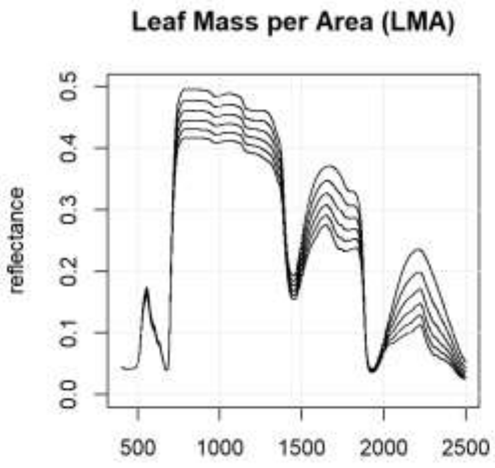
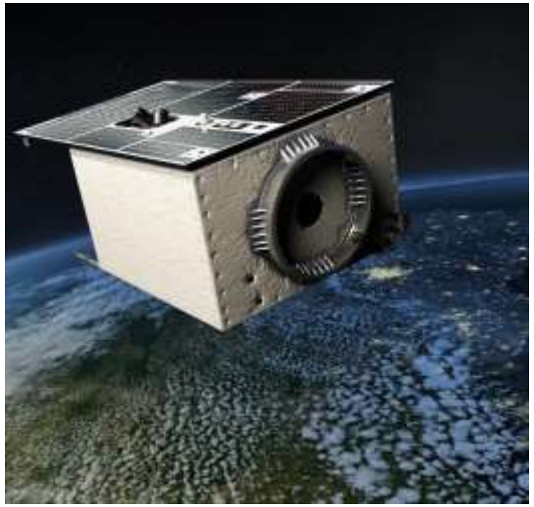
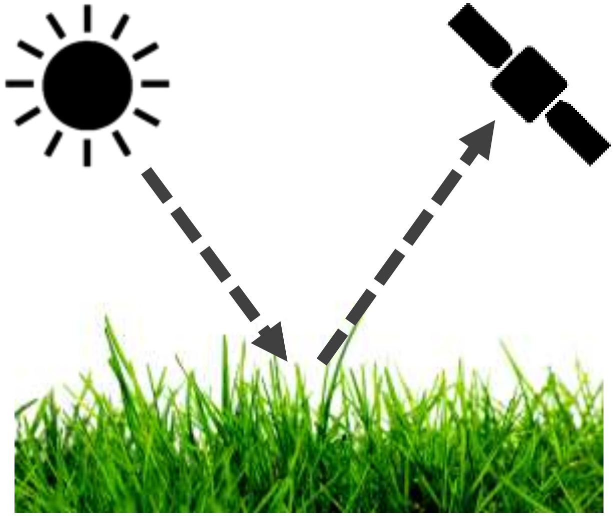
How are spectrally relevant plant traits distributed across plant functional gradients?

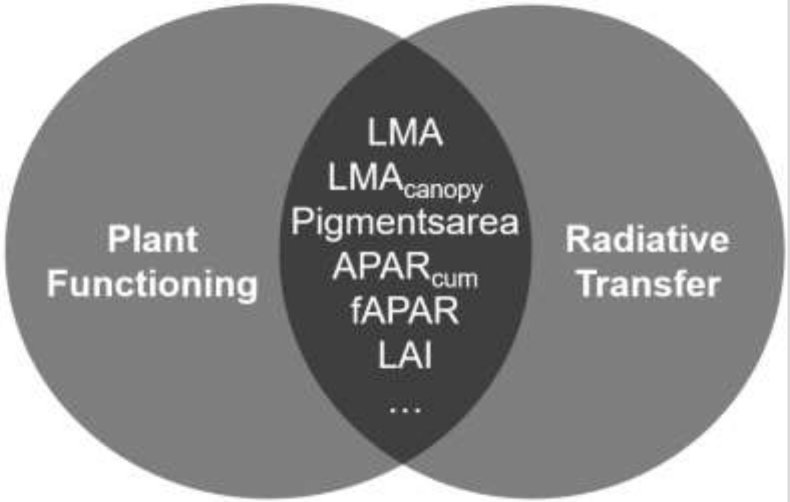
Teja Kattenborn & Sebastian Schmidlein

Institute for Geography and Geoecology (ifgg)



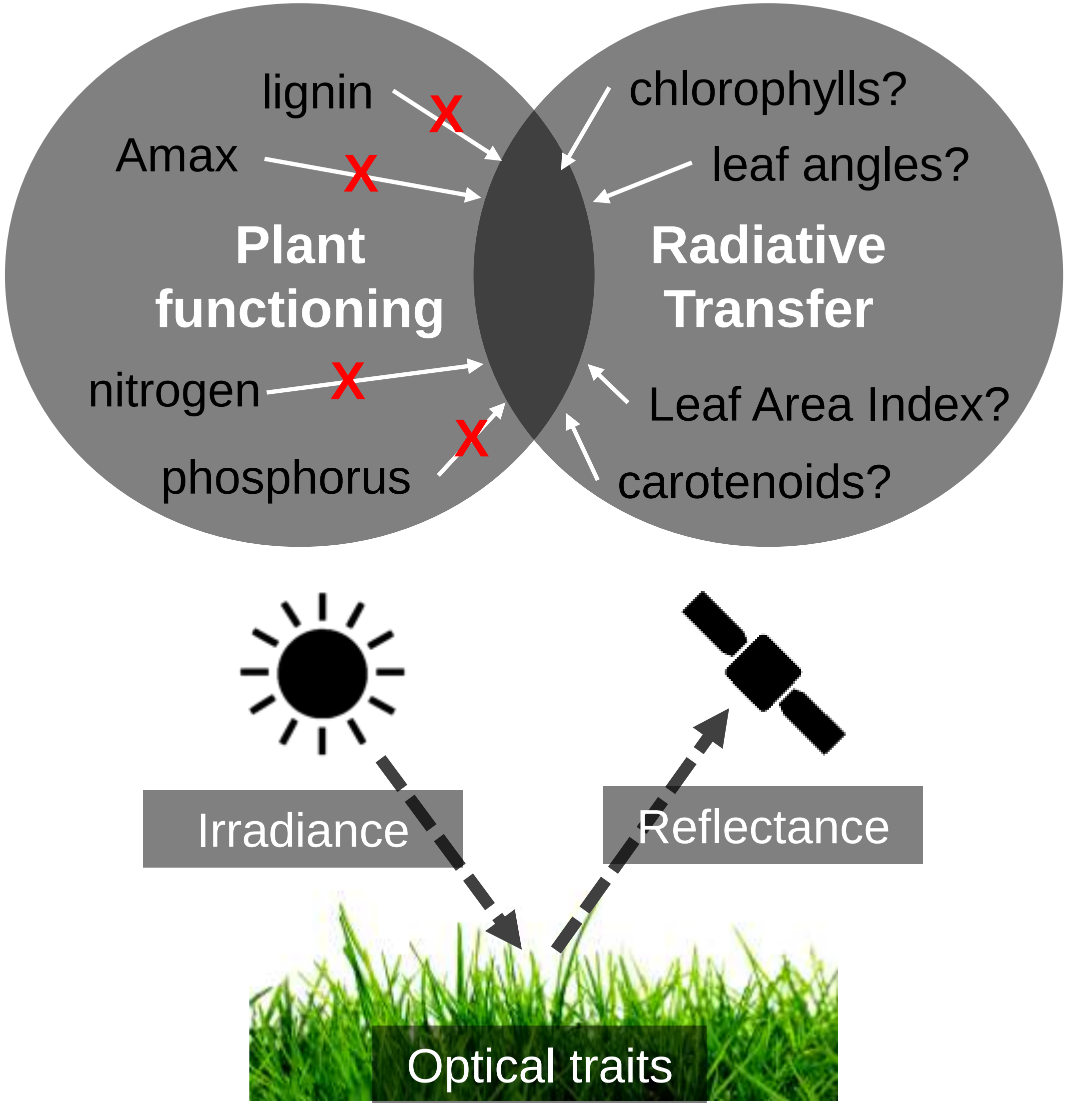






Rationale

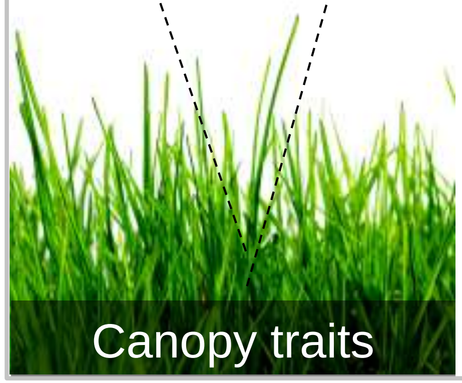
- Global picture of plant functioning still remains incomplete, remote sensing as a high potential to close this gap.
- The most frequently assessed functional traits have no explicit relation to radiative transfer!
  → limited causality and transferability!
- ‘optical traits’ have not yet been systematically linked to functioning.



Methods

OPTICAL TRAITS

- Chlorophyll content (Cab_{area})
- Carotenid content (Car_{area})
- Anthocyanin content (Ant_{area})
- Chlorphyll concentration (Cab_{mass})
- Carotenid concentration (Car_{mass})
- Anthocyanin concentration (Ant_{mass})
- Leaf mass per area (LMA)
- Leaf water content (EWT)
- Leaf dry matter content (LDMC)
- Mesophyll thickness (N)



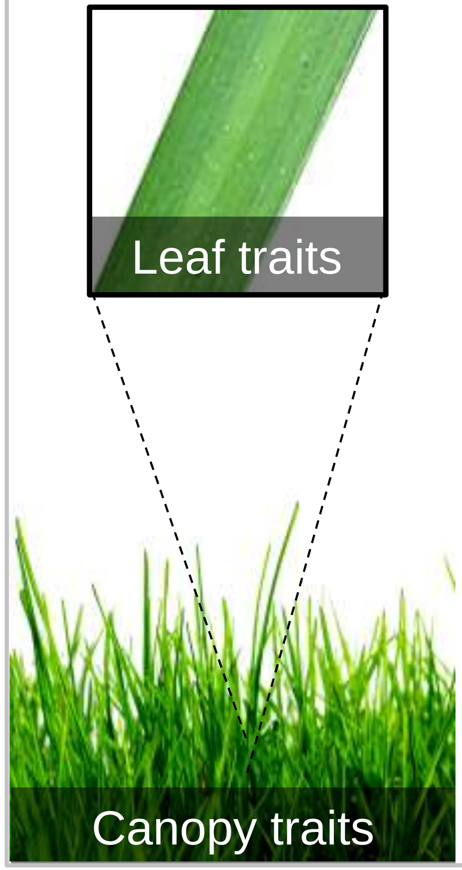
- Leaf angle distributio (ALA)
- Leaf Area Index (LAI)
- Fraction of absorbed PAR (fAPAR)
- Yearly accumulated PAR (APARcum)
- Foliage mass (LMA_{canopy} = LAI*LMA)

TRAIT MEASUREMENTS

- 42 Cultivated species (outdoor)
- grasses & herbs
- 30 * 30 cm pots, 4 repitions
- Median of weekly retrieved traits

Methods

OPTICAL TRAITS



- Chlorophyll content (Cab_{area})
- Carotenid content (Car_{area})
- Anthocyanin content (Ant_{area})
- Chlorophyll concentration (Cab_{mass})
- Carotenid concentration (Car_{mass})
- Anthocyanin concentration (Ant_{mass})
- Leaf mass per area (LMA)
- Leaf water content (EWT)
- Leaf dry matter content (LDMC)
- Mesophyll thickness (N)

- Average Leaf angle (ALA)
- Leaf Area Index (LAI)
- Fraction of absorbed PAR (fAPAR)
- Yearly accumulated PAR (APARcum)
- Foliage mass (LMA_{canopy} = LAI*LMA)

FUNCTIONAL GRADIENTS

Leaf Economic Spectrum

Slender leaves, fast growth quick returns → **Resource investments** → *Robust leaves, slow growth, slow returns*

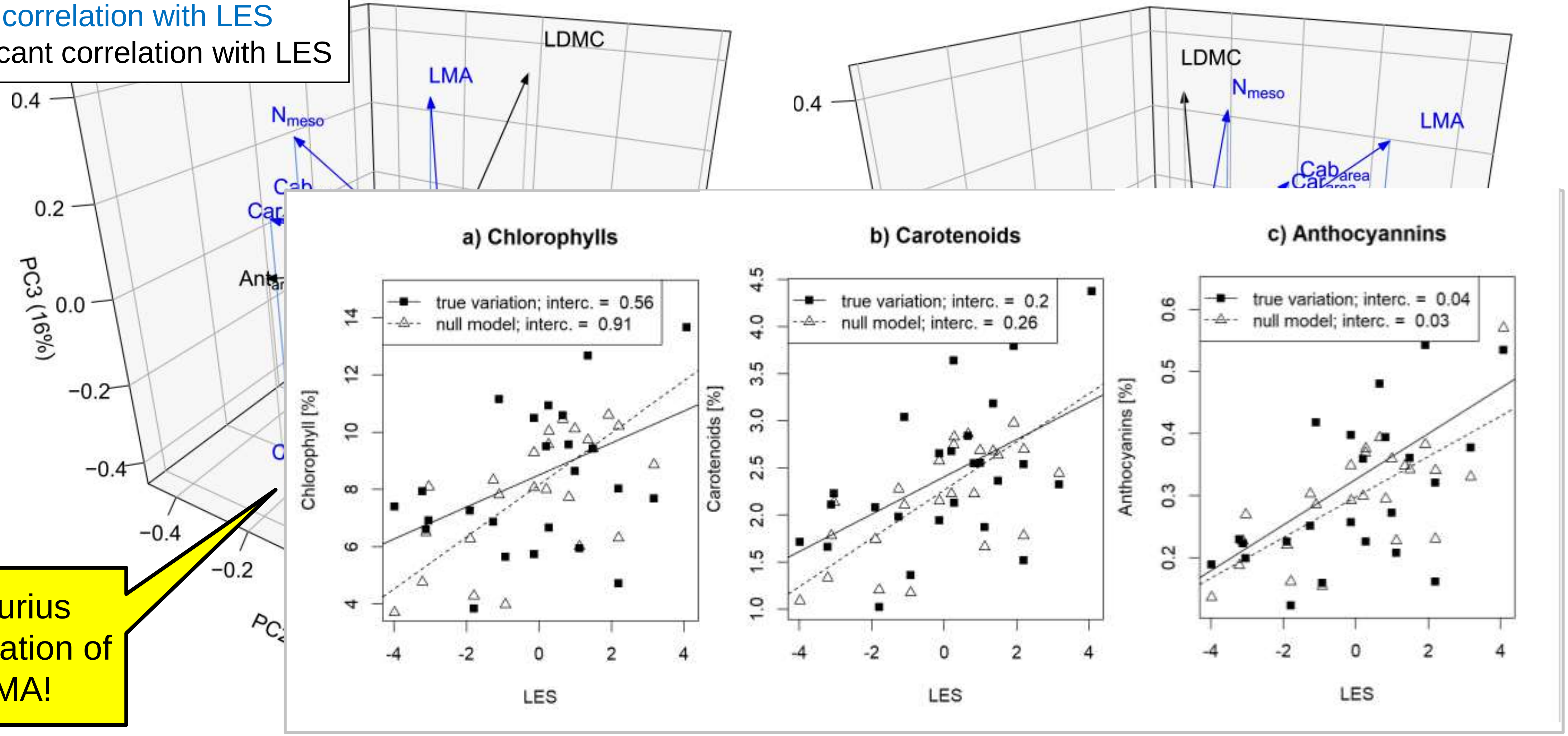
Wright et al. 2004

CSR plant strategies

Grime 1997

Results – Optical traits vs Leaf Economic Spectrum

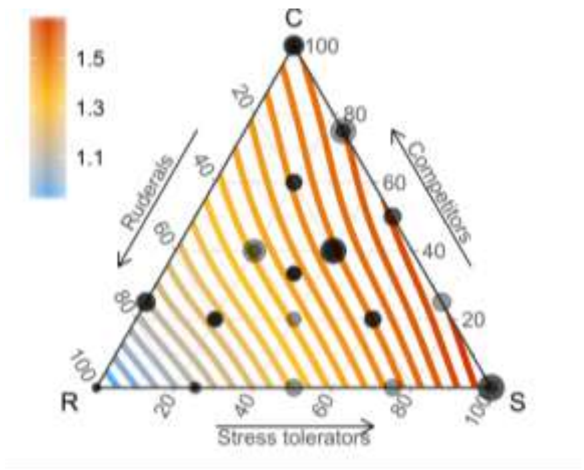
Leaf Economic Spectrum (LES)
Significant correlation with LES
Non significant correlation with LES



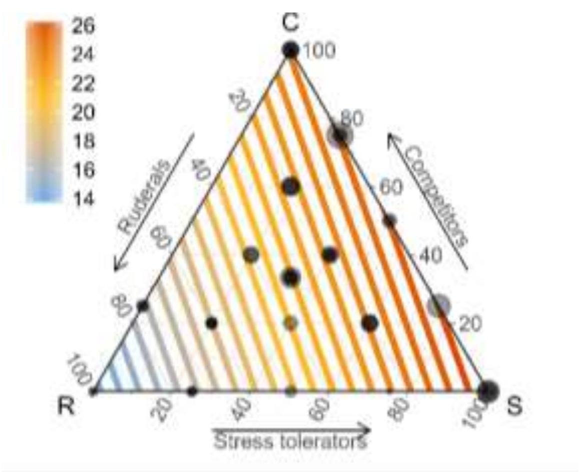
Spurius correlation of LMA!

Results – Optical traits vs CSR plant strategies

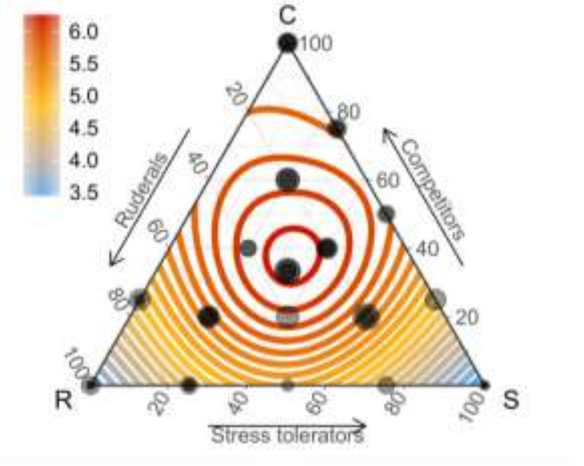
logLMA [g/cm²], R^2adj 0.42



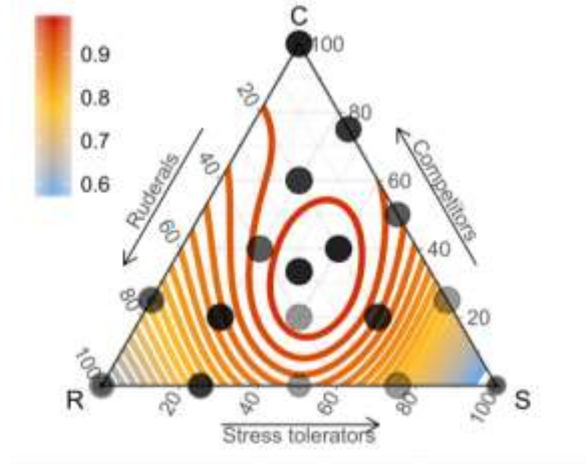
LDMC [%], R^2adj 0.43



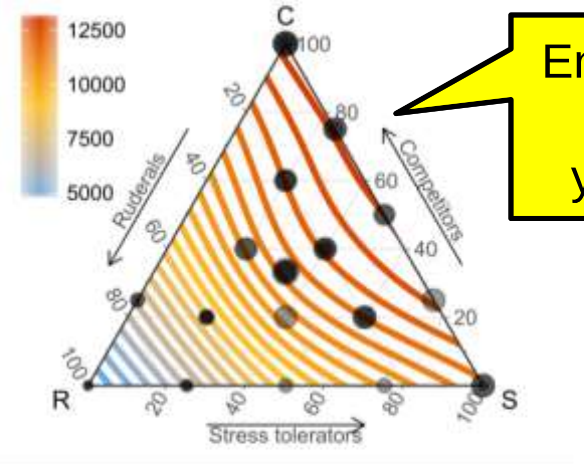
LAI [m²/m²], R^2adj 0.36



fAPAR [%], R^2adj 0.4

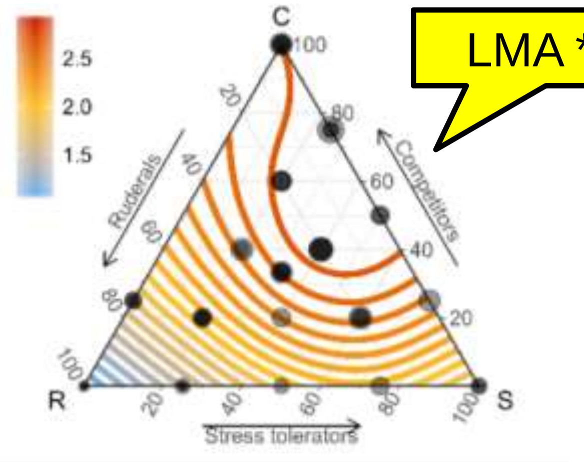


$APAR_{cum}$ [kWh/m²], R^2adj 0.57



Energy per year

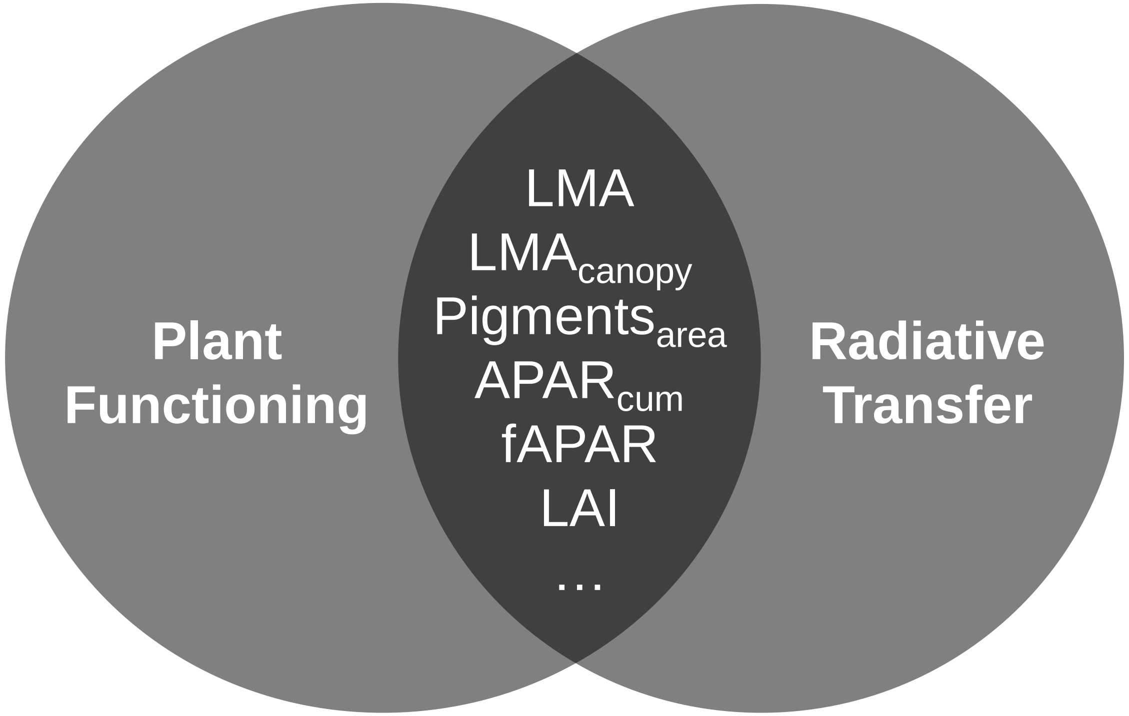
LMA_{canopy} [g/m²]. R^2adj 0.43



LMA * LAI

Conclusions & Outlook

- Pigments should be quantified as content [µg/cm²] and not as concentration [%]!
- Only leaf traits correspond to the Leaf Economic spectrum (LES). Canopy traits do not correspond to the LES but strongly to CSR plant strategies
- Optical traits are a promising complement or complement to ‘traditional’ traits used in trait-based ecology!
- Causal links between optical traits and plant functioning implies that ‘*Reflectance follows function*’!



Thank you for your attention!

More information on this topic?

Teja Kattenborn
teja.kattenborn@kit.edu

Journal of Vegetation Science (2017)

Linking plant strategies and plant traits derived by radiative transfer modelling

Teja Kattenborn, Fabian Ewald Fassnacht, Simon Pierce, Javier Lopatin, John Philip Grime & Sebastian Schmidtlein

Remote Sensing in Ecology and Conservation — Open Access — ZSL LET'S WORK FOR WILDLIFE

ORIGINAL RESEARCH

Differentiating plant functional types using reflectance: which traits make the difference?

Teja Kattenborn, Fabian Ewald Fassnacht & Sebastian Schmidtlein

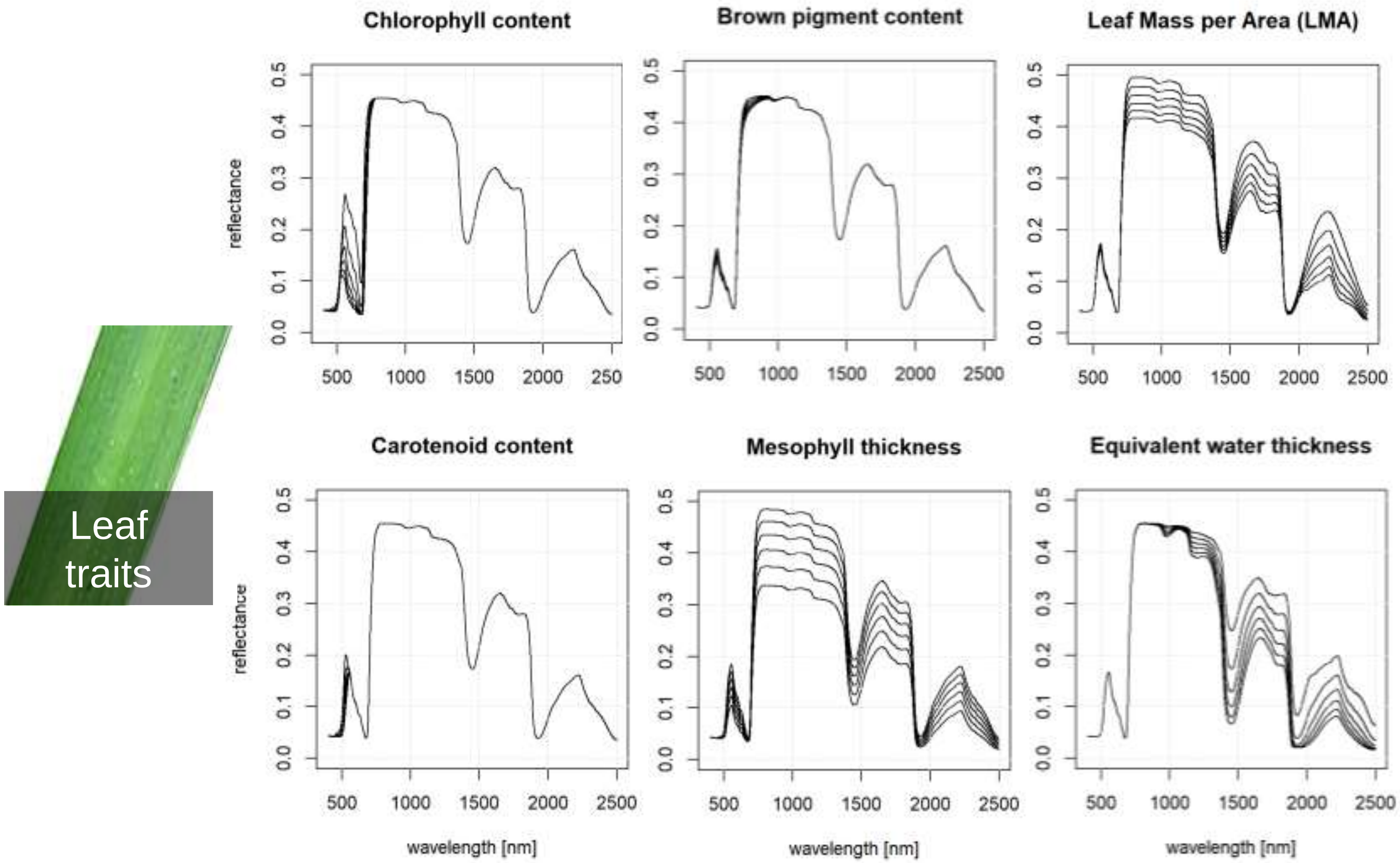
Institute of Geography and Geoecology (IFGG), Karlsruhe Institute of Technology (KIT), Kaiserstr. 12, 76131 Karlsruhe, Germany

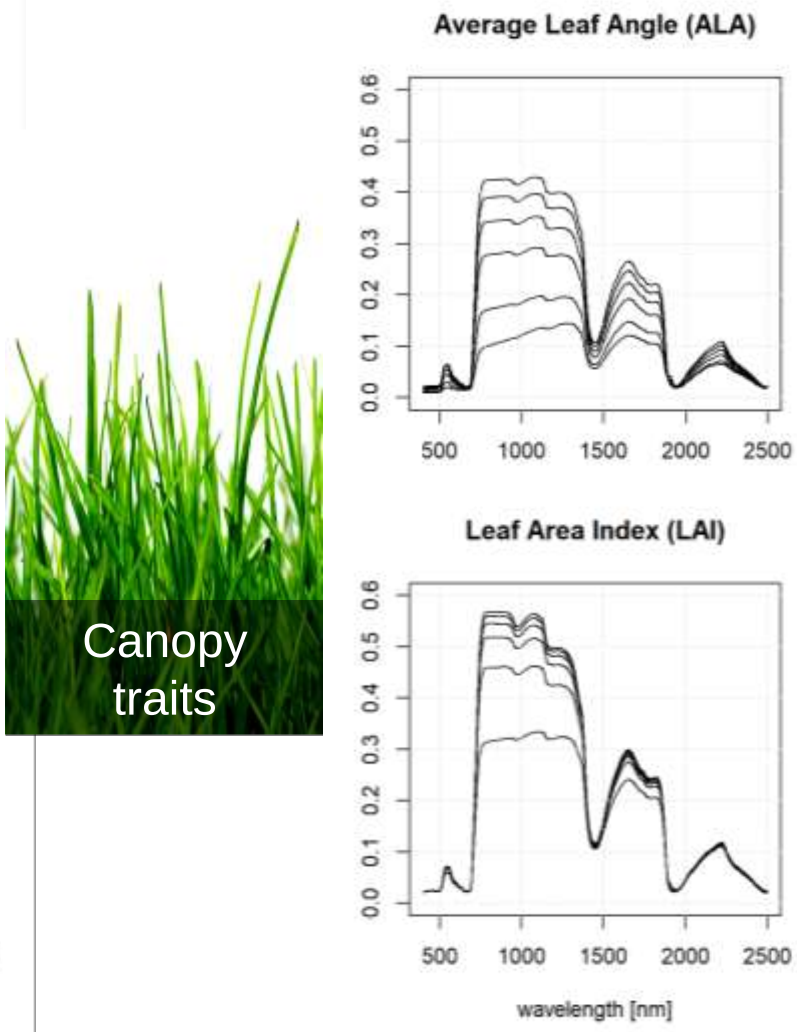
nature plants — LETTERS
https://doi.org/10.1038/s41477-018-0189-7

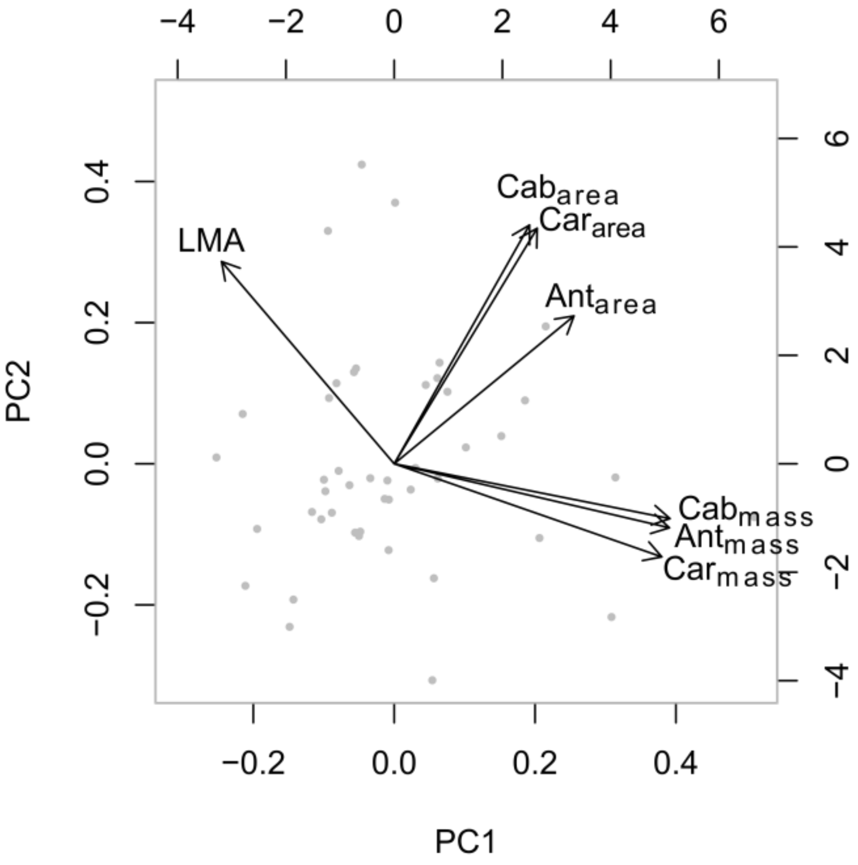
Previsual symptoms of *Xylella fastidiosa* infection revealed in spectral plant-trait alterations

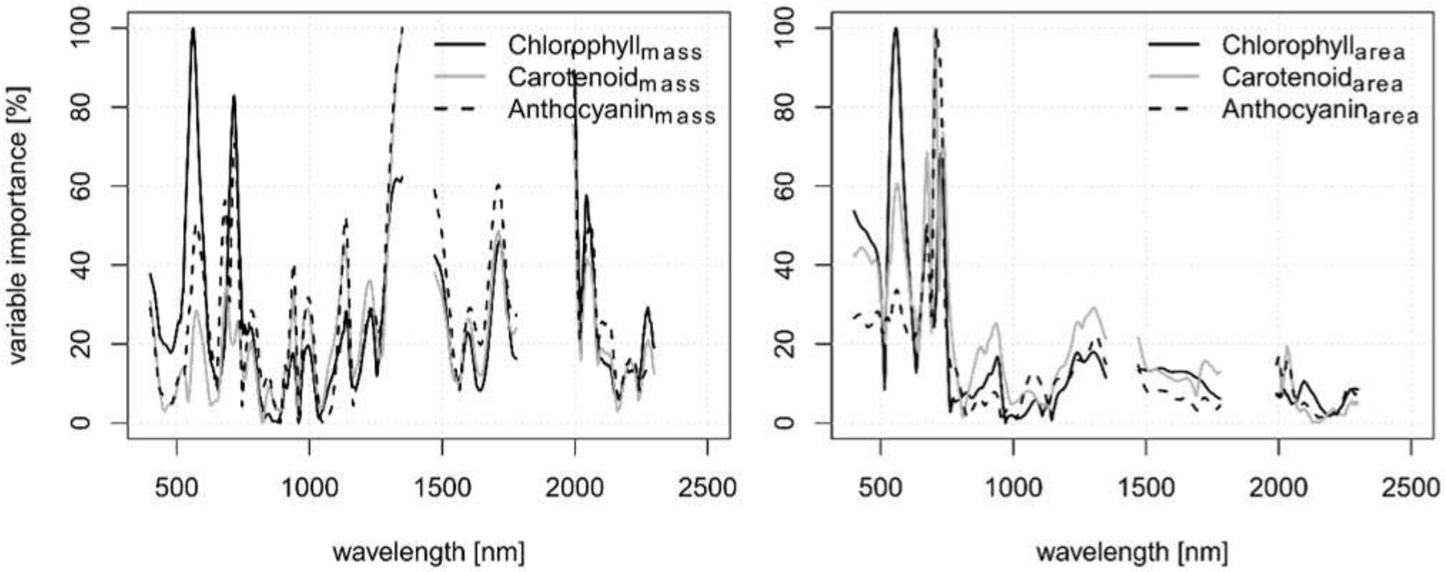
P. J. Zarco-Tejada[1*], C. Camino[2], P. S. A. Beck[1], R. Calderon[2], A. Hornero[2,3], R. Hernández-Clemente[3], T. Kattenborn[4], M. Montes-Borrego[2], L. Susca[5], M. Morelli[6], V. Gonzalez-Dugo[2], P. R. J. North[3], B. B. Landa[2], D. Boscia[6], M. Saponari[6] and J. A. Navas-Cortes[2]

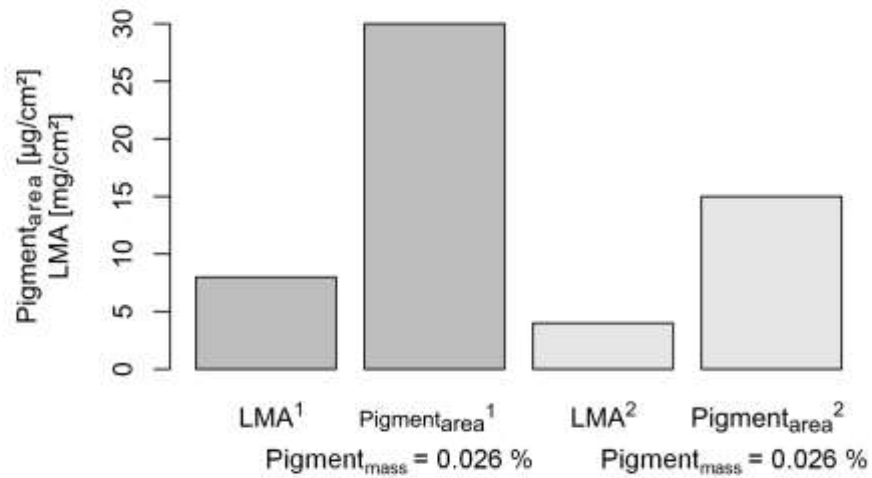
Rationale – `optical traits´ (PROSAIL radiative transfer model)






LMA
Cab$_{area}$
Car$_{area}$
Ant$_{area}$
Cab$_{mass}$
Ant$_{mass}$
Car$_{mass}$
PC1
PC2


Chlorophyll$_{mass}$
Carotenoid$_{mass}$
Anthocyanin$_{mass}$
Chlorophyll$_{area}$
Carotenoid$_{area}$
Anthocyanin$_{area}$
variable importance [%]
wavelength [nm]


Pigment$_{area}$ [µg/cm²]
LMA [mg/cm²]
LMA^1
Pigment$_{area}$^{1}
LMA^2
Pigment$_{area}$^{2}
Pigment$_{mass}$ = 0.026 %
Pigment$_{mass}$ = 0.026 %

Rationale

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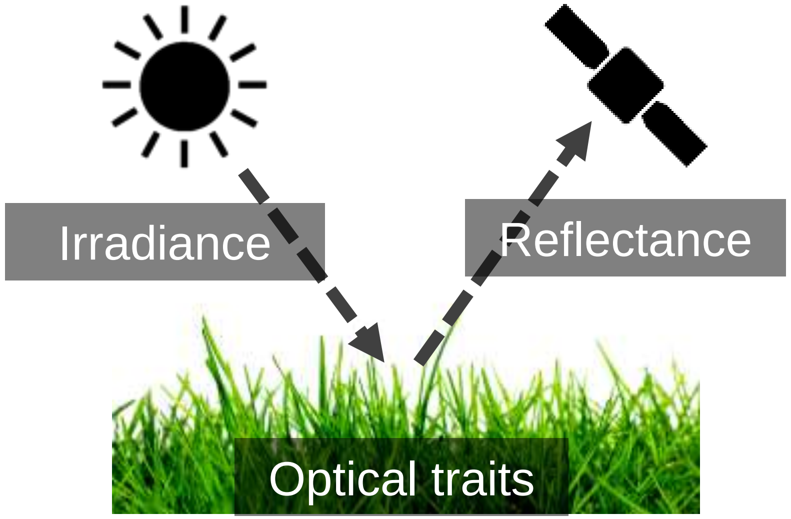
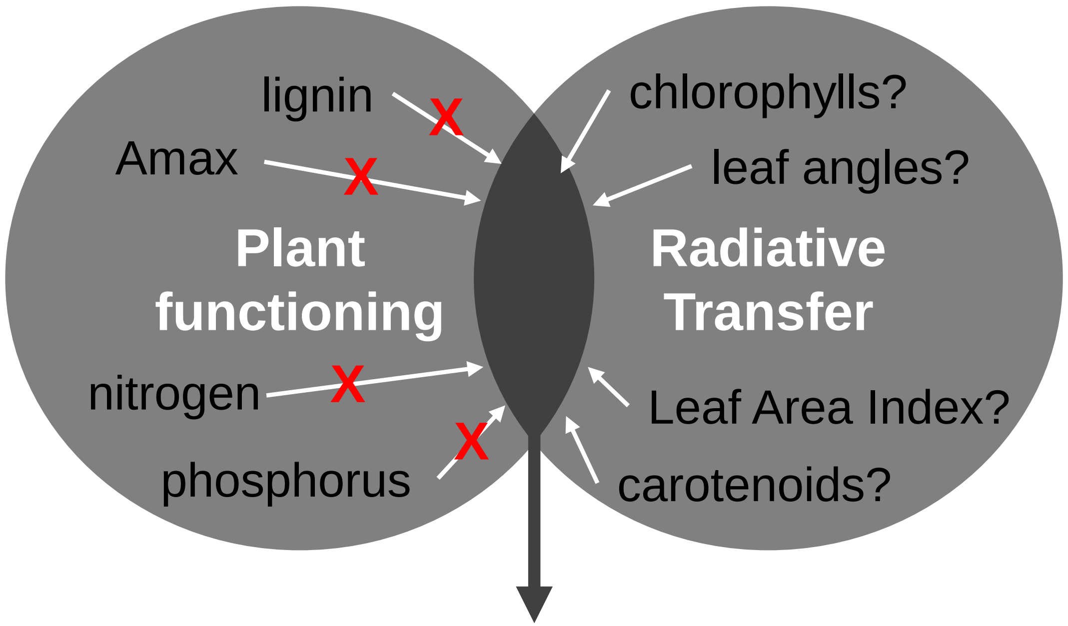
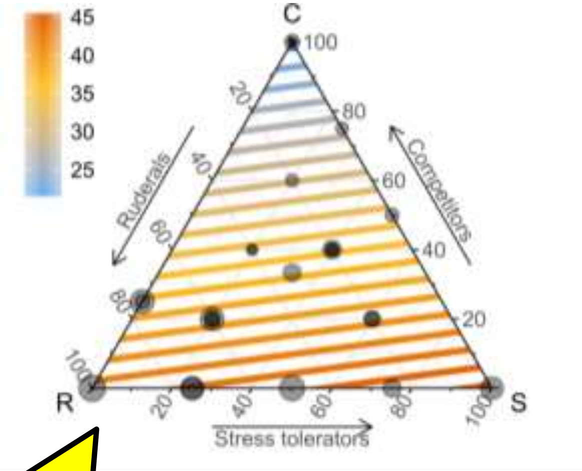




- Why can we separate plant functional gradients?
- How can we improve sensors and algorithms to differentiate plant functioning
- Can optical traits increase our understanding of plant functioning?

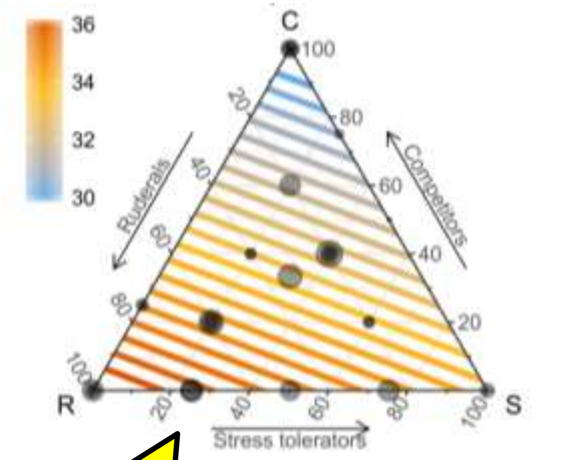
Results – Optical traits vs CSR plant strategies

ALA [°], R²adj 0.27



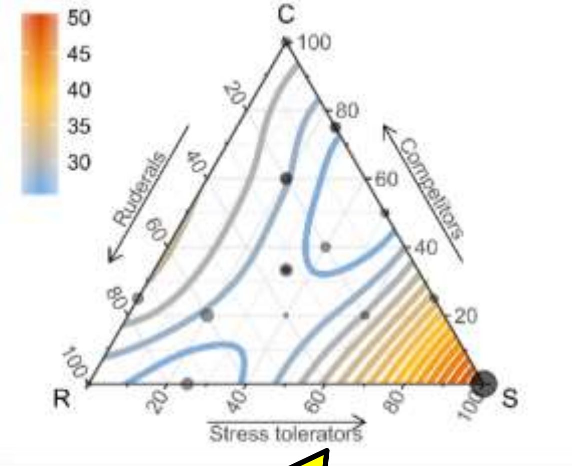
Forbs only

Cab_{area}[µg/cm²], R²adj 0.29



Forbs only

Cab_{area}[µg/cm²], R²adj 0.52



Graminoids only