Mapping Ecotonal Landscapes by Combining UAV and Satellite Imagery

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Department of Environmental Sciences

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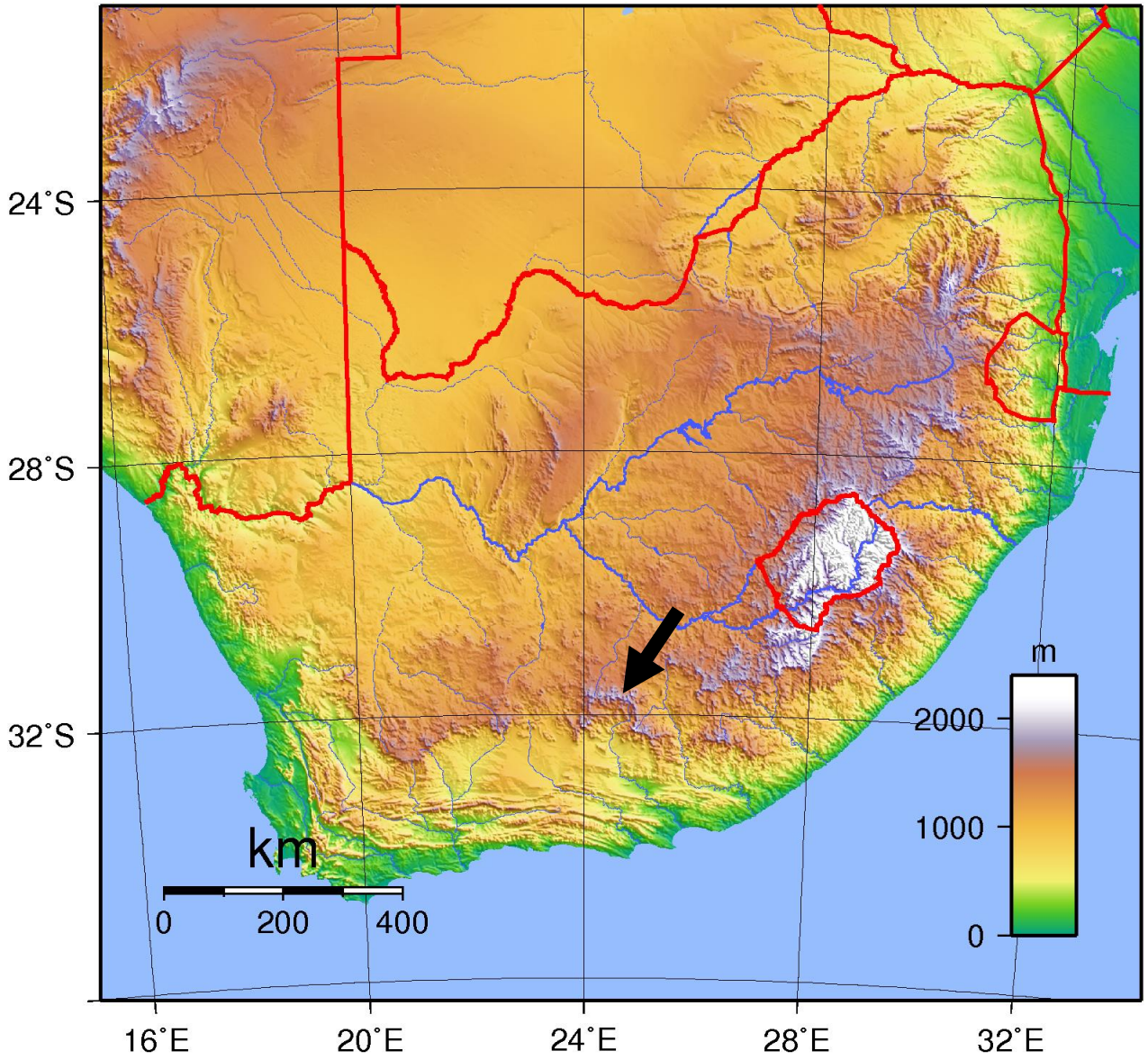
Study Site: Sneeuberg Nature Reserve (Eastern Cape, ZA)

Altitude between 1500 and 1800 m MSL on the Central Plateau



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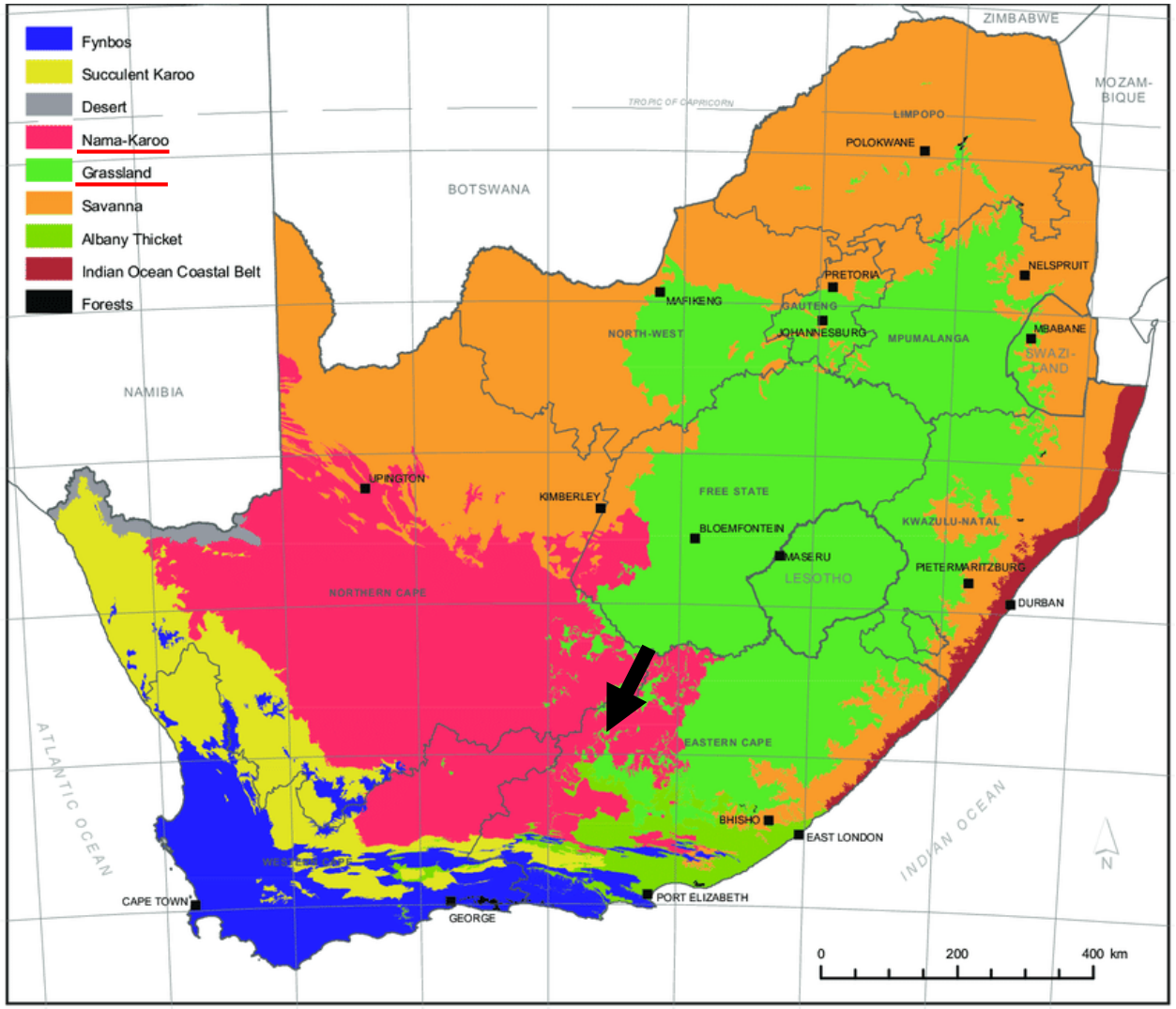
Transitional zone between the Nama-Karoo and Grassland biomes

- **Nama-Karoo**: Dry, grassy shrubland
- **Grassland**: Grass dominated



Mucina and Rutherford (2006)

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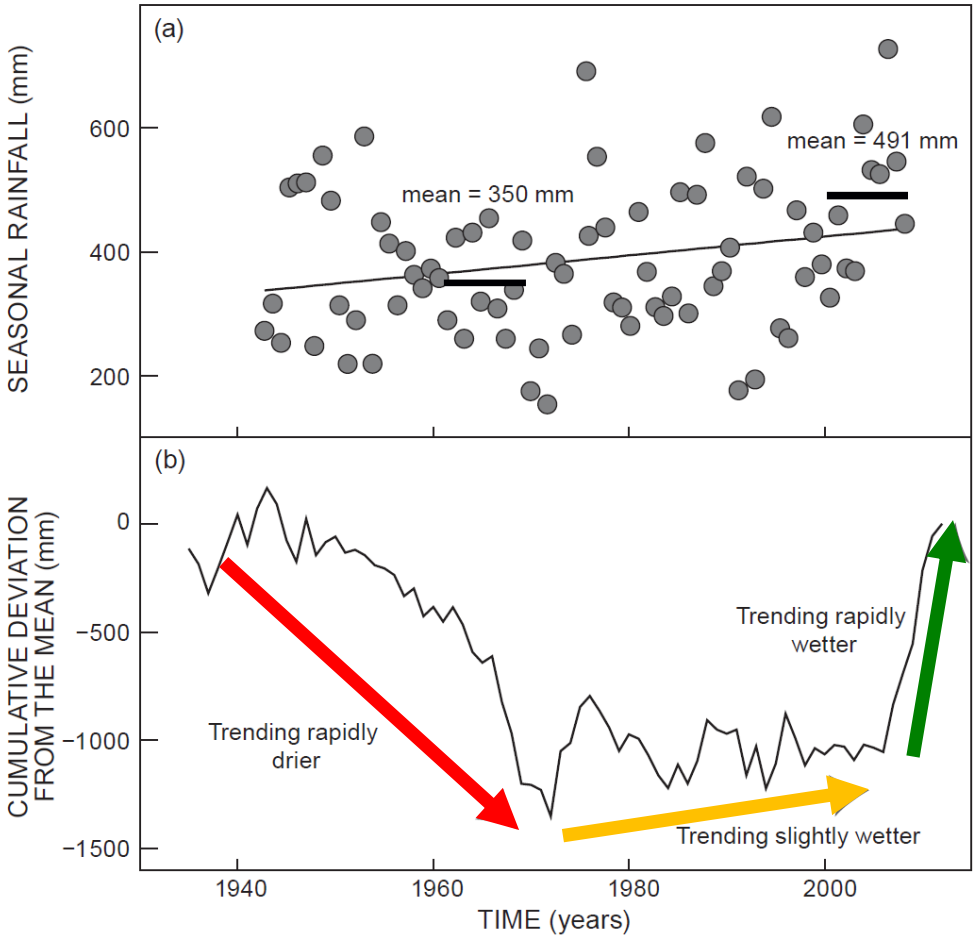
- Annual cycle: usually wet summers, dry winters
- Variability over longer time periods



Du Toit et al. (2018)

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Land degradation issue for local livestock farmers

- Drivers: stocking pressure, drought, fire and high intensity rainfall events (Boardman et al., 2016)

What we want to do

Long-term, large-scale land cover monitoring needed, in order to:

- improve understanding of climate / vegetation interaction
- quantify impact of degradation (soil erosion) on climate

Goal: Annual vegetation-cover classification map of the Sneeuberg Recreation Area:

- enabling biome-shift observation over decades (backwards and forwards in time)
- detecting land degradation and endangered areas
- methodology applicable to other semi-arid areas

Proposed Method: Stepwise Training of Classification Algroithm

Area covered

+ Altitude / - GSD

Satellite Level
multitemporal, multispectral image-stack (S-2, Landsat 8, *S-1*)

Airplane Level
multispectral orthomosaic, DSM

UAV Level
multispectral orthomosaic, *DSM*

Ground Level
groundtruth, soil samples

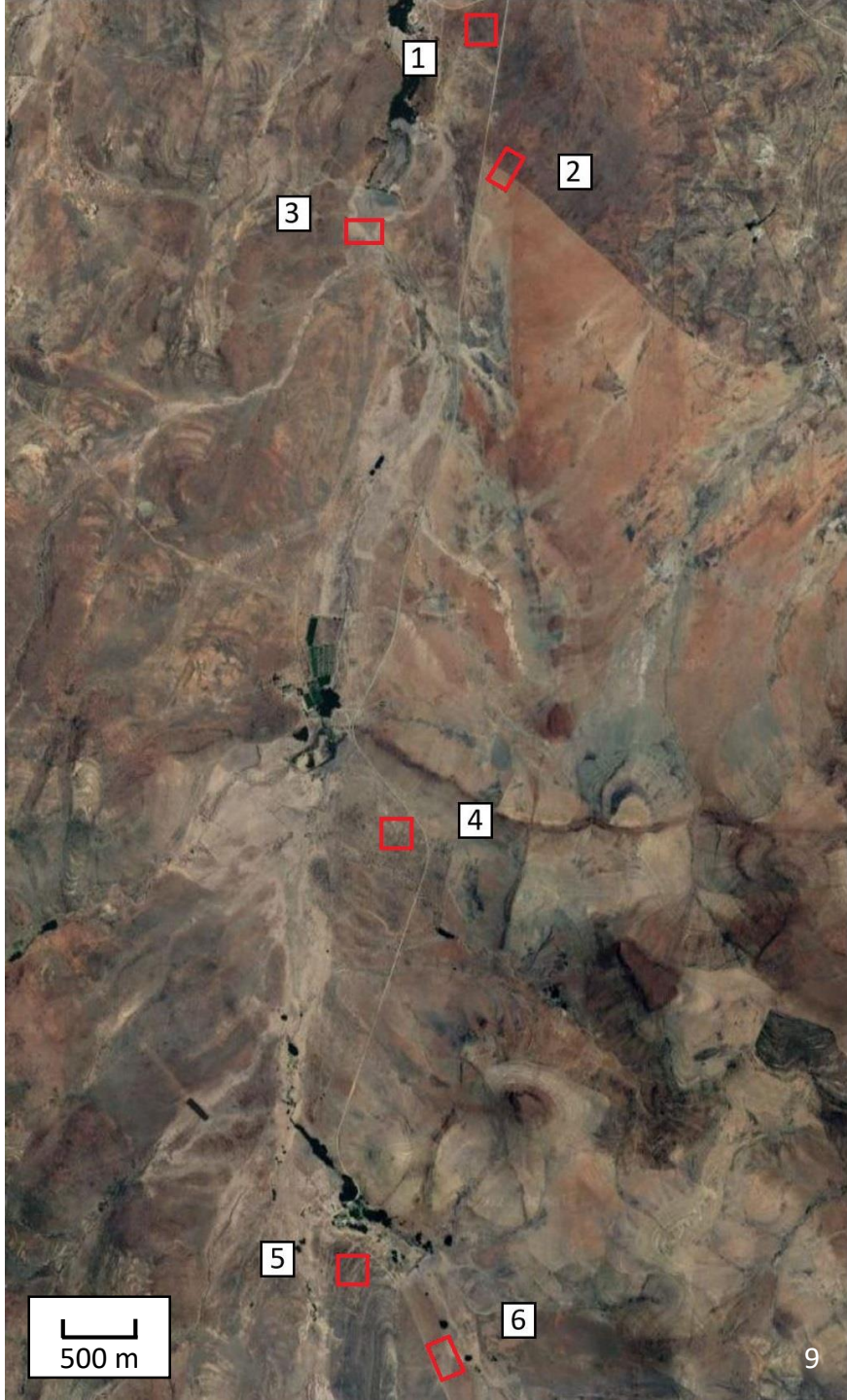
Calibration

Validation

Ground Level (January-February 2022)

6 plots (each about 4 ha) with characteristic land cover:

1) Dwarf-shrubs with grasses **(Shrubland)**
2) Dwarf-shrubs + burned area of originally same land cover
3) Grassy pasture land, close by reservoir **(Grassland)**
4) Degraded mix of shrubs and grasses, very heterogeneous
5) Larger Shrubs with grasses and rocks **(Shrubland)**
6) Grassy patch, few shrubs and degraded areas **(Grassland)**



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10-12 sub-plots per plot (each 2.5m²):

- Estimation of fraction of vegetation cover
- Species determination and categorisation (grass/shrub)
- Vegetation height measurements
- Soil sampling (organic carbon content, grain size)
- Taking photos

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DJI Phantom 4 RTK (RGB, 1 cm GSD)

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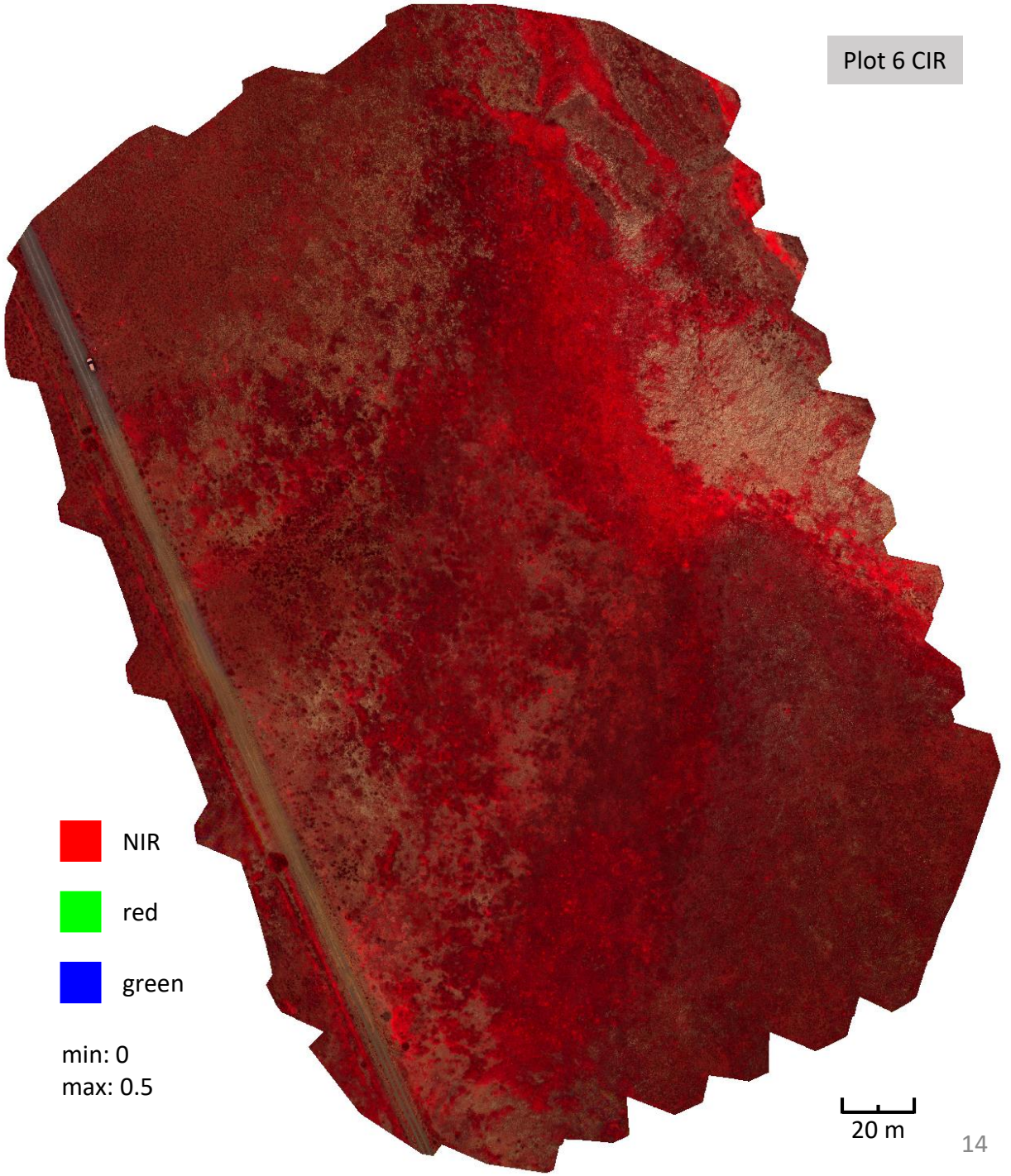
DJI Phantom 4 Multispectral (3.8 cm GSD)

- 5 Bands: blue, green, red, red edge, NIR
- Spectrally calibrated to SR with sun-sensor and calibration target



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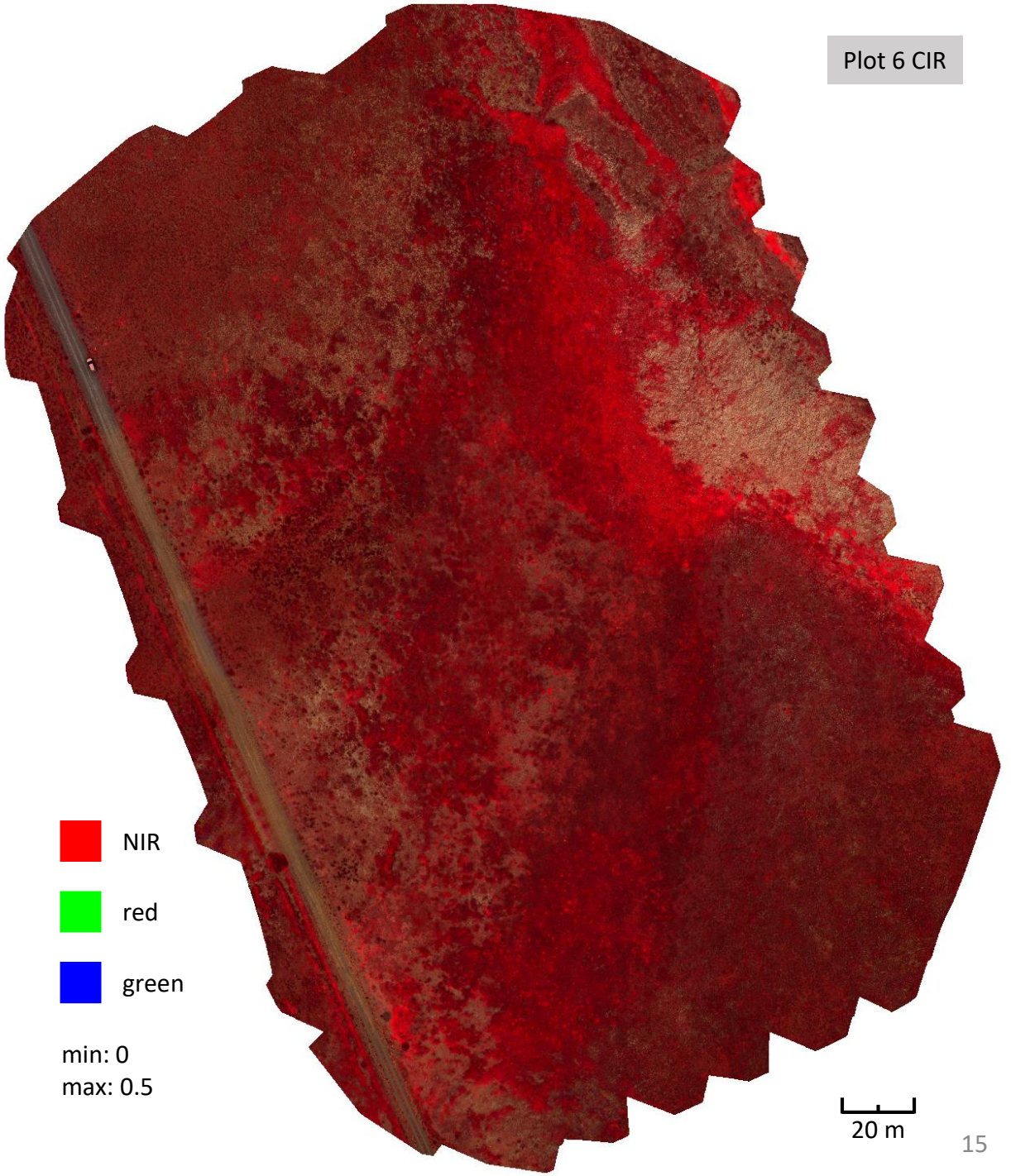
Photogrammetric processing done in Pix4D



UAV Level classification

Determine training areas for classificaton algorithm (random forest) using high-res RGBs on all plots

Find and mark sub-plot areas

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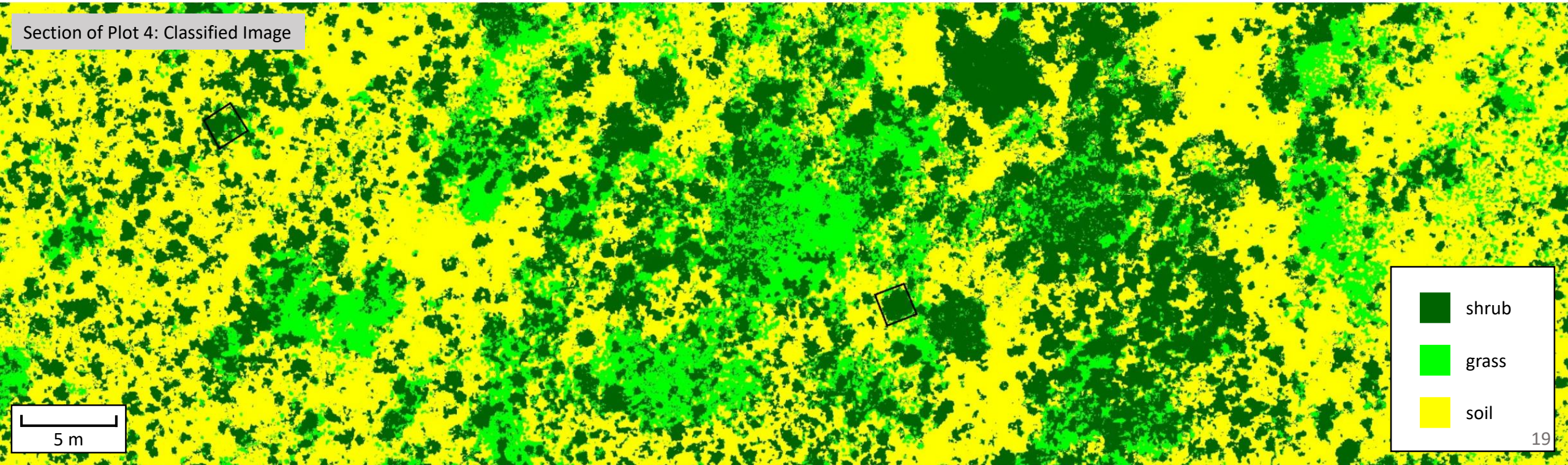
Assess accuracy using sub-plots and improve classification iteratively



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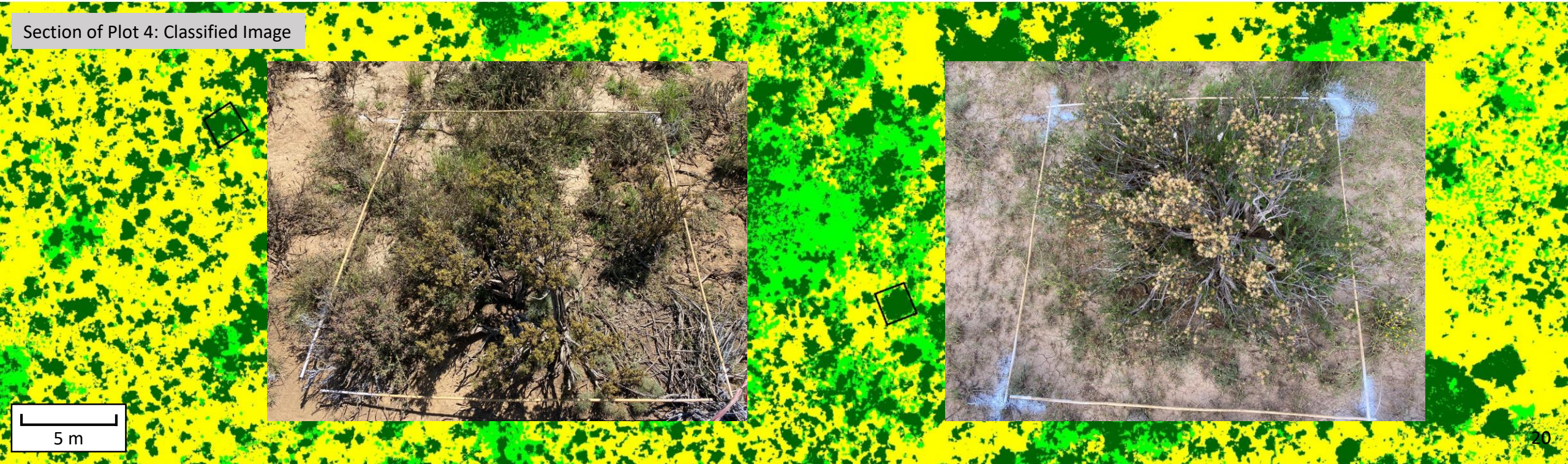
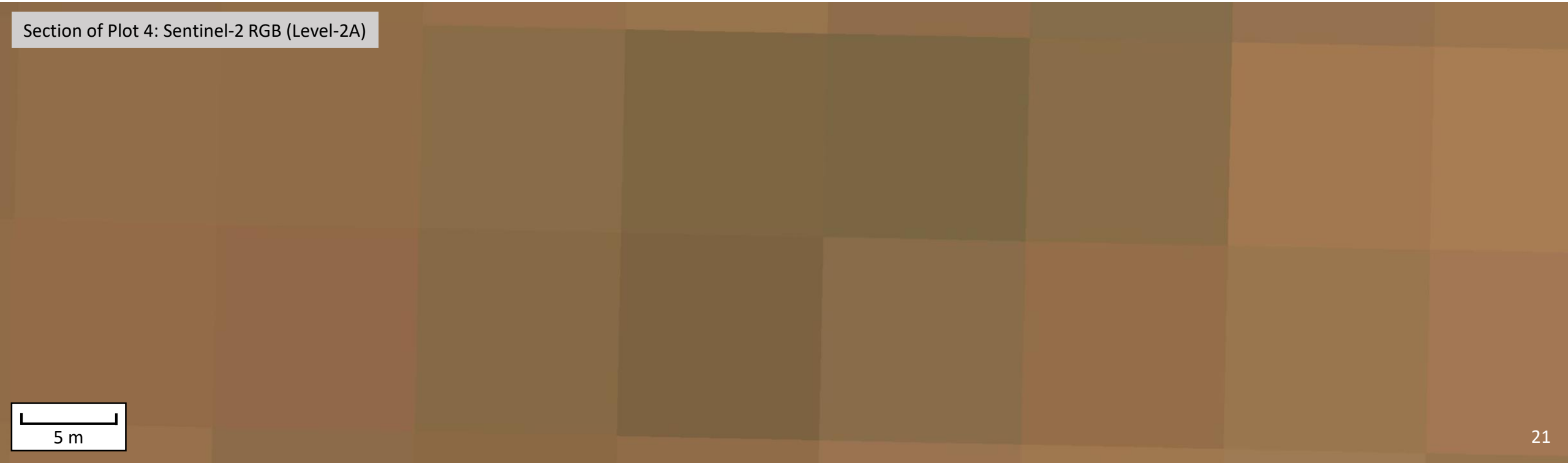
Section of Plot 4: Classified Image

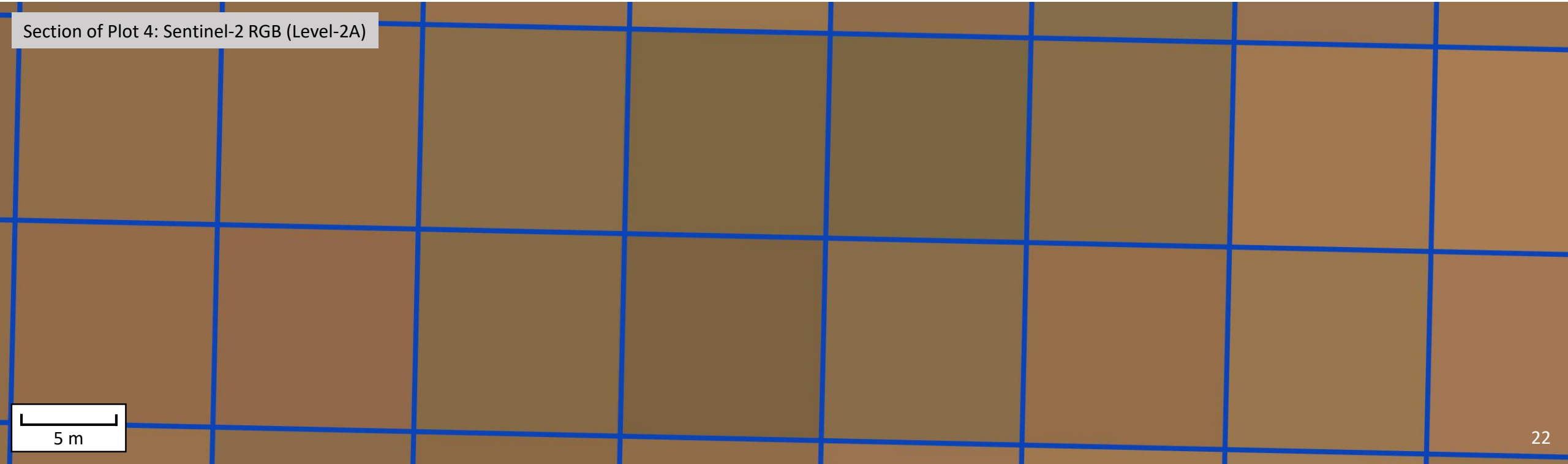


Simulating Satellite-Level Classification



Simulating Satellite-Level Classification

Grid subdividing the plots into satellite-pixel-sized and -aligned cells



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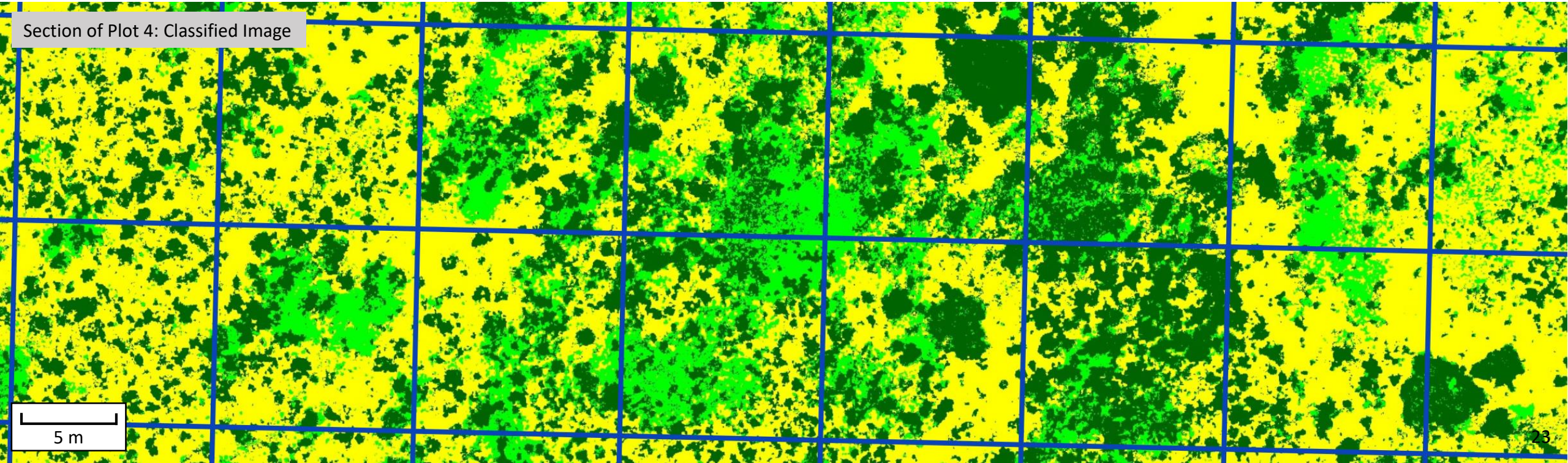
Grid subdividing the plots into satellite-pixel-sized and -aligned cells

Inventory of vegetation cover and type of each cell



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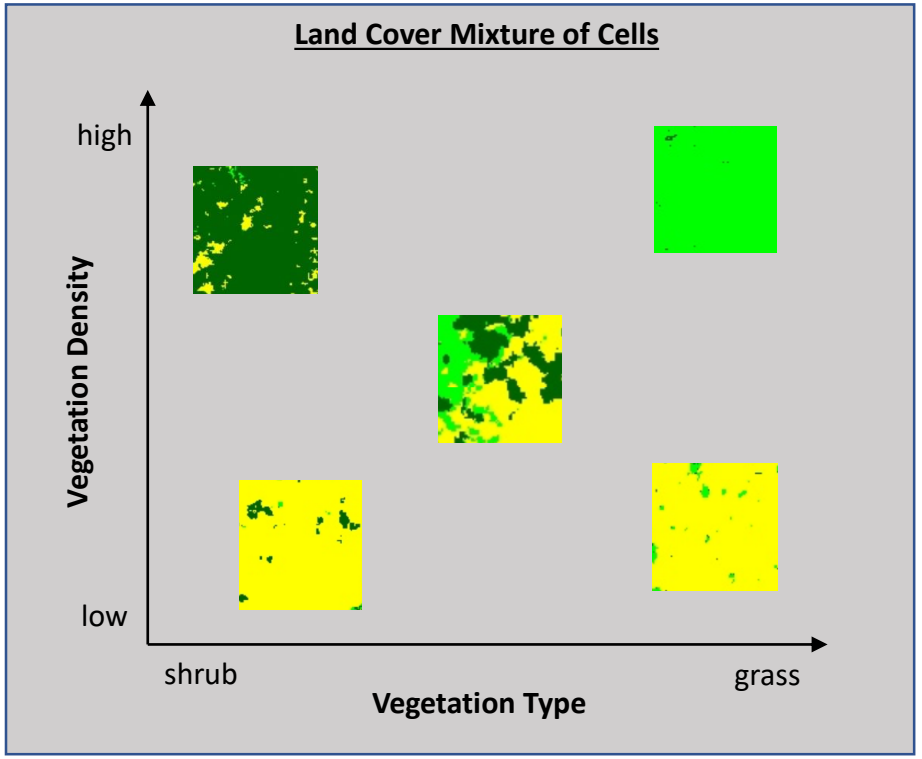

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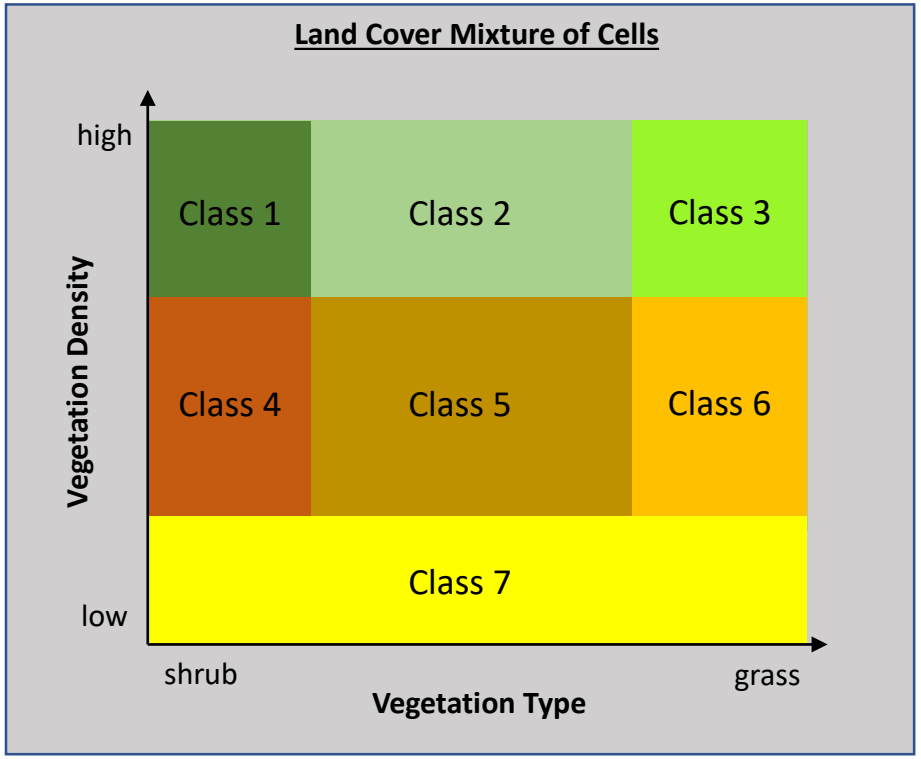
Mixture-classes based on cell-distribution and ecological meaningfulness



← Example!

Simulating Satellite-Level

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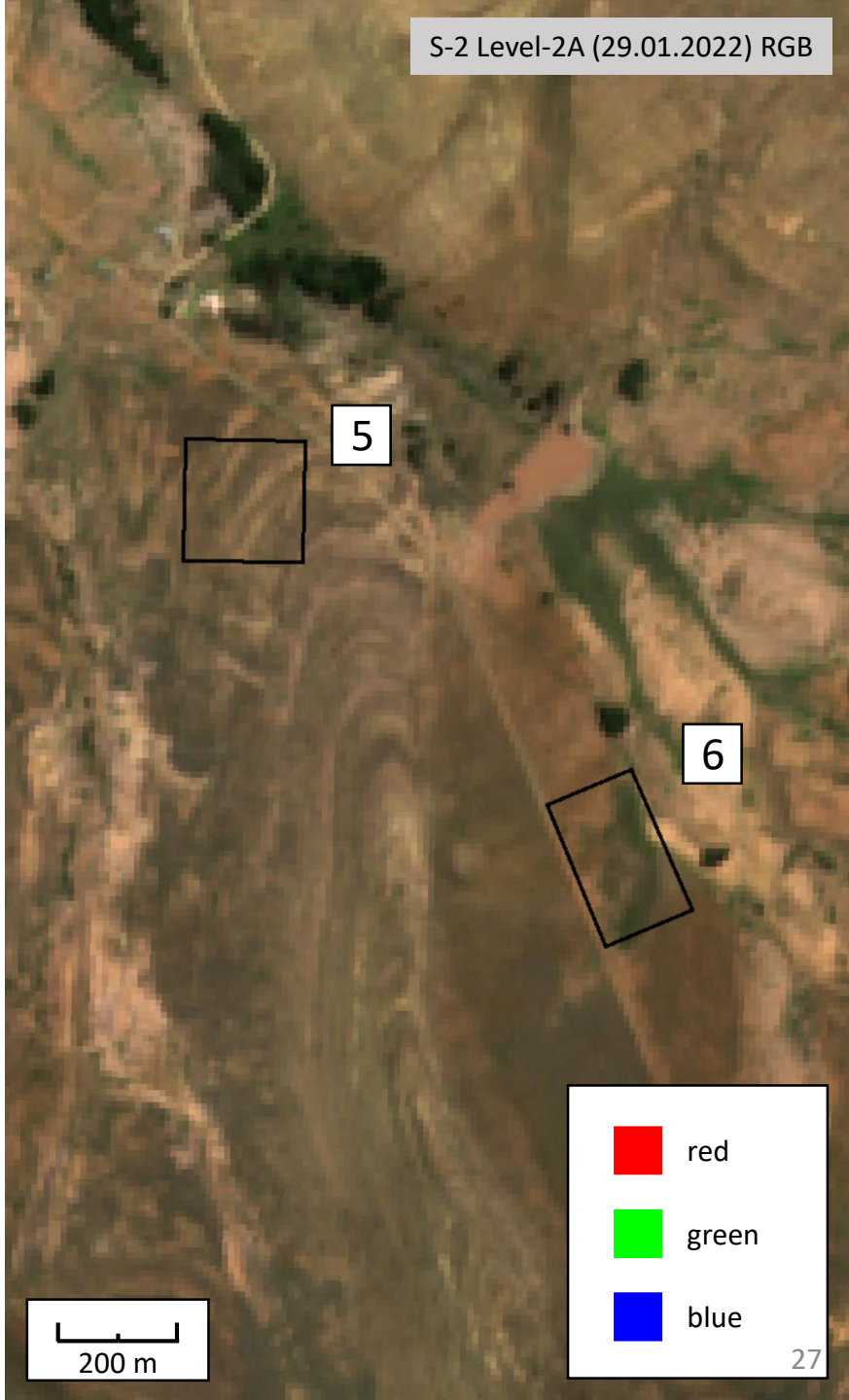
Classified cell-matrix ground truth and training area for satellite classification

Satellite-Level

Satellite image date close to UAV acquisitions



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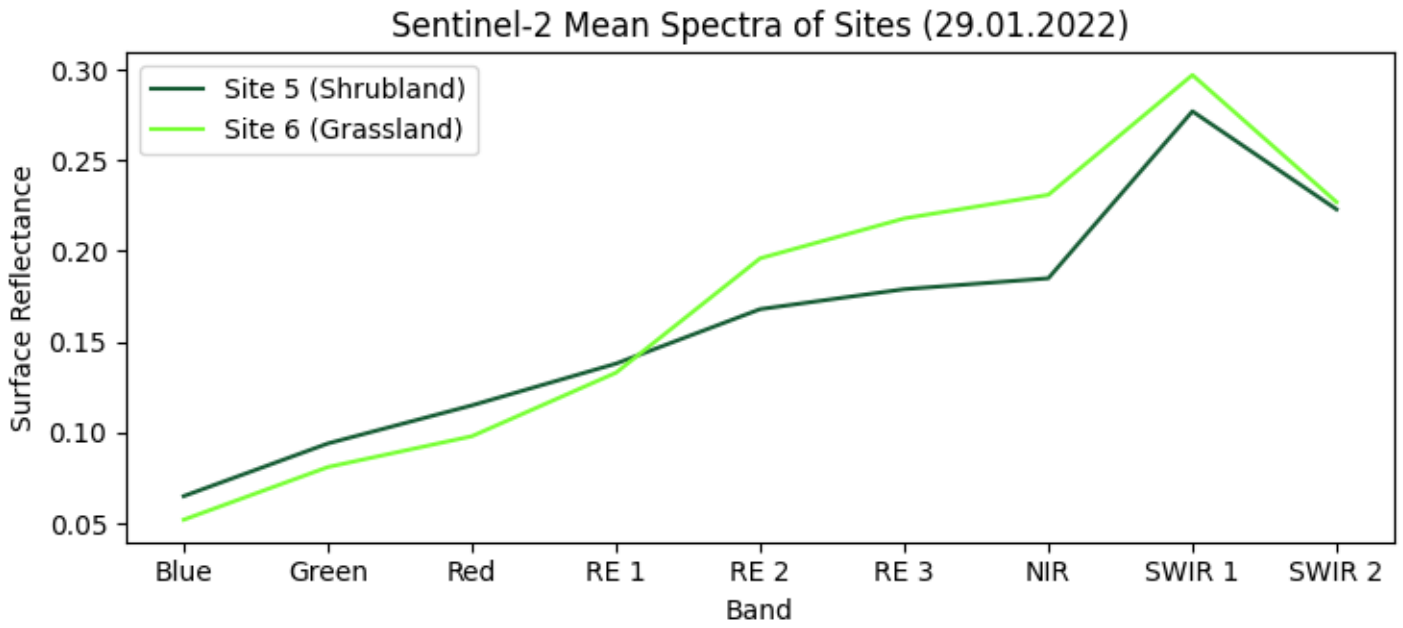
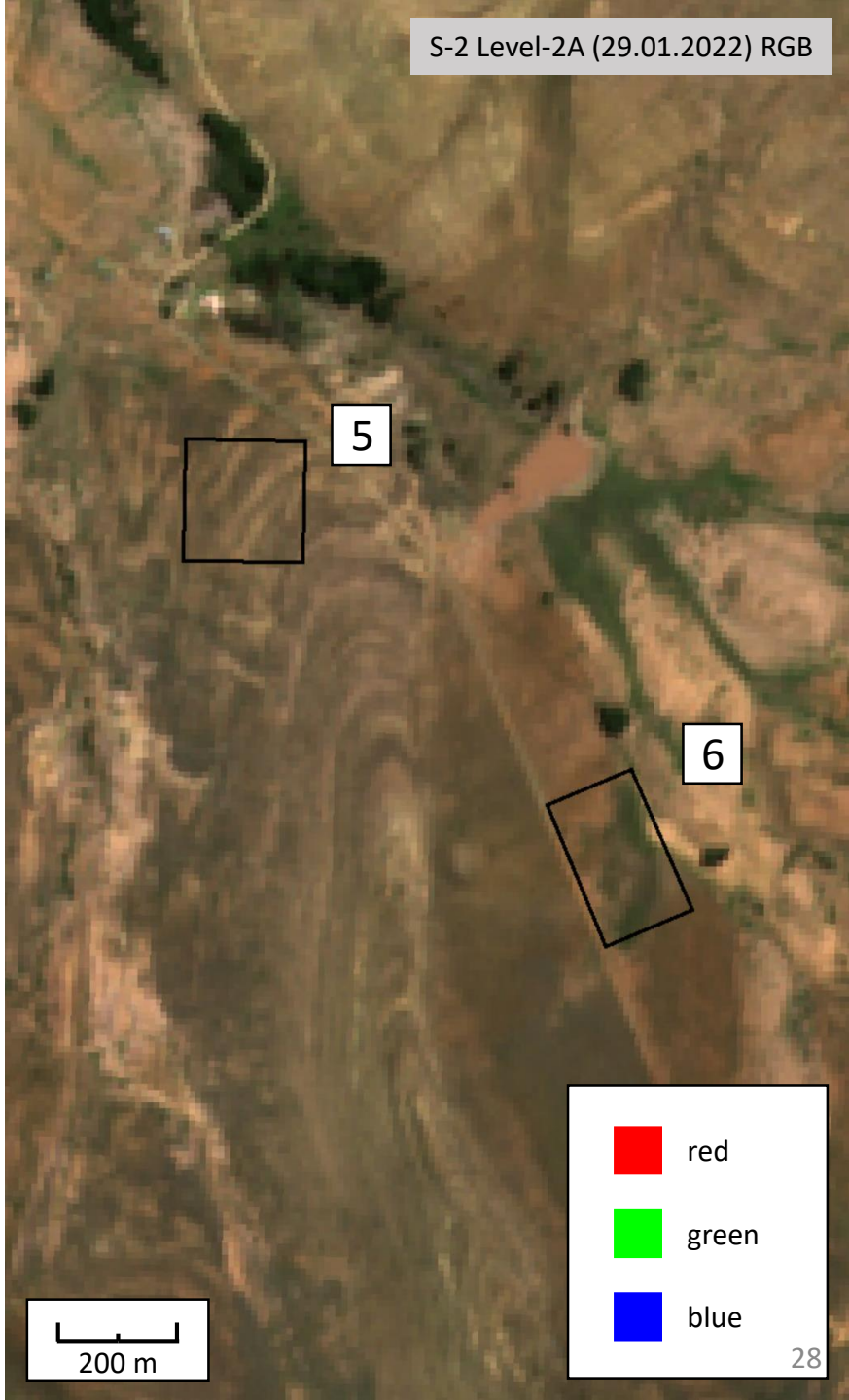
Different responses of shrubs and grasses between red edge 1 and SWIR





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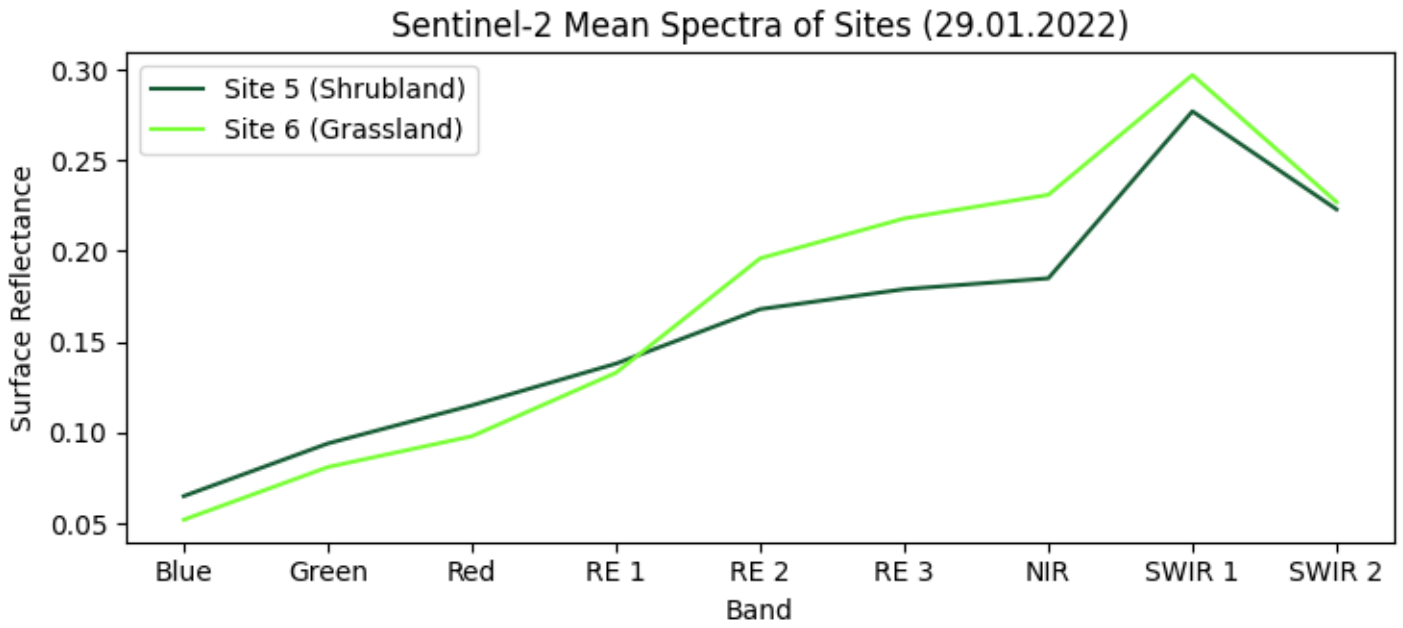

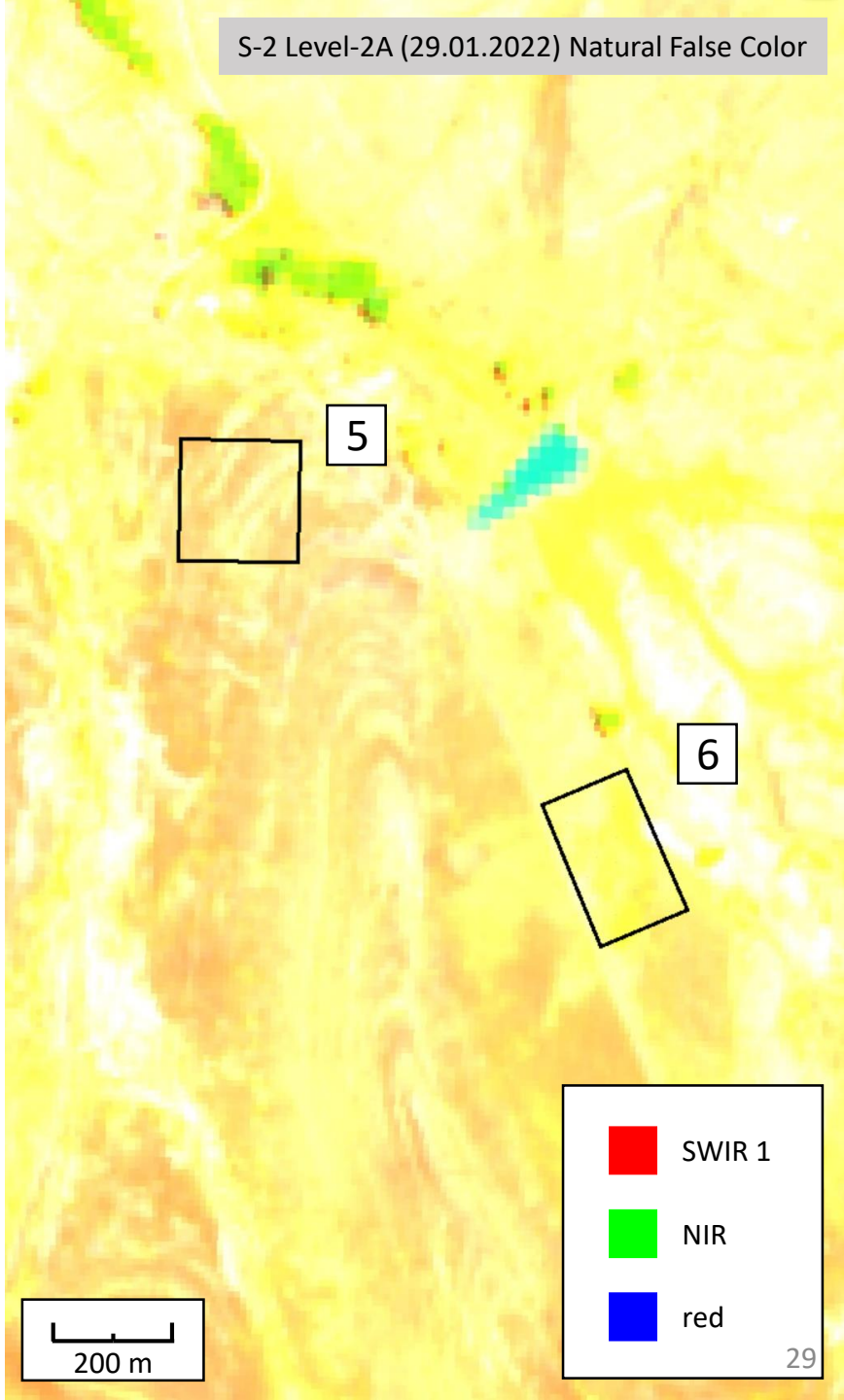

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Contrast in vegetation between summer and winter:

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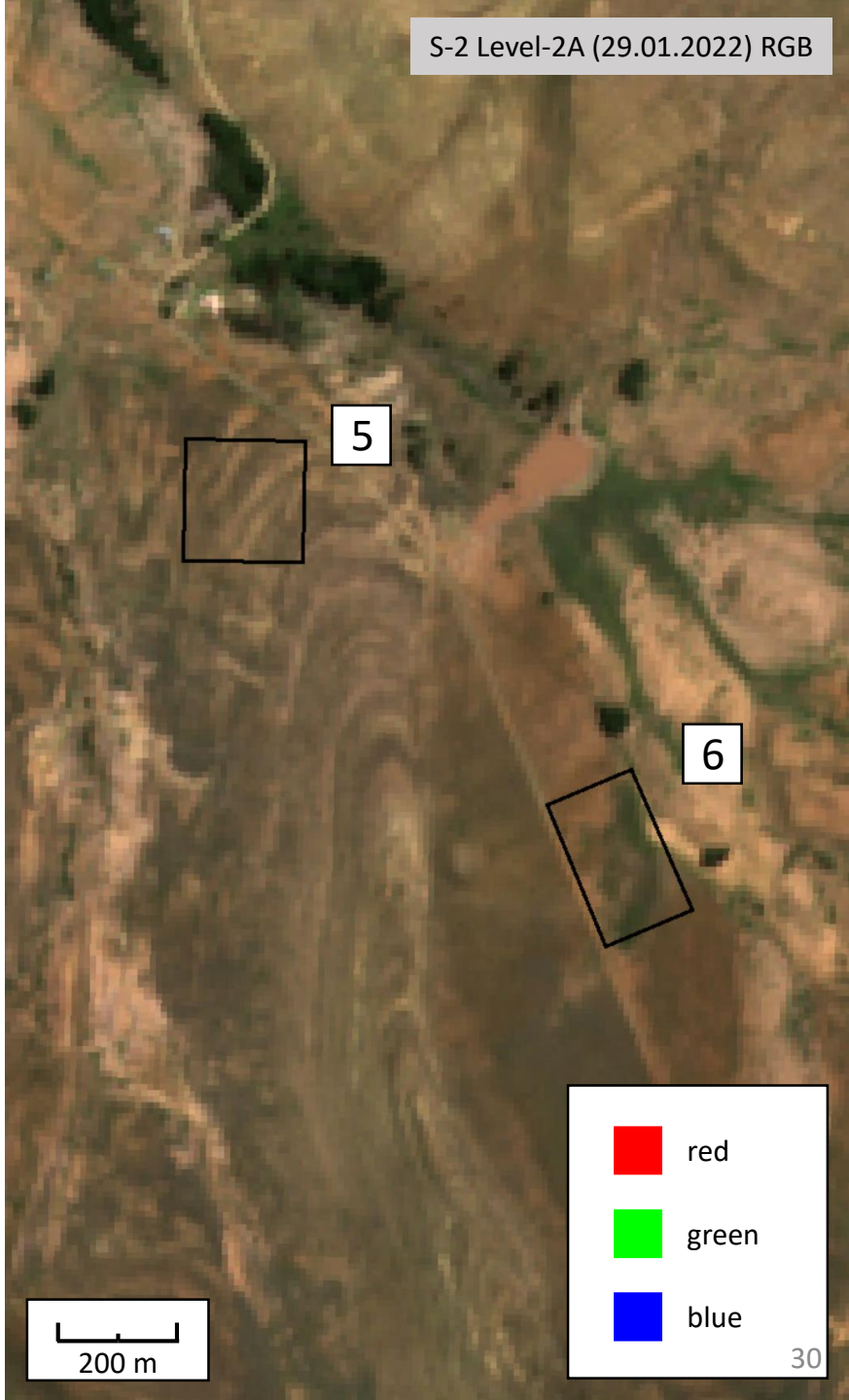
- Grasses die (annual) or dry out (perennial) in winter



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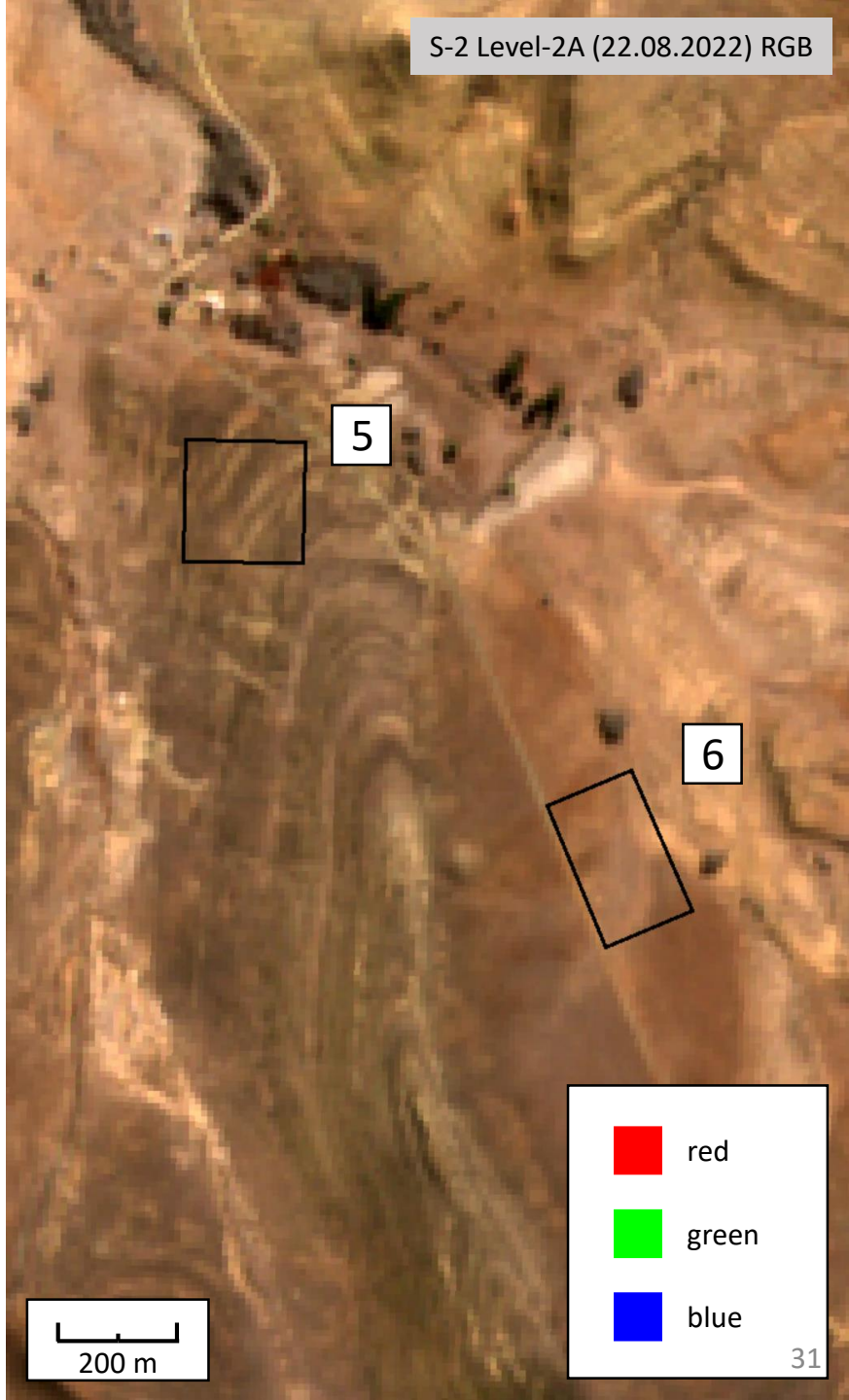

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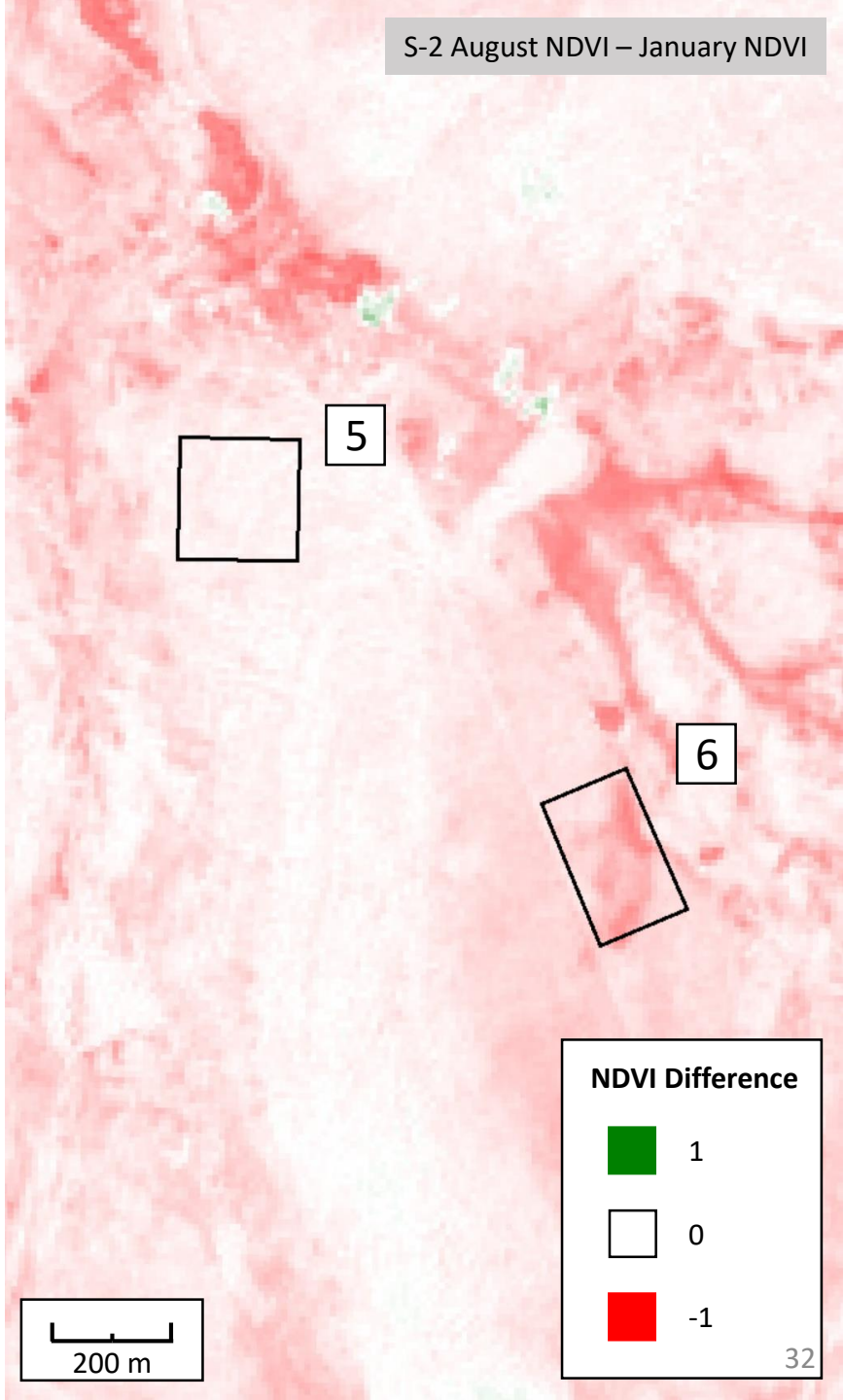
Compensation of coarse spatial with high spectral and temporal resolution



Outlook

Next fieldwork in January-February 2023

Expecting different conditions from 2022 (exceptionally wet year)

Fly same plots again from last year

New plots for accuracy assessment only (spatial extrapolation)

RGB and multispectral orthomosaic from airplane

Questions?

Literature

Boardman, J., I. D. L. Foster, K. M. Rowntree, D. T. Favis-Mortlock, L. Mol, H. Suich, and D. Gaynor. „Long-Term Studies of Land Degradation in the Sneeuberg Uplands, Eastern Karoo, South Africa: A Synthesis“. *Geomorphology* 285 (15. Mai 2017): 106–20. https://doi.org/10.1016/j.geomorph.2017.01.024.

Du Toit, Justin CO, and Timothy G O'Connor. „Changes in Rainfall Pattern in the Eastern Karoo, South Africa, over the Past 123 Years“. *Water SA* 40, Nr. 3 (29. Juli 2014): 453.

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Mucina, L., and M. C. Rutherford. „The Vegetation of South Africa, Lesotho and Swaziland.“ *The Vegetation of South Africa, Lesotho and Swaziland.*, 2006. https://www.cabdirect.org/cabdirect/abstract/20073221934.