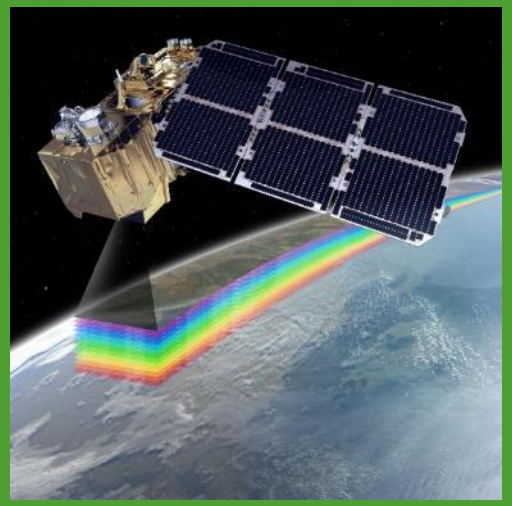

SLU
SCIENCE AND EDUCATION FOR SUSTAINABLE LIFE

Sensormätningar i vall
Sensor measurements for forages

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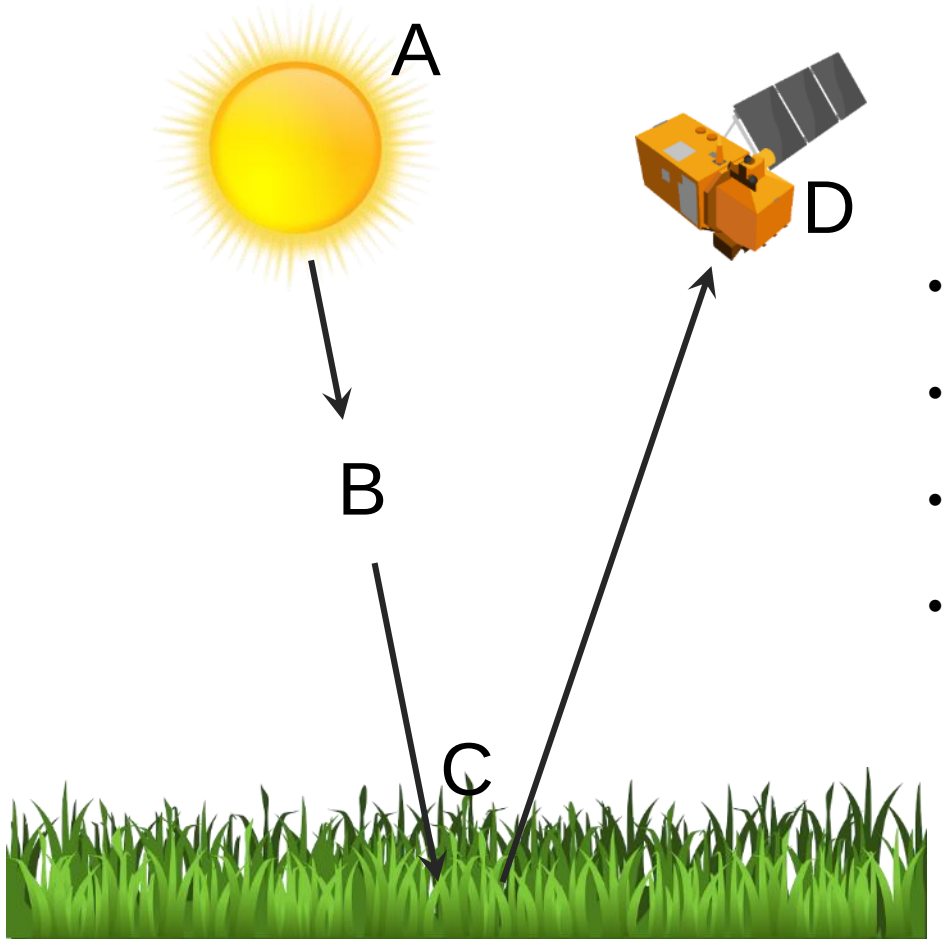
1. A very short introduction to remote sensing
2. Sensing in leys
   a) Field spectrometers
   b) Image analysis for clover content
   c) Satellites
3. Assessing variety trials

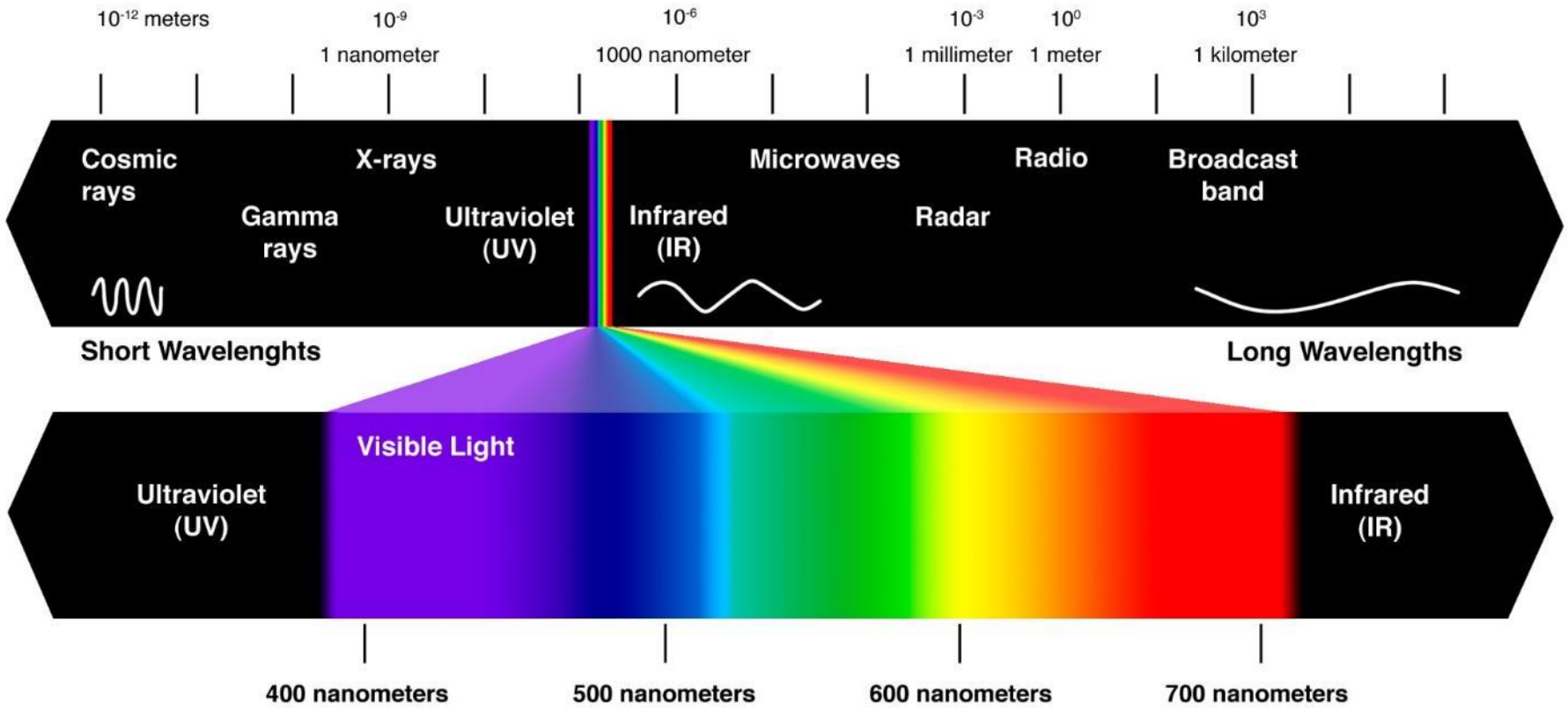
A very short introduction to remote sensing

1. Basics of remote sensing



- A: light source
- B: light – atmosphere interaction
- C: light – target interaction
- D: reflected light is recorded by a sensor

Light spectrum



Leaf spectrum

VIS

Visible

Pigment content

NIR

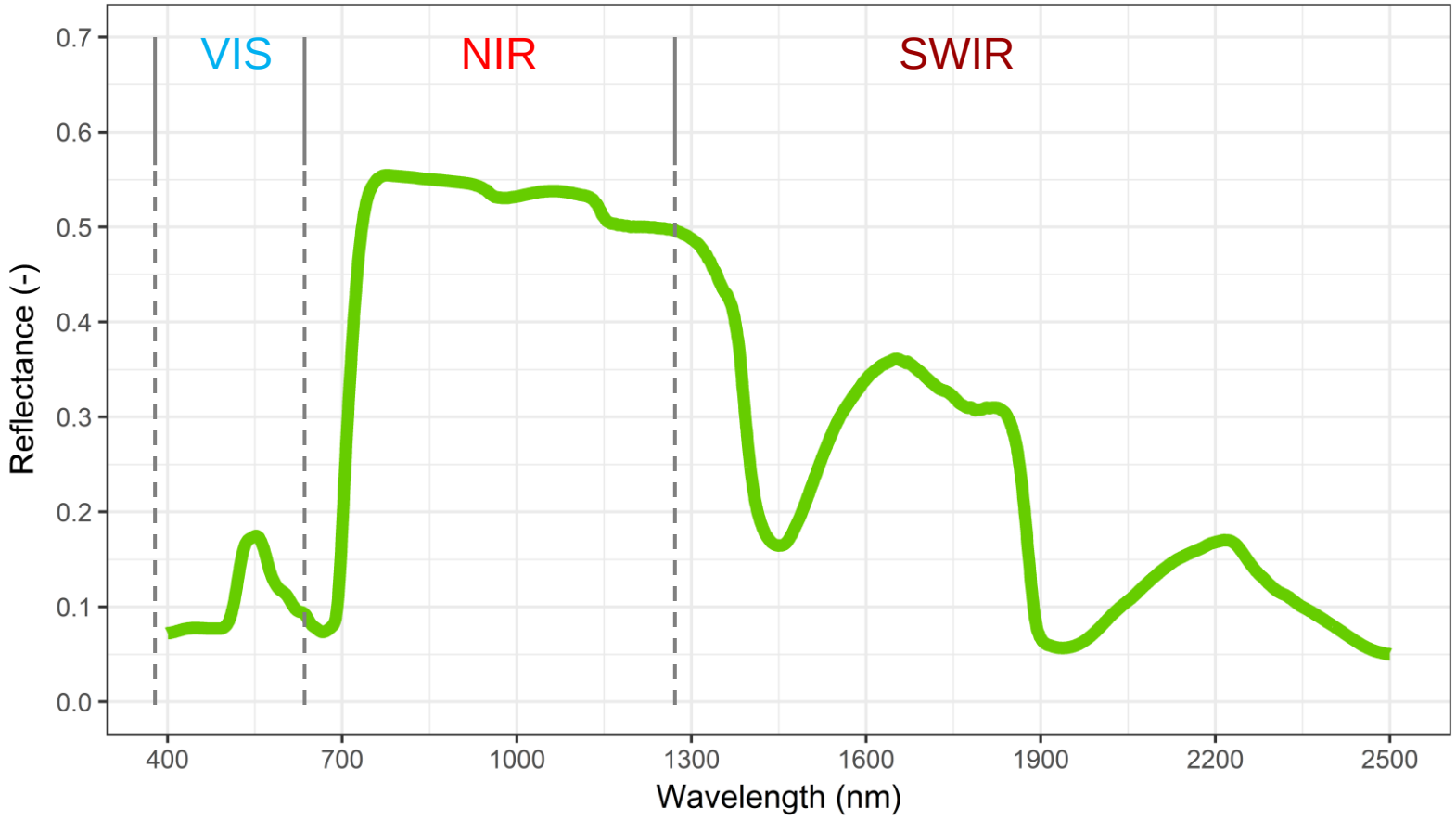
Near infrared

Structure of leaf/canopy

SWIR

Short-wave infrared

Water and protein content

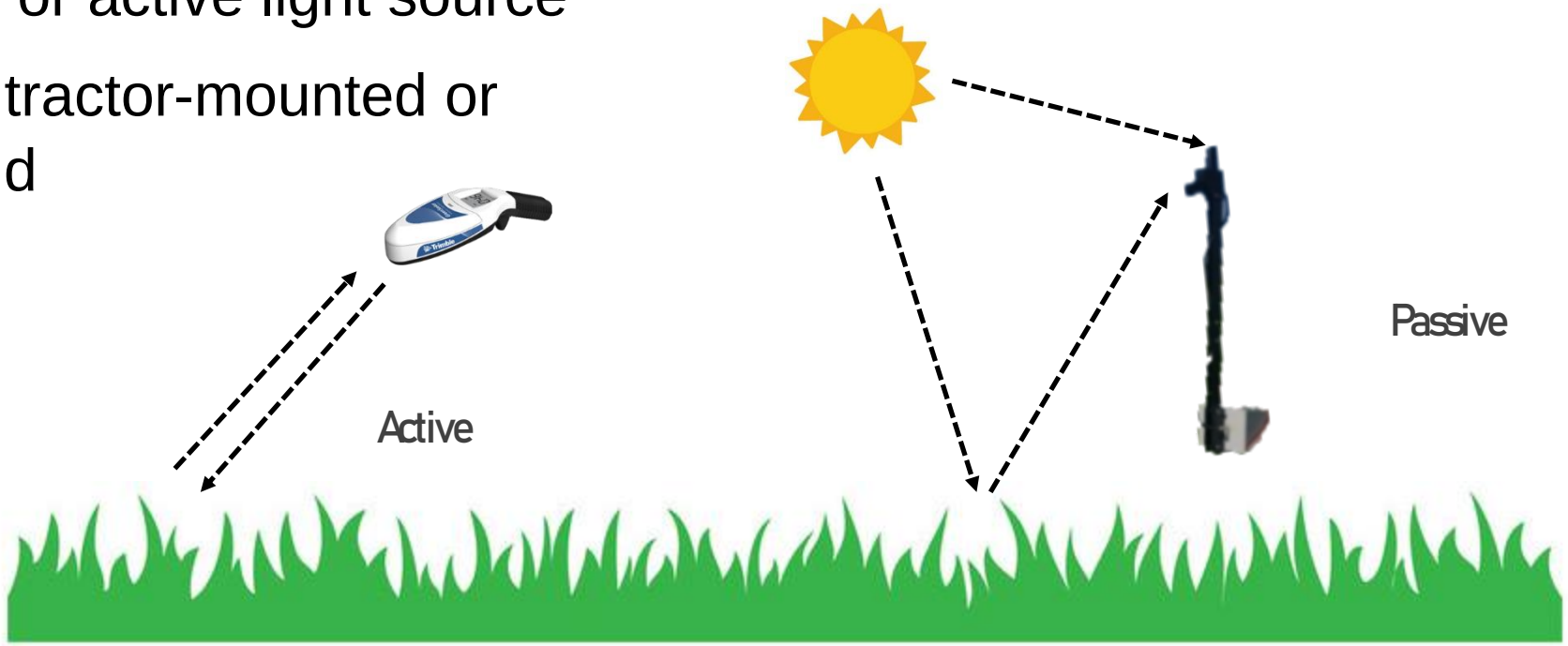


Estimating quality traits with field spectrometers

Image: ICAR

Field Spectrometers

- Measure reflectance
- Non-imaging
- Passive or active light source
- Usually tractor-mounted or handheld



Research-grade field spectrometers

- e.g. Fieldspec 4.
- Detailed spectral information
- Expensive

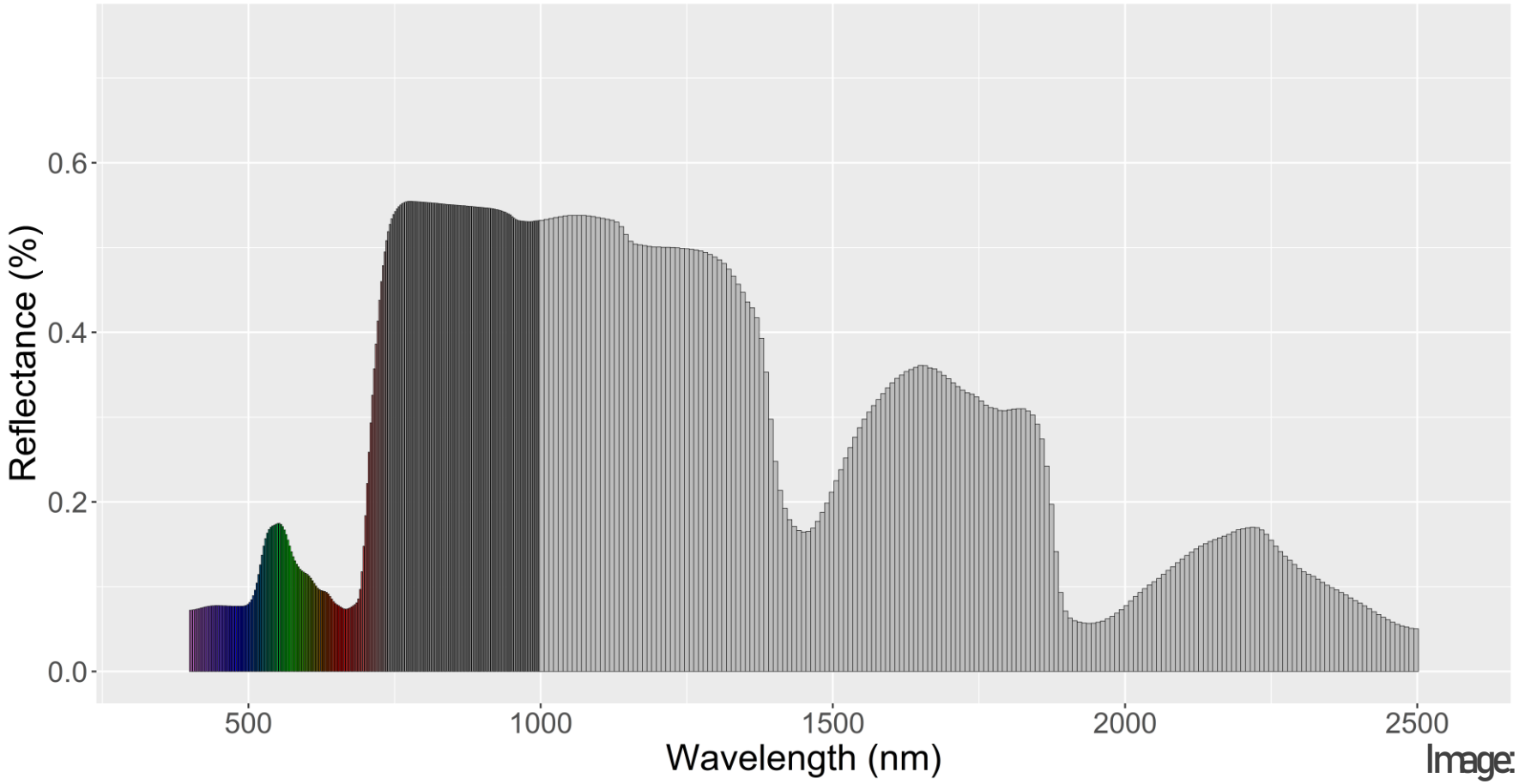


Image: ICAR

Classic Yara N-sensor

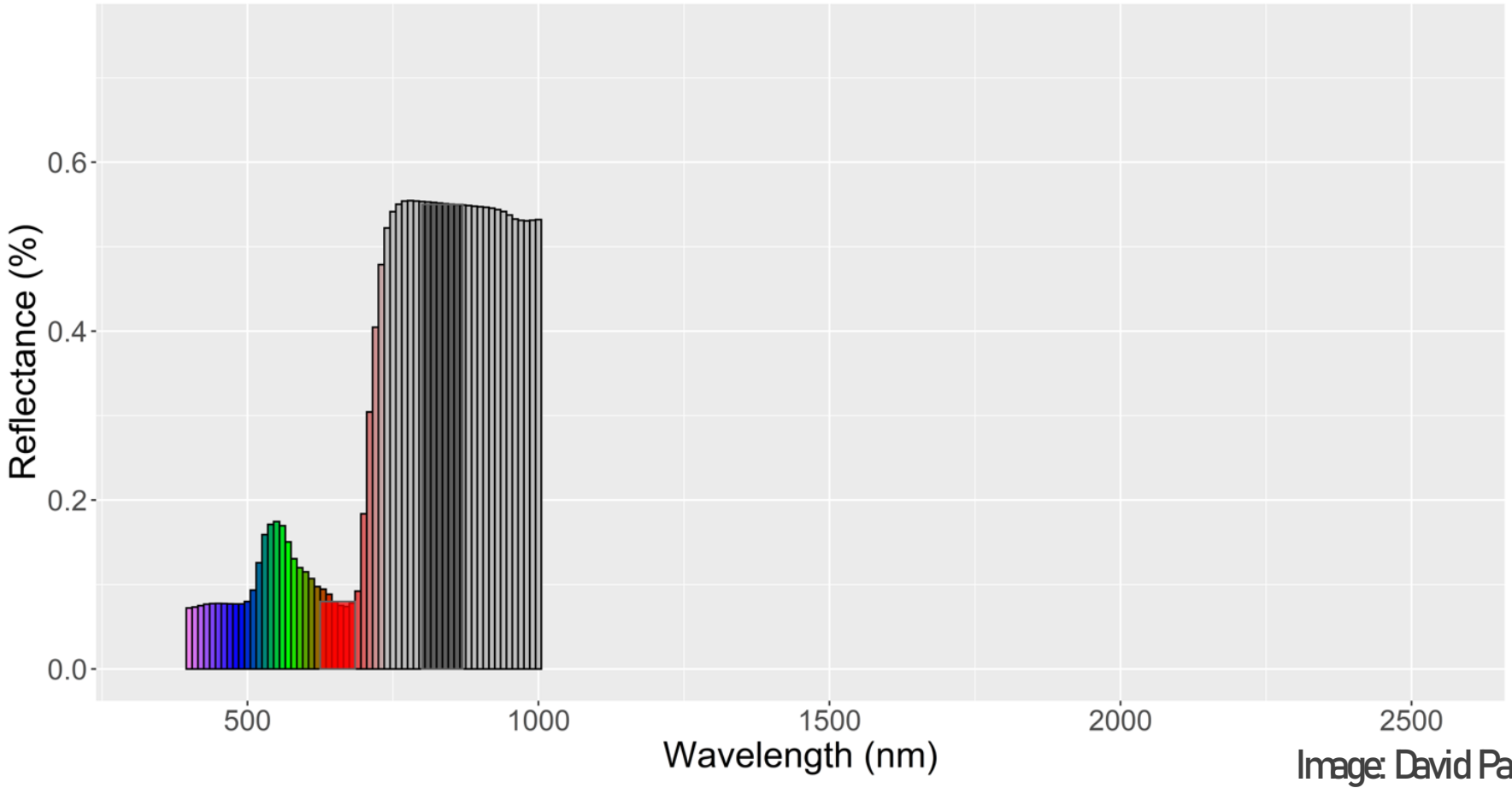
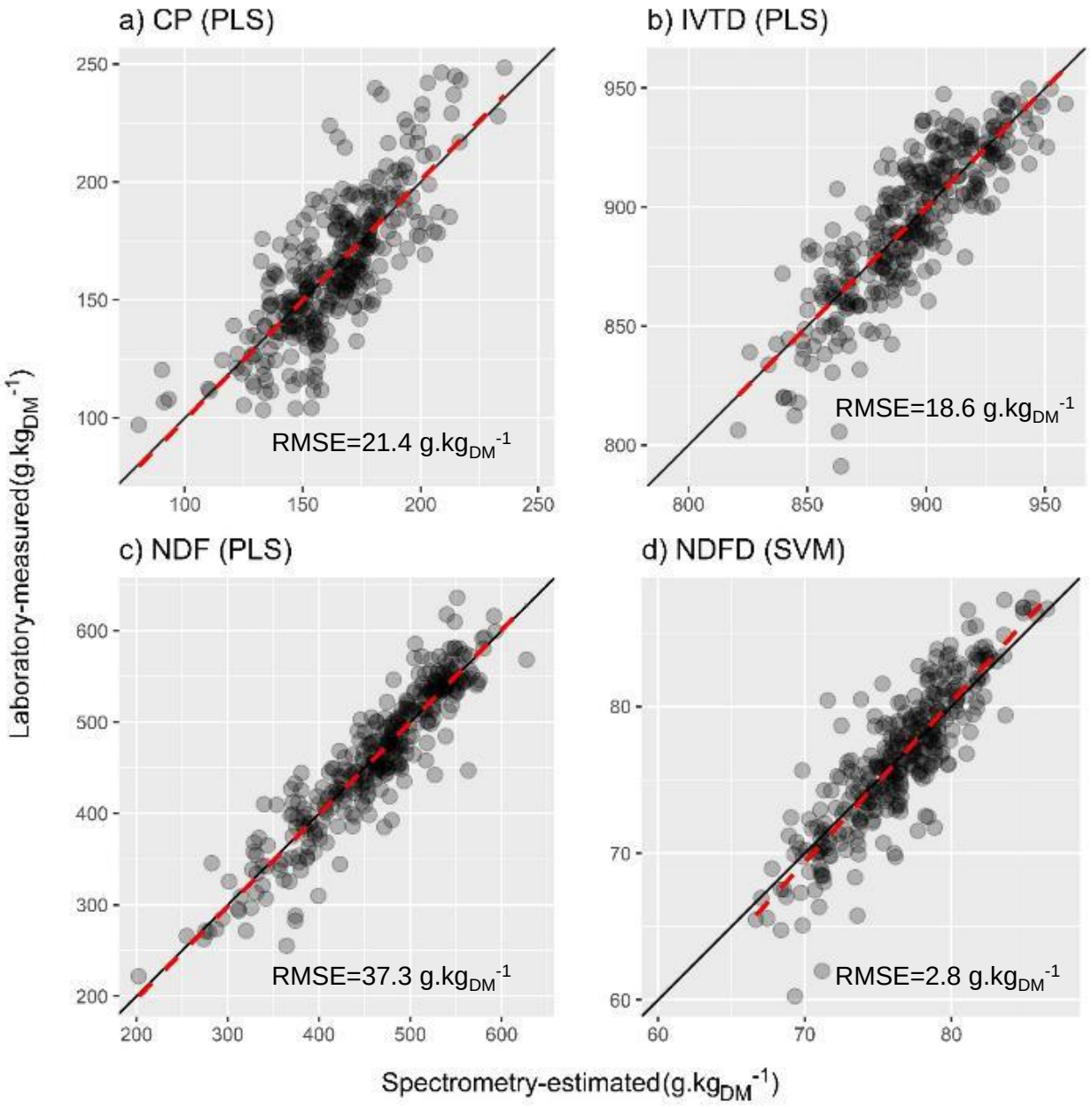


Image: David Parsons

Video: SLU



- Three years (2017-2019)
- Four sites (Lännäs, Röbäcksdalen, Ås, Öjebyn)
- Mixtures of timothy and red clover
- 337 samples

Variable	Cal. r^2	Val. r^2
CP	0.63	0.50
Digestibility	0.73	0.64
NDF	0.86	0.77
NDF Digestibility	0.77	0.65

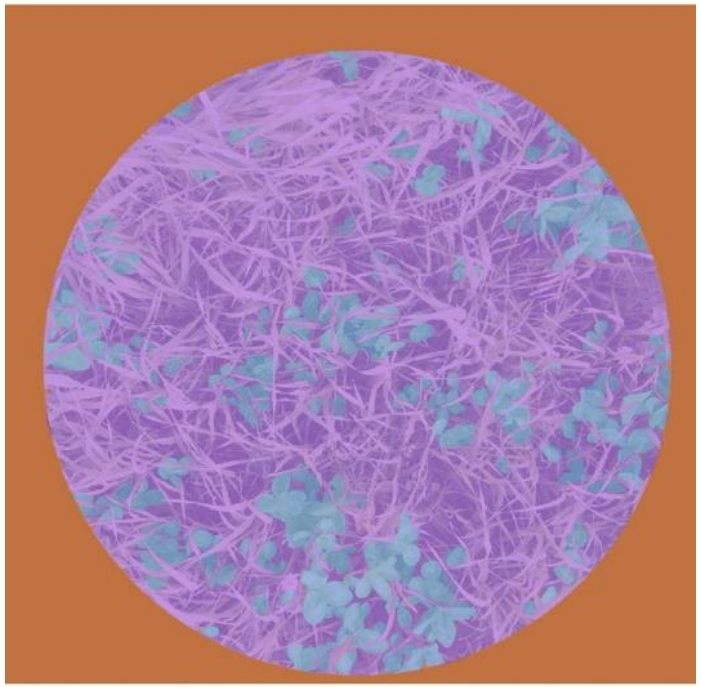
Outlook

- Testing models on larger datasets
- Other parts of Sweden
- Reliable models for different years, sites, equipment
- Testing low-cost spectrometers

Estimating clover content from RGB images

E-FAST Clover

- Three years (2017-2019)
- Four sites
- Mixtures of timothy and red clover
- iPhone images
- 347 samples and images collected
- 96 used to test the models
- Manual labelling of clover pixels



Source: Sun et al. 2021. https://doi.org/10.3389/fpls.2021.622429

Clover content

- Three different “transfer learning” models
- All had r^2 around 0.96

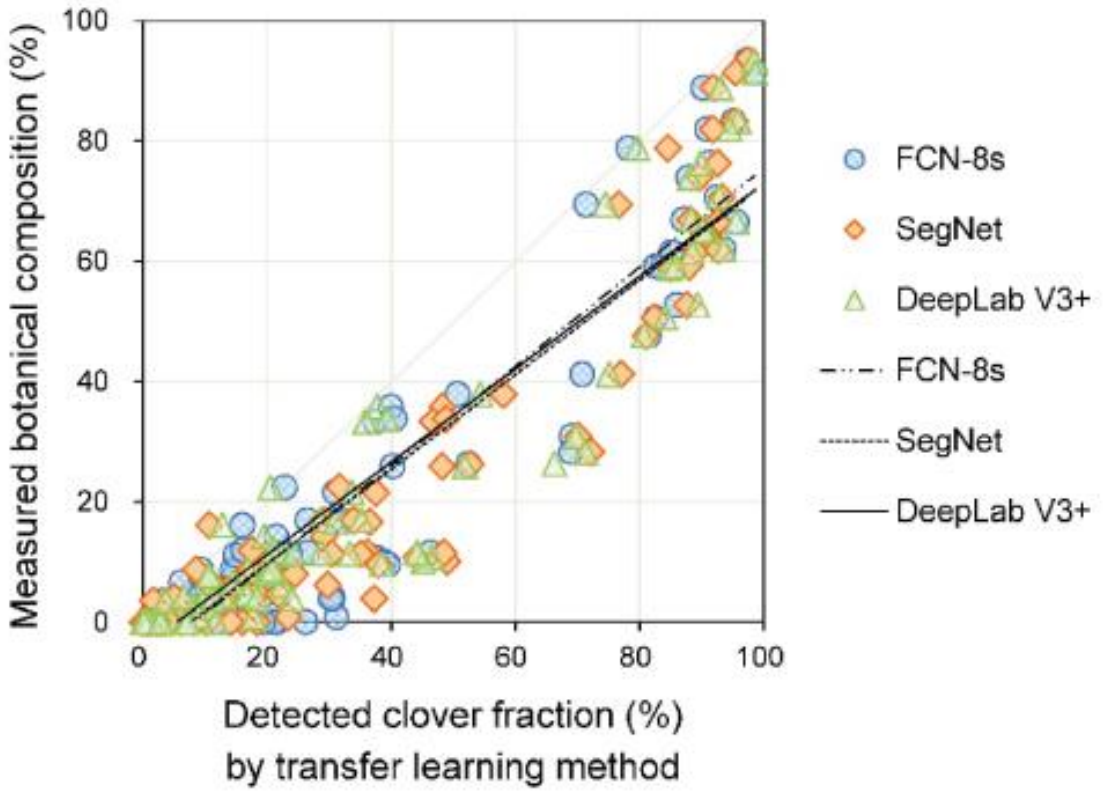
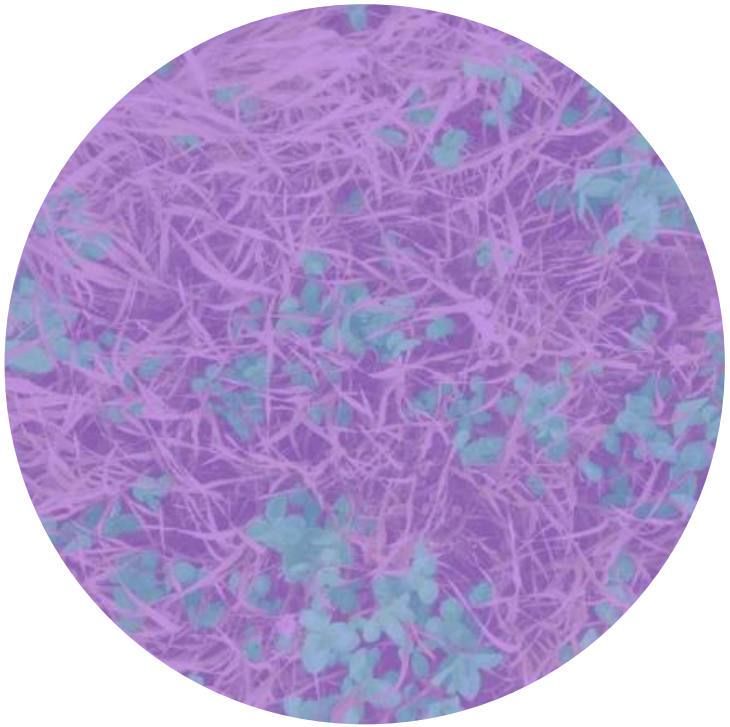
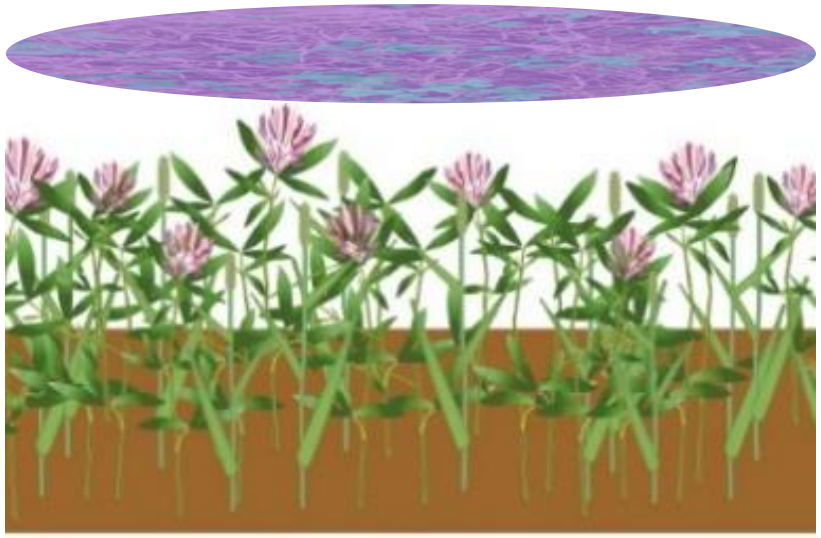


FIGURE 9 | Linear regression of the detected clover fraction and measured botanical composition.

Source: Sun et al. 2021. https://doi.org/10.3389/fpls.2021.622429



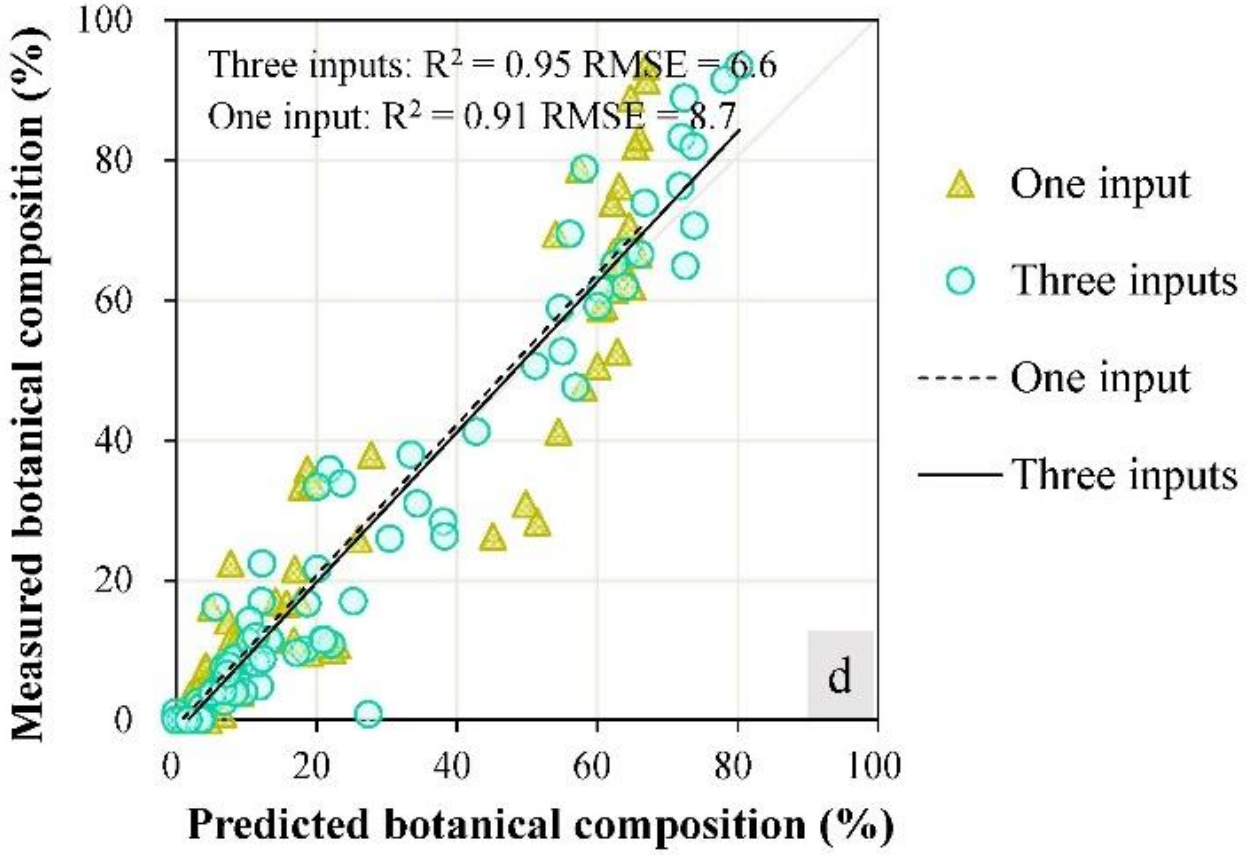
2D clover content



3D botanical composition

Botanical composition

- Combined clover content with measurements of plant height
- Slightly better results when plant height used



Source: Sun et al. 2021. https://doi.org/10.3389/fpls.2021.622429

Outlook

- Drones
  - Use lightweight & low cost drones to scout fields e.g. Mavic Mini (249g)
  - Repeatable height above ground
  - Testing algorithms on drone images
- Robots
  - Partnership with LTU
  - Very early stages

Image: SLU

Image: Adept Technology

Estimating quality traits from satellite imagery

Sentinel 2

- Constellations of earth observation satellites managed by ESA
- Free access for anybody
- Sentinel-2 satellites
  - 2 satellites
  - 10 m of pixel size
  - ~1 image every 2 days
  - 13 spectral bands (visible, NIR, SWIR)

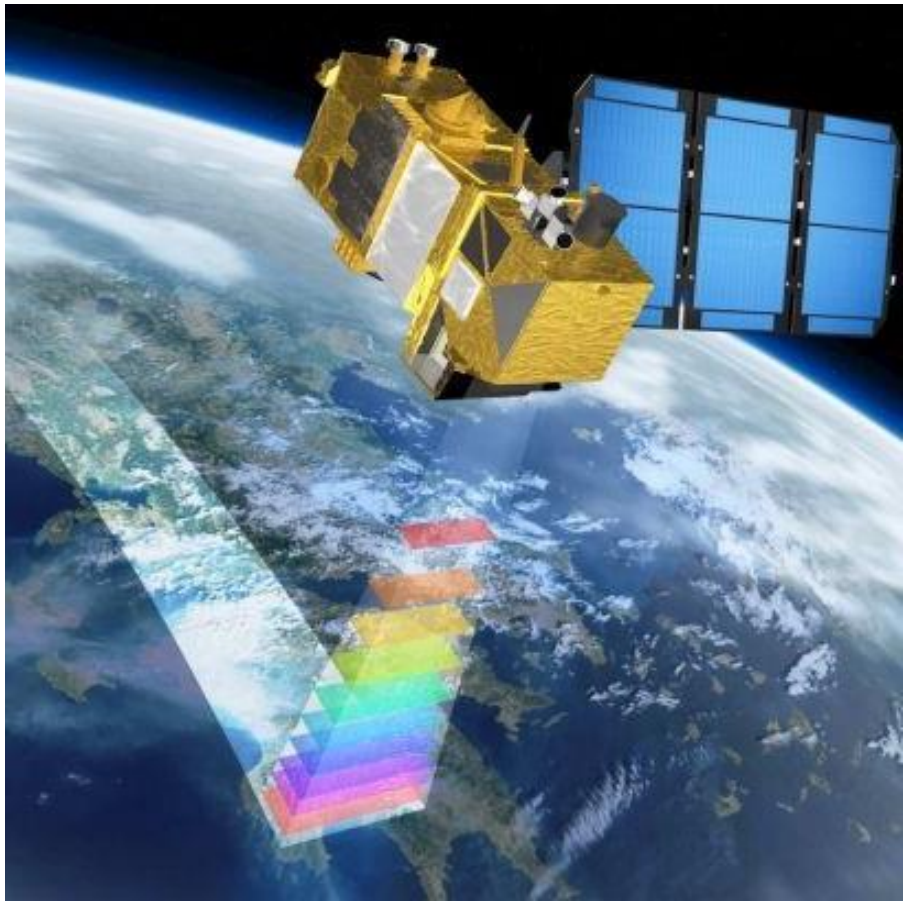


Image: ESA

Data

- Röbäcksdalen data collection
- Vallprognos
  - Two years (2020-2021)
  - >30 sites across Sweden
  - Range of ley conditions
  - 72 used for analysis

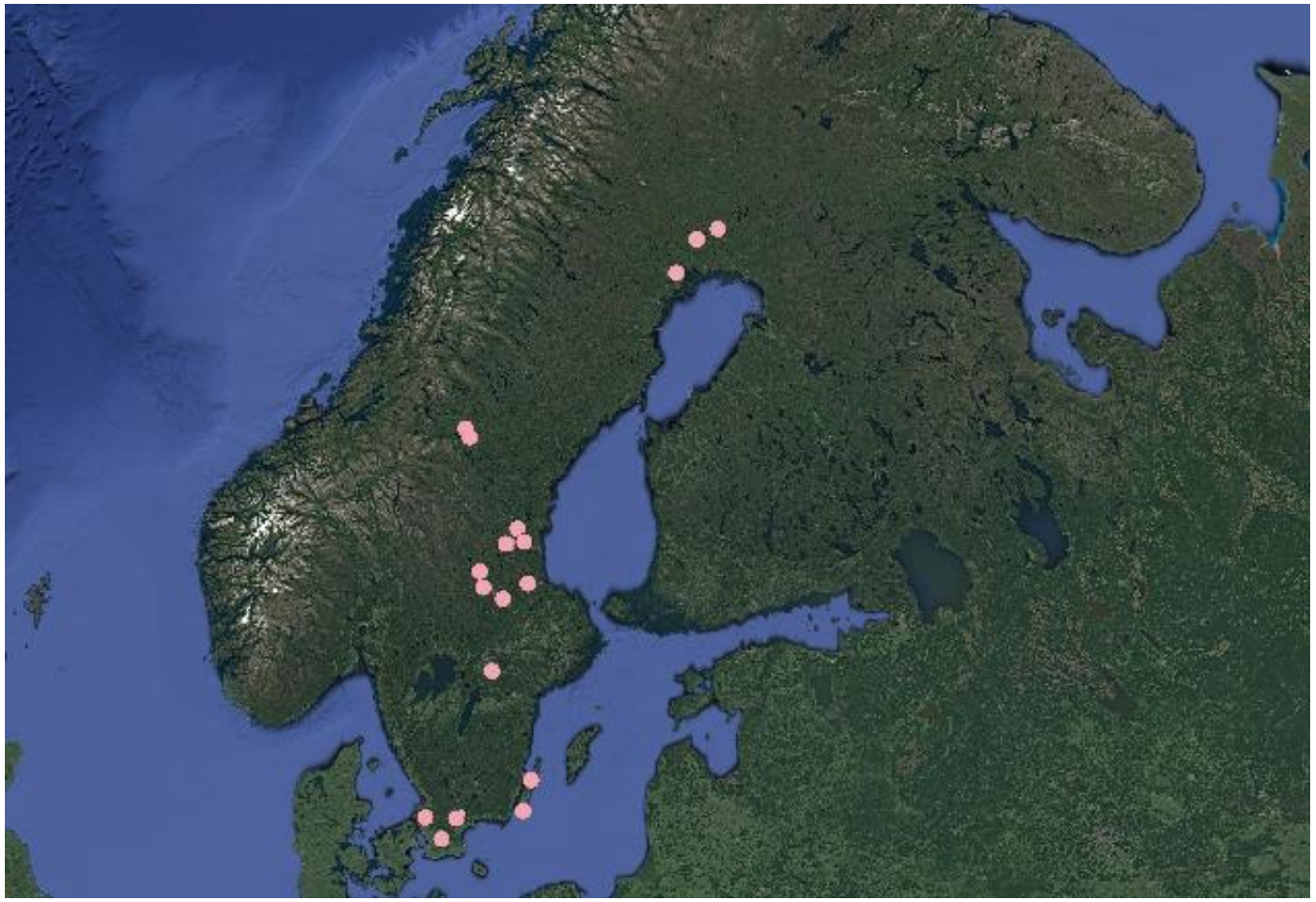


Image: Google/SLU

Data analysis

Image: Google/SLU

Image: Wikipedia

Reflectance B01 to B13

Multivariate regression

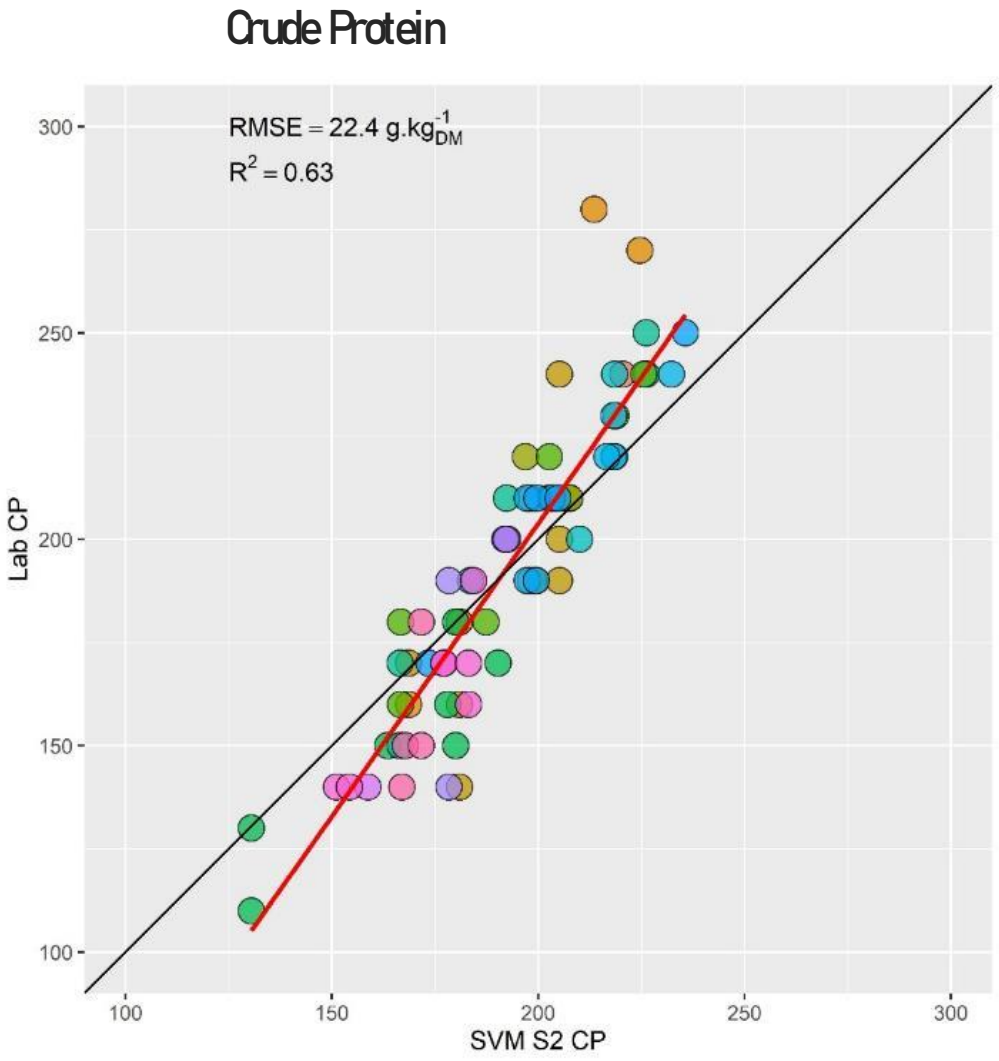
- *PLS*
- *SVM*

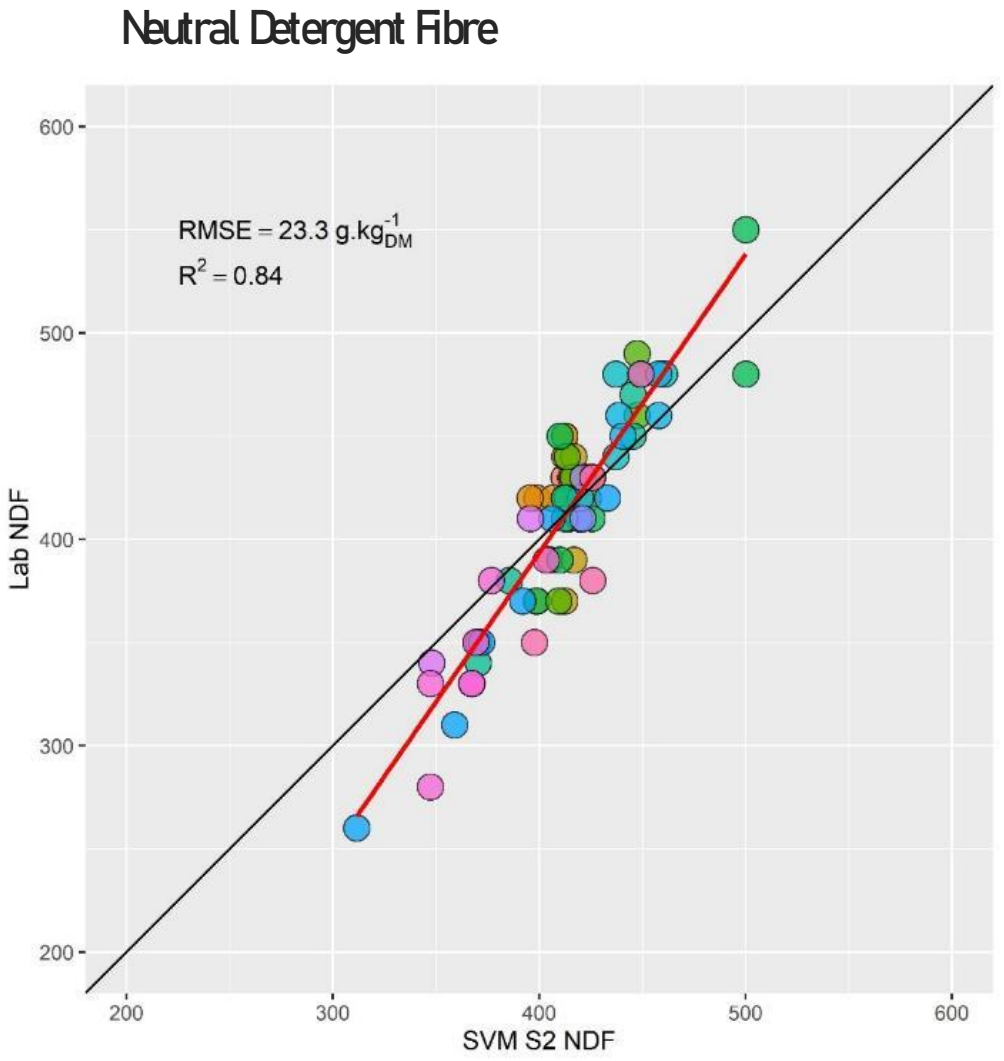
Quality variable

- *CP*
- *NDF*
- *OMD*
- *Energy*

Estimations

Results


Crude Protein
RMSE = 22.4 g.kg$^{-1}_{DM}$
R^2 = 0.63
Lab CP
SVM S2 CP
100
150
200
250
300


Neutral Detergent Fibre
RMSE = 23.3 g.kg$^{-1}_{DM}$
R^2 = 0.84
Lab NDF
SVM S2 NDF
200
300
400
500
600

Outlook

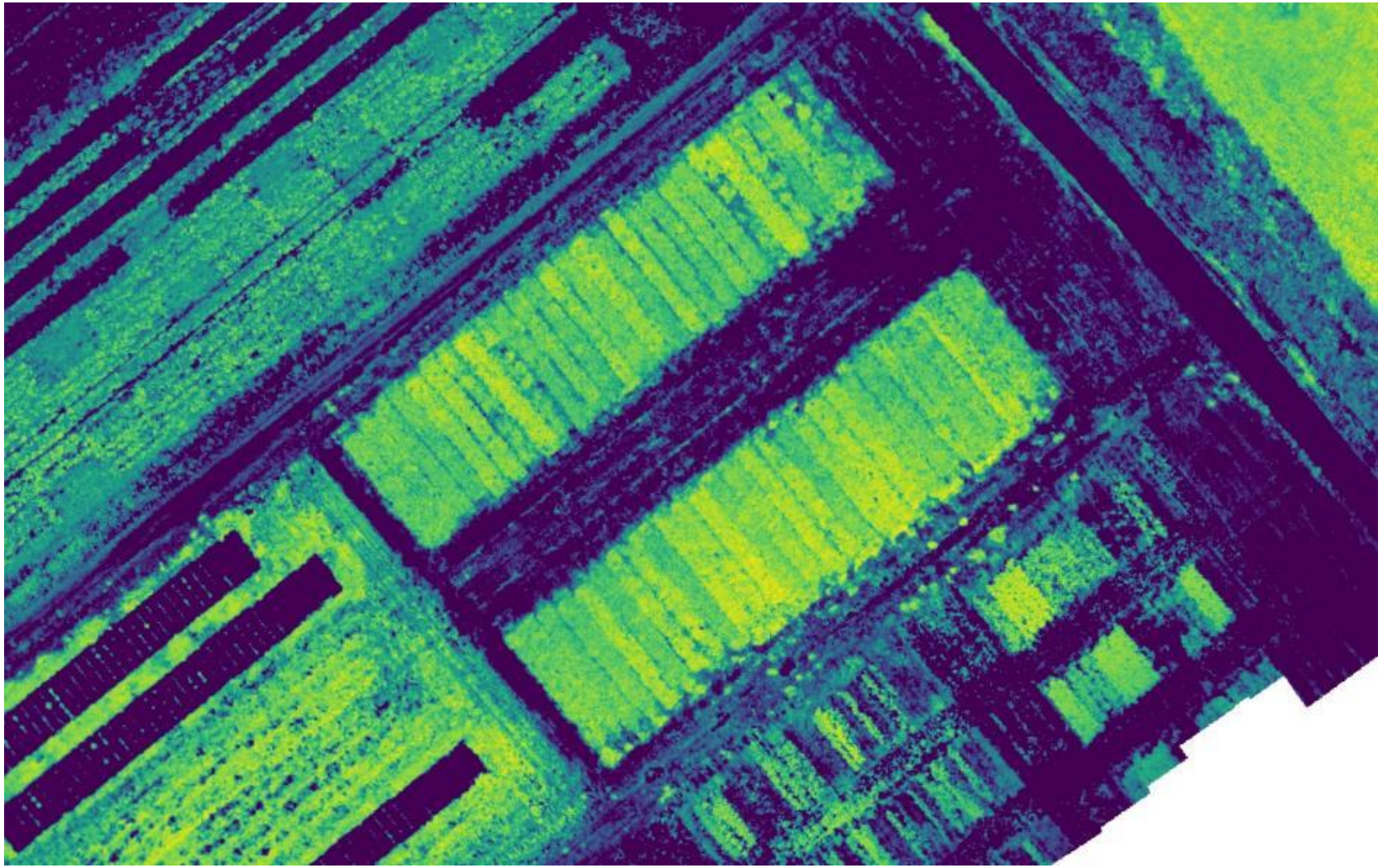
- Preliminary results are encouraging
- (much) more work is needed
- If results are confirmed, the models could be adapted into a practical tool similar to cropsat.se (in ~3 years)

Image: Julien Morel

Using drones for assessment of field experiment

Overview

- Parameters of interest
  - Plant cover (easy)
  - Plant density (medium)
  - Biomass (medium)
  - Forage quality (hard)
- Advantages
  - Fast
  - Objective
  - Within plot variability



Normalized difference red edge index (Matrice + MAIA S2)

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“Vall-Optimal project” funded by Werner Stiftelse
”R2D2” project was funded by Lantmännen Stiftelse
”Robots on grass” project funded by RJN & NorrlandsNavet