

10TH ADVANCED TRAINING COURSE ON LAND REMOTE SENSING



Bark beetle damage detection with UAV, Sentinel-2 and MODIS in Slovenia
Andrej Kobler and Nikica Ogris (both Slovenian Forestry Institute)

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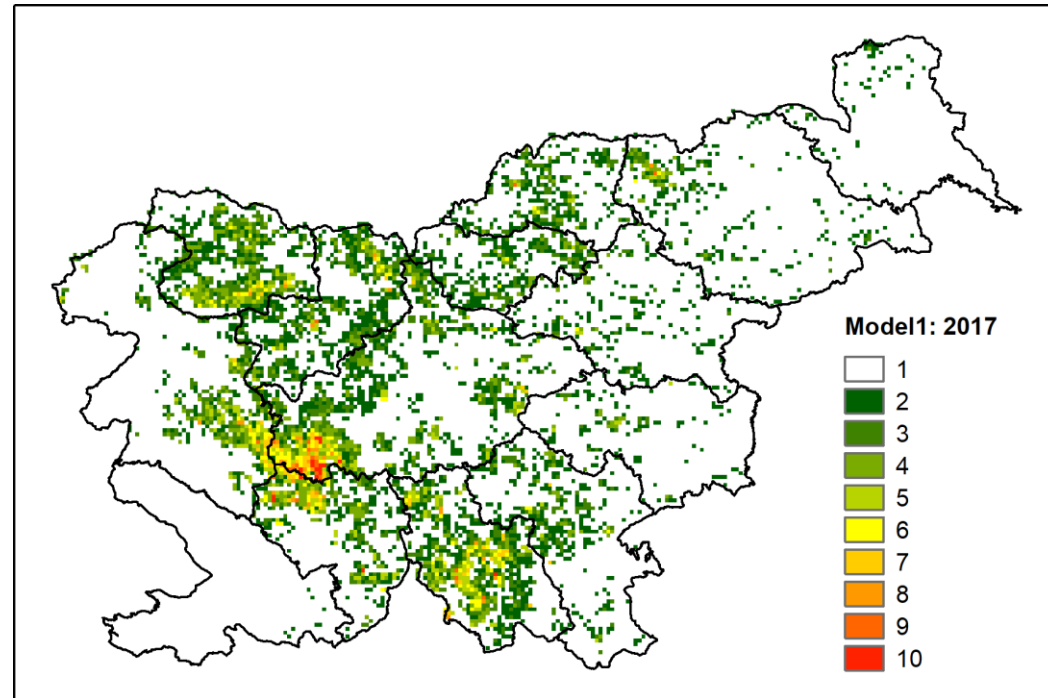
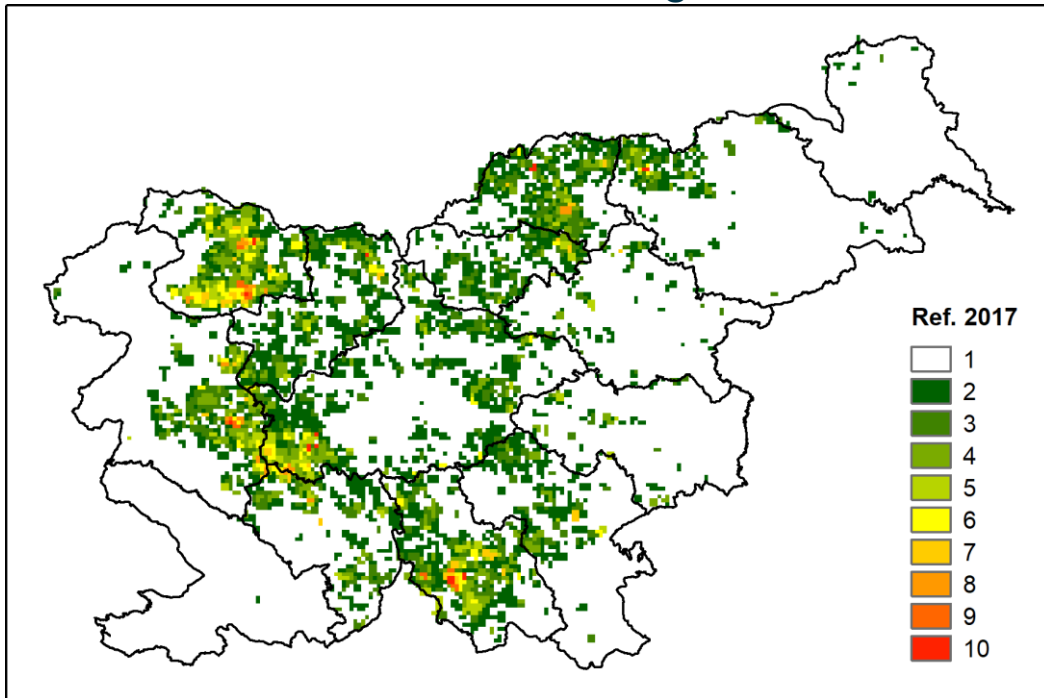
- Work Package 2 of the Project V4-1623 (Development of detection methods for injuries of coniferous trees due to spruce and fir bark beetles and development of forecasting models of spruce and fir bark beetles outbreaks in Slovenia) funded by the Ministry of Agriculture, Forestry and Food of Slovenia and by the Slovenian Research Agency
- Collaborators:
 - Andrej Kobler, Nikica Ogris, Andreja Kavčič, Matjaž Čater, Špela Planinšek, Jure Žlogar – Slovenian Forestry Institute
 - Tatjana Veljanovski, Peter Pehani, Žiga Kokalj – ZRC-SAZU
 - Marija Kolšek, Katja Kunc, Peter Čadež, Matej Kozamernik, Majda Petretič, Gregor Senegačnik, Barbara Slabanja, Klemen Zalokar – Slovenian Forestry Service
 - Milan Kobal – Biotechnical Faculty, University of Ljubljana
 - Jernej Moderer – C-astral
 - Janez Langus – ElevonX
 - Rok Valič – Geavis
 - Paulus Gernot - Fachhochschule Kärnten

To develop, test, and implement remote sensing-based models to forecast/monitor bark-beetle outbreaks in spruce and fir forests at three spatial levels:

- MODIS → Slovenia (~2M ha, resolution 1 sq. km)
- Sentinel-2 → Forest management unit (~10k ha, resolution 1 ha)
- UAV (C-astral Bramor + MicaSense camera) → Forest stand (~1 ha, resolution individual tree crown)

MODIS data to forecast the next-year sanitary felling

- **Modelled target variable:** yearly amount of sanitary timber felling in Slovenia due to spruce/fir bark beetles from 2003 to 2017 (aggregated at 1 sq. km from Slovenian Forestry Service xTi database)
- **Explanatory variables:** previous year MODIS 16-day composites of NDVI and EVI (at 250 m resolution), previous year mean monthly temperature and SPI values, elevation
- **Model:** random forest of 100 regression trees, 0.61 correlation between the true and the modeled values



Sentinel-2 data to monitor sanitary felling at regional level

Target variable:

- sanitary felling on a given date (from timber/felling database)

Explanatory variables:

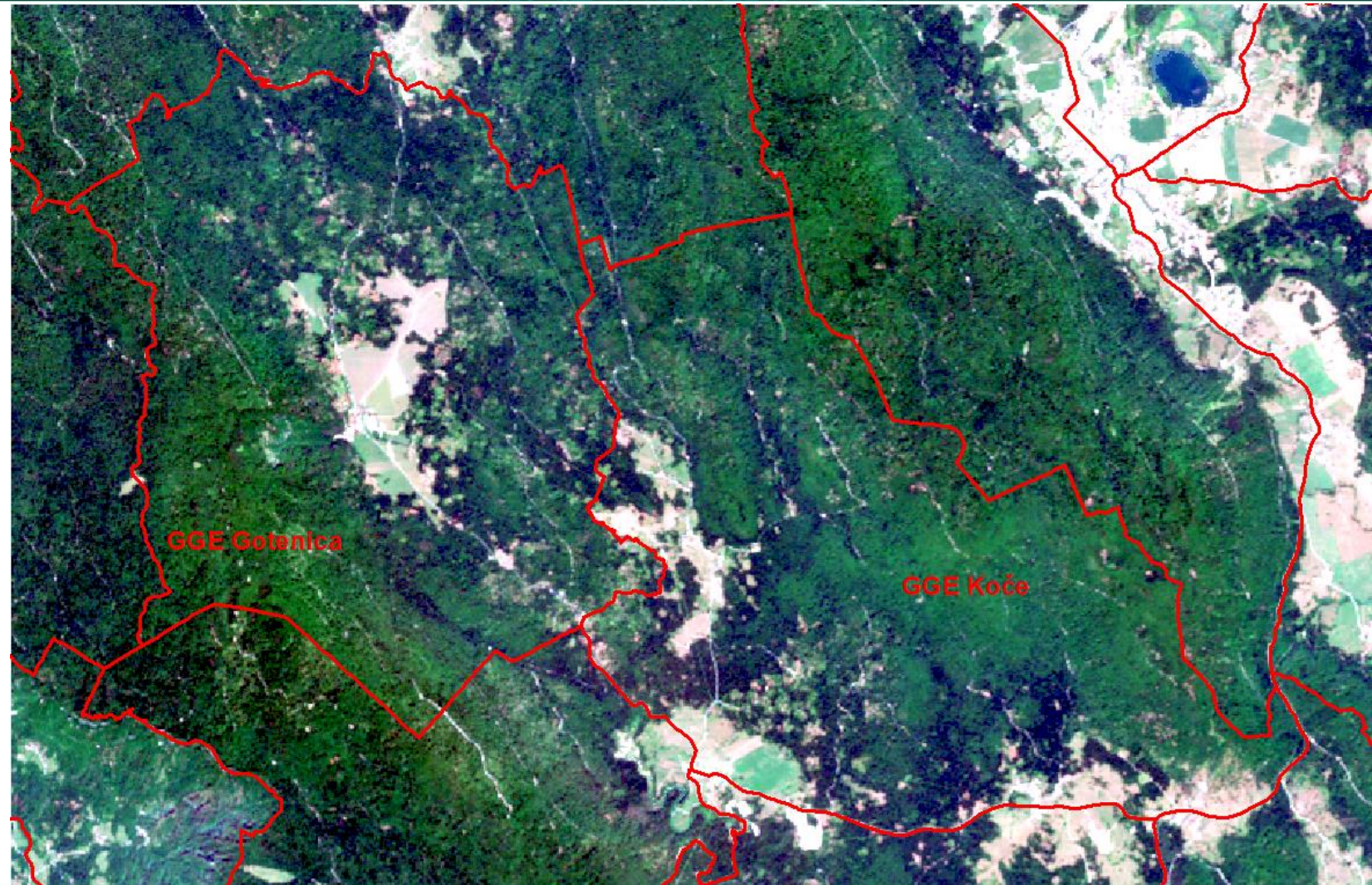
- 10 MS channels at 20 m resolution
- NDVI, EVI
- Consecutive day in year (→seasonal influence)
- Days between sanitary felling and the image acquisition

Model type:

- random forest

Sentinel-2 data preprocessing:

- Topographic & radiometric correction and cloud masking by ZRC-SAZU



Sentinel-2 data to monitor sanitary felling at regional level

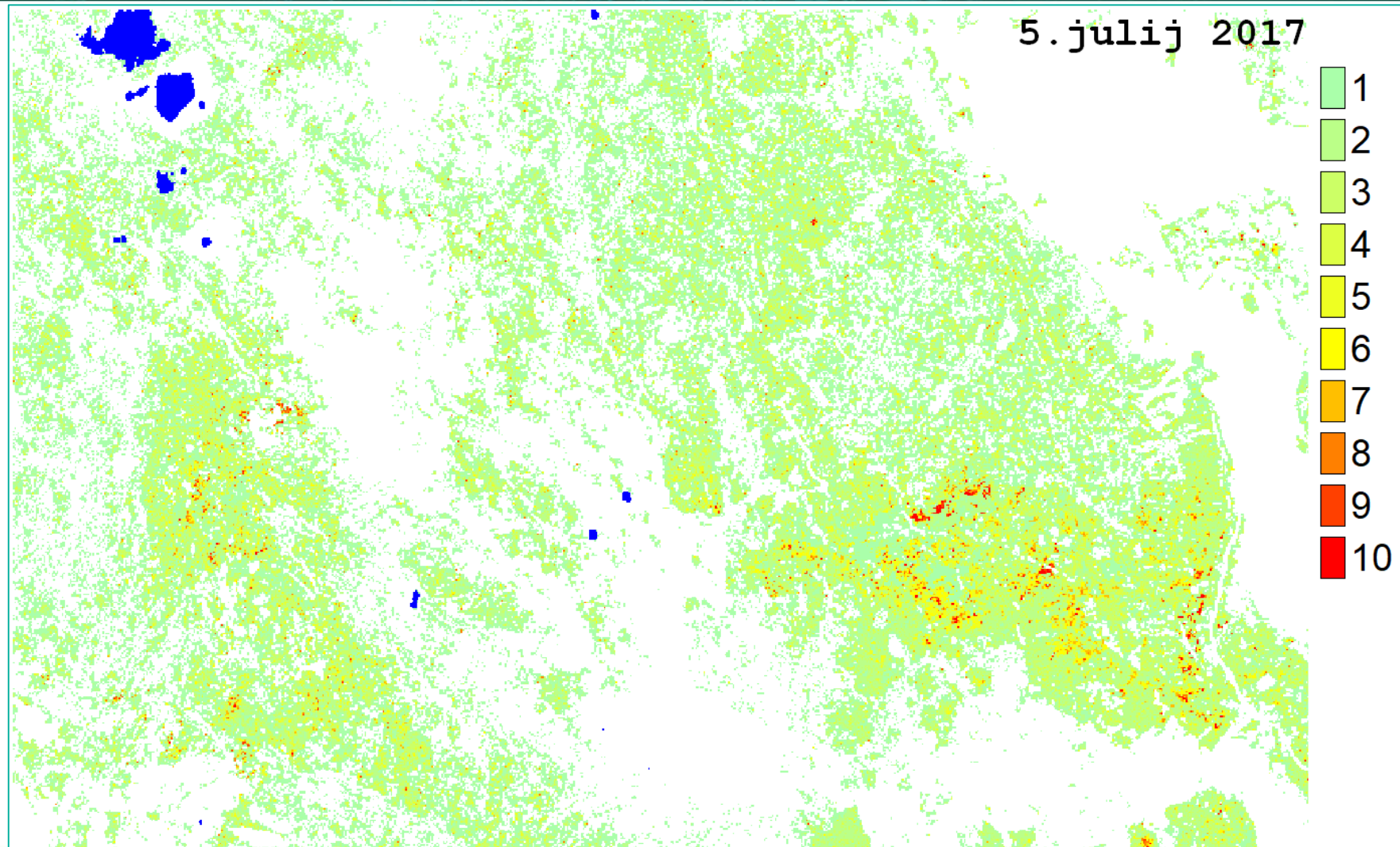
Correlation between true values of assigned sanitary felling volumes and model-based forecasts:

		Time interval before the date of assigning the forest stand for sanitary felling for the Sentinel-2 imagery to be used from				
		Up to 5 days	5 to 10 days	10 to 20 days	20 to 30 days	30 to 40 days
Number of Sentinel-2 pixels used to explain target variable value at the centroid of the felling area	1 pixel	0,50	0,57	0,46	0,56	0,26
	3x3 pixel neibourhood	0,72	0,78	0,71	0,72	0,72
	5x5 pixel neibourhood	0,76	0,82	0,75	0,78	0,76

Sentinel-2 data to monitor sanitary felling at regional level

Example of model-based identification of bark beetle-damaged forest stands in Kočevska region on July 5, 2017:

- Effective resolution of the model-based map: 1 ha.
- Correlation between true values and the model: 0.82
- Blue color indicates absence of Sentinel-2 data, i.e., clouds.



Individual tree level monitoring of bark beetle damage using UAV + MicaSense camera



UAV:

- C-Astral Bramor

Camera:

- MicaSense - 3 RGB channels + 2 IR channels
- Spatial resolution: 5 to 10 cm

Individual tree level monitoring of bark beetle damage using UAV + MicaSense camera

Two different random forest **models** were developed at a spatial level of individual trees:

- Tree crown defoliation (4 classes between no defoliation and dead tree)
- Tree crown discoloration (5 classes between no discoloration and dead tree)

Reference data:

- 513 spruce trees of all classes described and geolocated in the field

Explanatory variables:

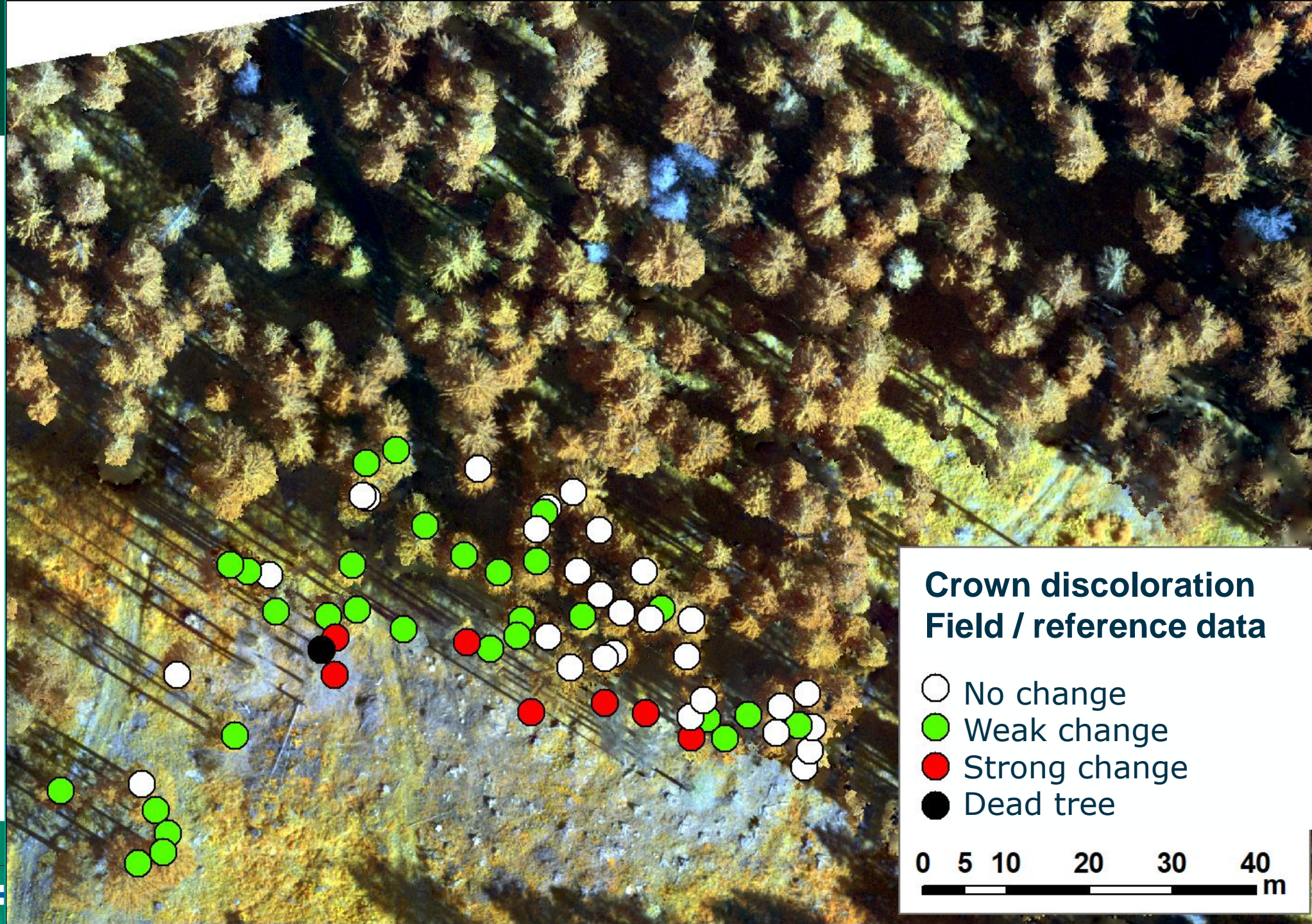
- MicaSense multispectral data
- NDVI, EVI
- Pixel value statistics around each tree for radius of 1 m, 2 m, 4 m, 8 m
- Consecutive day in the year to account for the seasonal effect

Tree-level training data
for crown discoloration

Micasanse camera

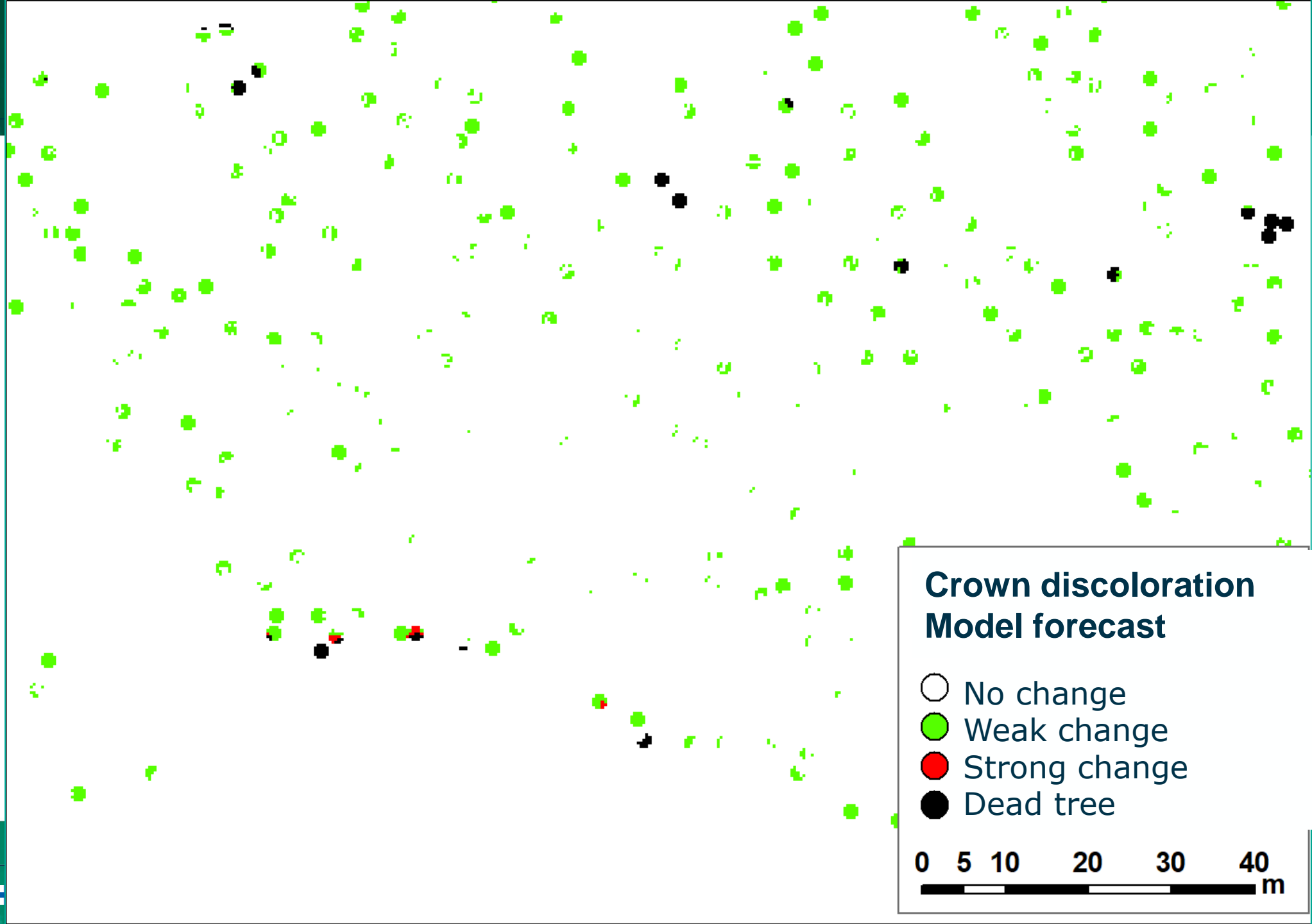
28 Avg 2018

Pokljuka



Tree-level map of
crown discoloration

Overall accuracy
based on error matrix:
75 %



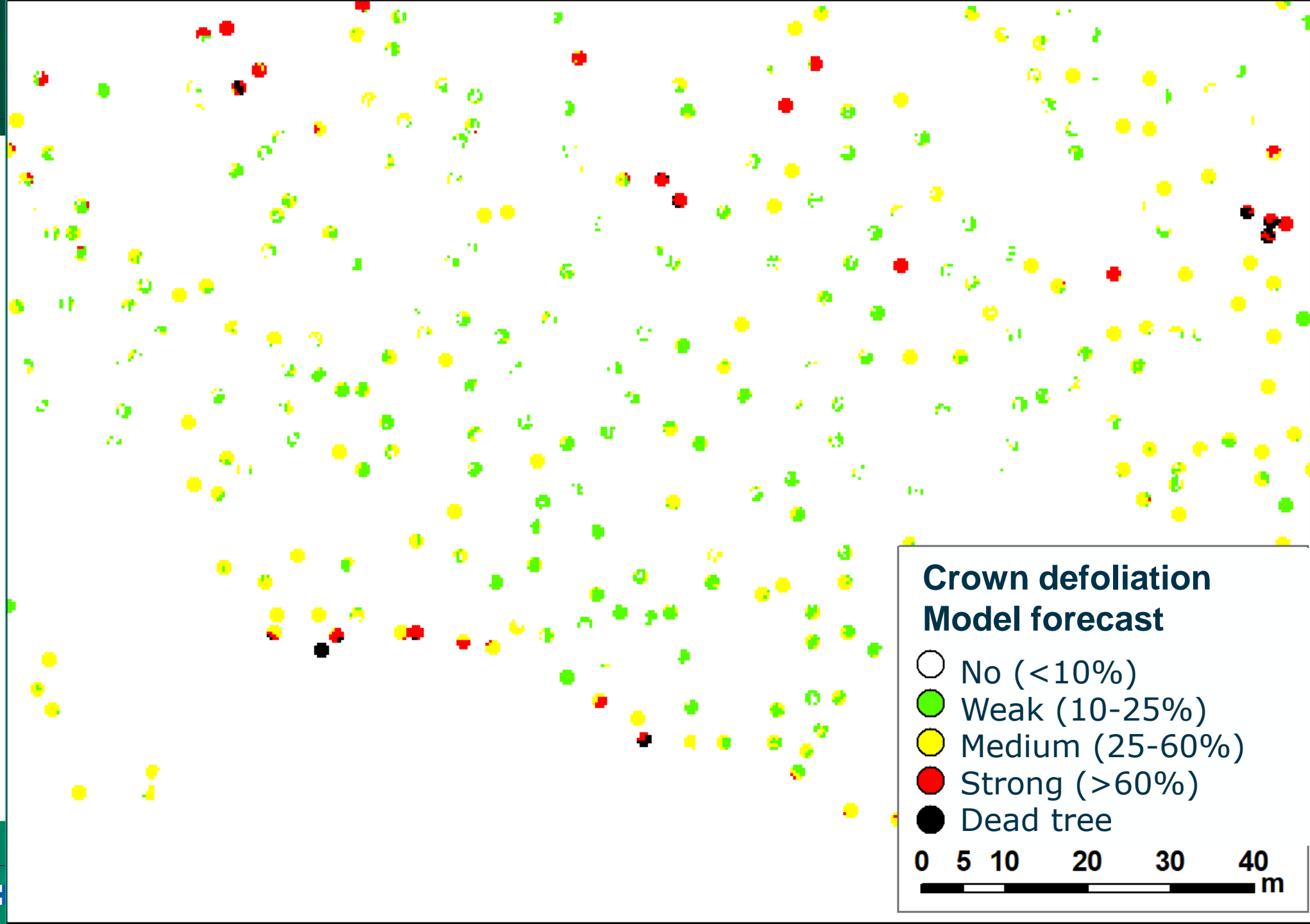
Crown discoloration Model forecast

- No change
- Weak change
- Strong change
- Dead tree

0 5 10 20 30 40 m

Tree-level map of
crown defoliation

Overall accuracy
based on error matrix:
52%



**Crown defoliation
Model forecast**

- No (<10%)
- Weak (10-25%)
- Medium (25-60%)
- Strong (>60%)
- Dead tree

0 5 10 20 30 40 m

A horizontal scale bar with tick marks at 0, 5, 10, 20, 30, and 40 meters. The bar is black with white tick marks and the unit 'm' at the end.

Thank you for your attention