AFORCLIMATE

LIFE15 CCA/IT/000089

Strumenti di monitoraggio degli impatti del cambiamento climatico sulle foreste

Università degli Studi della Basilicata

SAFE - Scuola di Scienze Agrarie, Forestali, Alimentari e Ambientali

Angelo Nolè

angelo.nole@unibas.it

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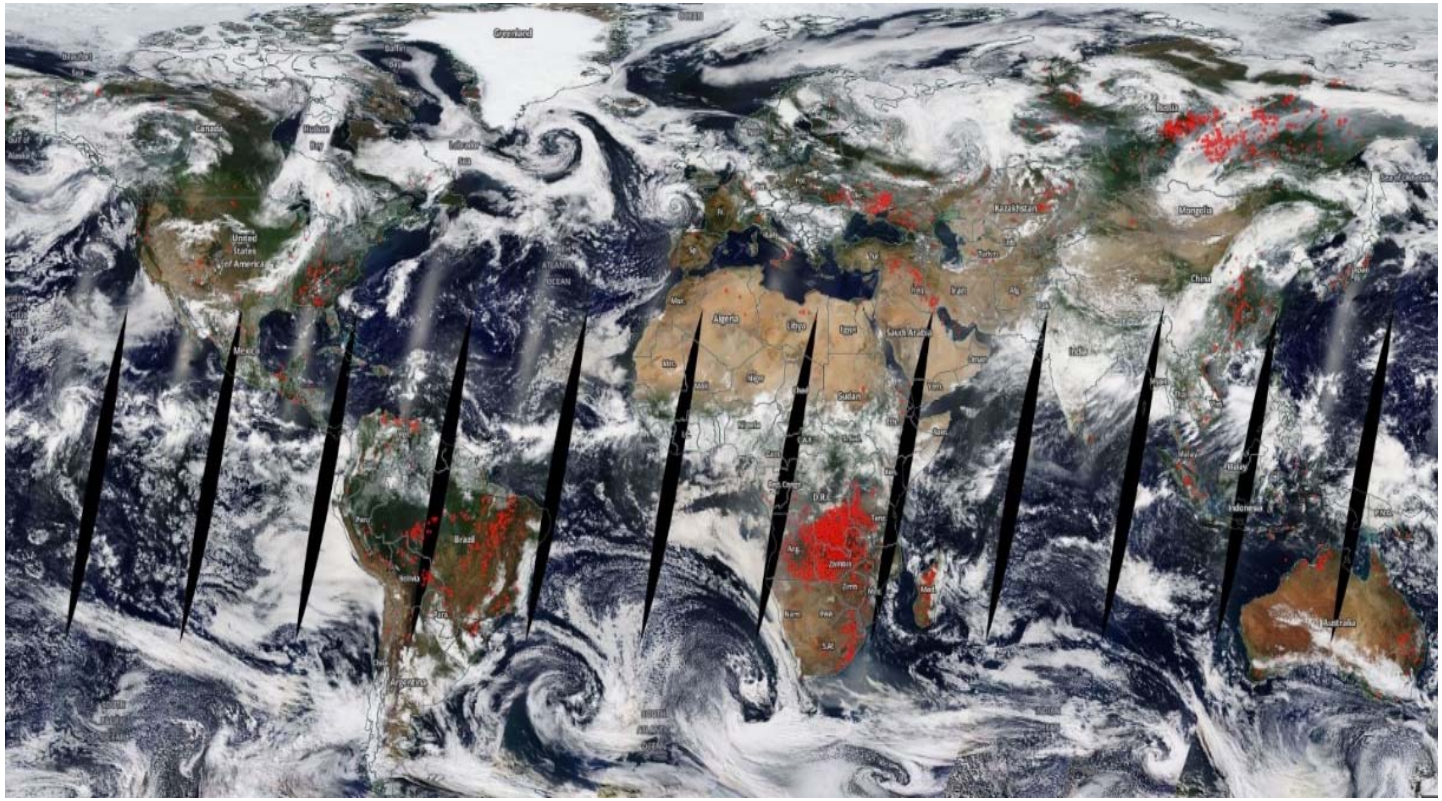
Foreste mediterranee e cambiamenti climatici: tra mitigazione e adattamento

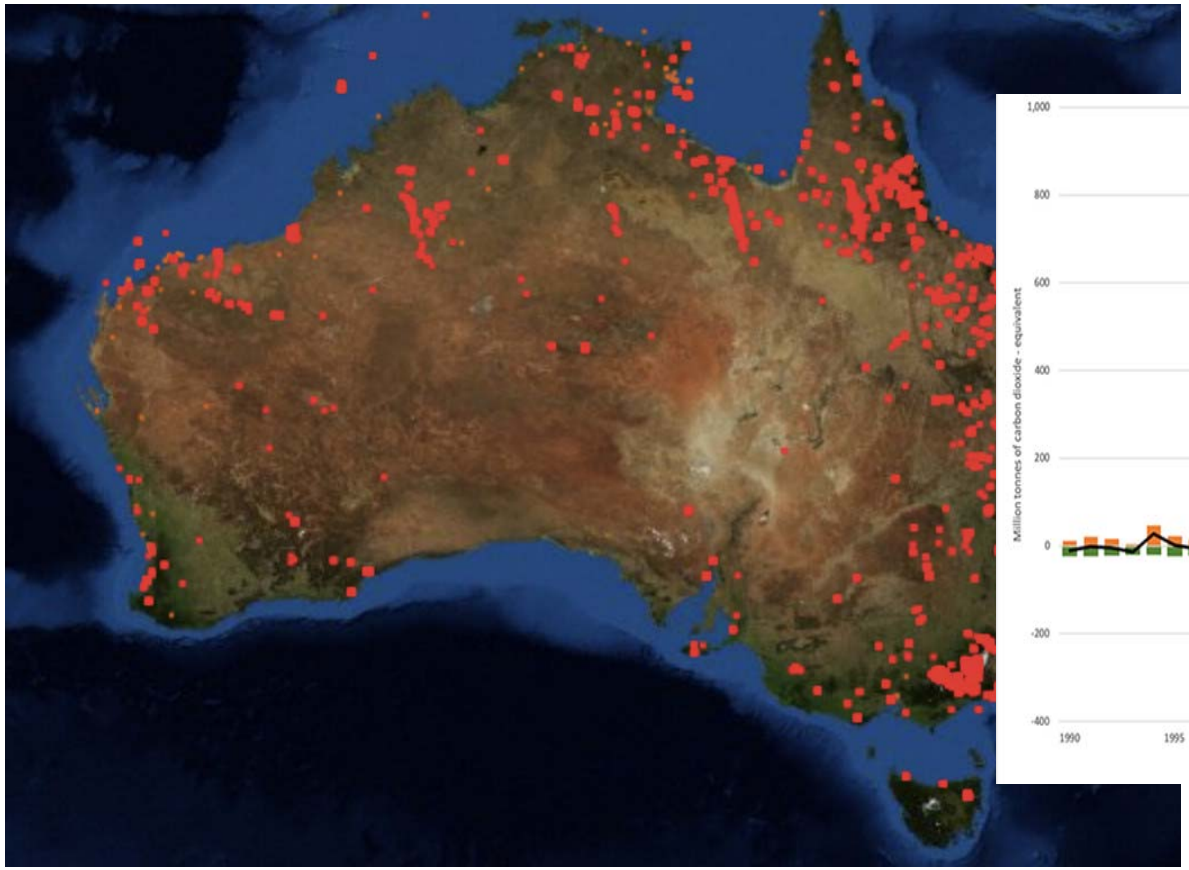
Disturbi e Impatti

Incendi Artico 2019

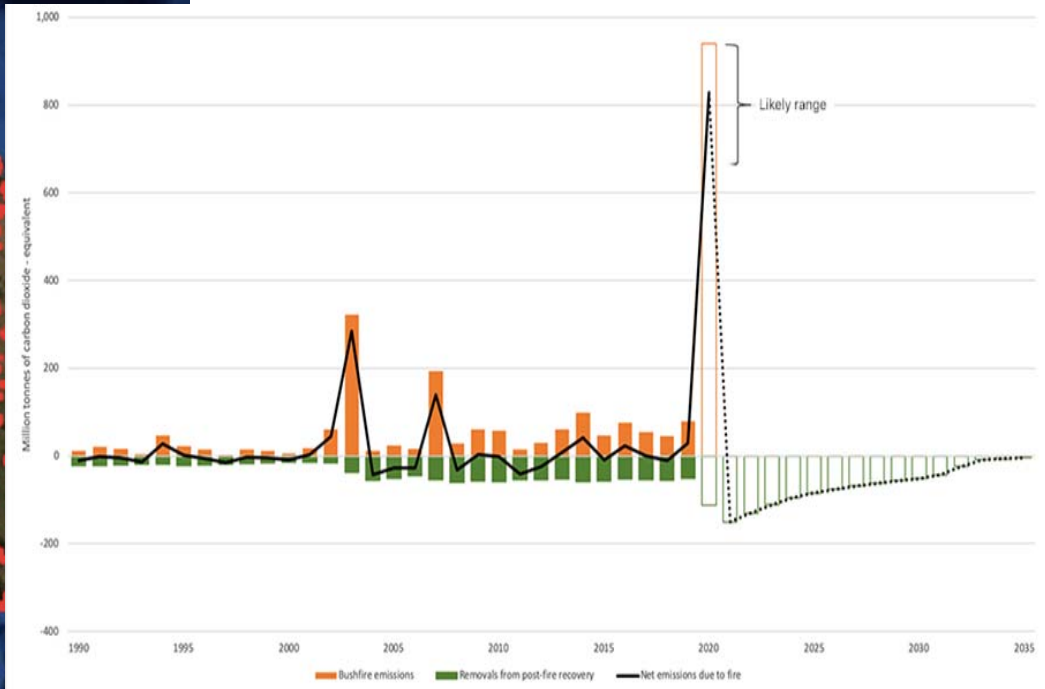


Active Fires del 29/07/2019, Immagine scaricata dal Fire Information for Resource Management System (FIRMS)
https://firms.modaps.eosdis.nasa.gov

Incendi Australia 2019-2020
Circa 19 Milioni di ettari

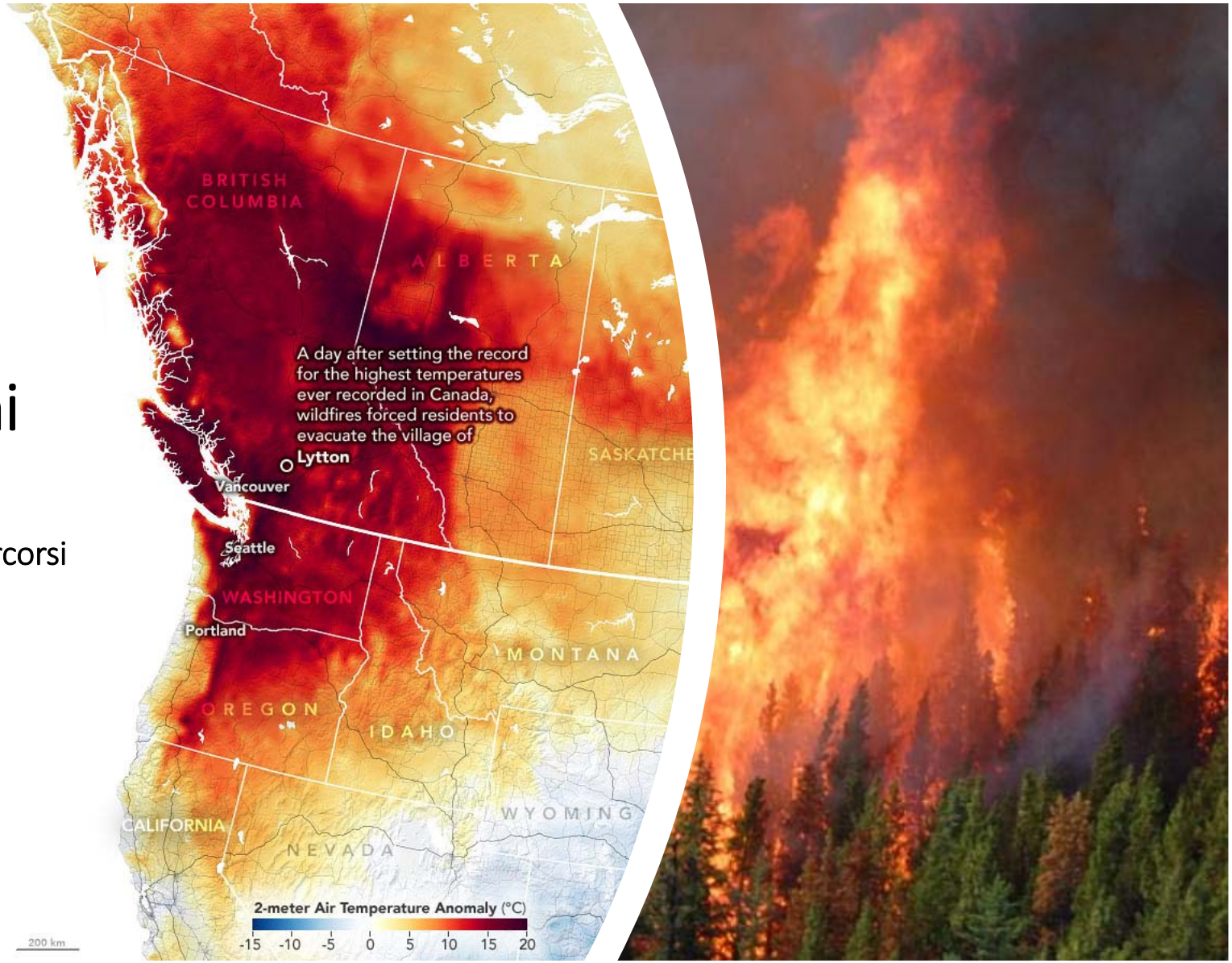


≈ 800 M ton di CO_2



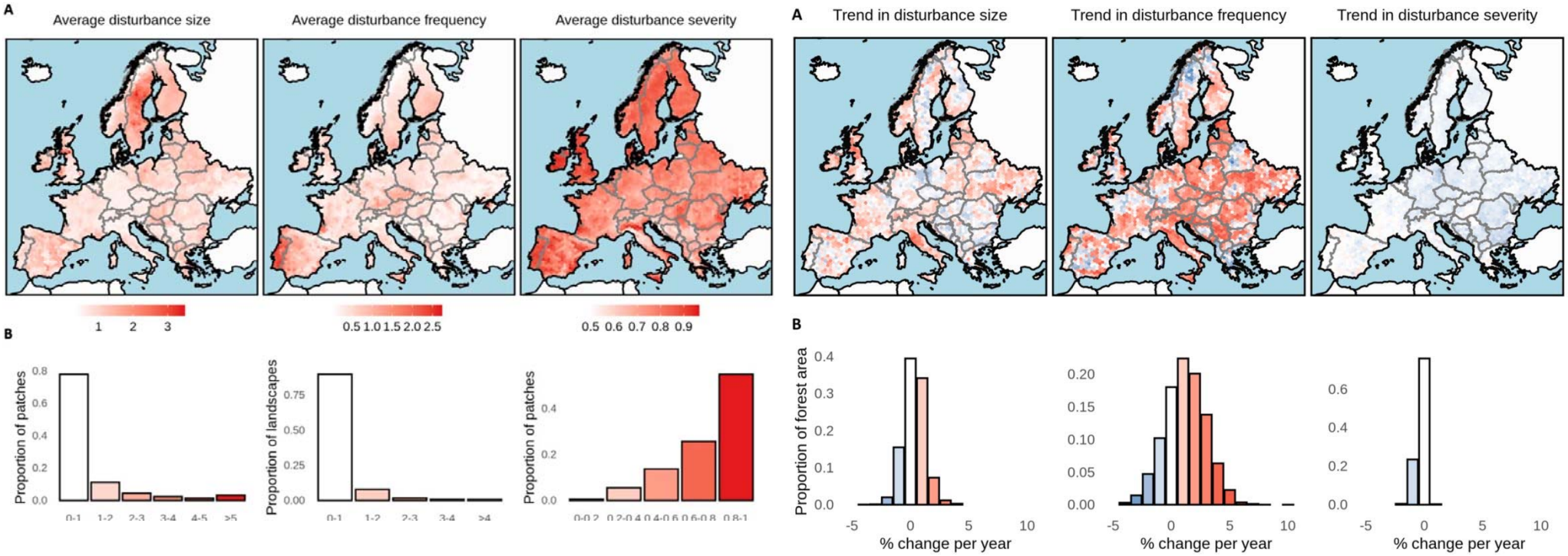
Eventi estremi Canada 2021

Circa 1 milione di ettari percorsi dal fuoco



Forest disturbance regimes of Europe

(1986-2016)



Senf and Seidl (2021) Mapping the forest disturbance regimes of Europe. *Nat Sustain*

Disturbi e Impatti

Disturbance

"Any relatively discrete event in time that disrupts ecosystems, community, or population structure and changes resources, substrate availability, or the physical environment." *(White and Pickett, 1985)*

Disturbi in foresta

Disturbi Naturali:

- **Fuoco (<2% incendi)**
- **Vento**
- **Siccità**
- **neve e ghiaccio**
- **Valanghe**
- **Alluvioni**
- **frane**
- **Vulcani**
- **insetti e patogeni**

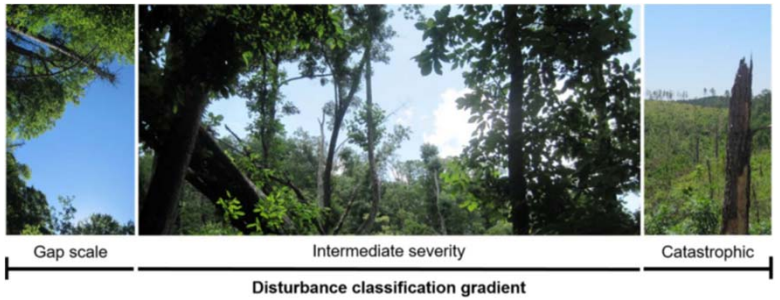
Disturbi Antropici:

- **Fuoco**
- **Deforestazione**
- **Cambio di destinazione d'uso del suolo**

Disturbi e Impatti

Classificazione

- **Tipo di disturbo**
- **Intensità del disturbo (magnitudo);**
- **Frequenza o tempo di ritorno del disturbo;**
- **Estensione spaziale del disturbo;**
- **Residui, quantità e qualità di organismi e servizi e funzioni ecosistemiche che sopravvivono al disturbo (*biotic and functional legacies)***



Regime di disturbo naturale

Magnitudo

disturbi minori (*minor disturbances*) sono quelli che rilasciano una parte più o meno consistente del popolamento preesistente

disturbi maggiori (*major disturbances* or *stand replacing disturbances*) sono quelli che provocano l'eliminazione completa del popolamento preesistente

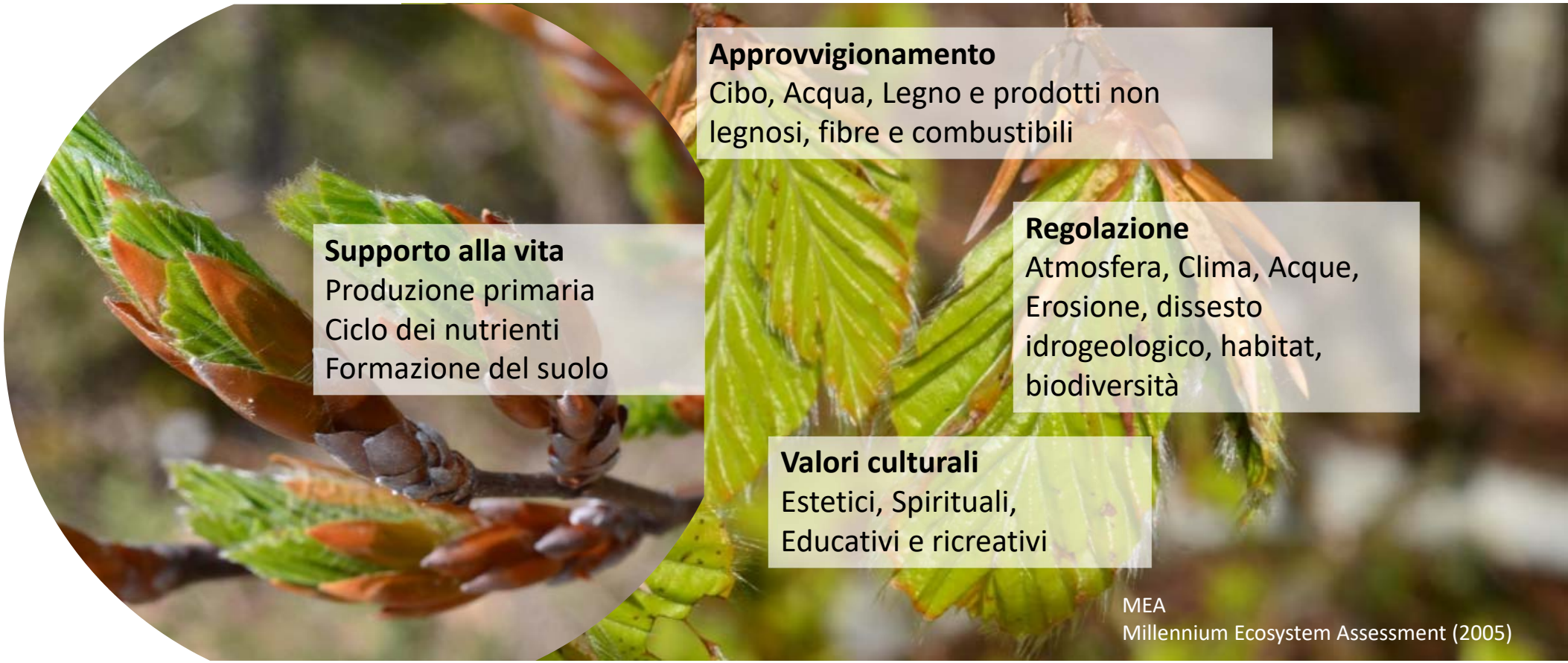
Dal punto di vista ecologico

La magnitudo e l'estensione del disturbo influenzano la *composizione e la struttura* del popolamento forestale

Disturbi e Impatti

Gli impatti dei disturbi possono essere misurati attraverso
Biotic and functional legacies

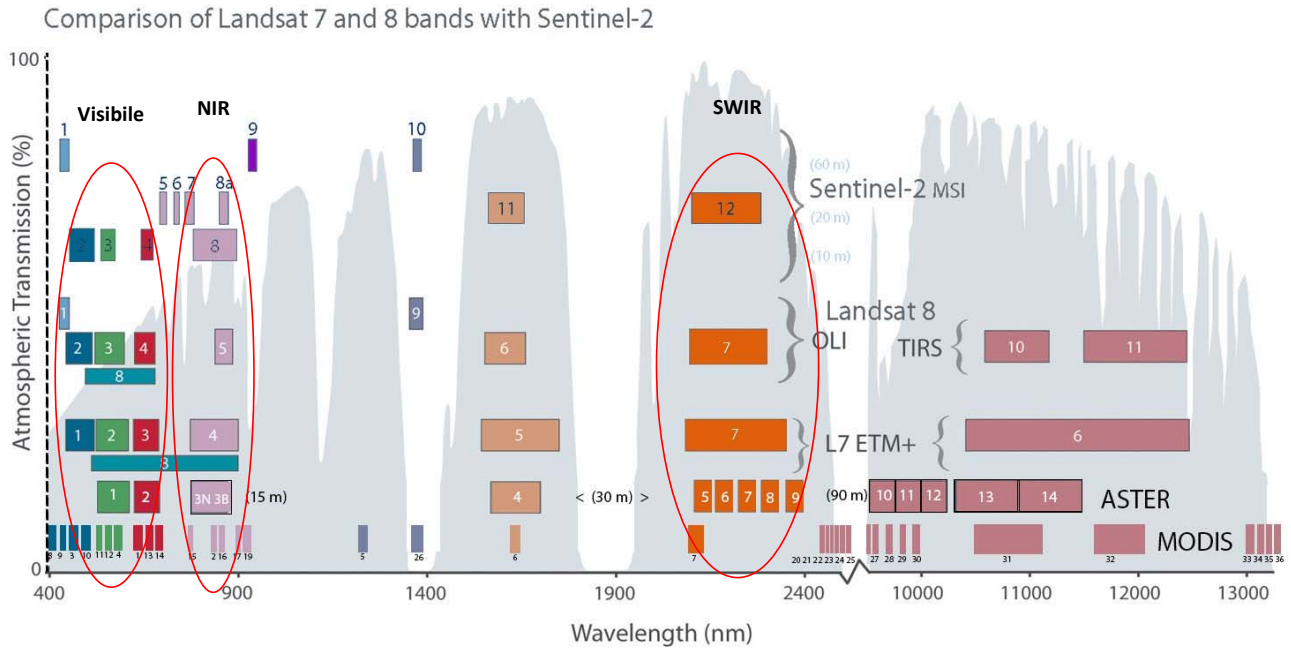
Servizi ecosistemici



MEA
Millennium Ecosystem Assessment (2005)

Monitoraggio Impatti

Remote sensing monitoring

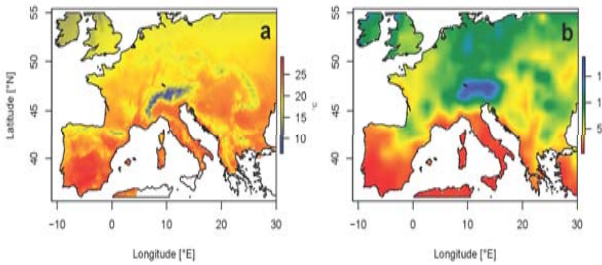


Le sfide delle foreste nel clima che cambia

Fuoco

Disturbi

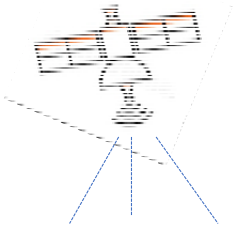
Acqua

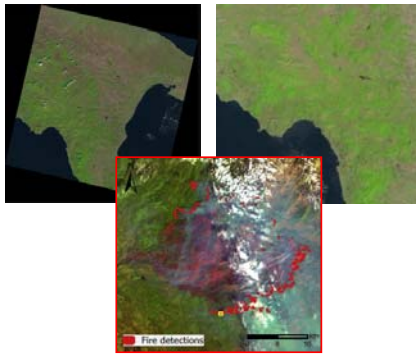


Freddo

Monitoraggio impatti incendi

SEVERITA' D'INCENDIO

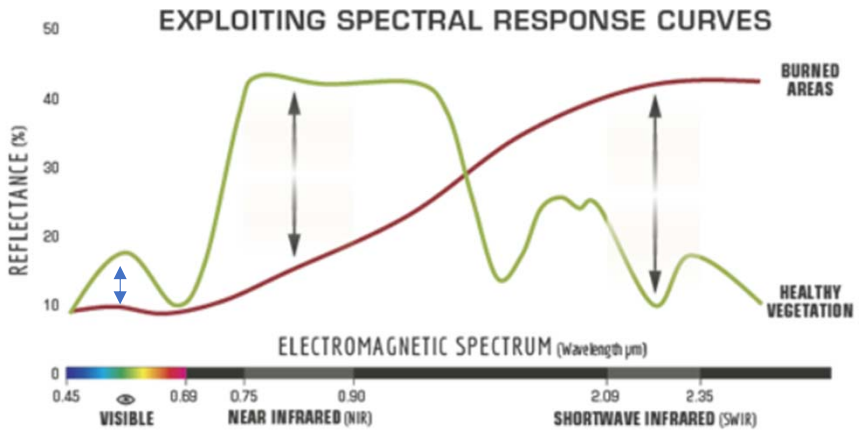




RECOVERY

Monitoraggio impatti incendi

Il monitoraggio post-incendio da remote sensing si basa sull'analisi delle proprietà spettrali, in termini di riflettanza, delle aree percorse dal fuoco



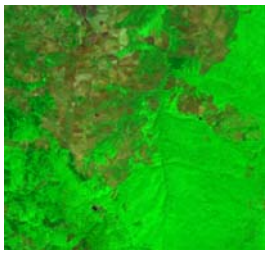
Monitoraggio impatti incendi

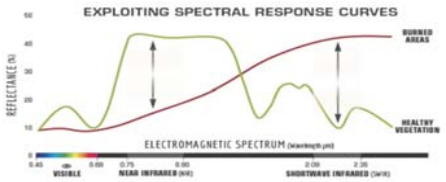
Fire severity $\Delta NBR = (NBR_{pre} - NBR_{post})$

$$NBR = \frac{NIR-SWIR}{NIR+SWIR}$$

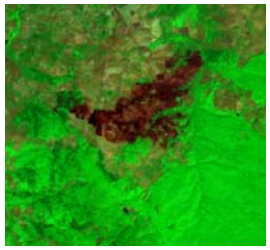
NBR (Normalized Burn Ratio)

Pre-fire



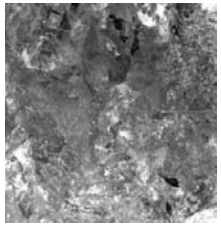


Post-fire

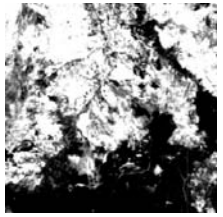


Landsat 8 false-color 752
(SWIR2,NIR, Blue)

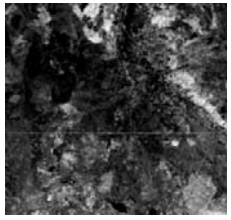
NIR



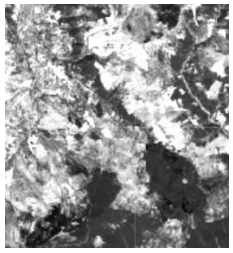
SWIR



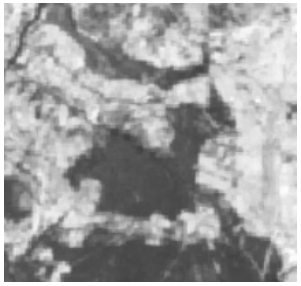
NIR



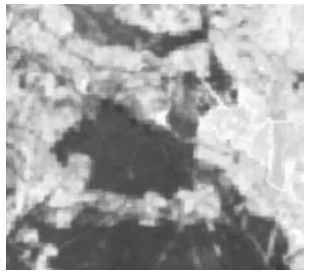
SWIR



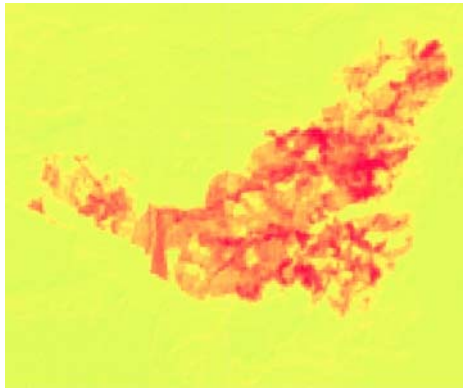
NBR_{pre}



NBR_{post}



$\Delta NBR = (NBR_{pre} - NBR_{post})$

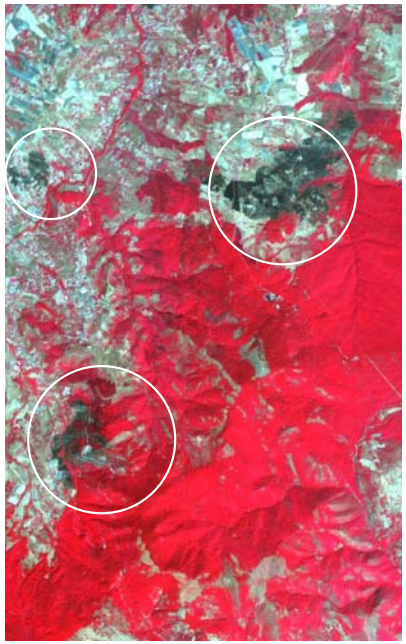


ΔNBR	Burn Severity
< -0.25	High post-fire regrowth
-0.25 to -0.1	Low post-fire regrowth
-0.1 to +0.1	Unburned
0.1 to 0.27	Low-severity burn
0.27 to 0.44	Moderate-low severity burn
0.44 to 0.66	Moderate-high severity burn
> 0.66	High-severity burn

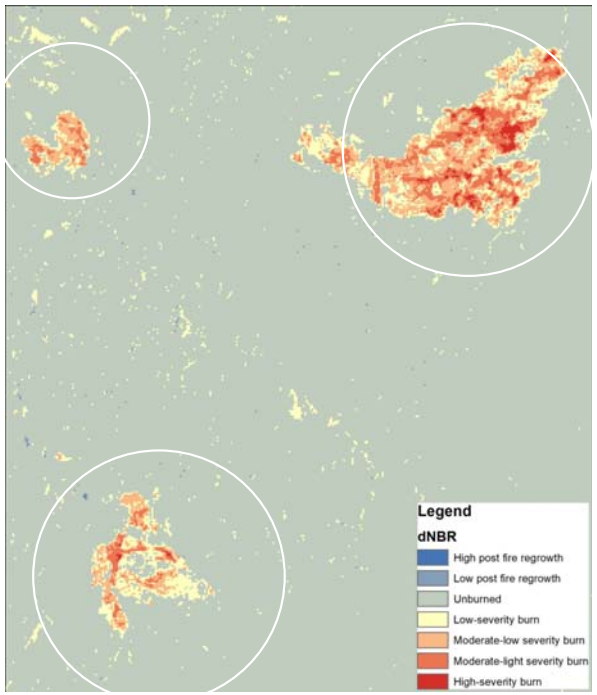
Monitoraggio impatti incendi

03rd - 26th august 2017
True color- bands 4-3-2

03rd - 26th august 2017
False Colro InfraRed - bands 8-4-3

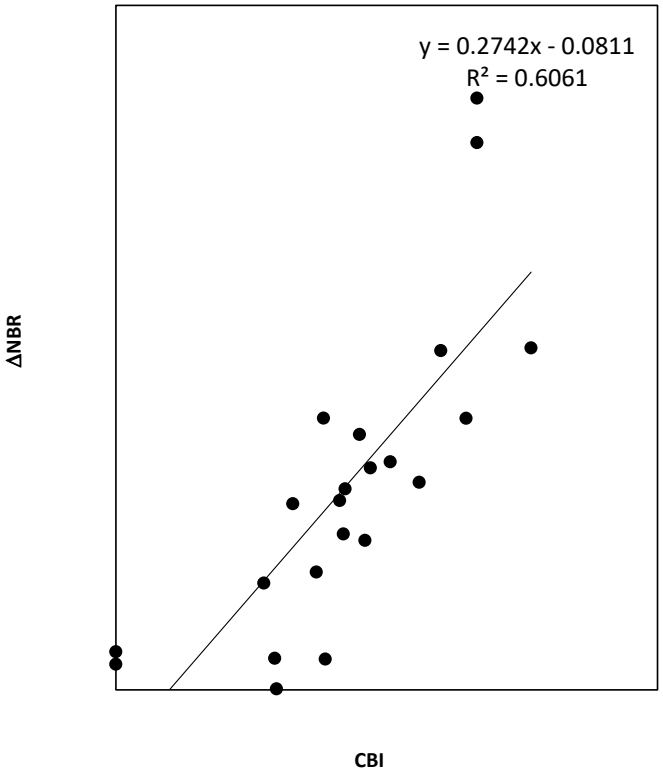


ΔNBR Burn Severity Categories
03rd -26th august 2017



Calibrzione e Validazione in campo

COMPOSITE BURN INDEX (CBI)

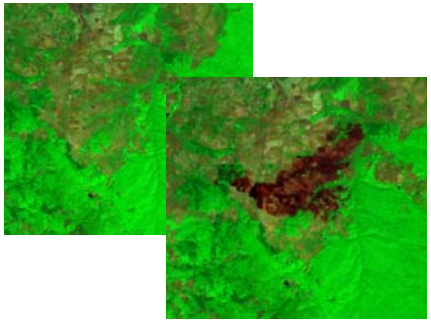


Validation of the fire severity index

Identification of study areas

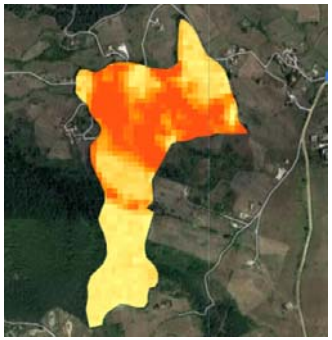
Image acquisition and Pre-processing

Google Earth Engine

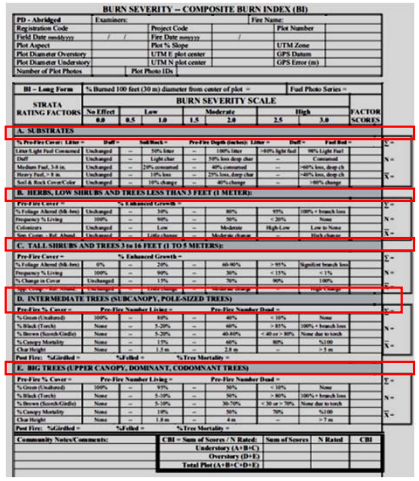


$$NBR = \frac{(NIR - SWIR)}{(NIR + SWIR)}$$

$\Delta NBR = (NBR_{pre} - NBR_{post})$



Field rating of burn severity by CBI (Composite Burn Index)



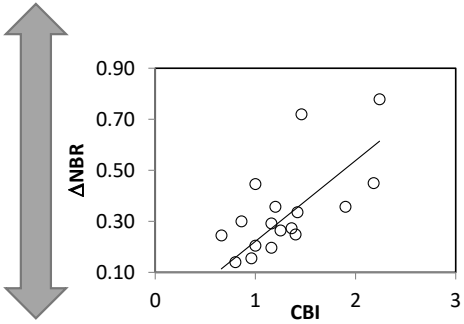
A. Substrates

B. Herbs, low shrubs

C. Shrubs and trees 1 to 5 m tall

D. Intermediate trees

E. Big trees

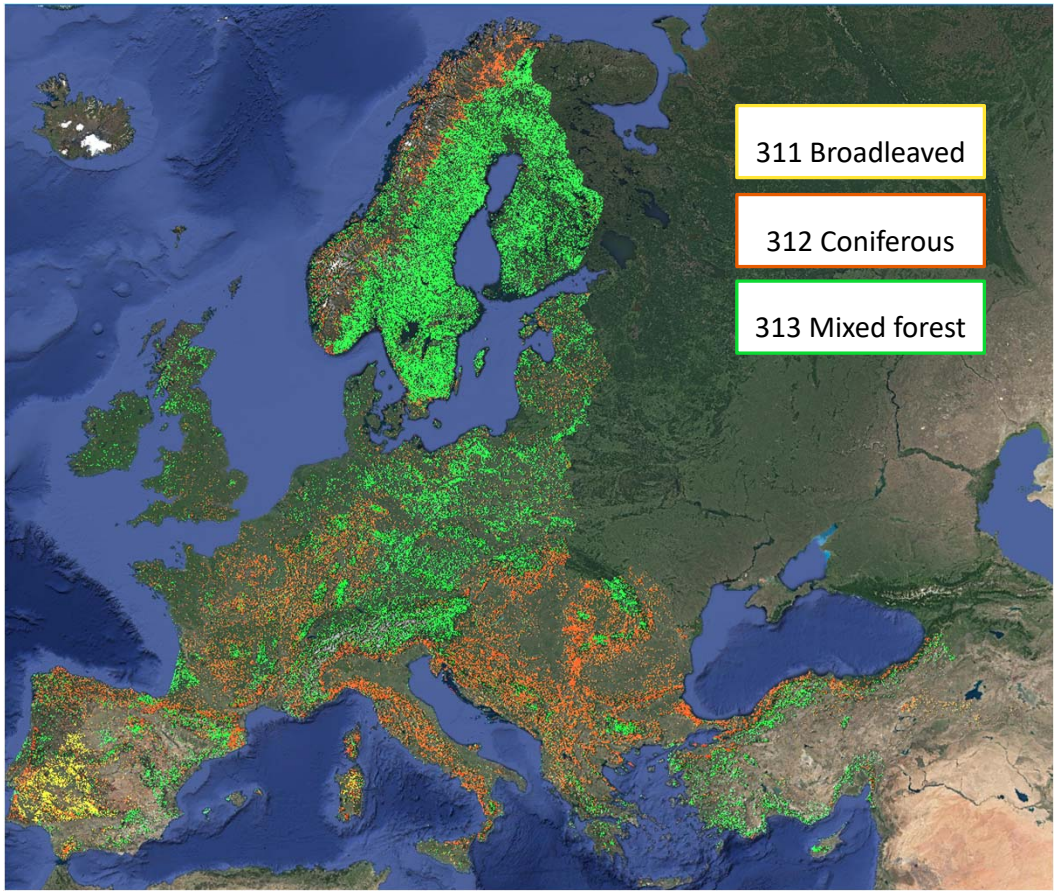


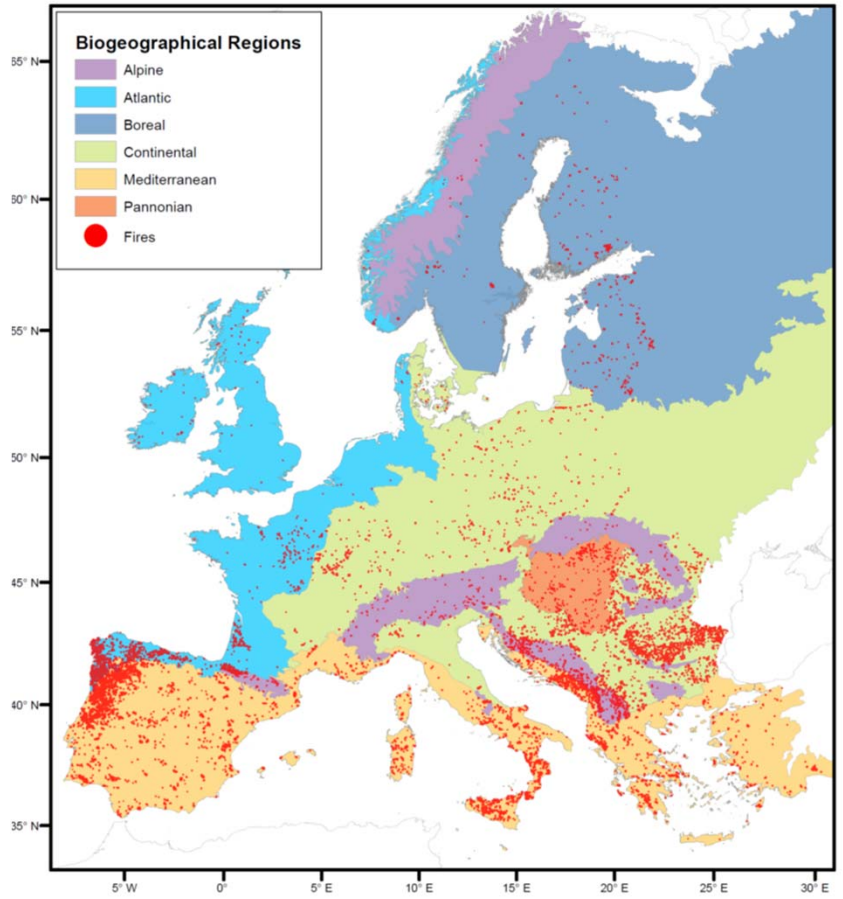
Validation between CBI field data with "fire severity index"

Monitoraggio post-fire recovery

Analisi dei trends di ripristino della vegetazione post-incendio
NDVI vs RRI trends (2002-2020)

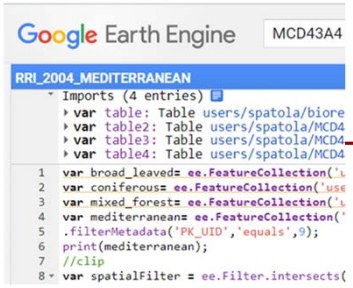
European Forests Corine Land Cover (CLC 2012)



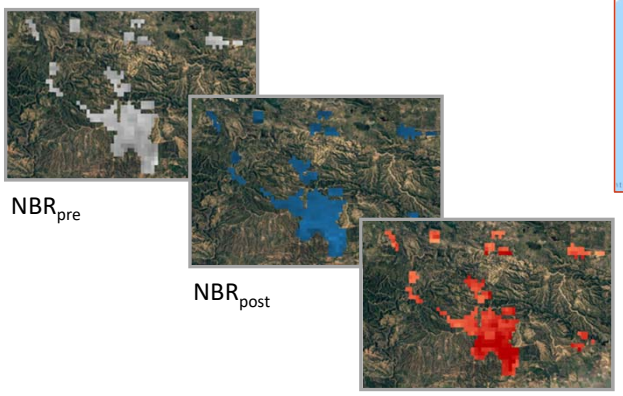


MATERIALS AND METHODS – Data Analysis

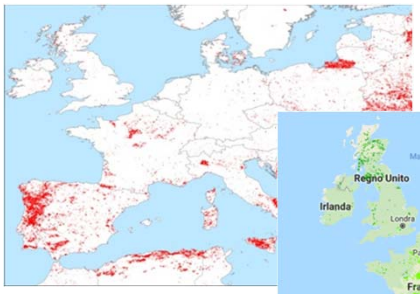
Google Earth Engine platform



Modis MCD43A4 (2002-2020)

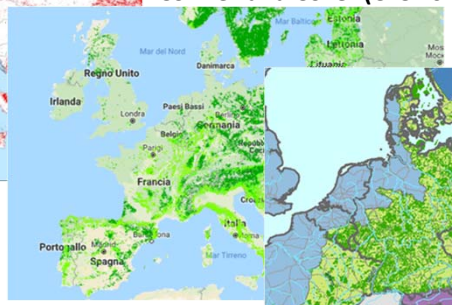


Burned Area Modis MCD45A1 (2004-2015)

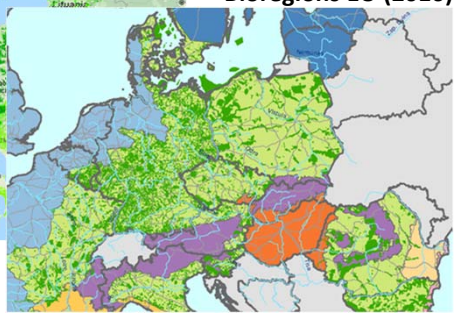


Incendi non stand-replacing

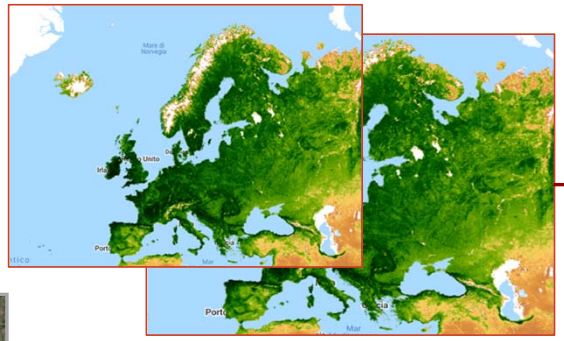
Corine Land Cover (CLC 2012)



Bioregions EU (2016)



Modis MOD13Q1 (2002-2020)



RRI time series

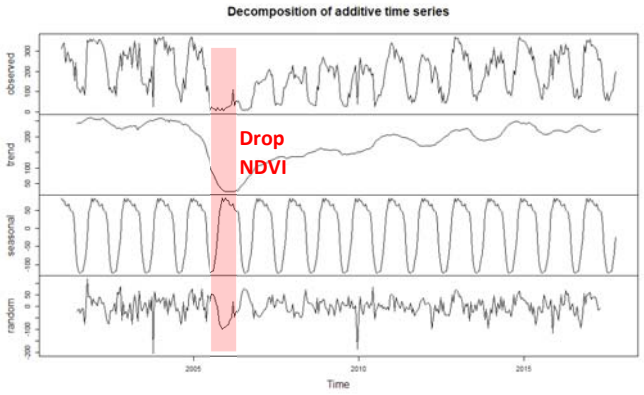
NDVI time series

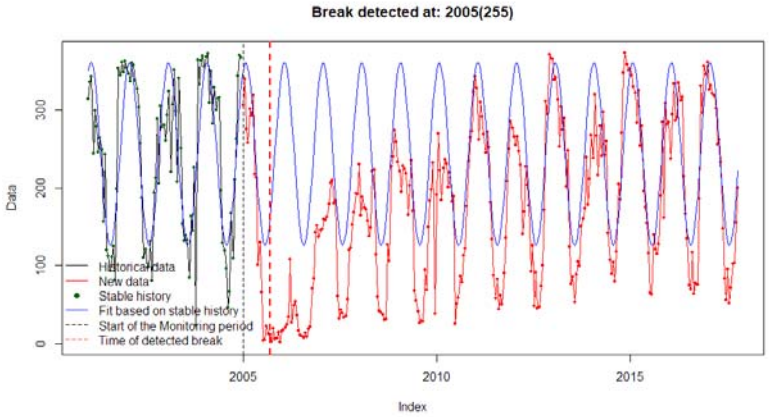
Analysis of recovery trends

Monitoraggio post-fire recovery NDVI

BFAST (Breaks for Additive Season and Trend) e recovery onset

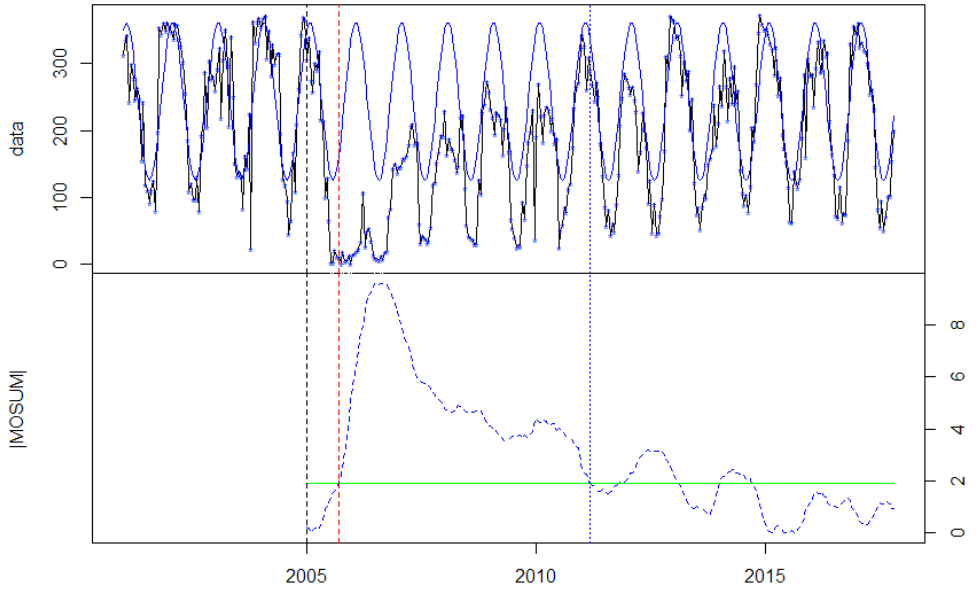
Scomposizione del trend di NDVI (2002-2020) per ogni area incendiata





BFAST: algoritmo per l'individuazione del break point (incendio).
Variazioni di NDVI in termini di deviazione del valore osservato rispetto al valore atteso stimato dal modello

Tempo di 'spectral' recovery post-incendio, basato sull'andamento della somma mobile dei residui MO (MOSUM) tra i valori osservati rispetto ai valori attesi di NDVI stimati dal modello



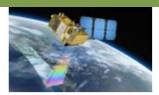
$$MO_t = \frac{1}{\hat{\sigma}\sqrt{n}} \sum_{s=t-h+1}^{t} \left(y_s - \hat{y}_s \right)$$

Lo spectral recovery avviene quando MO risulta minore della soglia statisticamente significativa (0.2) per almeno 2 stagioni vegetative successive.

[NDVI si attesta sui valori di 'equilibrio' per almeno due stagioni vegetative consecutive]

Monitoraggio post-fire recovery RRI

Post-fire monitoring *Remotely sensed data*



Spectral indices

BURN SEVERITY

Normalized Burn Ratio NBR = (NIR-SWIR)/(NIR+SWIR) [Key & Benson, 2006]

Delta Normalized Burn Ratio ΔNBR = NBRprefire-NBRpostfire [Key & Benson, 2006]

POST-FIRE VEGETATION RECOVERY

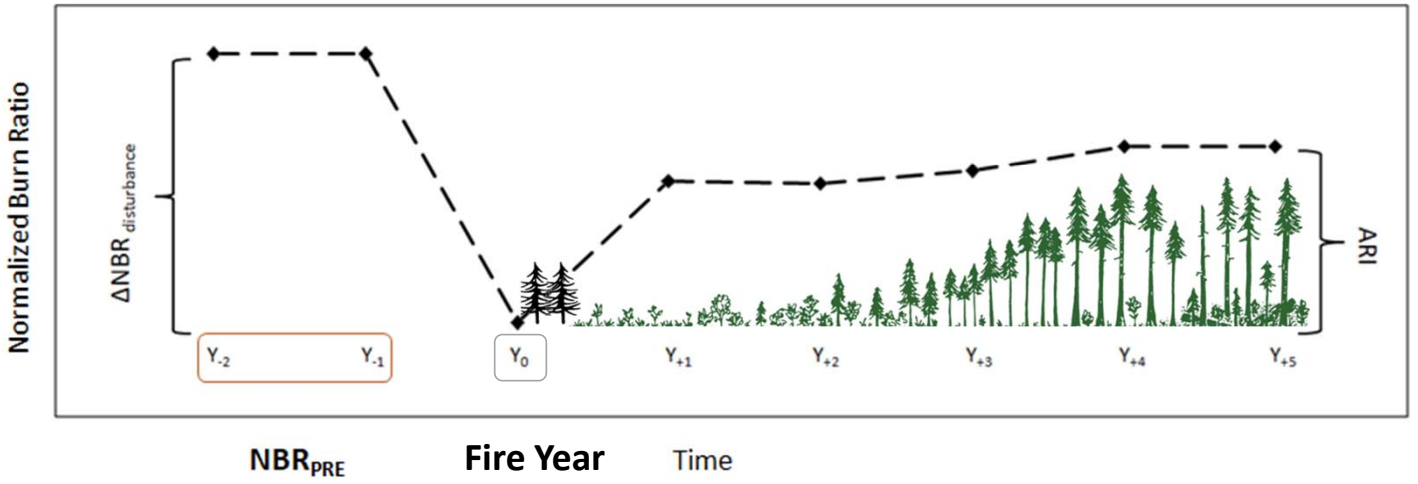
Relative Recovery Indicator RRI = ARI/ ΔNBRdisturbance [R.J Frazier et al.2018]

Absolute Recovery Indicator

ARI= Max (NBR_{Y+5}, NBR_{Y+4}) – NBR_{Y0}

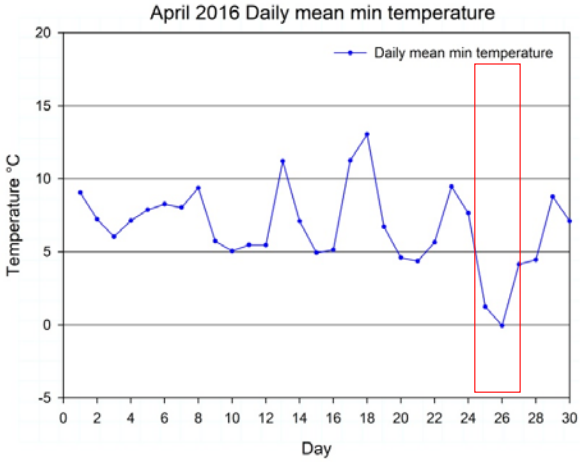
Delta Normalized Burn Ratio disturbance

$\Delta NBR_{disturbance}$ = NBRpre-NBRy0



Freddo - Gelata Faggete 2016

Late spring frost
25th-26th April 2016 (doy 116-117)



Freddo - Gelata Faggete 2016

Vegetation change detection 2015 - 2016

NDVI-Differencing $\Delta NDVI = NDVI_t - NDVI_{t-n}$

$\Delta NDVI < (\mu - n \times \sigma)$

μ ΔNDVI medio

σ Standard deviation

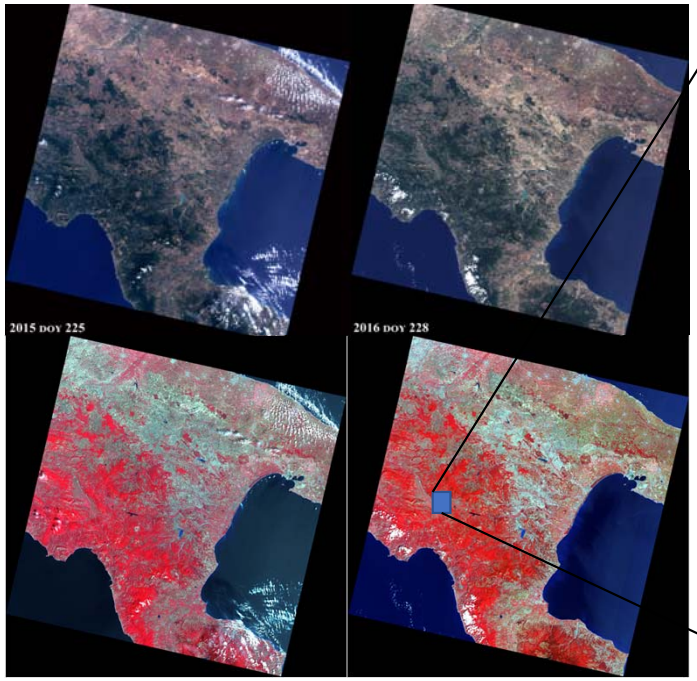
n threshold

$$\mu - n\sigma \leq \Delta NDVI \leq \mu + n\sigma \quad \textit{no change}$$

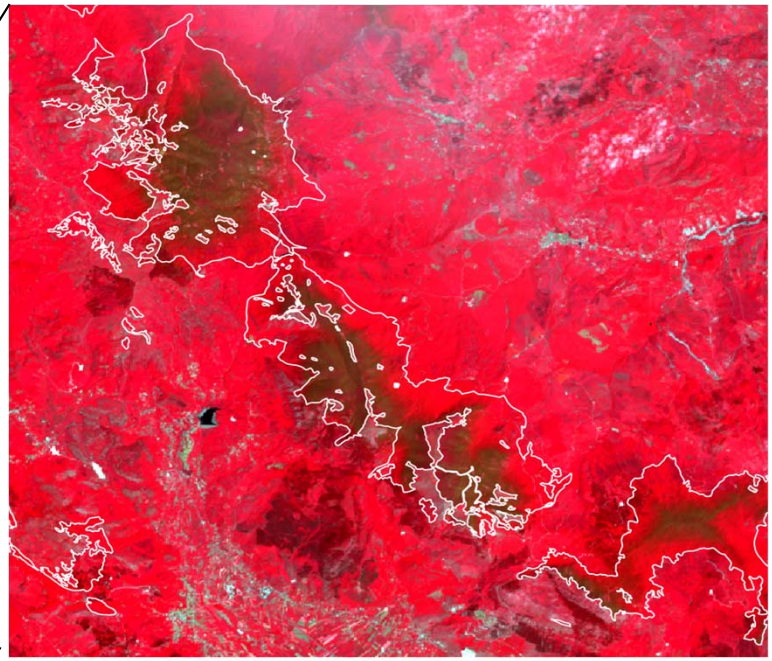
$$\Delta NDVI \leq \mu - n\sigma \quad \textit{negative change}$$

$$\Delta NDVI \geq \mu + n\sigma \quad \textit{positive change}$$

DOY 225 - 2015 **DOY 228 – 2016**

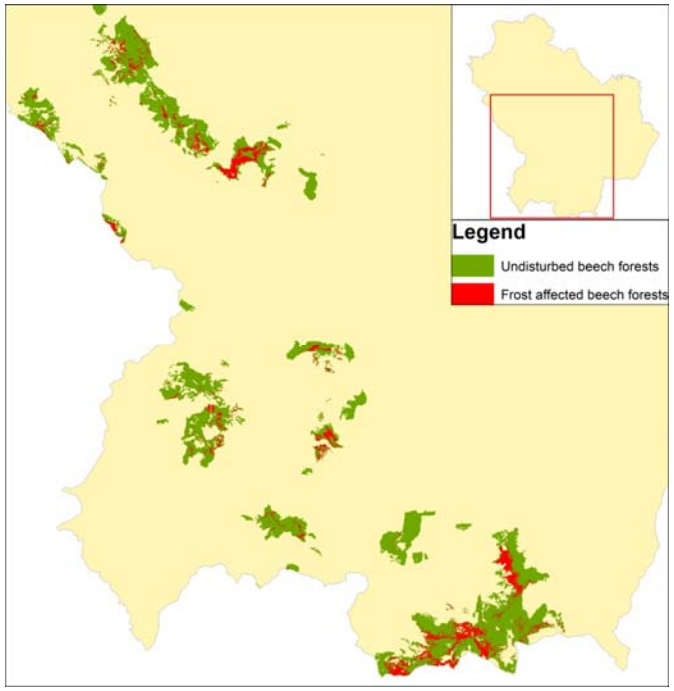


27th May 2016 – DOY 148
IRFC - bands 543



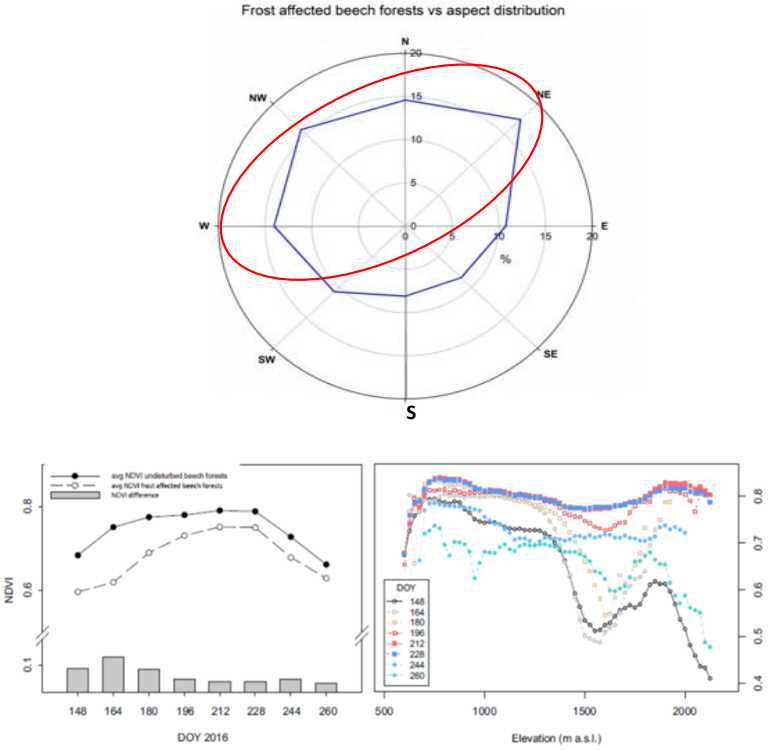
Freddo - Gelata Faggete 2016

Frost affected areas (13%; ≈ 4000 ha)



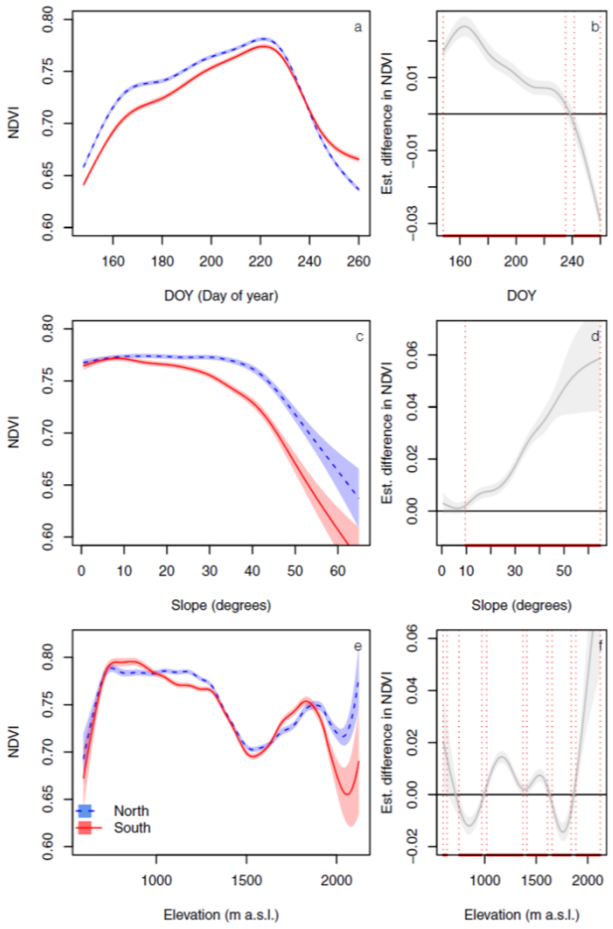
Nolè, A., Rita, A., Ferrara, A.M.S. and Borghetti, M. 2018 Effects of a large-scale late spring frost on a beech (Fagus sylvatica L.) dominated Mediterranean mountain forest derived from the spatio-temporal variations of NDVI. Annals of Forest Science, 75 (3

Frost disturbance aspect distribution



Seasonal patterns of average NDVI (disturbed and undisturbed)

Generalized additive model (GAM)



Freddo - Gelata Faggete 2016

NSC (Carbonio non strutturale)
Carbonio di riserva stoccato nei tessuti dalla piante, messo da parte dai 5 ai 9 anni prima

Riserve in grado di supportore fino a 4 ricacci

Bascietto M, Bajocco S, Mazzenga F, Matteucci G (2018) Assessing spring frost effects on beech forests in central Apennines from remotely-sensed data. Agric For Meteorol 248:240–250. https:// doi.org/10.1016/j.agrformet.2017.10.007

D'Andrea, E. , Rezaie, N. , Battistelli, A. , Gavrichkova, O. , Kuhlmann, I. , Matteucci, G. , Moscatello, S. , Proietti, S. , Scartazza, A. , Trumbore, S. and Muhr, J. (2019), Winter's bite: beech trees survive complete defoliation due to spring late-frost damage by mobilizing old C reserves. New Phytol, 224: 625-631. doi:10.1111/nph.16047

Grazie per l’attenzione