
	Medium	*3*	1	0	**54**	22	0
	Medium-High	*4*	3	**92**	0	13	1
	High	*5*	**61**	1	4	2	0

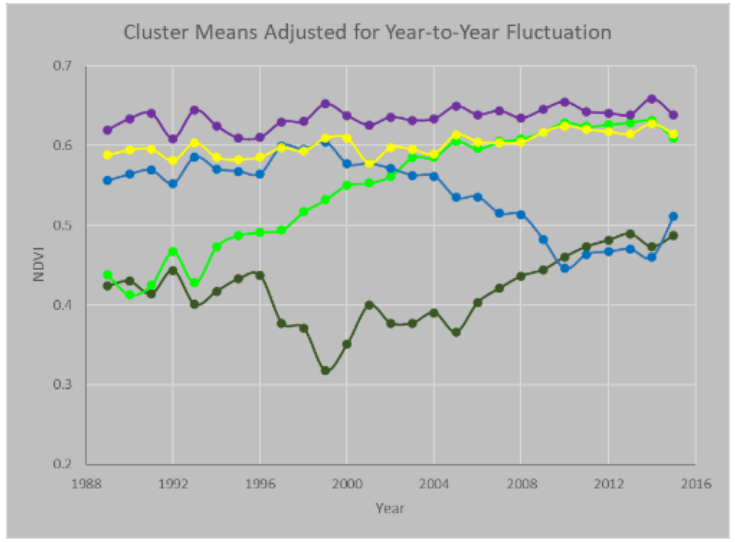
Cluster Name	Color
Class1	
Class2	
Class3	
Class4	
Class5	

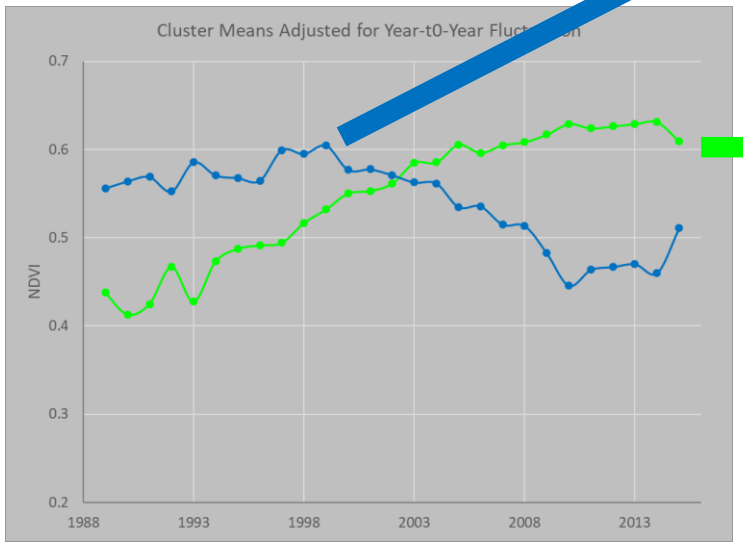
Comparison of grassland polygon assignments from two different vegetation indices. Matching number of grassland polygons in grey shaded cells.

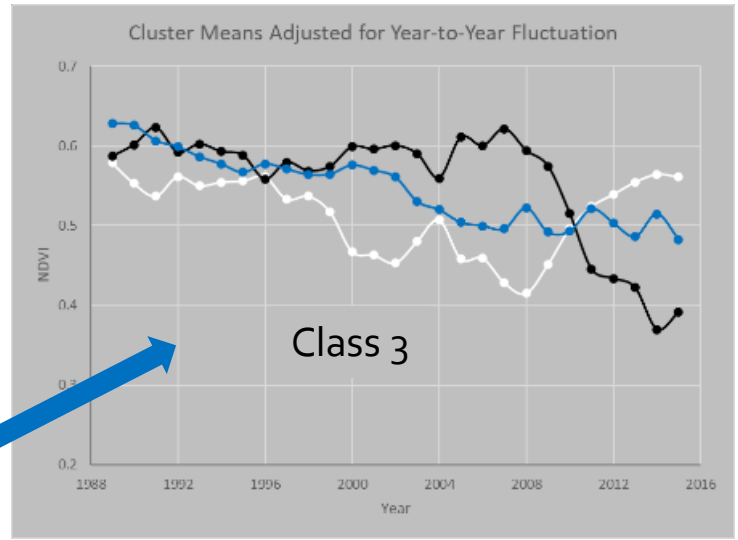
Further examination via sub-clustering

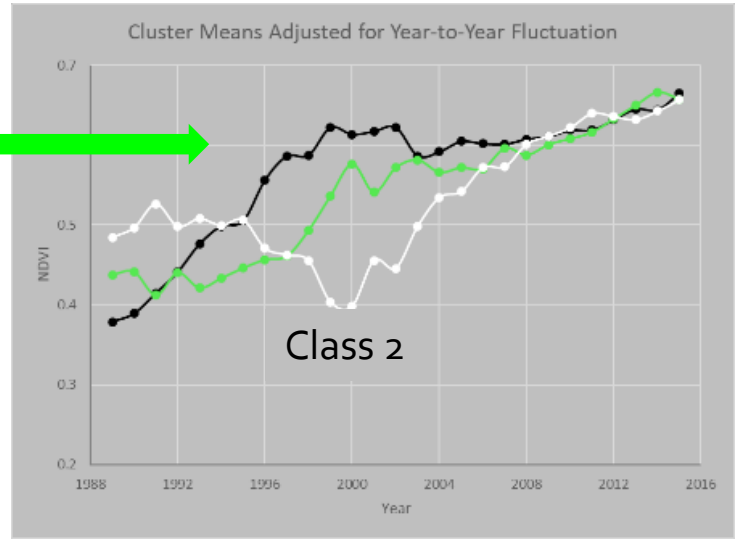
- Sub-categorization of the original clusters
- Further resolution in temporal trends
- Variations in timing of temporal NDVI increases or decreases

Wahnbachtal





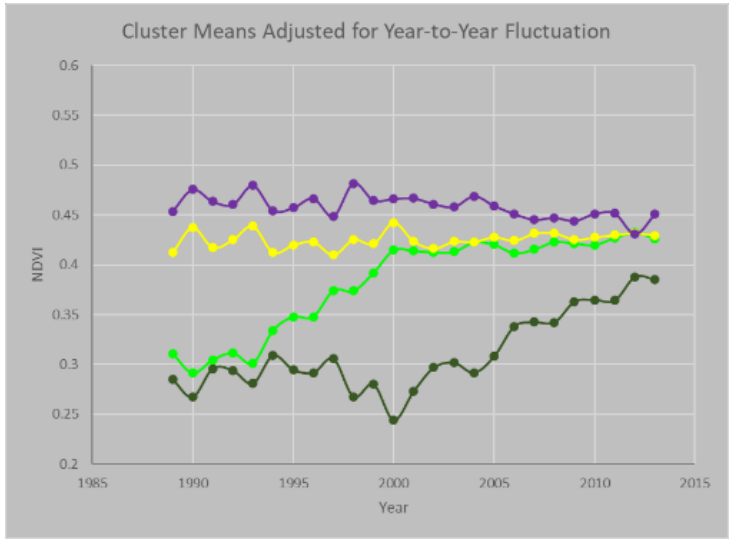




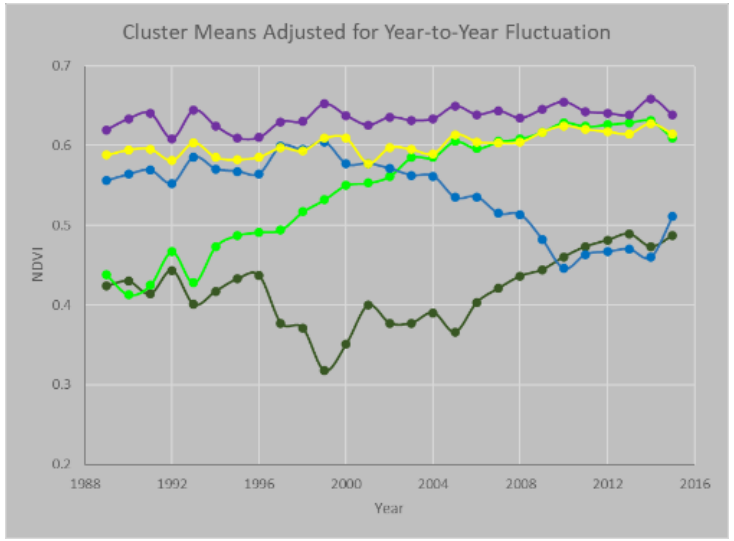
Results

- Periods of distinct changes in vegetation biomass indicate changes in grassland management practices
- Reduction in dairy farming
- Biogas generation
- Silage production

Krefeld



Wahnbachtal



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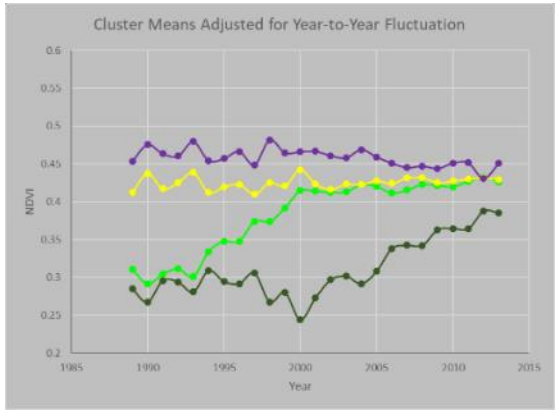
CONCLUSIONS

- Utilized freely available satellite image archives over a 25-year period
- Grassland clusters displayed different patterns over time
  - Different vegetation indices produced comparable results
  - Statistical review supported distinctness of the clusters
- Approach is applicable across geographies
- Suitable for spatially-explicit landscape-level ecological modeling

- Grassland areas are important habitat for some groups of insects
- Understanding historic changes in grassland extent and management provides a key factor in gaining knowledge about possible casual factors in observed changes

Thanks to Joshua Pritsolas, Randall Pearson, Carrie Butts-Wilmsmeyer and Thorsten Schad



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