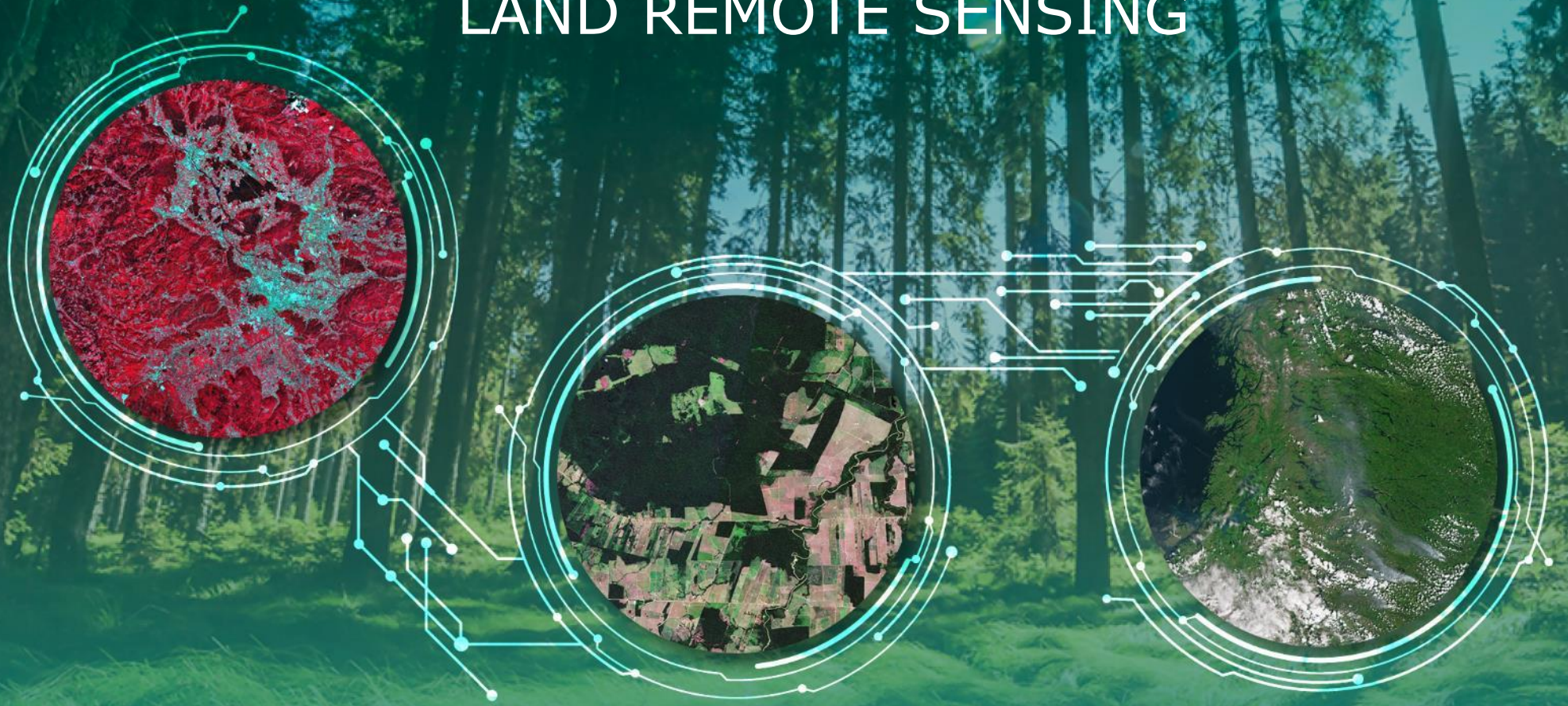
10TH ADVANCED TRAINING COURSE ON LAND REMOTE SENSING



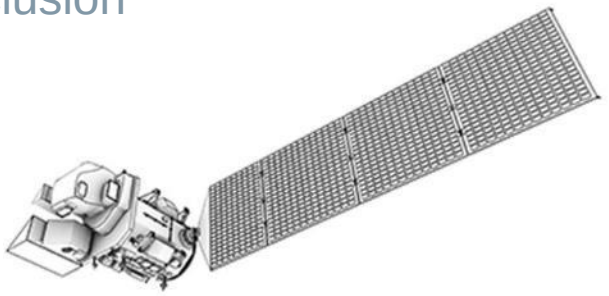
Observing forest regeneration using long term satellite image series

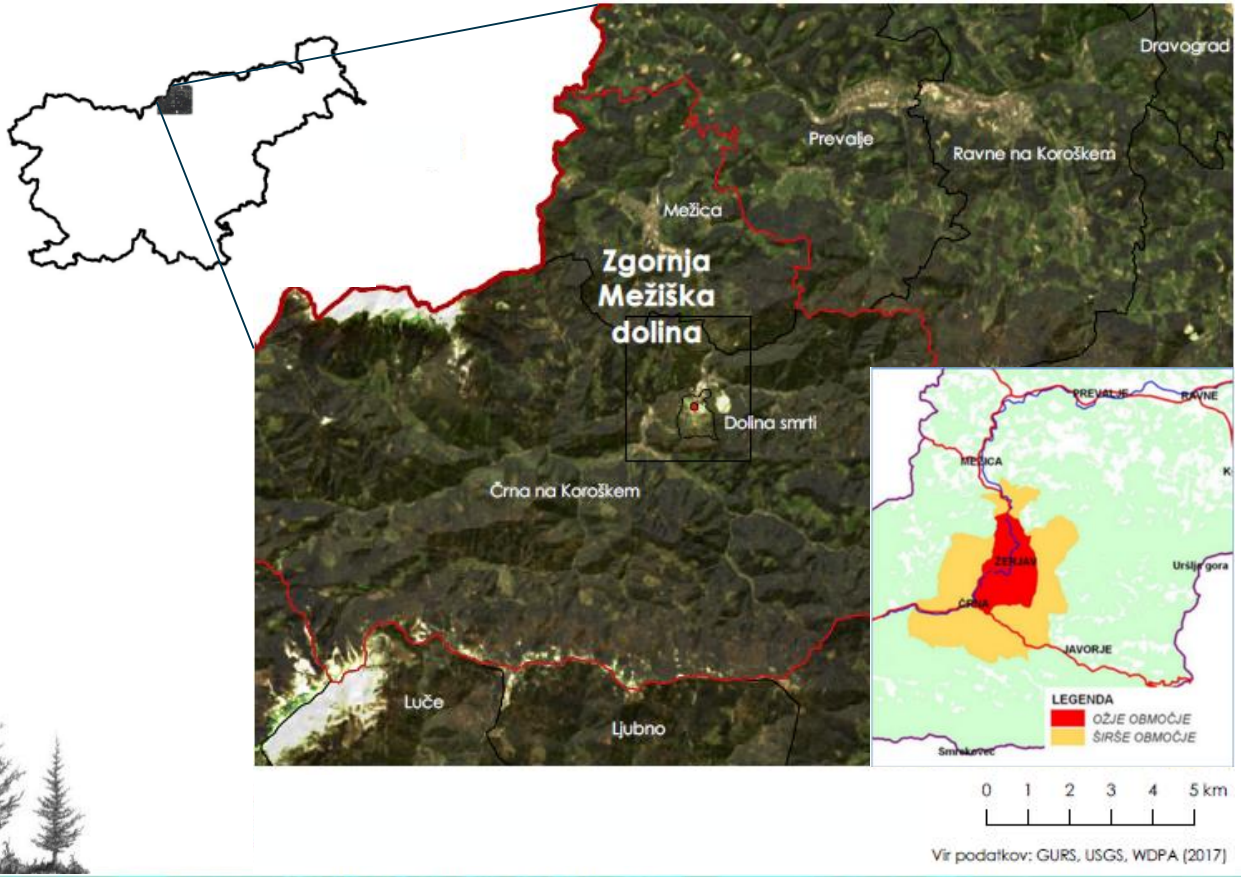
Krištof Oštir and Ana Potočnik Buhvald (UL FGG, Slovenia)

Ljubljana, 22.9.2021

Overview

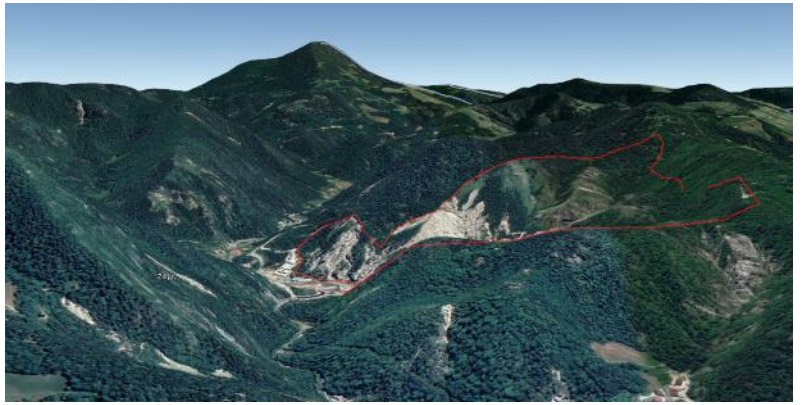
- Upper Meža Valley and Forest Regeneration with Remote Sensing (case study)
- Long Term Satellite Image Time Series (1984 – 2016)
- Methods – BFAST Monitor
- Results (pixel and spatial time series)
- Conclusion

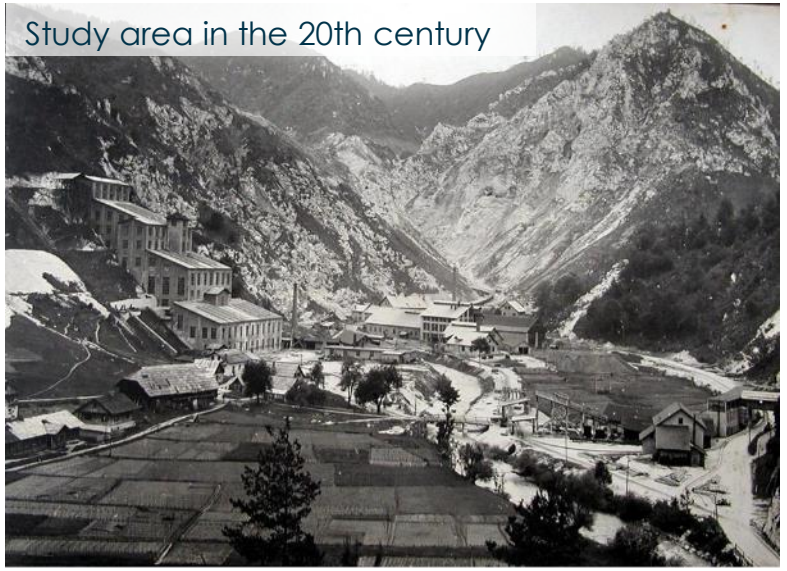


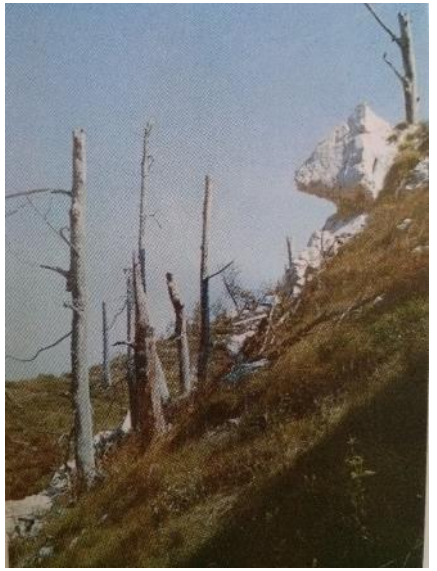


Upper Meža Valley (The Death Valley) and Forest Regeneration

- applicability of SITS for monitoring forest regeneration
- study area is located in the polluted former mining site in the Upper Meža Valley, near the lead smelter in Žerjav, Slovenia
- sensitive Alpine forest area was exposed to extreme pollution until 1994
- remediation activities started after 1994 (forests play a protective function)

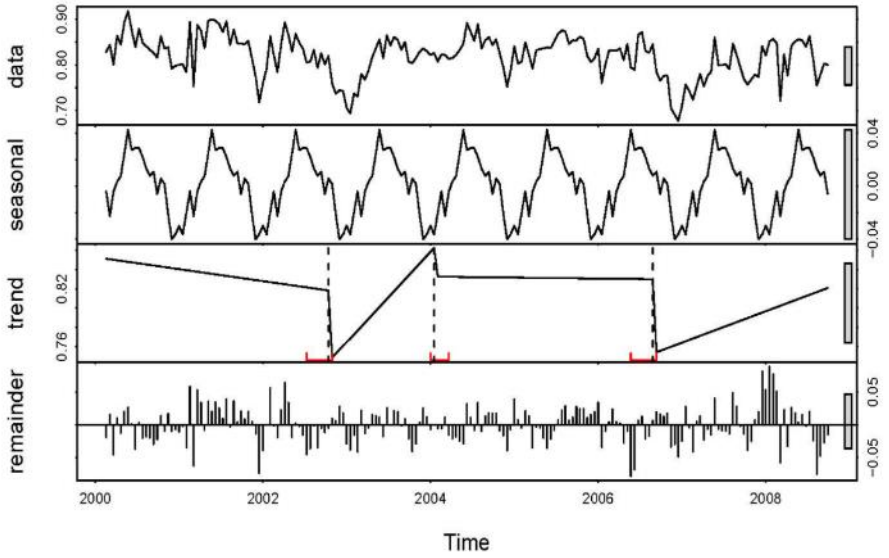




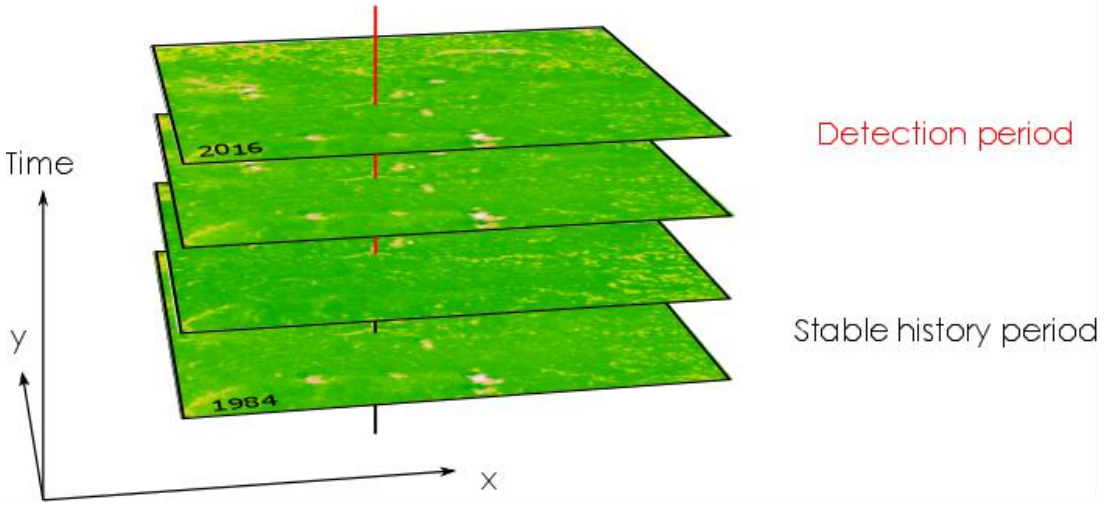


Long Term Satellite Image Time Series

- ability to identify changes over time with long term Landsat satellite data sets (1984 – 2016)
- Normalized Difference Vegetation Index (NDVI) as an input variable
- existed processing methods and algorithms (BFAST Monitor)
- to investigate temporal changes in trend and seasonal components, via breakpoint detection

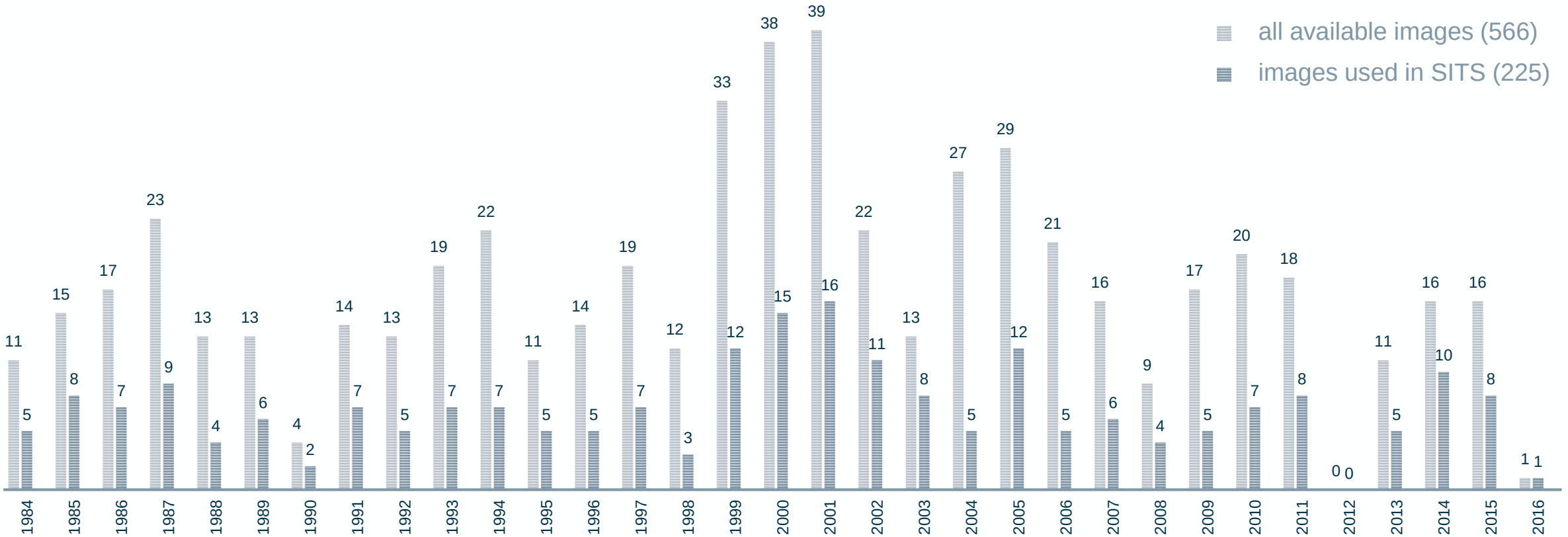


https://bfast.r-forge.r-project.org/



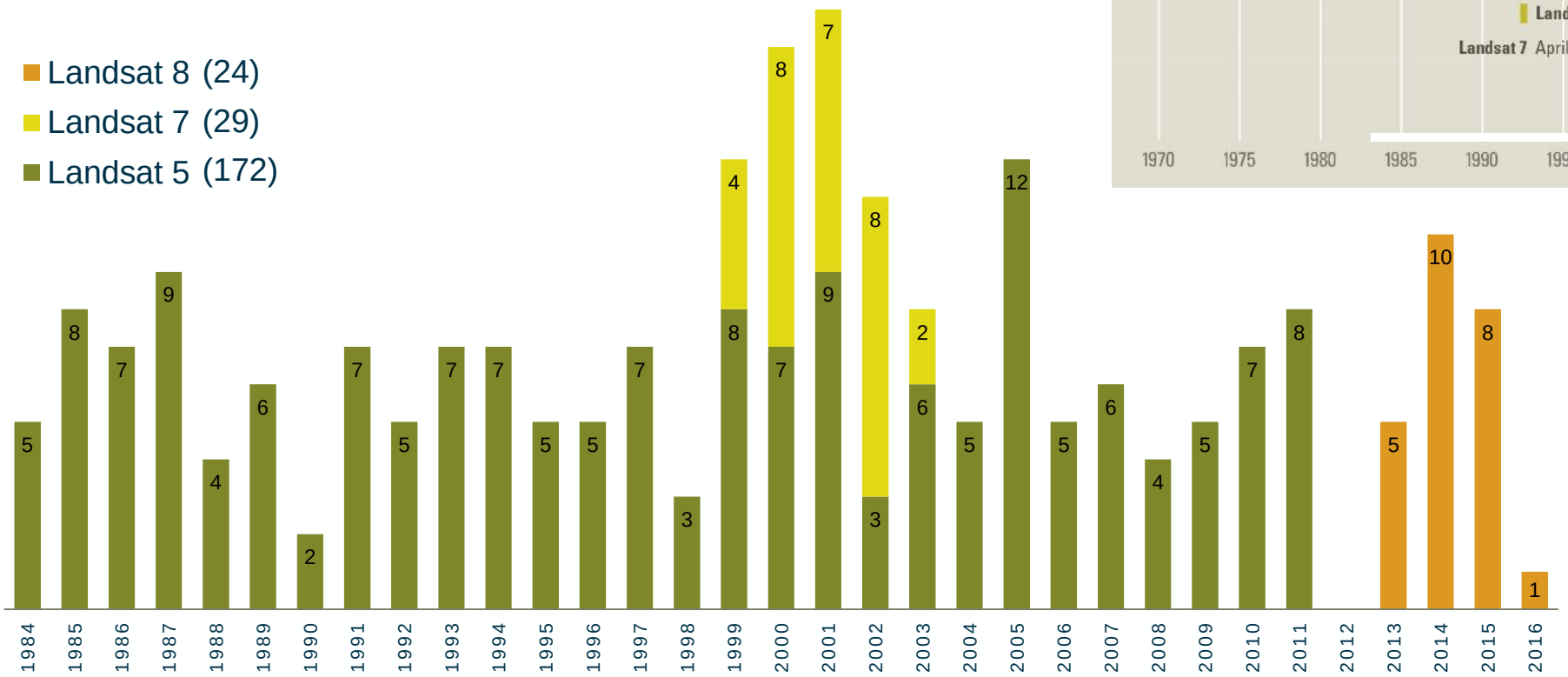
Long Term Satellite Image Time Series

- we use in SITS all images with cloud cover less than 30 %

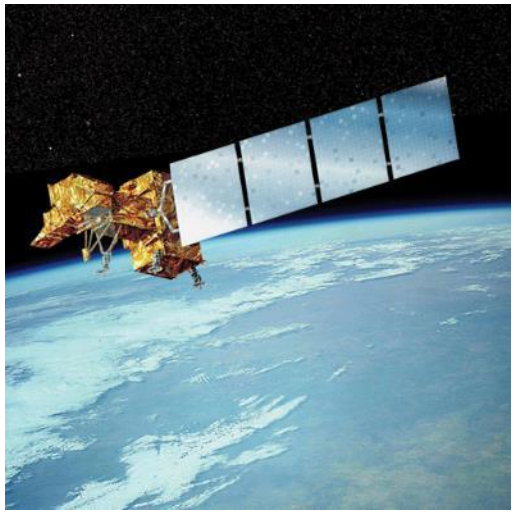


Landsat Satellite Image Time Series

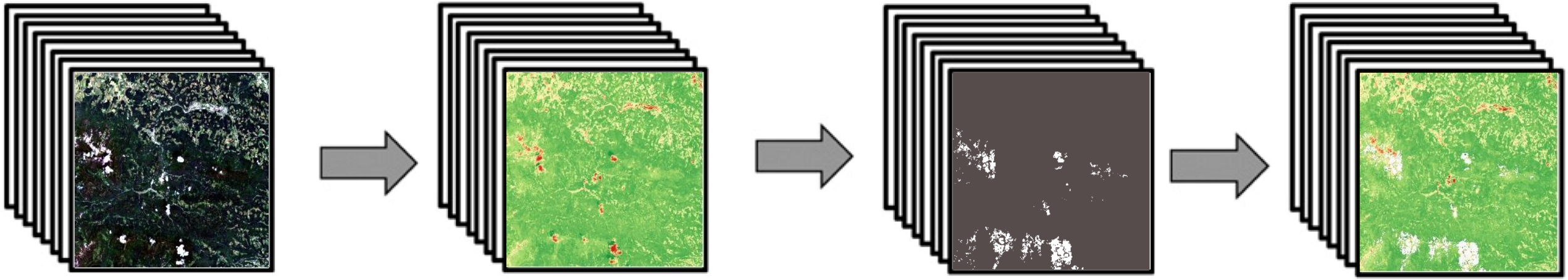
- 225 images in SITS raster stack



Source: USGS - USGS Landsat Timeline



Landsat Satellite Image Time Series – preprocessing data



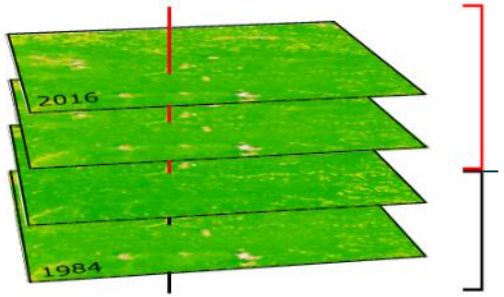
Landsat images

NDVI

cloud mask

masked NDVI

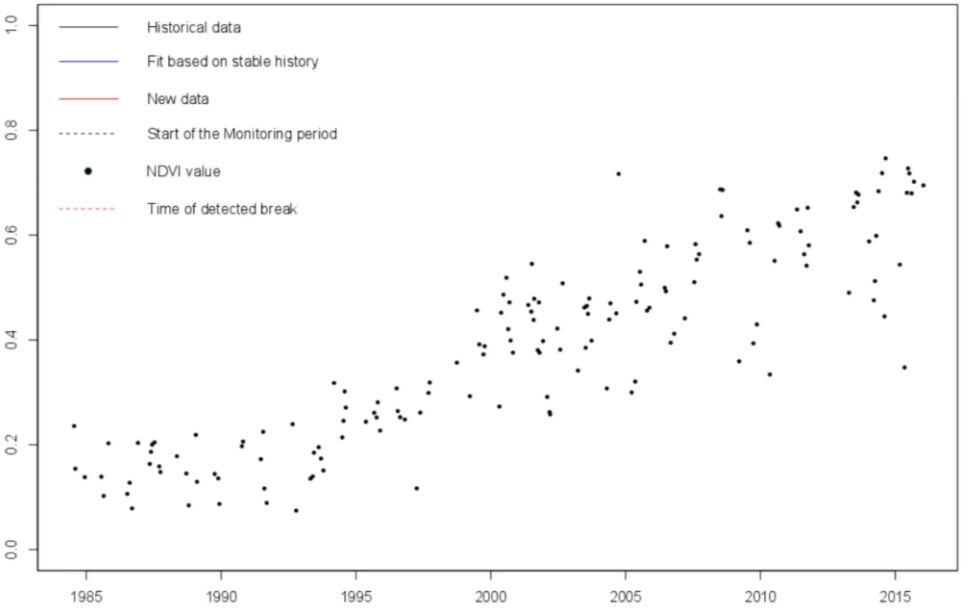
BFAST (Breaks For Additive Seasonal and Trend) Monitor



Monitoring period

start of the monitoring period

Historical data



Model can be used:
- season-trend,
- harmonic,
- trend.

$$Y_t = T_t + S_t + e_t,$$
$$t \in 1, \ldots, n$$

t	time series,
Y_t	observed data at time t,
T_t	**trend component**,
S_t	**seasonal component**,
e_t	remainder component.

$$T_t = \alpha_1 + \alpha_2 * t$$

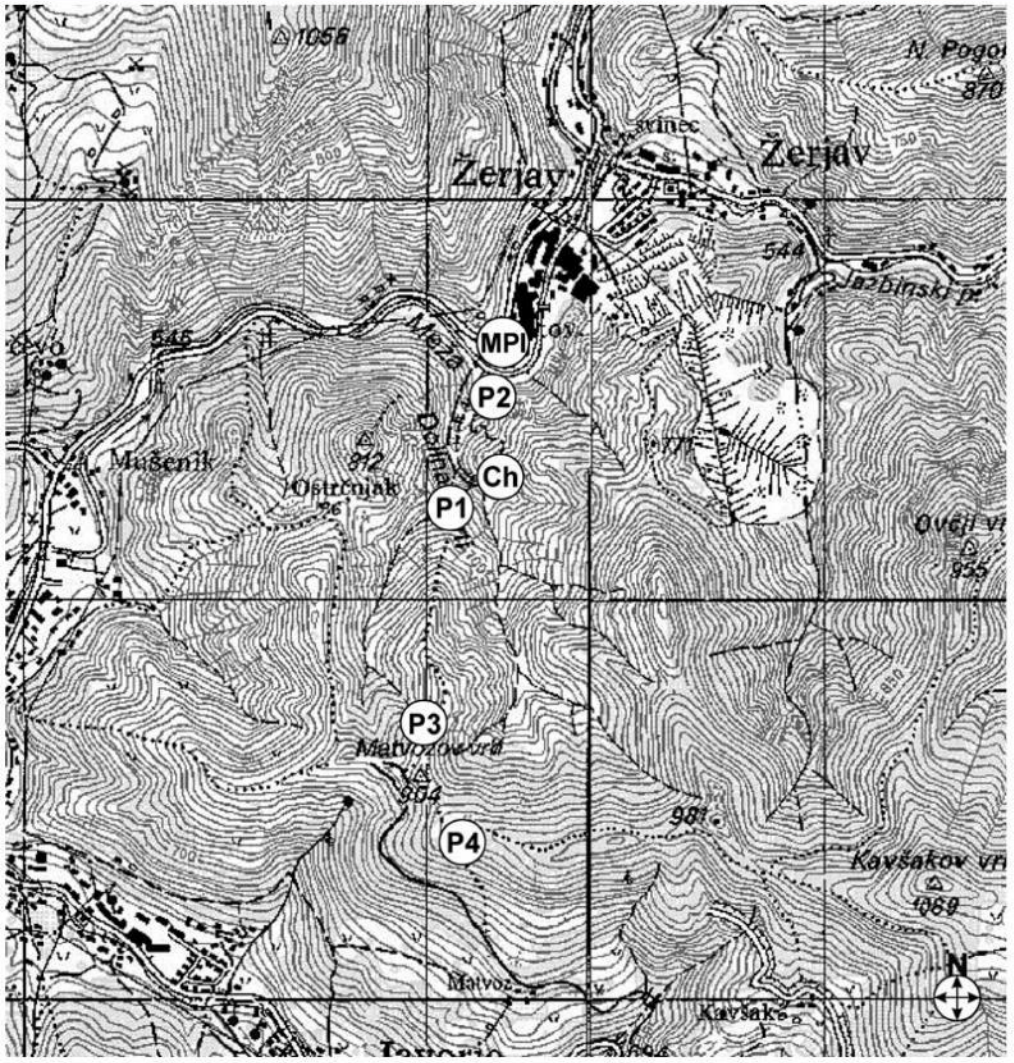
α_1	magnitude of the abrupt change,
α_2	direction of the abrupt change.

$$S_t = \sum_{j=1}^{k} \gamma_j * \sin\left(\frac{2\pi j t}{f} + \delta_j\right)$$

γ_j	amplitude,
δ_j	phase,
f	frequency of the time-series.

bfast (r-project.org)

Pixel time series analysis of regeneration



- plots P1, P2 and P3 of about 300 m2 each were selected at different distances from the lead smelter (previous research about revegetation, vegetational successions at a metal polluted site)
- soils are stony of rendzina type with various humus layers polluted with heavy metals, particularly lead, cadmium and zinc
- P1- plot with the highest lead concentration levels showed substantially reduced plant cover (predominated herbs species)
- P2 - is located near abandoned lead mine entrances with patches of vegetation (predominated grass species)
- P3 - is located about 500 m from the smelter, with closed vegetation (predominated tree species)


Mainuartia gerardii


Heliosperma pusillum

herbs species


Sesleria caerulea


Calamagrostis varia

grass species

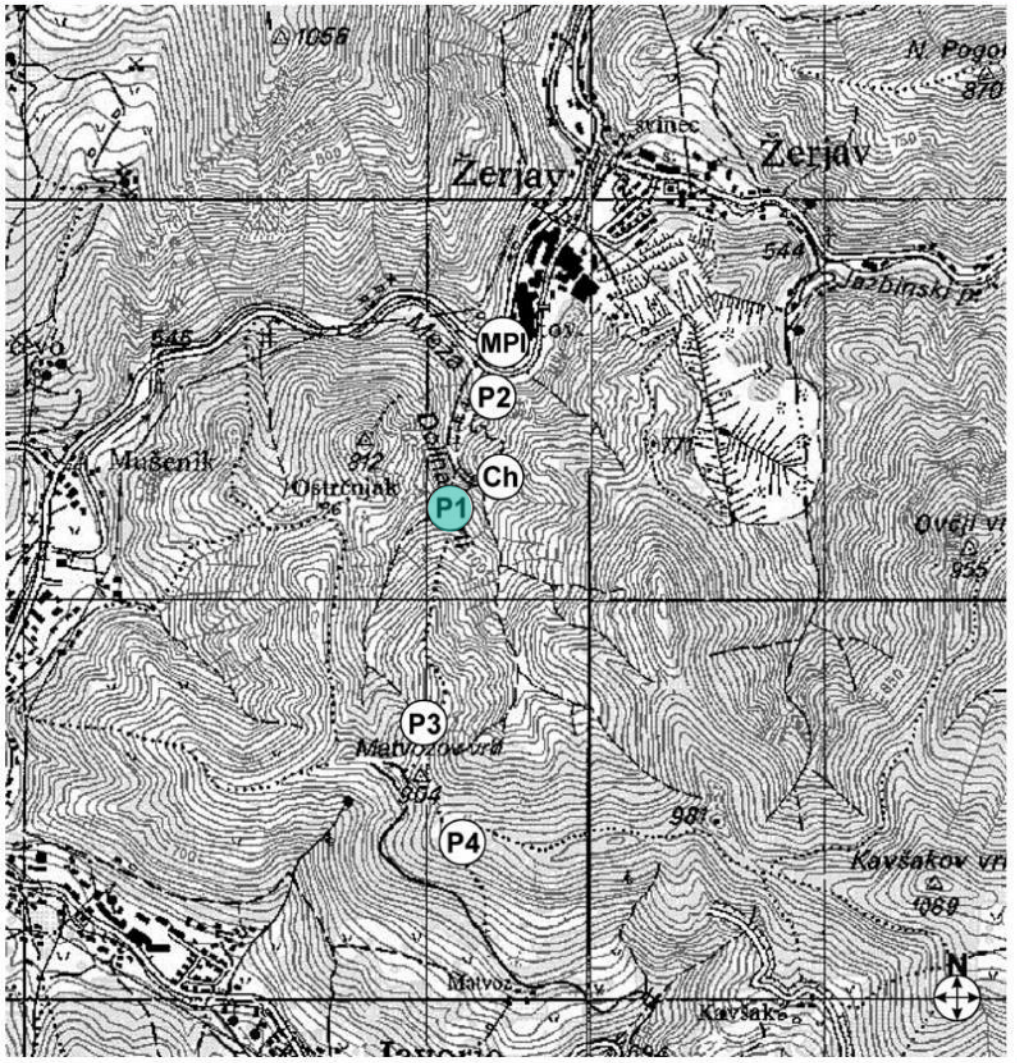

Salix appendiculata

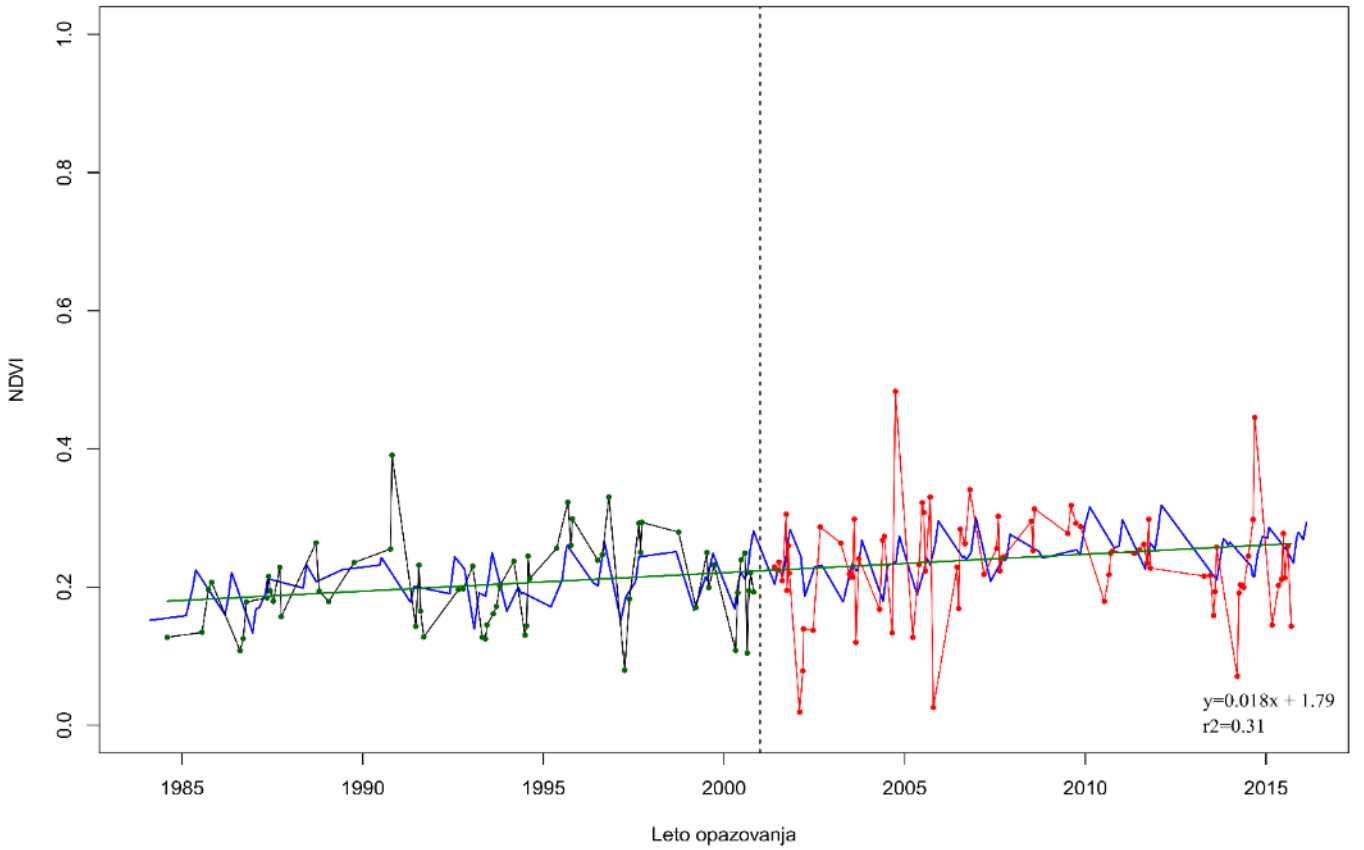

Salix caprea

tree species

P1 (50 m away from smalter)

BFAST Monitor – pixel time series






Mainuartia gerardii


Biscutella laevigata

herbs species


Sesleria caerulea


Calamagrostis epigejos

grass species

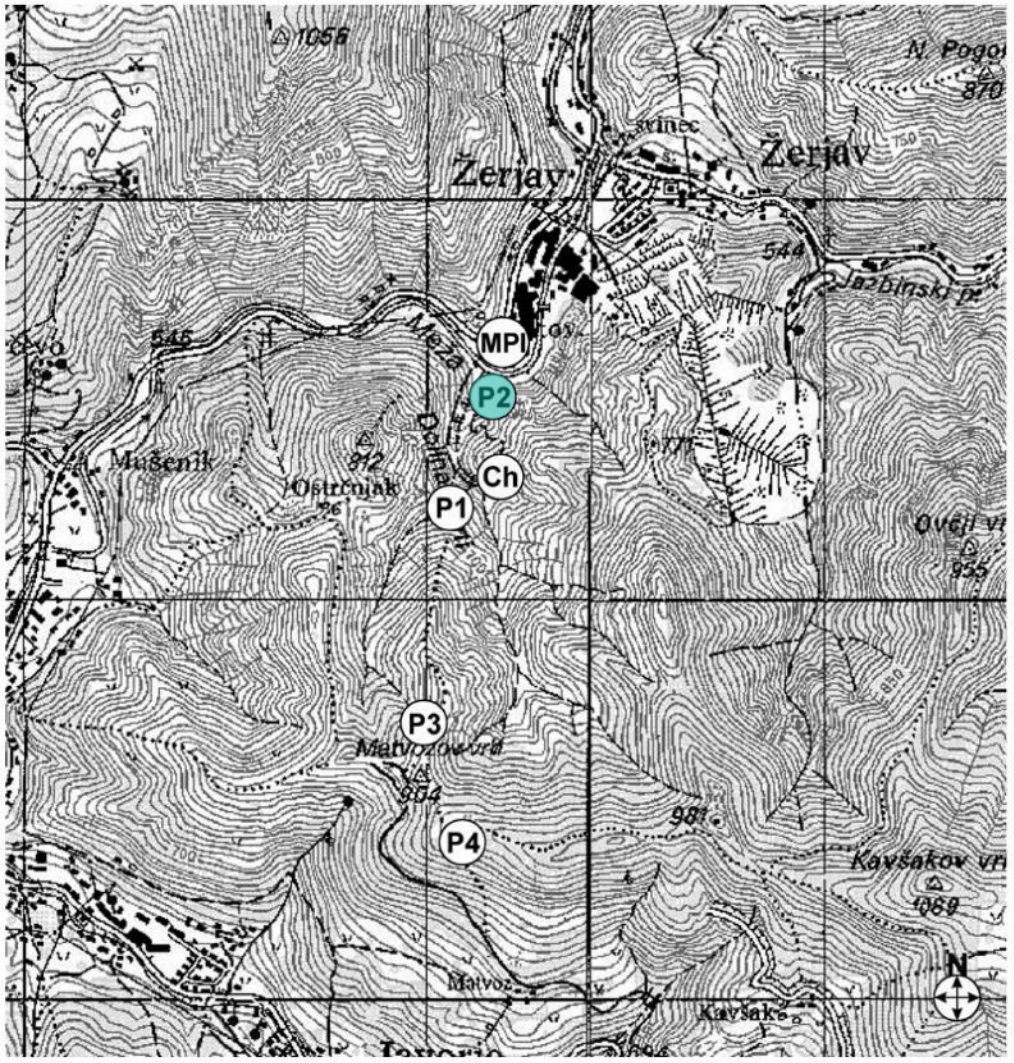

Salix appendiculata

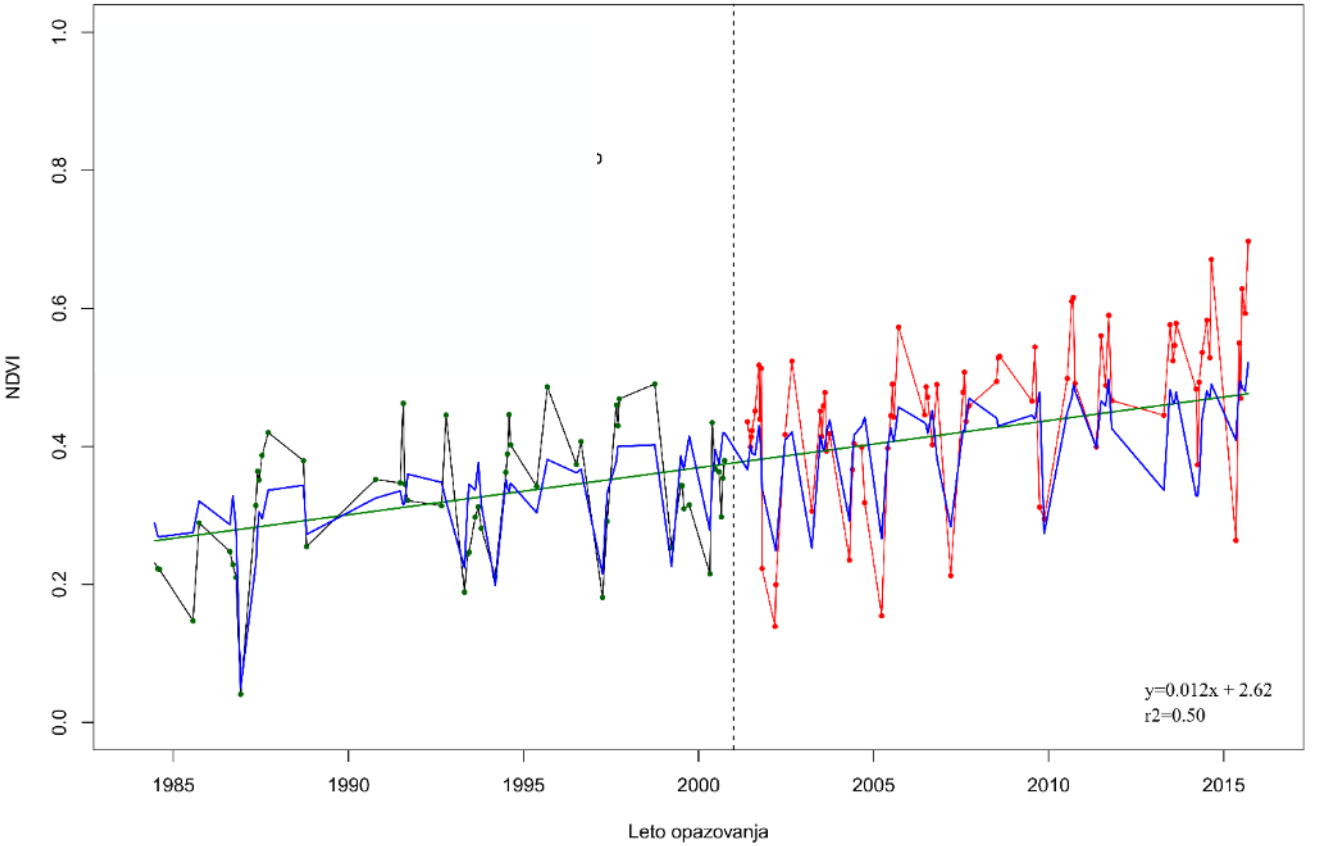

Salix purpurea

tree species

P2 (250 m away from smalter)

BFAST Monitor – pixel time series






Mainuartia gerardii


Sesleria caerulea

herbs/grass species


Betula pendula


Populus tremula

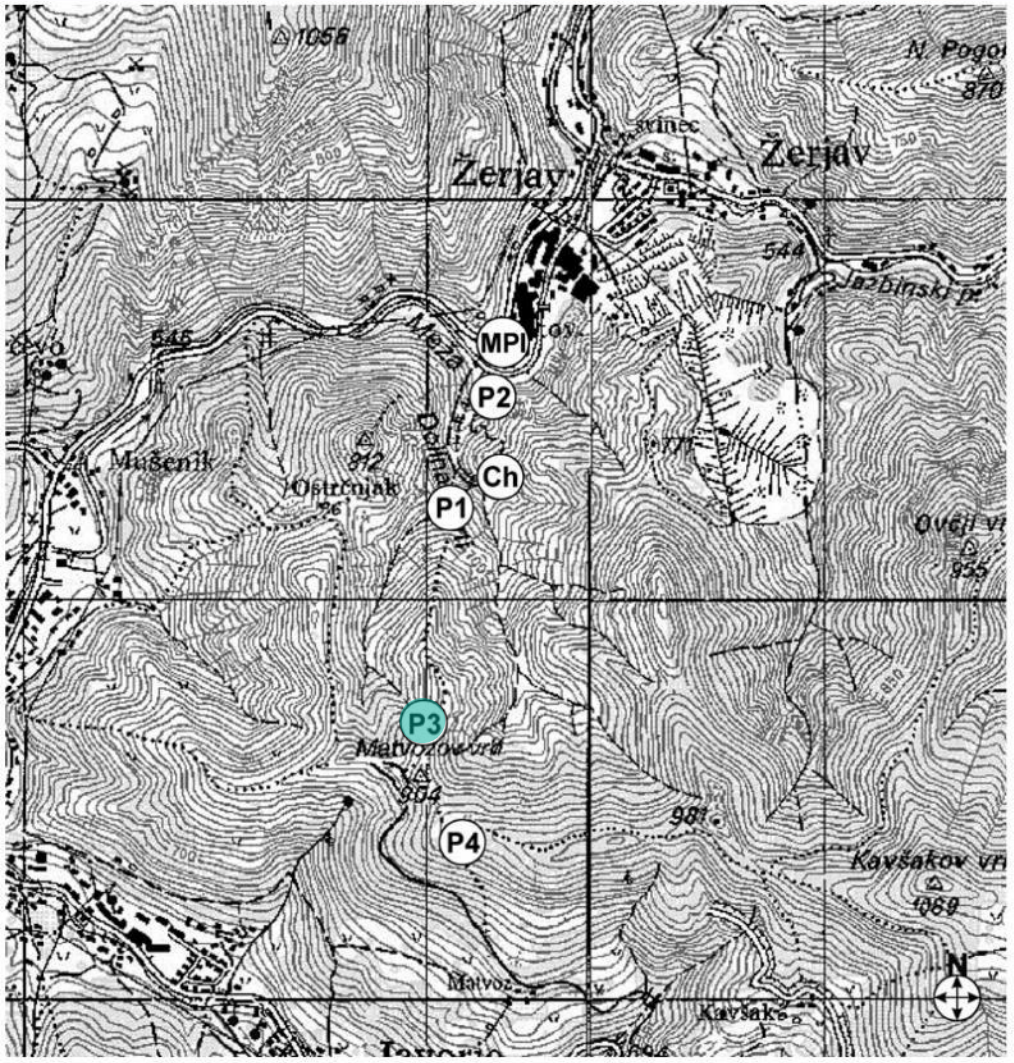

Erica carnea

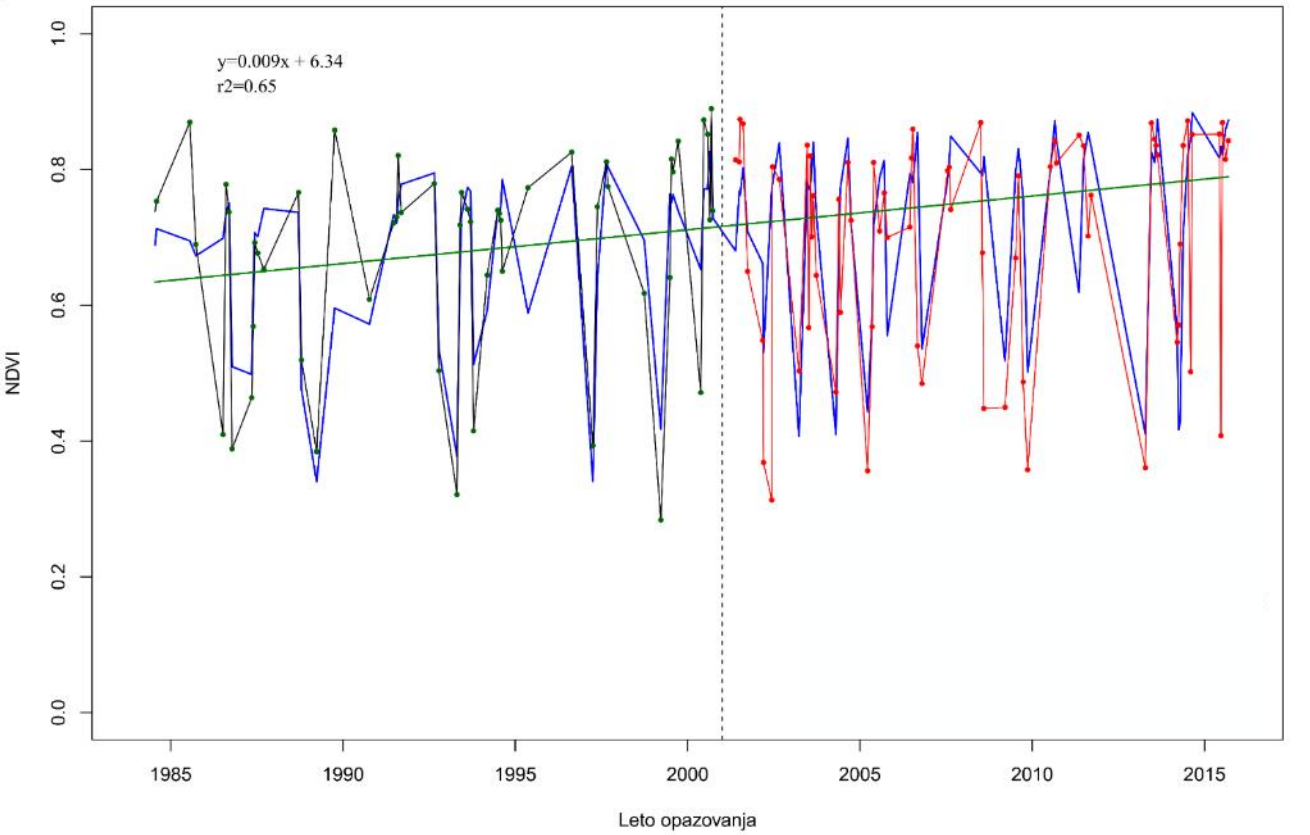

Salix caprea

tree species

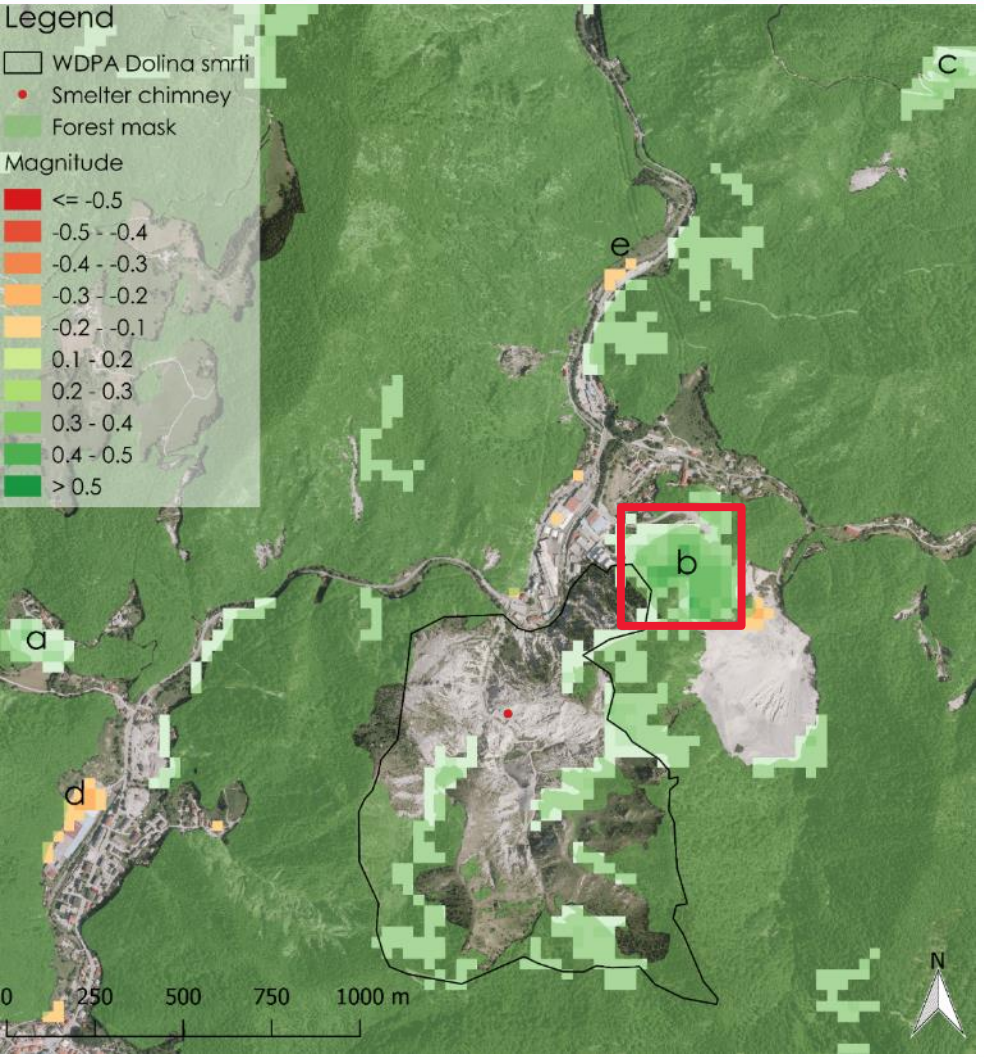
P3 (500 m away from smalter)

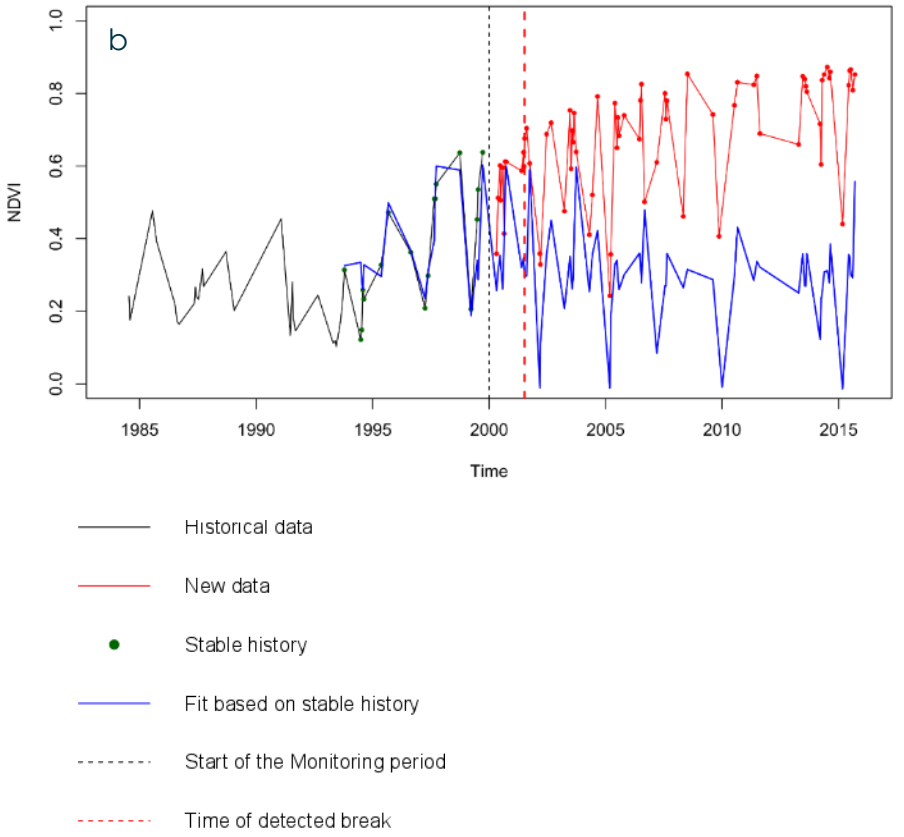
BFAST Monitor – pixel time series

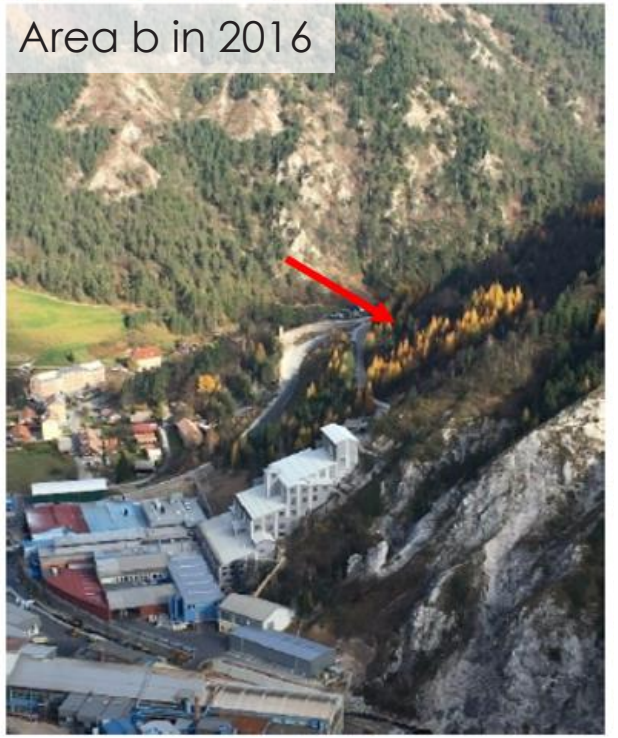




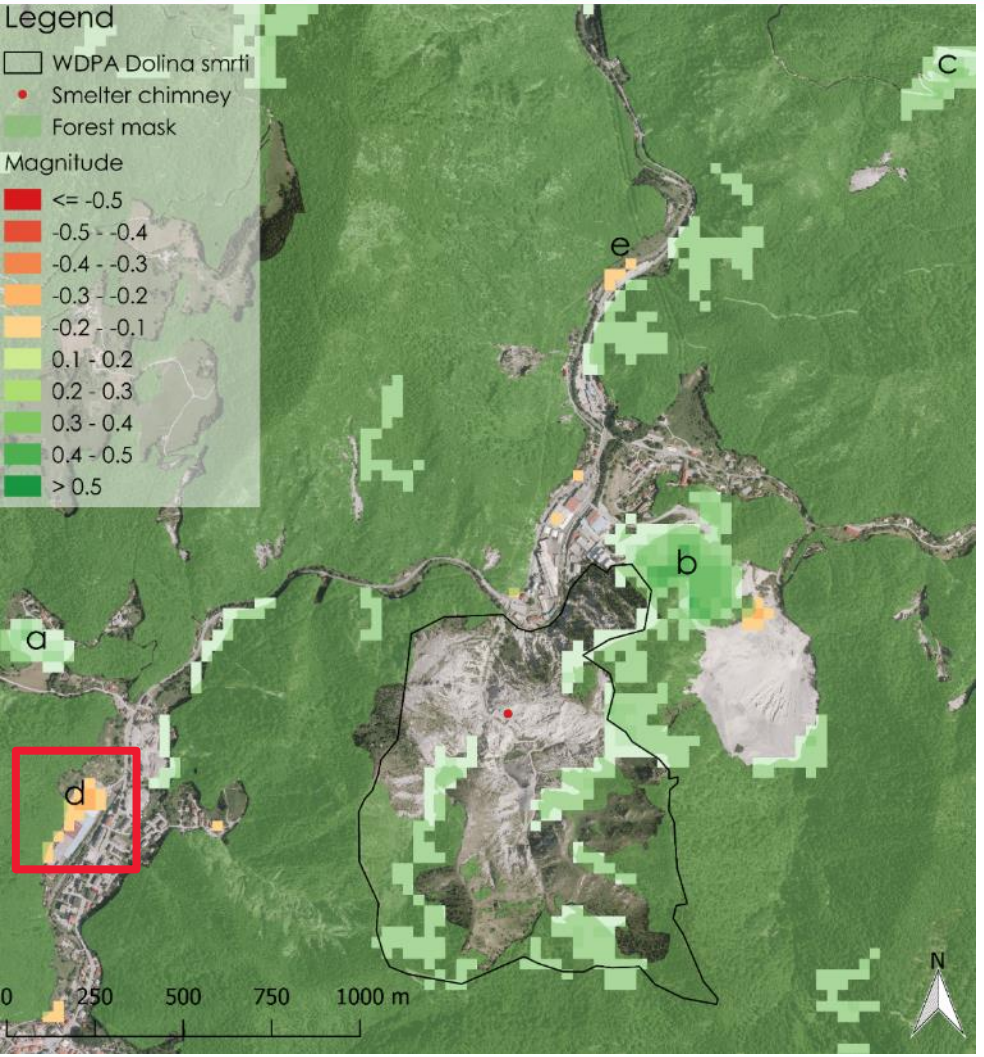
BFAST Monitor and forest regeneration (spatial paterns)

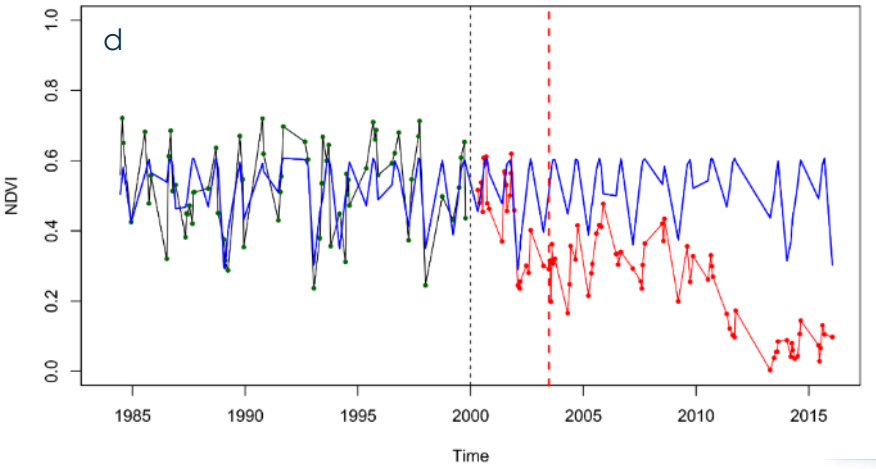






BFAST Monitor and forest degradation





Historical data

New data

Stable history

Fit based on stable history

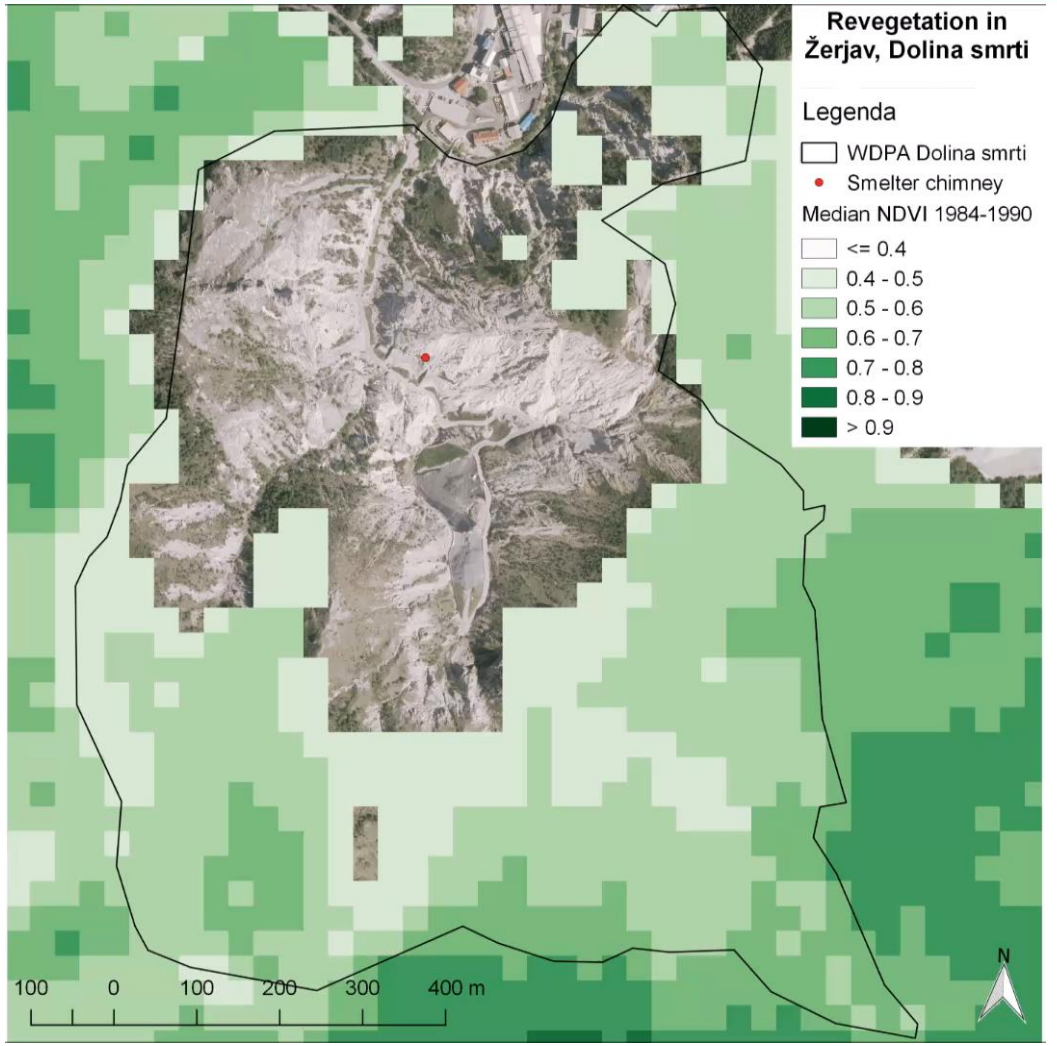
Start of the Monitoring period

Time of detected break

Destroyed forest area d in 2016

Conclusion

- long term Landsat NDVI SITS and BFAST Monitor are useful for forest regeneration detection
- Earth observation can be used as an affordable, fast and effective means of forest health monitoring
- BFAST is useful for pixel time series or spatial-raster analysing
- as input we also can take other EO data, like Sentinel, etc.



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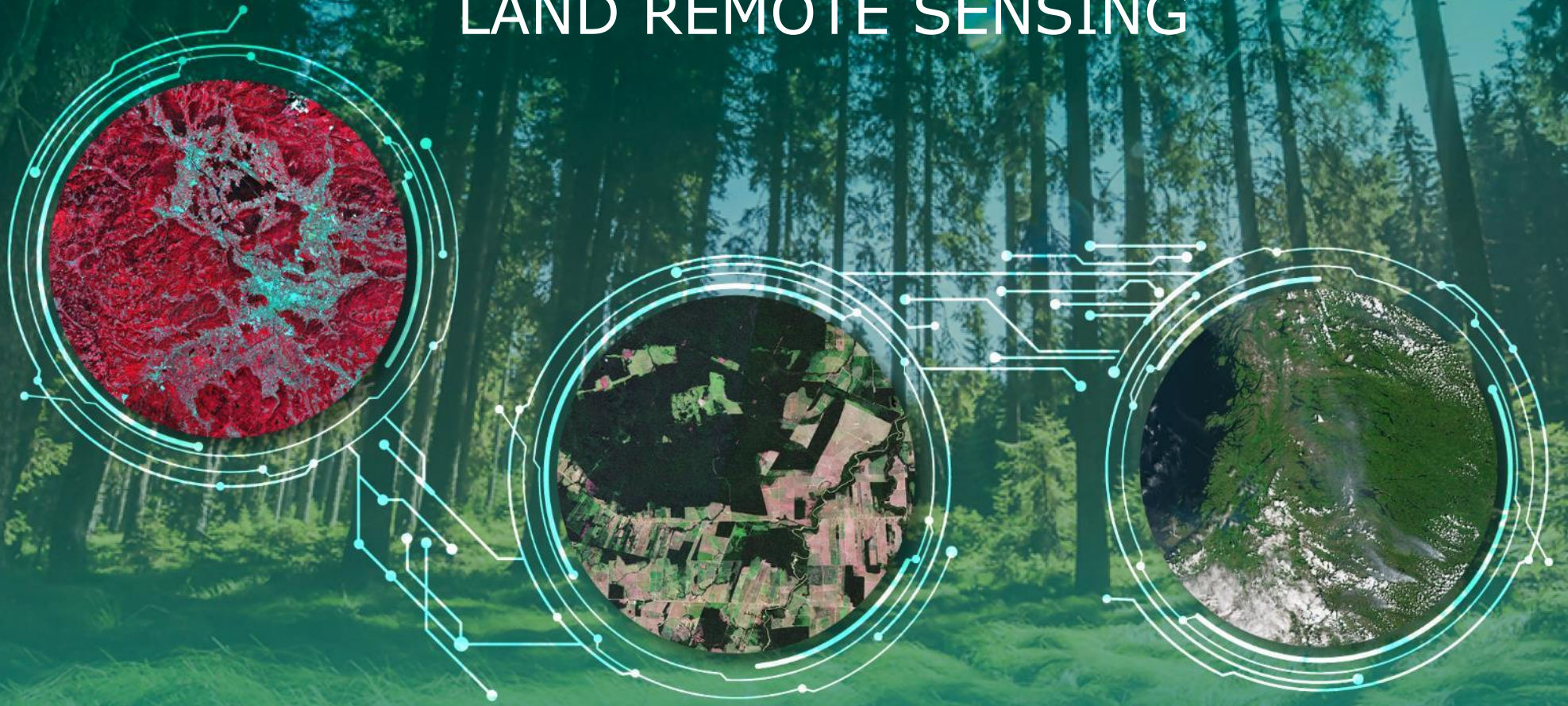

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