



7. Spatio-temporal mapping of deforestation using multispectral data



From EO signal to forest information content

NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI)

- Very popular in eco/geosciences
- Output values between -1.0 and 1.0
- Very low values (0.1 and below) = barren areas of rock, sand, snow
- Moderate values (0.2 to 0.3) = shrub and grassland
- High values (0.6 to 0.8) = temperate and tropical rainforests

HEALTHY
VEGETATION REFLECTANCE

50% NIR 8% RED



NDVI = 0.72

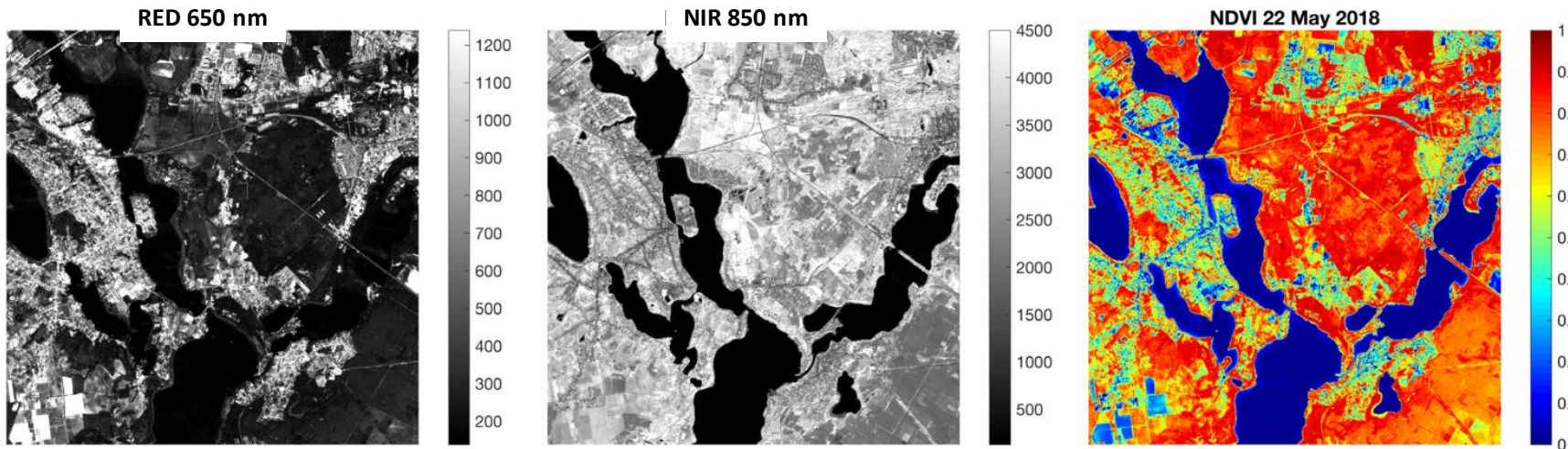
STRESSED
VEGETATION REFLECTANCE

40% NIR 30% RED



NDVI = 0.14

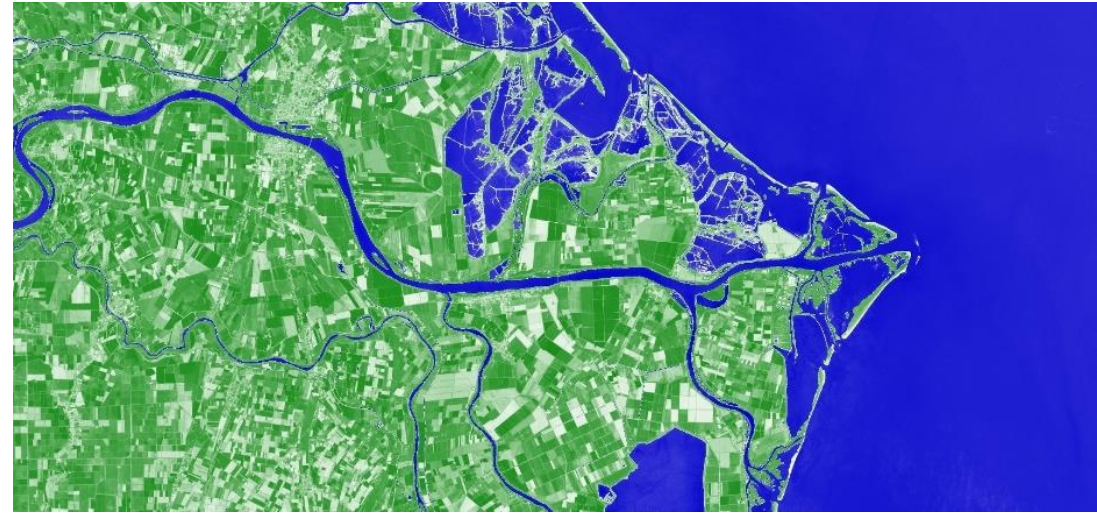
$$\text{NDVI} = \frac{\text{NIR} - \text{RED}}{\text{NIR} + \text{RED}}$$



From EO signal to forest information content

NORMALIZED DIFFERENCE WATER INDEX (NDWI)

- Highly correlated with canopy water content and more closely tracked changes in plant biomass than the NDVI
- Used to monitor changes related to water content in water/plant bodies
- As water bodies strongly absorb light in visible to infrared electromagnetic spectrum, NDWI uses green and near infrared bands to highlight water bodies
- Index values greater than 0.5 usually correspond to water bodies. Vegetation usually corresponds to much smaller values and built-up areas to values between 0 - 0.2

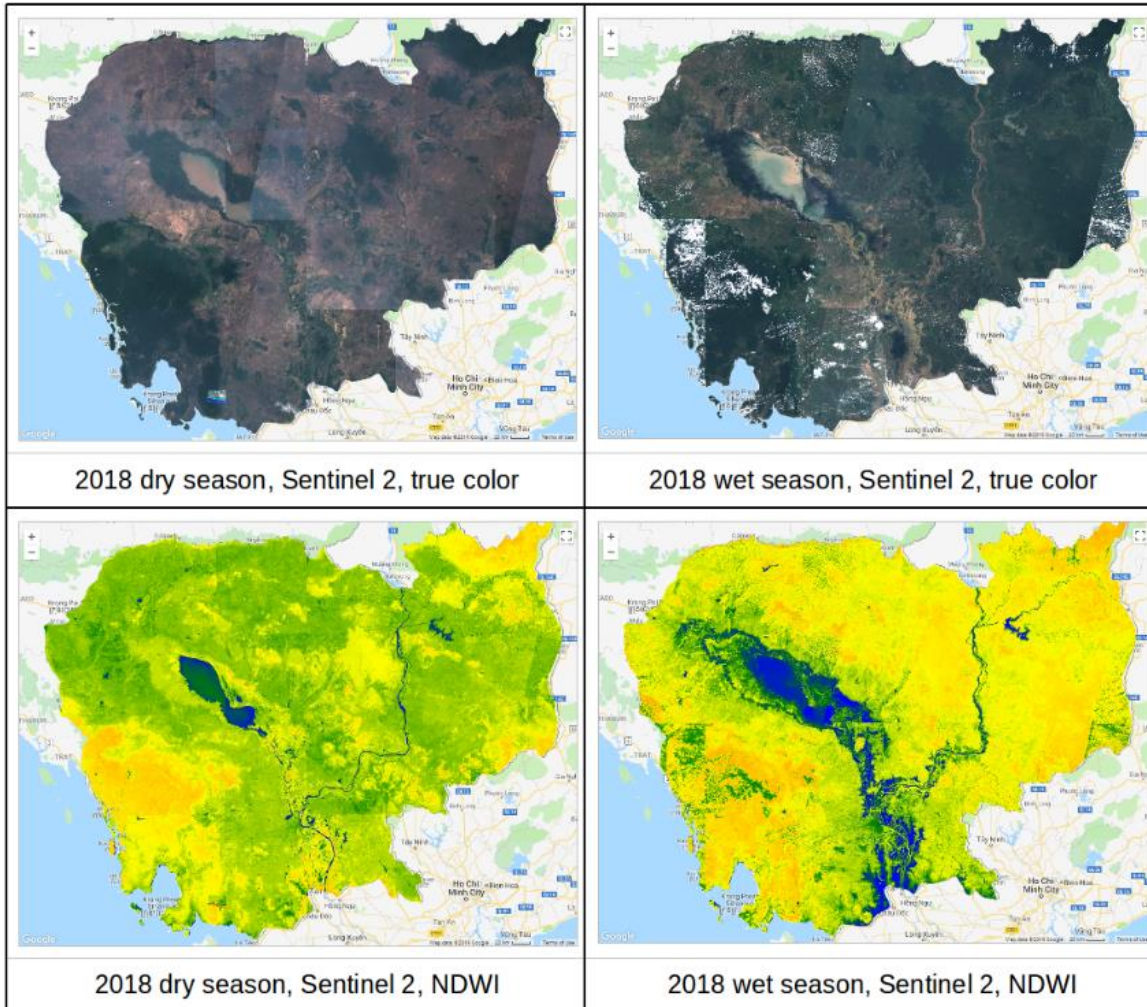


NDWI of Italy. Acquired on 2020-08-01.

$$\text{NDWI} = \frac{(\text{NIR} - \text{SWIR})}{(\text{NIR} + \text{SWIR})}$$

From EO signal to forest information content

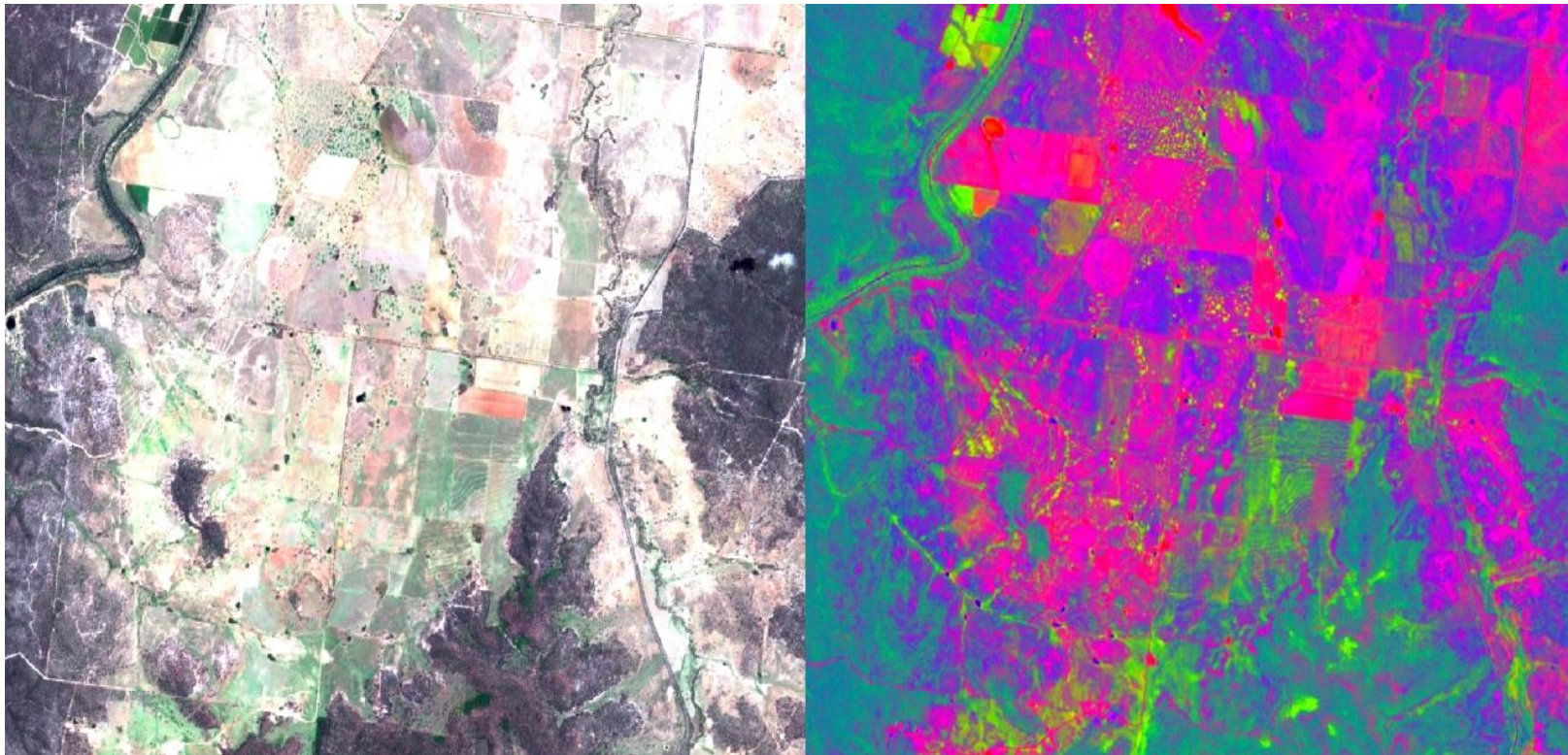
NORMALIZED DIFFERENCE WATER INDEX (NDWI)



From EO signal to forest information content

Fraction of green Vegetation Cover – FCover

- Corresponds to the fraction of ground covered by green vegetation
- Quantifies the spatial extent of the vegetation
- Independent of the geometry of illumination (unlike FAPAR)



The image on the left is a true-colour (red, green, blue) Sentinel-2 reflectance image. The darker areas are woodlands. The image on the right shows the same imagery, transformed using a model originally developed for Landsat which estimates fractional vegetation cover from the reflectance values. On each pixel, the proportions of red, green and blue represent the proportion of bare ground, live vegetation and dead vegetation respectively.

From EO signal to forest information content

Fraction of Absorbed Photosynthetically Active Radiation - FAPAR

- Quantifies the fraction of the solar radiation absorbed by live leaves for the photosynthesis activity.
- It refers only to the green and alive elements of the canopy
- Depends on the canopy structure, vegetation element optical properties, atmospheric conditions, and angular configuration

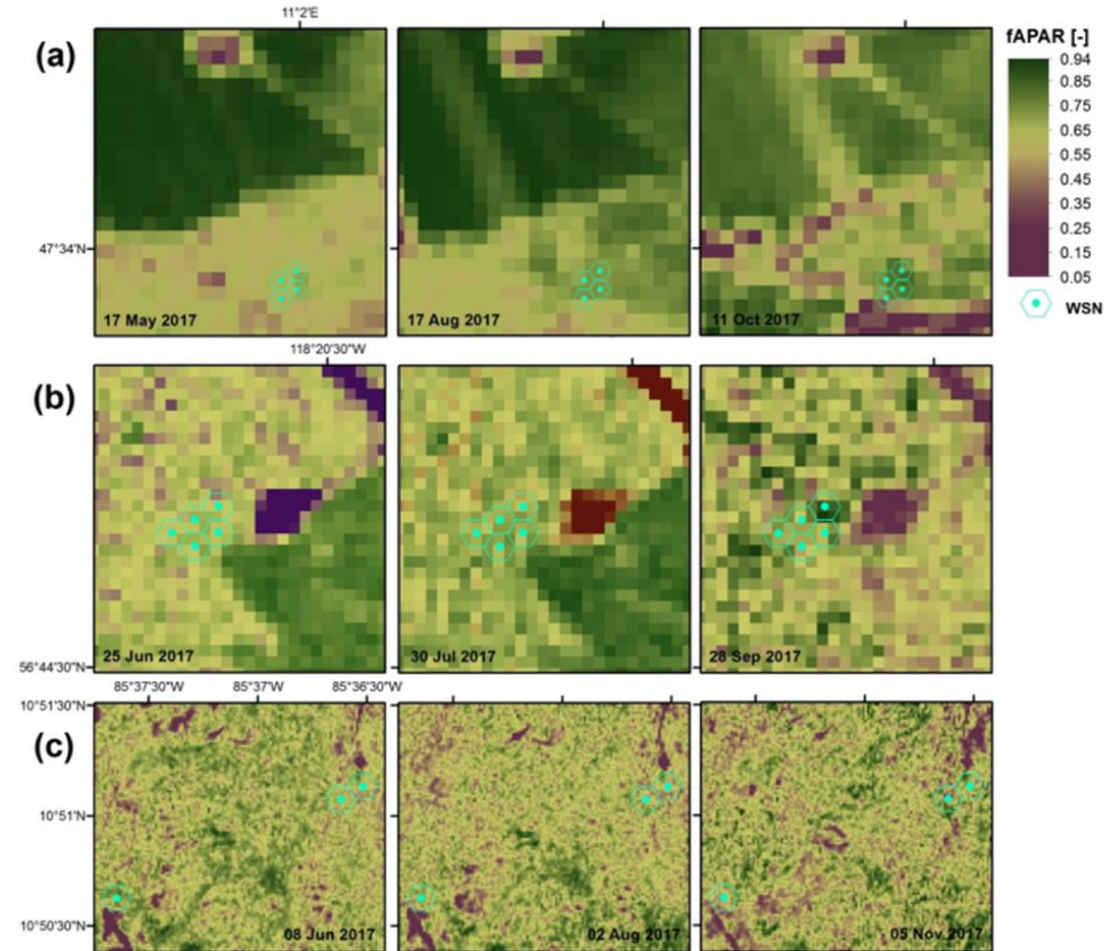


Fig. 7. The S2 FAPAR products at (a) Graswang, (b) Peace River and (c) Santa Rosa for several dates, representing early, peak and end of vegetation periods.

From EO signal to forest information content

Canopy Chlorophyll Content (CCC)

The **total amount of chlorophyll a and b pigments** in a contiguous group of plants per unit ground area (in g/m²)

- Closely related to the plant nitrogen content (fertilization)
- Absorption at 675 nm very sensitive to changes in chlorophyll content but only for low CCC values
- Lower chlorophyll absorption at 550 nm, sensitive to a greater range of CCC, not easily saturated but less sensitive to chlorophyll changes

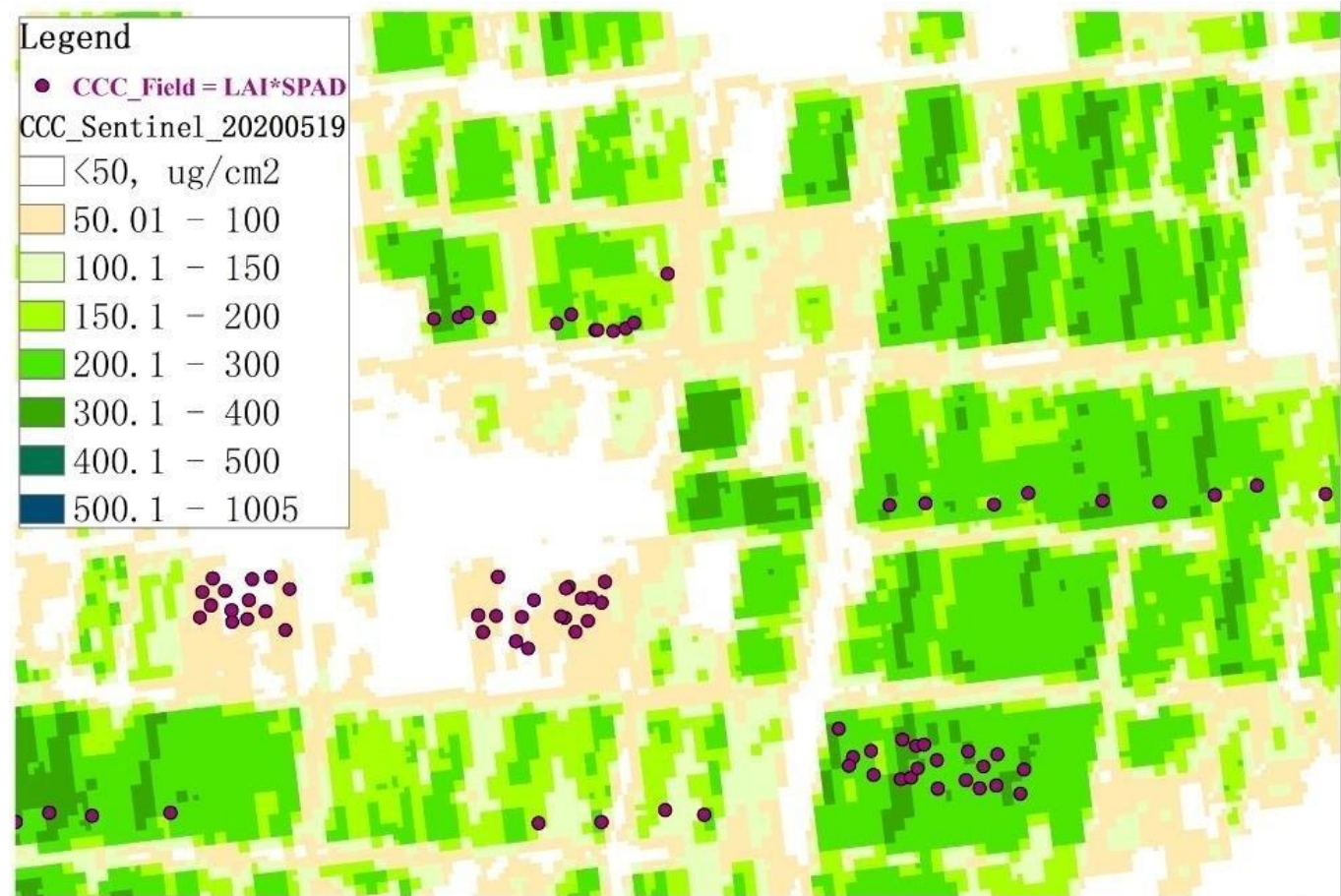


Figure 1 Winter wheat Crown Chlorophyll Content and sample sites in Yucheng, Shandong Province

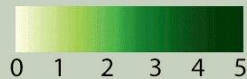
From EO signal to forest information content

LEAF AREA INDEX (LAI)

LAI is a dimensionless index measuring the one-sided green leaf area over a unit of land (m^2 / m^2).



Leaf Area Index (LAI)



750 m

Data from the Copernicus Sentinel-2 mission can be used to measure the 'leaf area index' of vegetation (left). This information can, in turn, be used to monitor crop growth and agricultural practices like harvesting. The animation shows the development of crop fields in Belgium between March and October 2016.

Deforestation

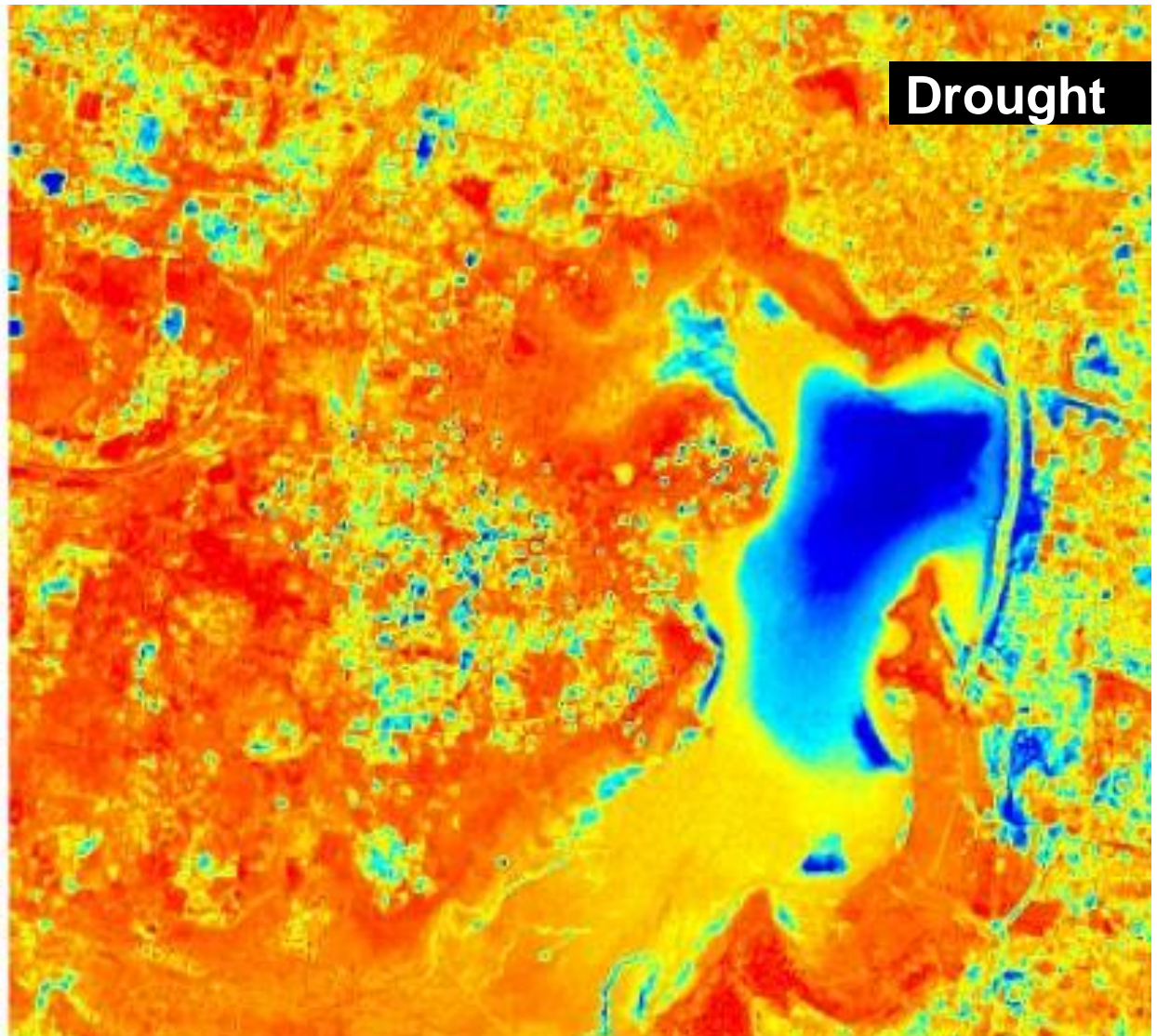
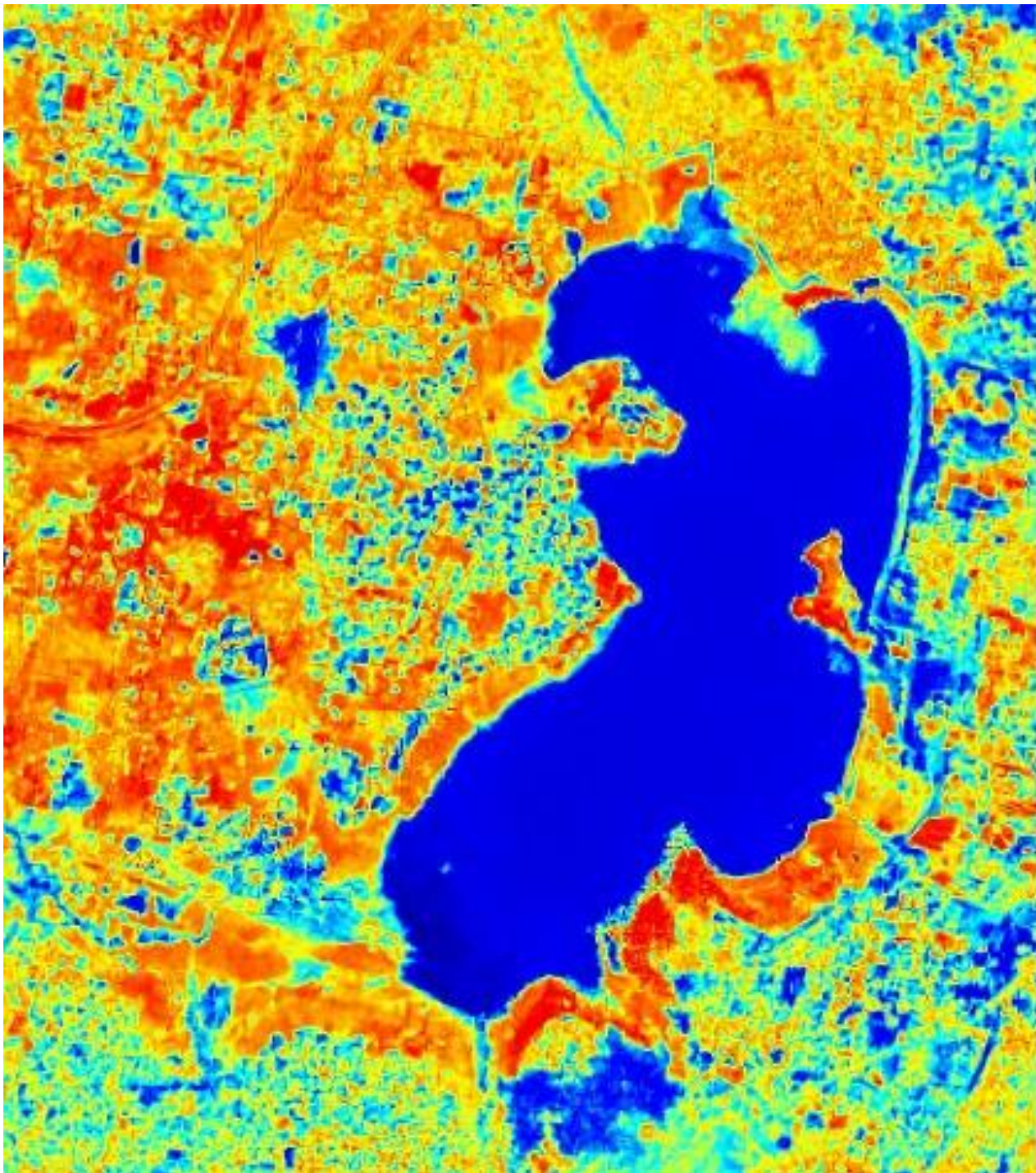
Rondônia, Brazil 1986





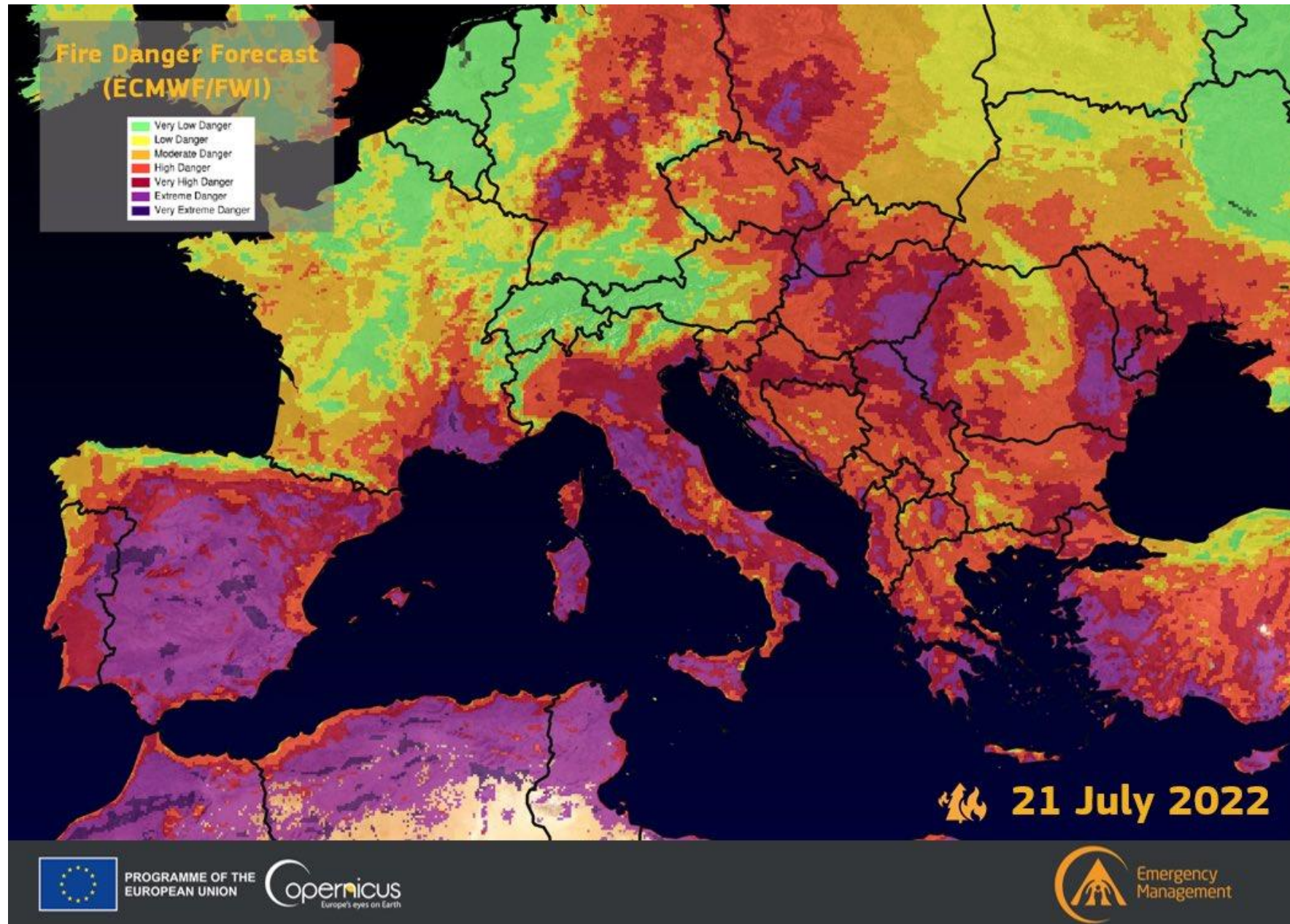
Deforestation

Rondônia, Brazil 2010
24 years of deforestation

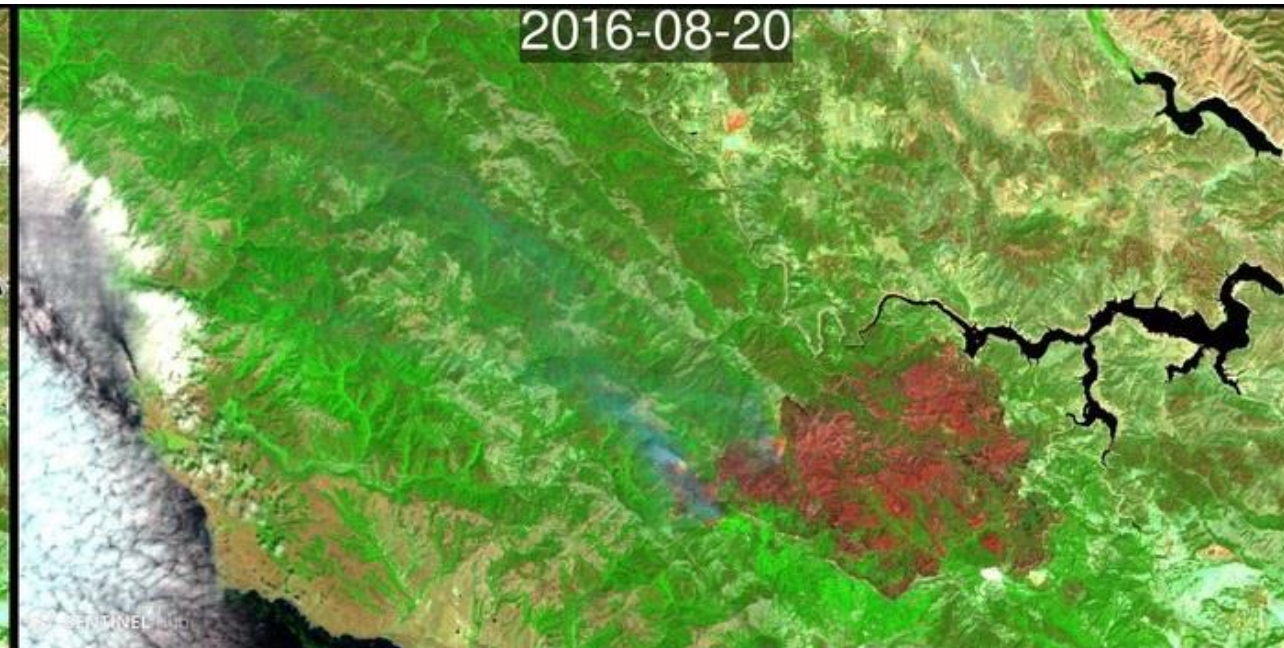


Sentinel-2 moisture index before (left) and during (right) the drought, showing the desiccation of the Red Hills Reservoir over the heat period in 2019 with a clearly retreating water line.

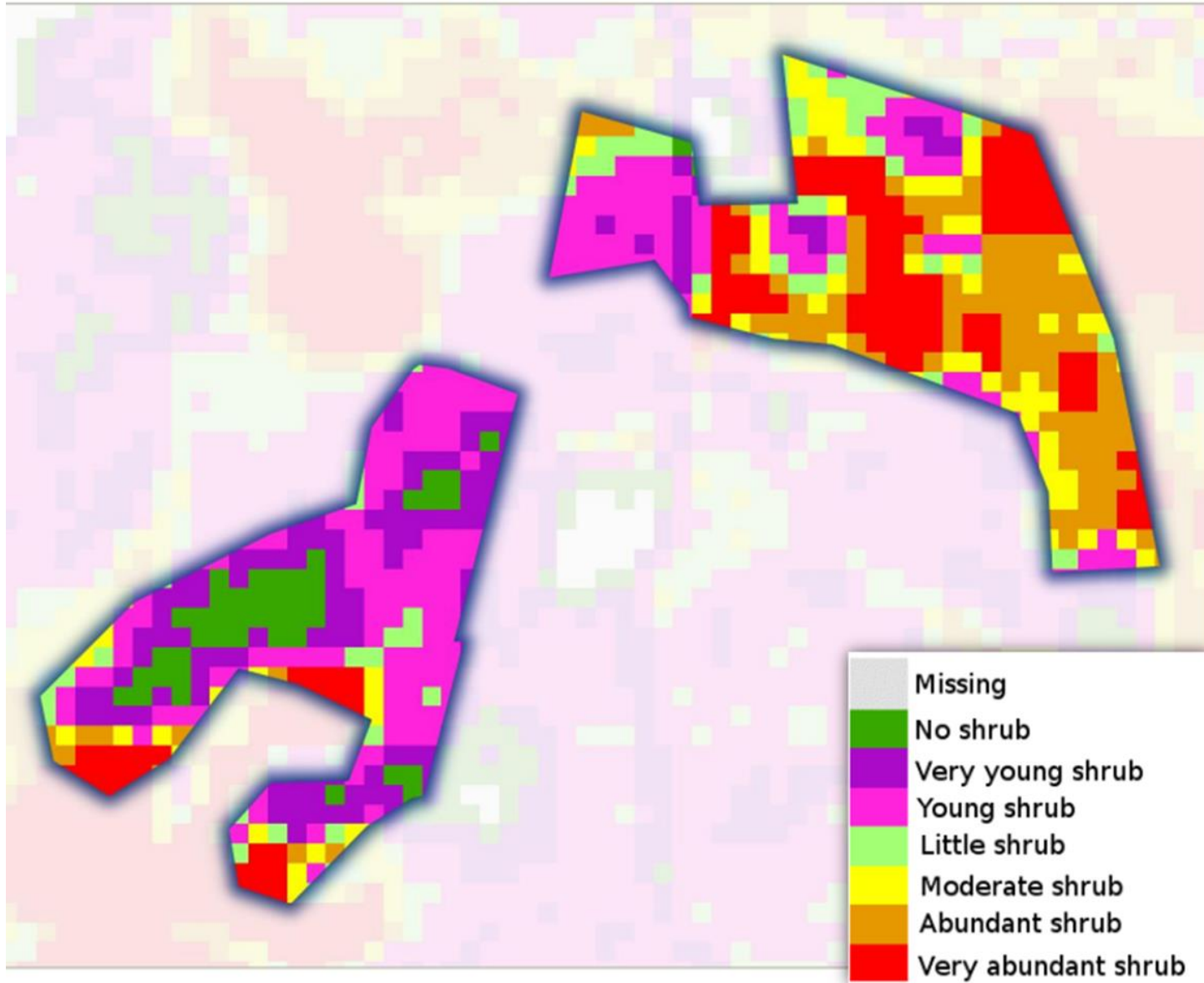
Emergency Management Service: Wildfires



Emergency Management Service: Wildfires



Information for Forest Management



Mapping of harmful broadleaved shrubs in forest regeneration areas based on Sentinel-2 data

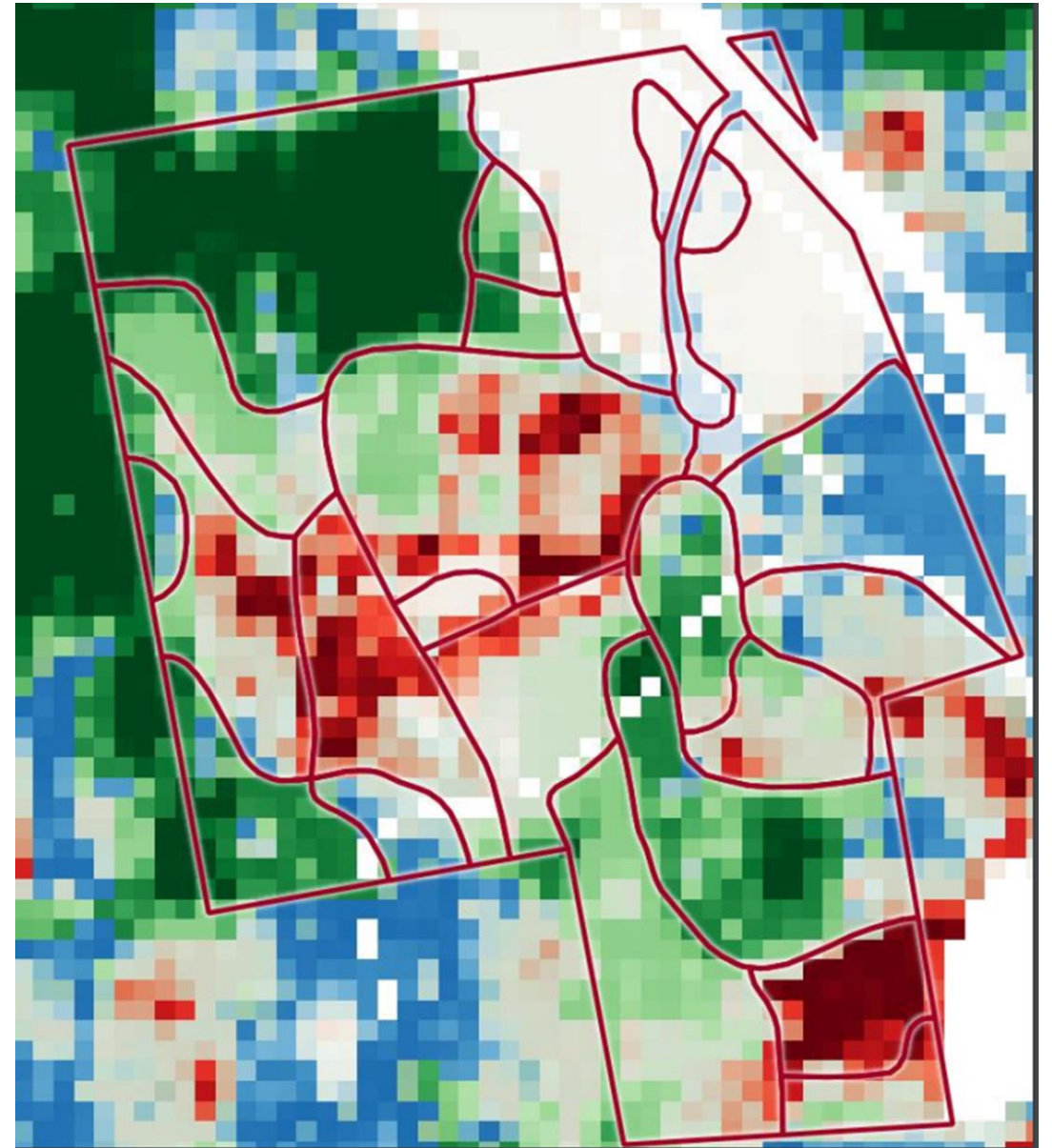
Information for Forest Management

- Stem volume per species

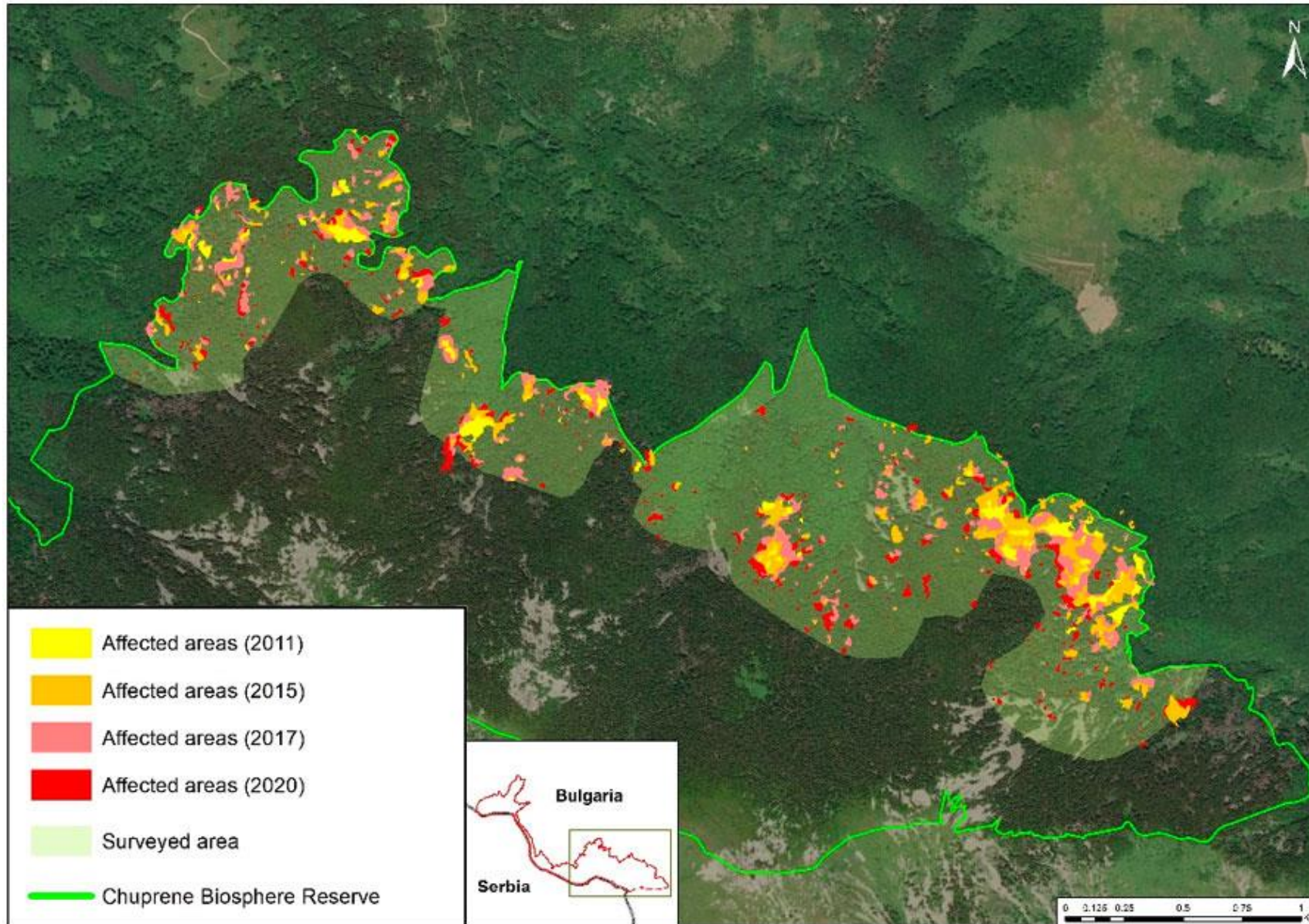
Red = Broadleaved

Blue = Pine

Green = Spruce



Detecting bark beetle damage



Bark beetle spots identified in the north-eastern area of the Chuprene Reserve.

Analysis determined from 2011 and 2015 airborne images; 2017 UAV images and 2020 satellite images

For more information, see the tutorial: [7. Spatio-temporal mapping of deforestation using Sentinel-2 data, comparison with high-resolution orthophoto imagery, using SNAP software](#)

Thank you for the attention