# LANDSAT TIME SERIES ANALYSIS – The Impact of Forest Ecosystem History on Biodiversity

CHAIR OF FOREST INVENTORY AND REMOTE SENSING
UNIVERSITY OF GOETTINGEN, GERMANY
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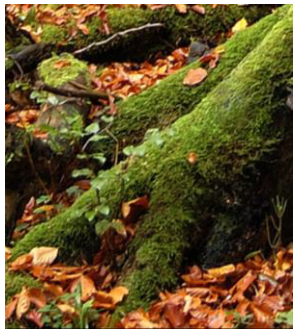
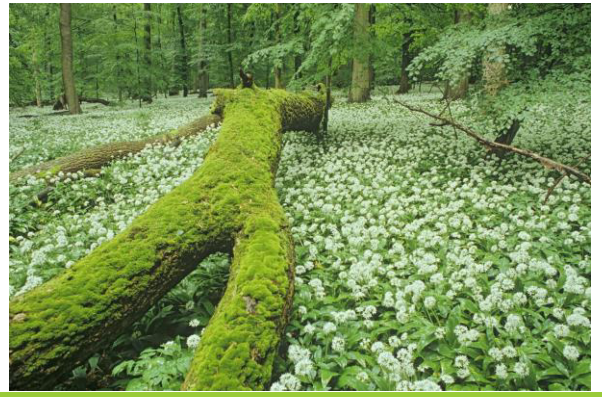
# Forest structure and biodiversity





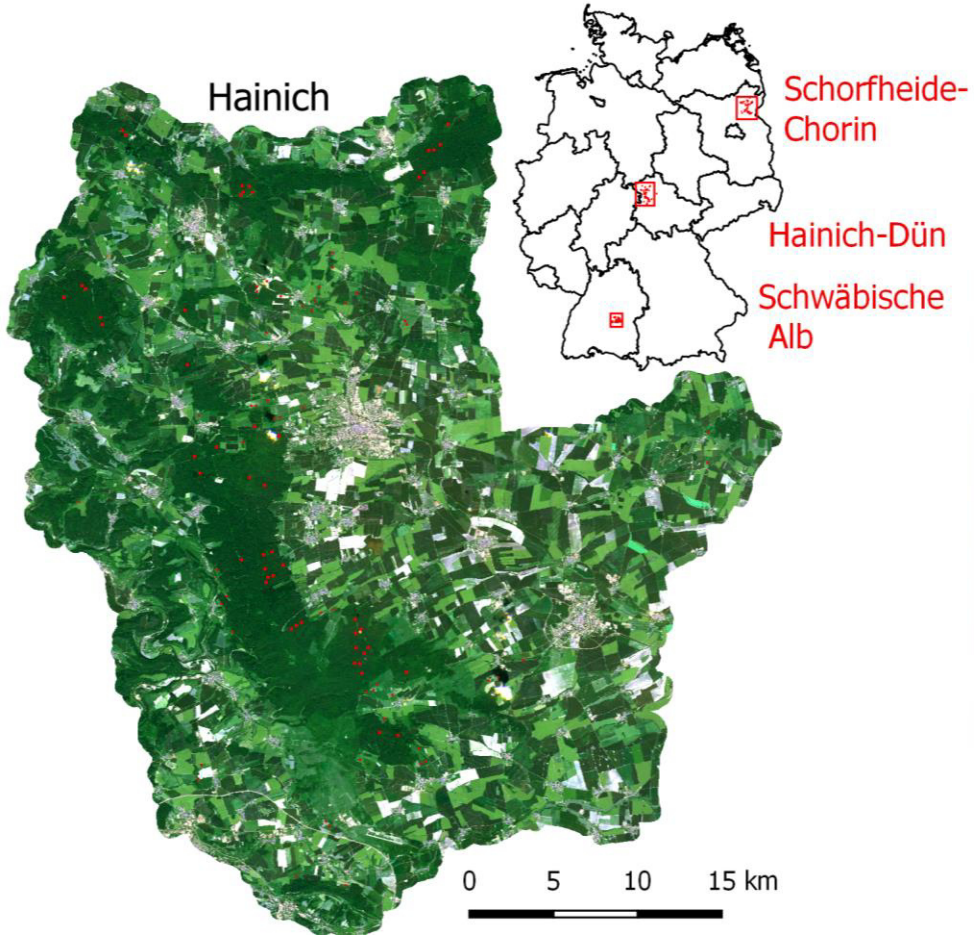
Pictures National Park Hainich
Thomas Stephan (www.thomas-stephan.com)
Rüdiger Biehl (Nationalpark-Hainich@NNL.thueringen.de)

# Objectives

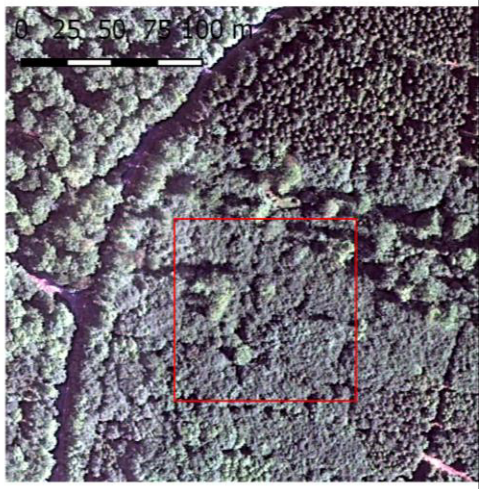
Relationship of ecosystem history and biodiversity in temperate forests in Germany.

1. Can **trends, changes in trend** or **disturbances** be detected in Landsat time series of temperate forests from 1985 to 2015?
2. Do disturbances and changes in trend affect **herbal layer plant species diversity** in temperate forests?

# Study area & Project background

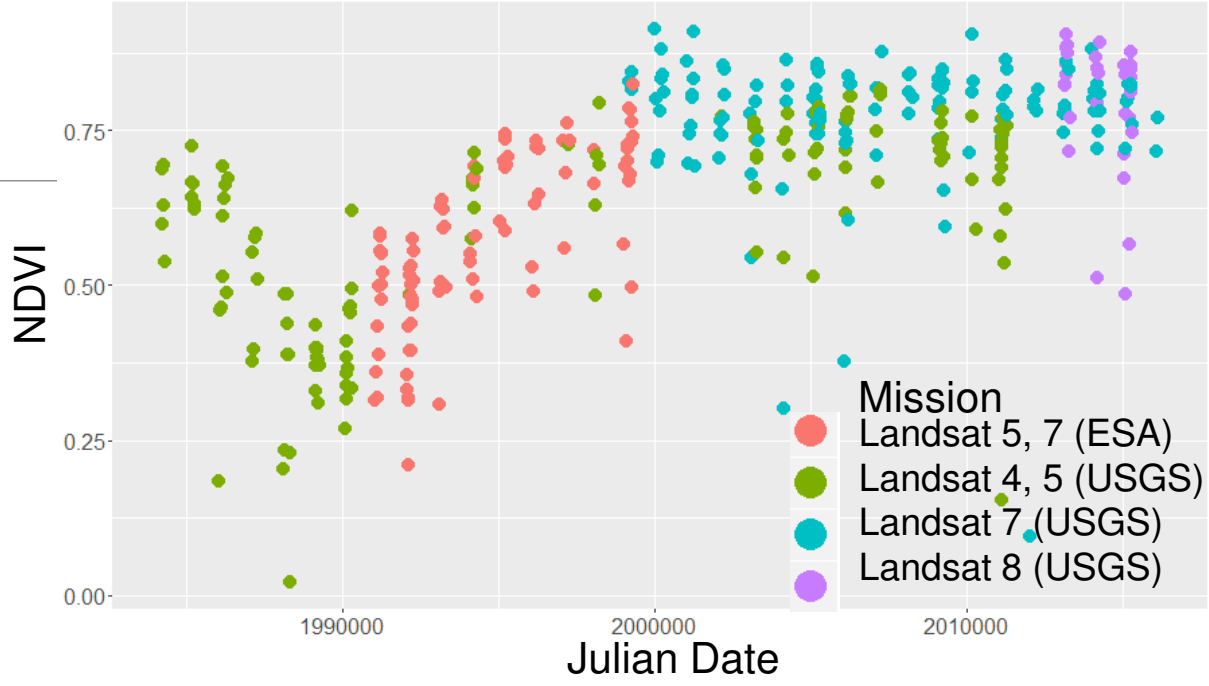







Administrative area of Germany by Hijmans et al. 2009

# Methods – NDVI time series




USGS archive (3365 images)

ESA archive (747 images)

Georeferenced data

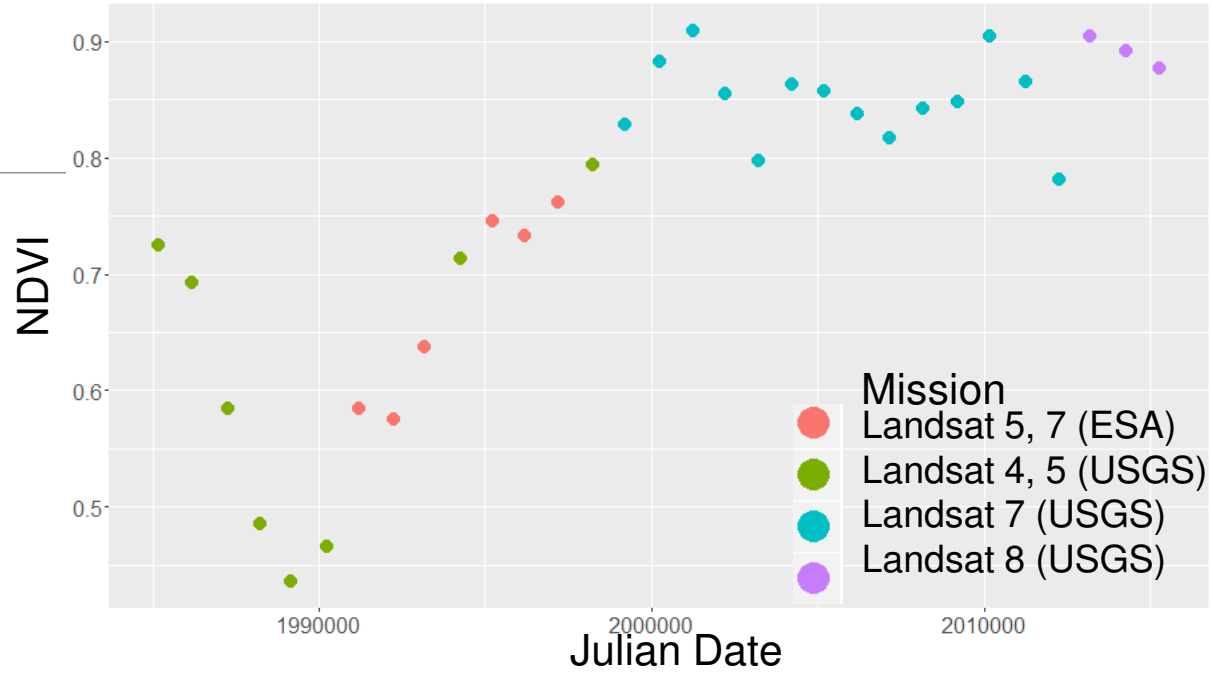
LEDAPS

Surface reflectance

CFmask

Masking → Extraction of surface reflectance values → Calculation of NDVI → Exclusion of cloud pixels (NDVI < 0.002) → Mean NDVI for each EP → Maximum of mean NDVI for each growing season

# Methods – NDVI time series

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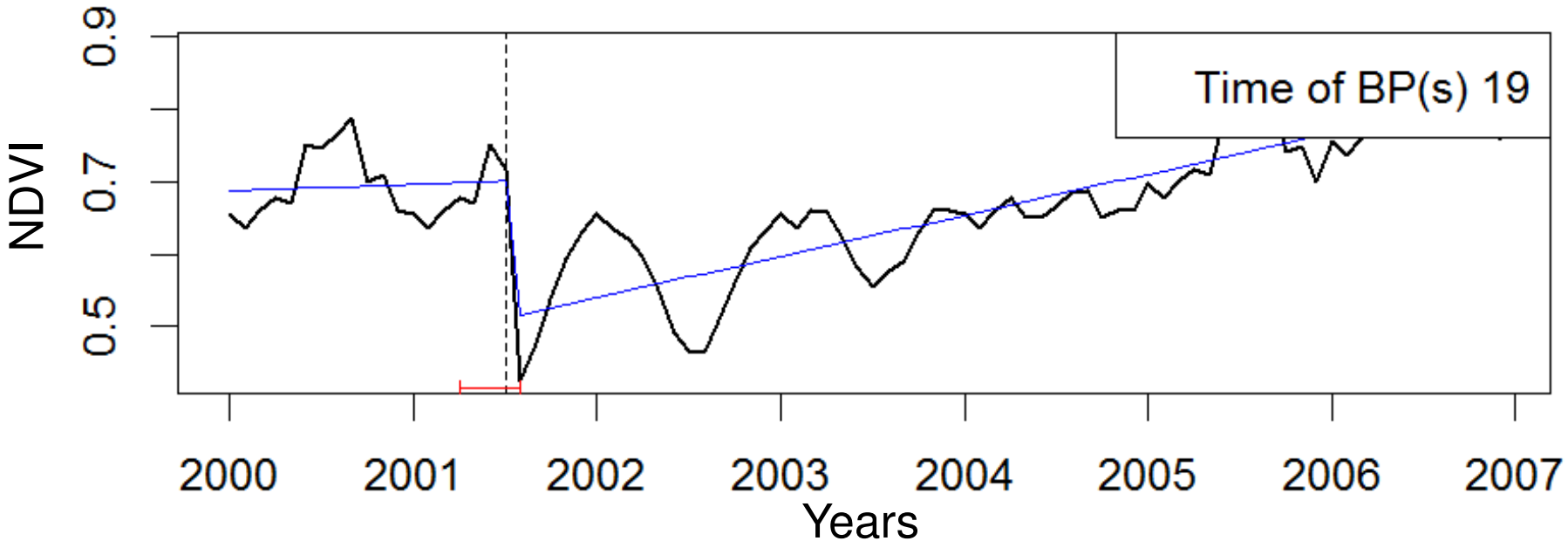
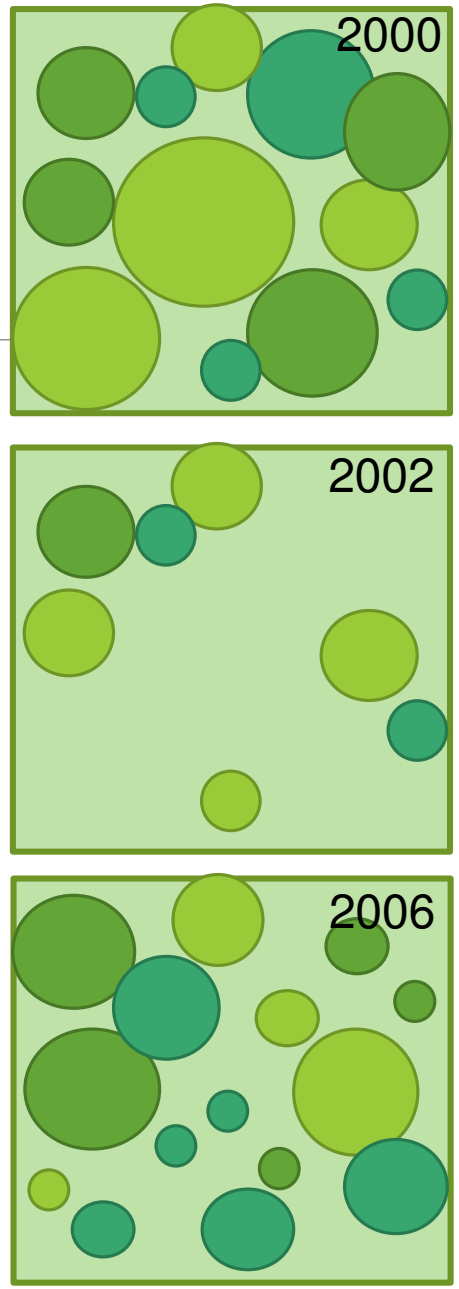
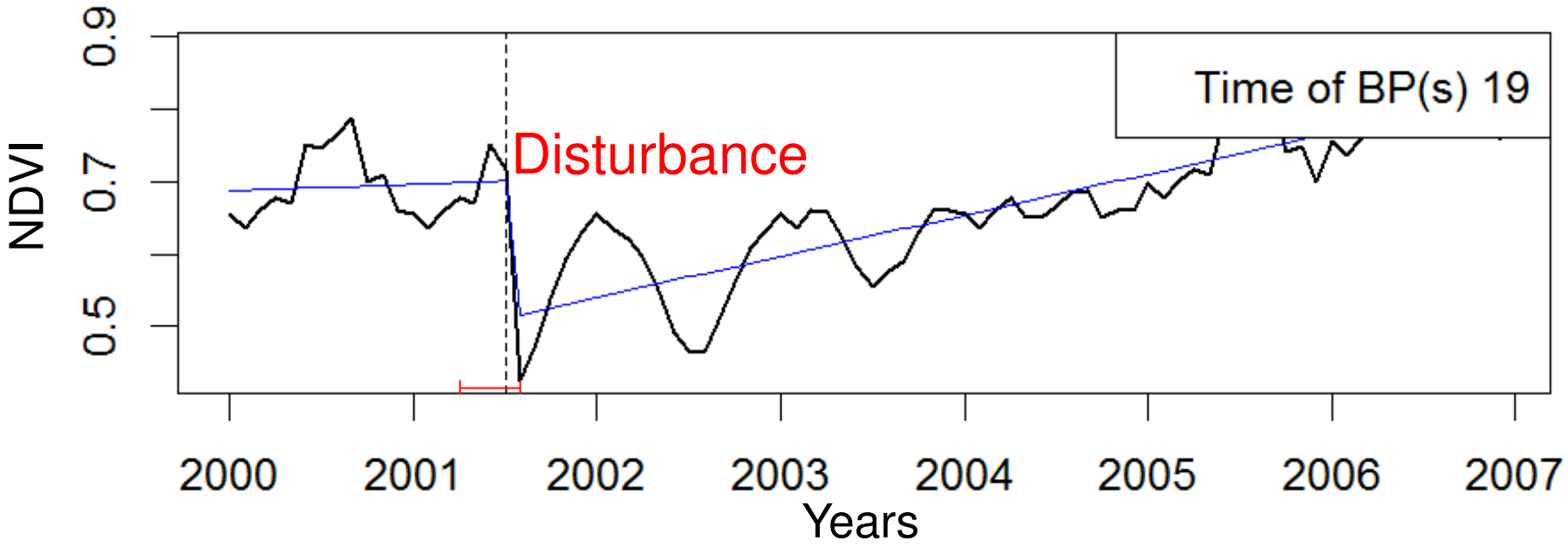
# Methods – Time series analysis

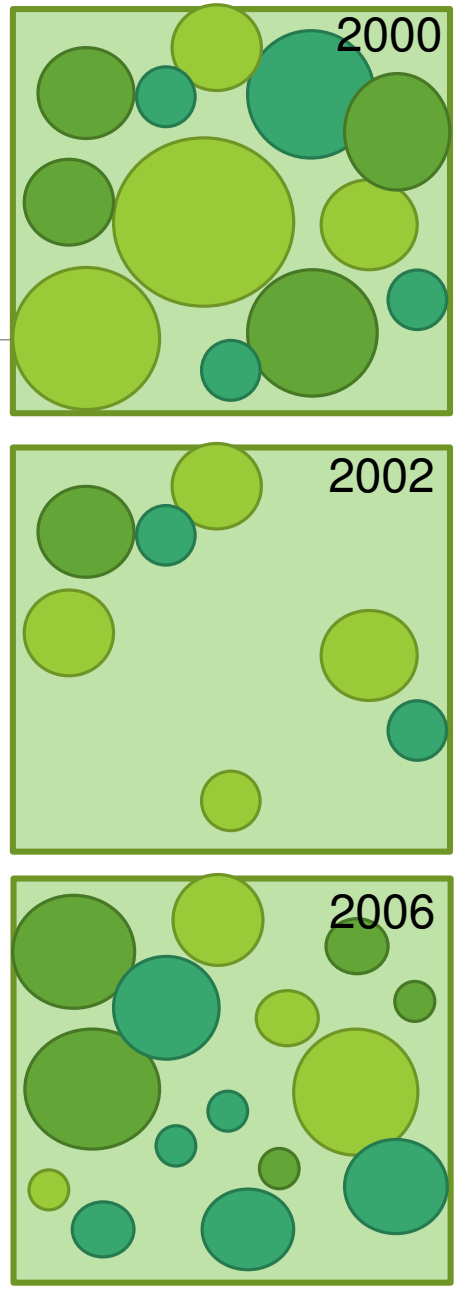



- Test for significant upward or downward trend
  - **Mann-Kendall trend test** (Mann 1945)
  - R-package: Kendall (Davison and Hinkley 1997, Hipel and McLeod 2005)

# Methods – Time series analysis

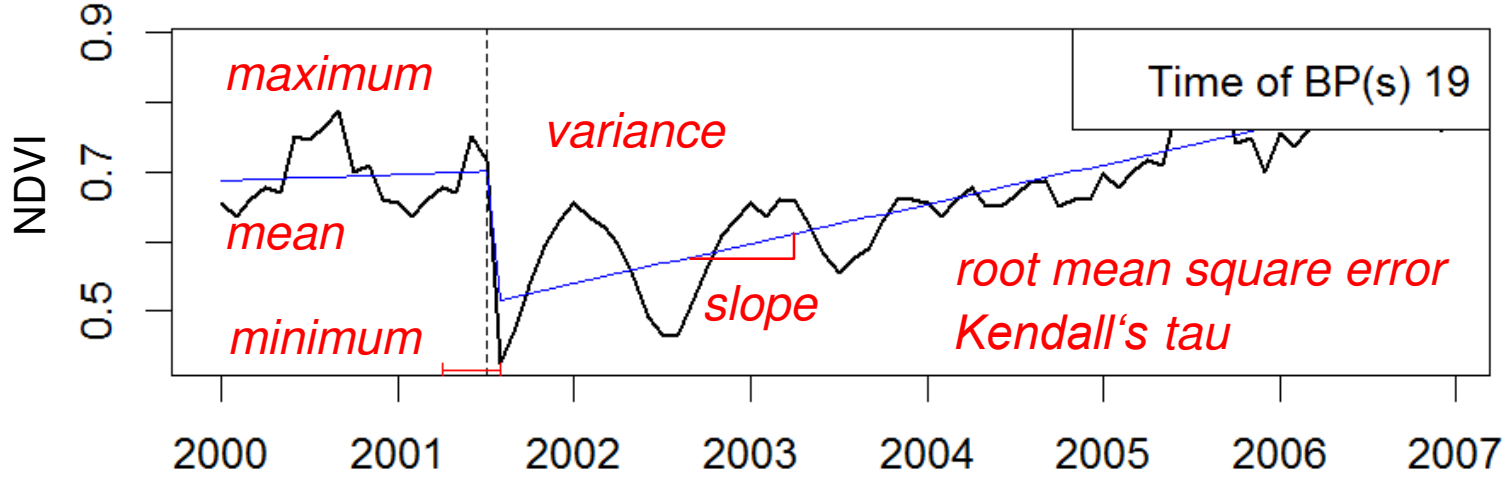


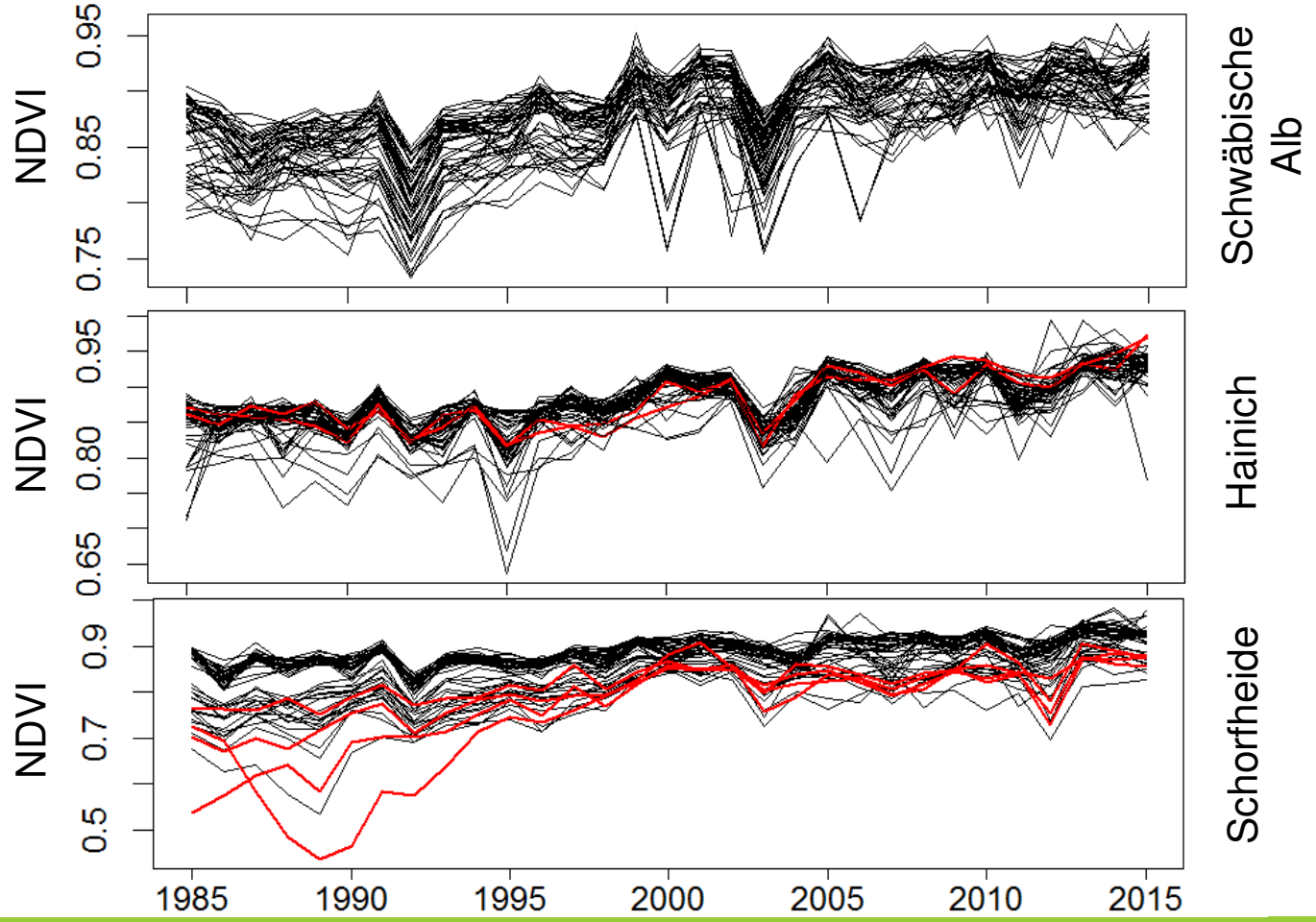

- Detection of breaking points and their magnitude in trend
  - **B**reaks **F**or **A**dditive **S**easonal and **T**rend (**BFAST**) algorithm
  - R-package: bfast (Verbesselt et al. 2010 a, b)
  - Ordinary least squares residuals based **MO**ving **SUM** (**MOSUM**) test (Zeileis et al. 2002)

# Methods – Relationship of biodiversity index and time series parameter

- **Simpson's diversity index** (Simpson 1949)
  - **Plant cover estimations** of species in the **herbal layer** in an area of 20x20m in all forest EPs in 2015 (Fischer et al. 2015)
- **Differences** in **Simpson's diversity index** between plots with and without **breaking points** (Wilcoxon-Mann-Whitney test (Bauer 1972))
- Linear relationship between **Simpson's diversity index** and **trend parameter**

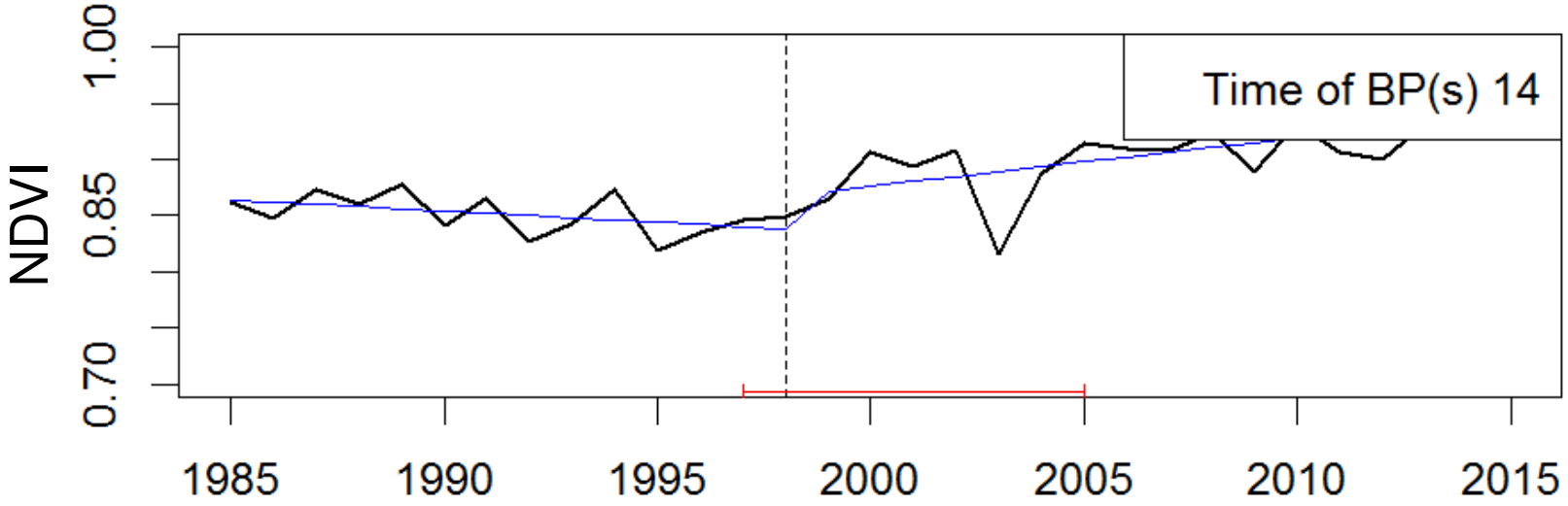


# Results – Trend

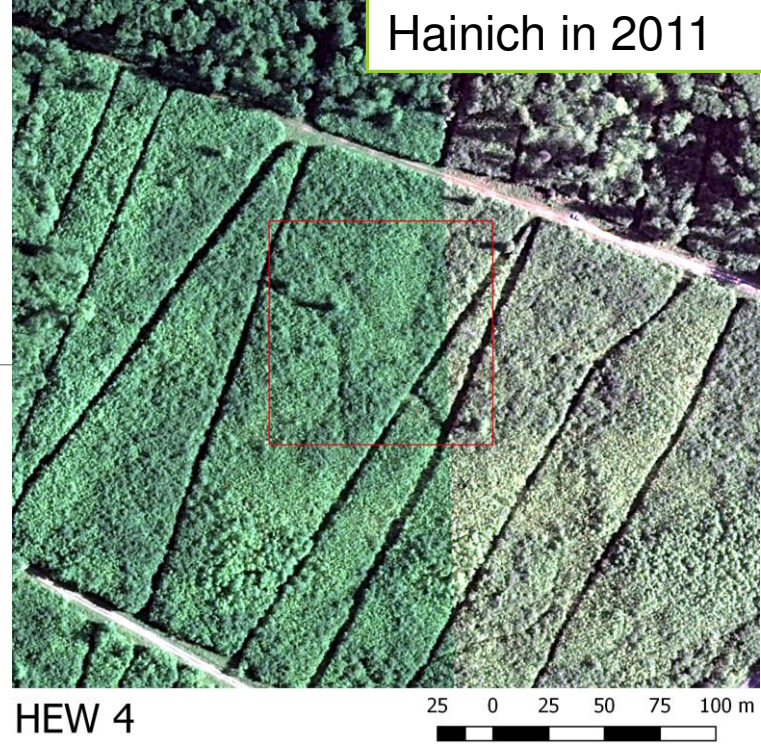


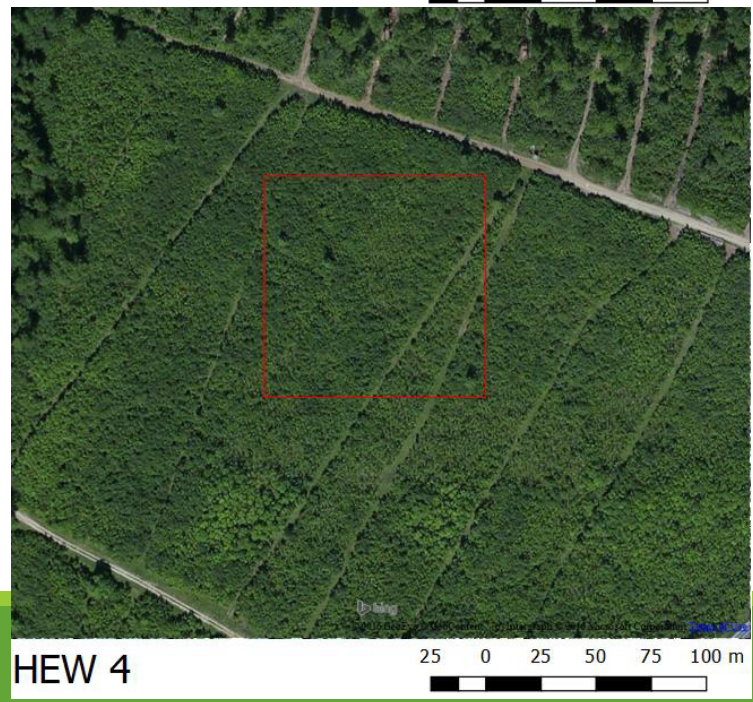

- Kendall's tau: **positive** between 0.31 and 0.82
- **Significant** at a significance level of 0.01 (44 trends) and 0.05 (3 trends)

# Results – Breaking points

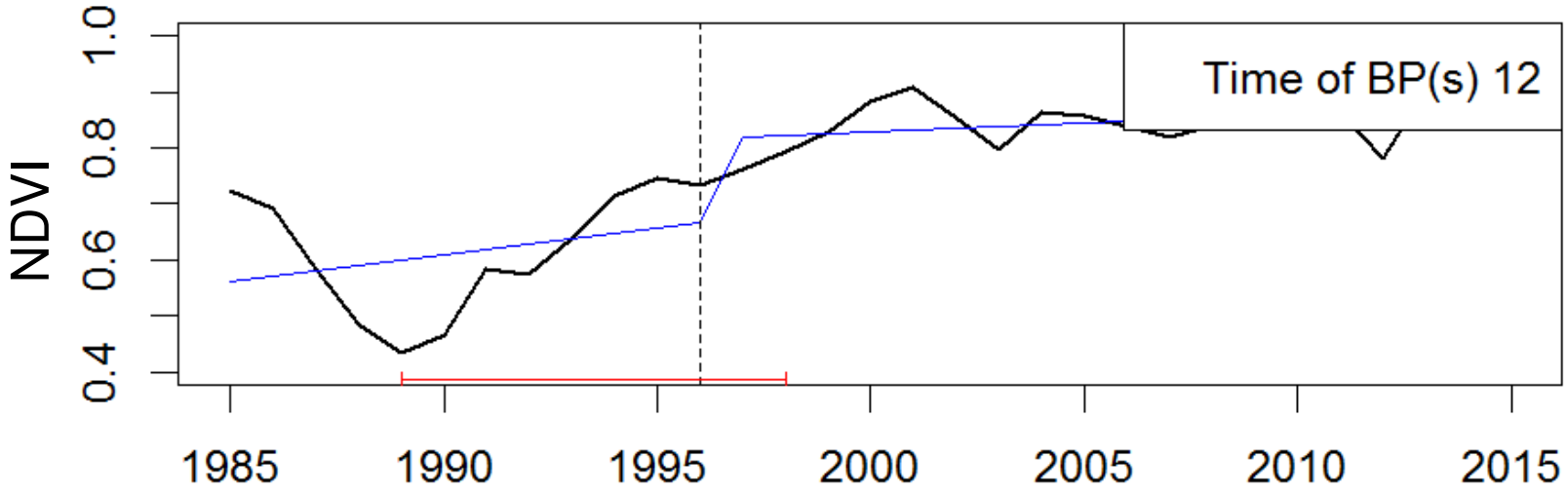



Magnitude of change: 0.033

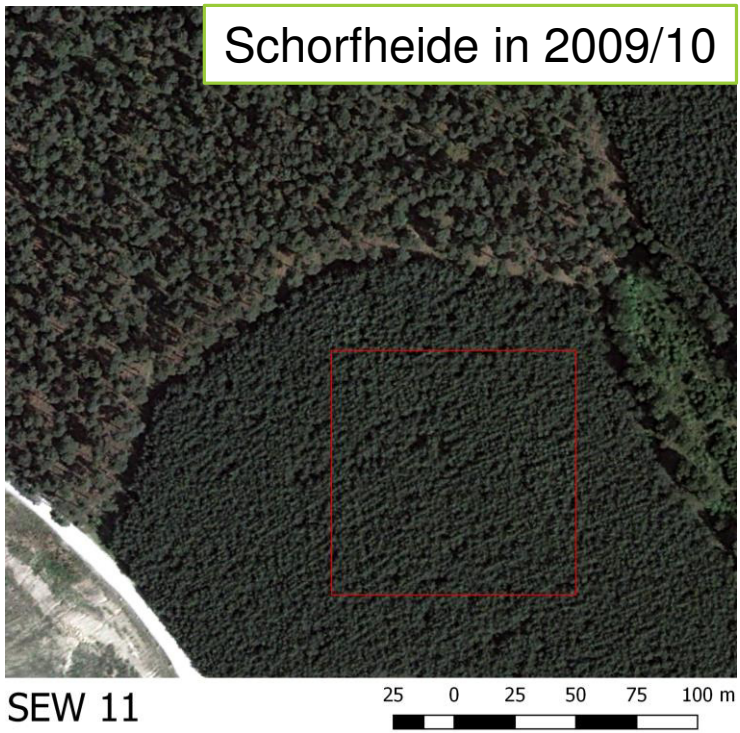


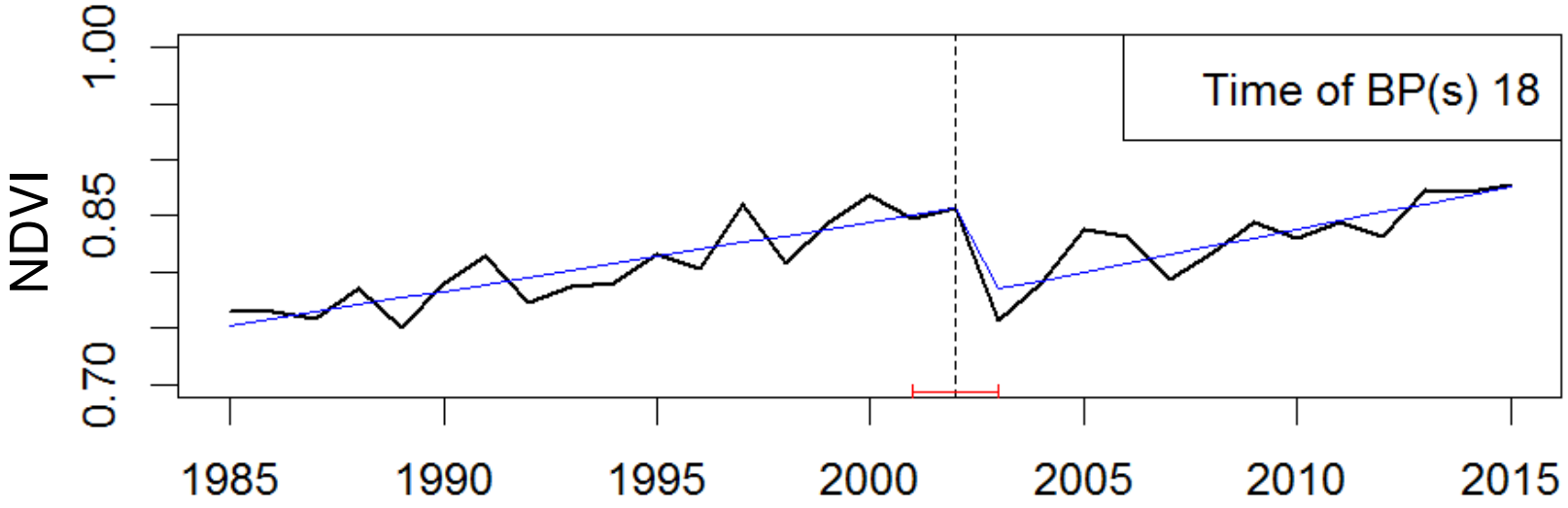
# Results – Breaking points



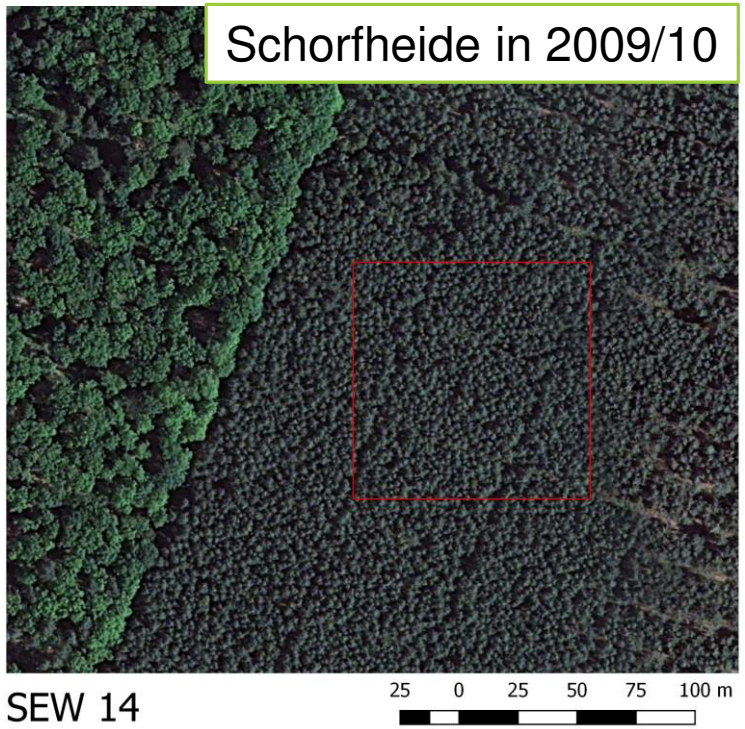

Magnitude of change: 0.152



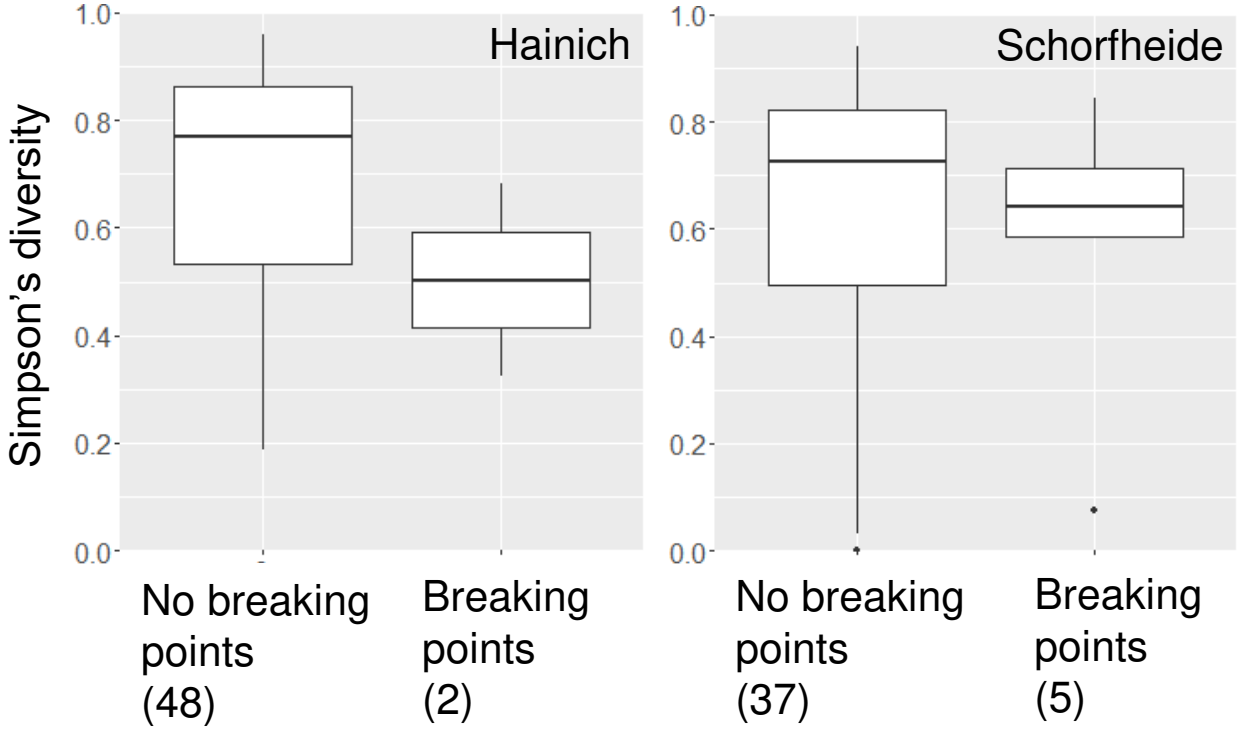
# Results – Breaking points




Magnitude of change: -0.072



# Results – Relationship of biodiversity index and time series parameter




- **Significant positive** linear relationship with Simpson's diversity index:
  - RMSE (Hainich)

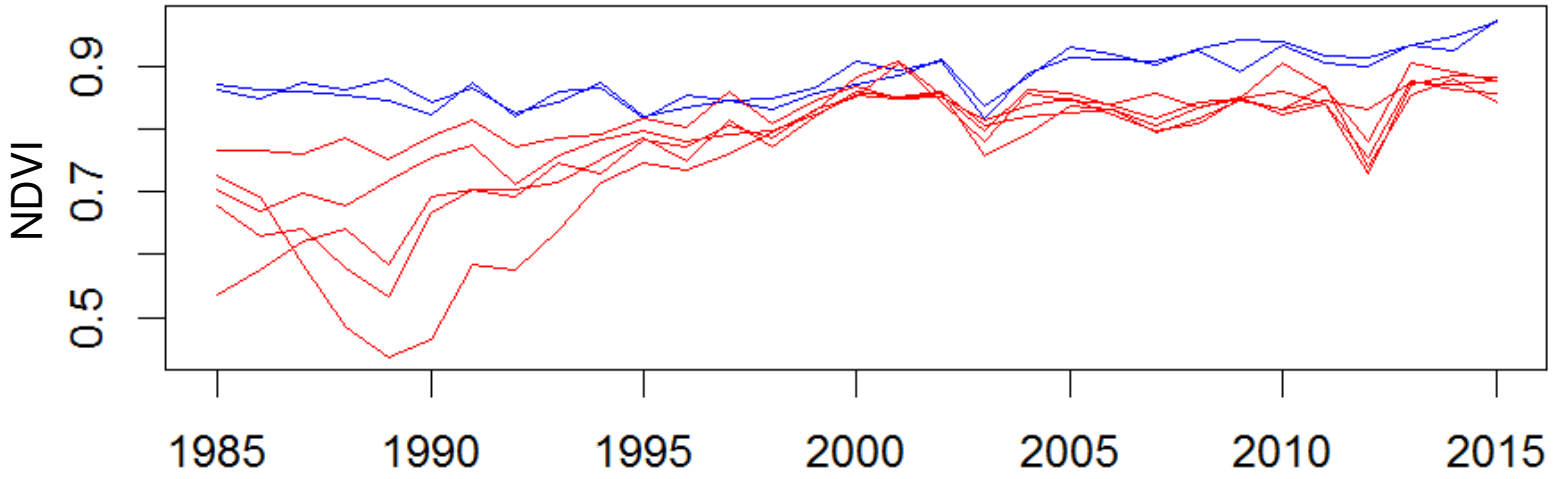
    R-squared: 0.15
- **Significant negative** linear relationship with Simpson's diversity index:
  - Kendall's tau (Hainich)
  - Mean NDVI (Hainich, Schwäbische Alb)
  - Minimum NDVI (Hainich)

    R-squared: 0.04 – 0.20

(Significance level at 0.05 or 0.01)

- Not statistically significant (Wilcoxon-Mann-Whitney Test)

# Discussion




Time series of EPs with significant breaking points in Hainich
Time series of EPs with significant breaking points in Schorfheide


# Discussion & Conclusion

1. The combined Landsat time series of the archives of USGS and ESA can be used to analyze **ecosystem history** in temperate forests in Germany from 1985 to 2015.
2. Further research on the **relationship** between **Simpson's diversity index** and **ecosystem history** is needed.
3. **Continuous forest cover management** in our study areas causes **small-scale, low magnitude disturbances**, which do not affect the greenness over several years.

→ Analyses of the **seasonal component**

- Algorithms allowing for discontinuous time series data
  e.g. Continuous Change Detection and Classification (Zhu and Woodcock 2014)
- Fusion of Landsat and MODIS time series to obtain dense, continuous time series
  e.g. Spatial and Temporal Adaptive Reflectance Fusion Model (Gao et al. 2006)

# Thank you for your attention

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- **Landsat archives**
  - Landsat 4-5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and Landsat 8 Operational Land Imager (OLI) Surface Reflectance data courtesy of the U.S. Geological Survey.
  - Landsat 5 Thematic Mapper (TM ), Landsat 7 Enhanced Thematic Mapper Plus (ETM+) 1992 – 1999 Data provided by European Space Agency.

# Picture credits

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