A. Altobelli[1], A. Sgambati[2], F. Bader[1], G. Fior[1], B. Magajna[3], L. Ferrazzo[1], R. Braut[1], P. Urrutia[1], P. Ganis[1], S. Orlando[1]

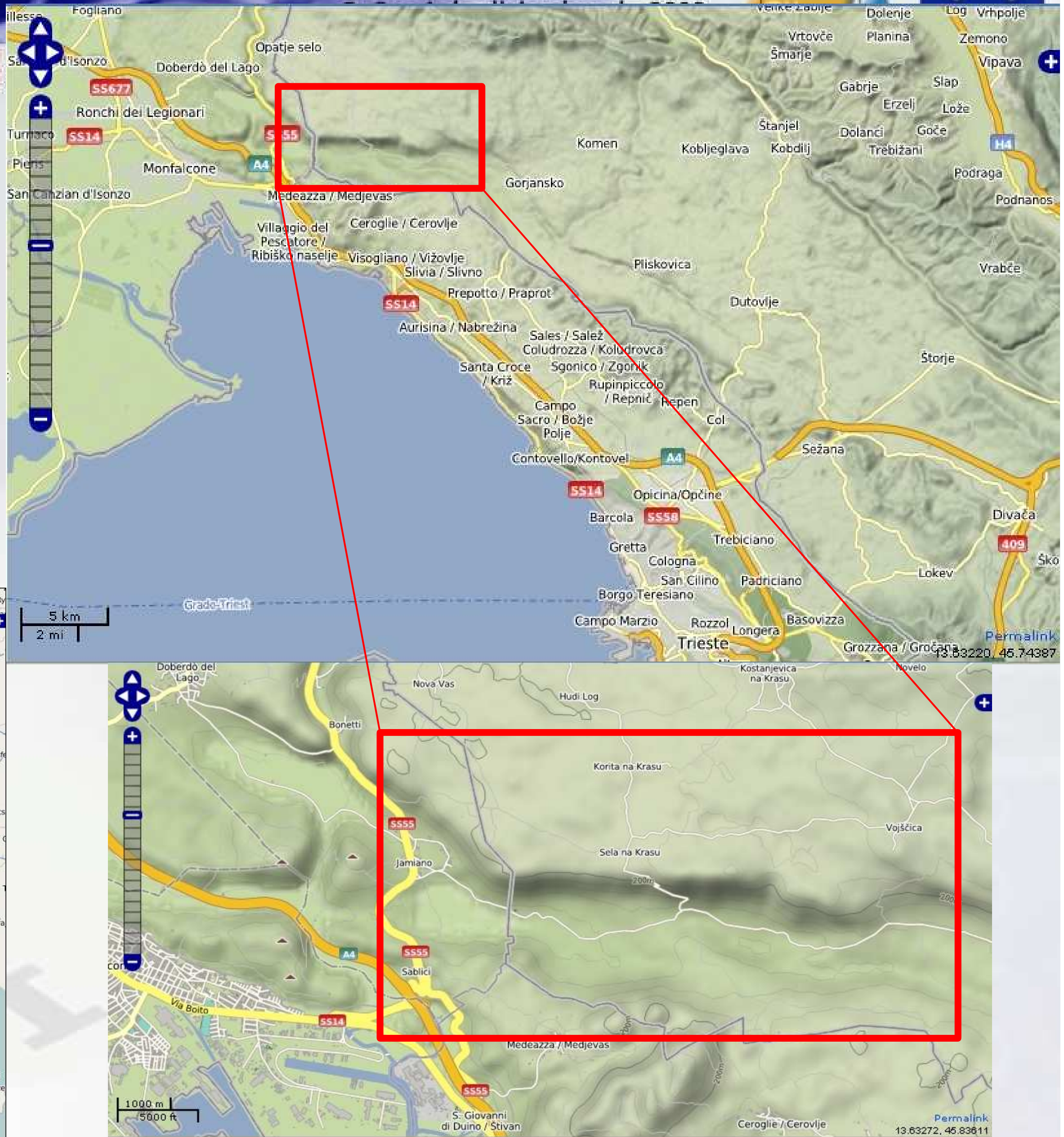
[1] Dipartimento di Scienze della Vita - Università degli Studi di Trieste
[2] Ispettorato Ripartimentale Foreste di Trieste e Gorizia
[3] Zavod za gozdove Slovenije - Območna enota Sežana

APPLICATION OF gvSIG IN A STUDY RELATED TO FOREST FIRE MONITORING

Lecturer: M.S. Paula Urrutia

The study region is located in Slovenia, a few kilometres from the Italian border (near Trieste) and it is part of the "anticlinal Karst area"

http://www.openstreetmap.org/



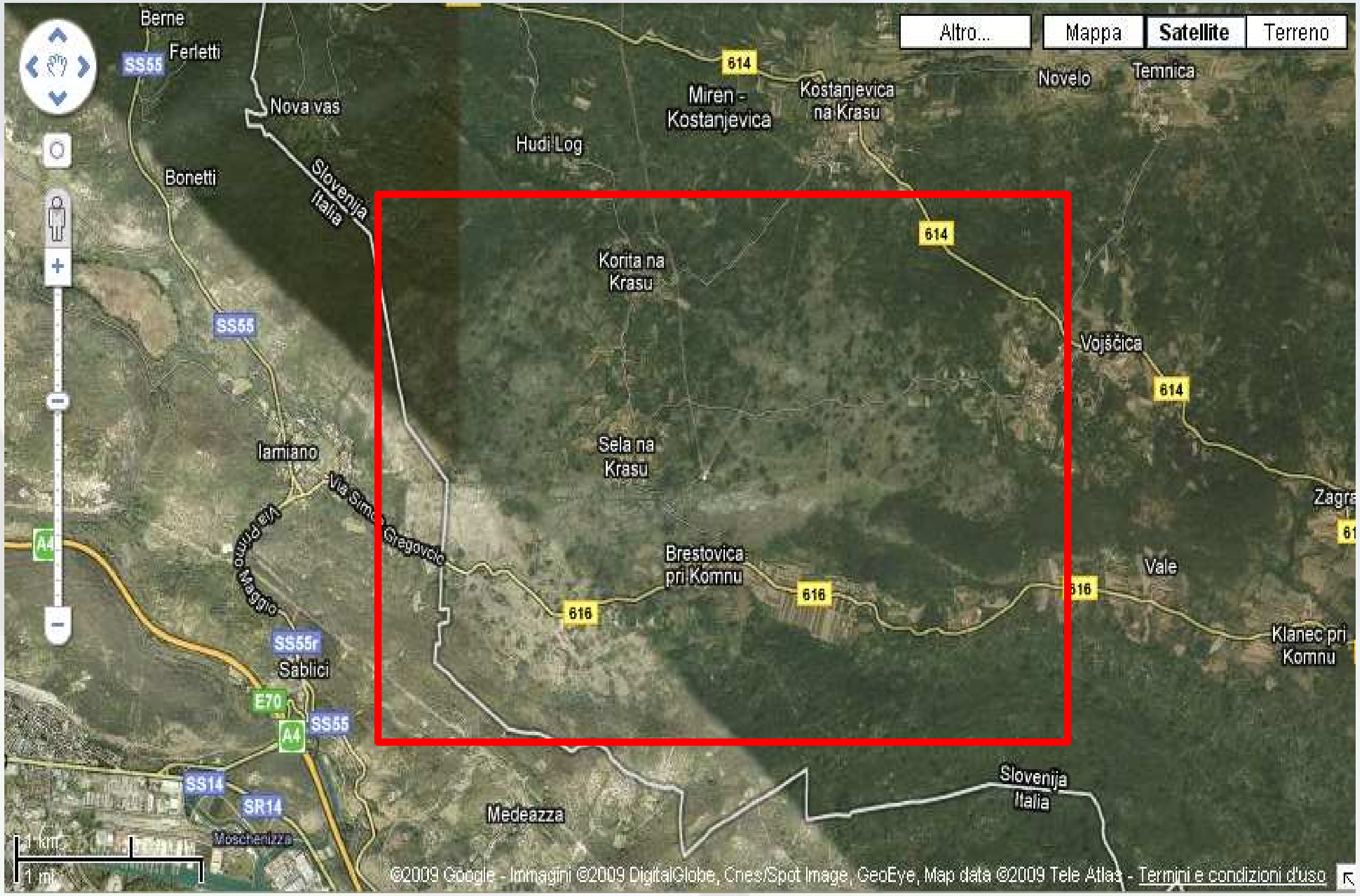
http://www.mapsurfer.net/

FRIULI VENEZIA GIULIA
CORPO FORESTALE

ZAVOD za GOZDOVE SLOVENIJE

UNIVERSITÀ DEGLI STUDI DI TRIESTE

Our research aims to compare the vegetation renewal of Karst woodland and pine forest in an area damaged by a fire occurred in July 2003, with the natural evolution of the same vegetation typologies in unburnt areas



Characteristics of Karst environment:

- rainy winters and relatively dry summers, extremely short spring and autumn
- discontinuous elevation
- predominant presence of carbonate rocks
- shallow soils, poor in *humus* and often moderately productive
- scarce presence of superficial water

In the study area two forest typologies are prevalent:

the Karst woodland (*Ostryo-Quercetum pubescentis*)

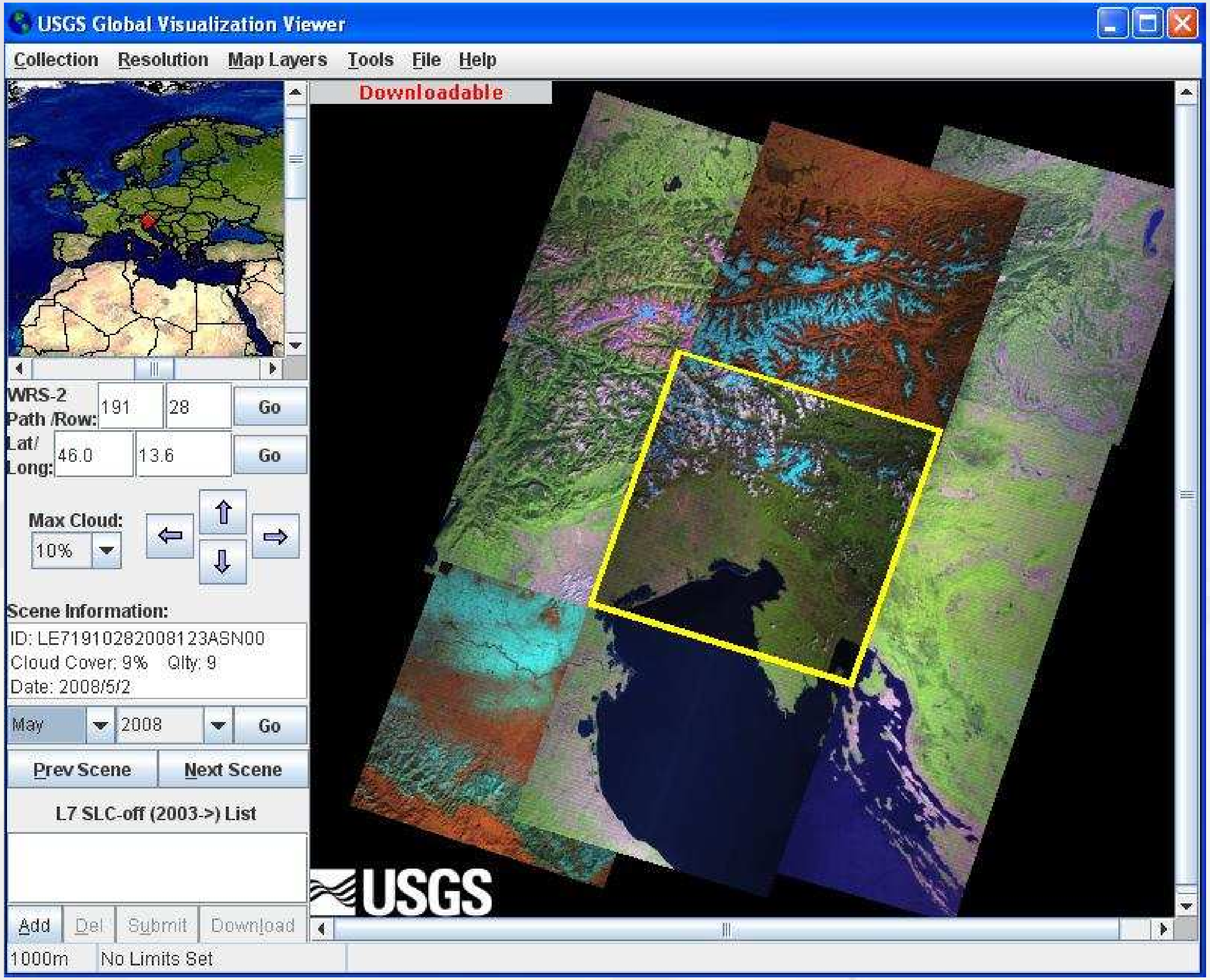
the black pine (*Pinus nigra*) planted forest

A forest fire occurred in this region on 29th July 2003, burning an area of 10.45 km^2

Generally severe fires cause almost total disappearance of vegetation cover and an hydrophobic soil condition, with consequent erosion risk due to superficial run-off

A forest immediately after a fire

Spontaneous vegetation renewal

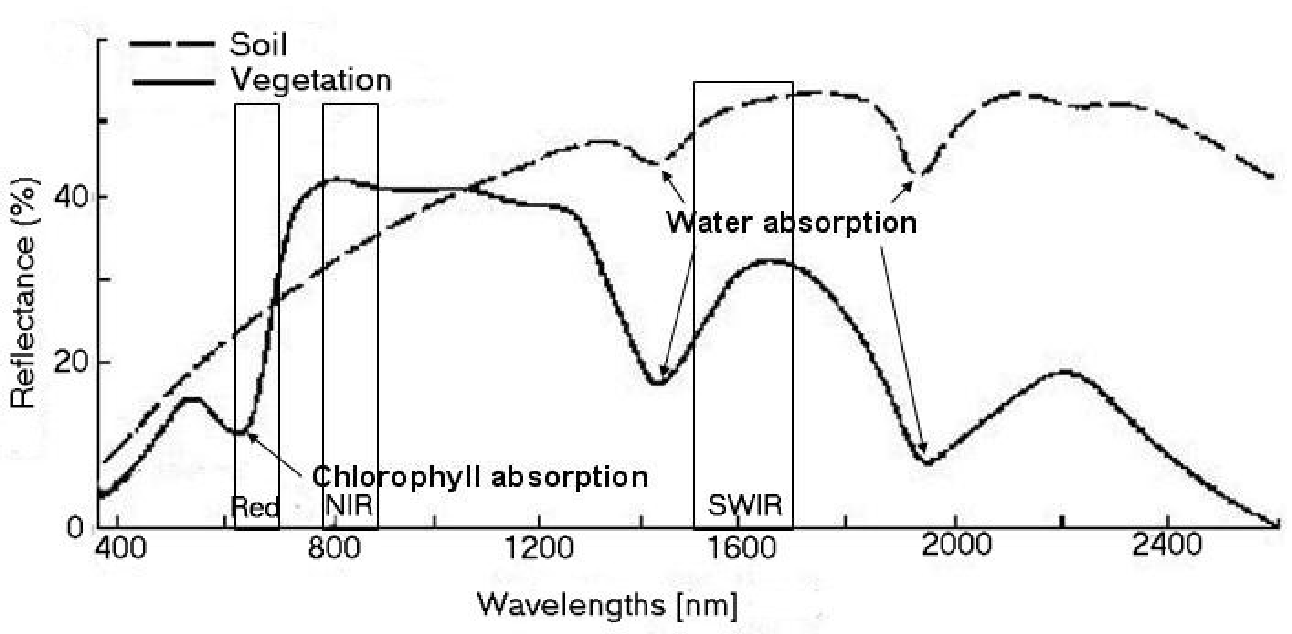


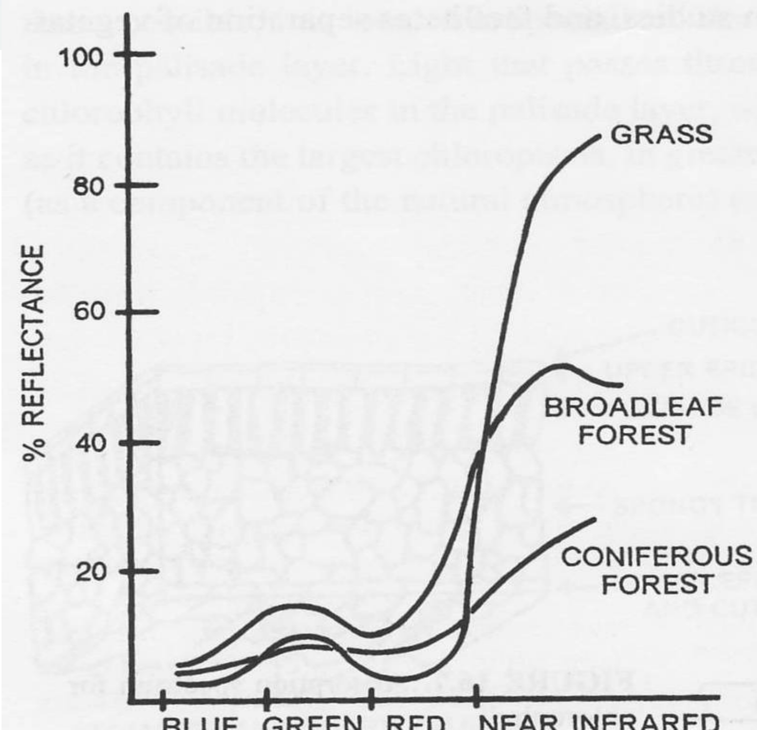
In order to follow the evolution of the vegetation in the burnt areas, we used a series of multi-temporal Landsat images (2003-2009) from Landsat 5 TM (Thematic Mapper) and Landsat 7 ETM+ (Enhanced Thematic Mapper Plus) downloaded from the Glovis website

In remote sensing analysis, NDVI (Normalized Difference Vegetation Index) is the most commonly used green biomass index. It is calculated using the reflectance in the Red and in the NIR (Near Infrared) bands

A second index called NDWI (Normalised Difference Water Index) is sensitive to leaf water content and soil humidity. NDWI is calculated using the NIR (Near Infrared) and the SWIR (Short Wave Infrared) bands

Spectral signatures

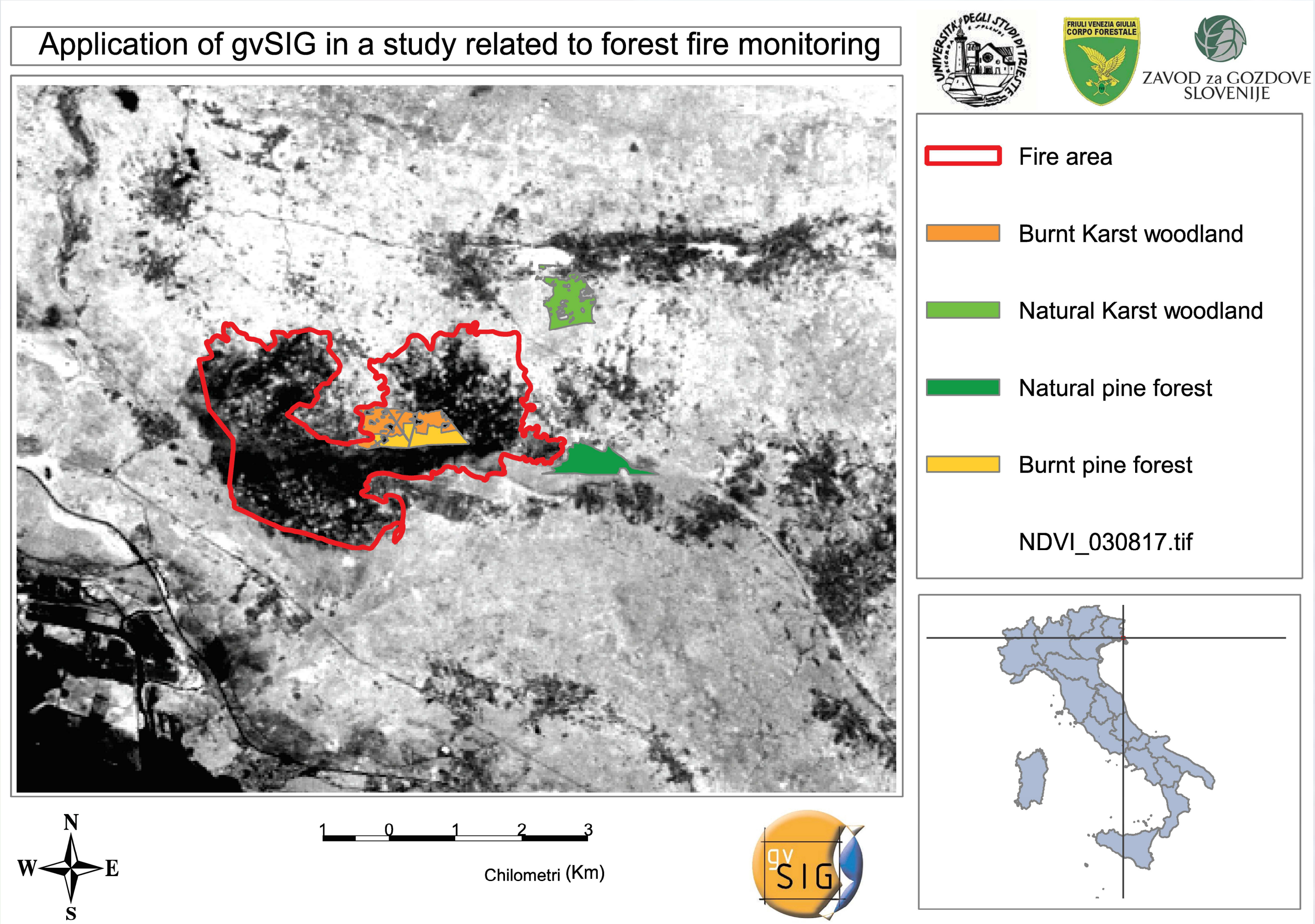




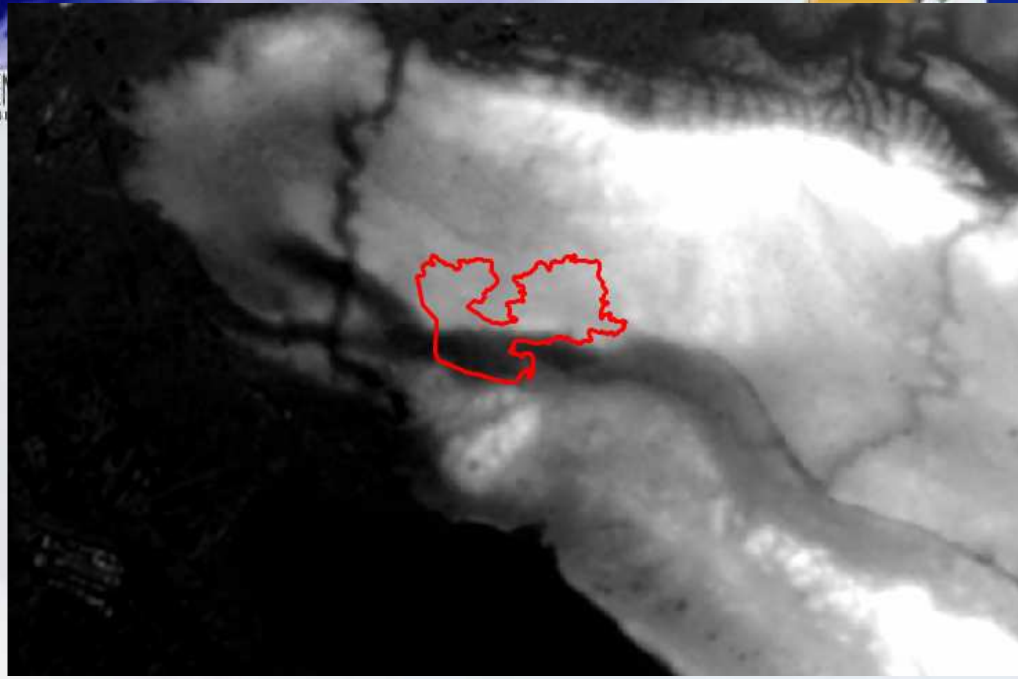
Data handling with gvSIG and Sextante:

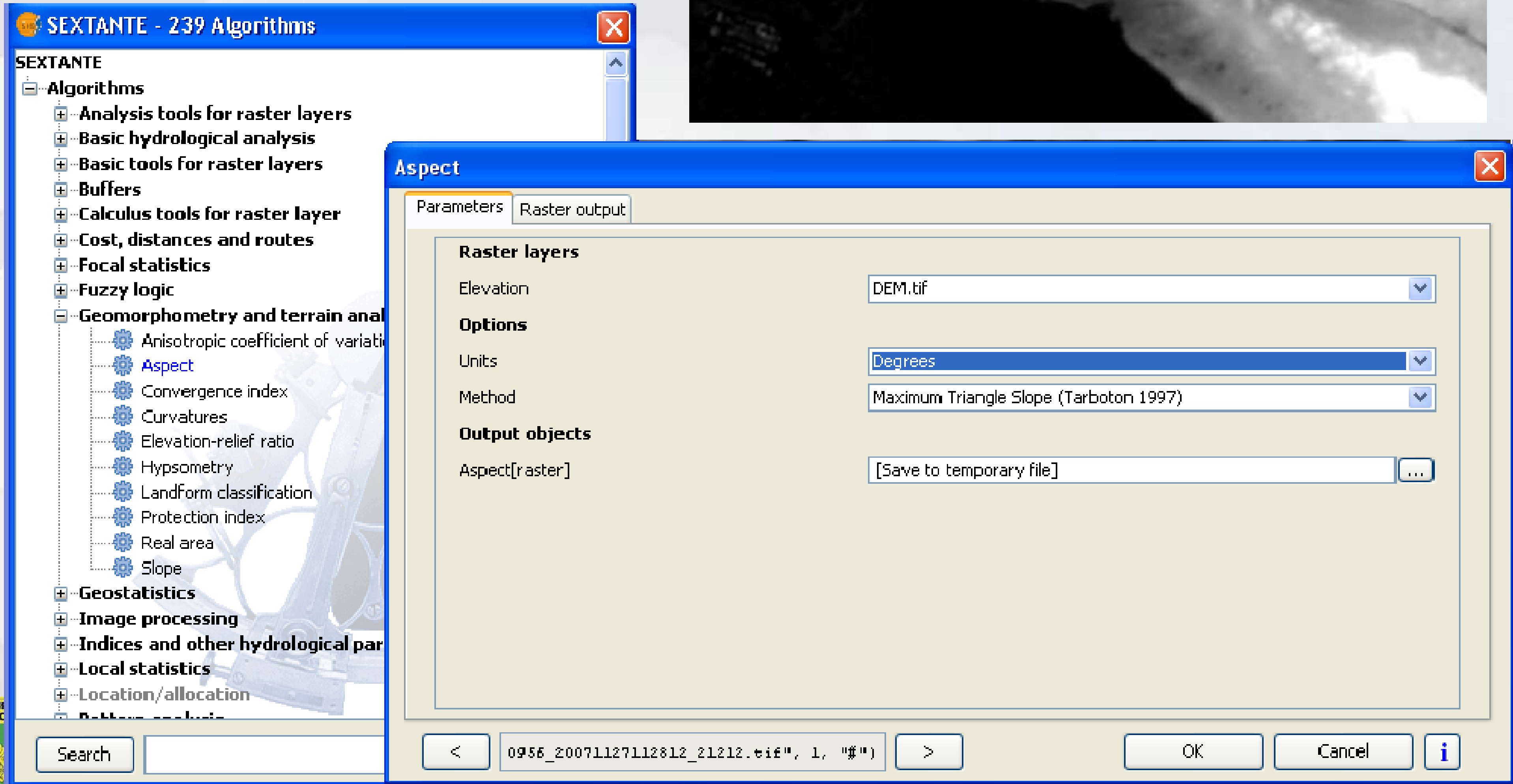
- importation of the fire area polygon and land cover data

- individuation of 4 polygons: a burnt and an unburnt Karst woodland, a burnt and an unburnt pine forest

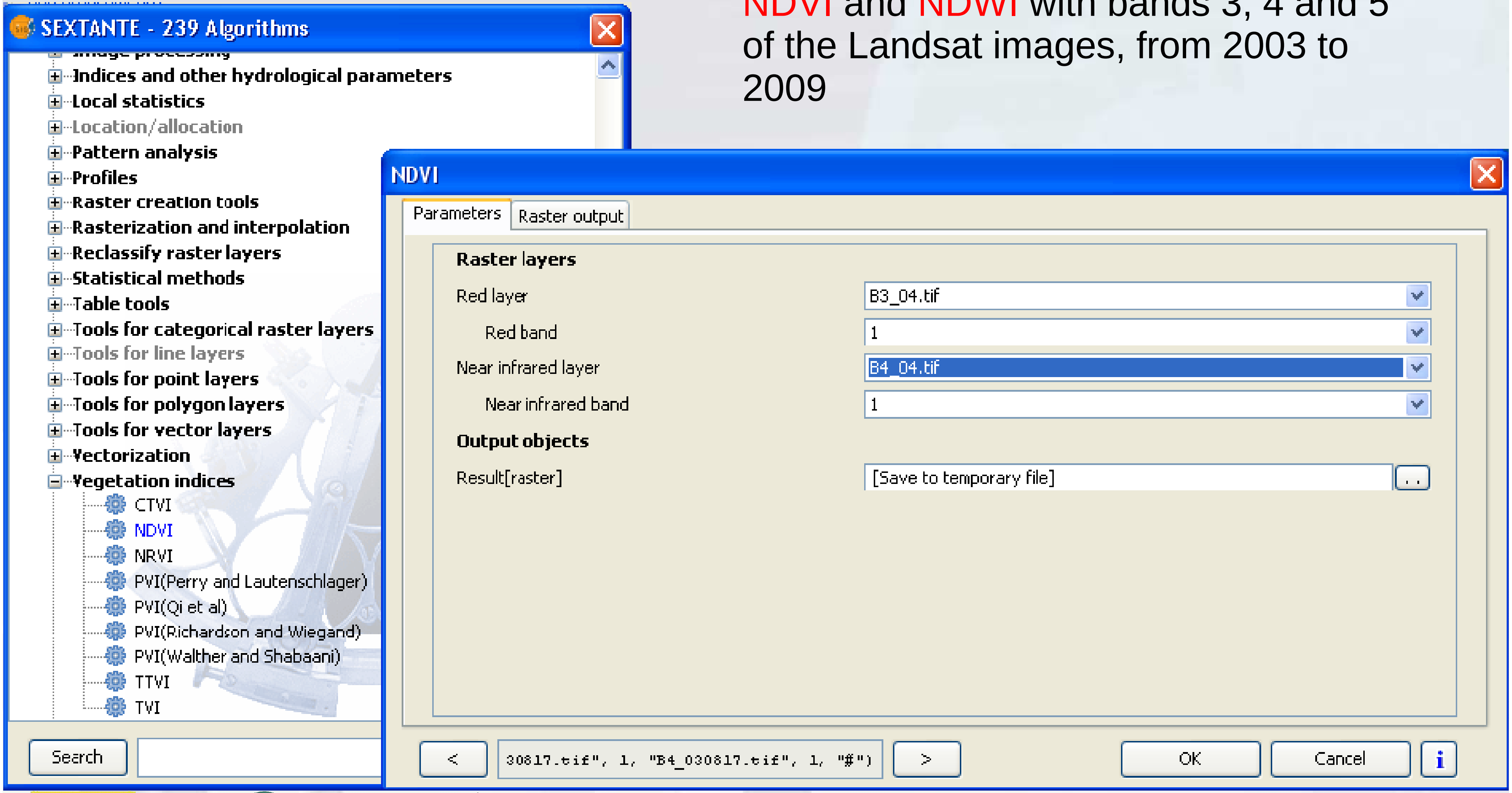


- importation of Aster DEM image (15 m resolution) and calculation of aspect and slope images

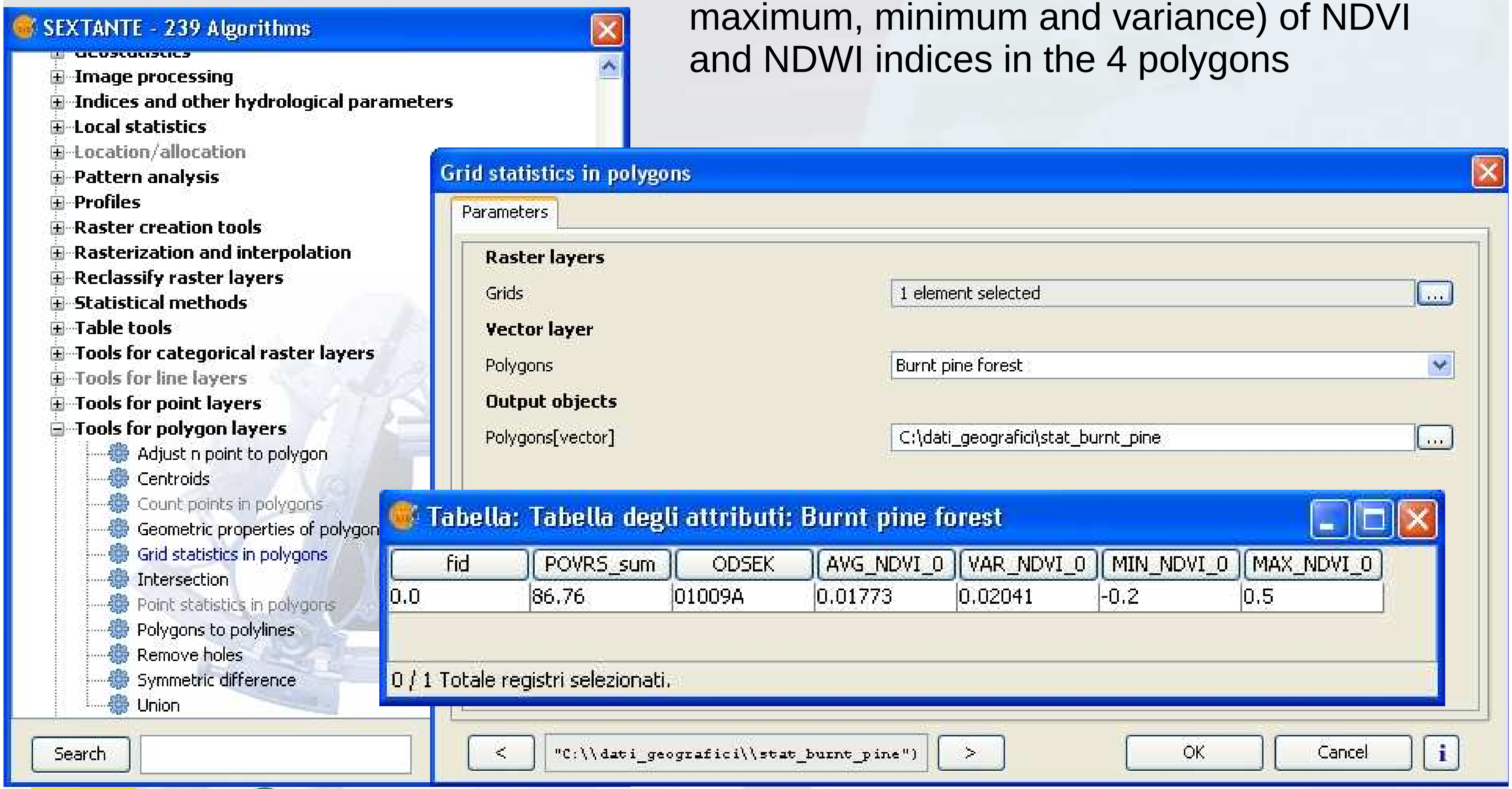




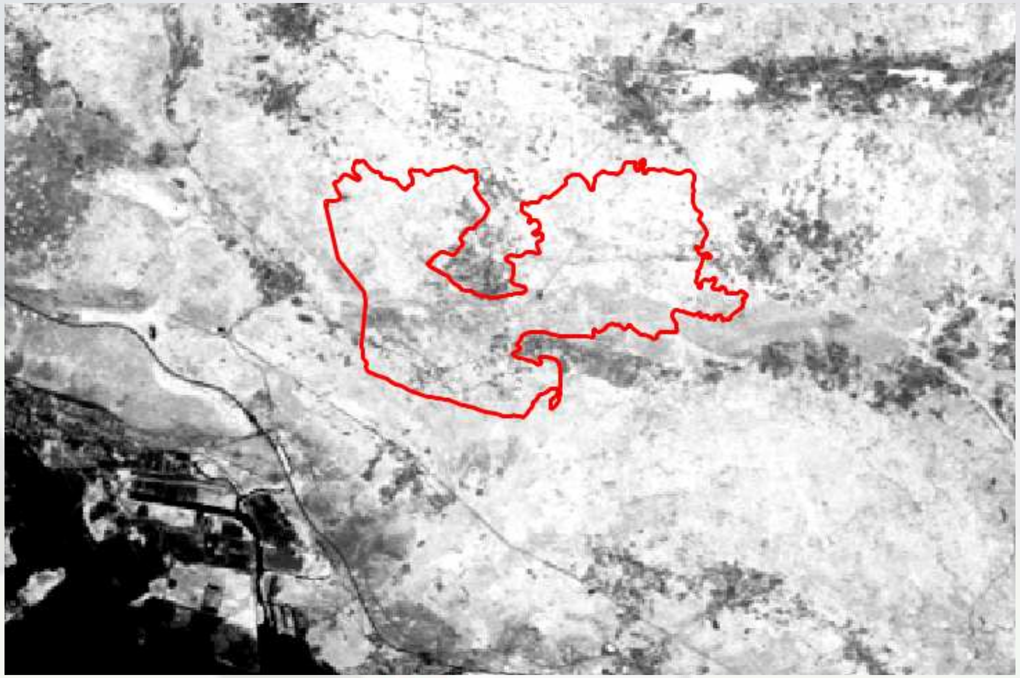
- calculation of the vegetation indices NDVI and NDWI with bands 3, 4 and 5 of the Landsat images, from 2003 to 2009



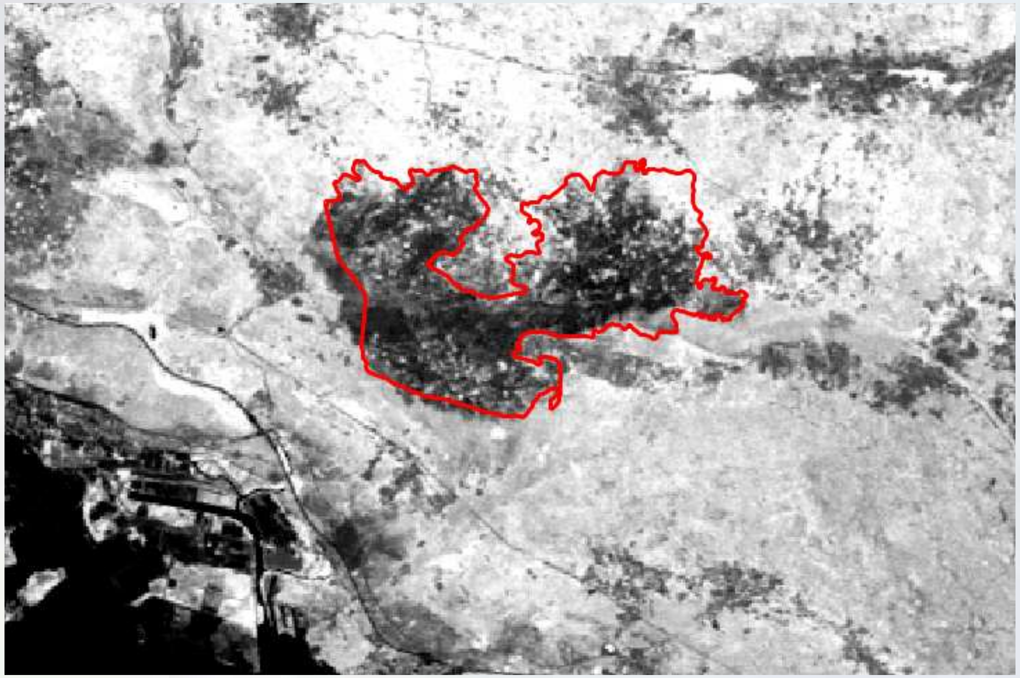
- calculation of some statistics (mean, maximum, minimum and variance) of NDVI and NDWI indices in the 4 polygons



Comparison of the NDVI mean values before and after the fire



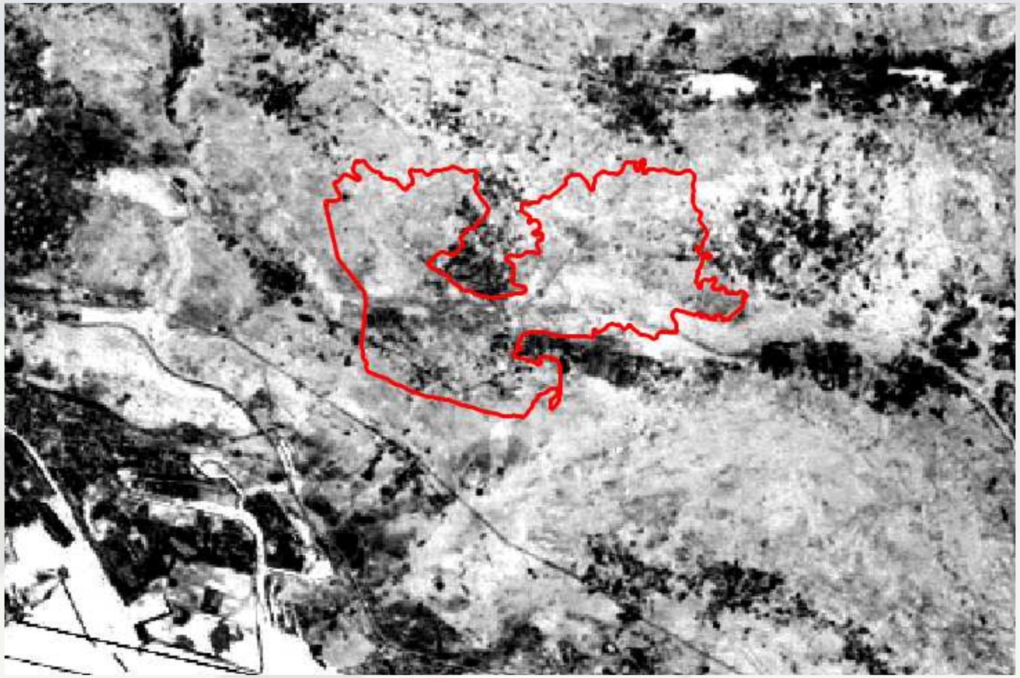
NDVI 16th July 2003 – Before the fire



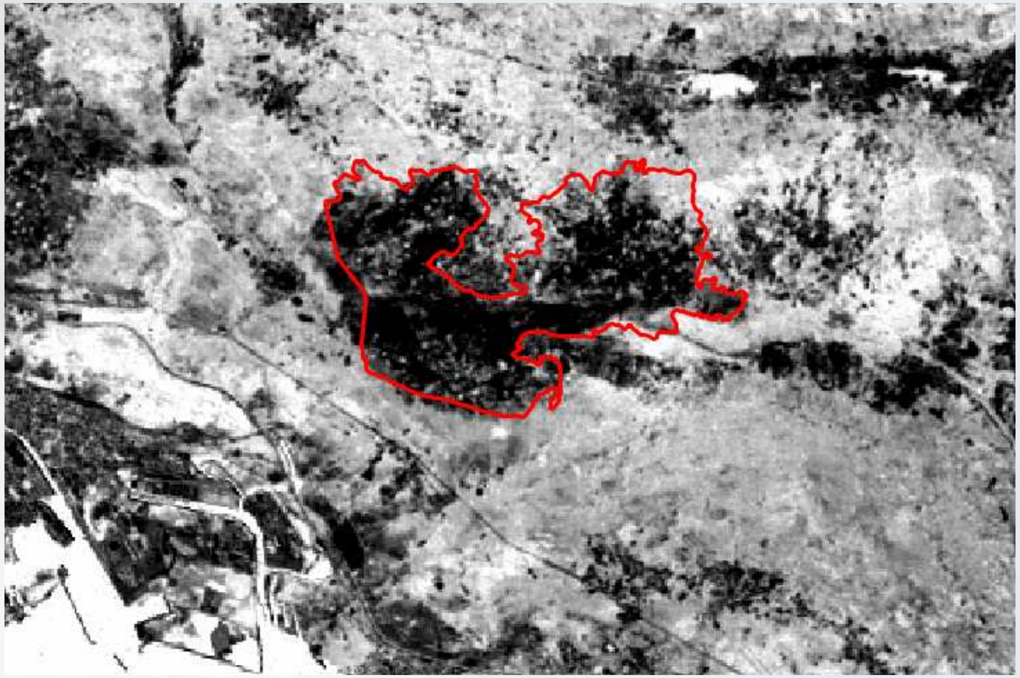
NDVI 17th August 2003 – After the fire

The damage caused by fire on both vegetation typologies leads to a strong signal loss in the Near InfraRed (NIR) and a decrease of NDVI value, due to leaf tissue degradation.

Comparison of the NDWI mean values before and after the fire

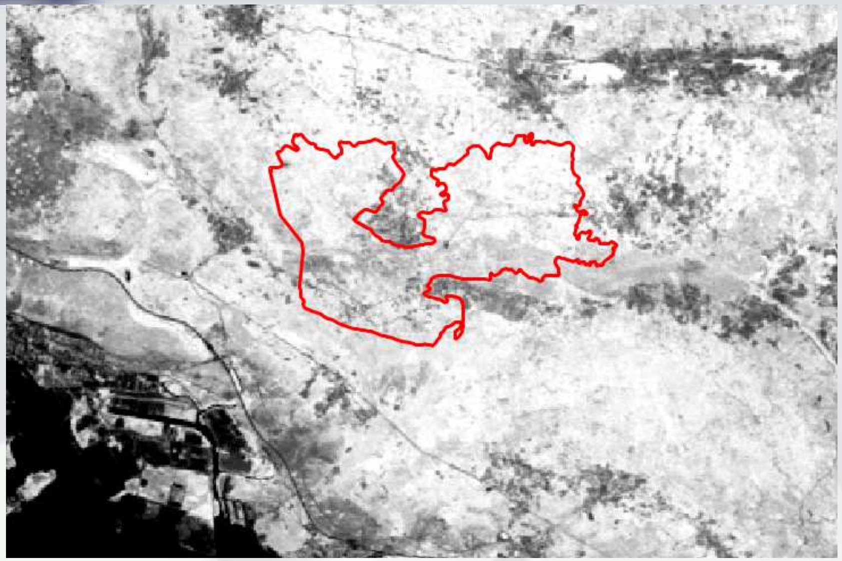


NDWI 16th July 2003 – Before the fire

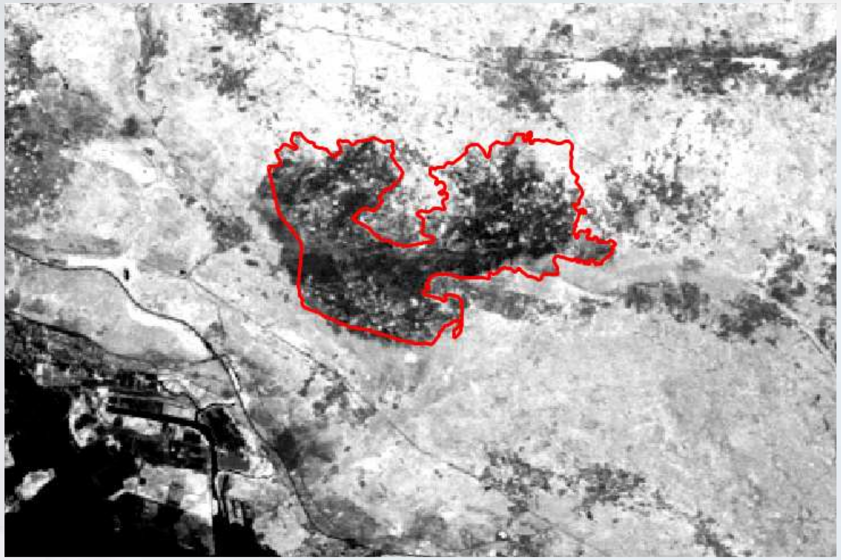


NDWI 17th August 2003 – After the fire

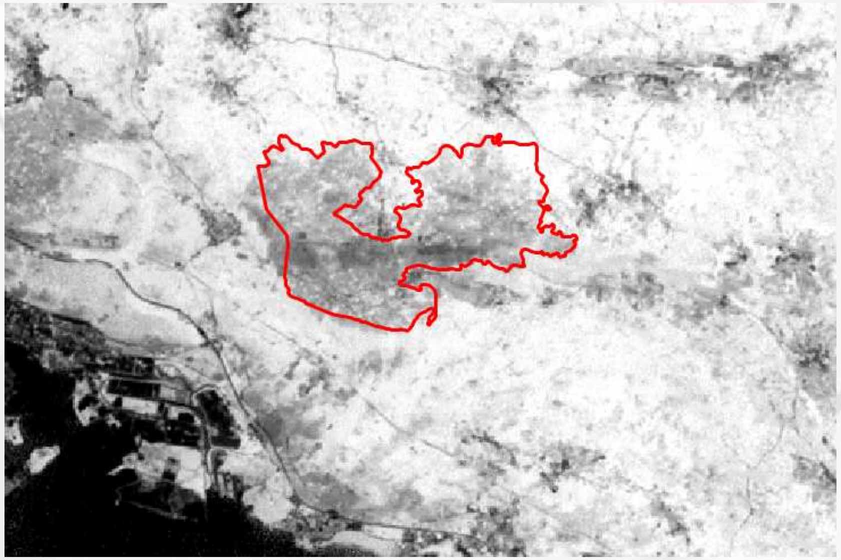
Leaf tissue dehydration and the development of a hydrophobic soil layer are the main causes of reflectance increase in Short Wave InfraRed (SWIR) and of the consequent decrease of NDWI value.



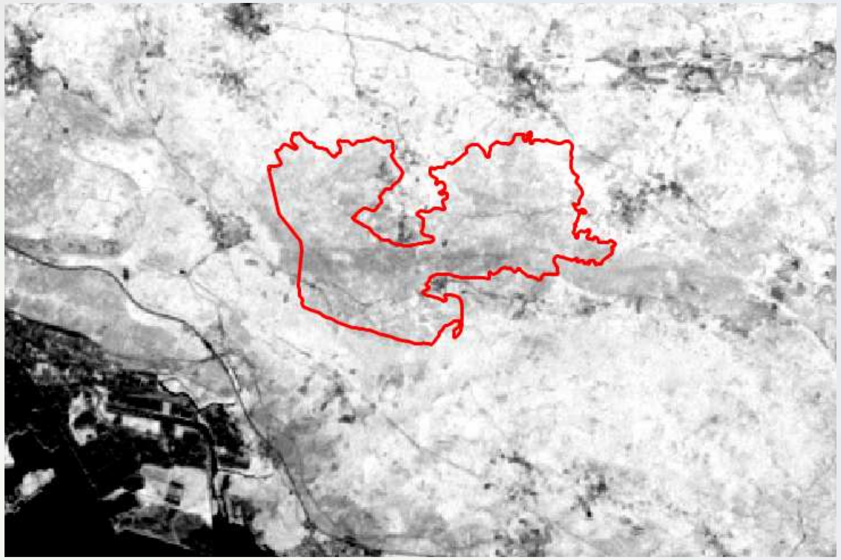
NDVI 16th July 2003 – Before the fire



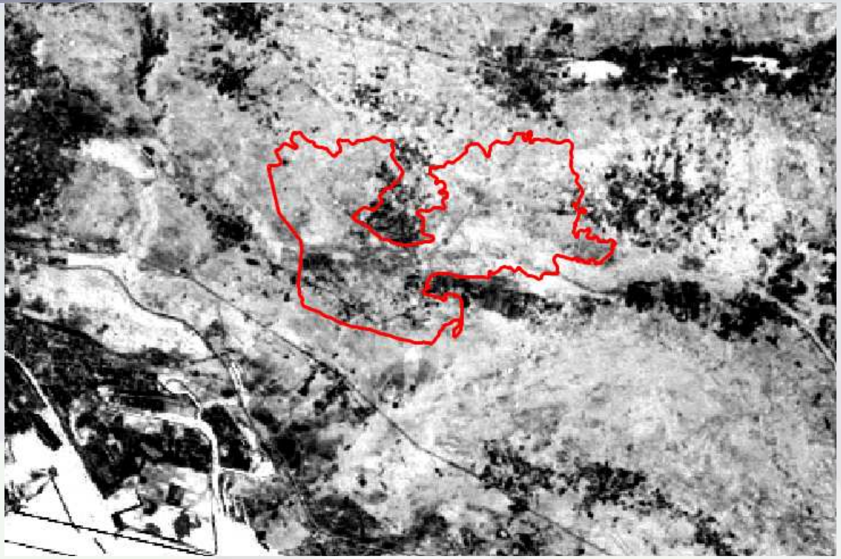
NDVI 17th August 2003 – After the fire



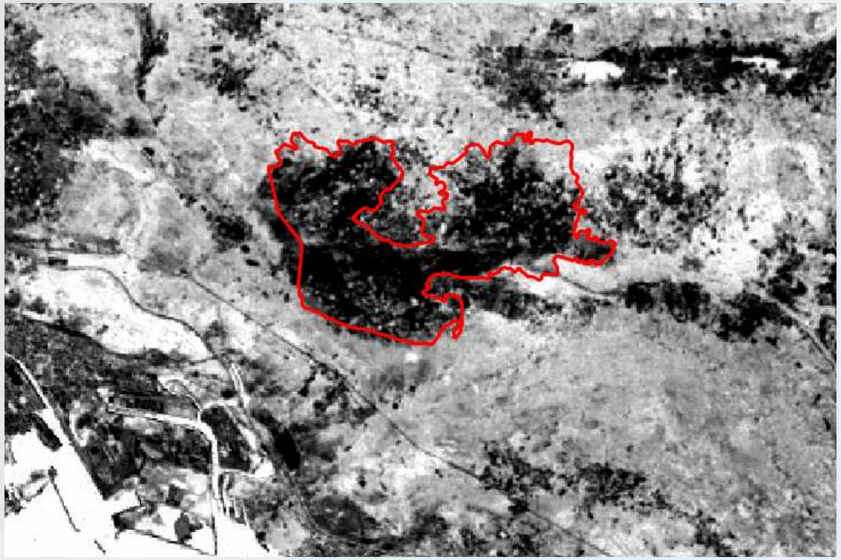
NDVI 29th July 2005



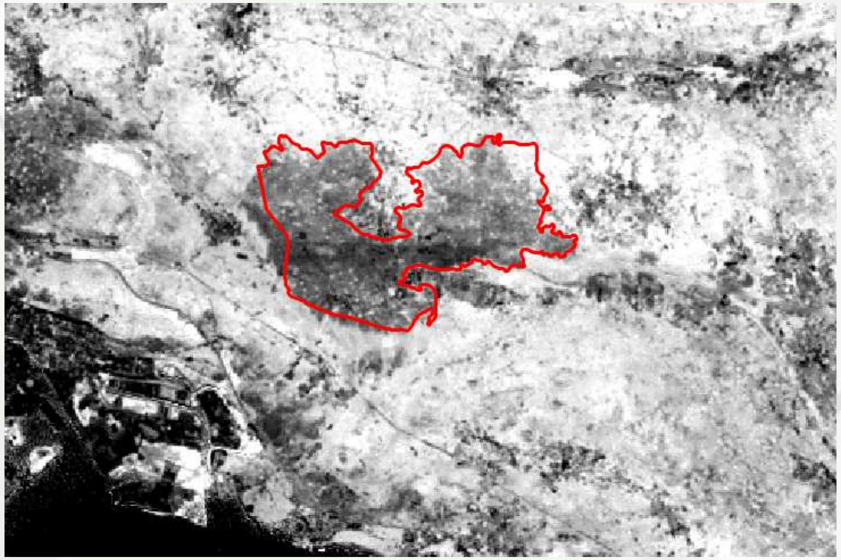
NDVI 24th July 2009



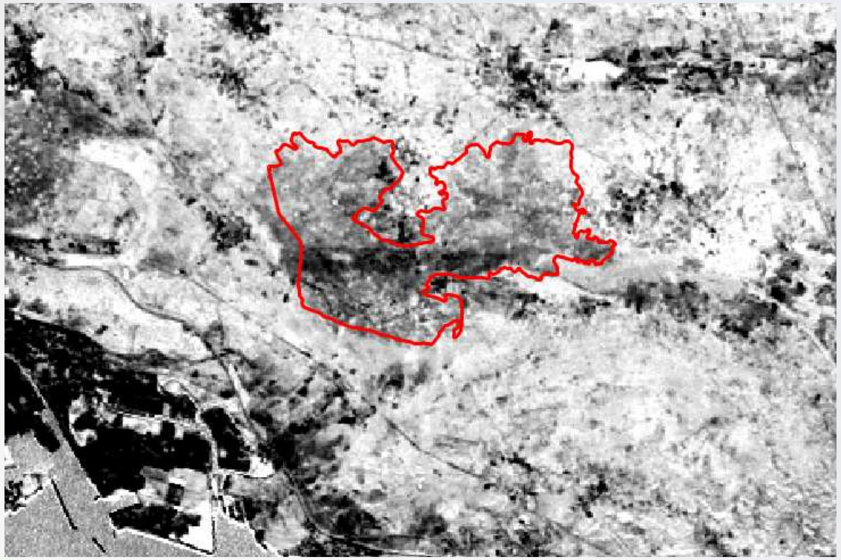
NDWI 16th July 2003 – Before the fire



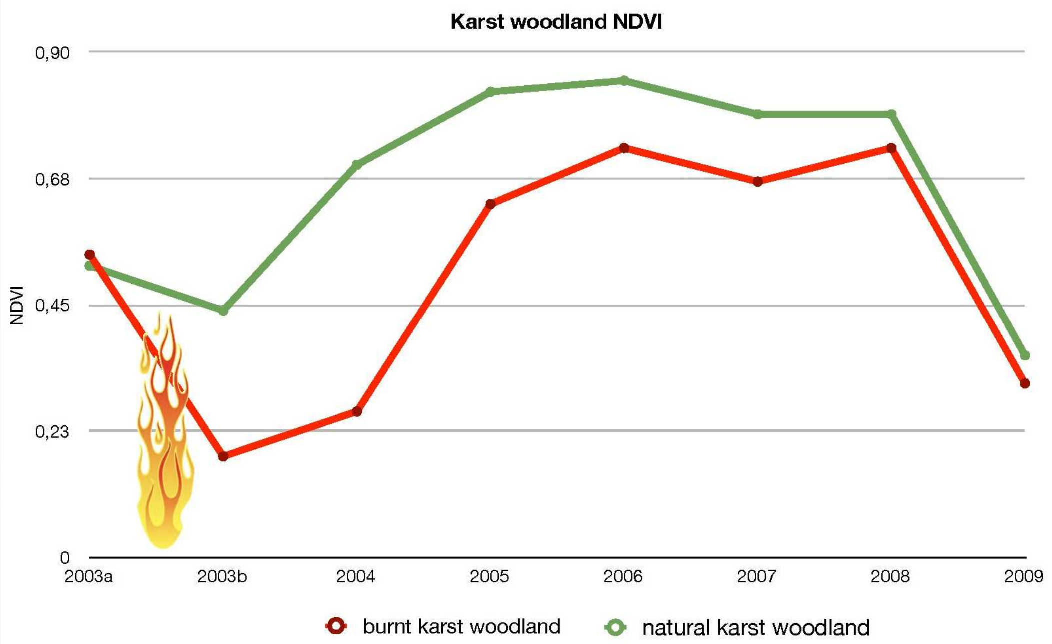
NDWI 17th August 2003 – After the fire



NDWI 29th July 2005



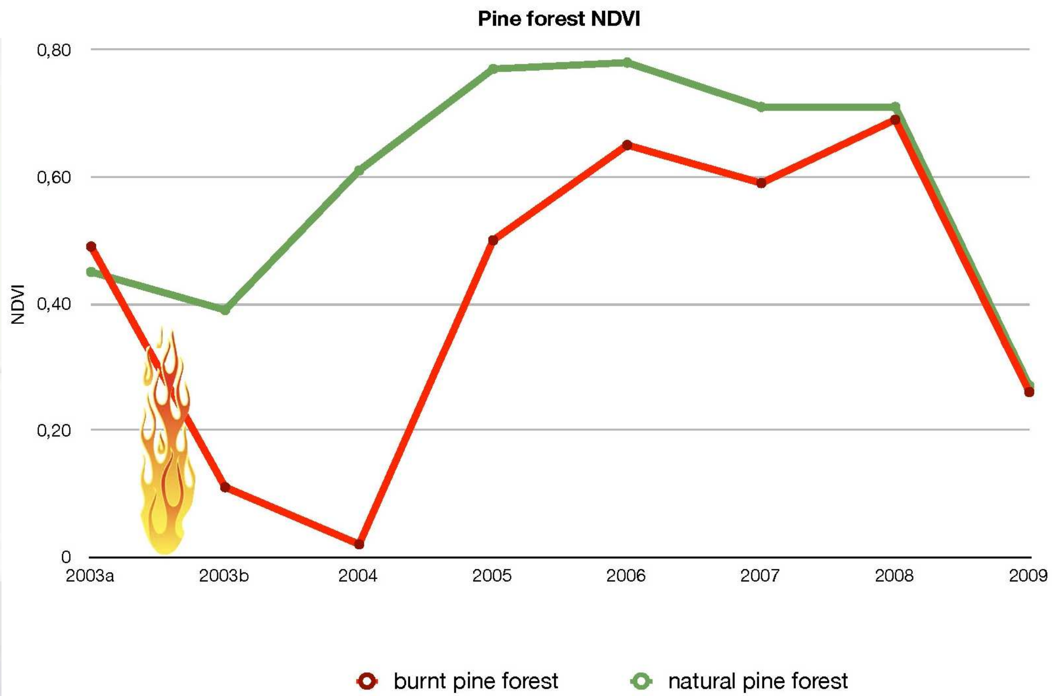
NDWI 24th July 2009



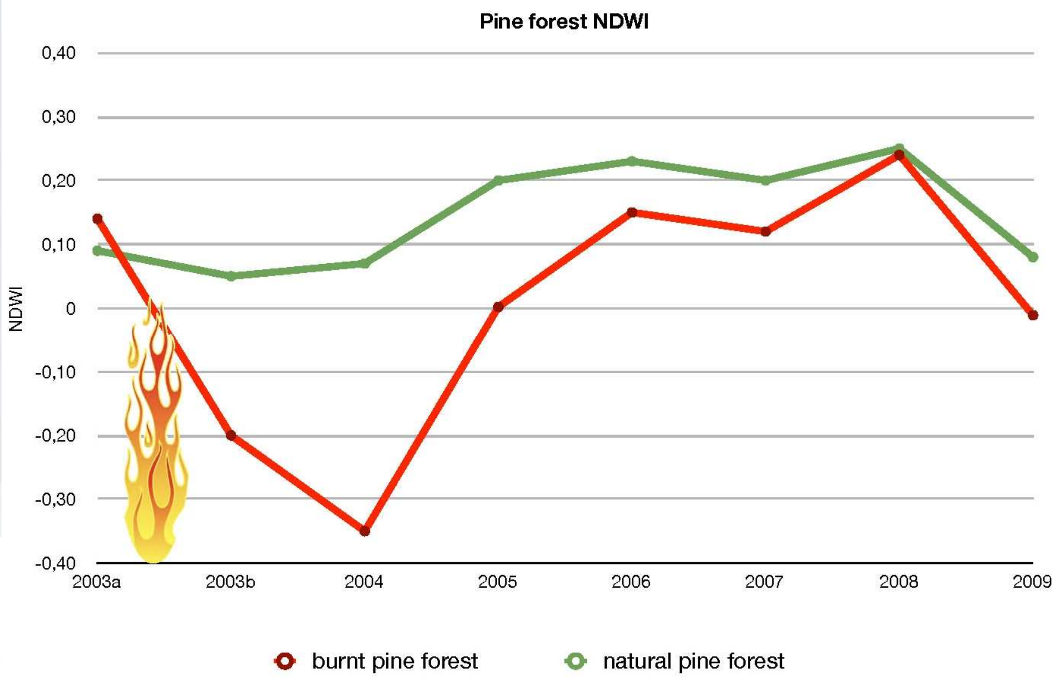
Signs of recovery for both vegetation typologies start appearing since spring 2005 (2 years after the fire).

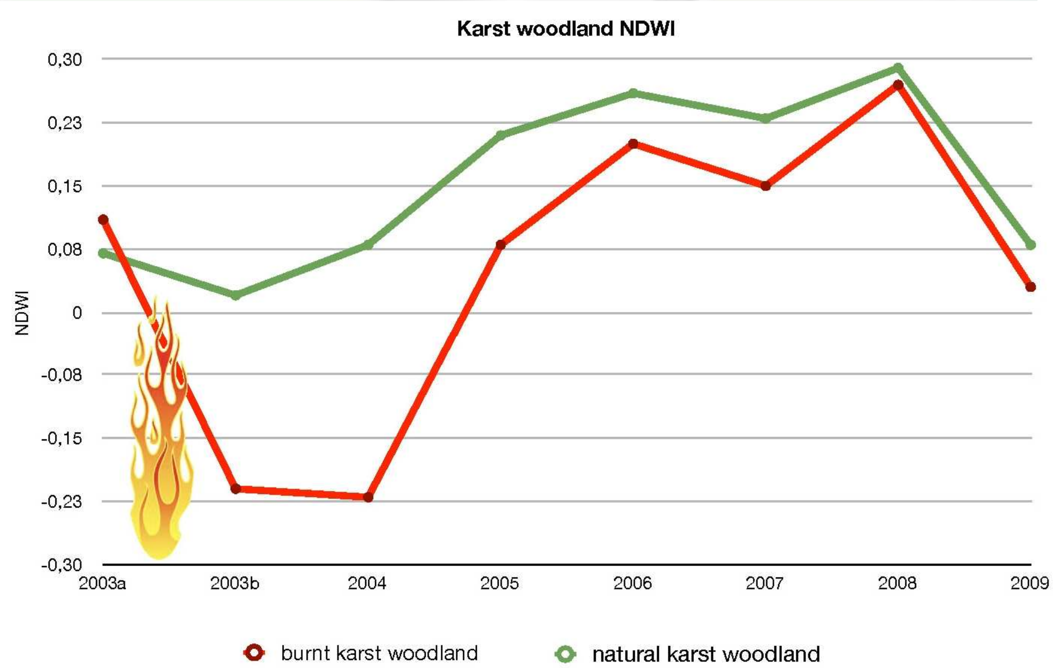
NDVI differences between the burnt and the unburnt areas consistently decrease in 2008 (5 years after the fire).

So the current photosynthetic activity and CO_2 balance could be considered similar to those before the fire, although the vegetation structure, verified during a field trip (May 2009), still differs.



The NDWI trend suggests that the humidity content of leaves and soil returns to “normal conditions” when the vegetation cover is regenerated, although the structure of the forest is still different.



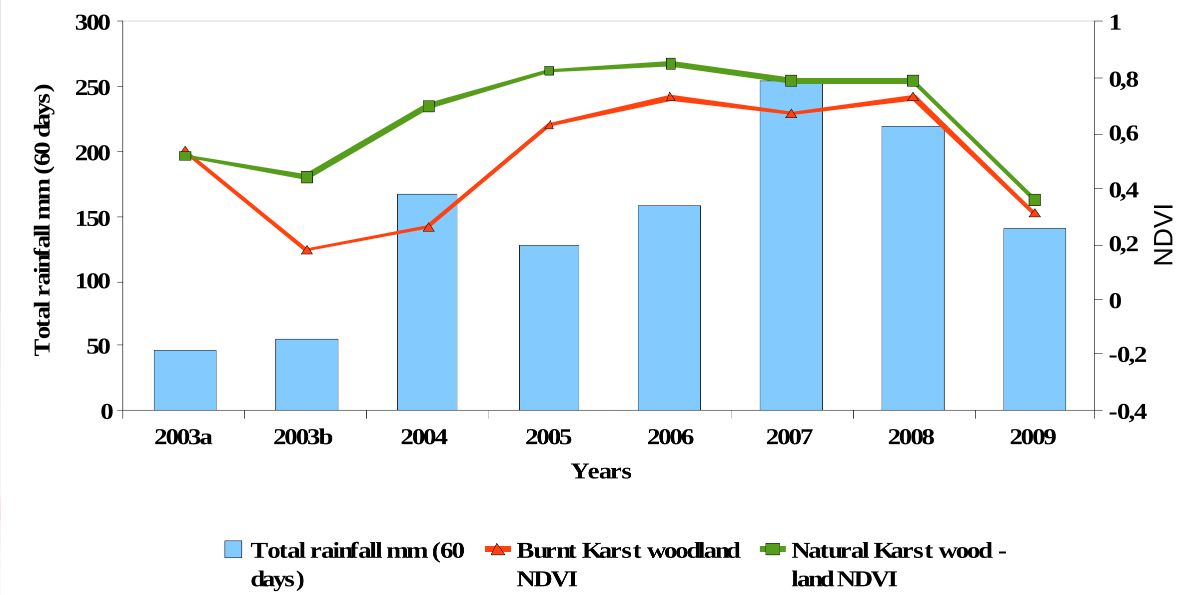


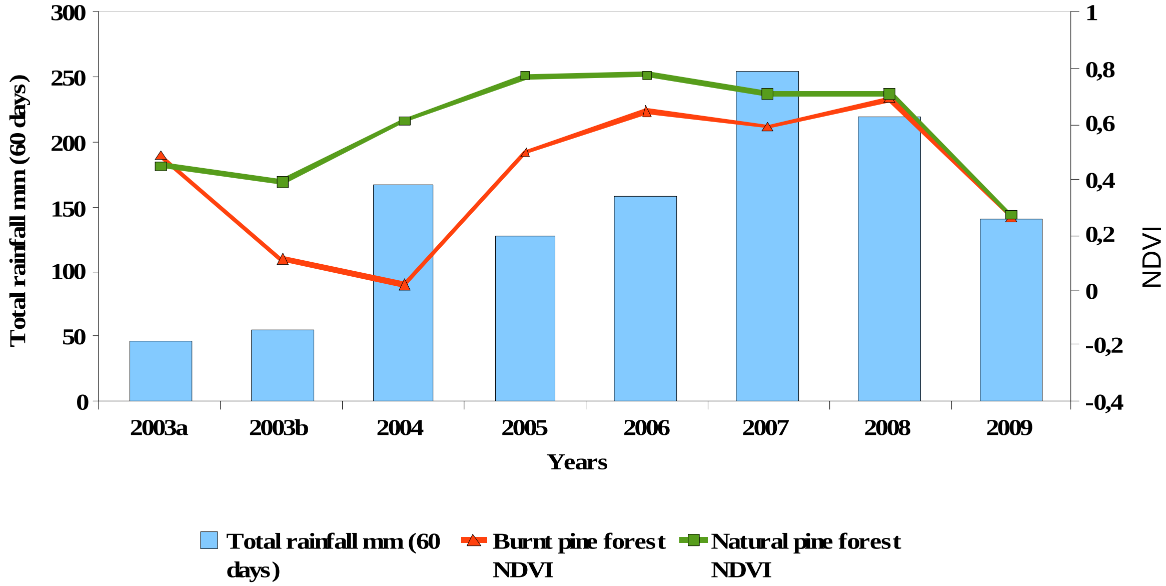
Just after the fire (August 2003) and one year later (2004) the soil water absorption was very low. This could be due to the lack of vegetation and to the formation of an hydrophobic sheet above the superficial soil layer, that blocks the water infiltration.

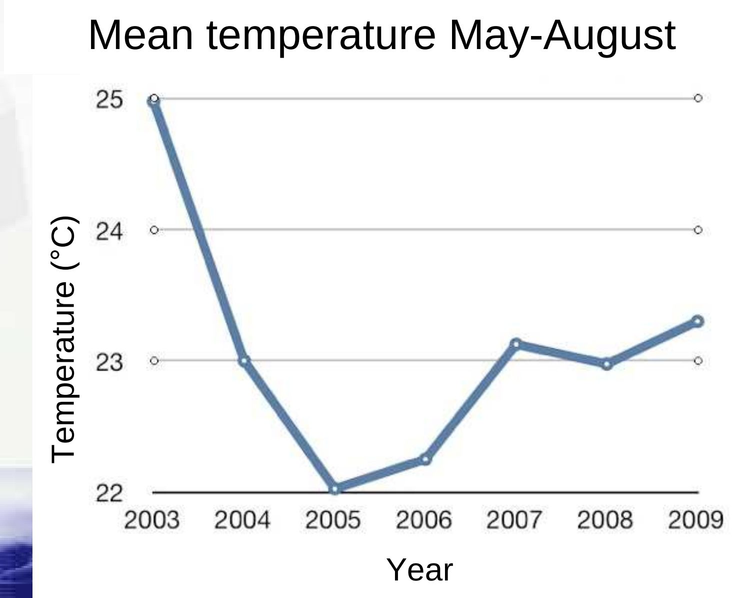
Comparison between cumulated rain data (60 days) and NDVI values

The rainfall histogram and the green lines (unburnt areas) have a similar trend, while the trend is different for the burnt areas (red lines).

Meteorological conditions in 2003 were extreme: summer temperatures were especially high, with scarce precipitations.



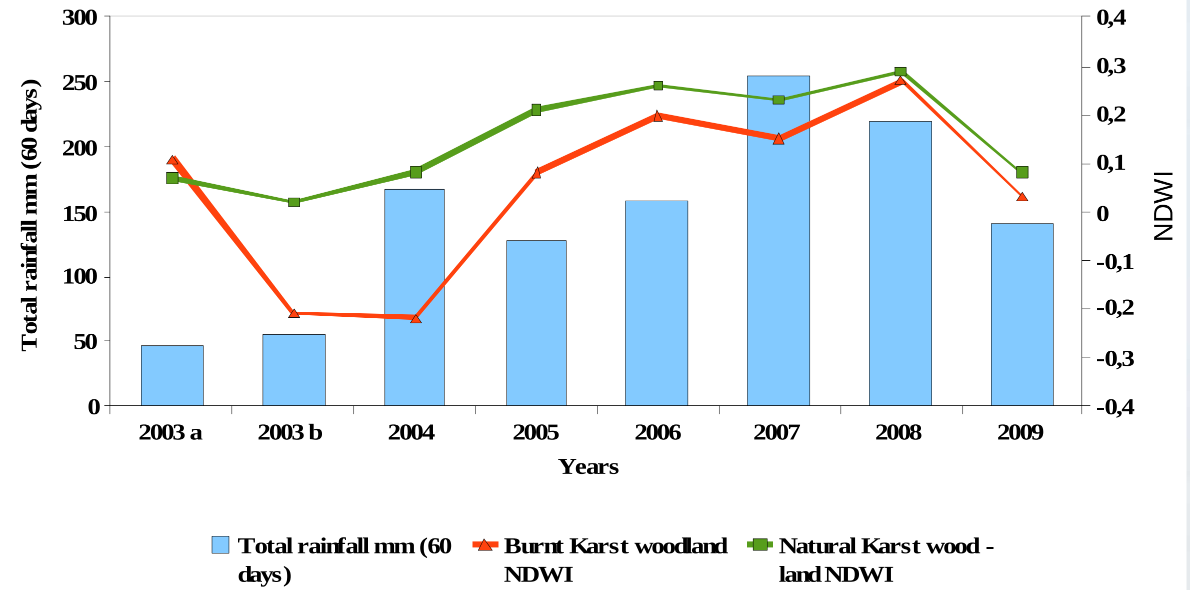


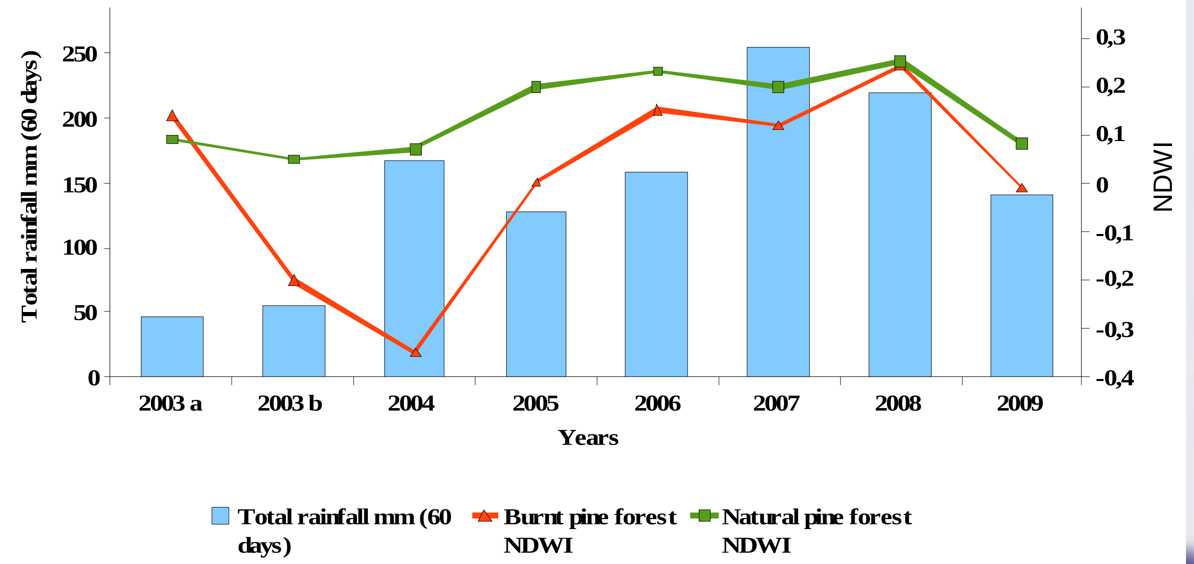


Comparison between cumulated rain data (60 days) and NDWI values

The NDWI index of the burnt areas (red lines) drops immediately after the fire and starts climbing again 2 years later.

This suggests that the soil in the burnt areas has difficulties in absorbing rain water (hydrophobic layer); this is particularly evident for the pine forest.





Values of U-Mann Whitney test applied to the NDVI and NDWI indices of two random sampled areas for each year (2003-2009), comparing burnt and unburnt areas for both vegetation typologies

(U-Mann Whitney indices (U) with two-tailed probability (*p*). In red non-significant differences. 2003a before the fire, 2003b after the fire)

NDVI		2003a	2003b	2004	2005	2006	2007	2008	2009
Karst woodland	U	**742.0**	106.0	0.0	44.0	64.5	140.0	173.0	328.0
	p	**0.580**	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pine forest	U	268.5	0.0	0.0	5.0	75.0	183.0	**550.0**	**602.5**
	p	0.000	0.000	0.000	0.000	0.000	0.000	**0.237**	**0.543**
NDWI		**2003a**	**2003b**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Karst woodland	U	**722.5**	78.5	22.0	63.0	107.0	108.5	436.0	156.0
	p	**0.459**	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pine forest	U	141.0	0.0	0.0	0.0	163.0	45.0	**656.5**	39.0
	p	0.000	0.000	0.000	0.000	0.000	0.000	**0.987**	0.000

NDVI		2003a	2003b	2004	2005	2006	2007	2008	2009
Karst woodland	U	**742.0**	106.0	0.0	44.0	64.5	140.0	173.0	328.0
	p	**0.580**	0.000	0.000	0.000	0.000	0.000	0.000	0.000

- Before the fire (2003a) the NDVI difference is **not significant**, confirming the expected similarity of the green biomass of the two woodland
- The NDVI values of the burnt and unburnt Karst woodlands are always **significantly different** after the fire (from 2003b to 2009)

NDVI		2003a	2003b	2004	2005	2006	2007	2008	2009
Pine forest	U	268.5	0.0	0.0	5.0	75.0	183.0	**550.0**	**602.5**
	p	0.000	0.000	0.000	0.000	0.000	0.000	**0.237**	**0.543**

- The NDVI values result **significantly different** already before the fire (2003a), probably because of the slope (29.76%) of the unburnt pine forest that does not allow an abundant growth of the vegetation cover
- The differences become **not significant** in 2008 and 2009, meaning that the quantity of green biomass in the burnt pine forest has reached the value of the unburnt one

NDWI		2003a	2003b	2004	2005	2006	2007	2008	2009
Karst woodland	U	**722.5**	78.5	22.0	63.0	107.0	108.5	436.0	156.0
	p	**0.459**	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pine forest	U	141.0	0.0	0.0	0.0	163.0	45.0	**656.5**	39.0
	p	0.000	0.000	0.000	0.000	0.000	0.000	**0.987**	0.000

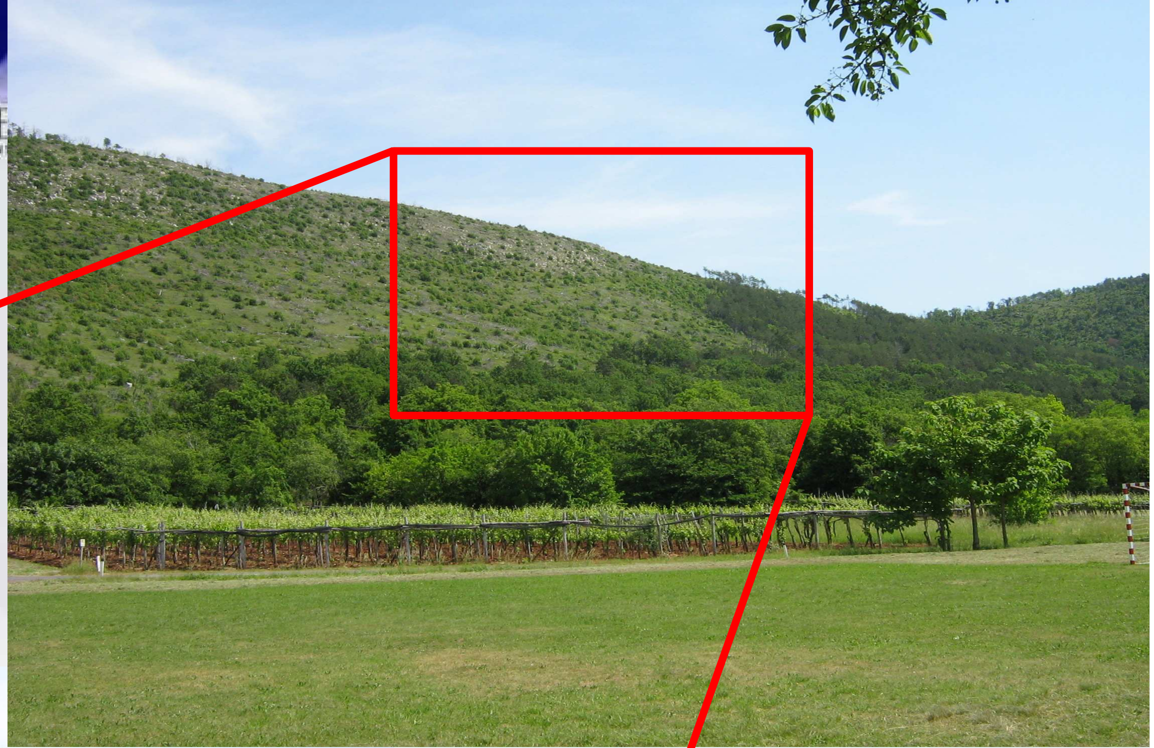
- NDWI statistical results are very similar to those of NDVI, except for the pine forest in 2009
- For the pine forest in 2009, the NDWI difference is **significant**, probably because the amount of rainfall was low and the vegetation cover is still on a developmental stage

Conclusions

- The consequences of the forest fire occurred in the study area in 2003 have been studied through free multi-temporal satellite images
- Using gvSIG, an open source software, it has been possible to analyze satellite images and rapidly obtain useful results for ecosystem monitoring
- NDVI and NDWI indices have been calculated to detect the time needed for the vegetation to recover after the fire
- According to the statistical analysis the whole study period (six years) is insufficient to reach the original NDVI and NDWI values, however from the values trend it can be assumed that this will happen in the next few years
- In ecological terms, although the vegetation has not achieved its original structure, 5 years after the fire, it can already accomplish some of its biological roles such as photosynthetic activity, CO_2 and water absorption

Field trip to the burnt area under the guidance of the Slovenian forest authority personnel (21/5/2009)

The difference between the burnt and the unburnt areas is still evident today (yellow line)



In the burnt areas the Slovenian forest authority began in 2004 a restoration program: some zones have been planted and other seeded

The inception of this research was the university course “Laboratory of biomonitoring by remote sensing” held at the University of Trieste in 2009