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Nature Conservation - Research - Technology



The Diversity of Heath Flowering Phenology – Revealing Fine Scale Patterns of Heterogeneity by High Resolution Drone Cameras

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Matthias Wichmann, Jörg Müller*





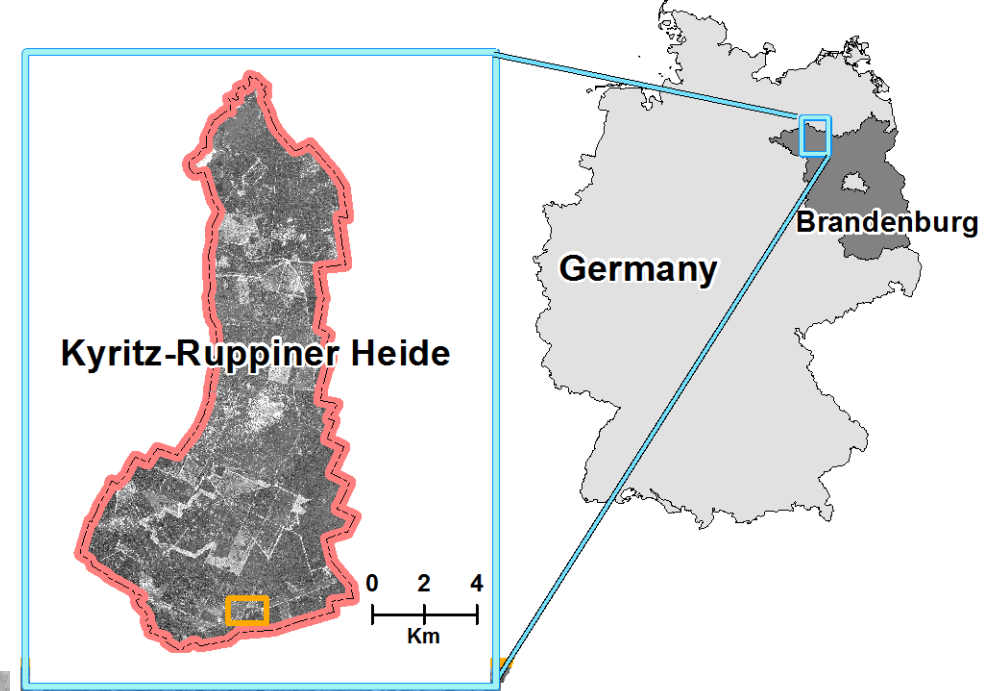
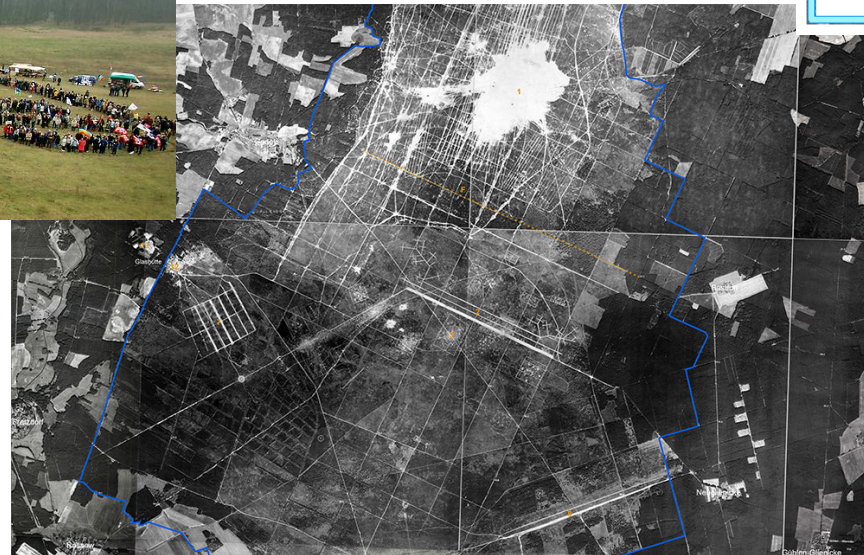
former military training area since 1993



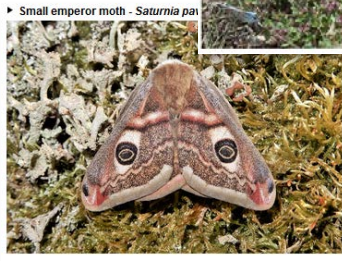
The citizens' movement for peace and nature



Today: Largest European unfragmented heathland area 120km² protected under Natura 2000



- > implementation of habitat management
- > create habitats and potential of change
- > phenology as biodiversity variable and state indicator
- > phenophase diversity

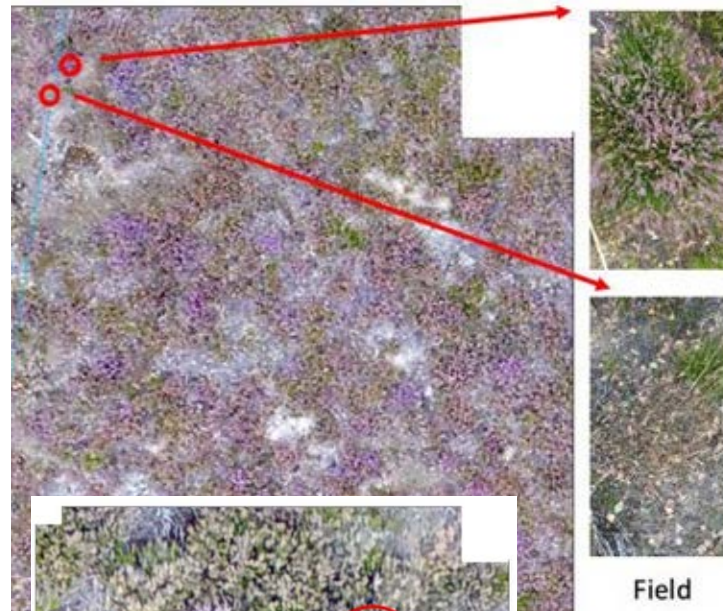
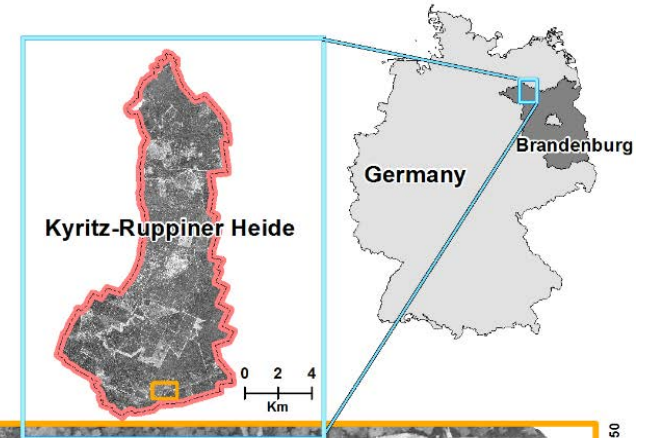


-> Development of UAV process chain for *Calluna vulgaris* phenophase mapping

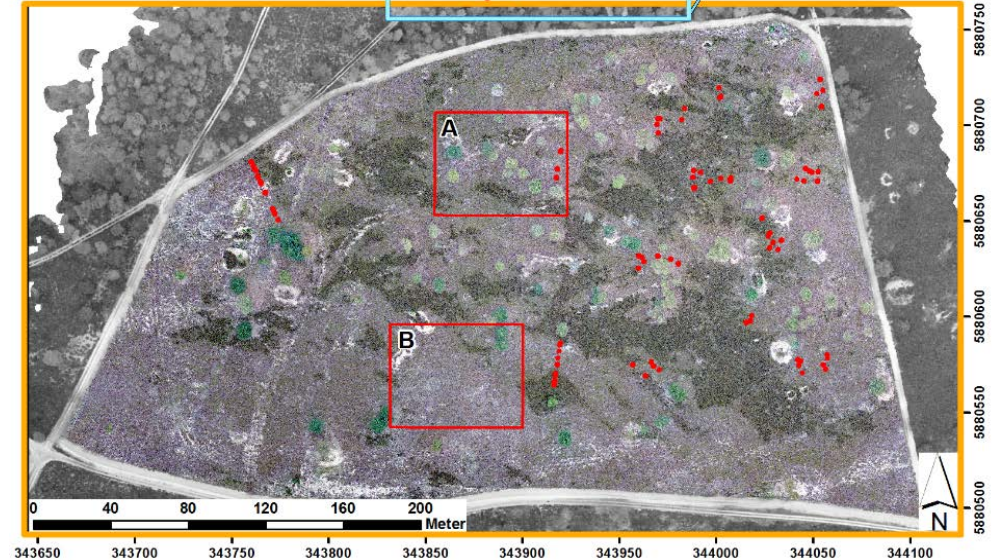
DJI phantom 4

- 1.4 kg
- Gimbal
- IMU
- RGB camera 12.5M pixels
- 8-bit silicon
- automatic flight planning for ~ 25min
- 2cm pixel size

1. Tree mask
2. Extract canopy heights
3. Extract *Calluna vulgaris* Pixels
4. Quantify Color Phenology
5. Extract individual plant units
6. Spatial Statistics



RGB-Drone Imagery



1. Tree mask

1 m² average filter

tree crown detection index

$$TCRI = \left[(\sum RGB_{av}) + \left(\frac{G_{av}}{B_{av} + R_{av}} \right) \right] \times t$$

bare ground correction

k-means clustering on bright, green objects (TCRI)

Area thresholding:

A < 0.5m² - artefacts
A > 10m² - trees

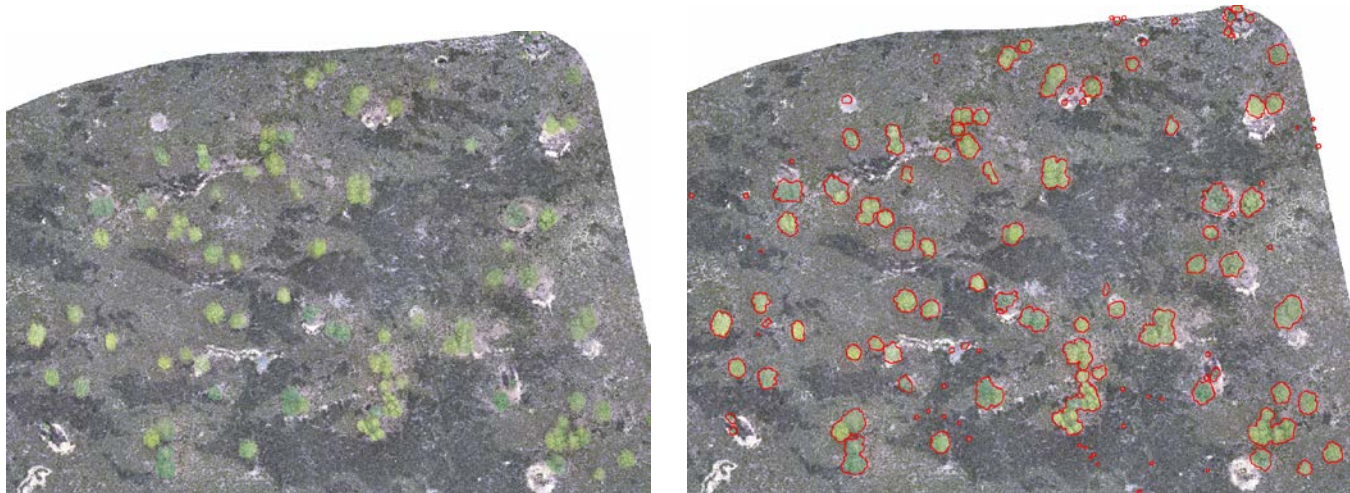
A > 0.5 <= 10m²

Maximize:

- Polsby-Popper compactness
- edge color range

$$PP_{in}(TCRI_n) = \frac{4\pi A(TCRI_n)}{p^2} \times \text{Diff}(\text{range}[TCRI_n])$$

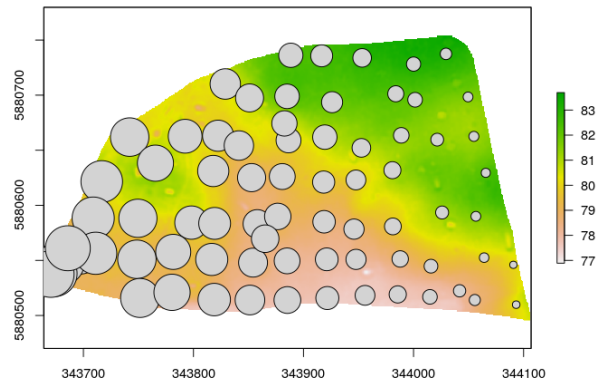
reduce A > 0.5 <= 10m² by
PP_{in} threshold



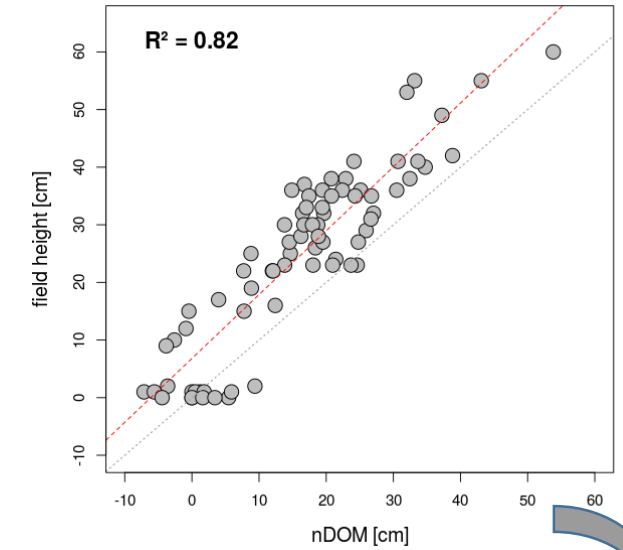
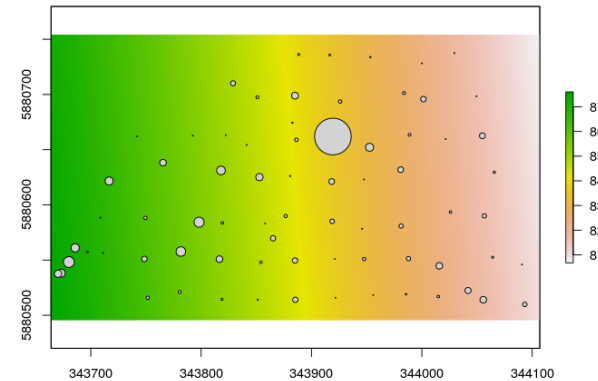
1. Tree mask
2. Extract canopy heights

1 m LIDAR reference

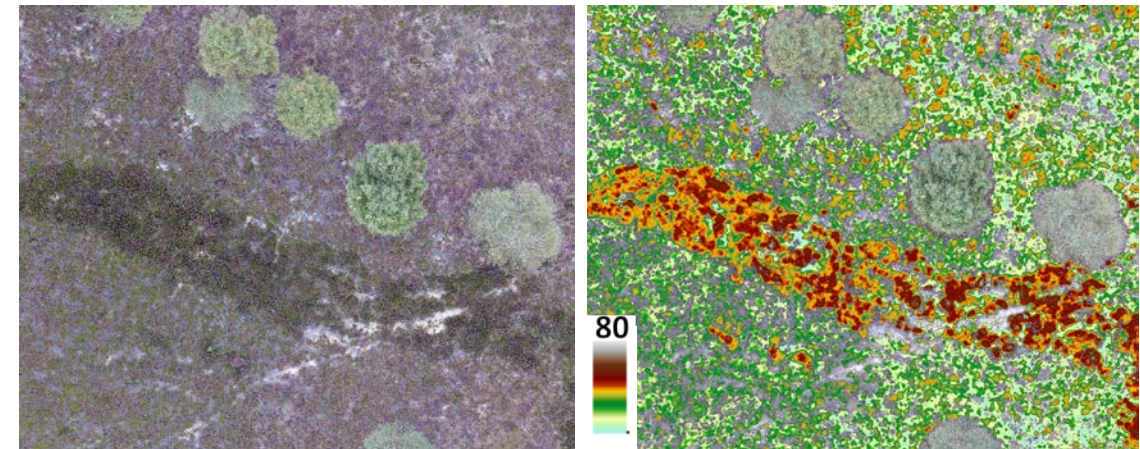
ortho k-means clustering
difference LIDAR – DEM UAV
at bare ground sampling



trend surface modeling
residual Kriging
surface differences



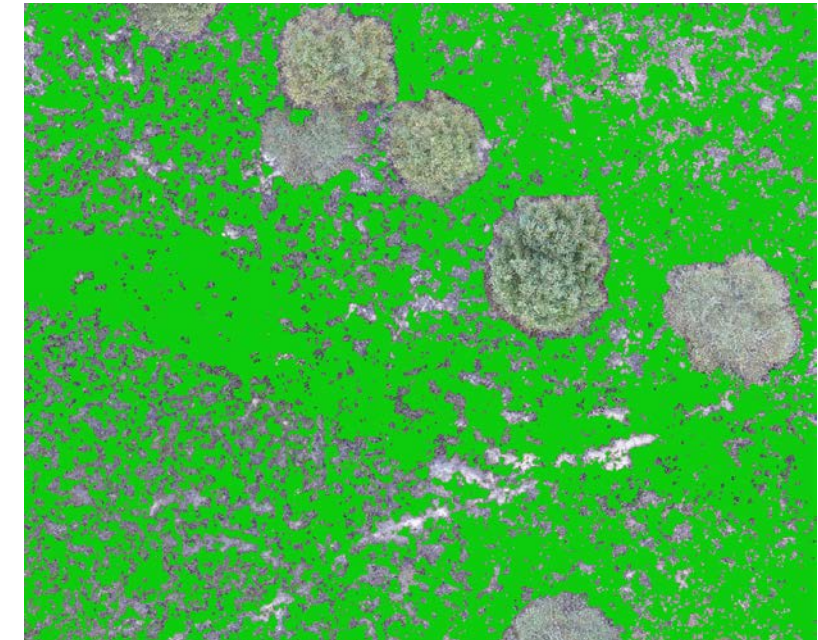
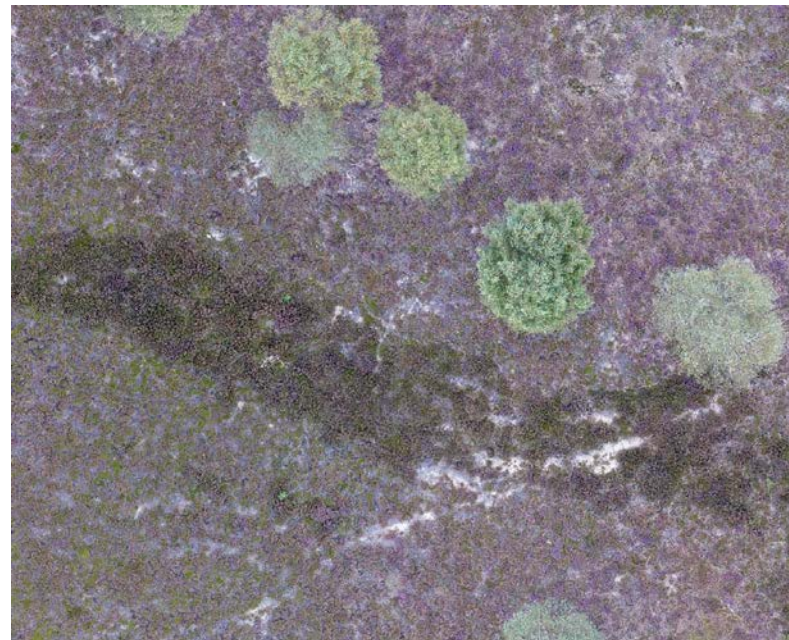
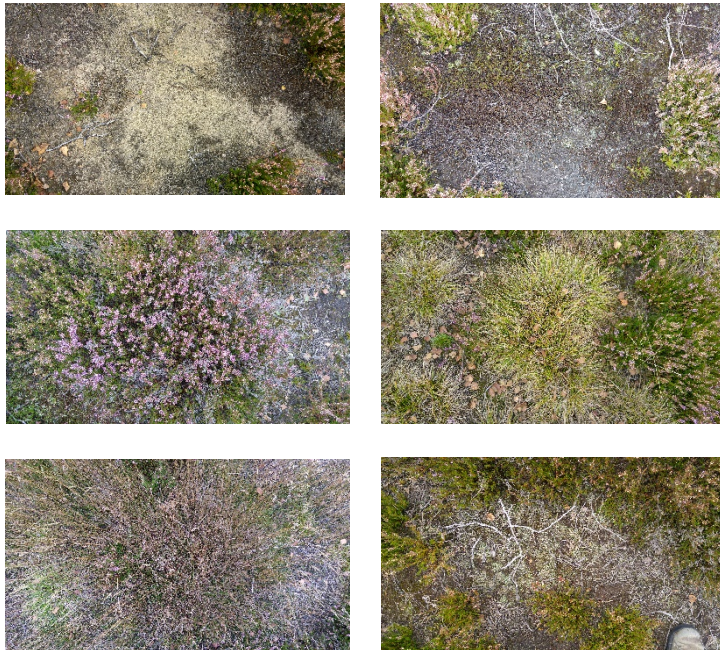
empirical line correction



2. Extract canopy heights
3. Extract *Calluna vulgaris* Pixels

Ortho RGB image Input
variogram model filter size
RGB reference pixels

5 Pixel co-occurrence texture filtering
RandomForest supervised classification
erosion filter



4. Quantify Color Phenology

Flower



Fruit



Leaf



4. Quantify Color Phenology

Flower



Fruit

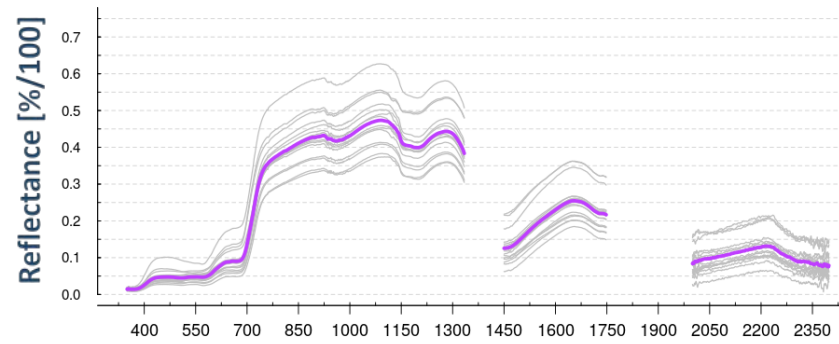


Leaf



4. Quantify Color Phenology

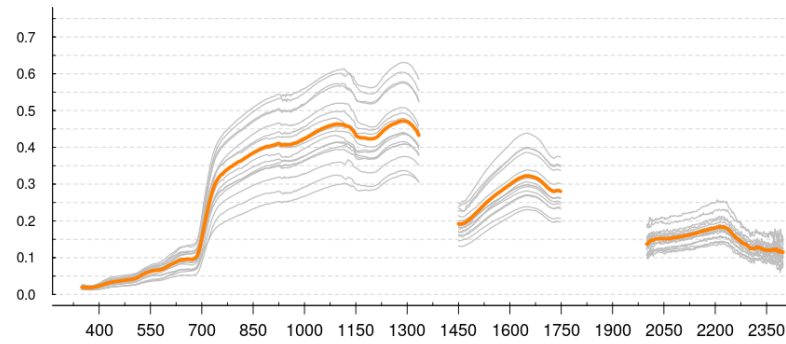
Flower



Wavelength [nm]



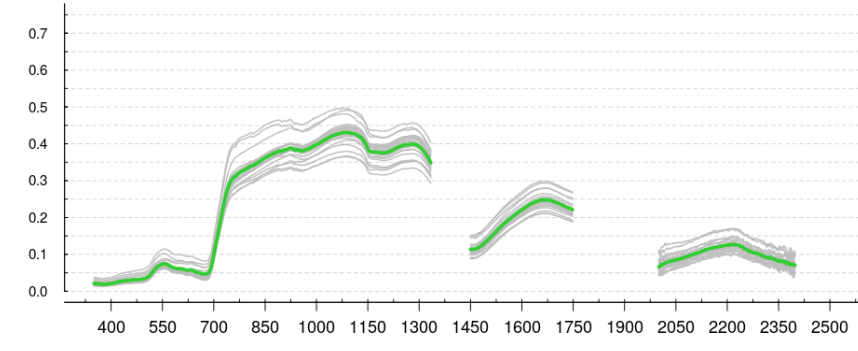
Fruit



Wavelength [nm]



Leaf

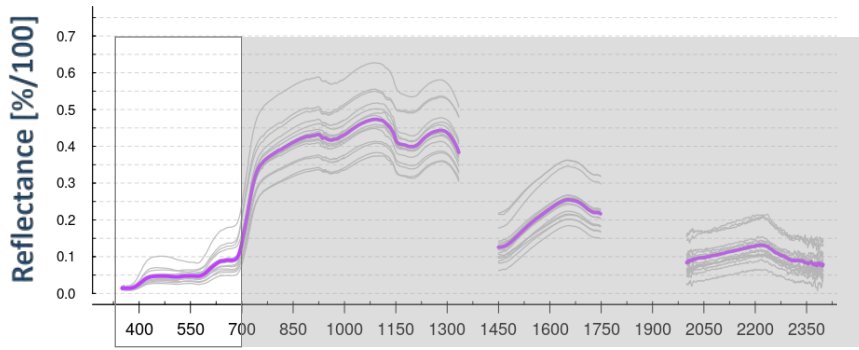


Wavelength [nm]

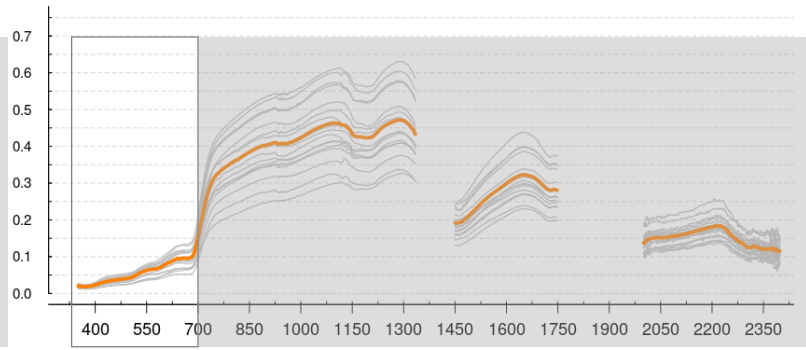


4. Quantify Color Phenology

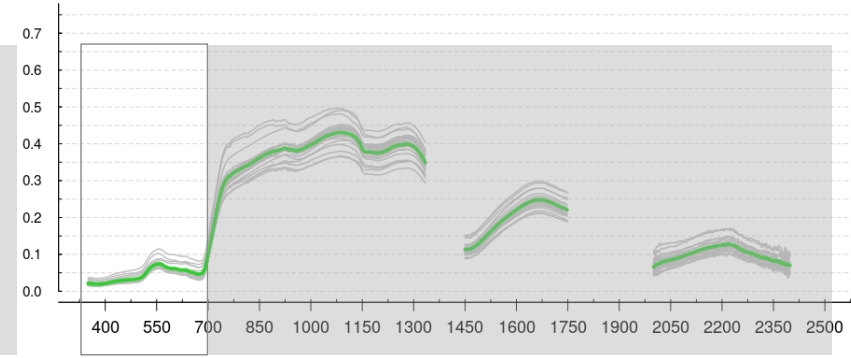
Flower



Fruit



Leaf

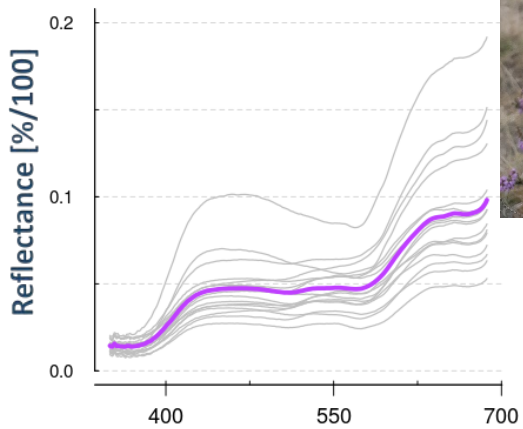


Wavelength [nm]

Wavelength [nm]

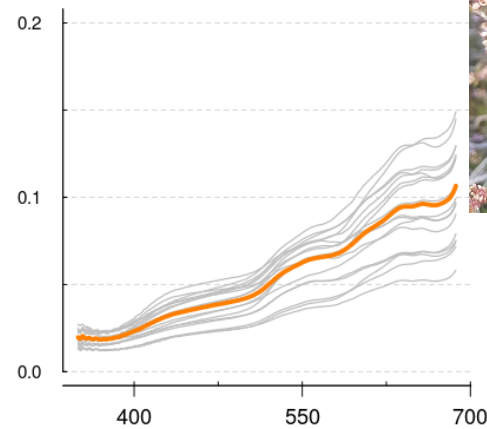
Wavelength [nm]

VIS



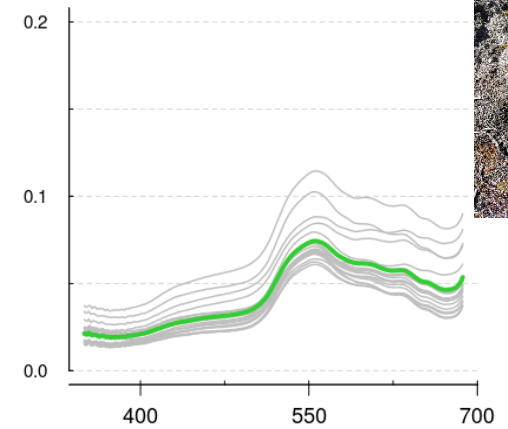
Wavelength [nm]

VIS



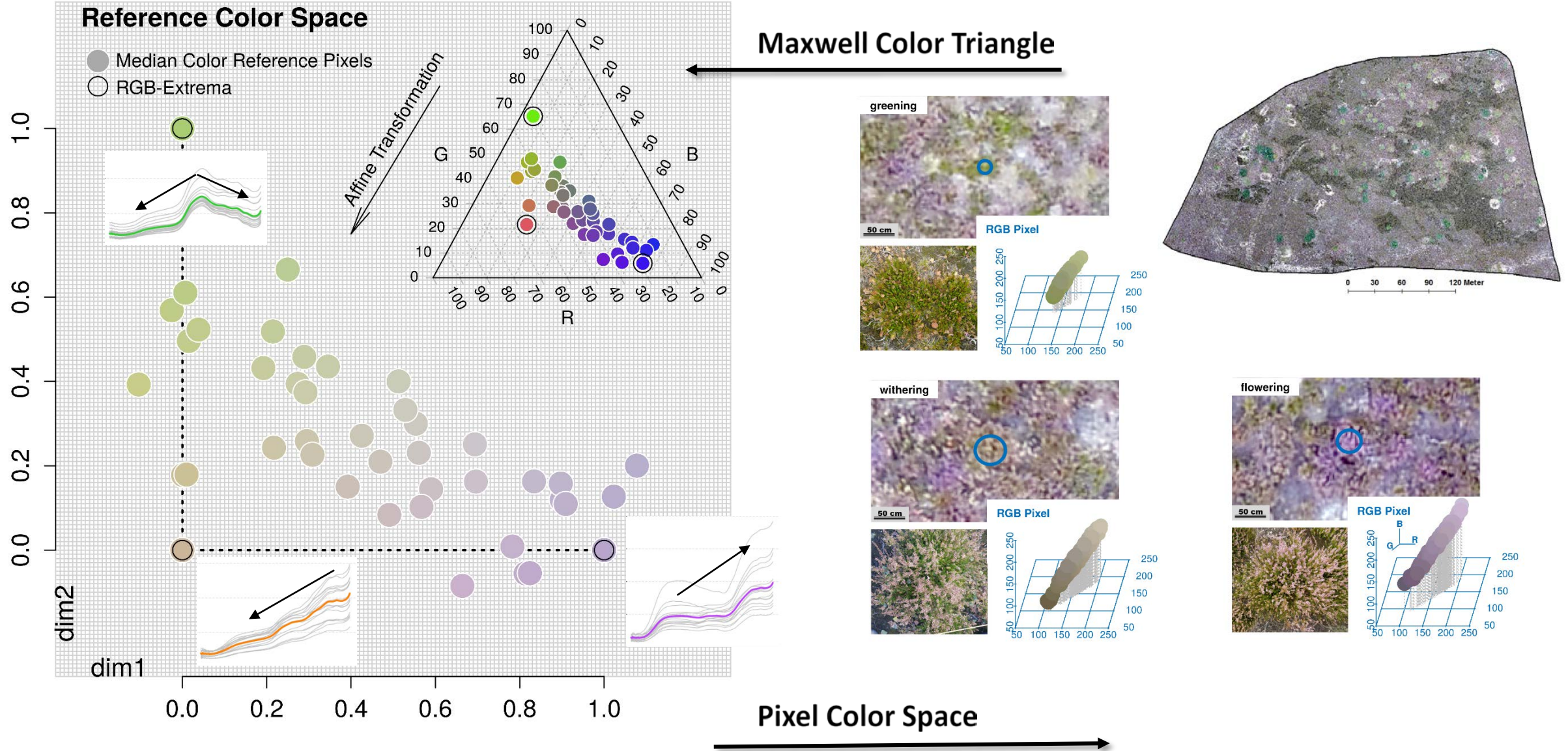
Wavelength [nm]

VIS

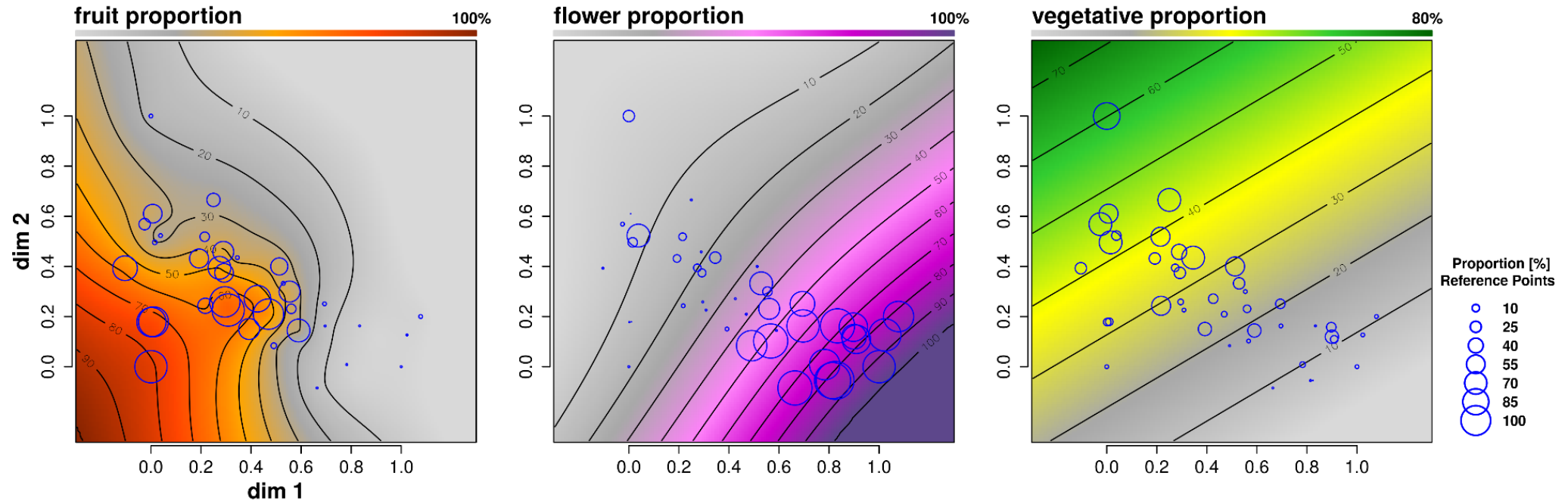


Wavelength [nm]

4. Quantify Color Phenology



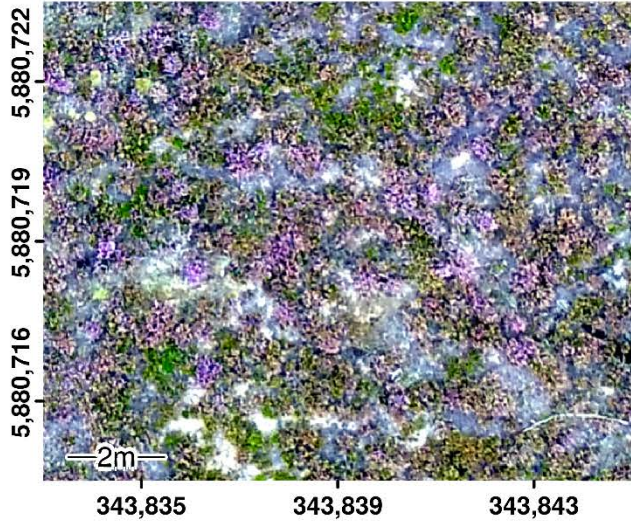
4. Quantify Color Phenology



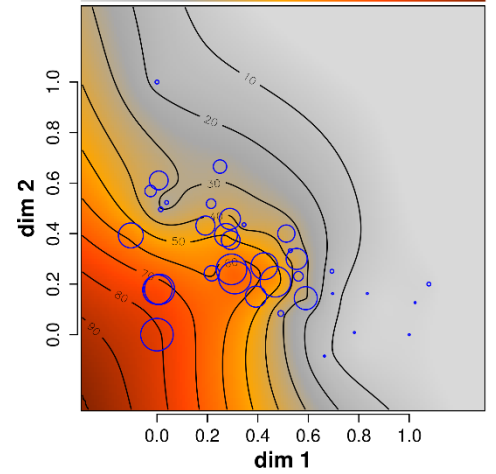
trend surface modeling
residual Kriging

4. Quantify Color Phenology

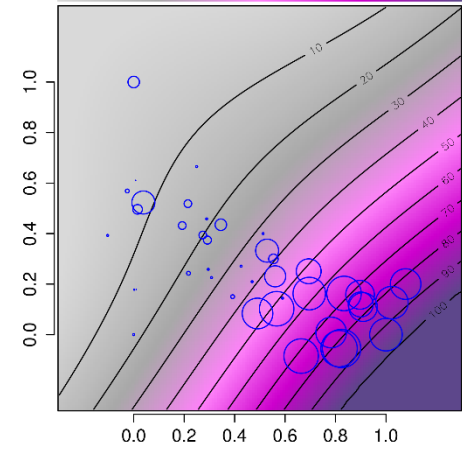
RGB-Composite



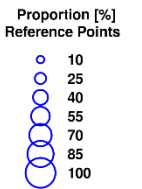
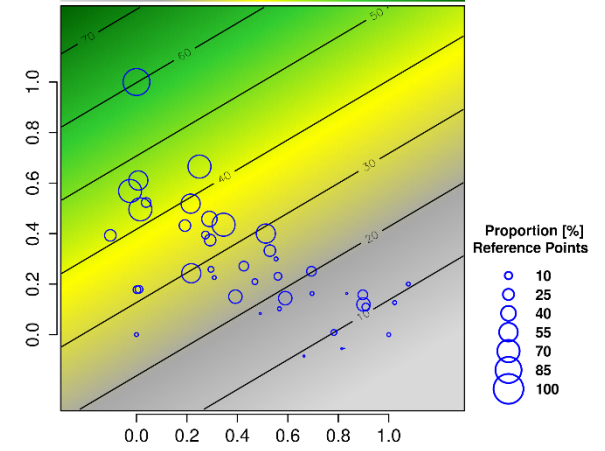
fruit proportion



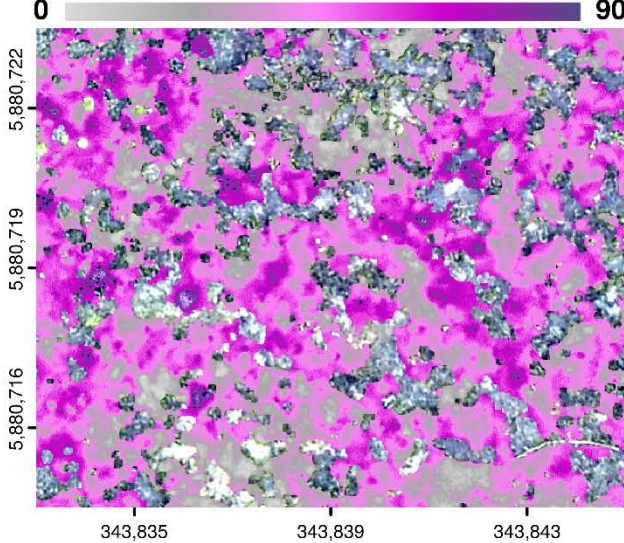
flower proportion



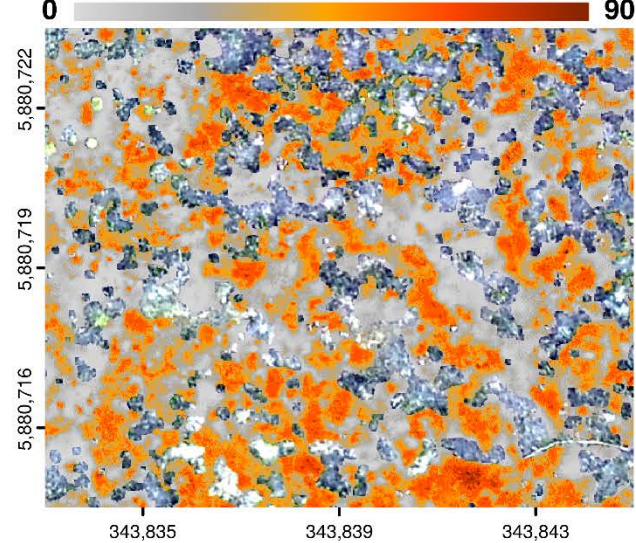
vegetative proportion



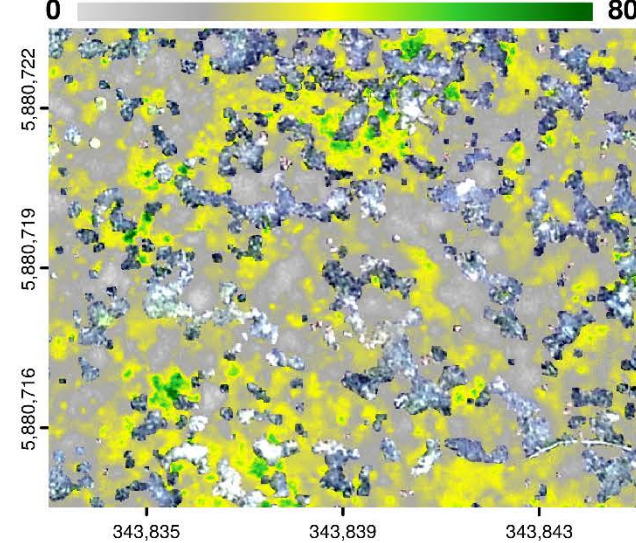
Calluna Phenology - Flower [%]



Calluna Phenology - Fruit [%]



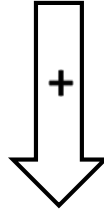
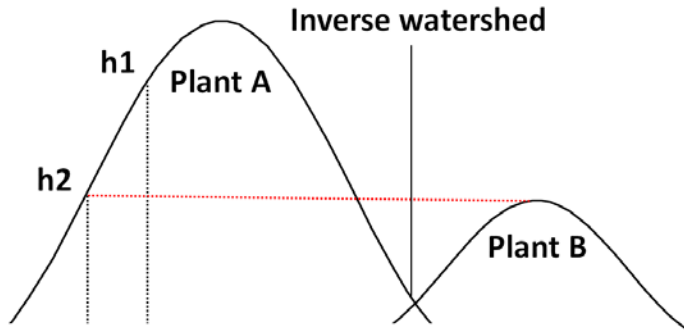
Calluna Phenology - Leaf [%]



5. Extract individual plant units

Pheno-Proportion Maps

Plant Height



flower



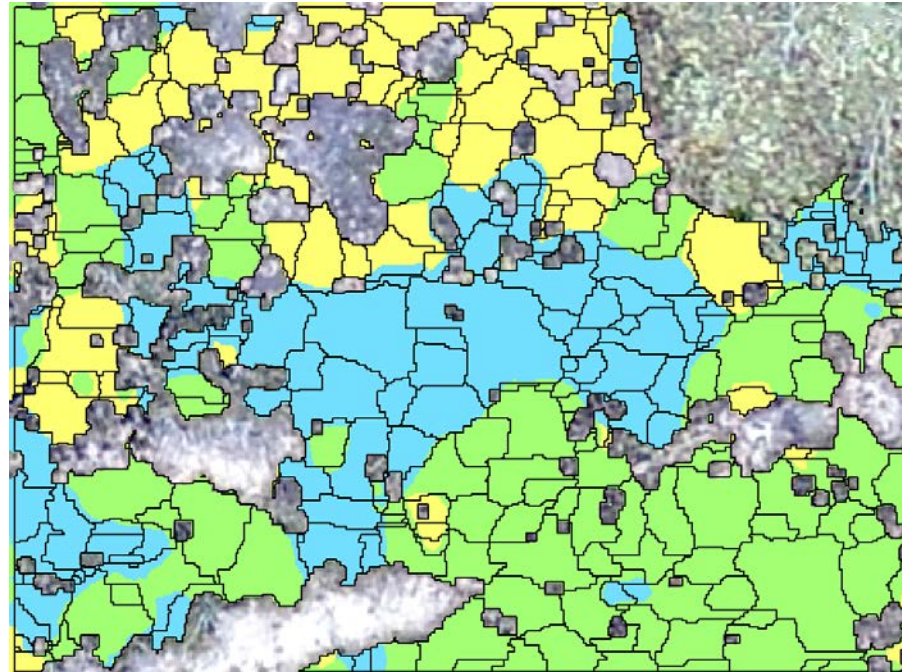
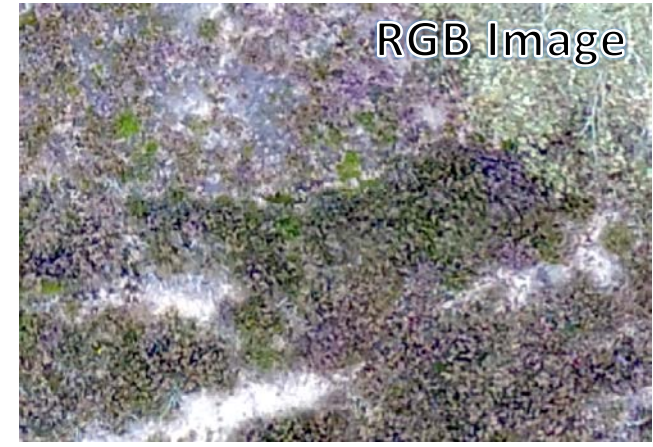
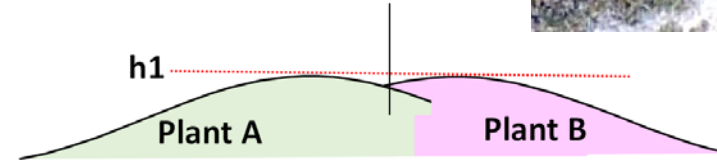
fruit



green

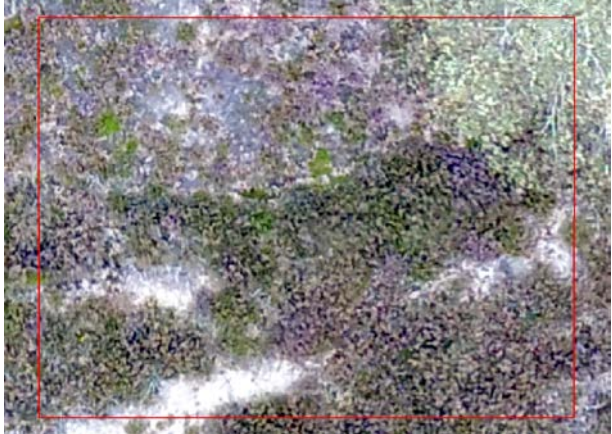
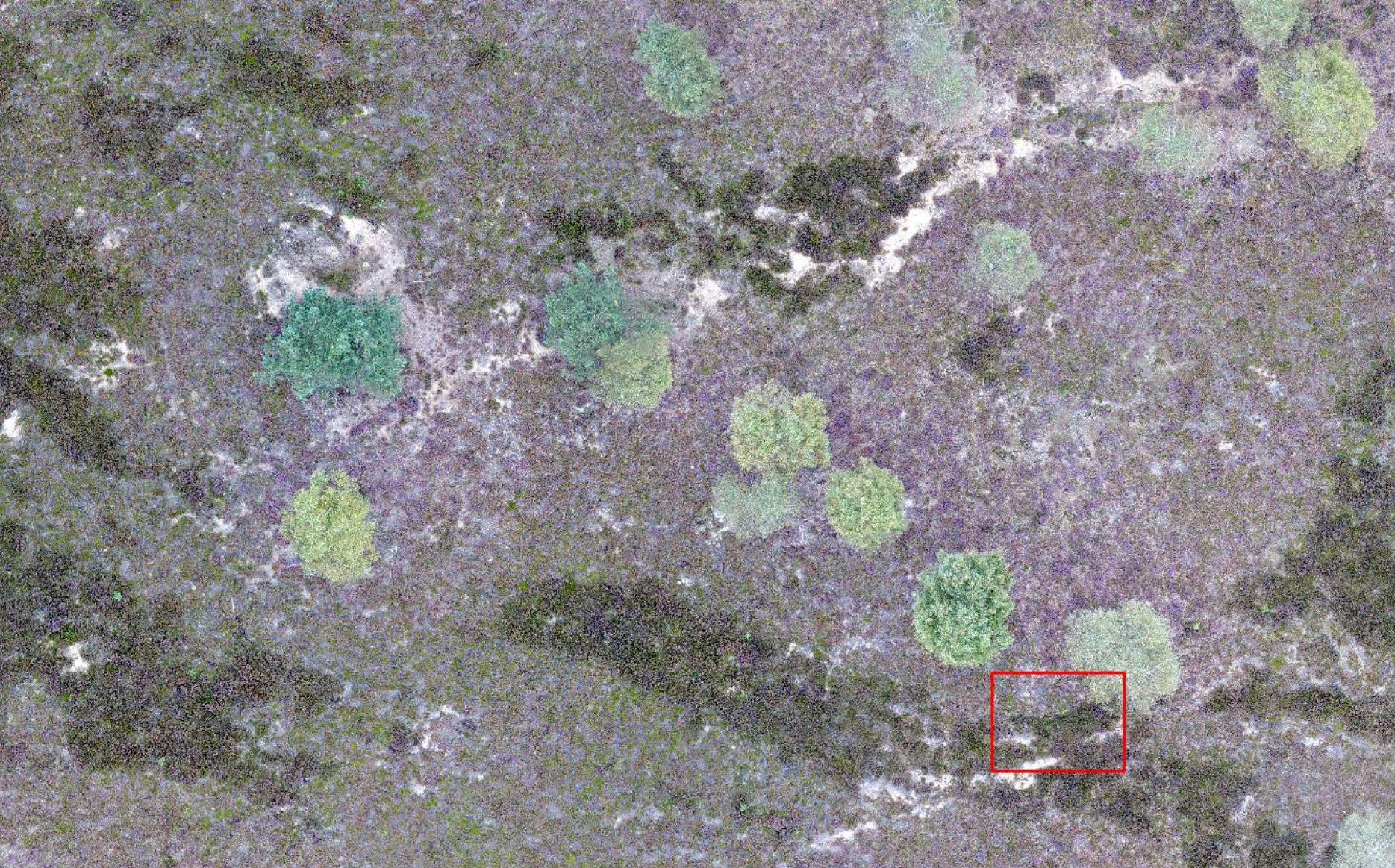


Plant Phenology

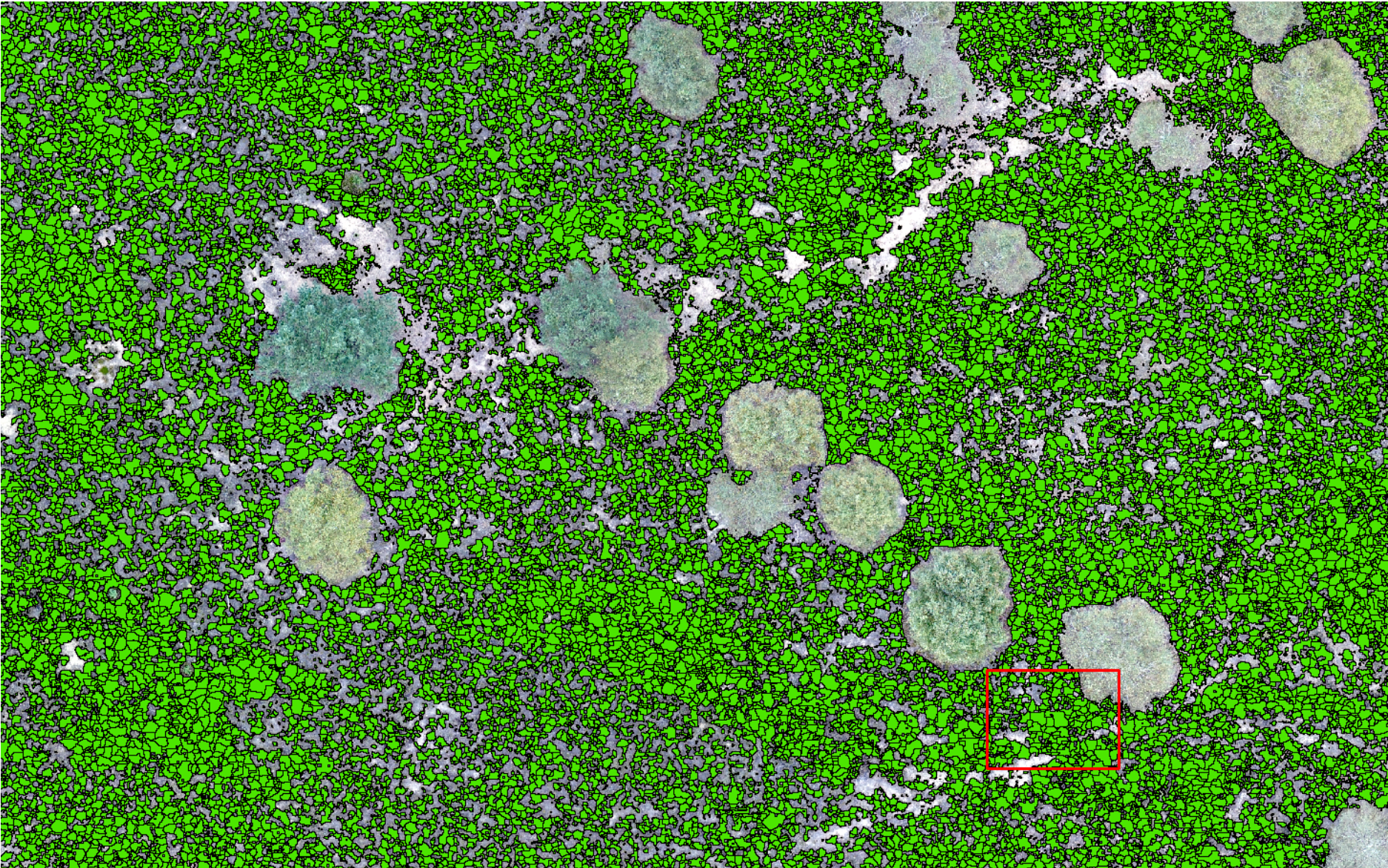


1. nDSM
2. Pheno-Proportions
3. Classification
4. Segmentation
5. Elimination

5. Extract individual plant units

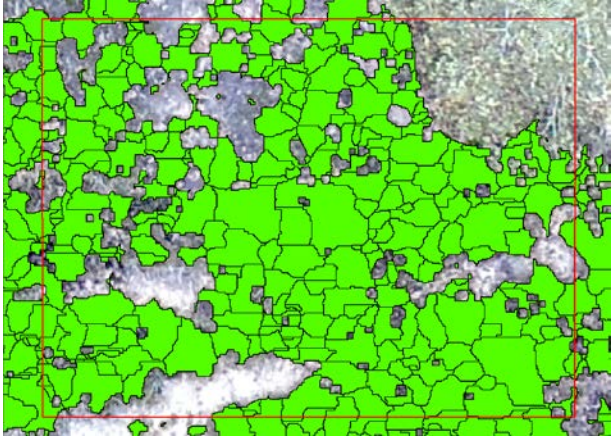


5. Extract individual plant units



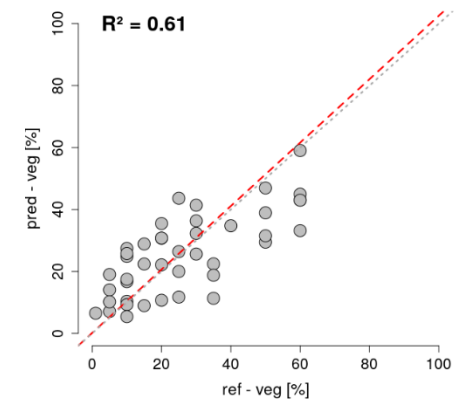
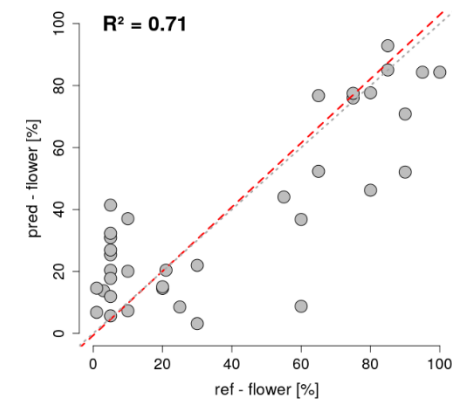
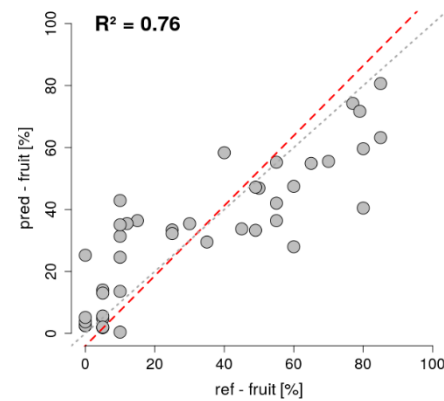
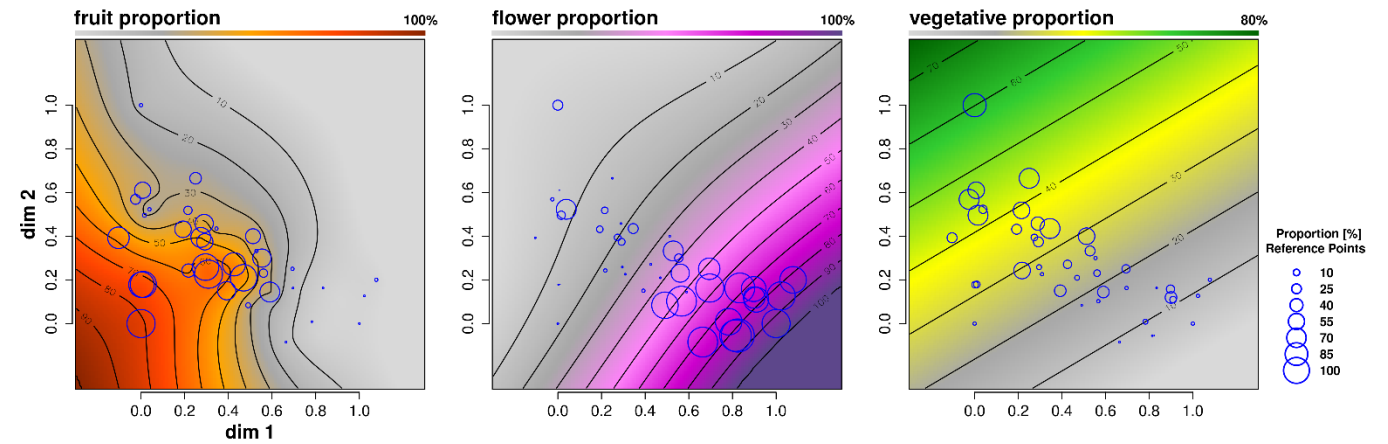
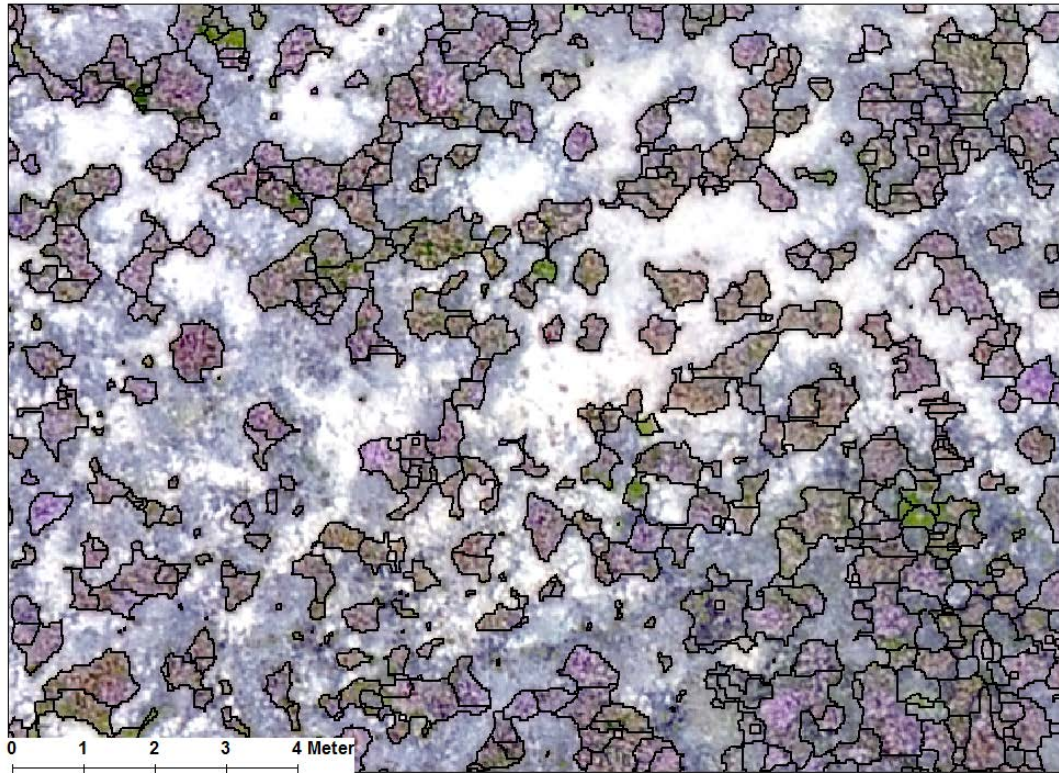
83.120 m²

356,131 plant units

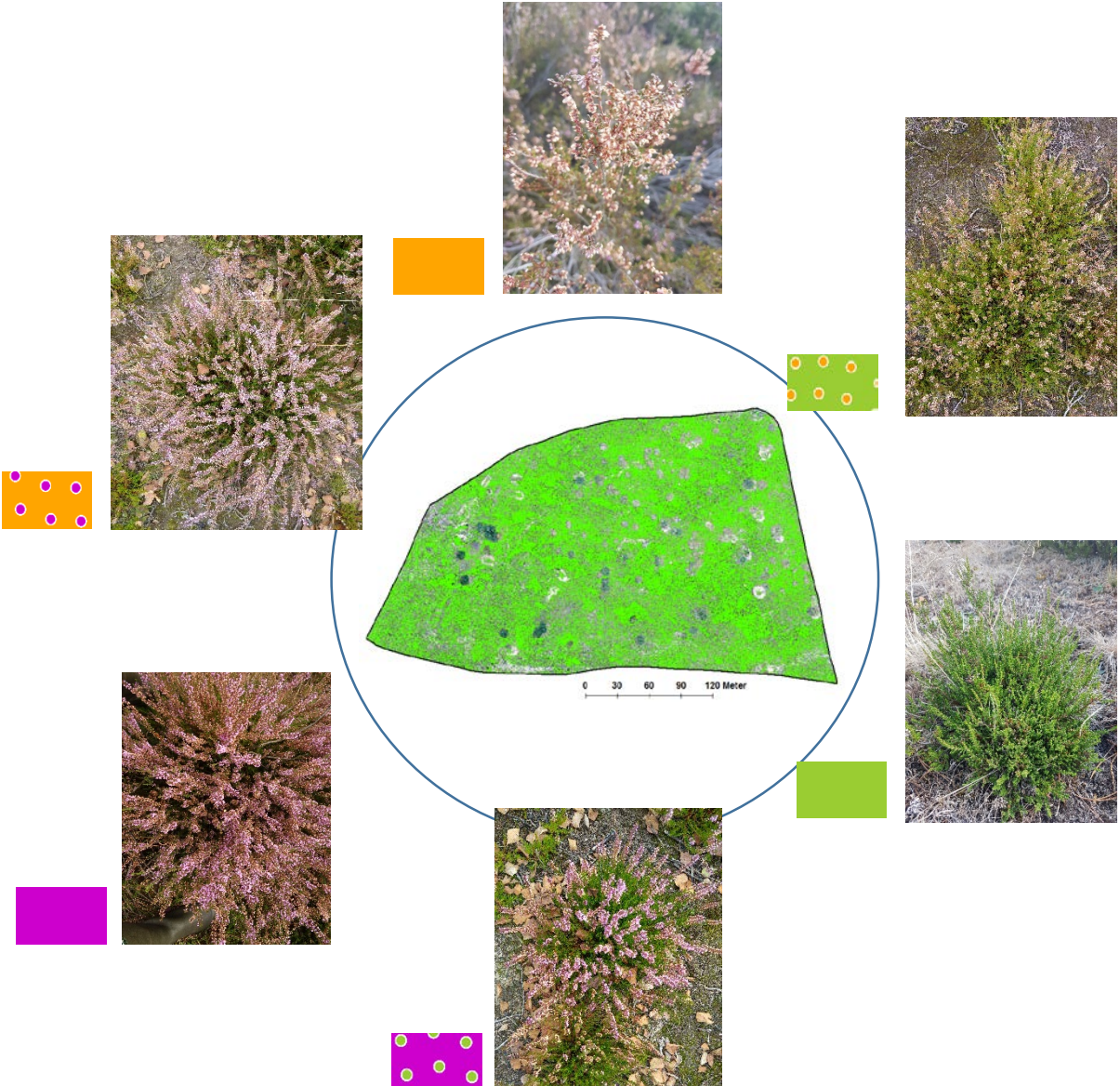
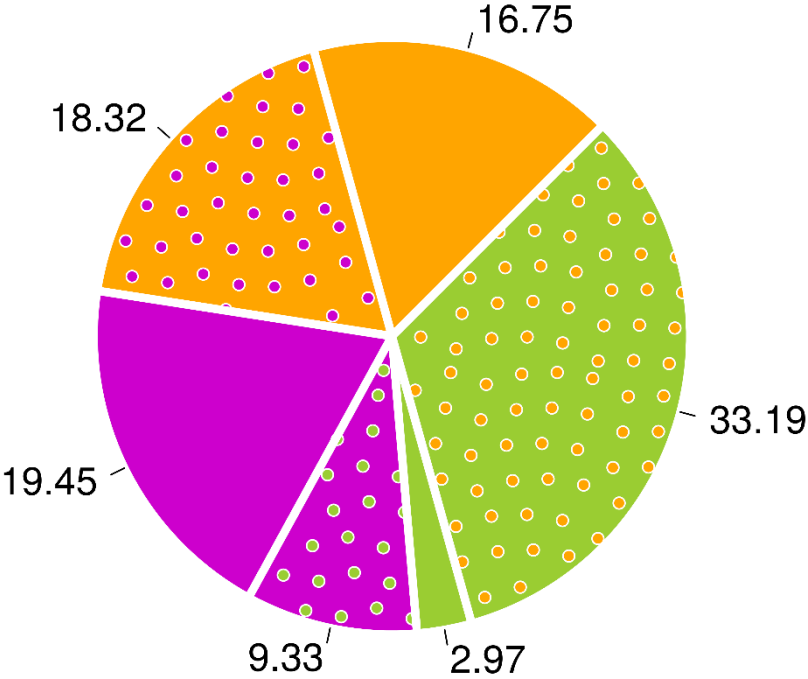


5. Extract individual plant units

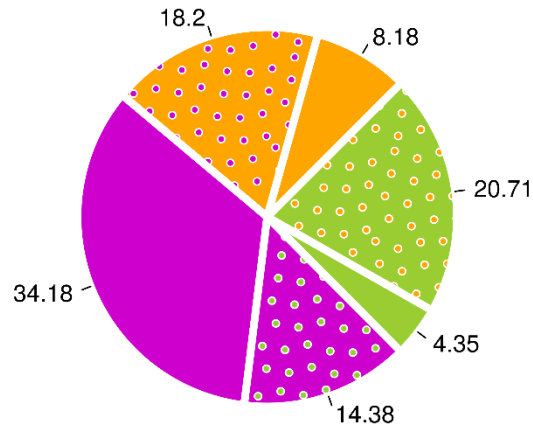
terrestrial validation on the basis of plant units



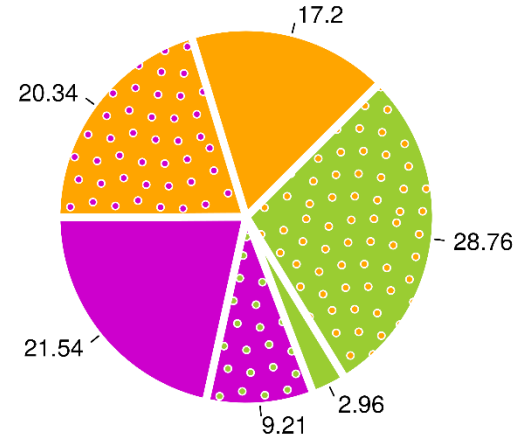
Phenophase Variability



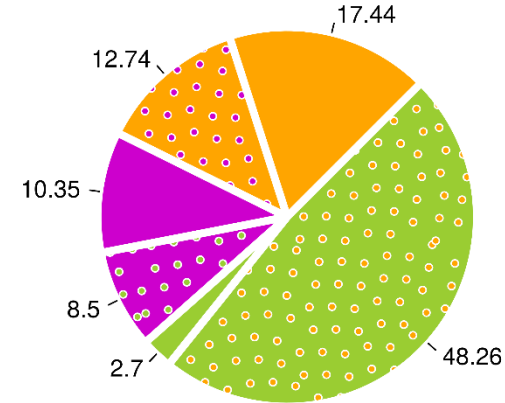
Plant Height < 10cm



Plant Height < 10cm >=35cm



Plant Height > 35cm



Pure (mainly) flowering phases: 60.56/59.08/40.53

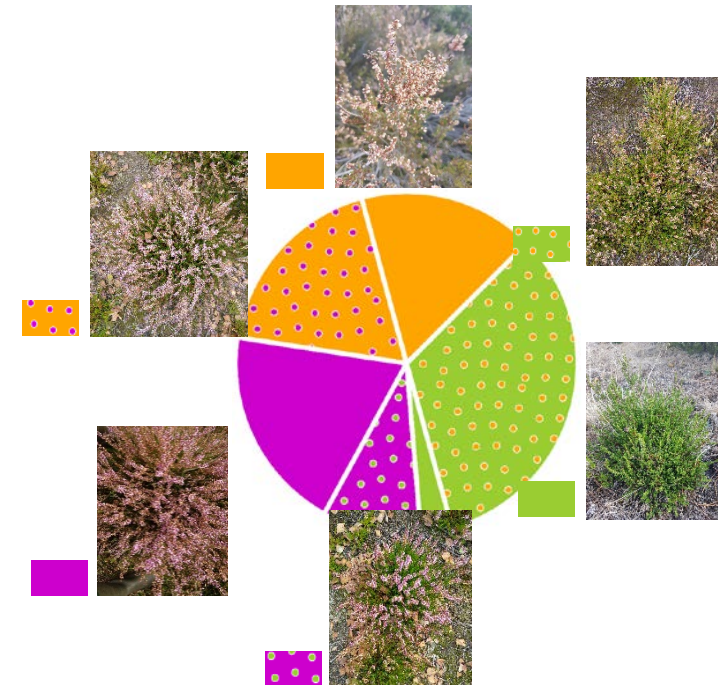
Phenological phase shifts visible!

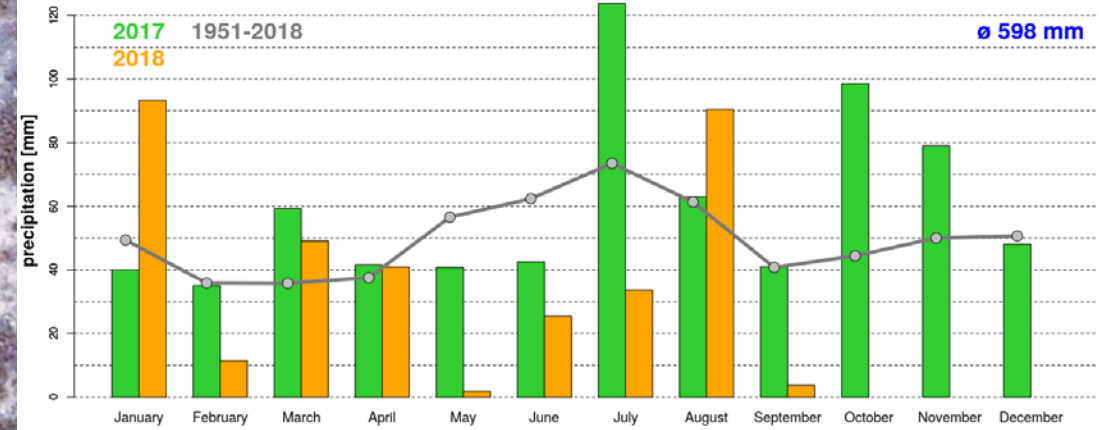
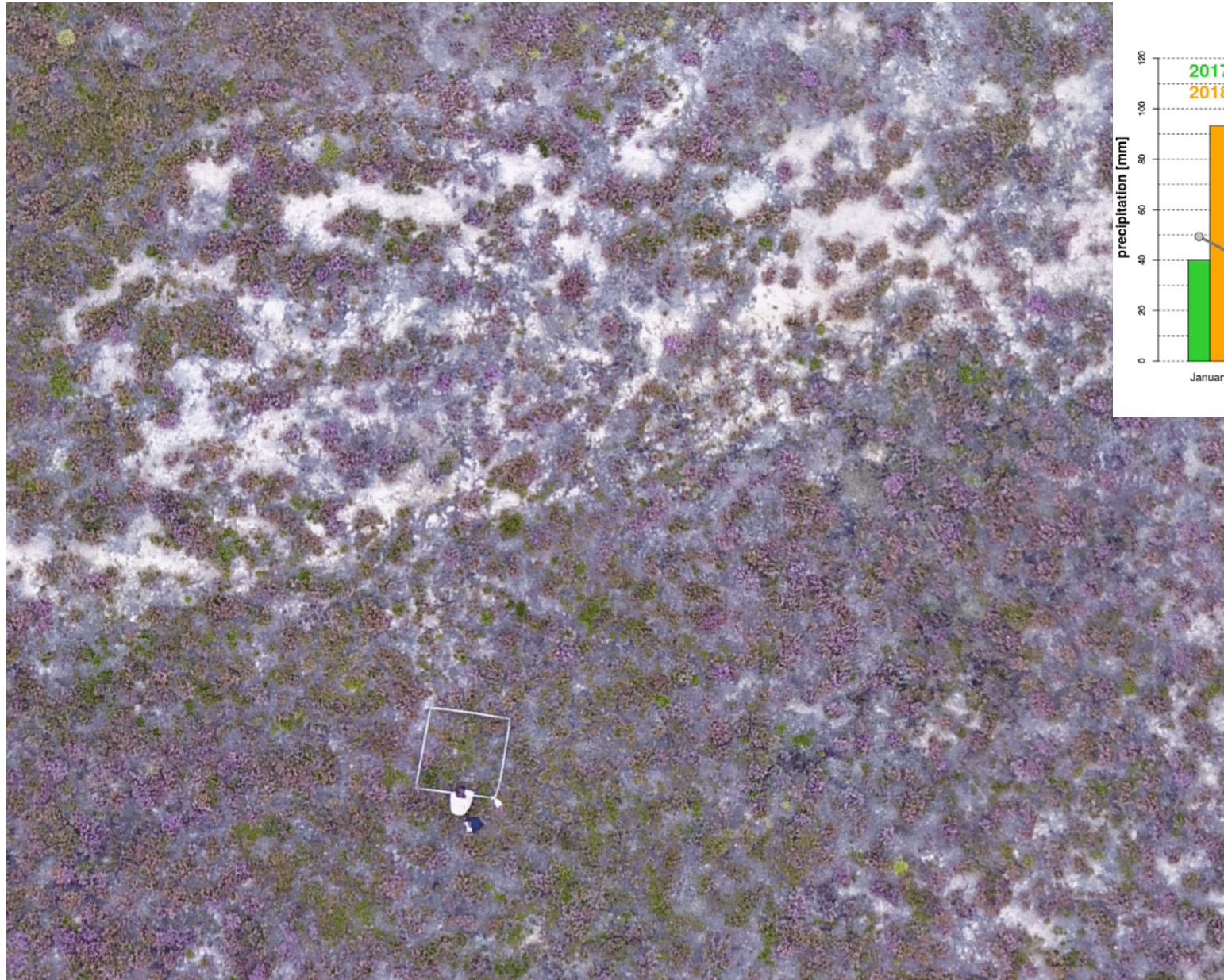
Age trends visible!

Exceptions are detectable (young green plants) -> anomalies!

Observe phenological behavior of single plants over years!

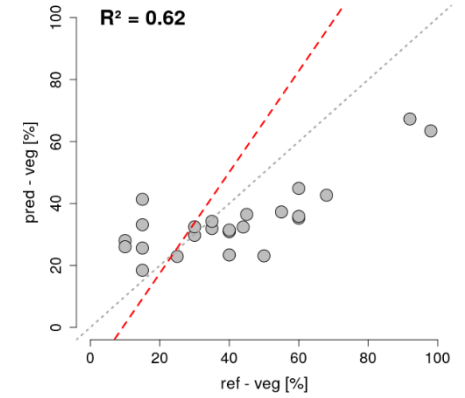
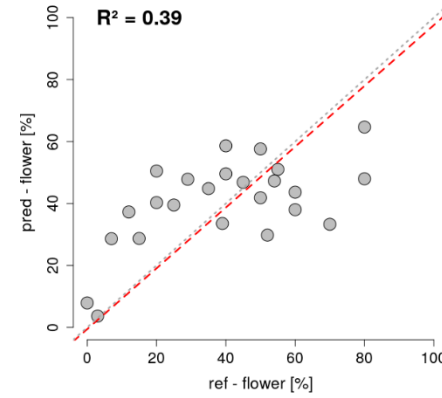
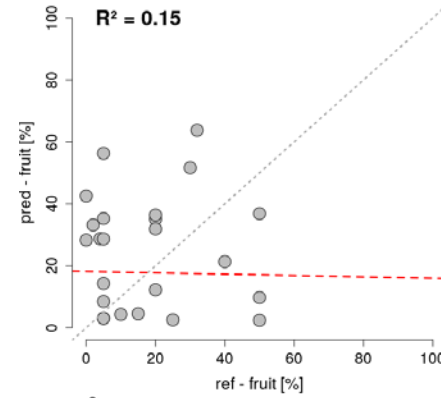
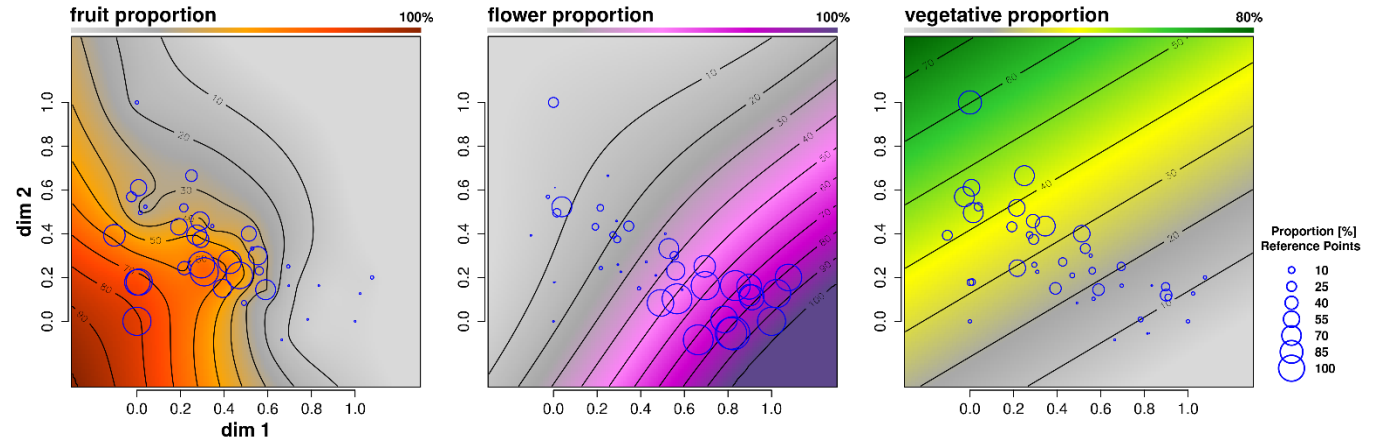
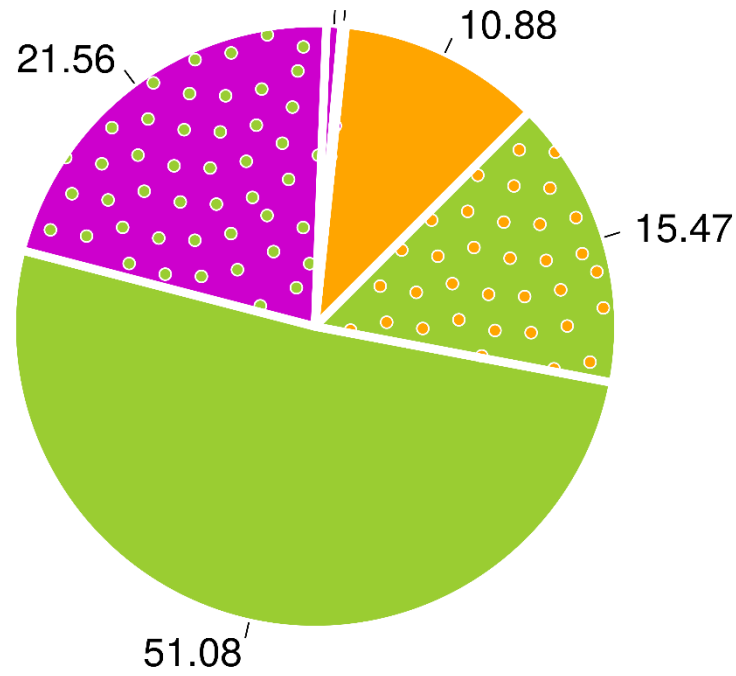
Why there are plants that do not flower under good conditions...why there are plants that flower under bad conditions?



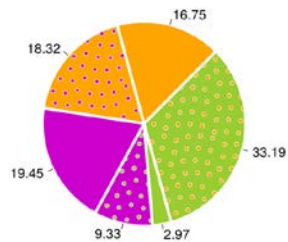


Observe anomalies....there are flowers!

Phenophase Variability 2018



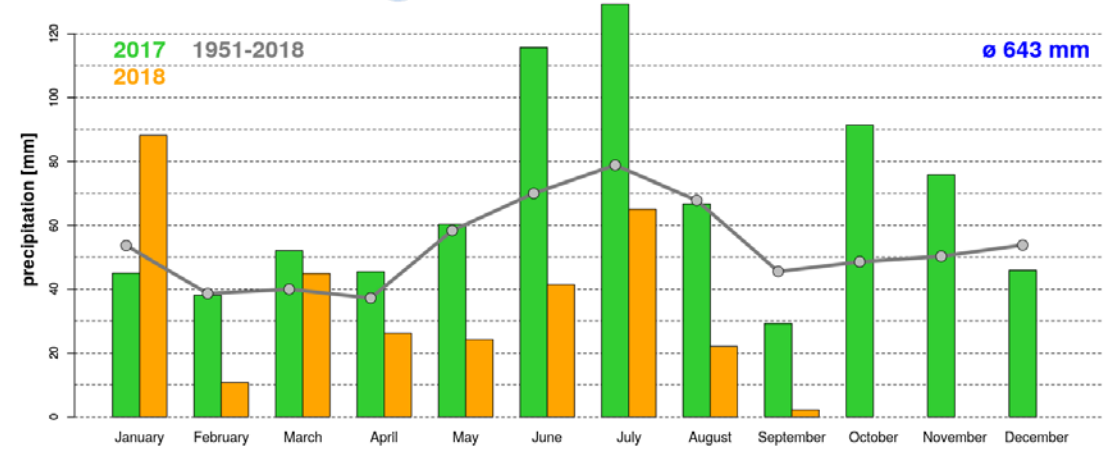
There are flowers, however the flowering intensity is decreased!



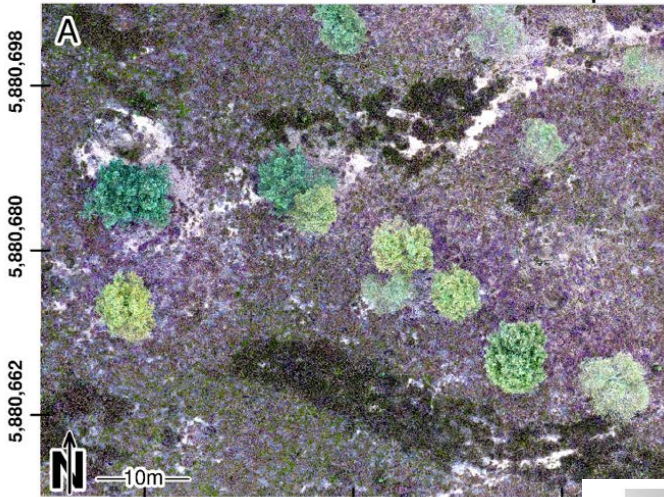
Pattern Comparison

a) climate/weather

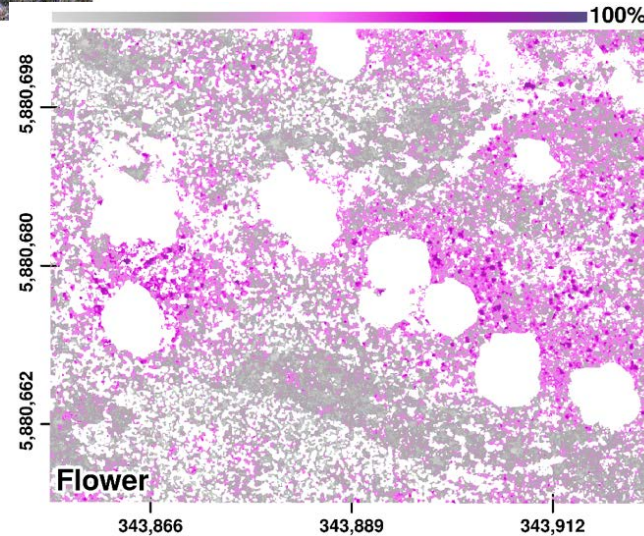
Heathland Tangersdorf



RGB-Composite

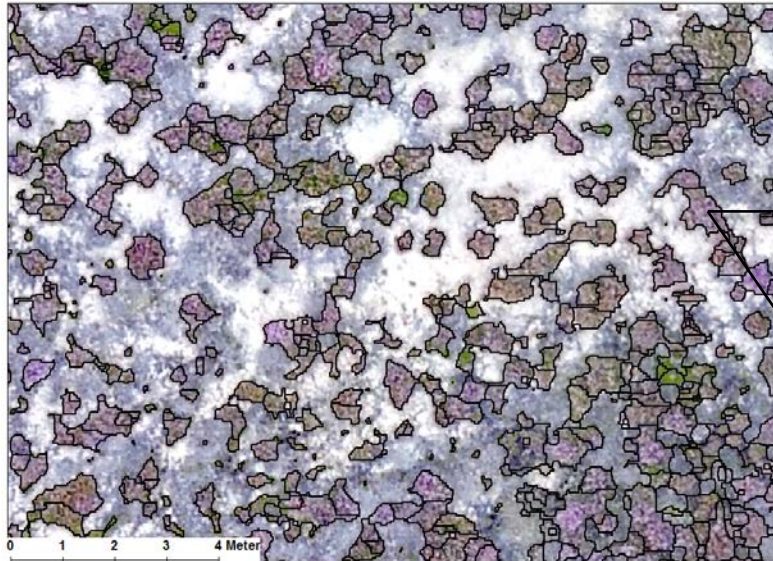


b) spatial interdependencies



Pattern Comparison

- d) temporal processes
- e) individual behavior



c) habitat management





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Thank you for your Attention!

