Forest fires in Mediterranean mountain forests: climate, land use, and management changes

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Fire is an integral part of many ecosystems, including the Mediterranean ones.

Forest fires are a major disturbance of Mediterranean ecosystems.

Natural disturbances

"A disturbance is any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment"

Pickett & White, 1985

Combustion

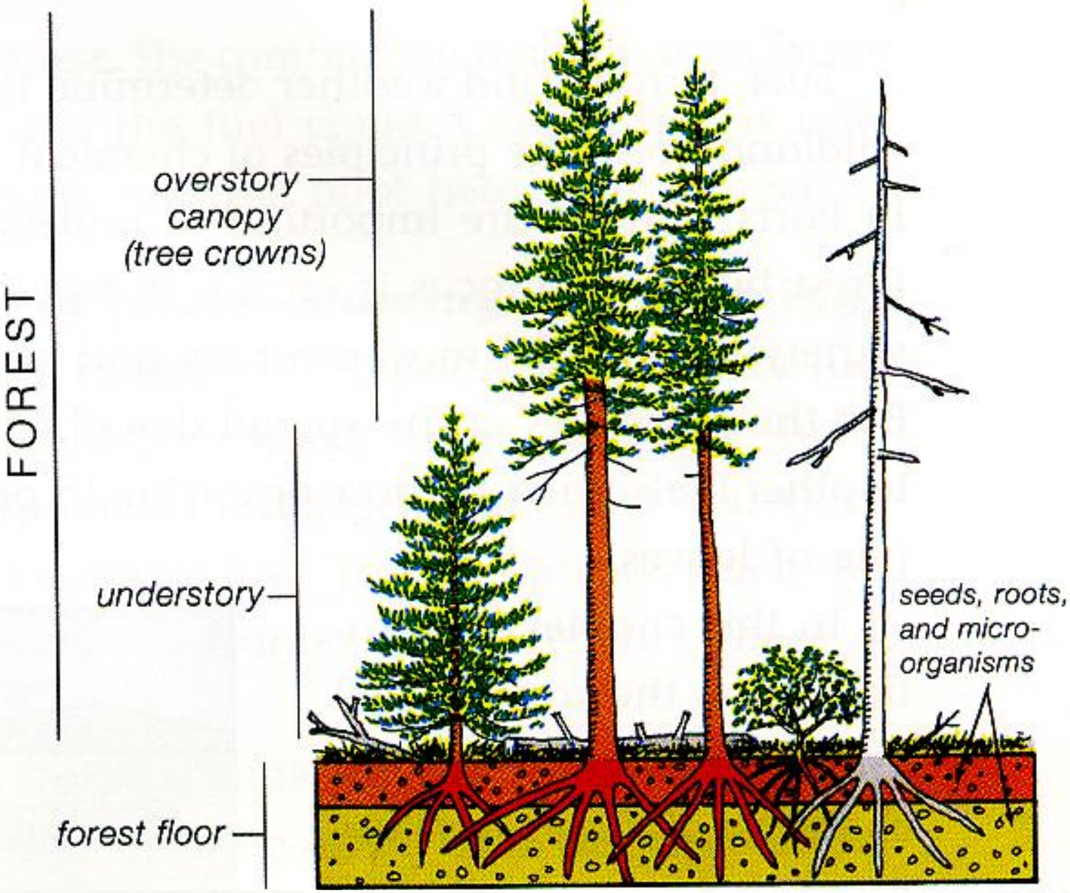
The **fire triangle** illustrates the relationship between the three basic elements needed to establish fire: **oxygen** (O_2), **combustible fuel** (a form of $(C_6H_{10}O_5)_n$), and **heat** to initiate and sustain combustion.

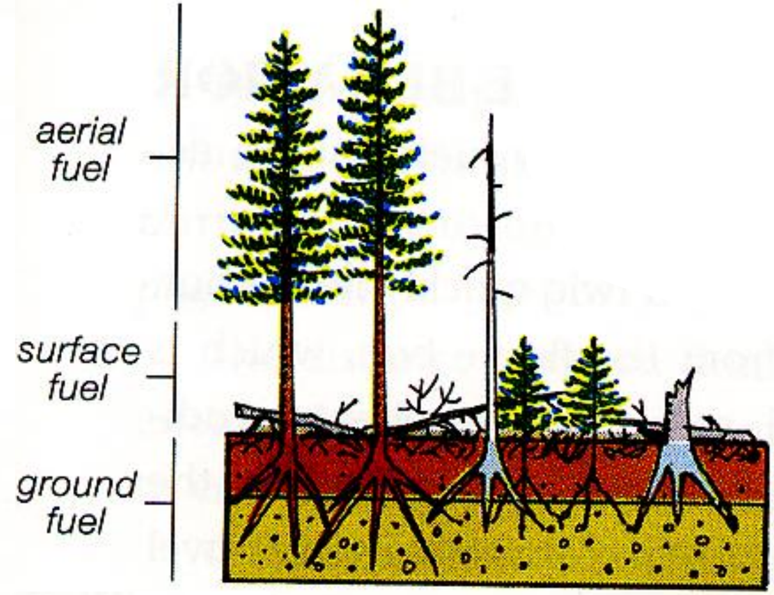
These three elements combined together in the proper ratio lead to fuel ignition and combustion.

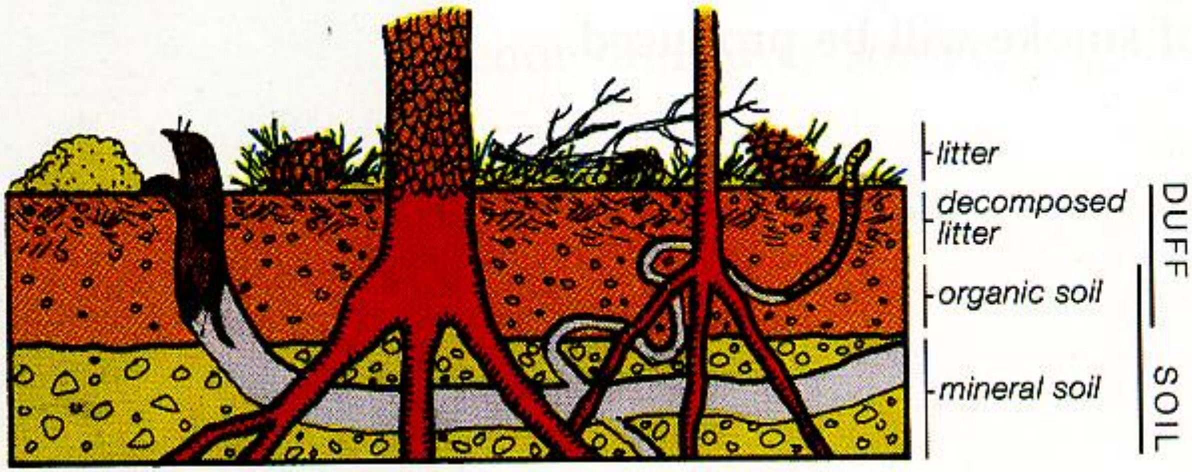
Fire behaviour

Fire behaviour is controlled by three interacting components:

- Fuels
- Topography
- Weather


FOREST
overstory
canopy
(tree crowns)
understory
seeds, roots,
and micro-
organisms
forest floor


aerial
fuel
surface
fuel
ground
fuel


litter
decomposed
litter
organic soil
mineral soil
DUFF
SOIL

Types of fire

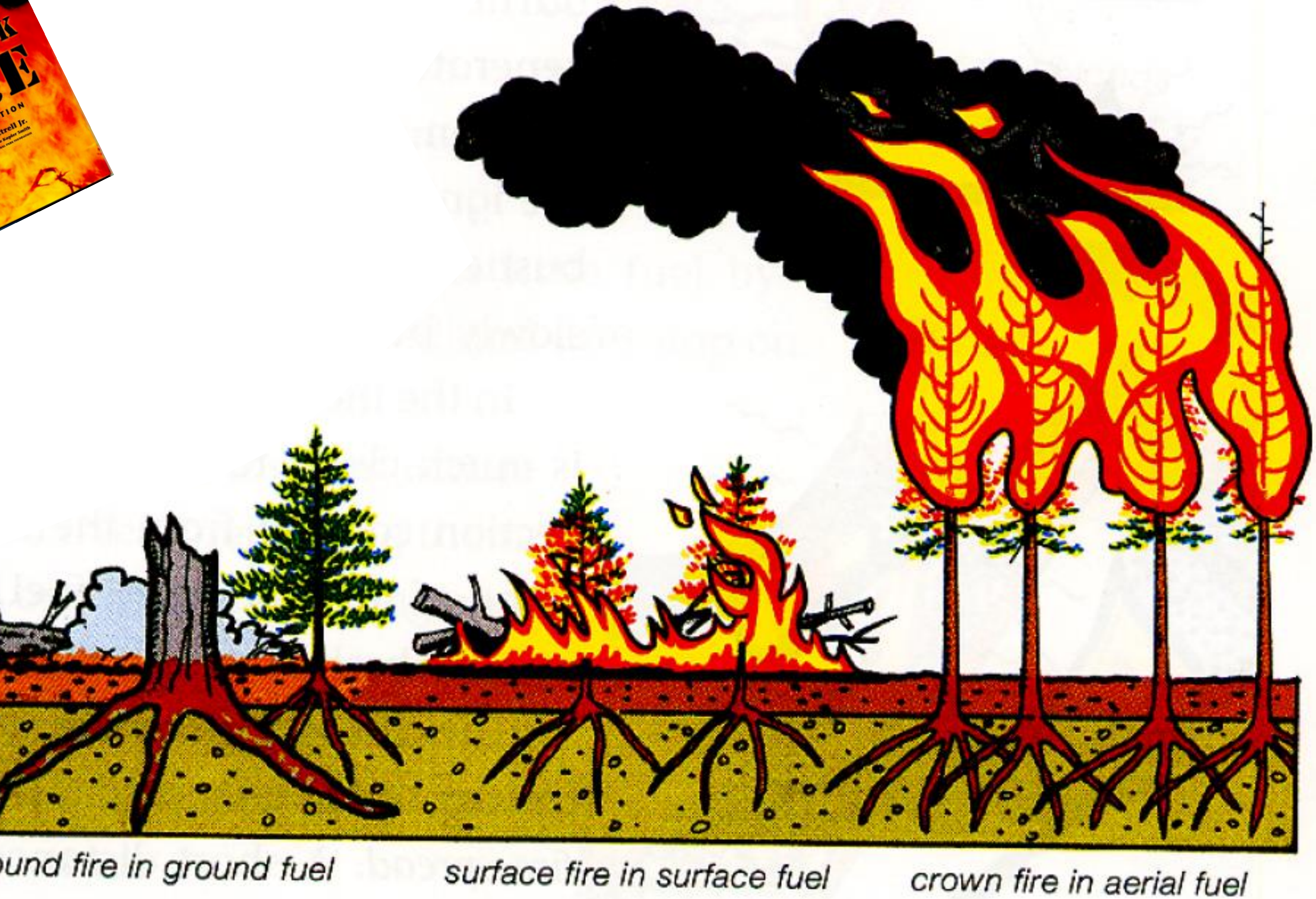
There are three general modes of propagation by which a fire can spread from one area to another:

Ground fires: restricted to the layer of duff, roots, and buried or partially buried dead and decaying logs.

Surface fires: propagate through fuels less than two meters high, which are commonly small trees, shrubs, herbaceous vegetation, and litter.

Crown fires: advance through the aerial strata of the forest more or less independently of surface fires.


THE BOOK OF FIRE
SECOND EDITION
William H. Cottrell Jr.


ground fire in ground fuel
surface fire in surface fuel
crown fire in aerial fuel

Ground fire

Photo Cesti

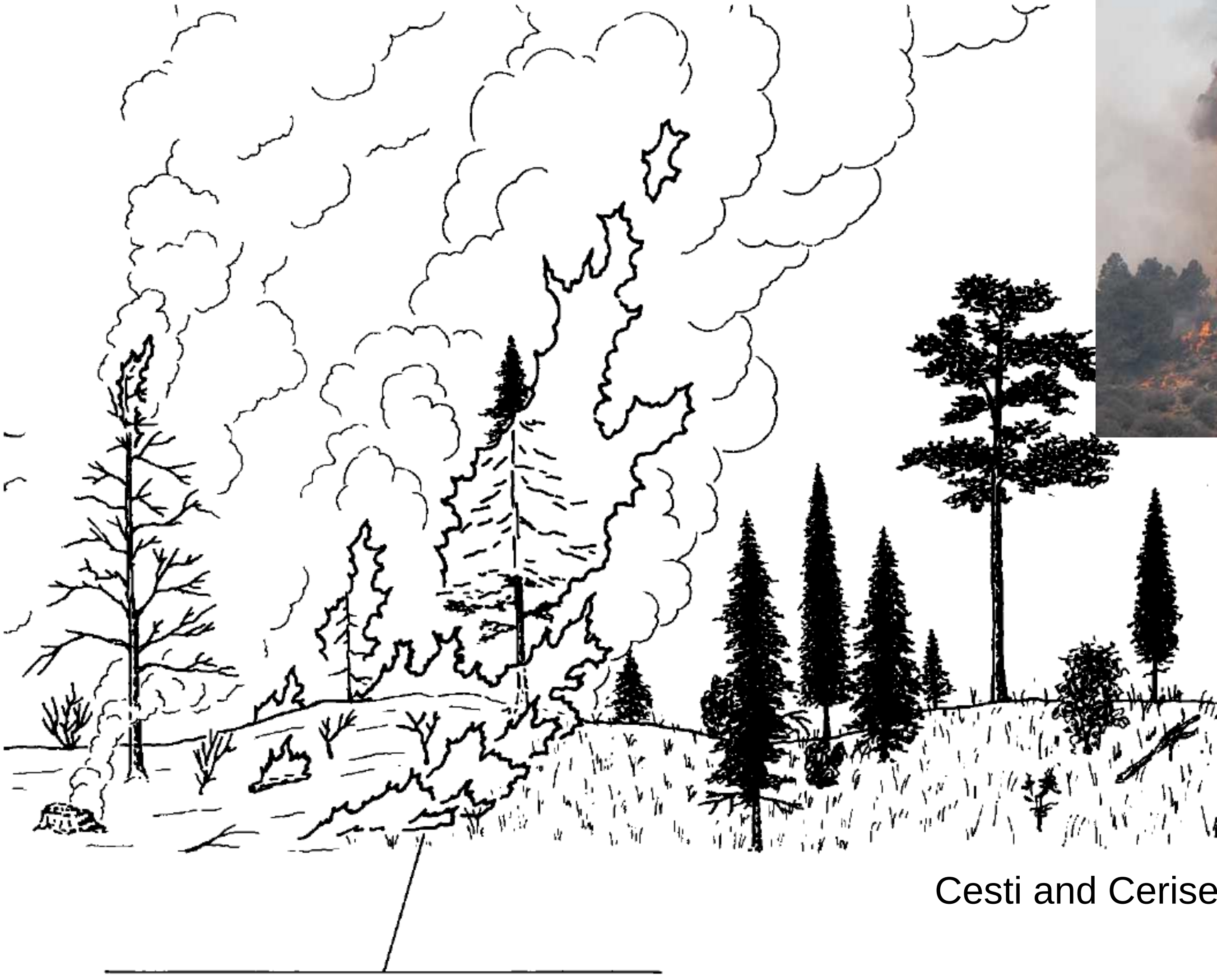
Ground fire

Surface fire


Photo Marzano

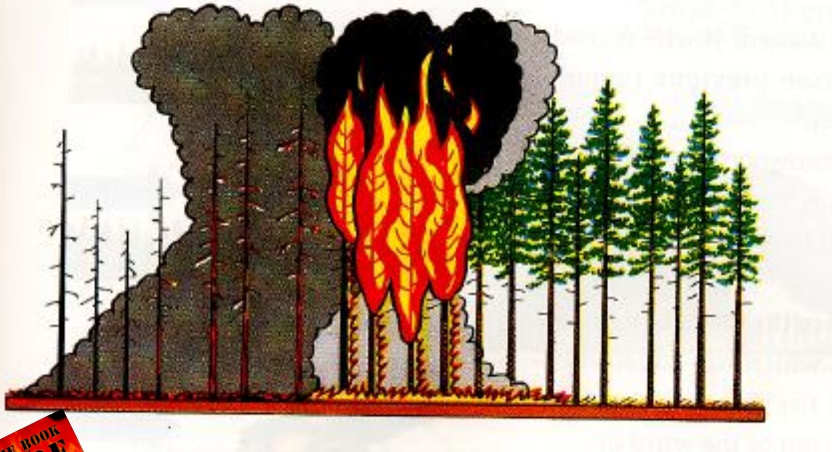
Surface fire


Passive crown fire

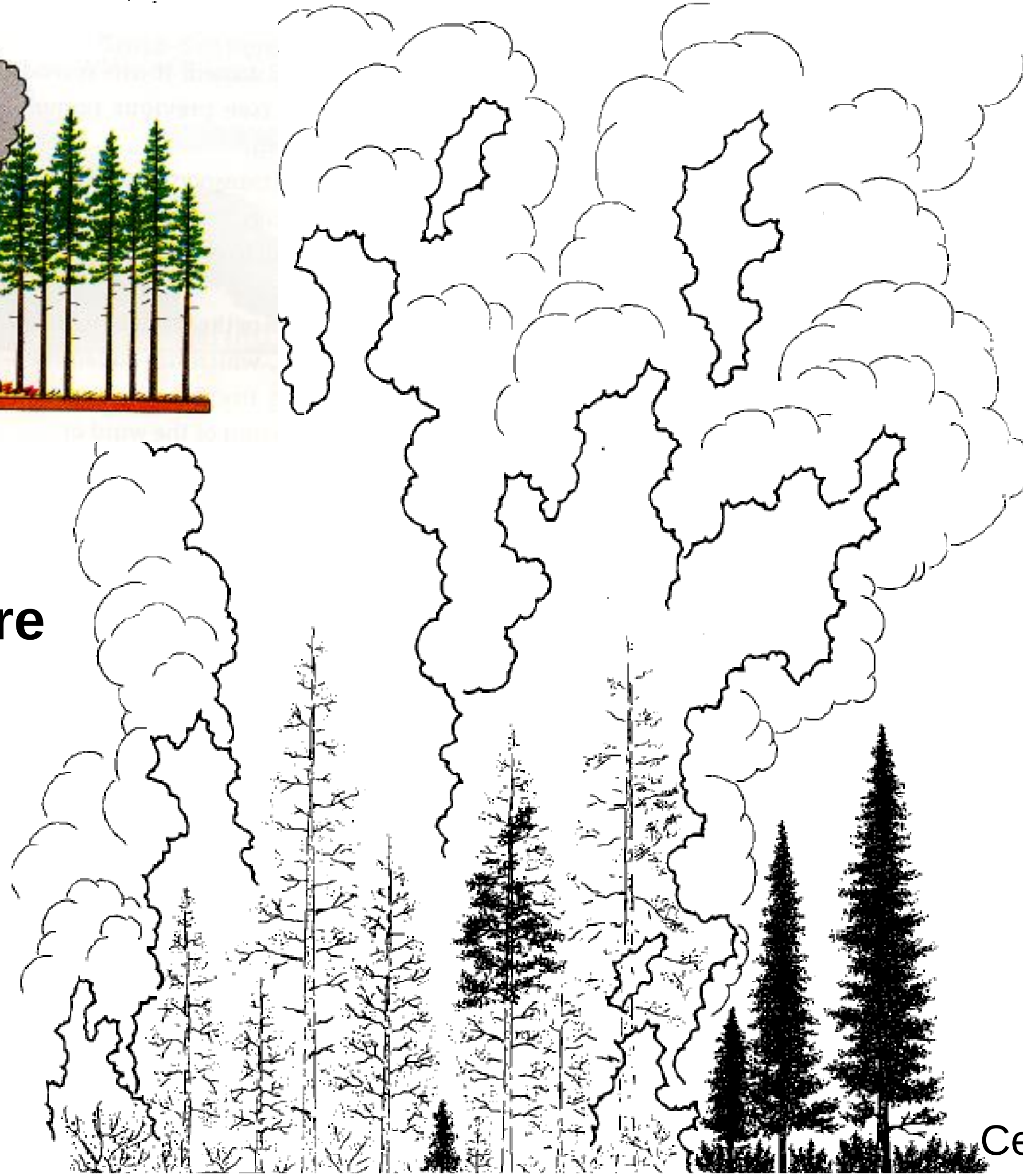


Cesti and Cerise (1992)

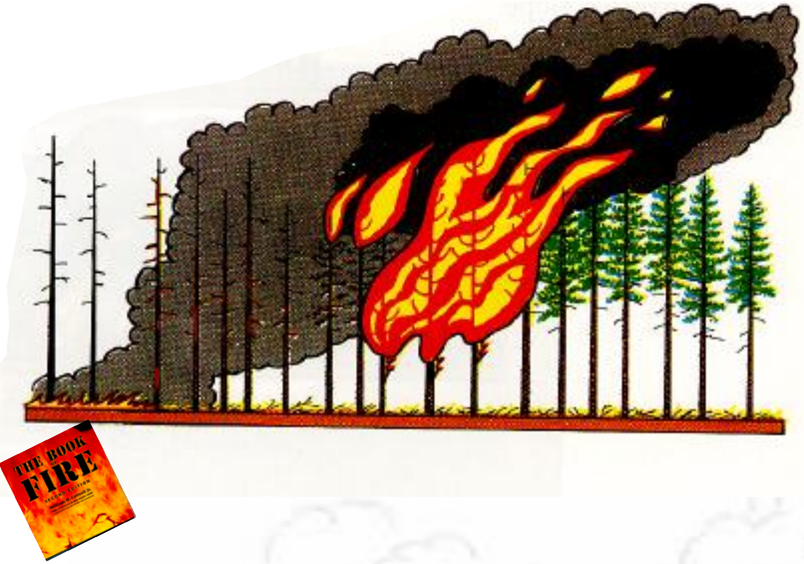
Surface fire



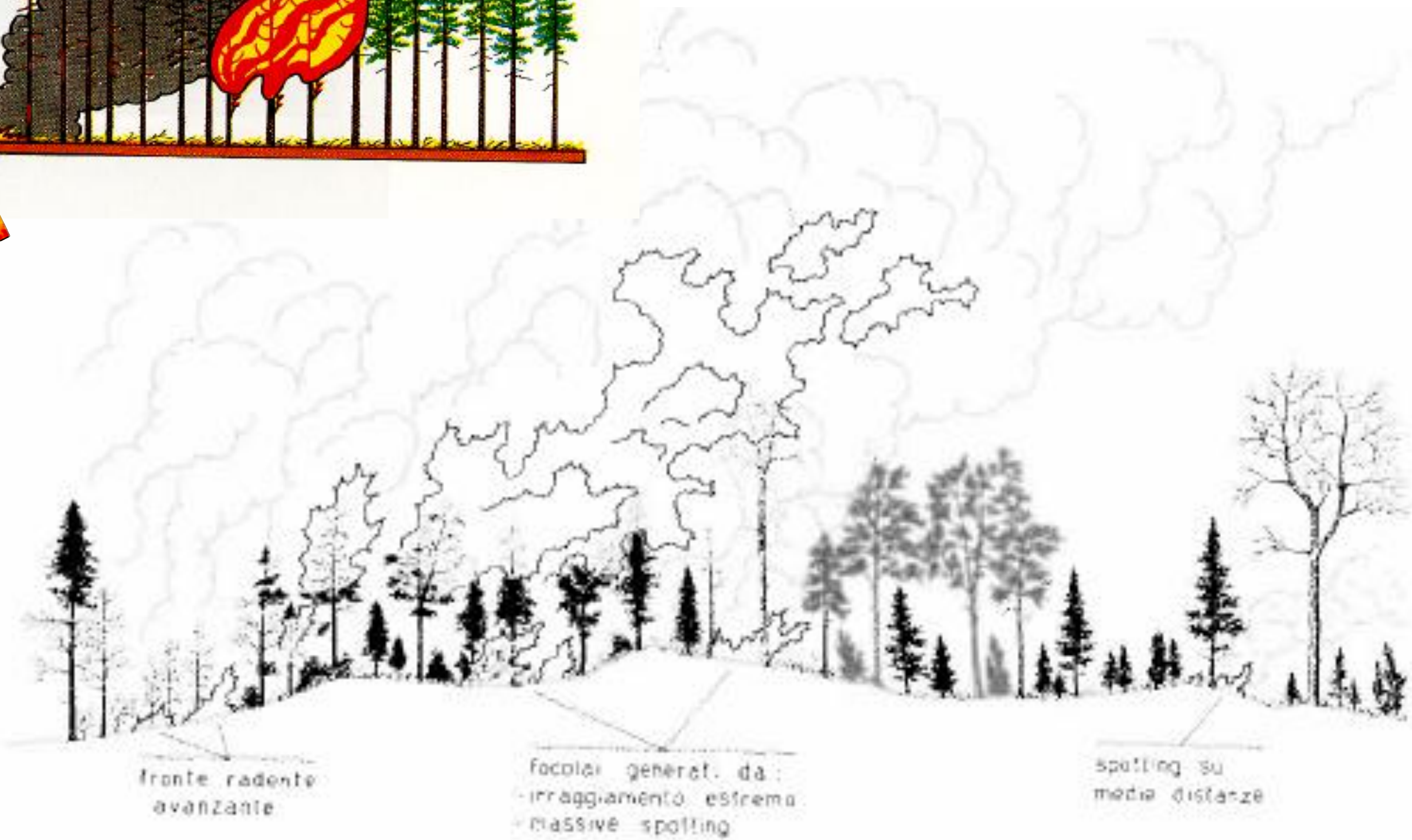
Active crown fire (dependent)



Cesti, 2002



Active crown fire (independent)



Cesti, 2002

Photo Cesti

Natural and **human-caused fires** associated with agriculture and grazing have historically defined the Mediterranean landscape.

Wildfires contribute to increase the biodiversity and complexity of the Mediterranean vegetation communities.

Mediterranean woody and scrub vegetation has been exposed to recurring fires for long periods, and has developed different adaptation strategies to survive.

Fire-adapted plants are defined as **pyrophytes** (fire loving plants), in some cases requiring wildfire for their reproduction. They can be divided into **passive** and **active** types in relation to the feed-back responses to fire**.**

Passive pyrophytes

Resistence

Active pyrophytes

Resilience

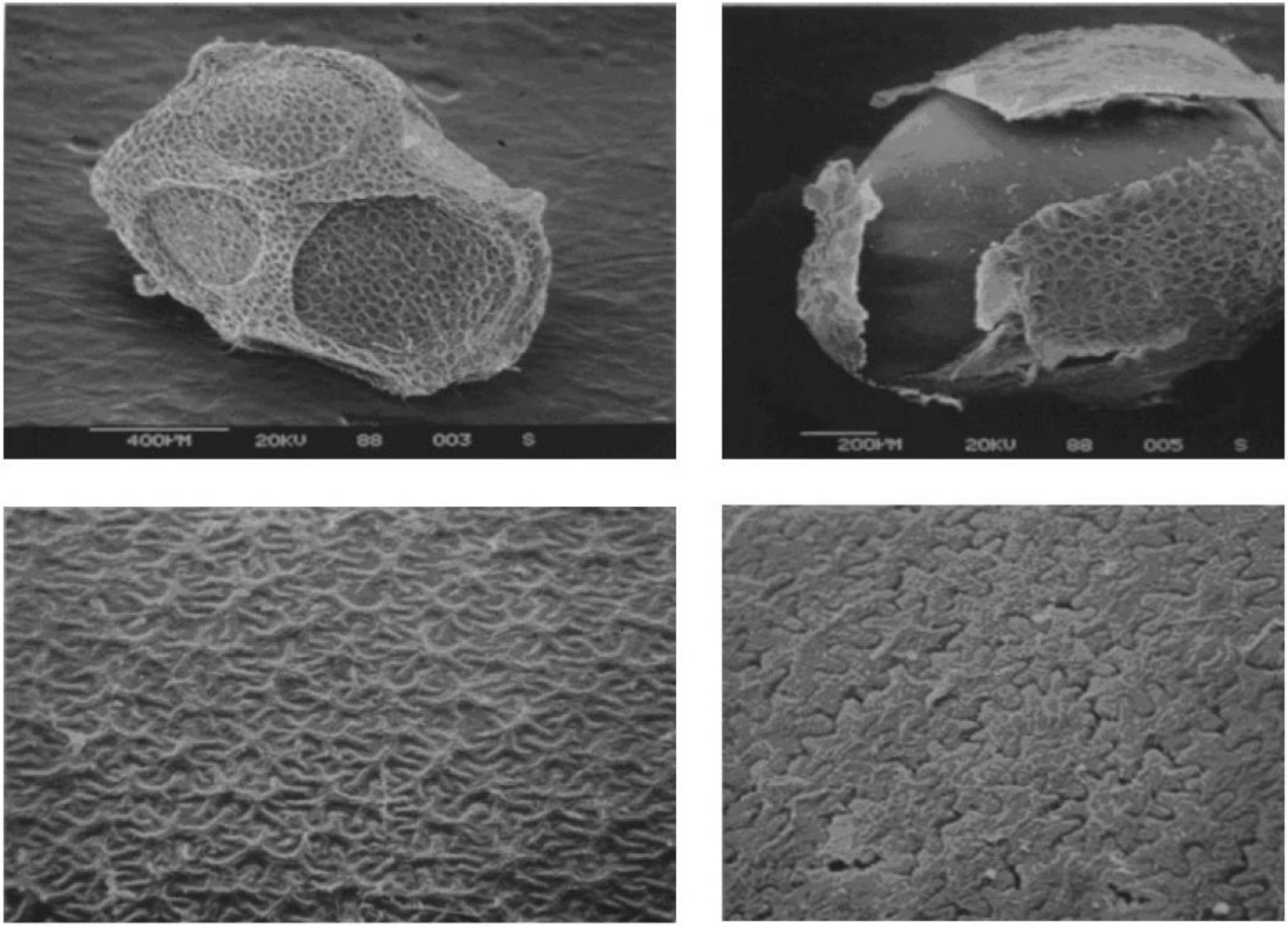
The **active pyrophytes** are able to regenerate after a fire even if damaged.

Two main strategies are identified.

One is **vegetative regeneration** through re-sprouting. These plants may store their nutrient reserves underground where they are protected from fires, and are heliophilous, so that the light of burnt areas stimulates their growth. Most of these trees and shrubs belong to the sclerophyllous vegetation group, such as oaks (*Quercus coccifera, Q. ilex, Q.calliprinos, Q. pyrenaica*), but also carob (*Ceratonia siliqua*), heath plants (*Erica arborea*, *E. australis*), myrtle (*Myrtus communis*), mastic (*Pistacia lentiscus*), Mediterranean buckthorn (*Rhamnus alaternus*), etc.

The other active strategy is **seed protection** and the requirement for the **stimulation of fire to germinate**.

This is the case for some of the Mediterranean conifers, such as Aleppo pine (*Pinus halepensis*), Turkish pine (*Pinus brutia*) and maritime pine (*Pinus pinaster*), which are unable to re-sprout, but develop cones which protect the seeds and which are opened by the heat of fires (**serotinous cones**).
The same strategy is also adopted by some rock roses of the genus *Cistus*, which have seeds protected by **thick teguments**.



Aronne and Mazzoleni, 1989


5 years after wildfire

Pinus pinaster - Liguria

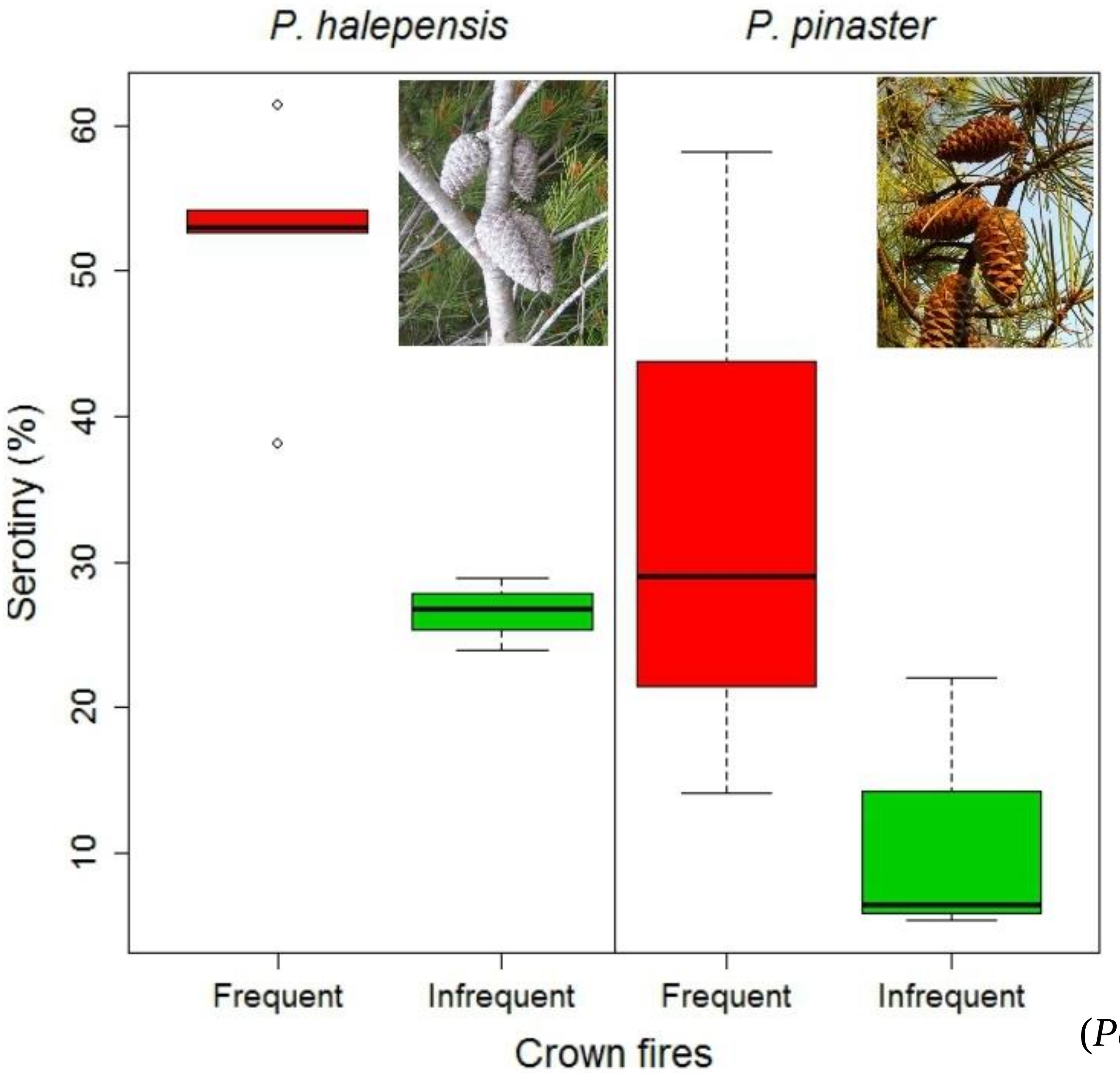
CONE SEROTINY

Pinus halepensis (Aleppo pine)

Pinus pinaster Ait.
Maritime pine

Pinus halepensis Miller.
Aleppo pine

http://www.floracatalana.net/pinus-pinaster-aiton


P. halepensis
P. pinaster
Serotiny (%)
60
50
40
30
20
10
Frequent
Infrequent
Frequent
Infrequent
Crown fires

(*Pausas 2015*)

Epilobium angustifolium
Fireweed

Massive post-fire flowering

Saponaria ocymoides

Massive post-fire flowering

On the other hand, the **passive** pyrophytes are plants adapted to avoid or limit fire damage.

These species can have thick or suberized barks which protect the cambium from heat damage, such as stone pine (*Pinus pinea*) or cork oak (*Quercus suber*).

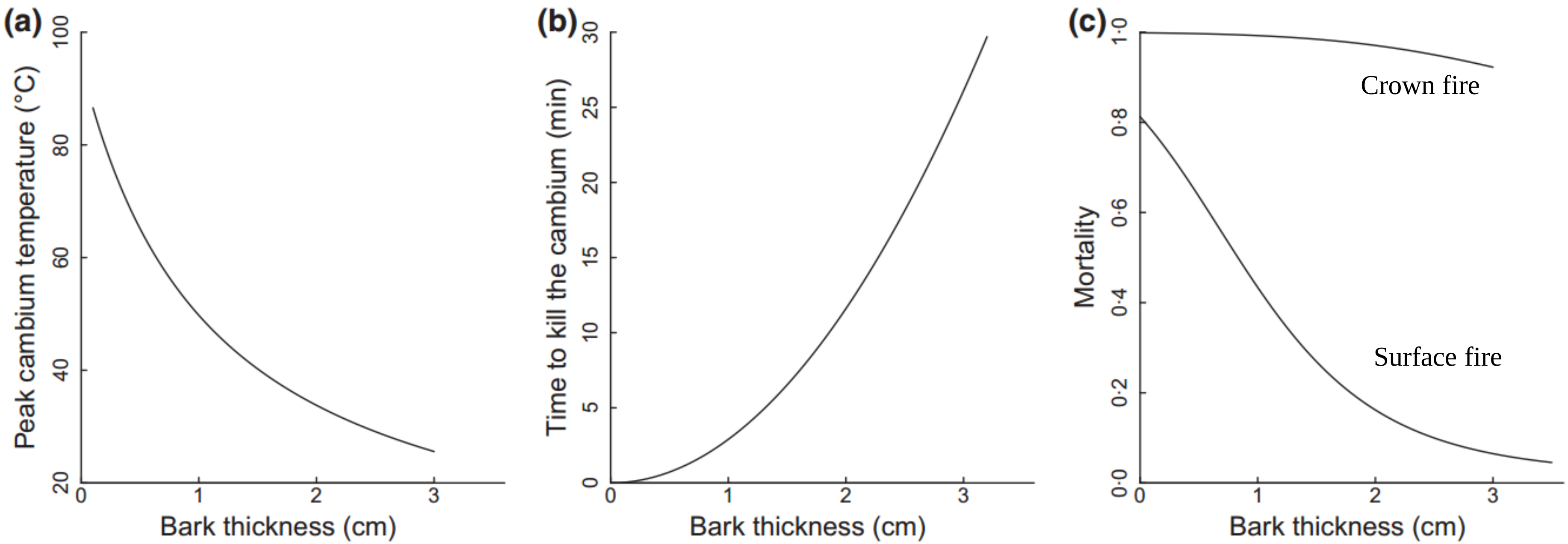
Some limit the exposure of the crown to fire thanks to rapid height growth during the juvenile period or to a strong self-pruning habit which increases the height of the lowest part of the crown, adopted by various species of the genre *Pinus*.

Others have leaves with low flammability due to high water or ash content, or lower amounts of resins; e.g cypress (*Cupressus sempervirens*) or many broadleaves.

Pinus pinea L. – Stone pine

Quercus suber L. – Cork oak

Bark thickness

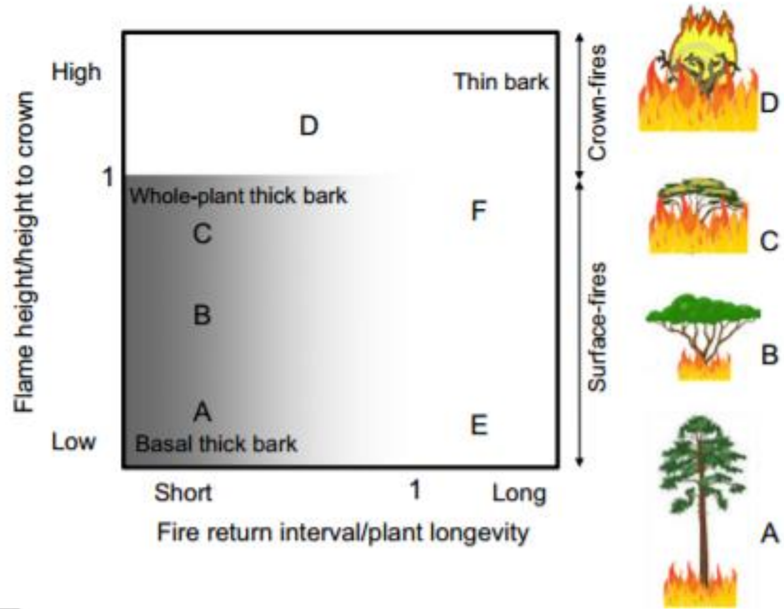


(*Pausas 2015*)

Table 1 Predicted total bark thickness in relation to the fire regime (Pausas, 2015)

Fire regime	Examples	Prediction of bark thickness
Frequent surface fires in forests and woodlands (A)	Southern North American pine forests	Trees with thick basal bark, understory shrubs with thin bark
Frequent grass-fuelled surface fires in open ecosystems (B)	African savannas	Trees with modera bark thickness
Frequent tall grass-fuelled fires affecting crowns (C)	Brazilian savannas (cerrado)	Trees and shrubs with thick bark in the stem and branches
Frequent high-intensity, woody-fuelled crown fires in forests and shrublands (D)	Mediterranean shrublands	Thin bark
Infrequent drought-driven high-severity fires (E)	Rainforests, cold temperate forests	Thin bark
Infrequent fuel-limited fires (F)	Arid ecosystems	Variable

Pausas, 2017



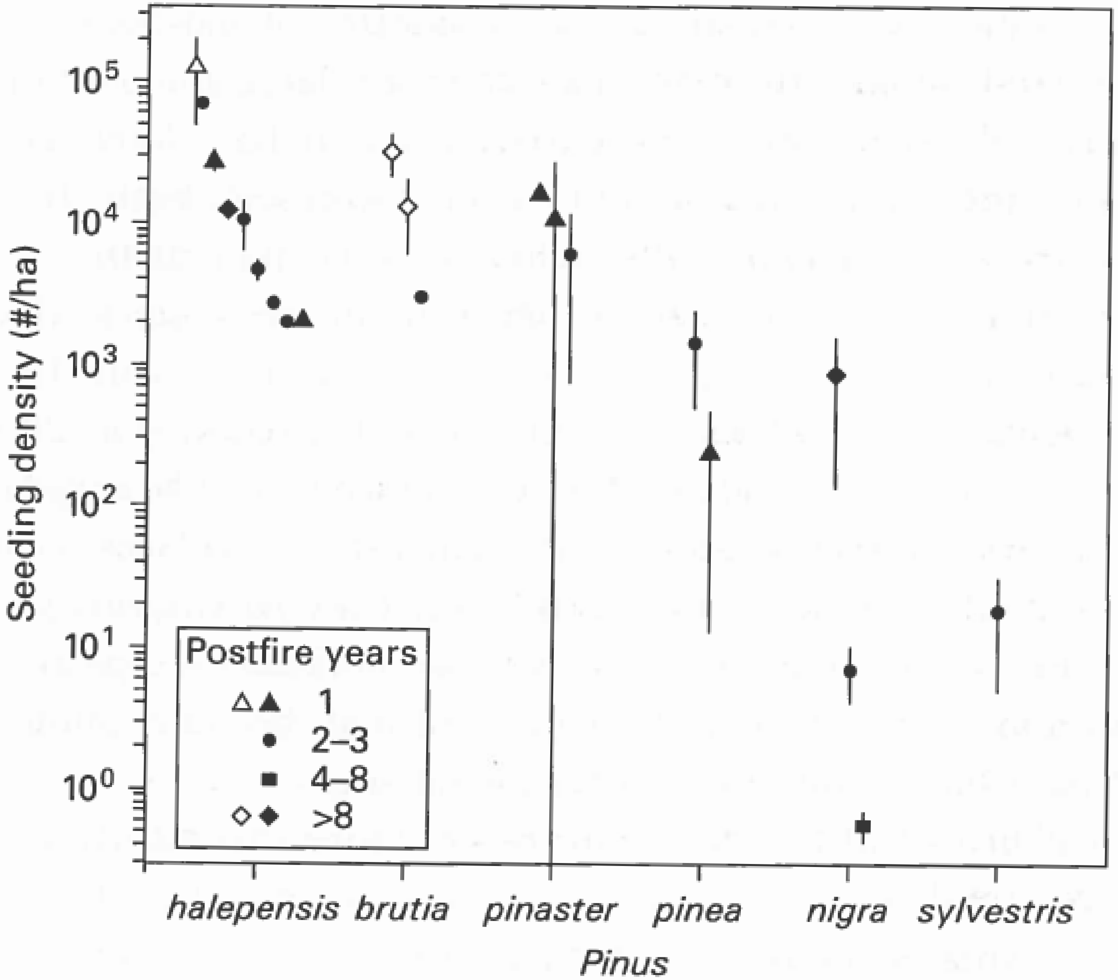


Fig. 4.7 *Seedling density after crown fire (log scale) for Mediterranean Basin* Pinus *species in different localities and with different postfire ages. Position of the symbols indicates the mean values, and type of symbol indicates the postfire age (time since fire); vertical lines are standard deviation (in solid symbols) or range values (in open symbols). (Compiled from different sources by Pausas et al. 2008.)*

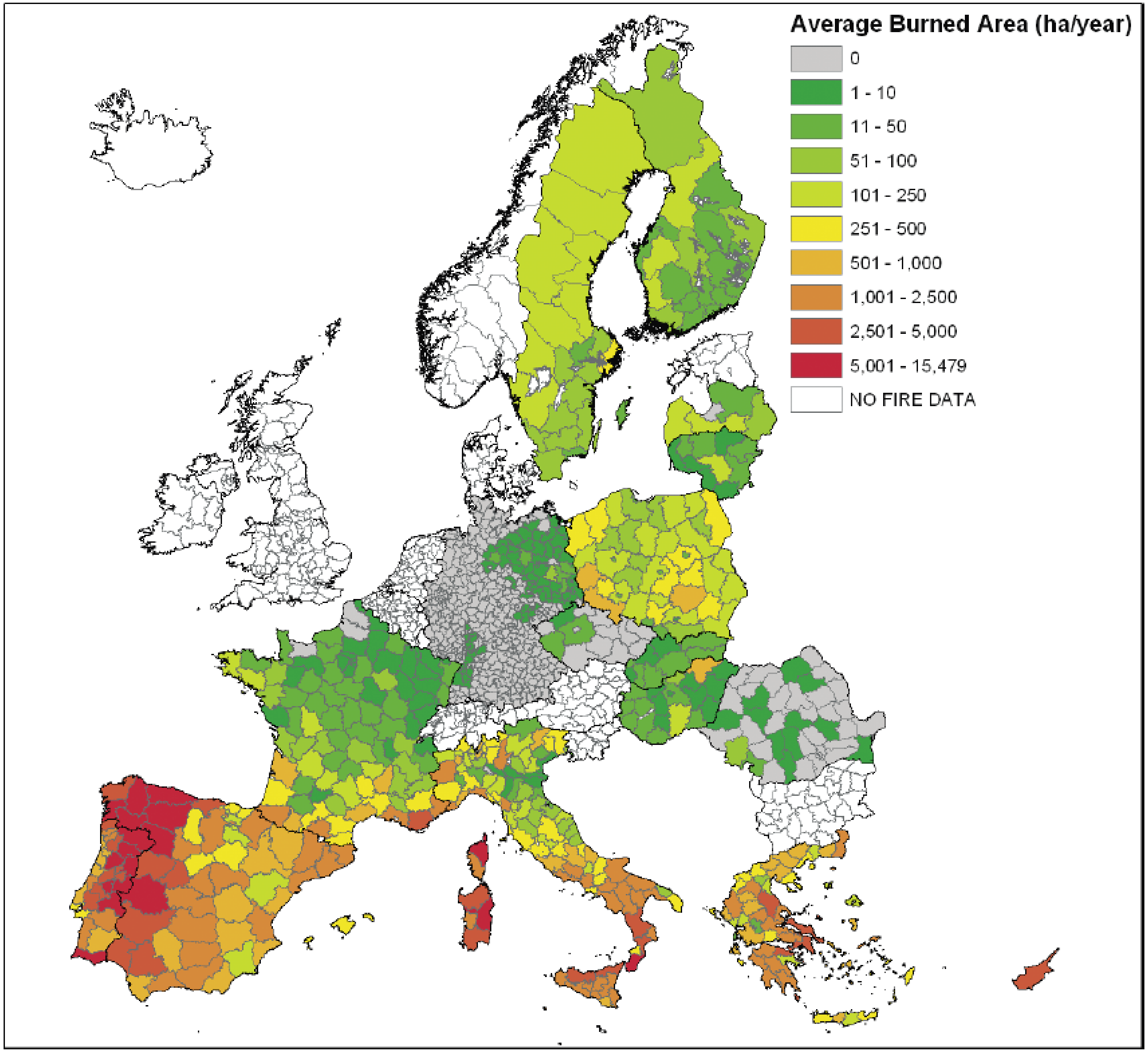


Figure 6. Map of burned areas in the EU by province.

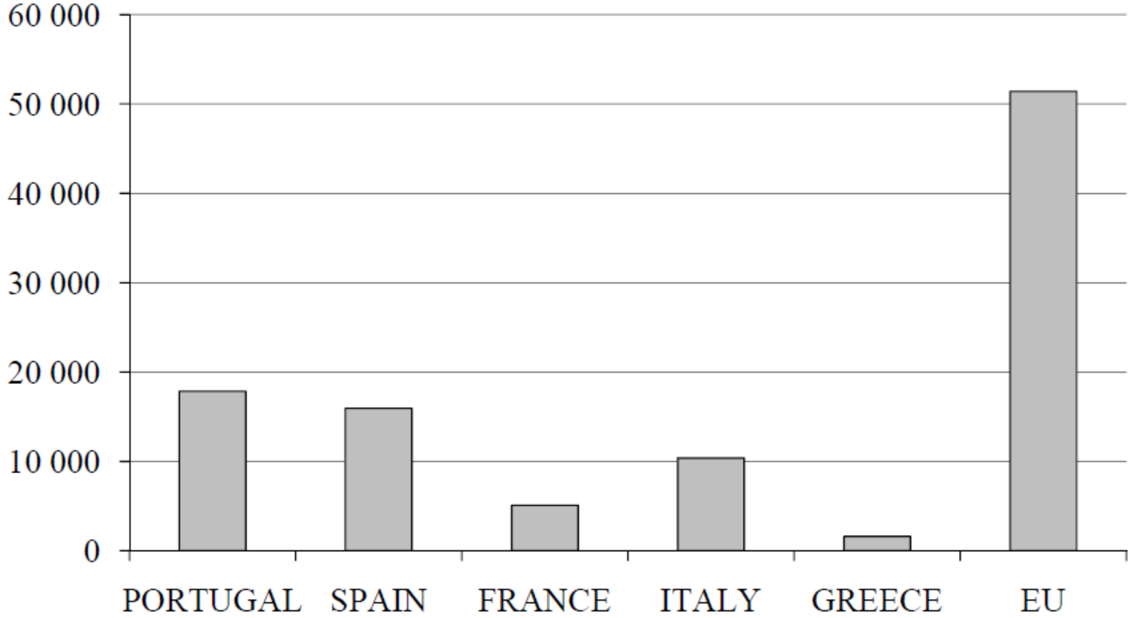


Figure 2. Average number of fires in each of the EU Mediterranean countries in the period 2000–2006.

TESAF Dipartimento Territorio e Sistemi Agro-Forestali
Università degli Studi di Padova

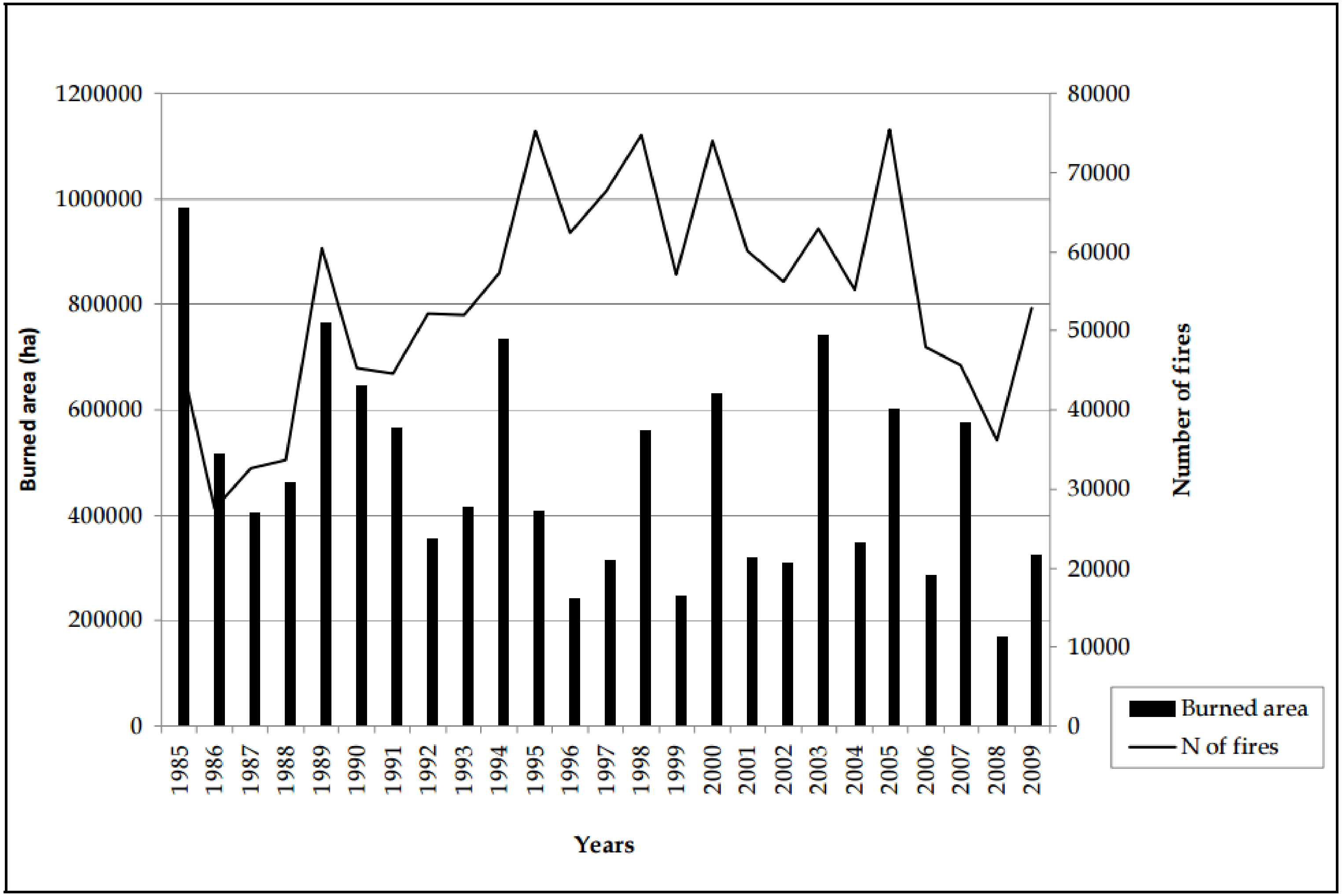
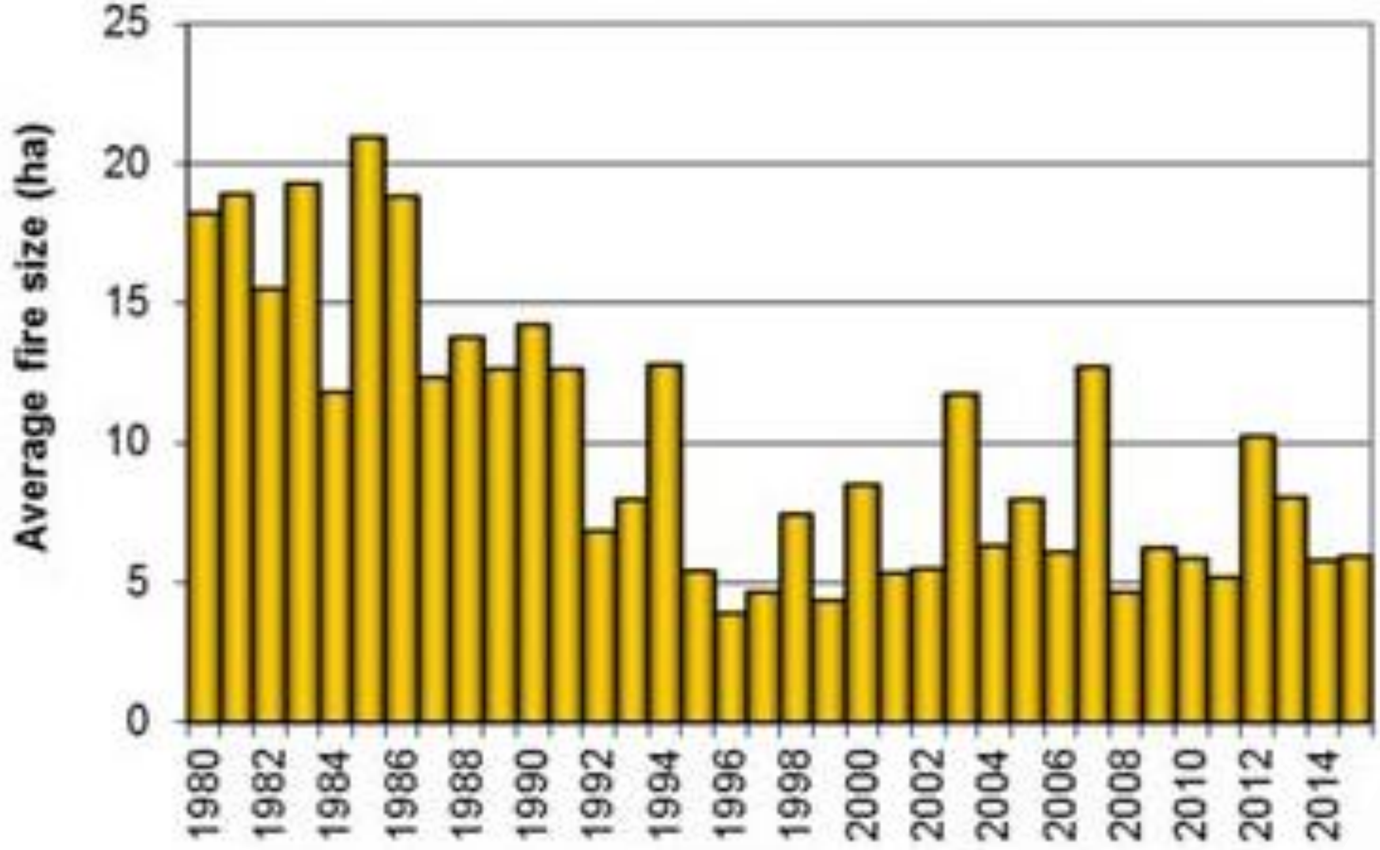


Fig. 6. Total annual number of fires and annual burnt area in the EUMed region from 1985 until 2009



Average fire size in the EU Mediterranean region

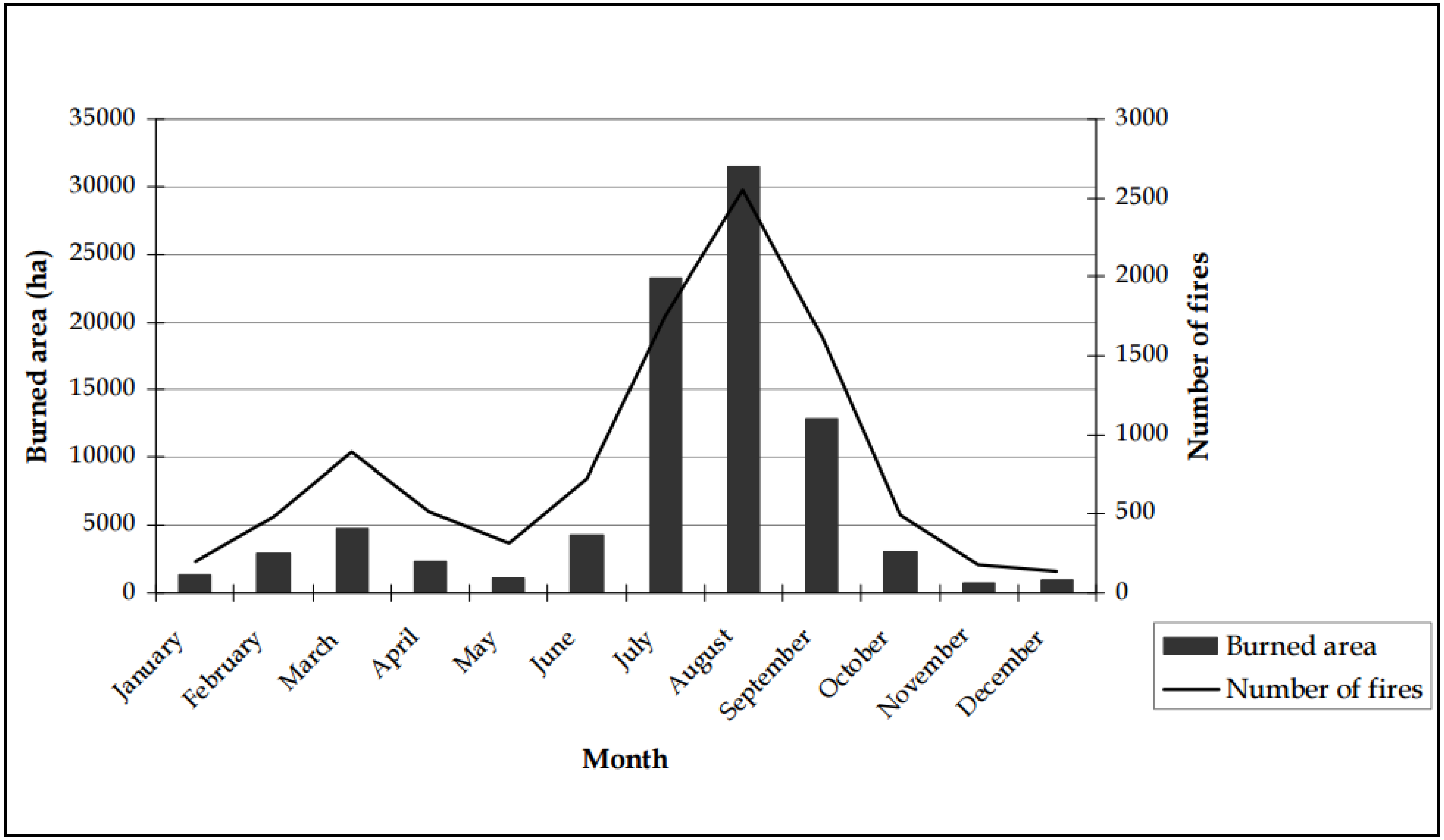


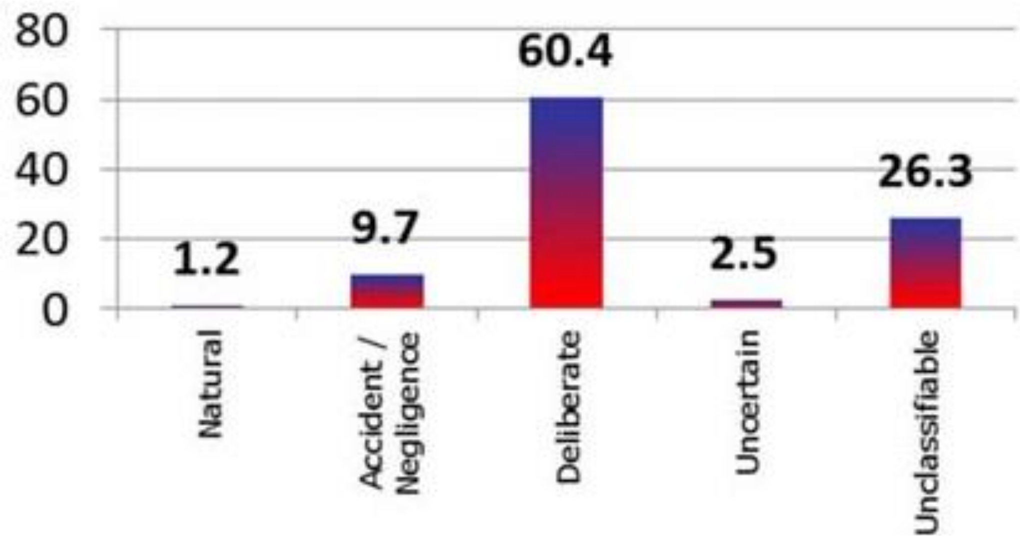
Fig. 7. Annual average (1985–2009) number of fires and burnt area per month in the EUMed region

Summer fires

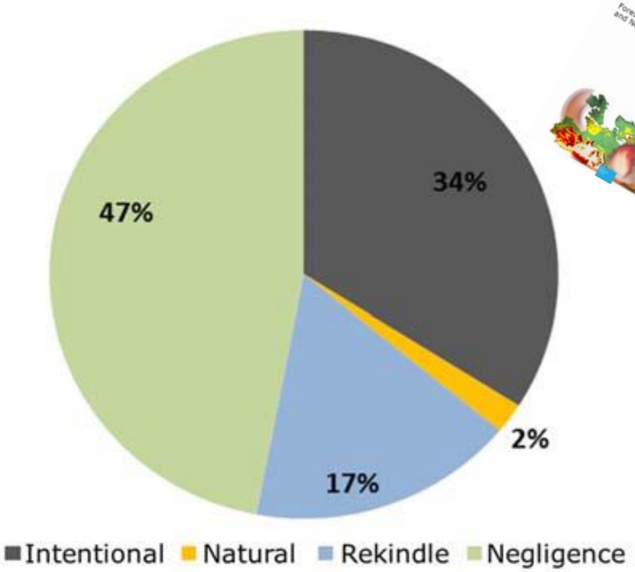
Winter- early spring fires

Low to medium intensity surface fires

Cause of ignition



Italy, 2015



Portugal, 2015

Lightning?

La Muda, Agordo (BL), 11/05/2011

COPERNICUS
Emergency Management Service

European Commission > JRC EU Science Hub > DRM > Copernicus EMS > European Forest Fire Information System (EFFIS)

About EFFIS | Reports and Publications | Applications | Partners

Welcome to EFFIS

The European Forest Fire Information System (EFFIS) supports the services in charge of the protection of forests against fires in the EU countries and provides the European Commission services and the European Parliament with updated and reliable information on wildland fires in Europe.

A number of specific applications are available through EFFIS:

Since 1998, EFFIS is supported by a network of experts from the countries in what is called the Expert Group on Forest Fires, which is registered under the Secretariat General of the European Commission. Currently, this group consists on experts from 40 countries in European, Middle East and North African countries. In 2015, EFFIS became one of the components of the Emergency Management Services in the EU Copernicus program.

The link to some of the most widely used applications is provided below. Additional applications such as the extension of EFFIS to the global level into a Global Wilfire Information System (GWIS) are available through the side "Applications" box.

Current Situation

The most up to date information on the current fire season in Europe and in the Mediterranean area. This includes today meteorological fire danger maps and forecast up to 6 days, daily updated maps of hot spots and fire perimeters.

Fire News

A selection of news from the press on wildland fires in Europe updated daily by the EFFIS team. News can be browsed for specific countries selected by the user from the news map.

Visit the brand-new Global Wildfire Information System Viewer

EFFIS Damage Assesment

EFFIS Burned Area (ha)
Total EU28 Countries
Mapped: 152991 (10.1 % Forest)
Estimated: 203988
Total EFFIS Coverage
Mapped: 229792
Estimated: 306389.33

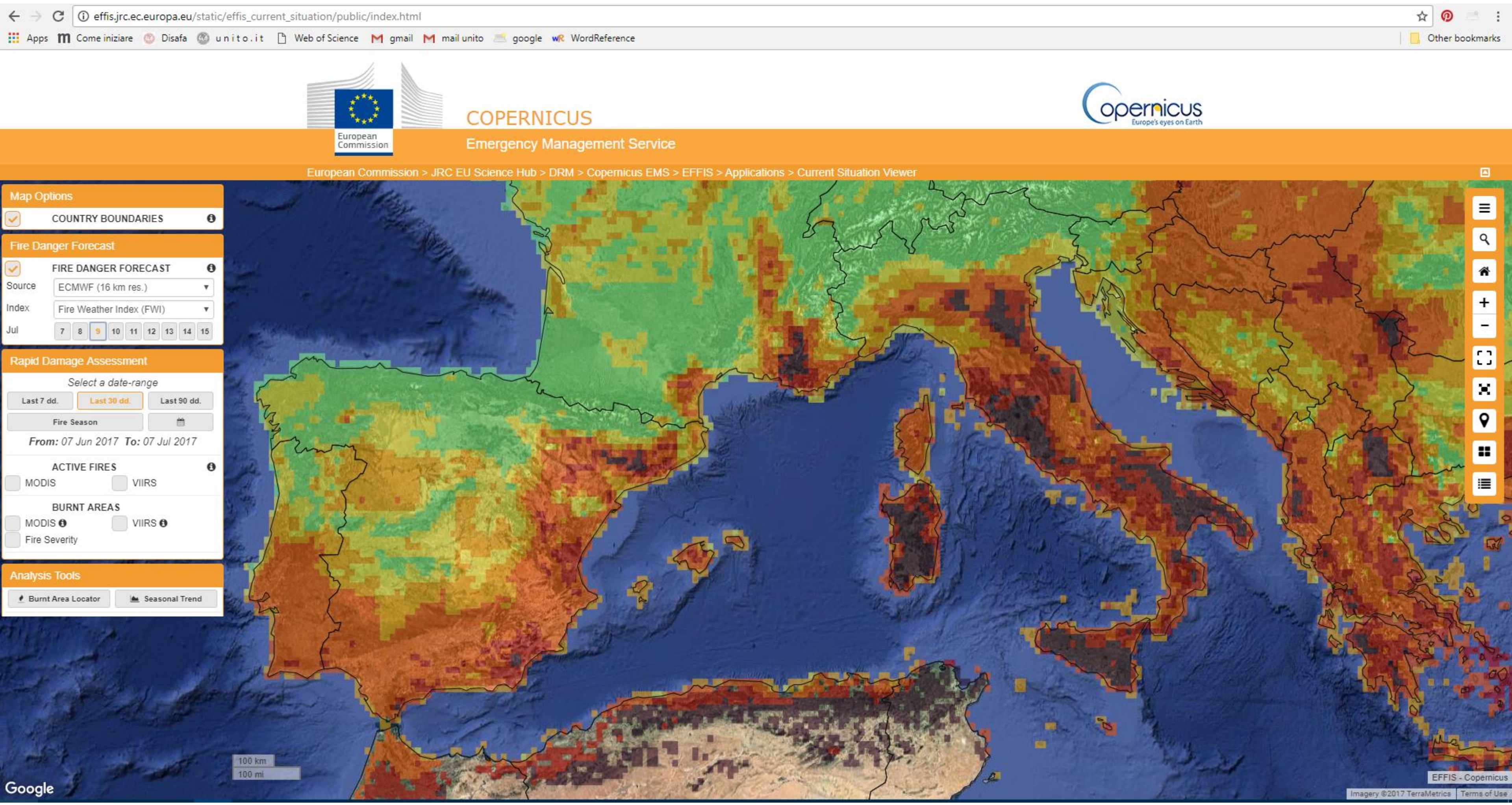
(Updated daily)

RDA Disclaimer and layer information

Applications

Current Situation Viewer
Long-term seasonal fire weather forecast
Long-term monthly fire weather forecast
Fire History
Fire news
Data and services

http://effis.jrc.ec.europa.eu/



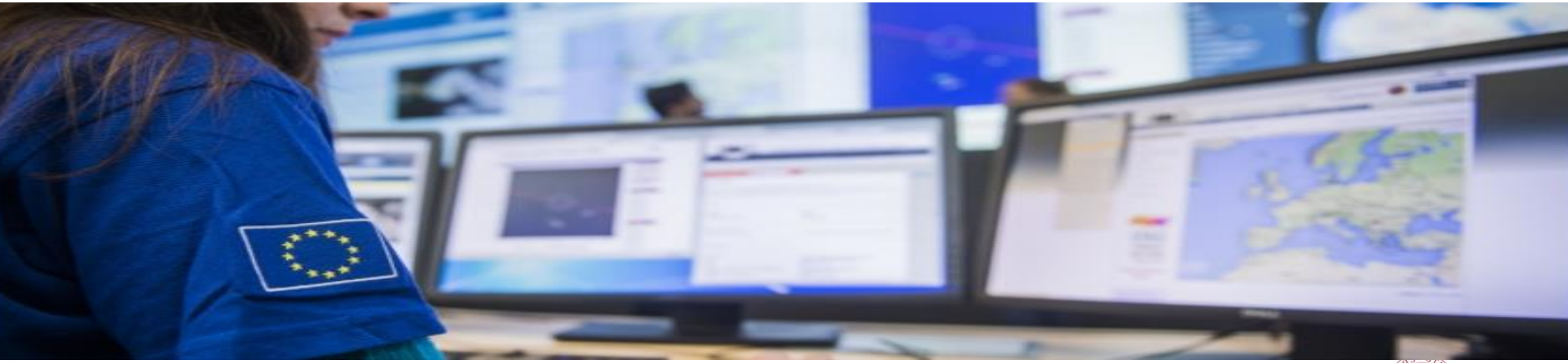
09 July, 2017

http://effis.jrc.ec.europa.eu/static/effis_current_situation/public/index.html

“…Fire management policies in southern Europe remain strongly biased toward **fire suppression.”**

When a country cannot give an appropriate answer to forest fires due to a lack of national capacities, other EU countries can show solidarity by sending assistance in the form of water bombing aircraft, helicopters, fire-fighting equipment and human resources.

The Emergency Response Coordination Centre (ERCC) is the emergency response hub of the EC. The centre coordinates assistance on the European level in the case of disasters. The EU Civil Protection Mechanism can also be used to facilitate and co-finance the transport of assistance to the affected area.

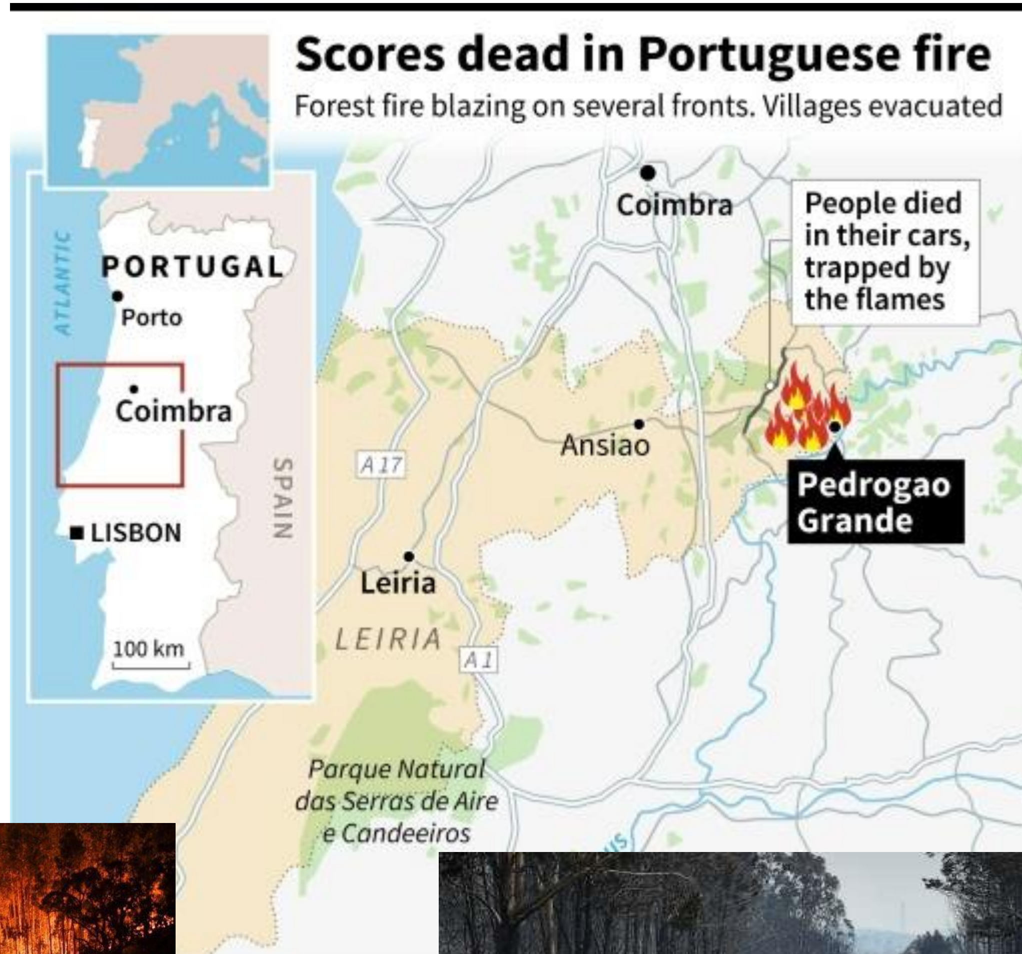


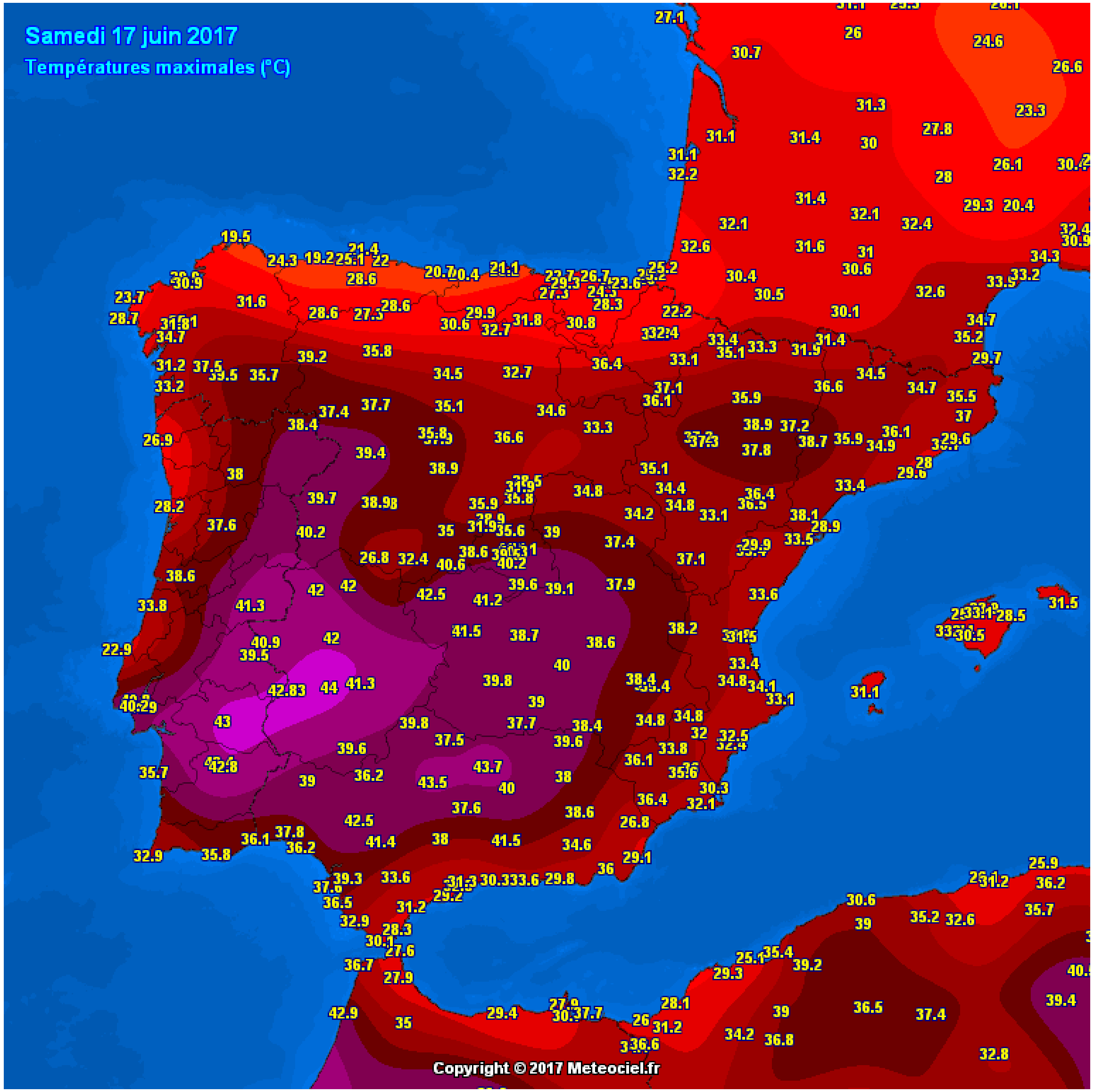
AB 412

S 64 skycrane

Canadair

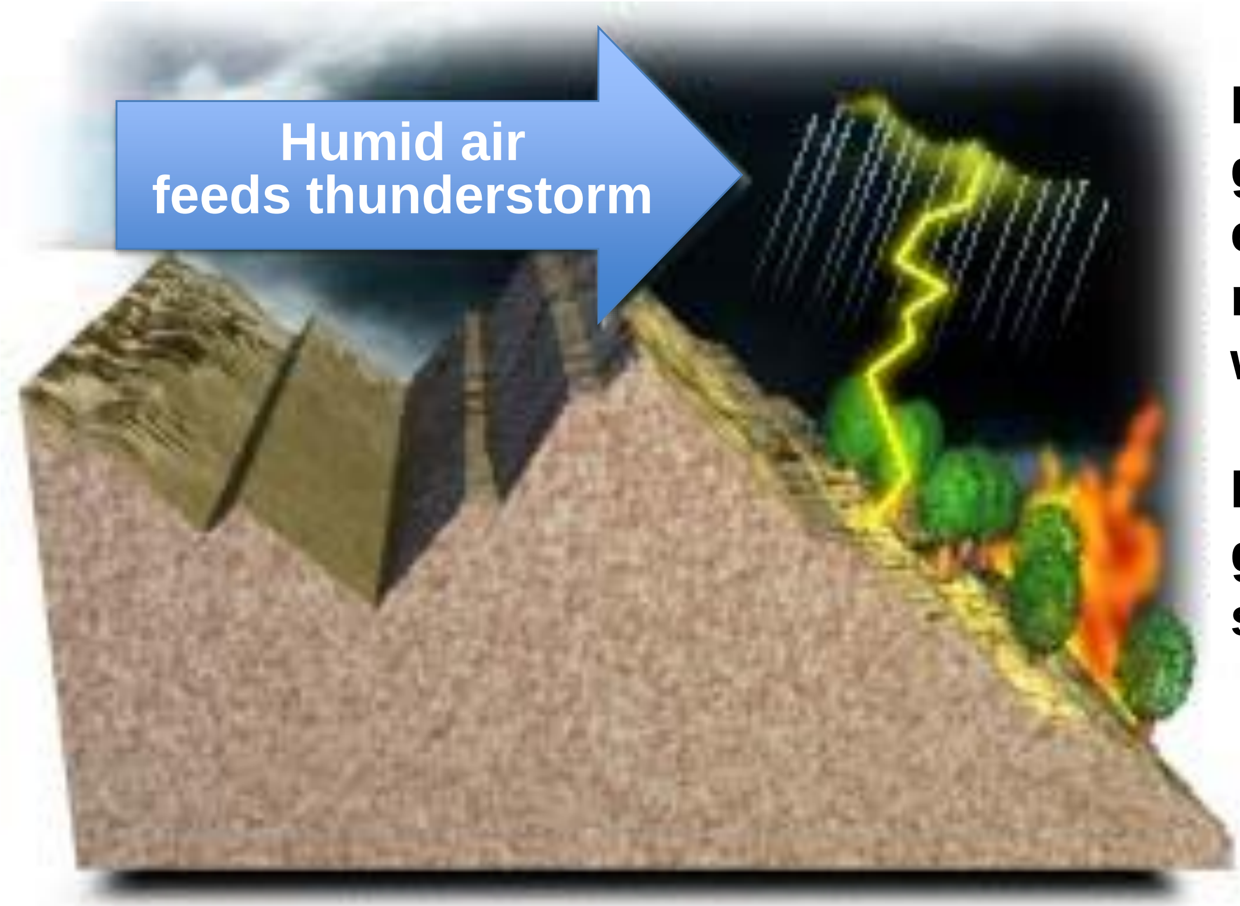
Portugal 17/06/2017





Daytime highs across the Iberian peninsula on Saturday, June 17. Map: Meteociel.fr

Dry thunderstorm

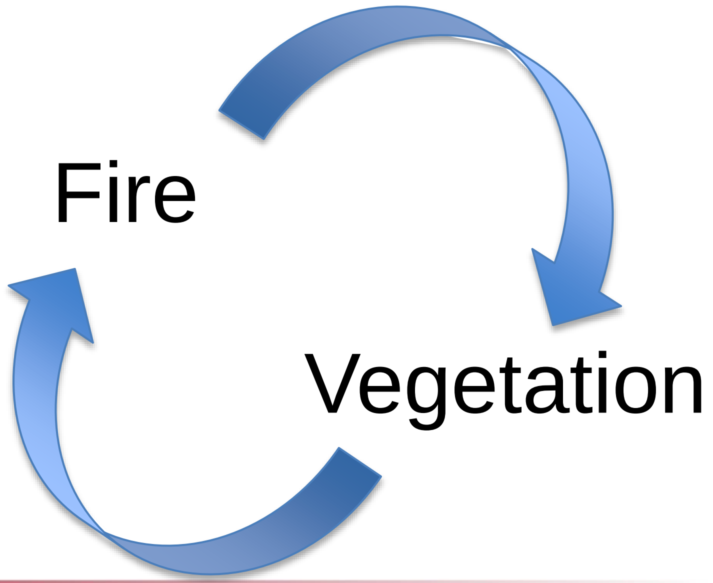


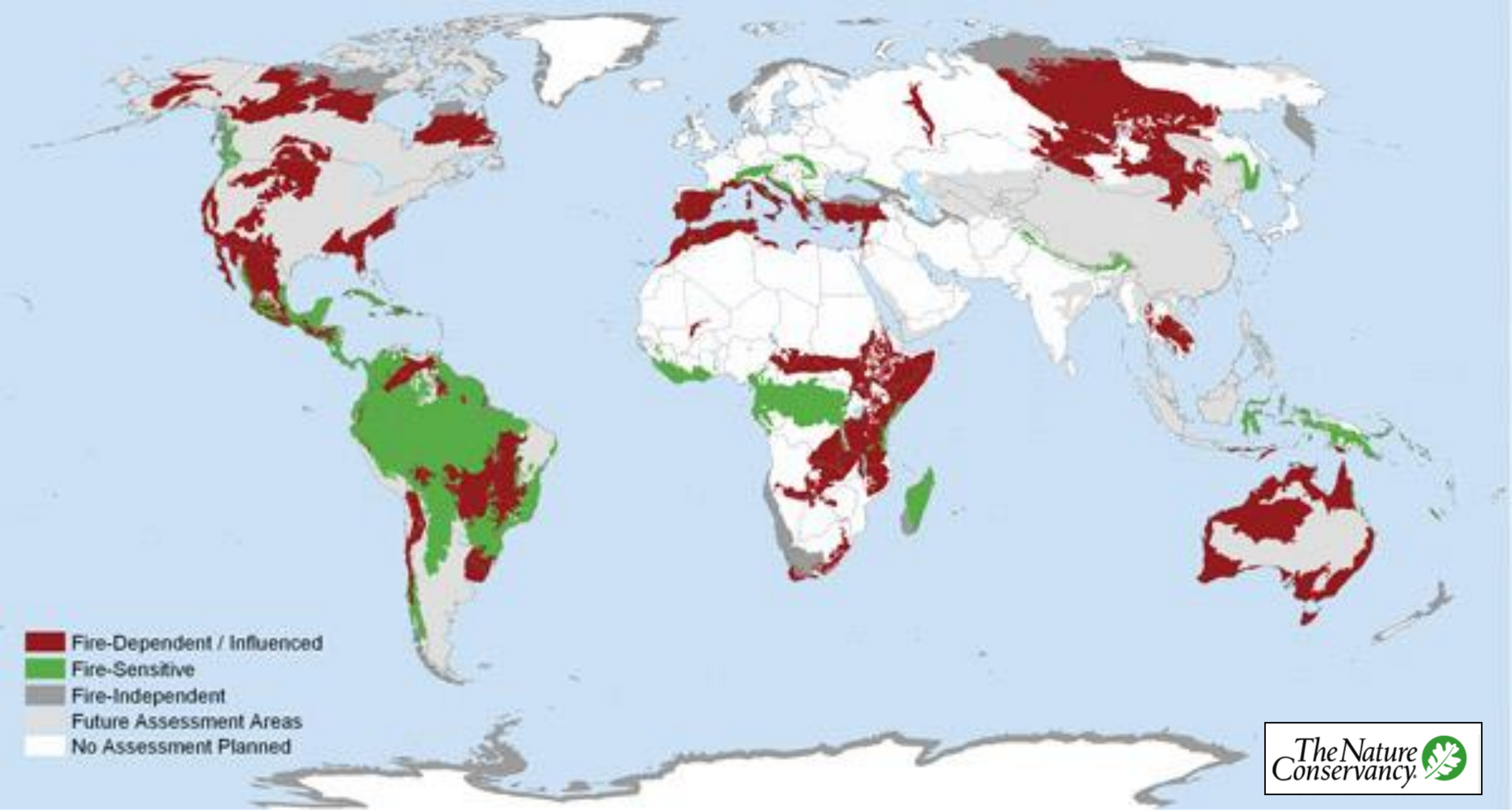
Dry air near ground evaporates rain on the way down.

Lightning hits ground; it can start wildfires.

The general temporal and spatial patterns of fire behaviour and effects within a particular vegetation type or ecosystem over multiple fire cycles (decades to centuries) determine the **fire regime** over a specific period for any given ecosystem.

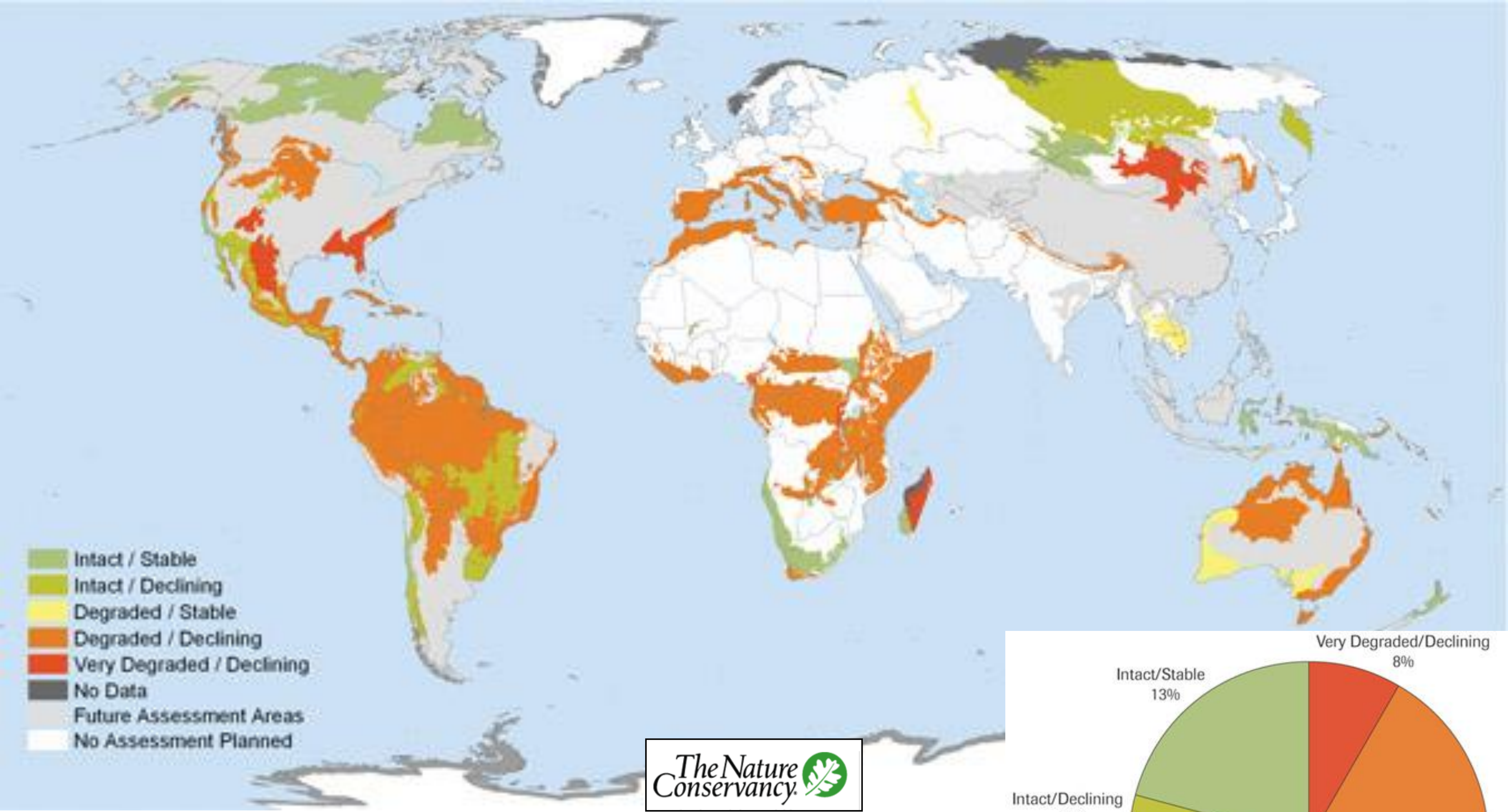
Not only does climate (as reflected in dominant weather patterns) directly affect the frequency, size and severity of fires, it also affects fire regimes through its influence on vegetation vigour, structure, and composition.

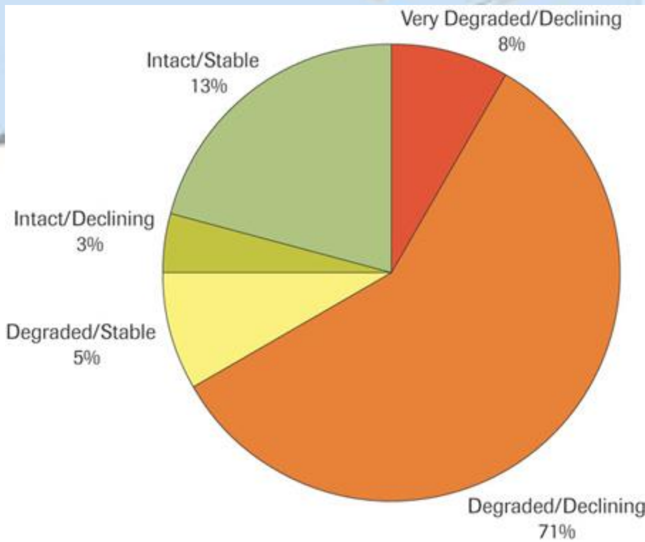




Dominant Fire Regime Types in Priority Ecoregions

Almost half of priority conservation ecoregions can be classified as "fire-dependent " where wildfires are fundamental to sustaining native plants and animals



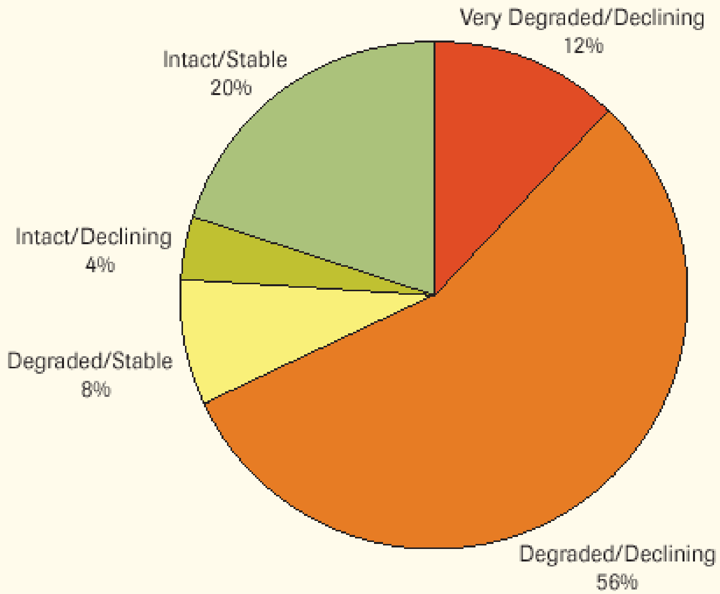


Fire Regime Status and Trend

Fire regimes are degraded in over 80% of globally important ecoregions assessed in this report.

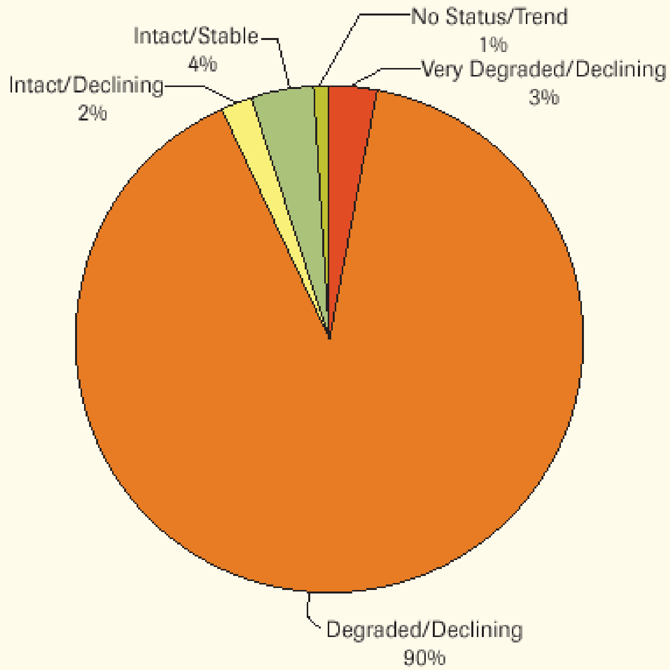
Fire Regime Status & Trend | Sources of Alteration

Fire-Dependent/Influenced



National Policies	11%
Climate Change	11%
Grazing	9%
Rural Growth	9%
Arson	9%
Fire Management Capacity (lack of)	8%
Crop Production	6%
Cultural Attitudes	6%
Ecosystem Conversion	5%
Invasive Species	4%
Traditional Fire Use Cessation	3%
Mining, Oil, Gas Development	3%
Fire Suppression	3%
Urban Growth	3%
Other	7%

Fire-Sensitive



Forestry Practices	12%
Rural Growth	11%
National Policies	11%
Fire Management Capacity (lack of)	10%
Traditional Fire Use	10%
Illegal Forestry	9%
Ecosystem Conversion	8%
Arson	8%
Crop Production	8%
Climate Change	3%
Other	11%

The Nature Conservancy

Climate change

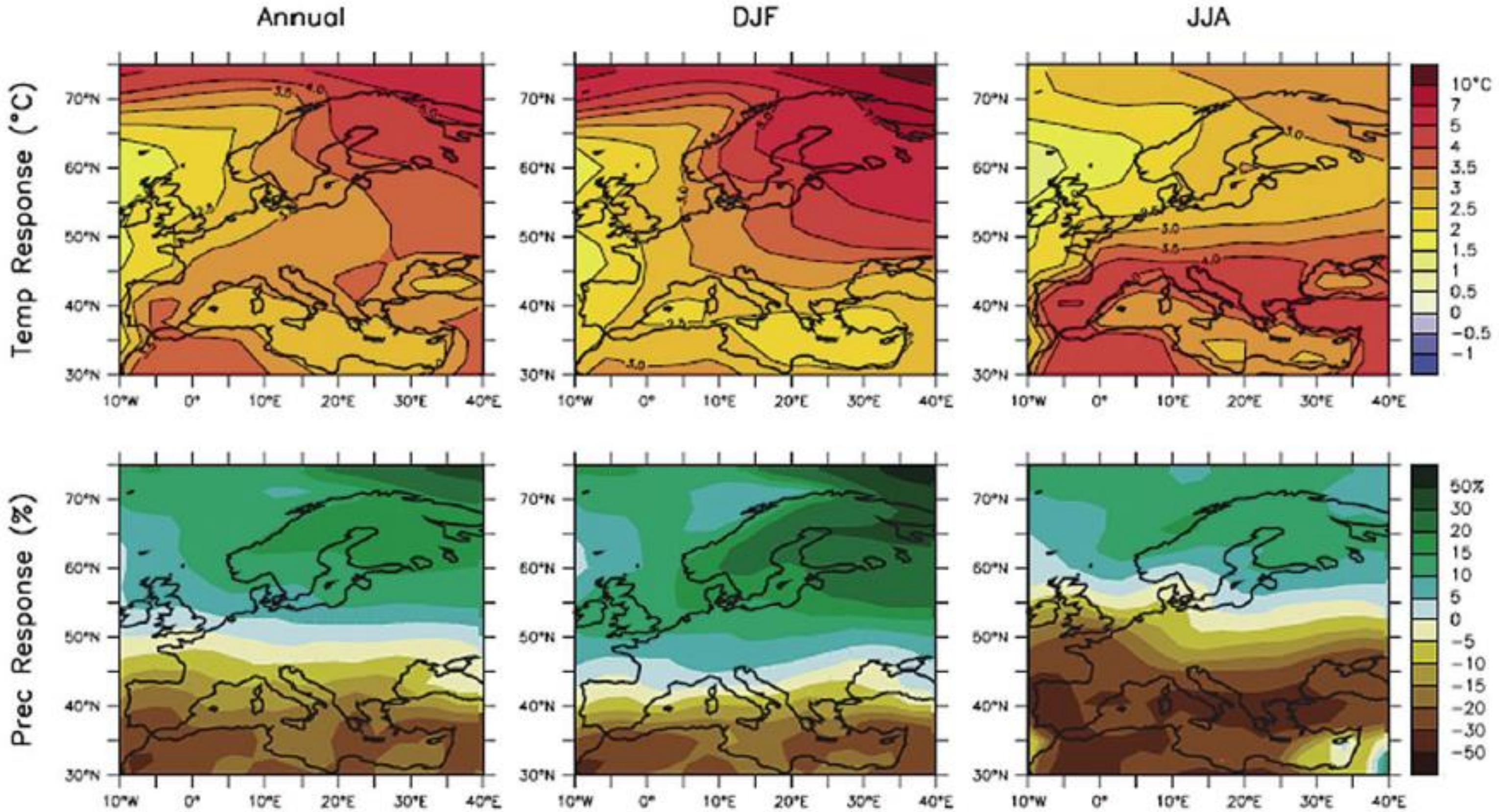


Figure 19. Simulated temperature and precipitation changes over Europe for the A1B scenario. Top row: annual mean, winter (DJF), summer (JJA) temperature change between 1980 to 1999 and 2080 to 2099, averaged over 21 models. Bottom row: same as top, but for fractional change in precipitation. Source: IPCC 4AR 2007.

The **A1** storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (**A1B**).

The scenario, **E1**, is an aggressive mitigation scenario that includes reduced fossil fuel use with the goal of keeping global mean warming below 2°C. In the E1 scenario, carbon dioxide increases to 435ppm by 2050 and then drops to 421ppm by 2099, with a global mean temperature increase of 2.12°C

A1B Scenario in 2099: 774 ppm of CO_2
4.41 °C global mean temperature increase

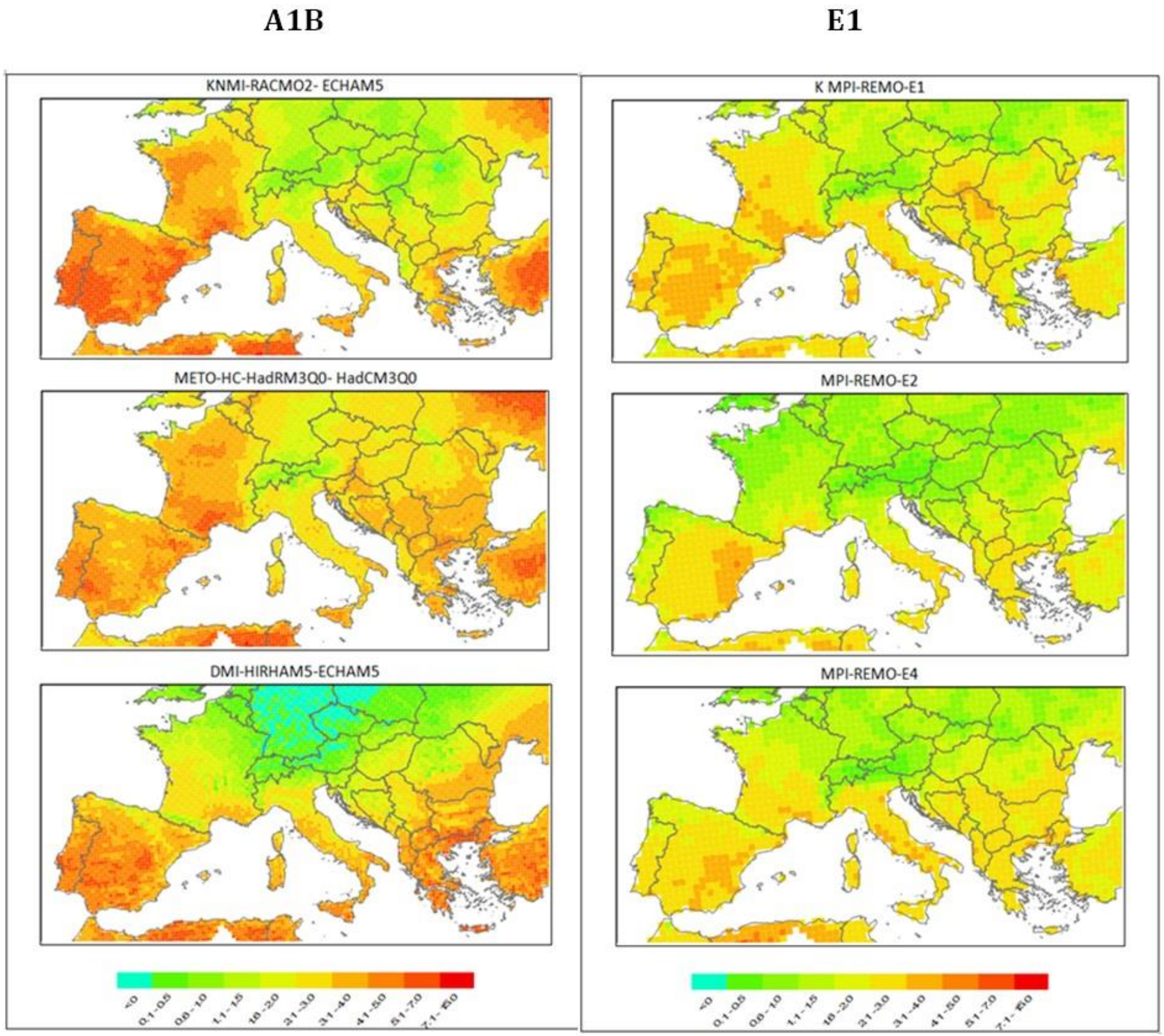
E1 Scenario in 2099: 421 ppm of CO_2
2.12 °C global mean temperature increase

Climate change

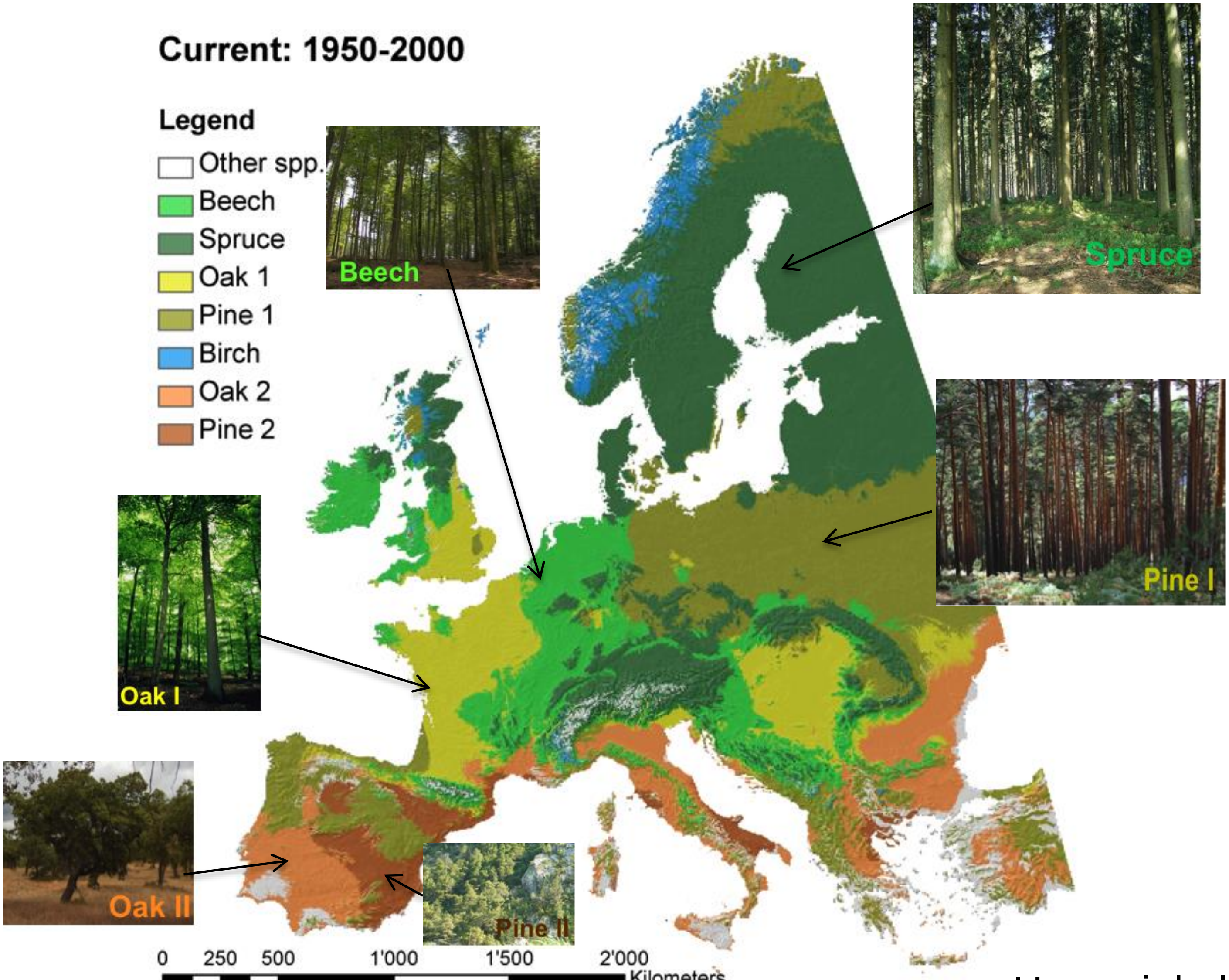
Climate models have predicted increases in both temperature and drought conditions in the Mediterranean (Giorgi and Lionello 2008; Somot et al. 2008). These changes are expected to result in **increased frequency**, **intensity and duration of drought**, especially during the warm season.

Under climatic change, warmer and drier conditions are expected to **increase the pressure from wildfires** in the Mediterranean.

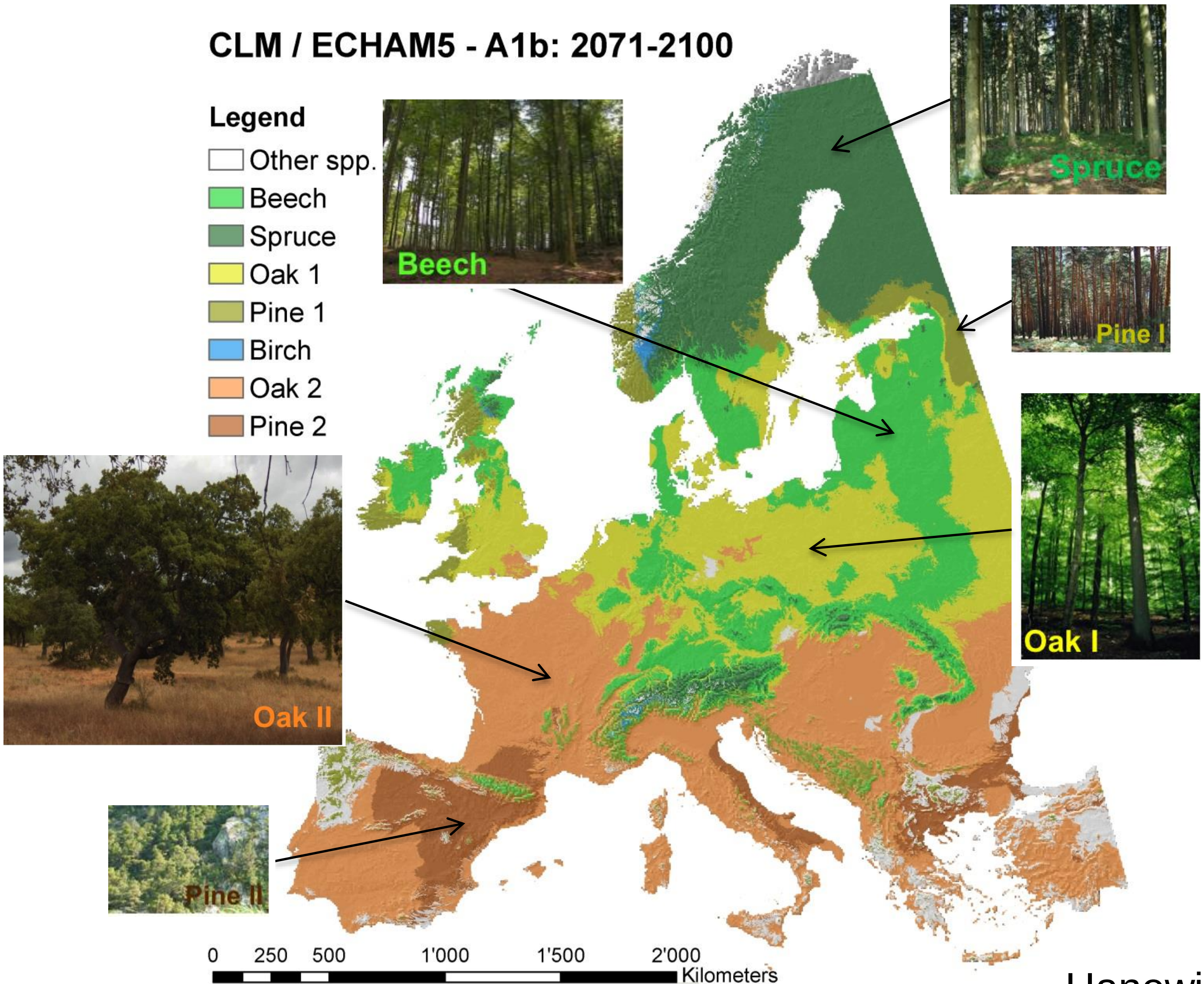
Gaquelin et al.2016



Difference of FWI annual averages between 2071-2100 and 1961-1990 simulations



Hanewinkel et al. 2012



Hanewinkel et al. 2012

"…pine-oak forest landscape composition dynamics in a near future may be strongly influenced by a harsher fire regime that may accelerate a shift towards **landscapes less dominated by pines but with more oaks and shrubby vegetation**."

"….although forest ecosystem functioning may be locally altered as a consequence of fire regime, ongoing afforestation may counteract negative impacts at the regional scale and suppression opportunities may arise from forest landscape composition dynamics favouring **less fire-prone species** (oaks) or **fuel limitations** (shrublands) due to climate change."

Gil-Tena et al. 2016

Many Mediterranean species have evolved strategies that allow them to survive periodic fires (Naveh 1975, Gill 1981).

However, although Mediterranean vegetation is able to cope with fire (Trabaud 1987, 1991, Pausas 1999), changes in the area burned and the consequent changes in **fire recurrence** (and inter-fire periods) are **altering the fire regime** generating important consequences.

High fire recurrence may prevent seeders from replenishing seed banks (Zedler et al. 1983), may deplete resprouter bud banks (Canadell and López-Soria 1998), and/or may favour certain species with invasive characteristics (D'Antonio and Vitousek 1992, Vilà et al. 2001, Lloret et al. 2003).

Turner MG, Baker WL, Peterson, CJ, and Peet RK. 1998. Factors Influencing Succession: Lessons from Large, Infrequent Natural Disturbances. Ecosystems 1: 511-523.

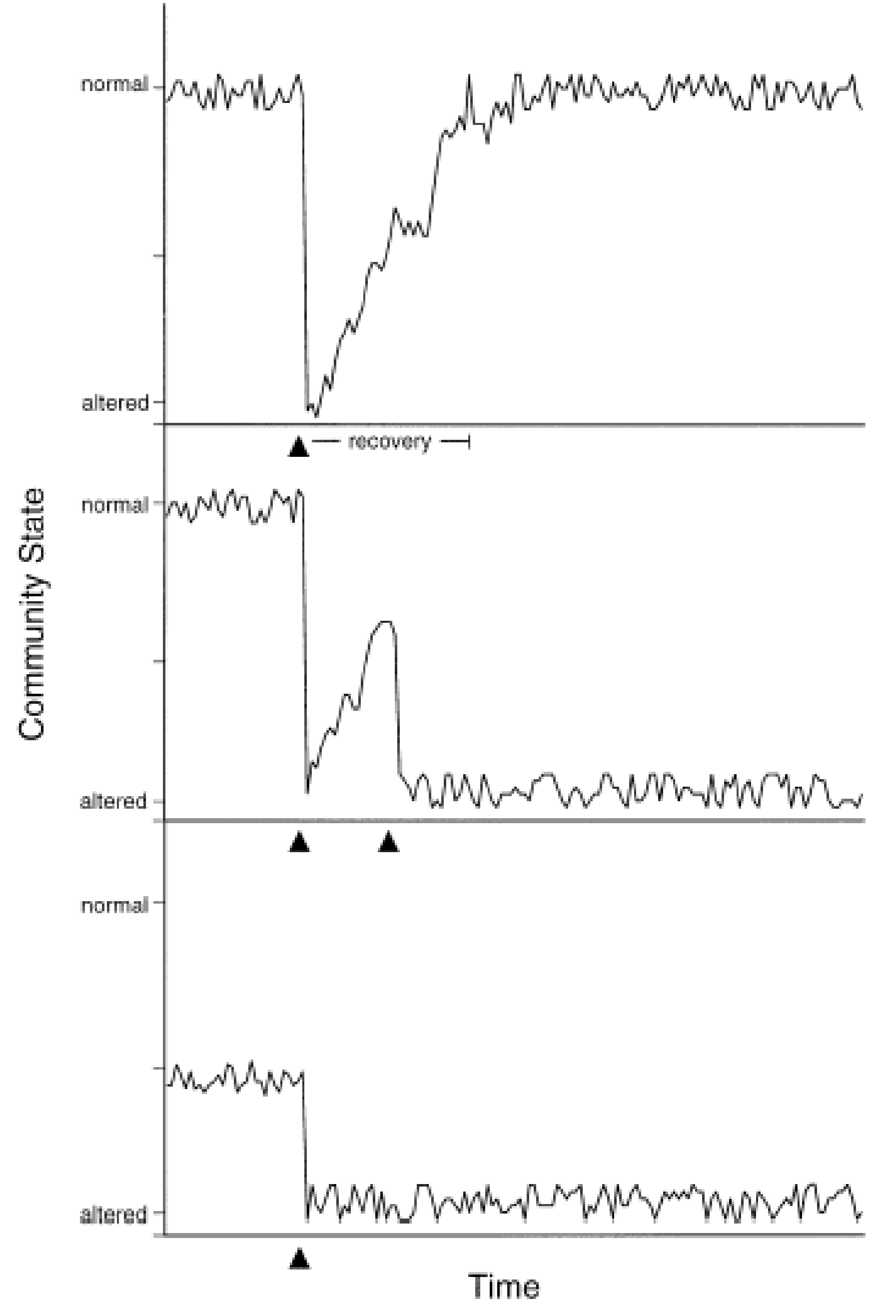


Figure 1. Schematic representation of the effects of large, infrequent disturbances (LIDs) on community state. **Top,** A normal community is subjected to a single LID and subsequently recovers. **Middle,** A normal community undergoes a second (or multiple) disturbance(s) before recovery from the first is completed; the combined effects lead to long-term alteration in community state. **Bottom,** A major disturbance is superimposed on an assemblage already already altered by anthropogenic processes or disease; again the combination of stresses leads to long-term alteration of comunity state. Arrowheads mark the disturbances.

Land use & land cover changes

Table 2.1 Changes (in hectares) among land cover classes from 1990 to 2006 in Mediterranean Europe (Portugal, Spain, France and Italy)

	To 2006	Urban	Artificial	Agricultural	Forest	Shrubland	No vegetation
From 1990	Urban	11,012,514	75,795	197,427	**11,957**	**5,897**	723
	Artificial	70,972	2,826,169	107,870	**21,353**	**62,476**	7,292
	Agricultural	1,220,019	765,940	180,616,767	**815,487**	**1,188,775**	25,636
	Forest	*43,099*	*101,413*	*583,320*	85,029,222	*3,192,178*	*82,721*
	Shrubland	*44,331*	*99,291*	*1,071,732*	**2,299,768**	26,980,642	*199,171*
	No vegetation	3,362	12,183	57,788	**43,162**	**468,750**	4,120,242

Note: Changes associated to significant increases in fire hazard are signaled in bold, whereas changes leading to major decreases in fire hazard are in italics

San-Miguel-Ayanz et al. 2012

Fire regime changes in the Western Mediterranean Basin: from fuel-limited to drought-driven fire regime

Juli G. Pausas[1*] & Santiago Fernández-Muñoz[2]

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"…The main driver of this shift was the increase in fuel amount and continuity due to rural depopulation (vegetation and fuel build-up after farm abandonment) suggesting that fires were fuel-limited ………fires are currently less fuel limited and more drought-driven than before the 1970s."

CLIMATE HUMAN ACTIVITIES

FIRE REGIMES

Climatic Change (2012) 110:215–226
DOI 10.1007/s10584-011-0060-6

Fire regime changes in the Western Mediterranean Basin: from fuel-limited to drought-driven fire regime

Juli G. Pausas · Santiago Fernández-Muñoz

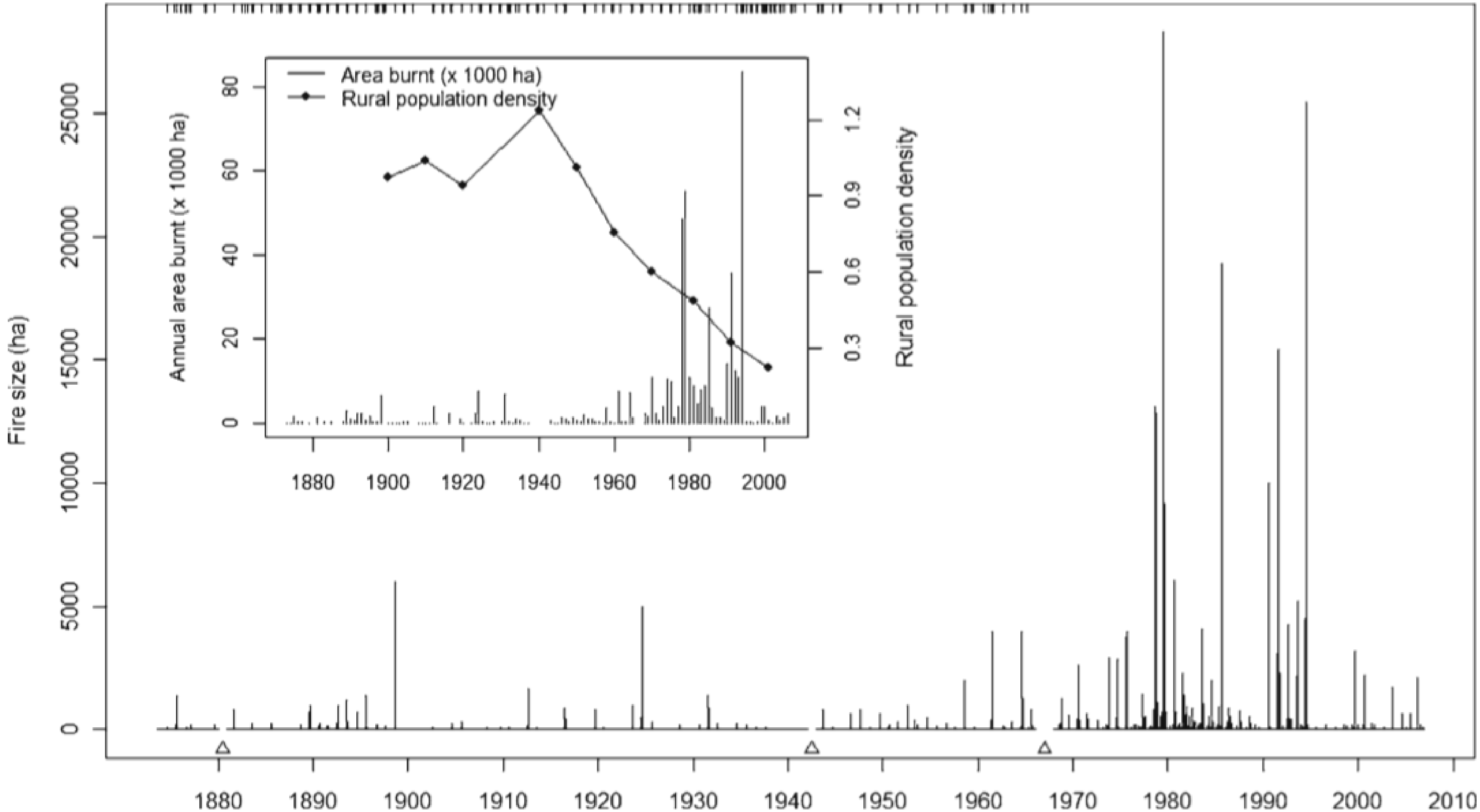
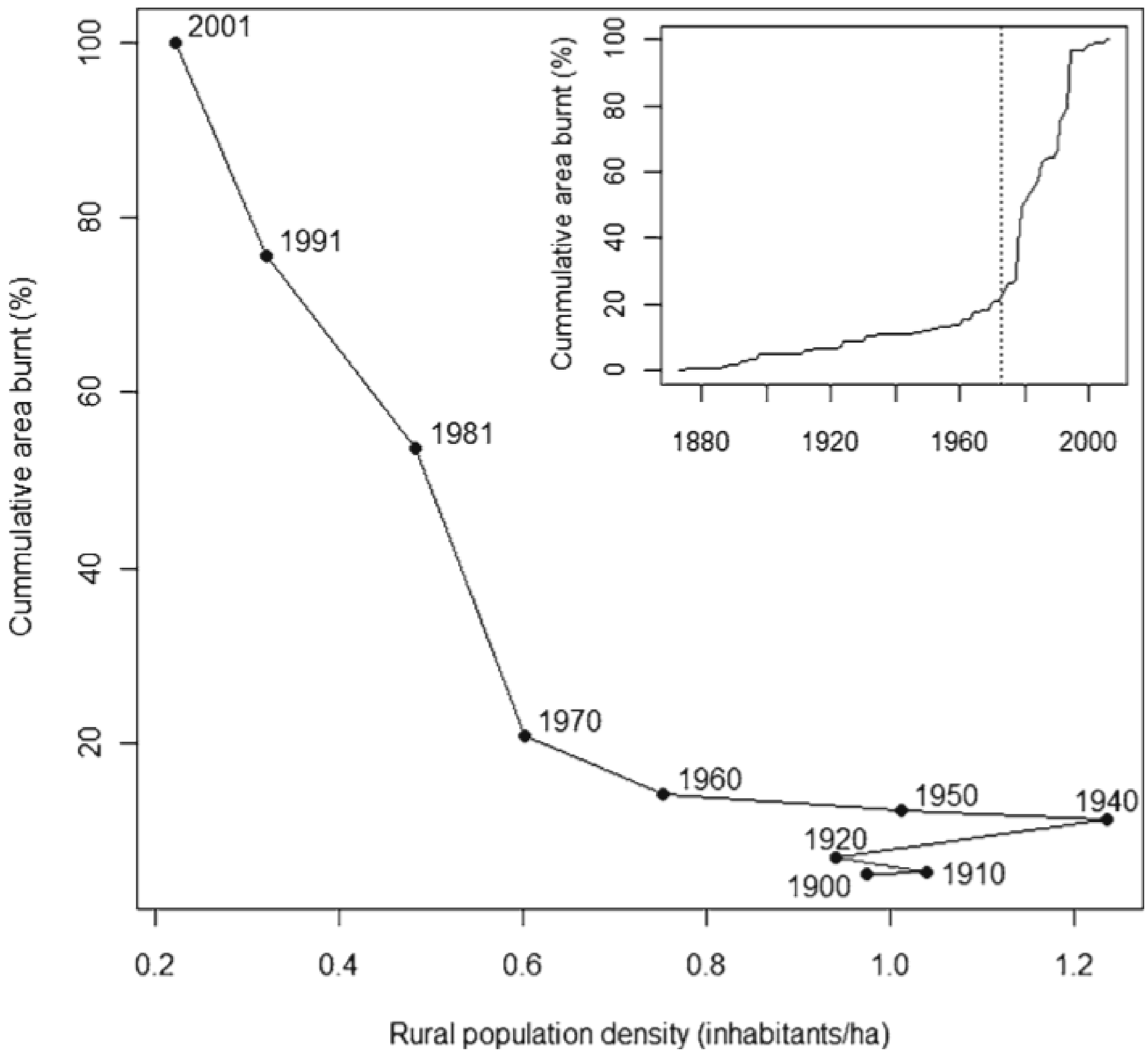


Fig. 2 Fire occurrence and size (in ha) in the Valencia province for all the period available (1873–2006). *Triangles* in the lower *x*-axis indicate the periods without data; ticks in the upper *x*-axis indicate fires of unknown size. *Inset figure*: annual area burnt (ha × 1000, vertical lines) for the same period and region and the rural population density (inhabitants/ha); for computing annual area burnt, fires without size data are given the value of the average fire size during the historical period (1873–1965)

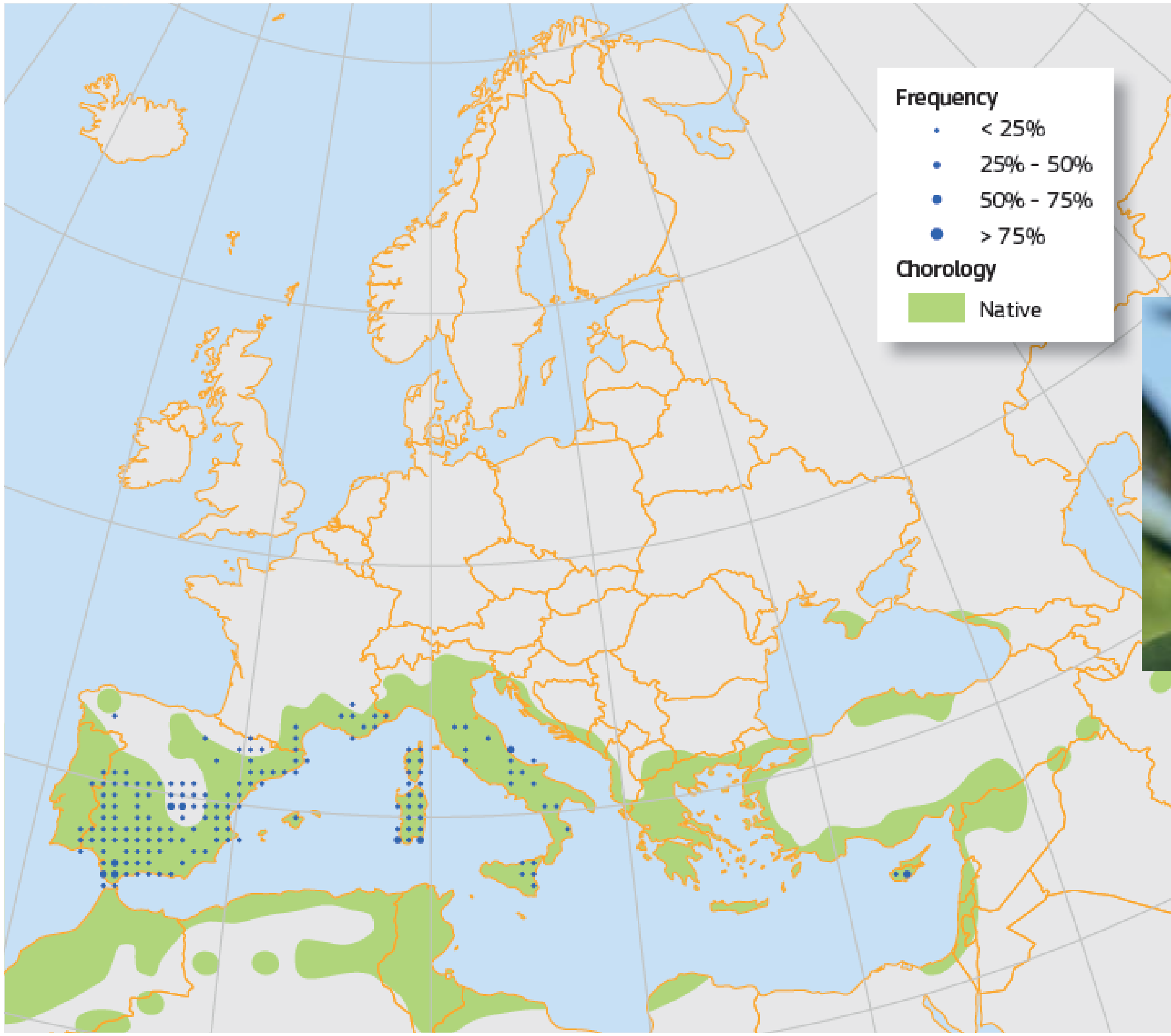
Pausas and Fernández-Muñoz 2012

Fig. 5 Relation between the rural population density (inhabitants/ha) and the cumulative area burnt (%) during the twentieth century in the Valencia region (see also inset in Fig. 2). The relation is strongly significant ($r = -0.925$, $p = 0.0001$, log–log transformation). The figure suggest that fires where fuel-limited up to ca. 1970



Pausas and Fernández-Muñoz 2012


ROMAN EMPIRE
AT ITS GREATEST EXTENT
OCEANUS ATLANTICUS
CALEDONIA
HIBERNIA
BRITANNIA
OCEANUS GERMANICUS
MARE SUEVICUM
SARMATIA EUROPEA
GERMANIA
OCEANUS GALLICUS
OCEANUS CANTABRIUS
Germania
Belgica
Lugdunensis
GALLIA
Aquitania
Narbonensis
VENDELICIA
RHAETIA
NORICUM
PANNONIA
IAZYGES
Carpates Mons
DACIA
SARMATIA
CASPIUM MARE
MAEOTIS PALUS
Taurica
Caucasus Mons
ALBANIA
COLCHIS
IBERIA / IBER
PONTUS EUXINUS
Tarraconensis
Pyrenaei M.
HISPANIA
Lusitania
Baetica
Gallia Cisalpina
ITALIA
ILLYRICUM
Dalmatia
MARE HADRIAETICUM
MOESIA
THRACIA
CORSICA
SARDINIA
MEDITERRANEUM MARE
MACEDONIA
EPIRUS
Hellas
AEGAEUM MARE
BITHINIA
GALATIA
PONTUS
ARMENIA MINOR
ARMENIA MAJOR
ATROPATENE
MEDIA
CAPADOCIA
Mysia
Phrygia
ASIA
Lydia
Caria
Lycia
Lycaonia
PAMPHYLIA
CILICIA
REGNUM PARTHORUM
MESOPOTAMIA
SYRIA
Cyprus
Creta
SICILIA
MAURITANIA
Tingitana
Atlas Mons
Caesariensis
NUMIDIA
AFRICA
CYRENAICA
Syriae Deserta
BABELONIA
JUDEA
ARABIA PETRAEA
AEGYPTUS
ARABICUS SINUS
ARABIA
Libyae Deserta
LIBYA



Map 1: Plot distribution and simplified chorology map for *Olea europaea*.

Europe

Area	10 300 734 km²
Population	734 183 926
Density	70,88 /km²

Australia

Area	7 617 930 km²
Population	24 145 600
Density	2,79 /km²

New South Whales

Area	800 642 km²
Population	7 565 500
Density	9,45 /km²

Italy

Area	301 340 km²
Population	60 592 548
Density	201,32 /km²

Map 3.1 **Europe by night — the extent of urbanisation and infrastructure on European territory and forest ecosystems**

Pressures on forest ecosystems

- Forest cover
- Light/urban infrastructure
- Background

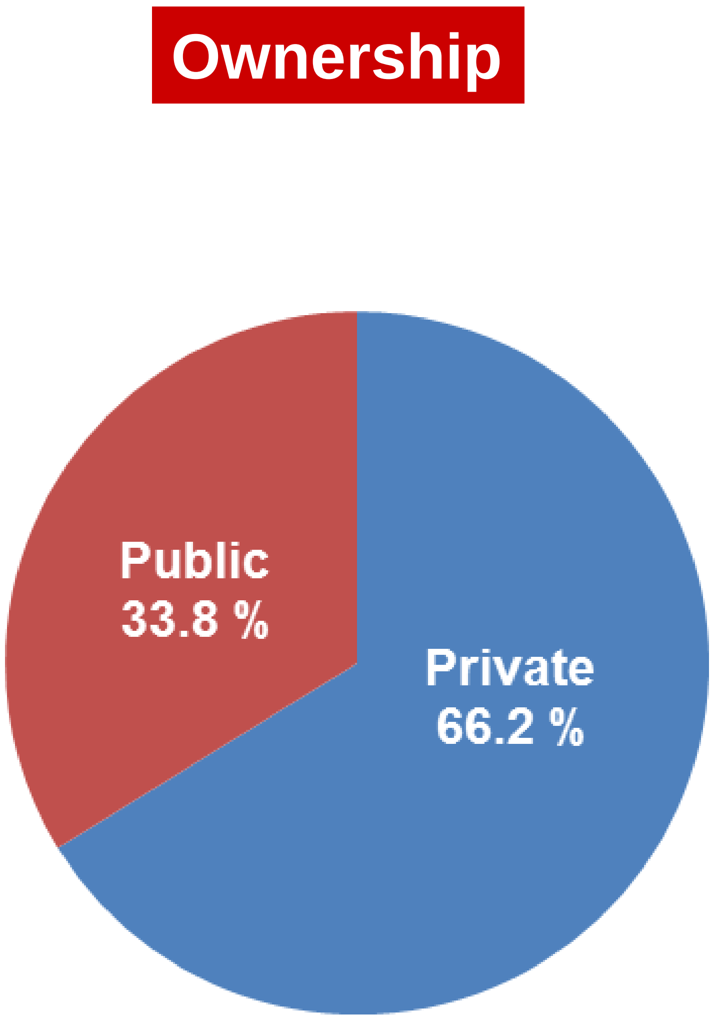
Source: http://svs.gsfc.nasa.gov/vis/a000000/a002200/a002276/index.html and EEA Copernicus High-Resolution layer forest type (2012).

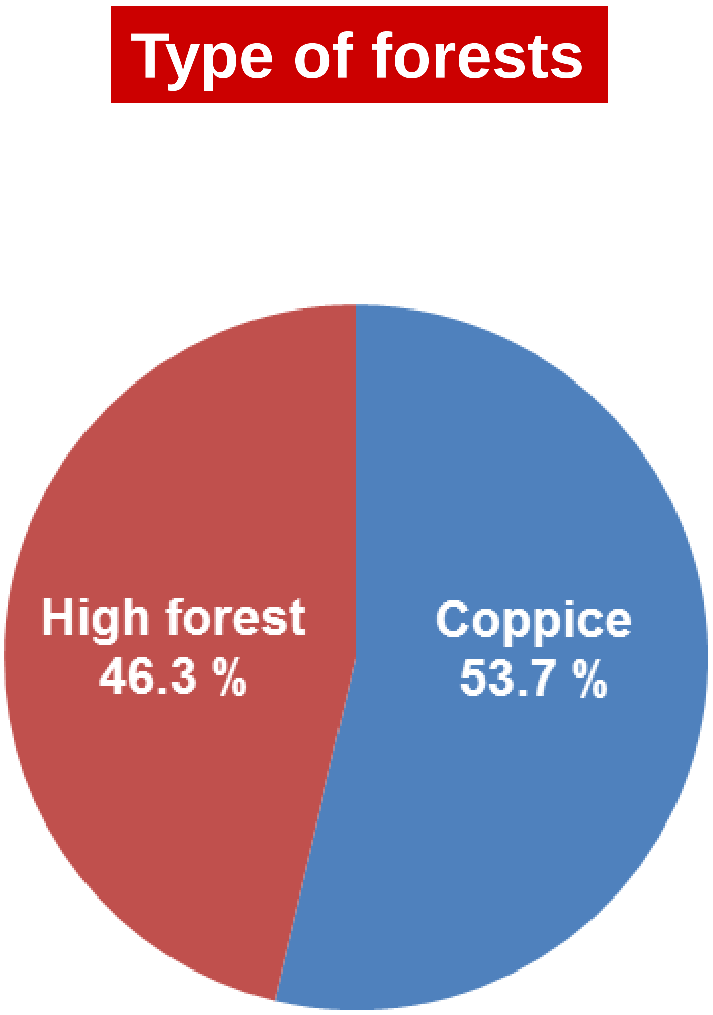
FOREST AREA

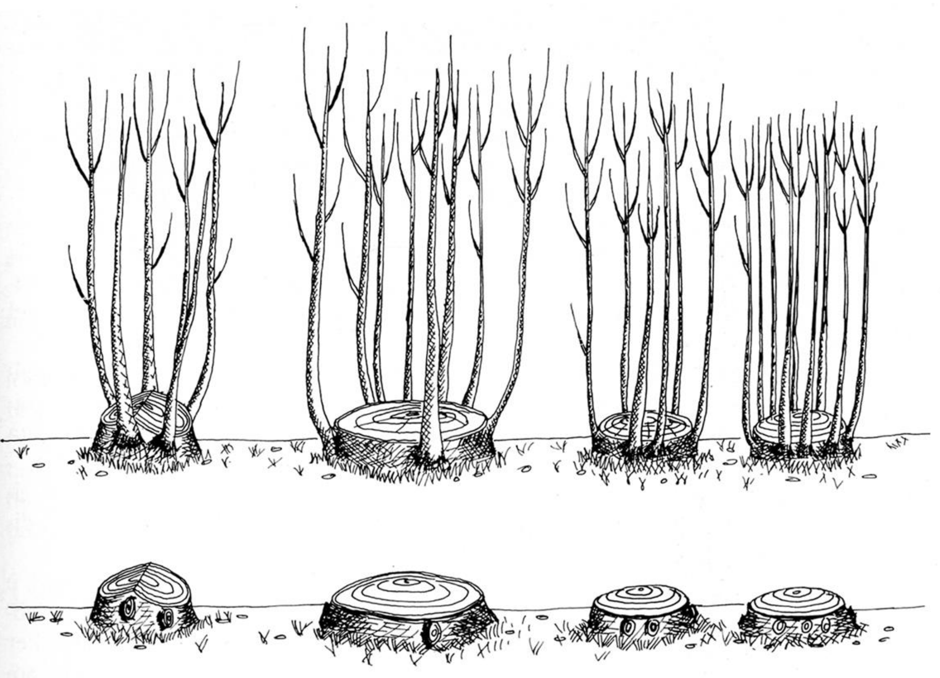
Land use	Area (ha)	Proportion	S.E. %
Forest	8,759,200	29%	0.4
Other wooded land	1,708,333	6%	1.3
Total wooded area	10,467,533	35%	0.3
Total land area	30,132,845	100%	

- Forest
- Other wooded land

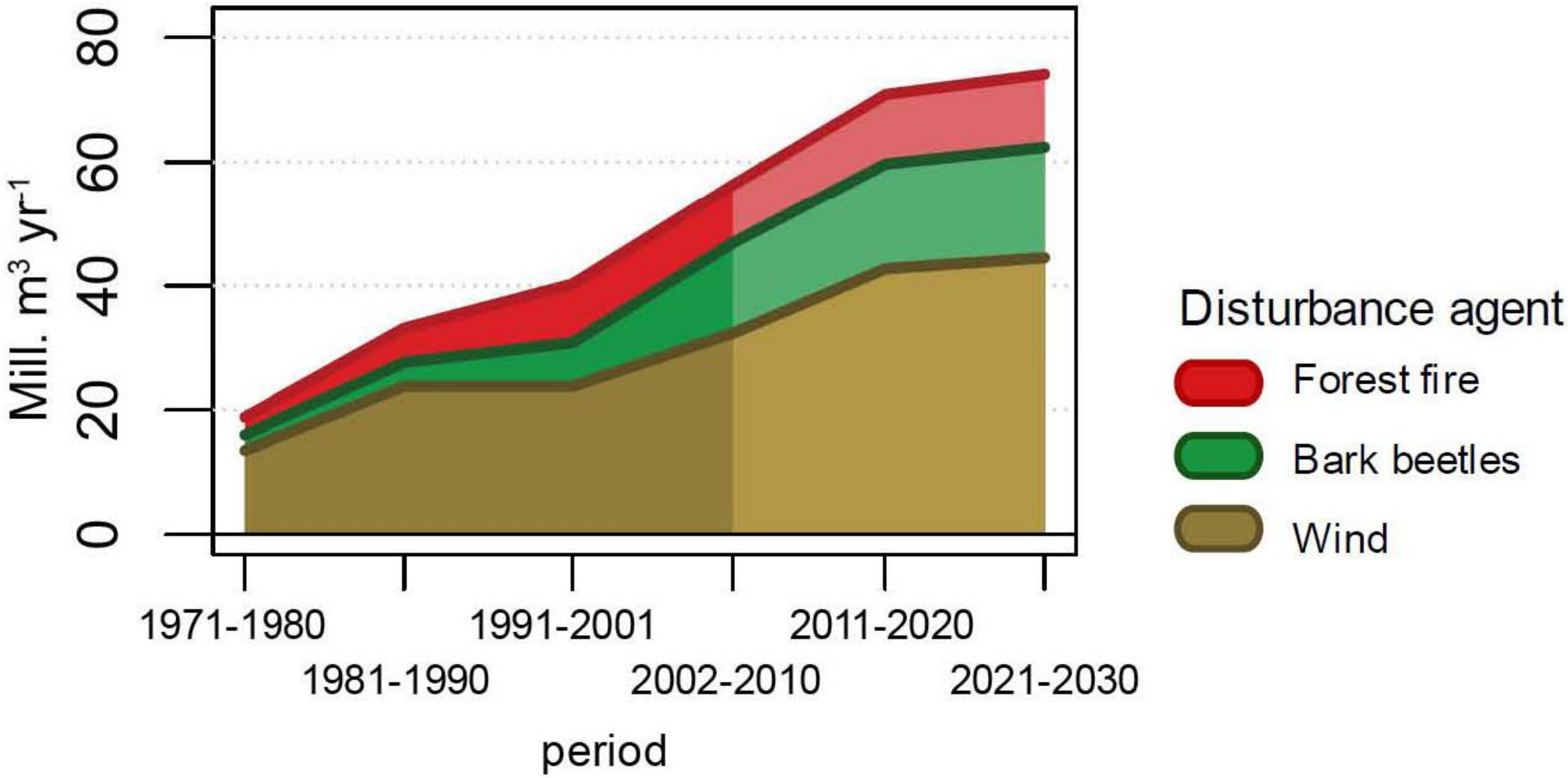
www.infc.it


Ownership
Public
33.8 %
Private
66.2 %


Type of forests
High forest
46.3 %
Coppice
53.7 %



Coppice systems



Increasing forest disturbance damage in Europe (© *Nature Climate Change*, the authors)

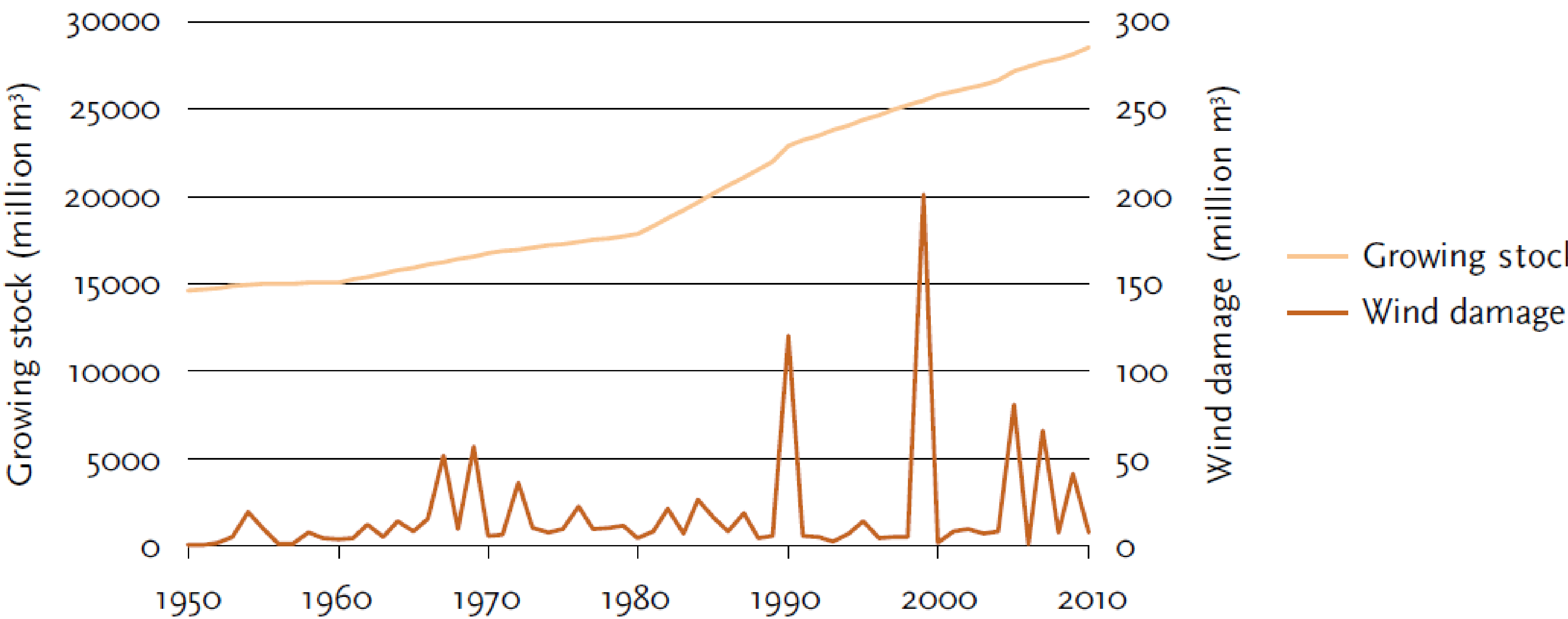
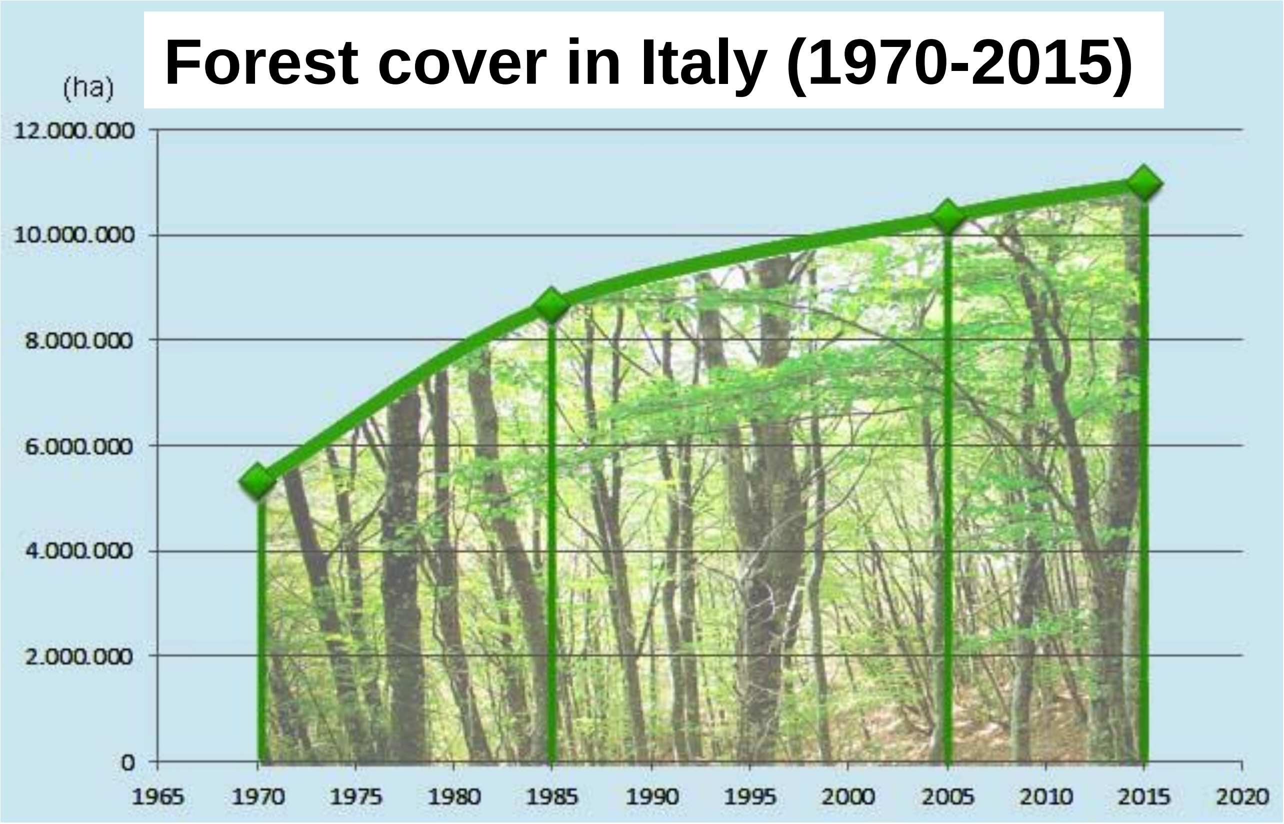


Figure 2. Development of growing stock and damage caused by storms in the period 1950–2010.

Area covered by forests in Europe has increased at a rate of approximately 0.4% per year since 1990, as a result of afforestation programmes, natural succession of vegetation and abandonment of farming (EU MEMO, Sep.2013).

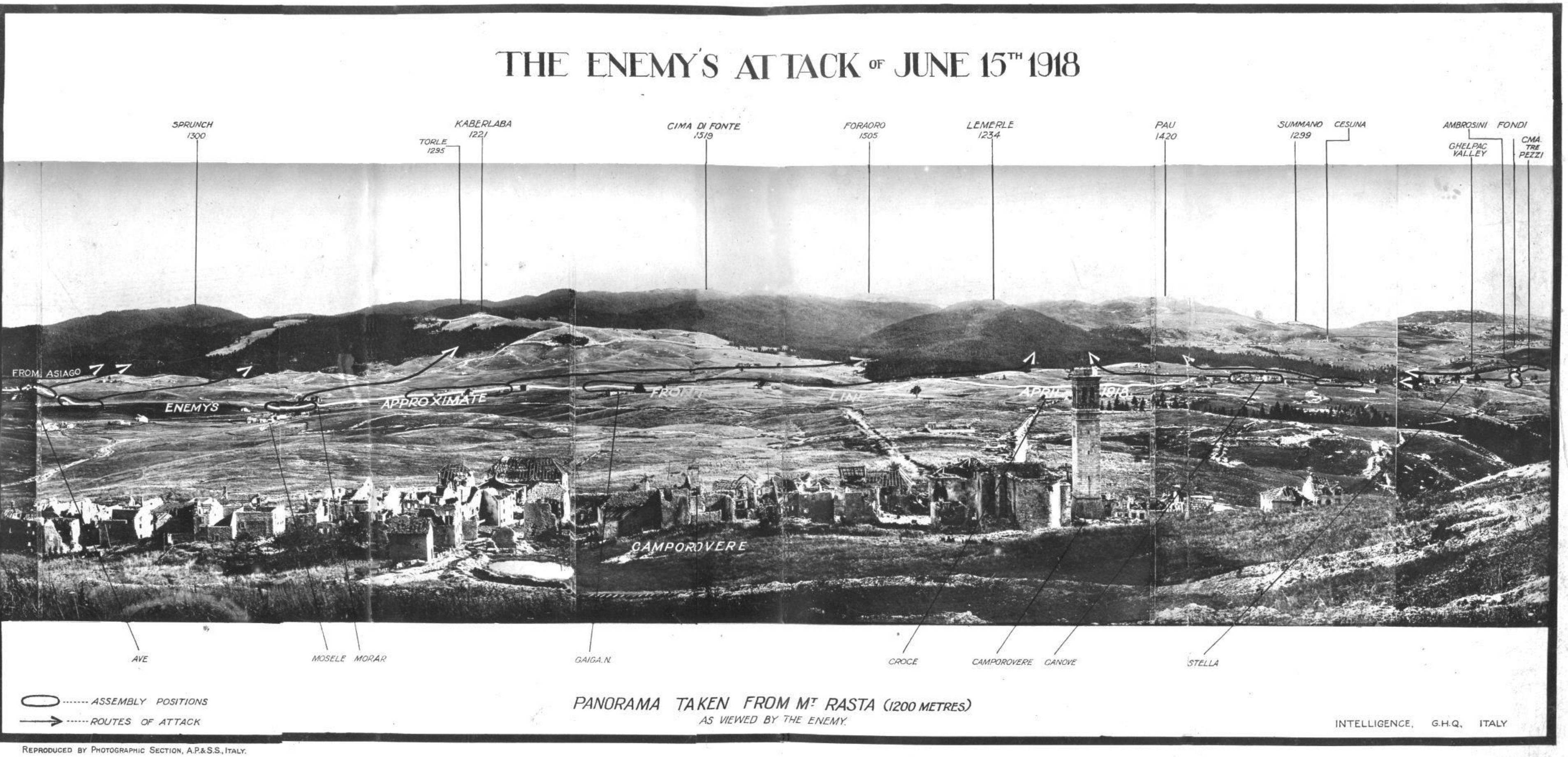


Overexploitation

Overgrazing

WWI & WWII

Floods, landslides, soil erosion



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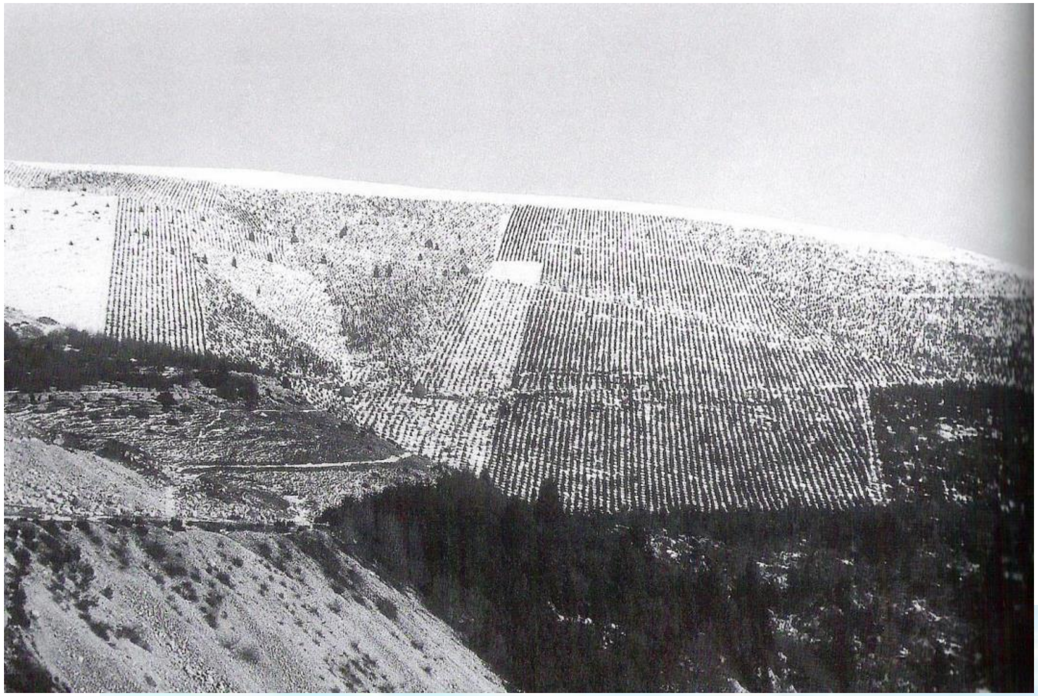
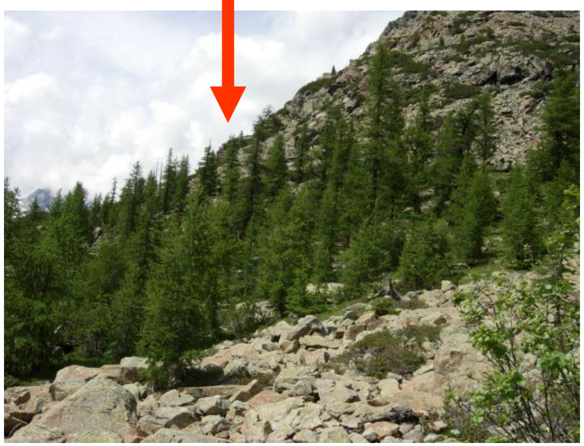


Afforestation in the Asiago plateau (VI) after the WWI and nowadays.

Cultural landscape

HUMAN traditions

interactions



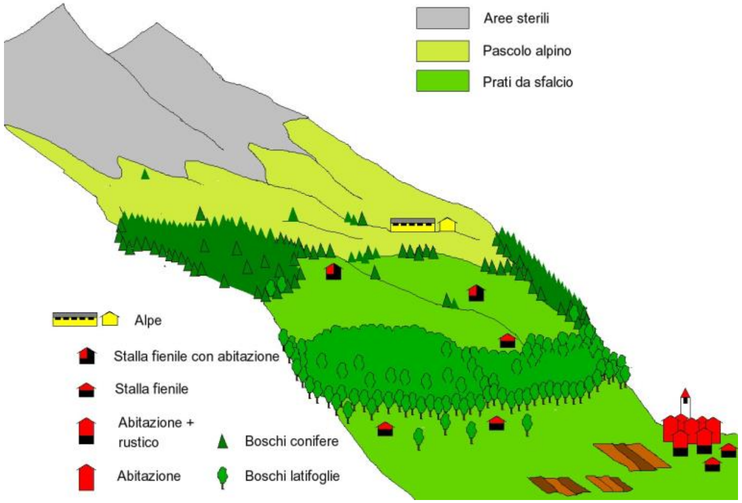
NATURAL environment

Semi-natural systems

CULTURAL LANDSCAPES
(Naveh, 1982,1995; Antrop, 1997)

Fire as a tool

Summer grazing
Lowered treeline
Tree regeneration cleared by fire



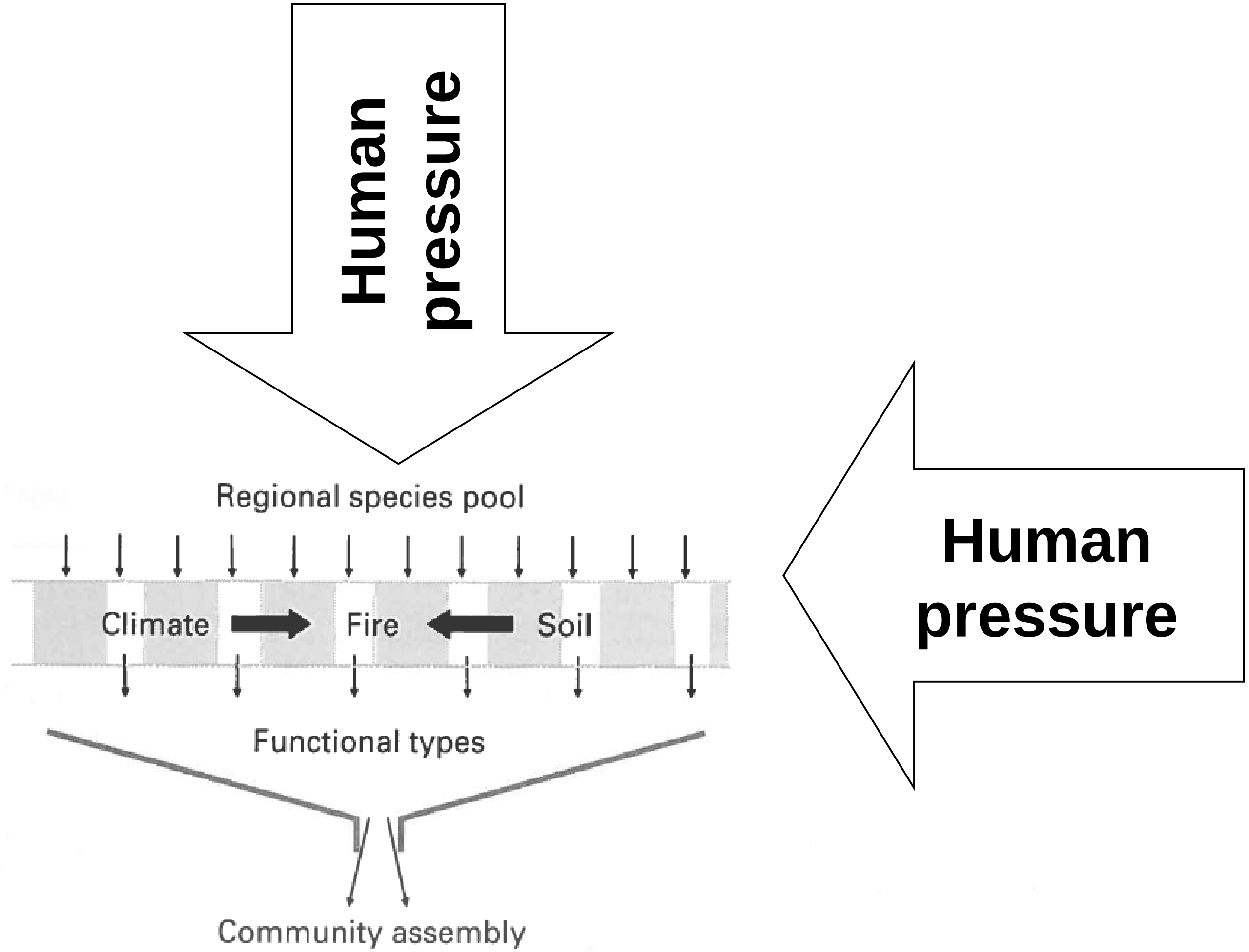


Fig. 1.4 *The environmental template in fire-prone landscapes can be thought of as a process in which the regional species pool is filtered to a subset of functional types. The combination of climate and geology places bounds on the range of plant traits that control fire regimes and feedback from fire further affects the pool of available functional types. This climate, fire, geology interaction acts as a control on community assembly, with the important emergent property of fuel types and ignition probabilities determining fire regime.*

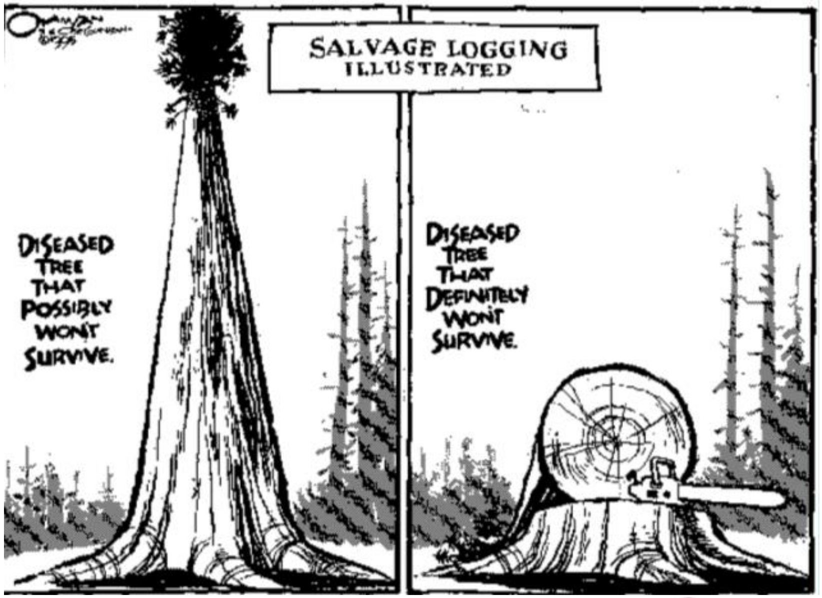
Post-disturbance management?

active

passive

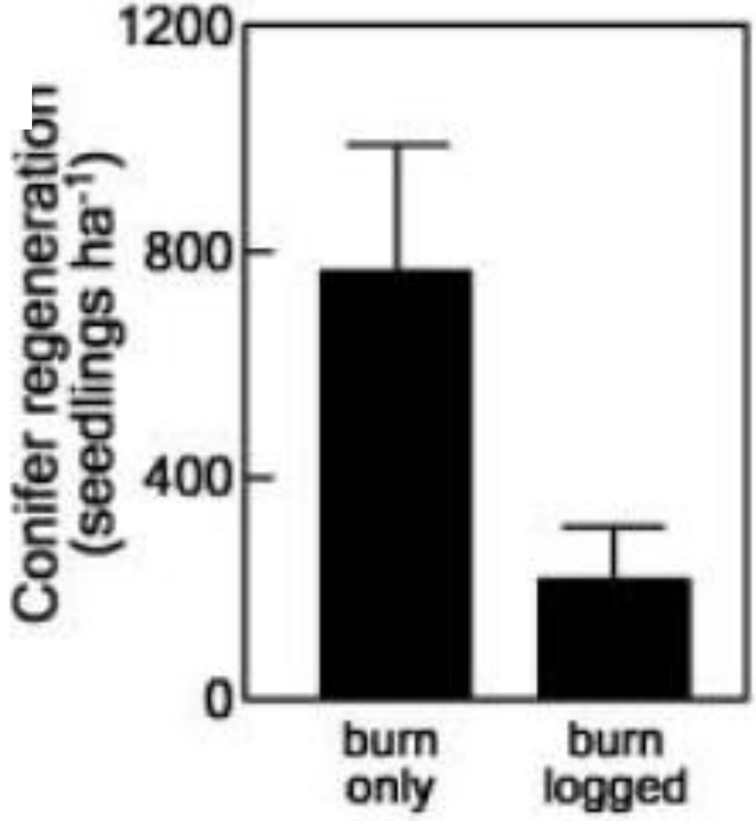
Salvage logging

= the harvesting of dead or damaged trees from sites after natural or human-caused disturbance events



Donato controversy

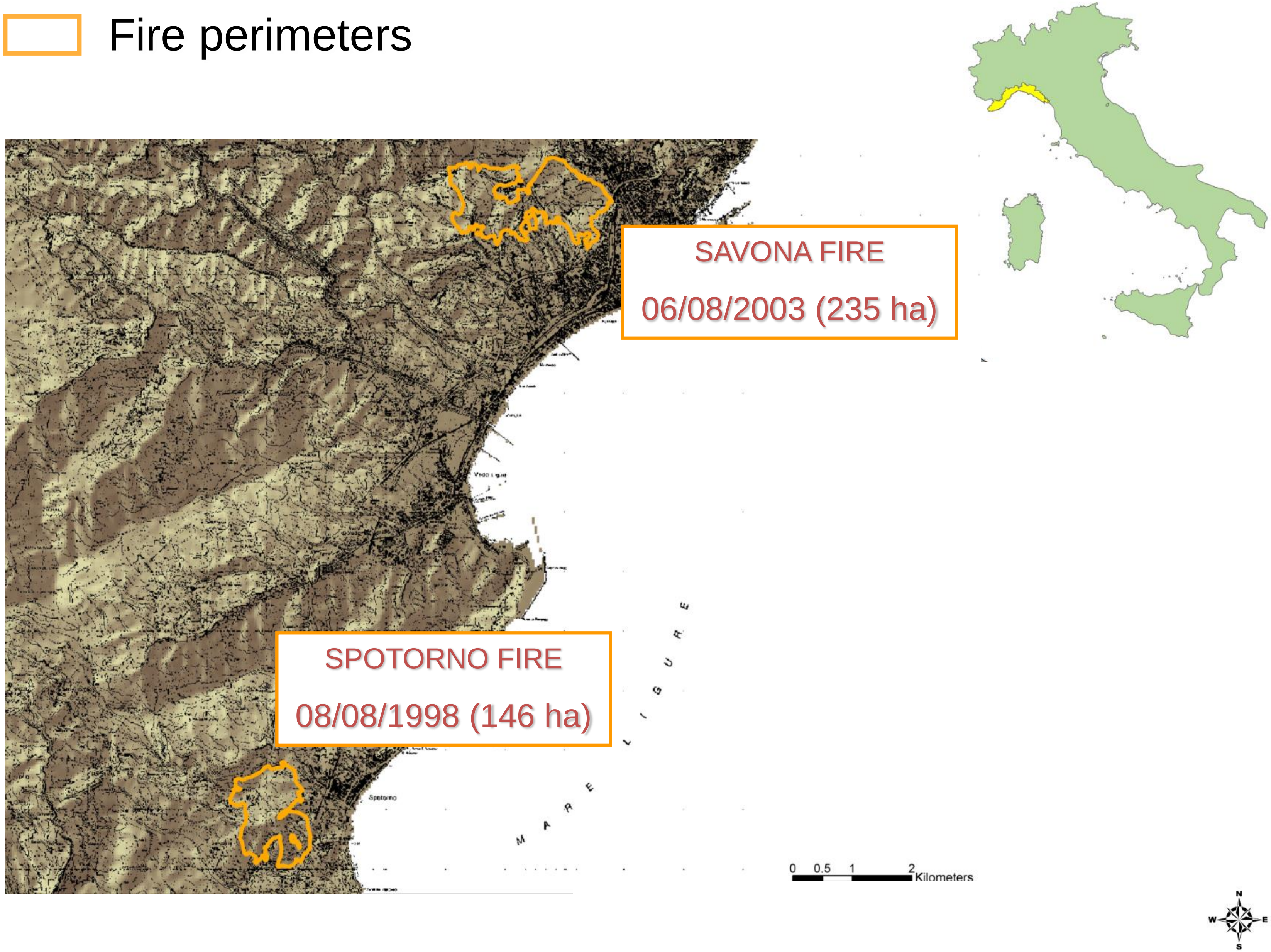
Biscuit fire, USA (2002)



Donato D.C., Fontaine J.B., Campbell J.L., Robinson W.D., Kauffman J.B., Law B.E., 2006, Post-wildfires logging hinders regeneration and increase fire risk. Science 313: 311-352


Spotorno 08/08/1998

Fire perimeters



Spotorno 08/08/1998

Spotorno 08/08/1998 (NO SALVAGE LOGGING)

Fire regime in the Alps

- Winter-early spring fire season (peak: February-March)
- Low/medium intensity surface fires
- Average size < 10 ha

- Longer fire season (increase in summer lightning fires)
- More stand replacing crown fires (mostly in coniferous forests)
- Increase in size and severity

CLIMATE & LAND USE CHANGE

Long term research on wildfire effects and post-fire management in the Italian Alps

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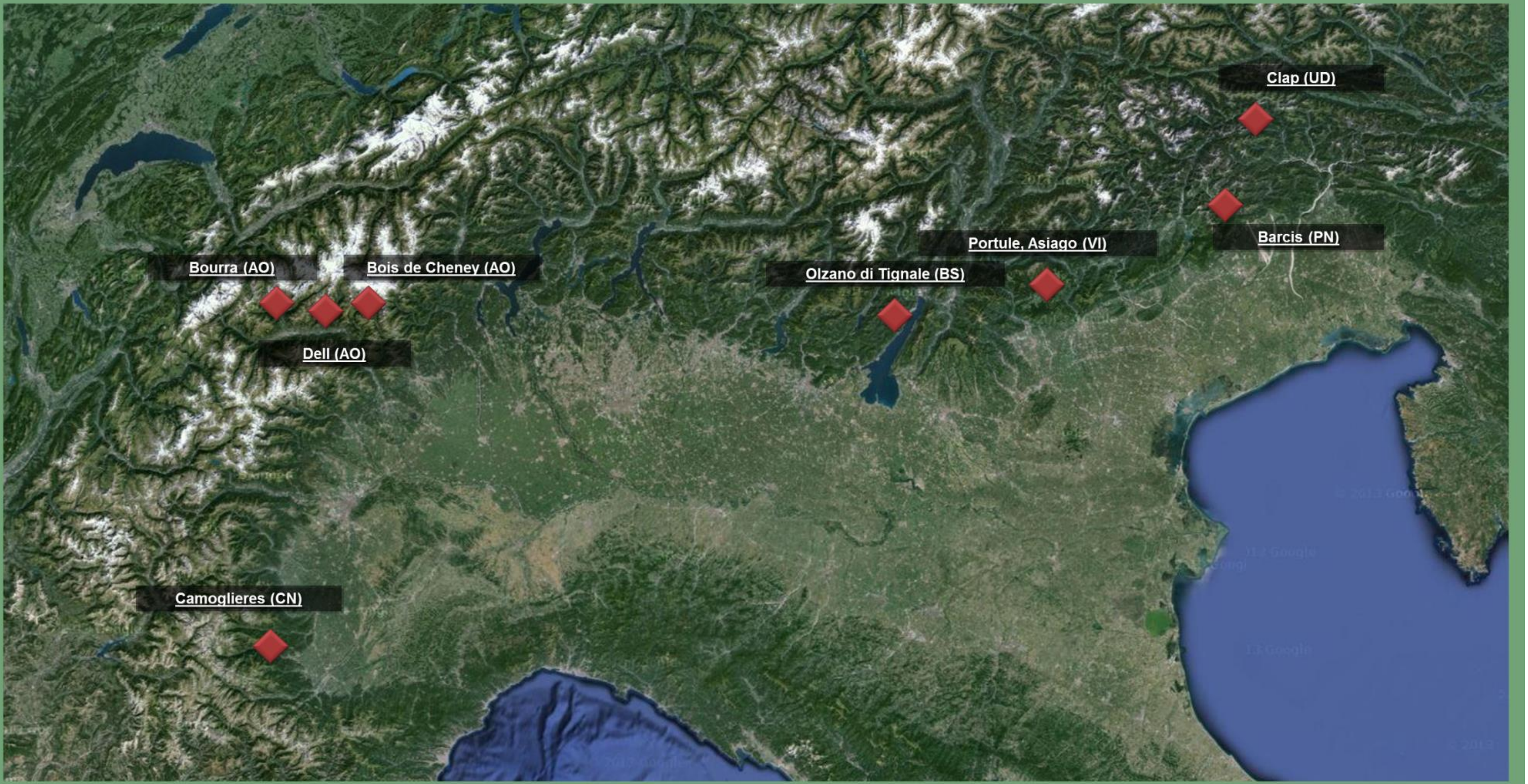
Study sites in the Italian Alps



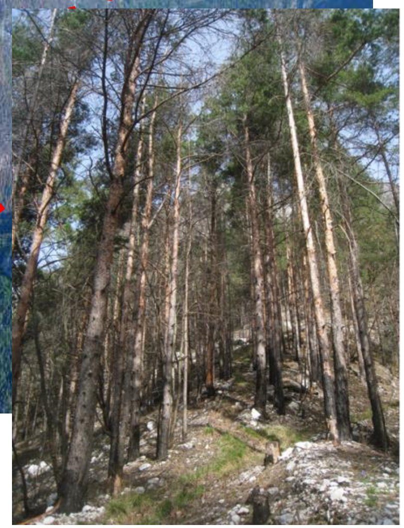
Study sites in the Italian Alps

Coniferous forests

High severity stand-replacing crown fires

Recent (less than 30 years)

Size range	25 - 3185 ha
Time span	1990 - 2016



- Landscape
- Stand
- Seedling

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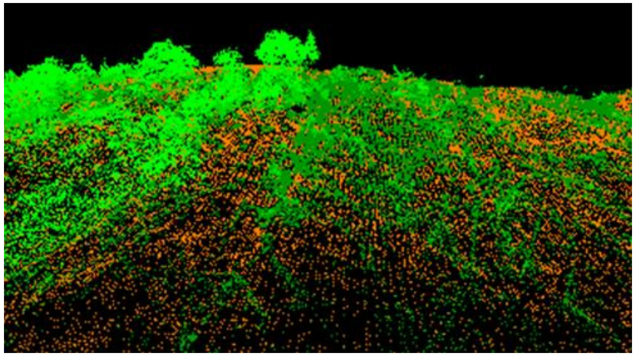
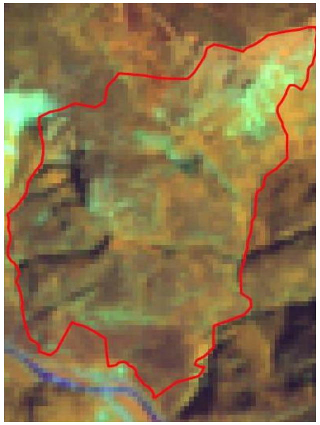
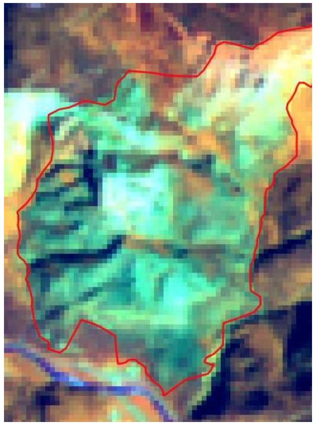
Dataset implementation



- Field data
- GPS location
- Temperature and soil moisture
- Hemisph. photos
- Aerial photos
- Landsat images
- LiDAR data



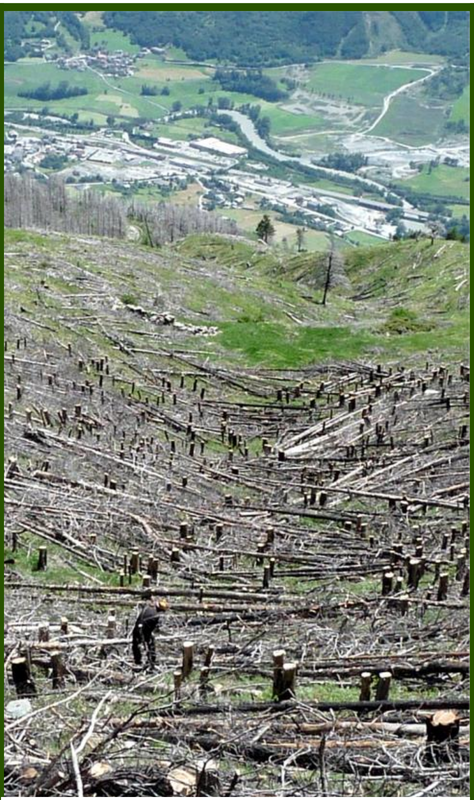


Post-fire restoration strategy and management

human impact

\- → +

No intervention

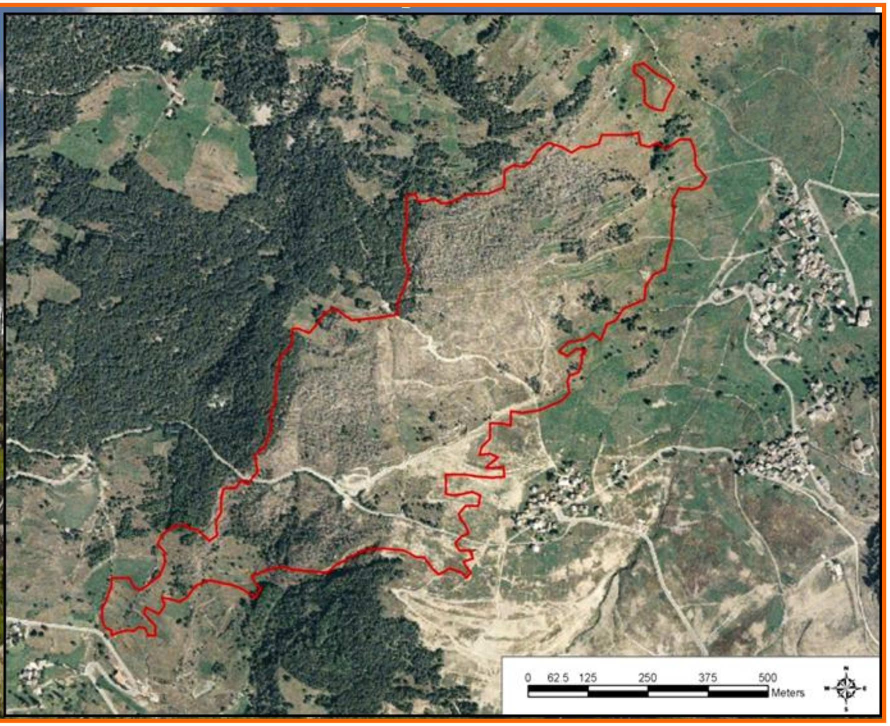


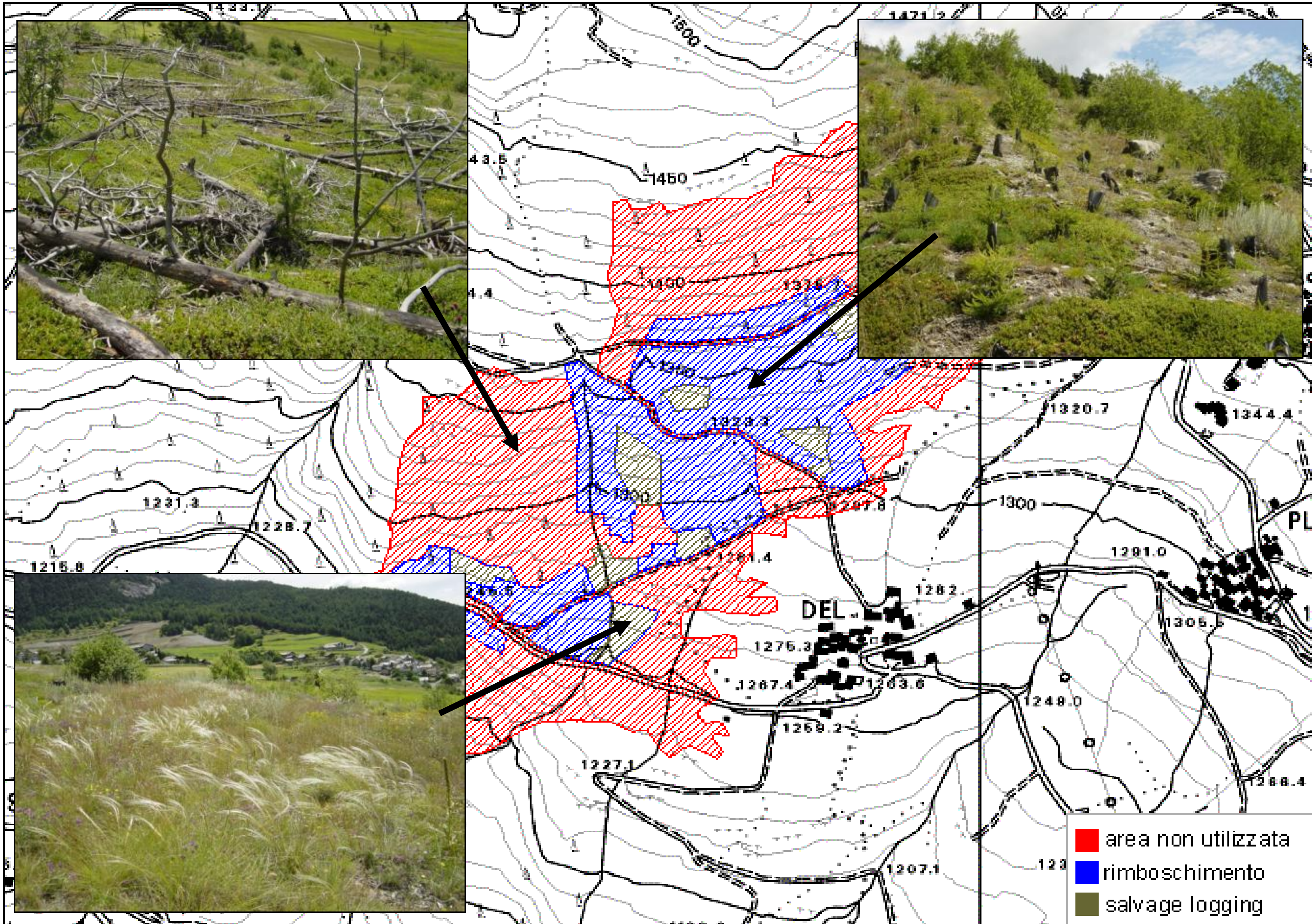
Cut and release

Salvage logging

Salvage logging
+ plantation

Dell (04/09/1995)




area non utilizzata
rimboschimento
salvage logging
DEL
1300
1400
1460
1500
1320.7
1344.4
1291.0
1282
1275.3
1267.4
1263.6
1269.2
1249.0
1227.1
1207.1
1231.3
1228.7
1215.8
1266.4

Dell 04/09/1995


Dell 04/09/1995

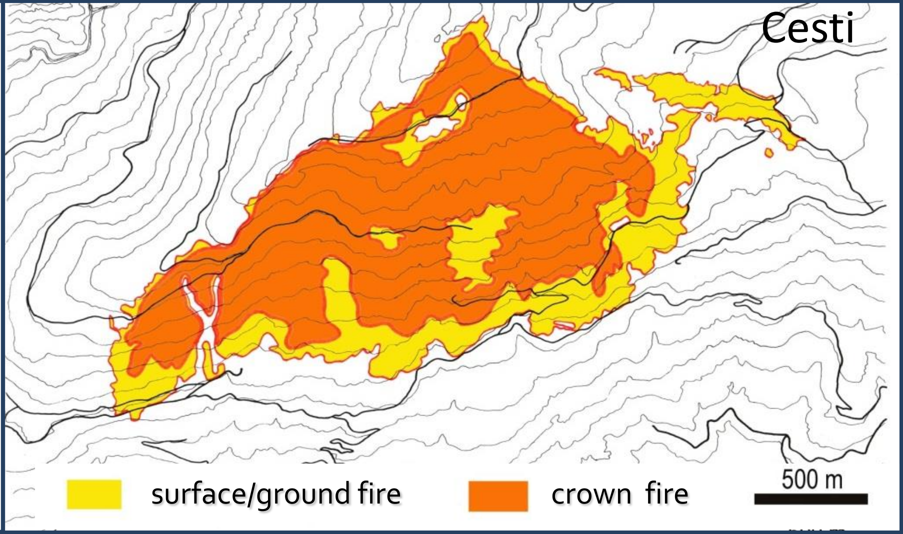
Main results

- High mortality of artificial regeneration
- Natural regeneration was more abundant where no post-fire intervention was realized
- Higher species and structural diversity of regeneration were found in not treated areas compared to logged and planted ones
- Natural regeneration structure was significantly influenced by post-fire restoration activities
- Deadwood in unsalvaged areas may have provided favorable sites for regeneration, given the high insolation and low precipitation in the areas

Nus/Verrayes wildfire (AO)

12/03/2005

- **burned area: 257 ha (160 ha pure *P. sylvestris* forest)**
- **stand replacing fire**
- **high severity**



Post-fire restoration strategy and management

human impact

\- → +

No intervention

Felling + no removal (random direction)

Felling/branches removal (fishbone)

Salvage logging

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Main results

Regeneration established close to deadwood.

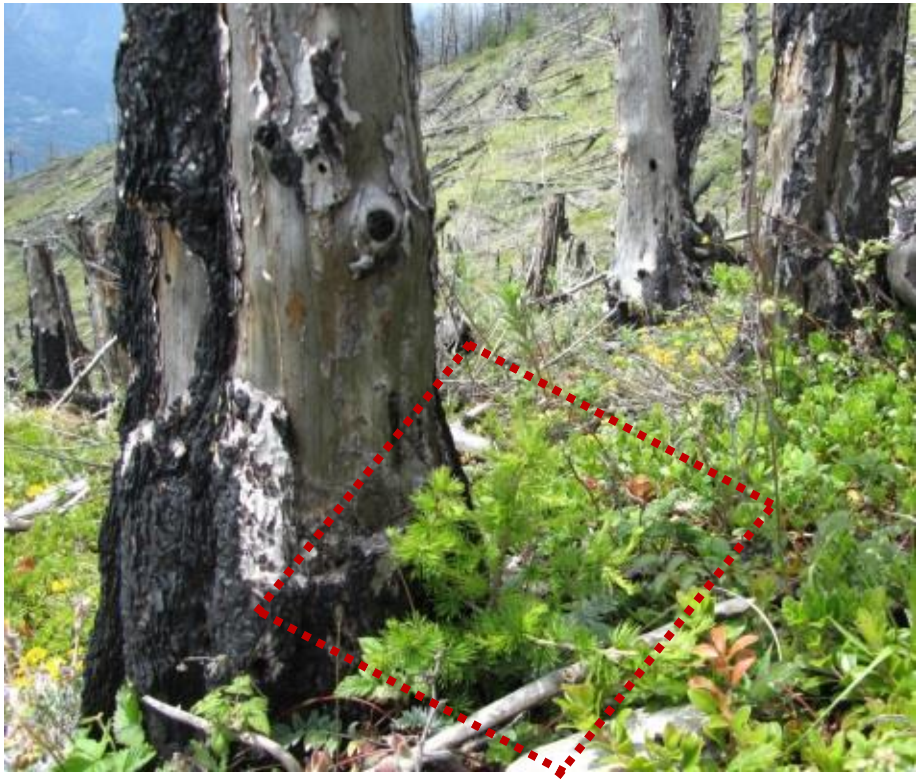
Deadwood enhances the probability of seedling establishment and survivorship ('safe sites').

Establishment probability up to 4 times higher (particularly for *P.sylvestris*).

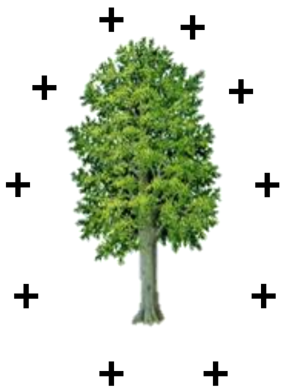
Main results

Positive anisotropic spatial interactions (attraction) were found between deadwood and natural regeneration.

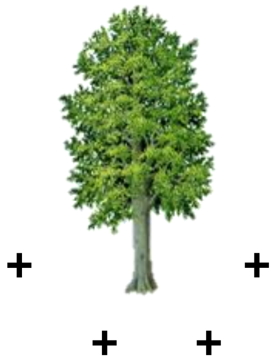
Shelter objects to south significantly increased odds of regeneration. Stronger in early post-fire environment.



Isotropy vs anisotropy



Isotropy



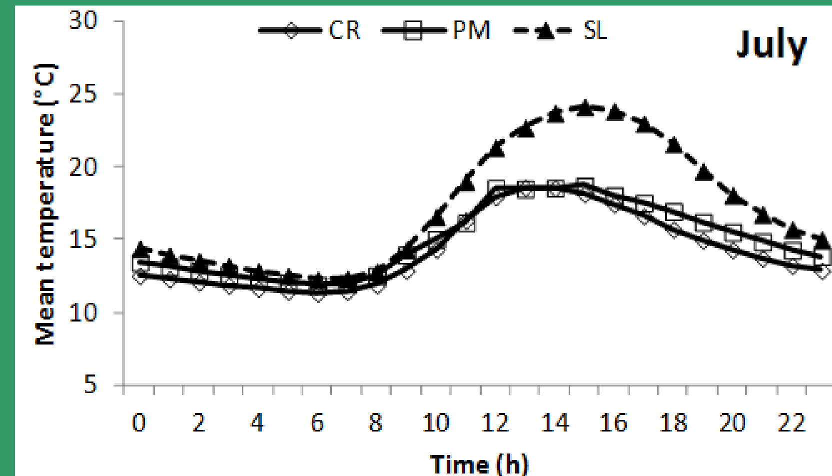
Anisotropy

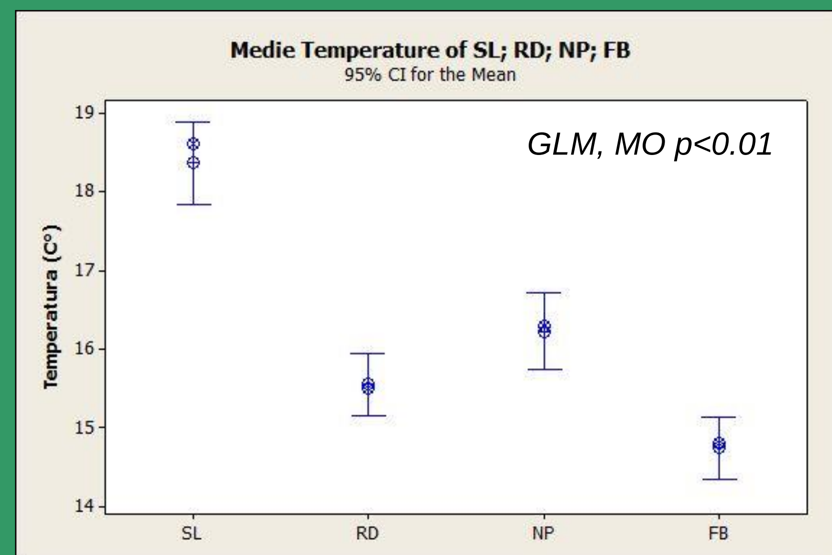
Isotropy vs anisotropy

Salvaged sites were dryer than the other treatments:

- significantly higher mean soil temperature and near-ground solar radiation
- lower soil moisture
- higher daily and seasonal variability (highest extreme values)

Deadwood elements provide shadow and wind protection to seedlings.





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Main results

Salvage logging altered and/or slowed down natural dynamics (particularly in limiting conditions).

Post-fire management should take into account the ecological role of deadwood.

Cost of intervention (per m^3)

0 €	13.9 €	24.9 €	87 €

- +

No intervention

Felling + no removal (random direction)

Felling/branches removal (fishbone)

Salvage logging

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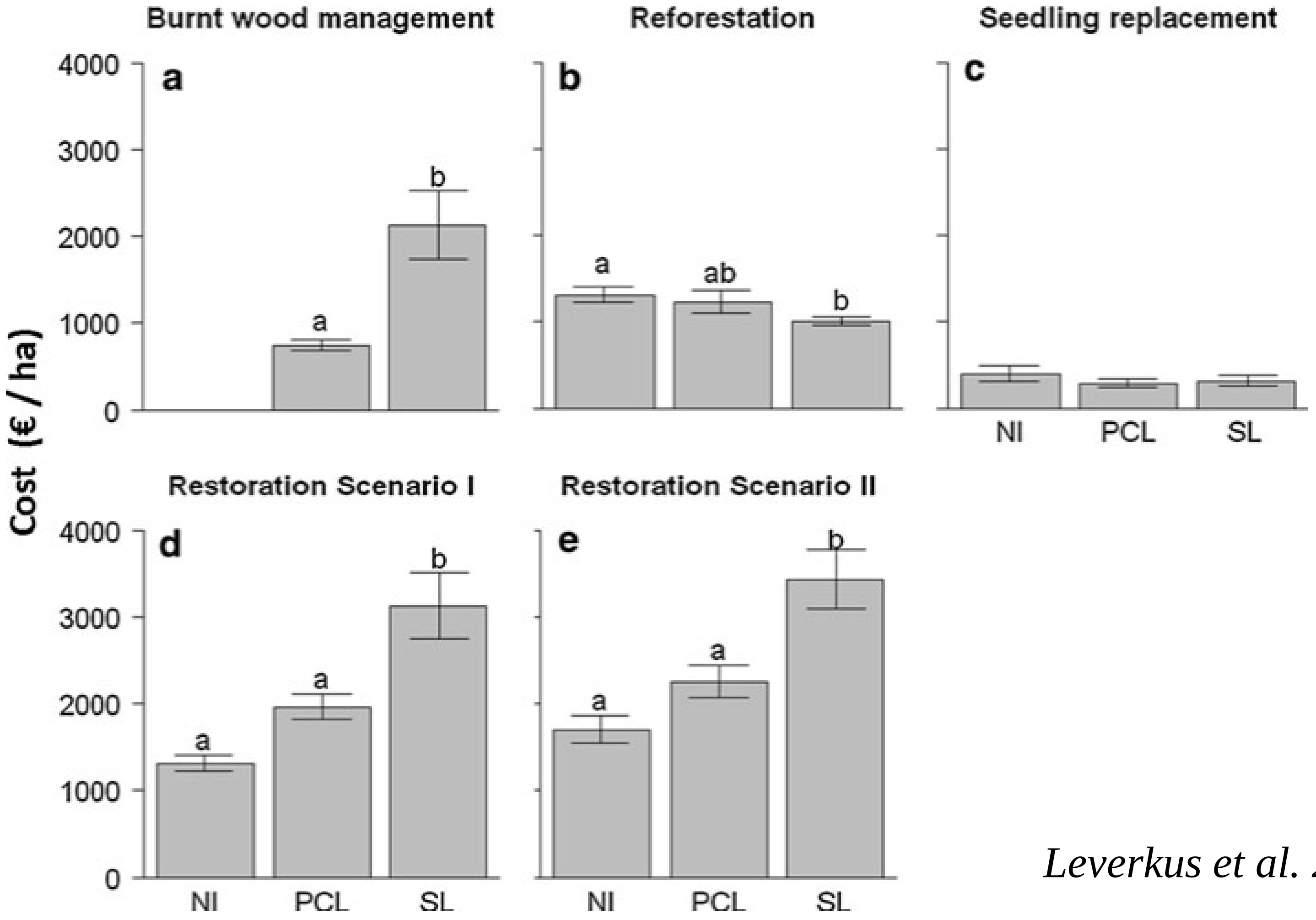
Lanjaron Fire: Sierra Nevada Natural Park ,September 2005, 1,300 ha



Leverkus et al. 2012

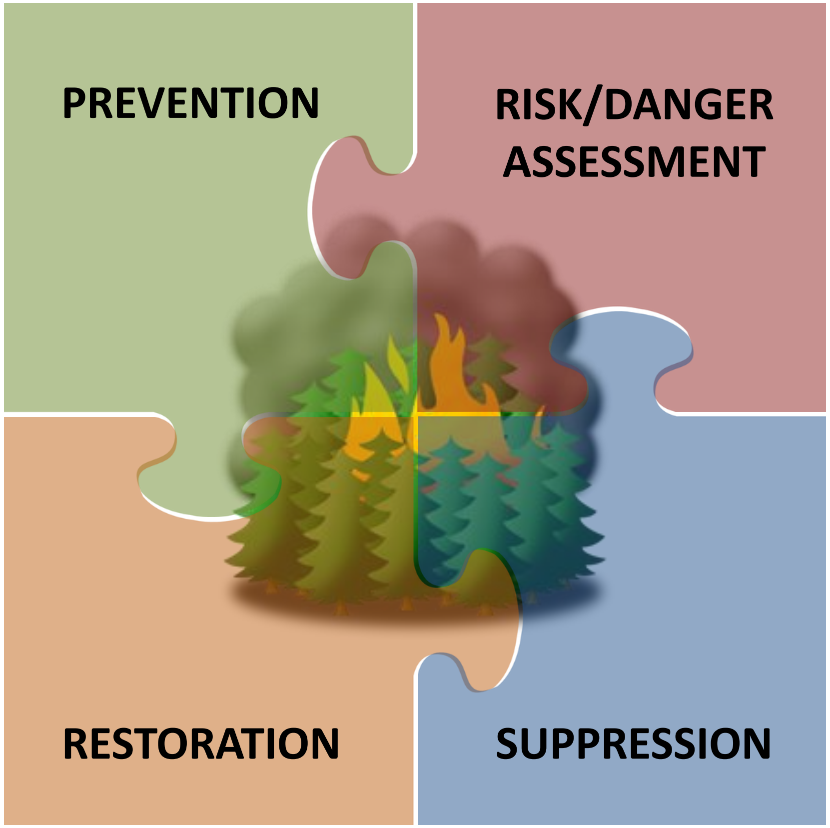
NI = Non Intervention

PCL = Partial Cut plus Lopping (ca. 90% of burnt trees cut and felled, main branches lopped off but leaving all the biomass in situ)

SL = Salvage Logging (trees were cut and the trunks cleared of branches)

Conclusions

- Given the expected alterations in fire regimes (climate/land use change interactions), scientists, land managers, and policy makers should devote more attention and efforts to the **forest fire issue:**



Conclusions

- Taking advantage of **natural restoration** processes may be a preferred strategy to salvage logging and replanting in coniferous forests of the Alps
- Current restoration activities for post-disturbance management altered natural forest structure and delayed its development
- Salvage logging and no intervention are not the only options!

Conclusions

Ecological and economical sustainability of current post-fire management

Impact on ecosystem resilience!

Climate is changing; Land use is changing…..
Management has to change too!

Thanks for your attention!

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