

Spaceborne and In-Situ Remote Sensing for Monitoring Enhanced Forest Structural Complexity Promoting Biodiversity in Central European Forests

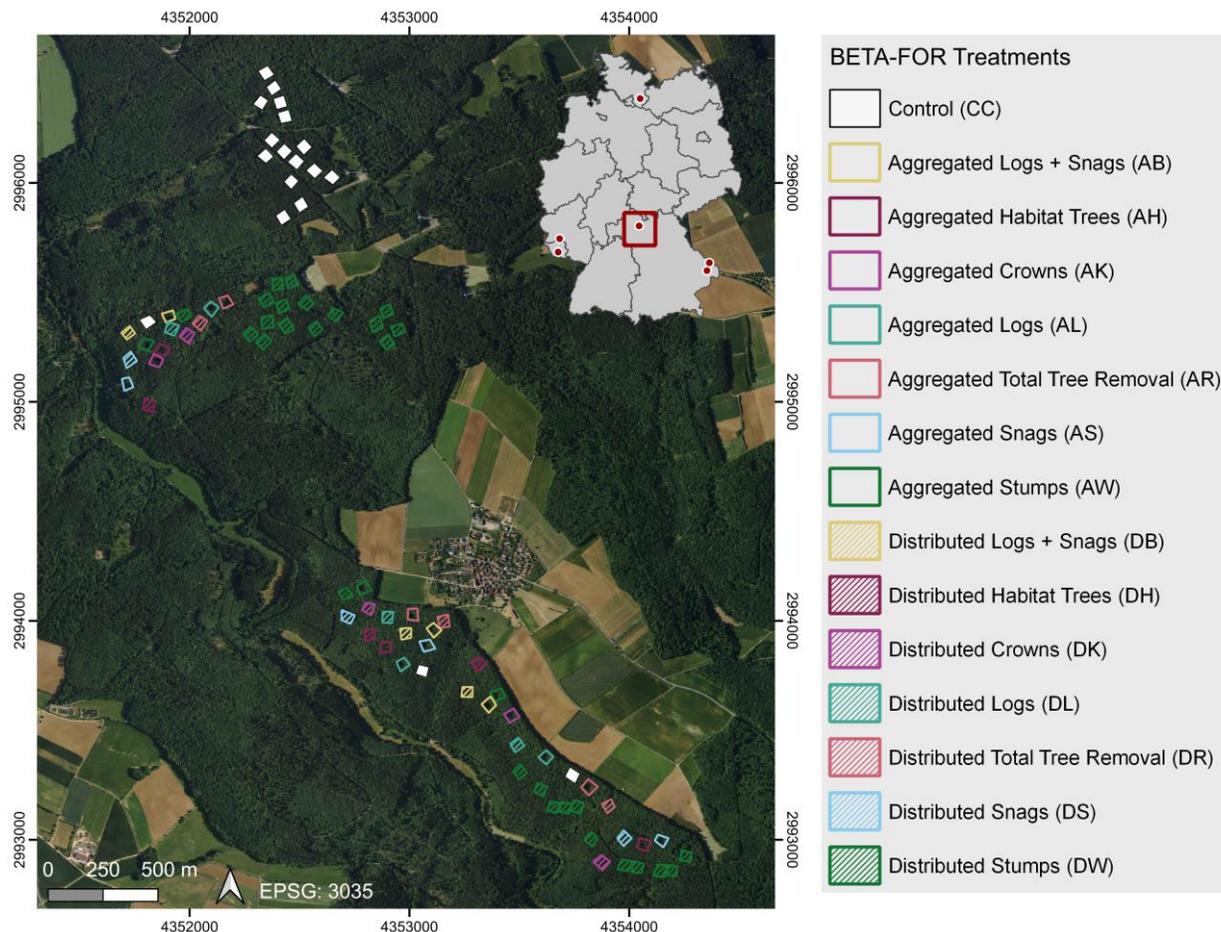
Patrick Kacic, Ursula Gessner, Christopher R. Hakkenberg, Stefanie Holzwarth, Jörg Müller, Kerstin Pierick, Dominik Seidel, Frank Thonfeld, Michele Torresani, Claudia Künzer

Institute of Geography and Geology, Department of Remote Sensing

University of Würzburg



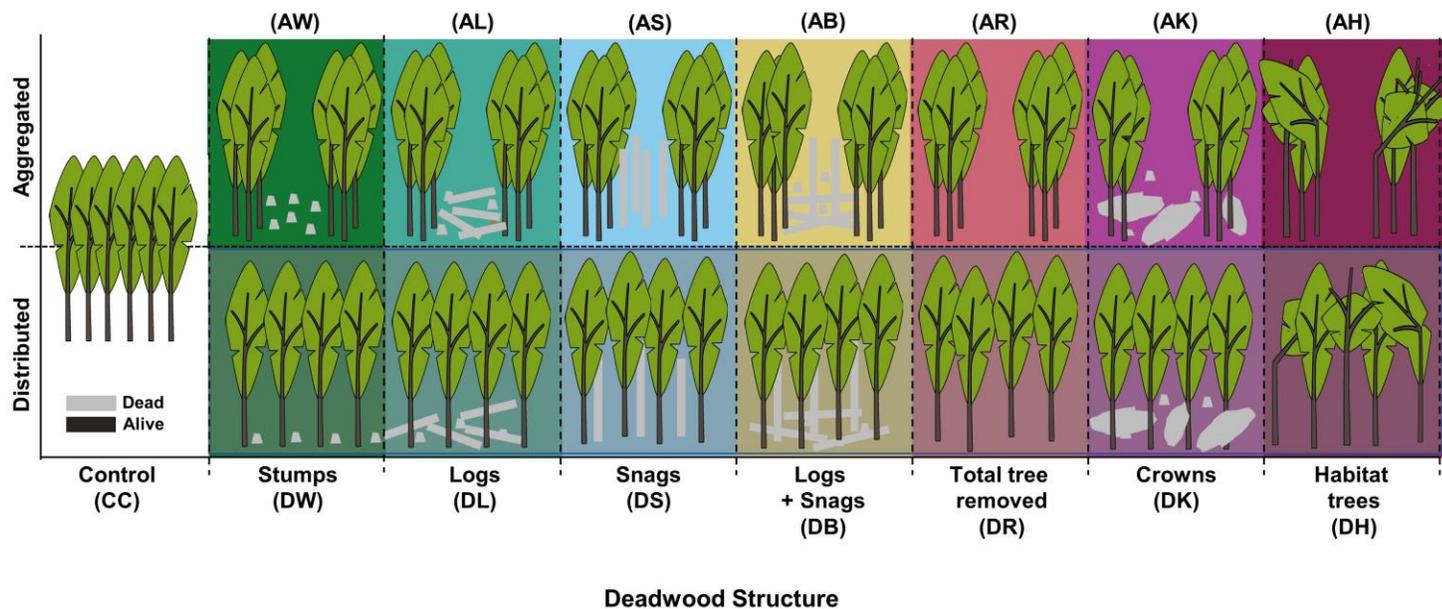
Experimental silvicultural treatments (50 x 50 m) in six German regions:



Experimental Silvicultural Treatments Manipulate Forest Structure

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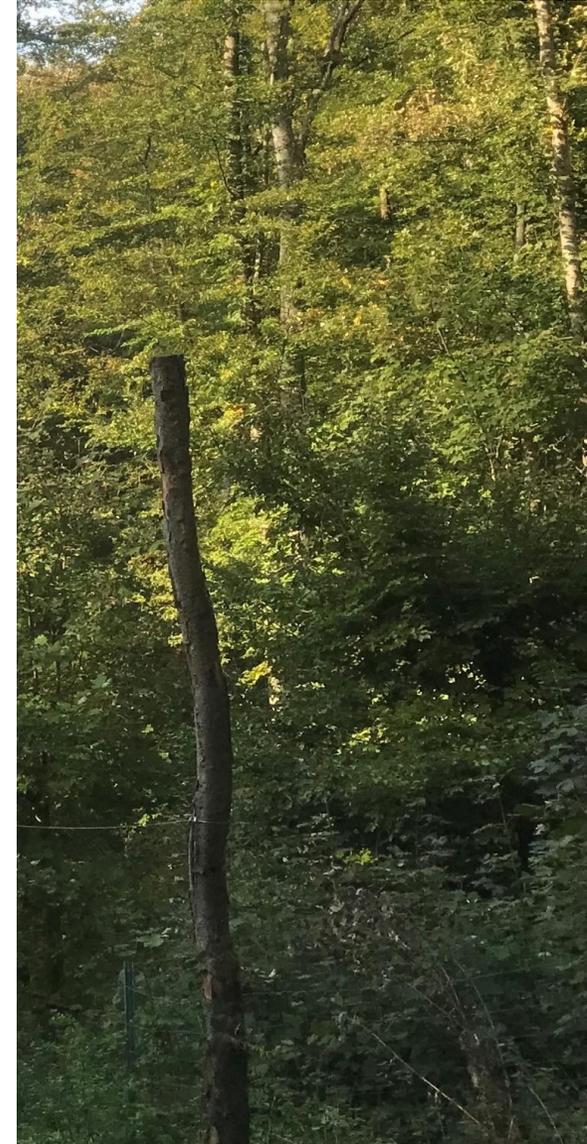
Spatial arrangement of cuttings (Light)



Assessing Forest Structural Complexity

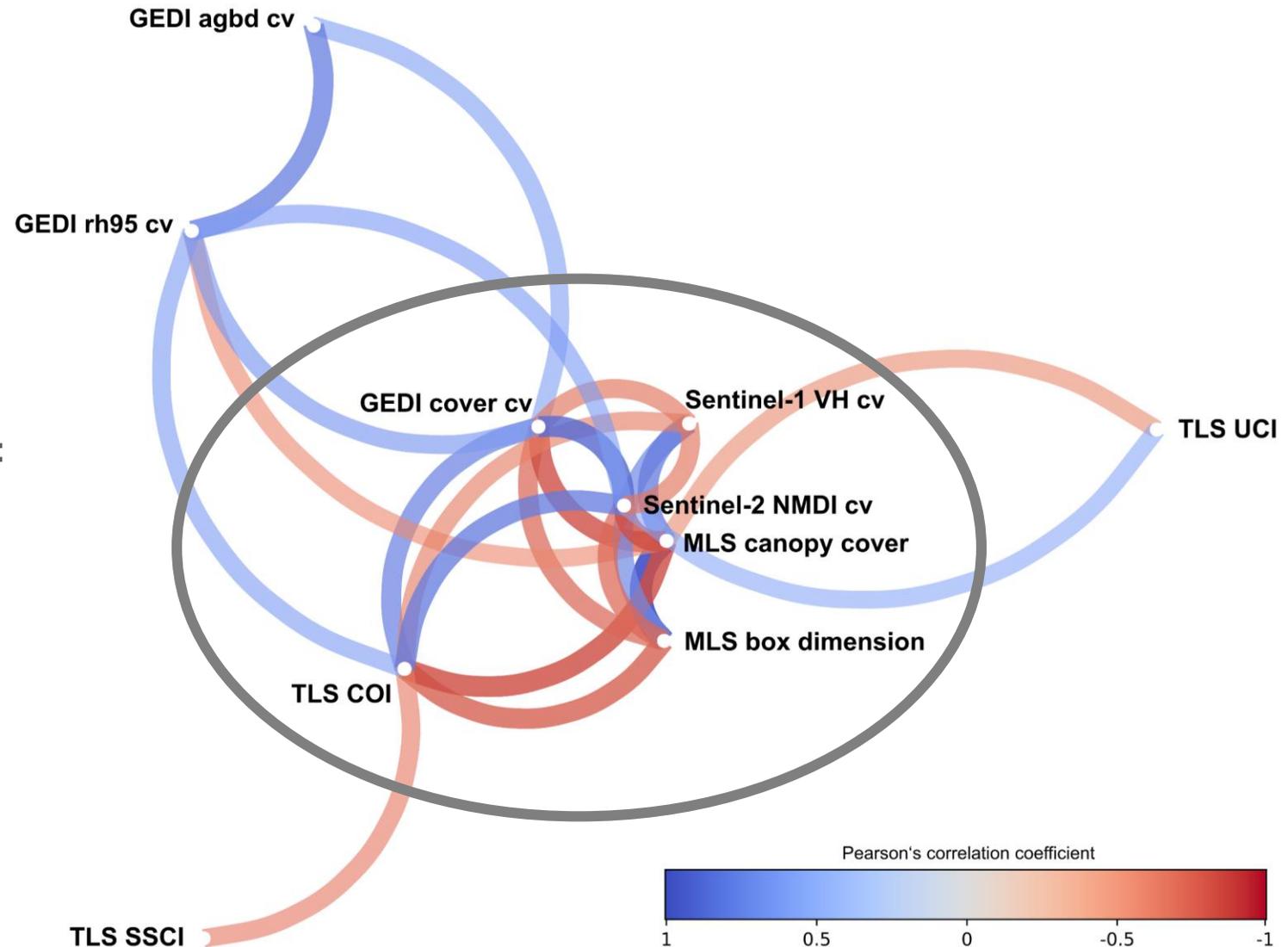
Forest structural attribute

	Platforms		
	MLS	TLS	Spaceborne
Canopy cover / openness	Canopy cover	Canopy Openness Index (COI)	-
Structural complexity	Box dimension	Stand Structural Complexity Index (SSCI), Understory Complexity Index (UCI)	-
Structural heterogeneity	-	-	Sentinel-1 VH cv, Sentinel-2 NMDI cv, GEDI rh95 (canopy height) cv, GEDI cover cv, GEDI agbd cv



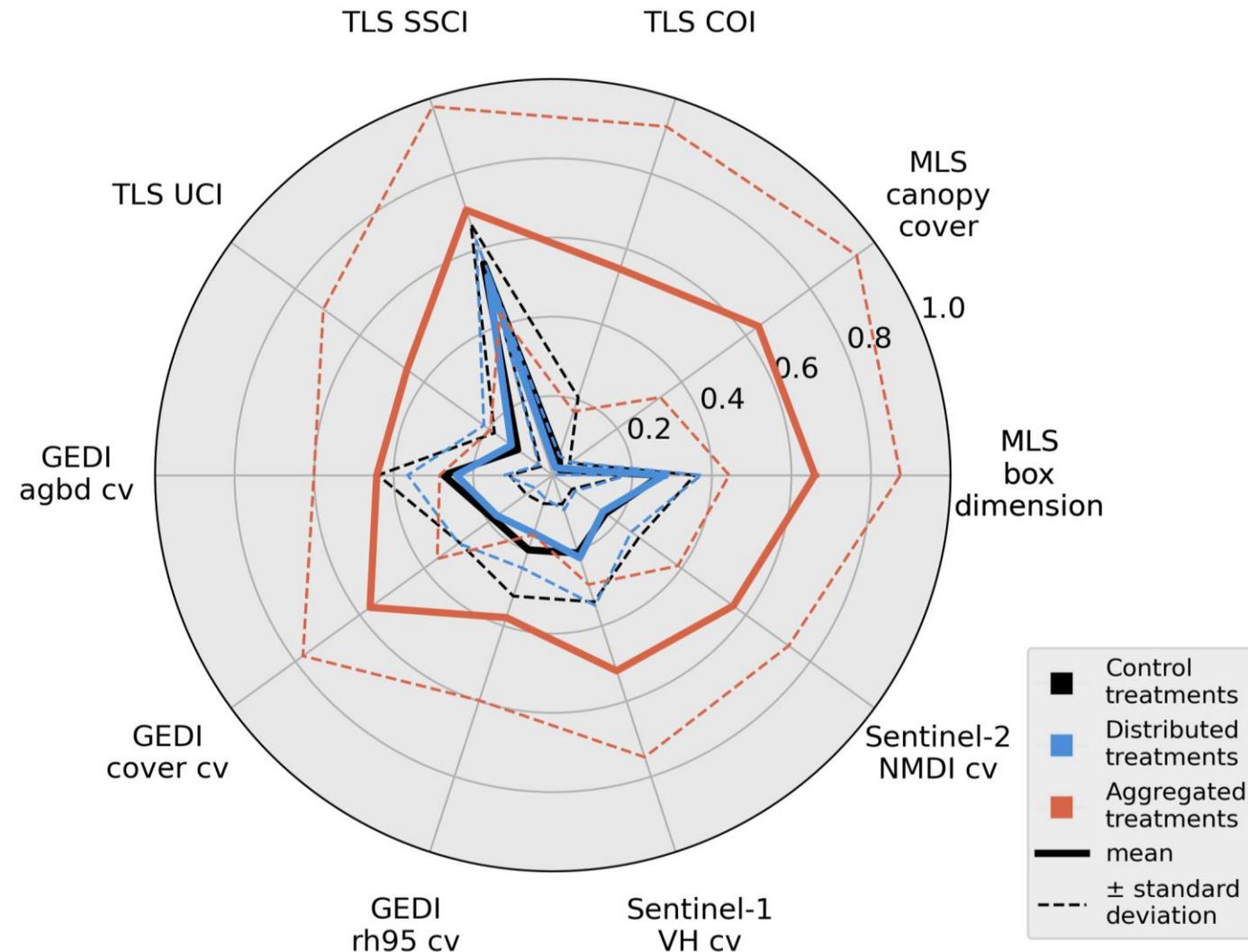
Correlation Network of Remotely Sensed Data

- **Correlation network** to present multivariate relationships
- Only **correlations with an absolute value > 0.5** are shown
- The **proximity of indicators** indicates a high number of strong correlations
- **Core network group (most correlative):**
 - GEDI cover cv
 - Sentinel-1 VH cv
 - Sentinel-2 NMDI cv
 - MLS canopy cover
 - MLS box dimension
 - TLS COI



Comparative Analysis of Treatment Groups

- **Treatment groups:**
 - Control** (unaltered structure)
 - Distributed** (selective removal of trees)
 - Aggregated** (gap felling)
- Indicators were **rescaled:**
 - 0** indicating a **low structural complexity**
 - 1** representing a **high structural complexity**
- **Indicators of all platforms delineate well among aggregated and control/distributed treatments**



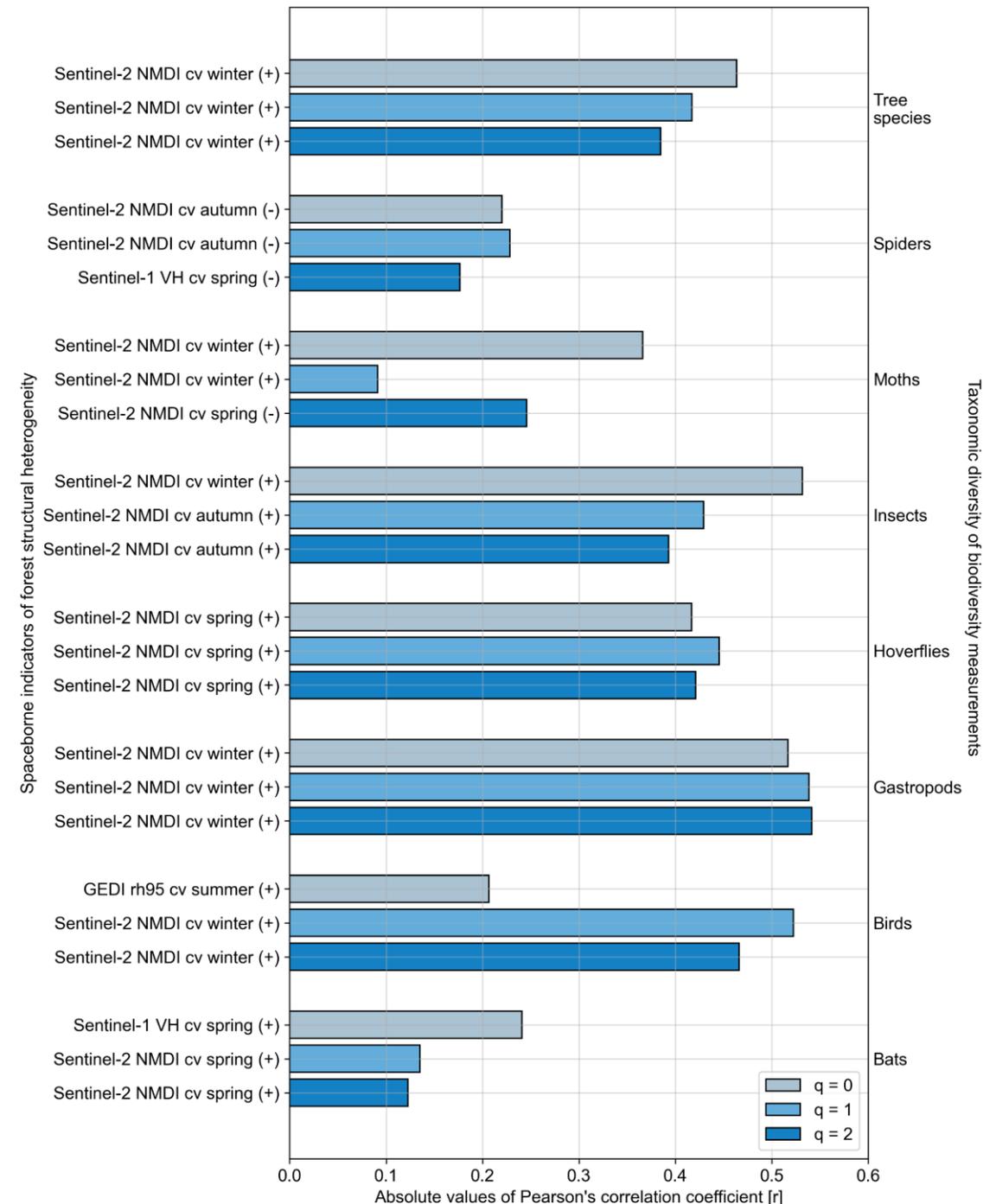
Assessing Structure-Biodiversity Relationships

- Integration of in-situ biodiversity data
- Assessment of best spaceborne forest structure indicator per taxonomic diversity level:
 - $q = 0$ (species richness)
 - $q = 1$ (Shannon index)
 - $q = 2$ (Simpson index)
- Moderate correlations for
 - Birds
 - Gastropods
 - Hoverflies
 - Insects
- Seasonal biases



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Overall Summary

- **Strong correlations of indicators on structural complexity could be identified across sensors and platforms:**
 - MLS box dimension, MLS canopy cover,
 - TLS COI,
 - Sentinel-1 VH cv, Sentinel-2 NMDI cv, GEDI cover cv
- **The increase in forest structure complexity of aggregated treatments compared to control and distributed treatments can be identified from all remote sensing platforms**
- **Spaceborne indicators of forest structure complexity from complementary sensors hold similar capability to characterize experimental silvicultural treatments as close-range techniques**
- **The delineation of different levels of forest structural complexity is essential to characterize structure-biodiversity relationships**



Foto: Lisa Albert, Forest of University of Würzburg, Germany

Assessment of Forest Structure - Publications



Article

Forest Structure Characterization in Germany: Novel Products and Analysis Based on GEDI, Sentinel-1 and Sentinel-2 Data

Patrick Kacic ^{1,*} , Frank Thonfeld ² , Ursula Gessner ² and Claudia Kuenzer ^{1,2}

Remote Sensing in Ecology and Conservation
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RESEARCH ARTICLE

Assessing experimental silvicultural treatments enhancing structural complexity in a central European forest – BEAST time-series analysis based on Sentinel-1 and Sentinel-2

Patrick Kacic ¹ , Ursula Gessner ² , Stefanie Holzwarth ² , Frank Thonfeld ²  & Claudia Kuenzer ^{1,2}



Patrick Kacic, Spaceborne and In-Situ Remote Sensing for Monitoring Enhanced Forest Structural Complexity



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Original articles

Characterizing local forest structural complexity based on multi-platform and -sensor derived indicators

Patrick Kacic ^a , Ursula Gessner ^b , Christopher R. Hakkenberg ^c , Stefanie Holzwarth ^b , Jörg Müller ^{d,e} , Kerstin Pierick ^{f,g} , Dominik Seidel ^f , Frank Thonfeld ^b , Michele Torresani ^h , Claudia Kuenzer ^{a,b}

