BioSpace25 - Biodiversity insight from Space
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# Functional Trait Responses to Drought in a temperate forest: Insights from Earth Observation

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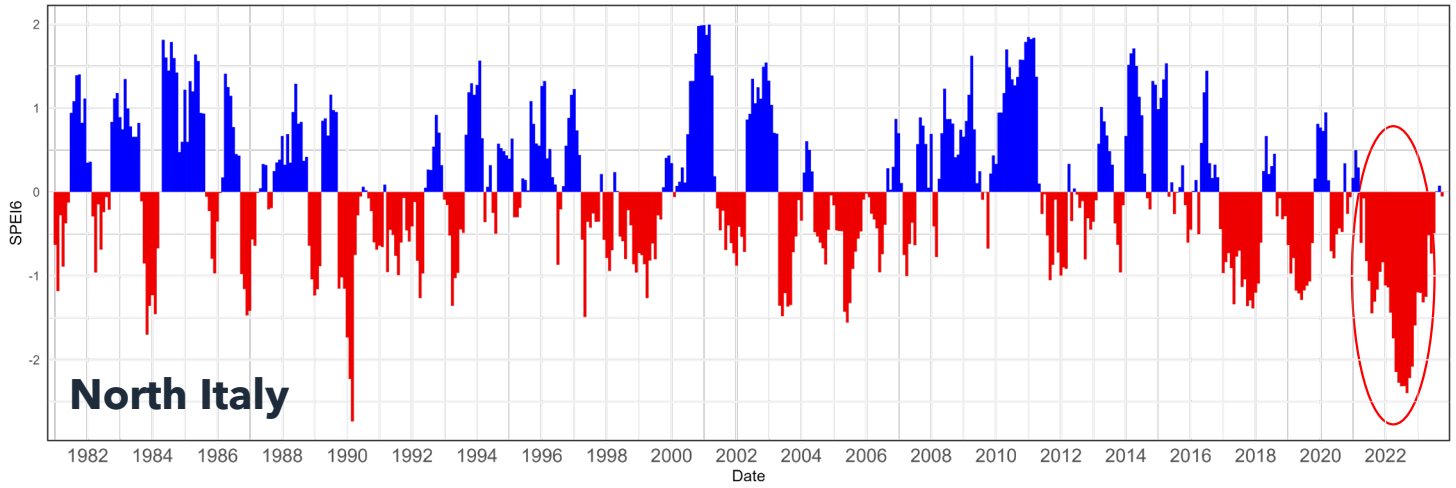
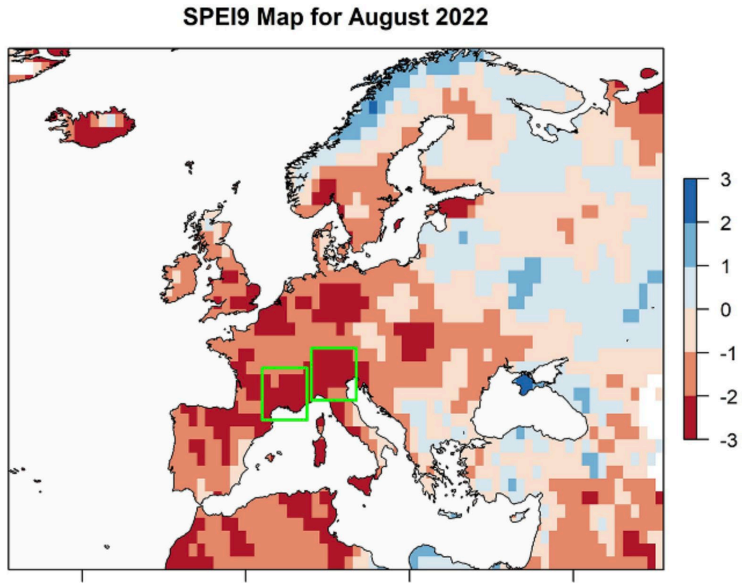
# Objectives

Evaluate the spatial and temporal impact of the **2022 extreme drought** on the forest of the **Ticino Park** (Italy) by analyzing Sentinel-2 imagery from 2017 to 2022

Drought has become a **major stressor** to Earth's system functioning and is projected to intensify in both frequency and intensity




Faranda et al., *2023*

Record-breaking negative values of the 9-month **Standardized Precipitation Evapotranspiration Index** (**SPEI9**) in August 2022

# Data collection

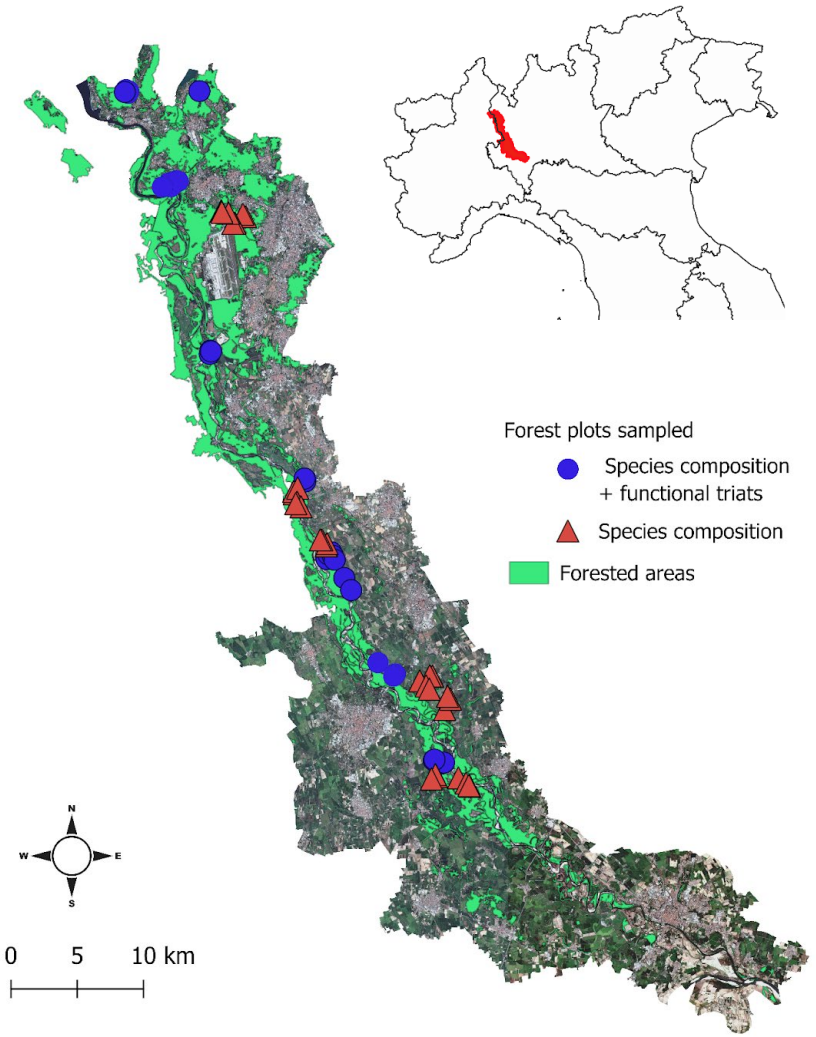
→ 2 intensive **field campaigns** were organized in **June and September 2022**

✓ **Plant trait sampling**: Leaf Area Index (**LAI**), Leaf Chlorophyll Content (**LCC**), Leaf Water content (**LWC**)

✓ **50** Elementary Sampling Units (**ESU): 30 x 30 m**

✓ **More than 200 trees sampled**

22.000 ha of **temperate mixed forest**



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✓ **More than 200 trees sampled**

✓ **Species composition of the overstory and understory**

✓ **63** Elementary Sampling Units (**ESUs): 30 x 30 m**

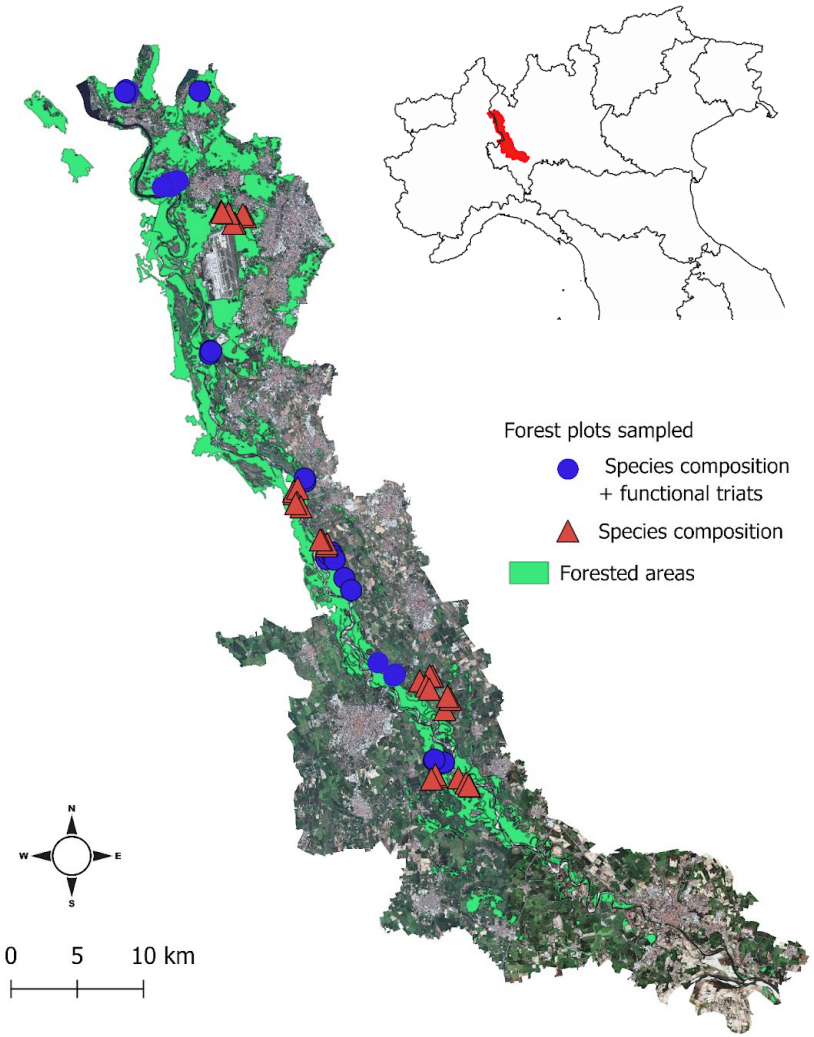
**Ellenberg indexes** and **% of alien species**

- light radiation (L)
- heat (T)
- water availability (U)
- nutrients (N)
- PH (R)

10 different **forest associations**

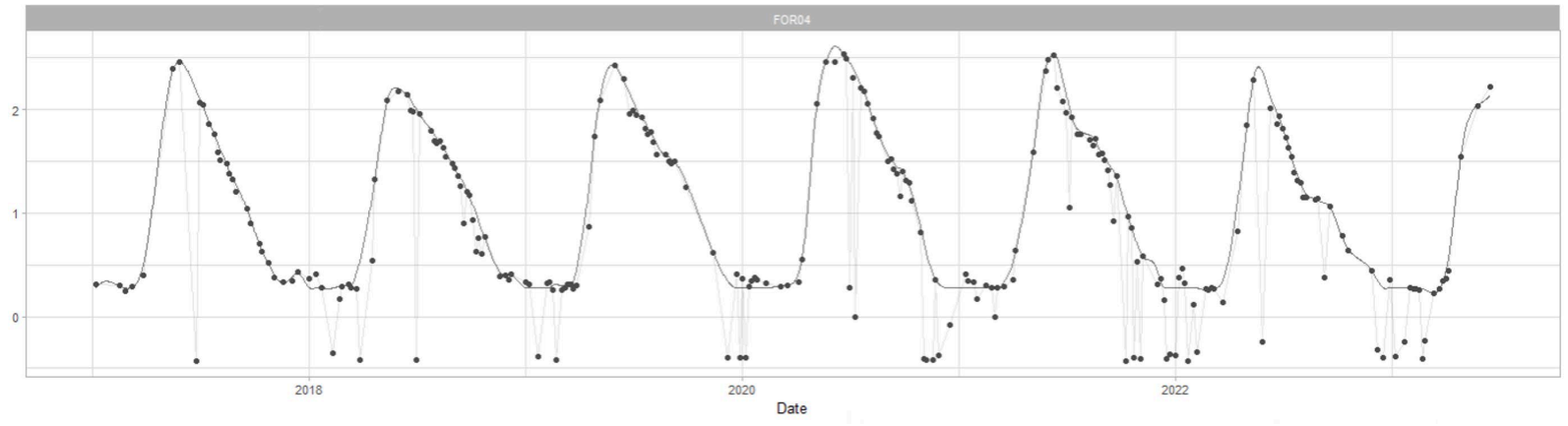
Alder, Chestnut, oak with different water availability, Meso-xerophilic oak, Mixed deciduous, Pine sp., Black cherry

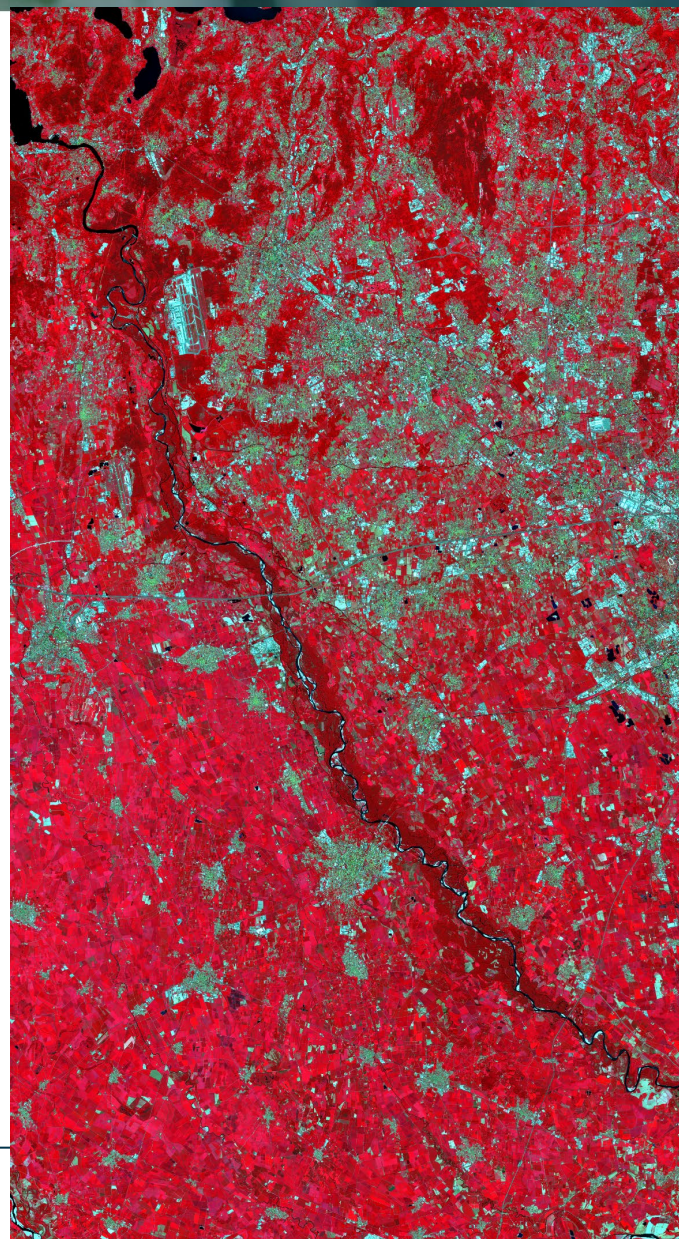
22.000 ha of **temperate mixed forest**



# ESA Sentinel-2 processing

- ✓ **'Sen2r'** R package to download and pre-process **243 Sentinel-2** images (Ranghetti *et al.*, 2020)
- ✓ **Sentinel-2 Biophysical Processor** in **SNAP** to retrieve Leaf Area Index (**LAI**), Canopy Chlorophyll Content (**CCC**) and Canopy Water Content (**CWC**)
- ✓ **'sen2rts**' R package (Ranghetti *et al.*, 2021) to create daily time series of LAI, CCC and CWC for each forest plot



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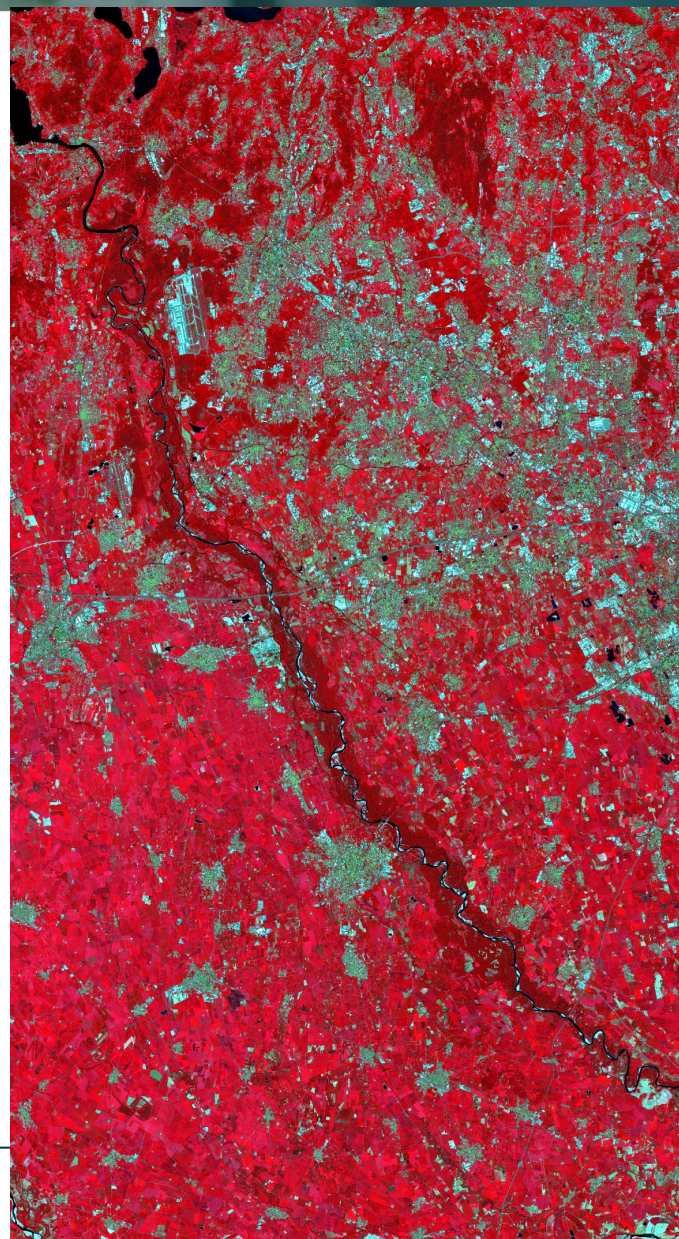
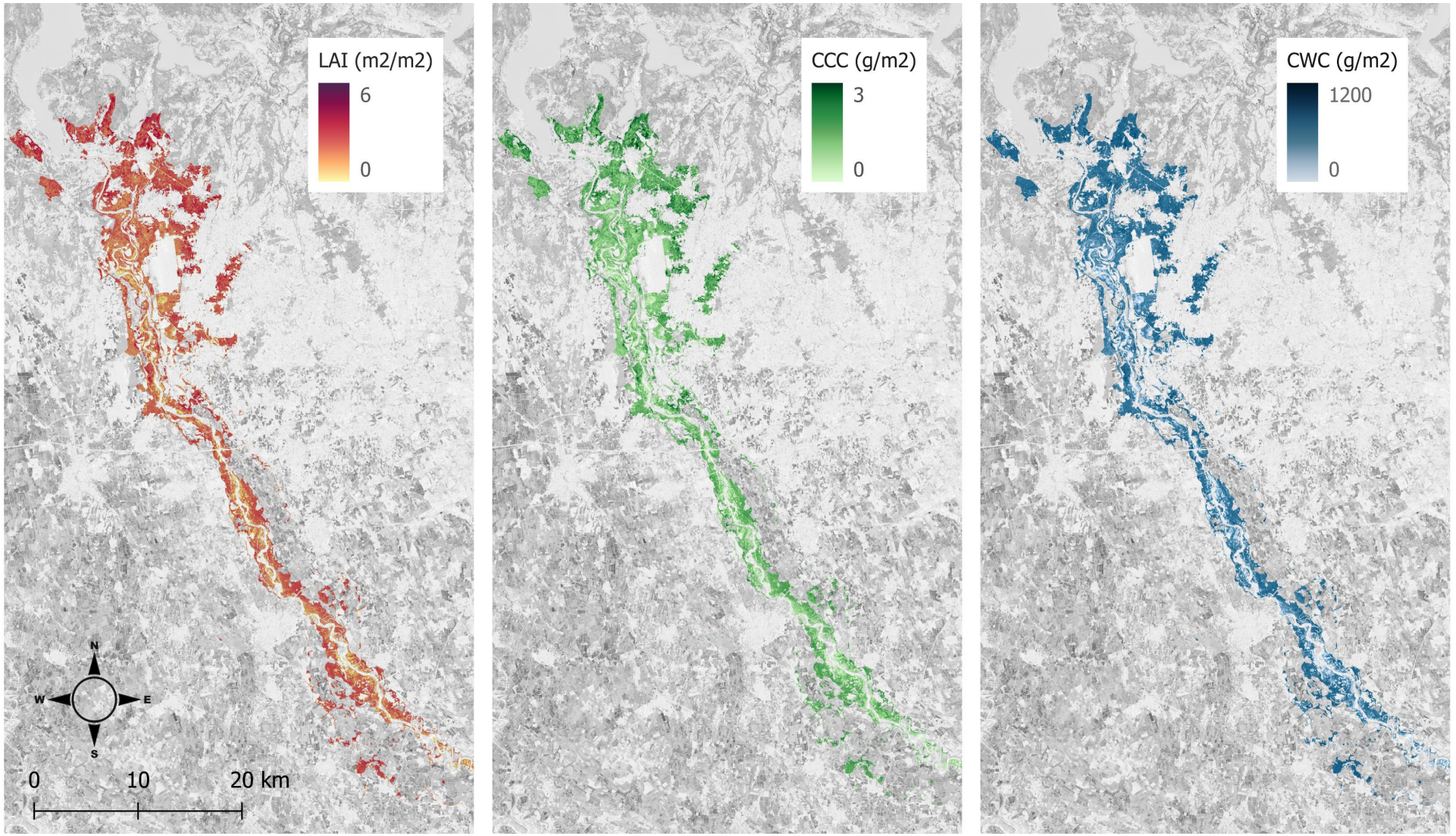
- ✓ Calculation of the plant trait **standardized daily anomalies** (compared to the 2017-2022 average)

$$\boldsymbol{Std.\,daily\,anomaly} = \frac{anomaly\ at\ pixel\ (x,y) time\ t - multi\ year\ daily\ average\ at\ pixel\ (x,y)}{multi\ year\ \ standard\ deviation\ at\ the\ pixel\ (x,y)}$$

- ✓ **Generalized Additive Model** analysis to explore how different forest types and environmental factors are related to standardized anomaly values at plot level



# Sentinel-2 plant trait maps (June)



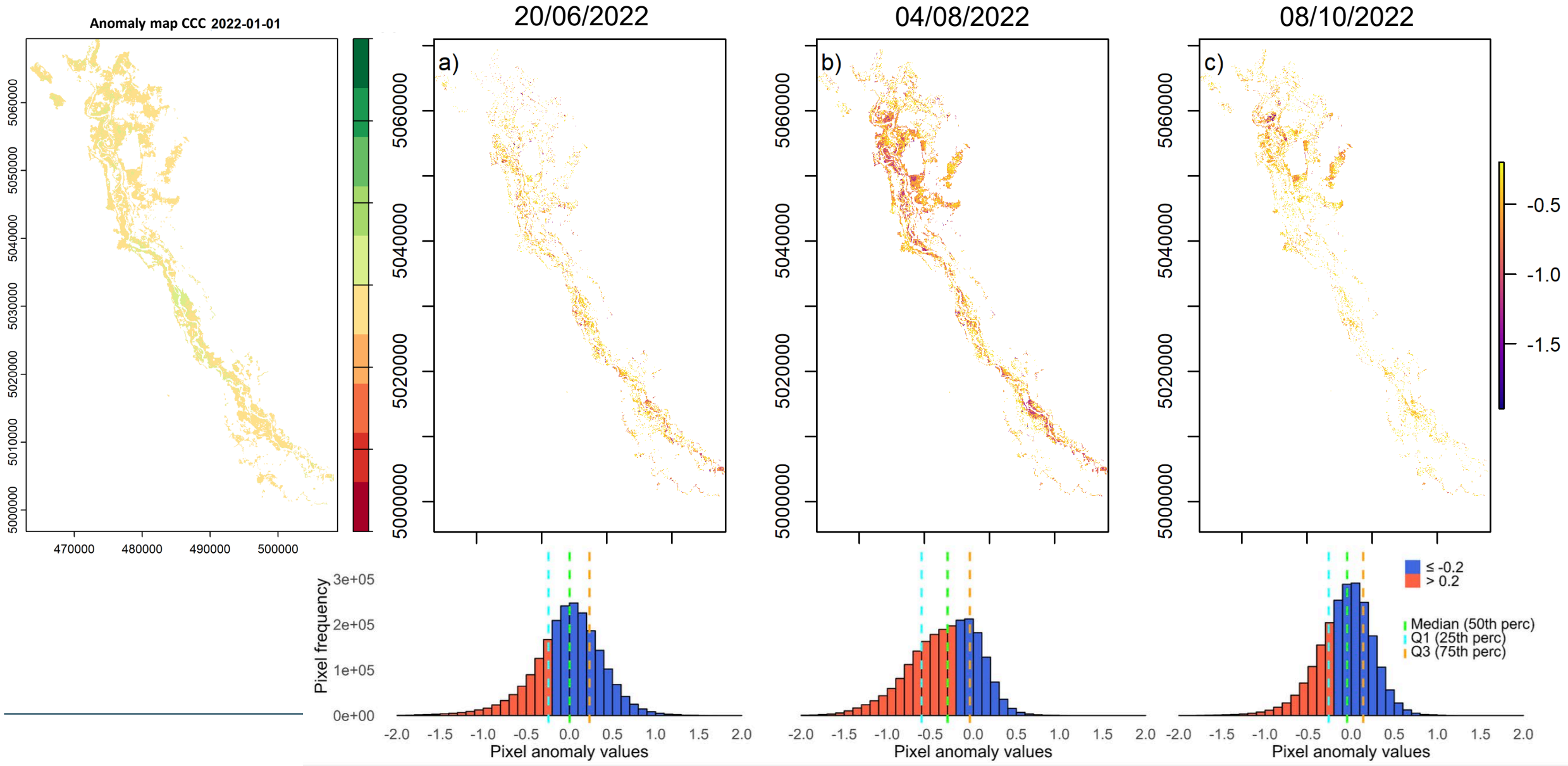

Savinelli et al., *2024*

$R^2$ 0.75, nRMSE 11.5%

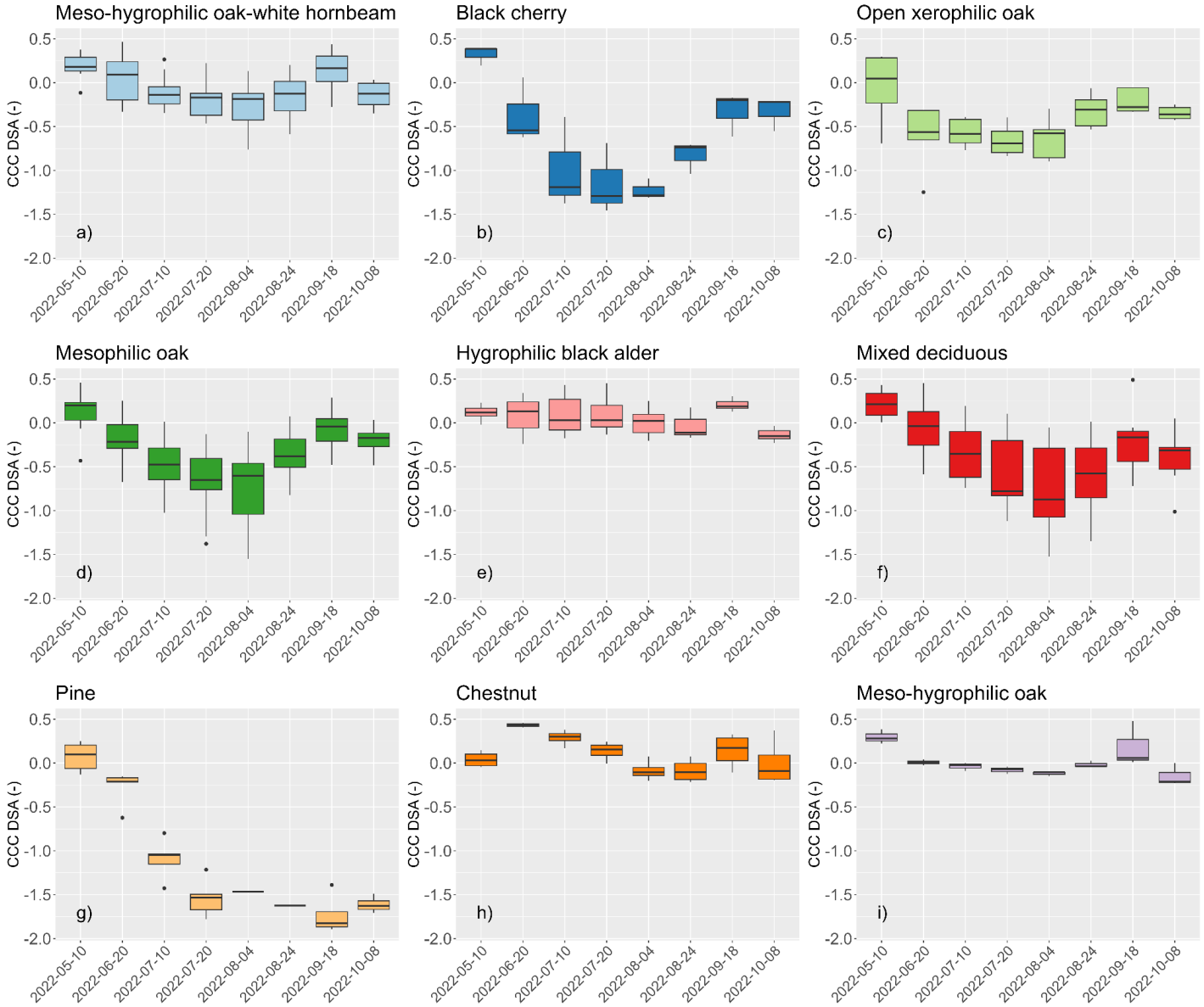
$R^2$ 0.82, nRMSE 13.6%

$R^2$ 0.64, nRMSE 28.8%

# 2022 CCC anomaly maps



# Evolution of CCC mean standardized anomalies




- GAMs highlighted that the deviance explained increases with the progression of summer because of the **increase and diversification of anomalies response between forest associations**
- The anomalies are significantly **related to forest associations,** with decline being **particularly evident** for **pine and black cherry**
- Forest types like **hygrophilic black alder, chestnut** and **meso-hygrophilic oak** exhibited almost **no signs** of negative anomalies
- **Elevation** is also significantly influencing the forest spectral response to stress

Savinelli et al., *2024*

# Conclusions and future work

- ✓ The analysis of Sentinel 2 trait time series allowed to **identify anomalies related to** the **water stress** conditions that occurred in the summer 2022 in northern Italy
- ✓ **GAMs** revealed that **the response to drought** stress depends on the **species ecology** and **local environmental conditions**
- ✓ **Remote sensing can effectively support forest monitoring,** allowing to detect and track the evolution of plant stress, supporting effective management strategy design

**Future work and priorities**

- ✓ Integration of **multiple sensors** and data streams to monitor ecosystem structure, diversity and function, enabling our understanding of biodiversity's role in conferring resilience to disturbances
- ✓ **Scalable approaches** in space and time to better understand dynamic changes from local to global scales

# Conclusions and future work


**EO-based biodiversity indicators assessing forest resilience**
funded by ESA in response to Sentinel Users Preparation (SUP) initiative

**Partners:** Sarmap S.A., University of Zurich, University of Milano-Bicocca

**Objective**: to propose innovative EO based biodiversity indicators - incorporating EBVs estimated by the synergistic use of hyperspectral imaging spectroscopy (CHIME) and Synthetic Aperture Radar (SAR) data (ROSE-L) - to assess the resilience of forest ecosystems to drought

Thank you for the attention

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