Forest productivity and ecosystem services under climate change scenarios in the Mediterranean region

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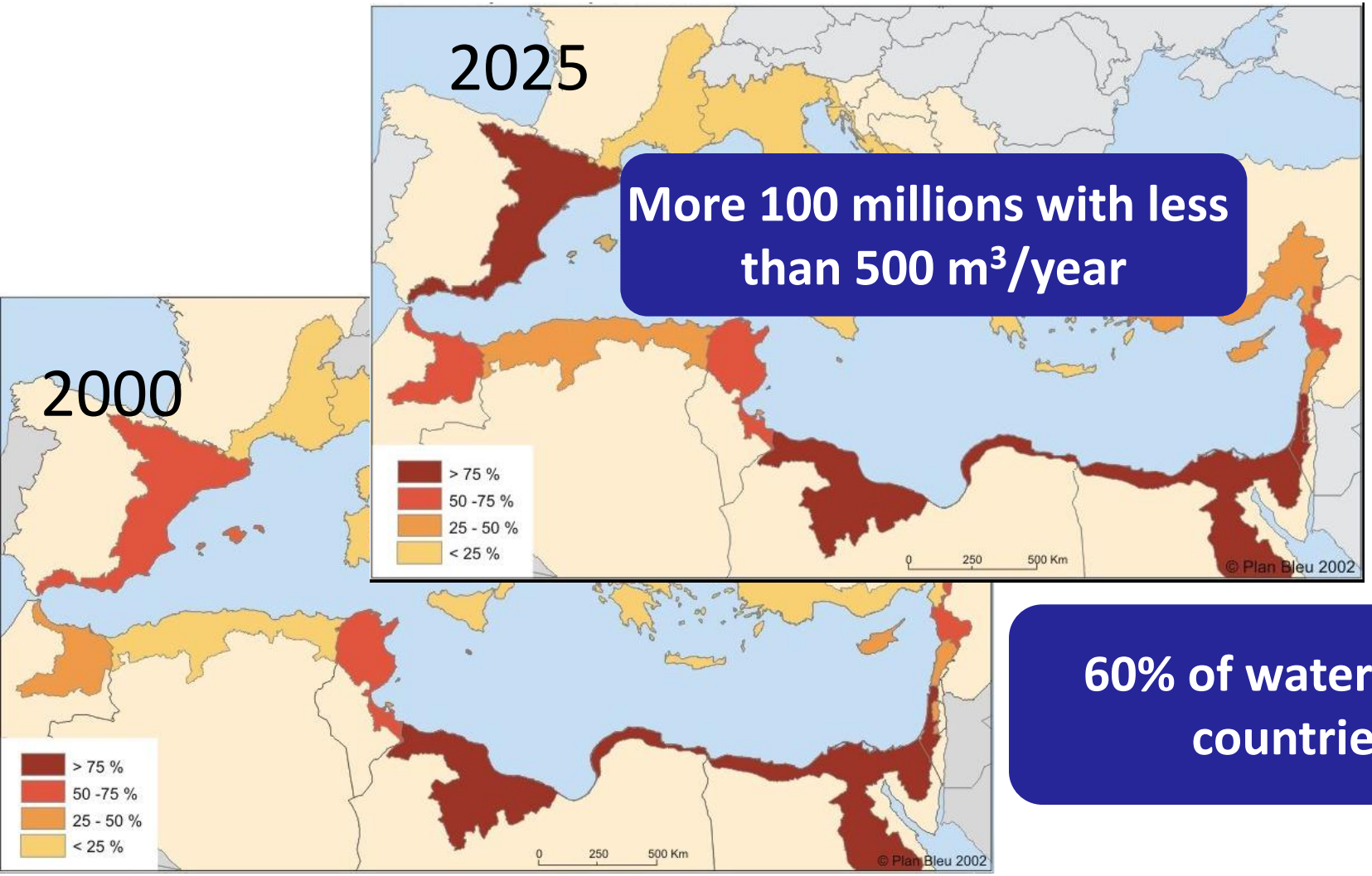
Summary

- Mediterranean environment and green infrastructures: the forest ecosystems
- Forest ecosystem services: C-sequestration, H_2O production, remediation, biodiversity
- Impact of climate change on forest structure and functions
- Which role for management and research?

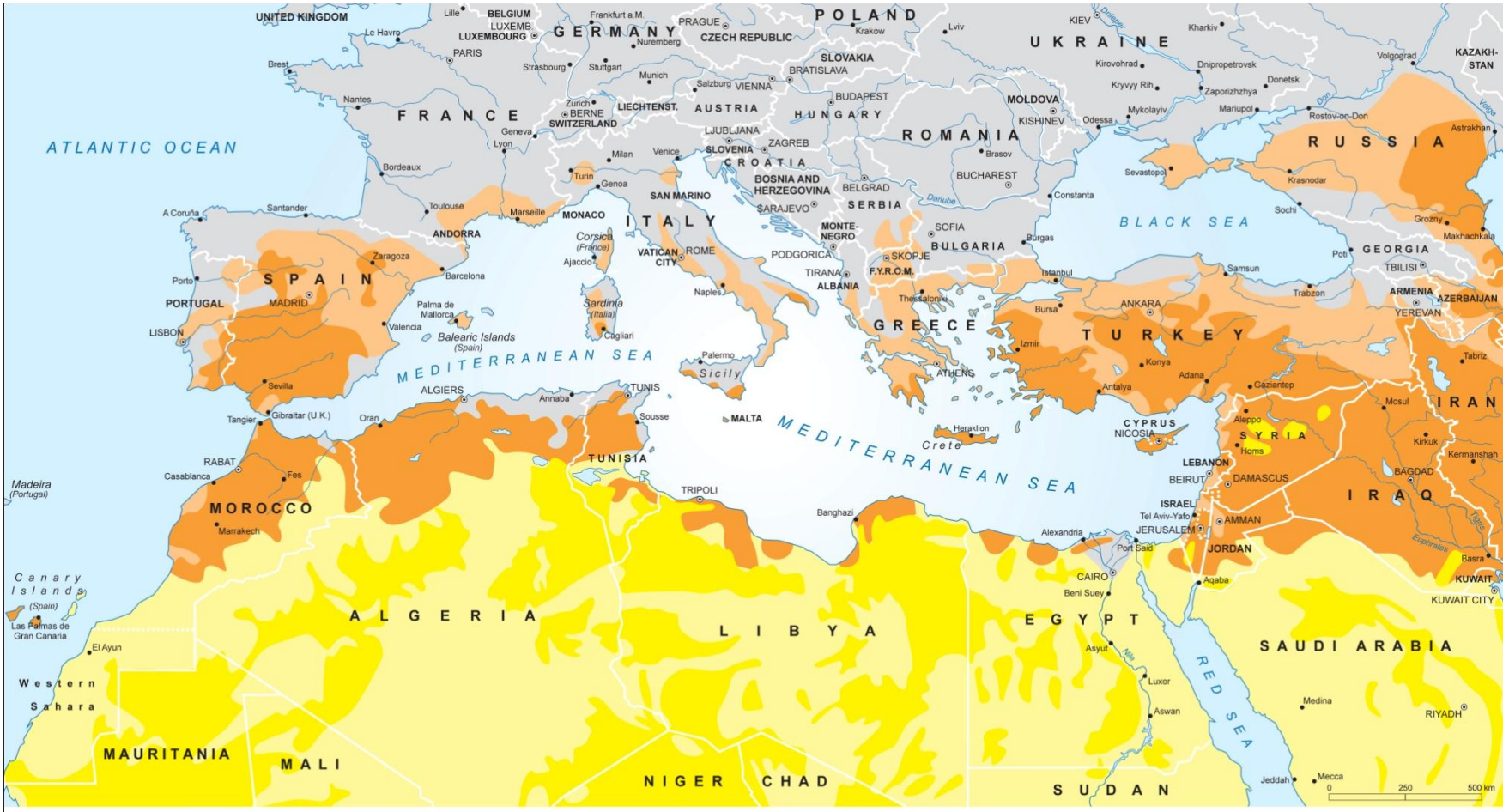


More 100 millions with less than 500 m^3/year

60% of water-poor countries

Water exploitation index

SOURCE: Plan Bleu, 2003



Environment and Security in the Mediterranean: Desertification

- Desert
- Semi-desert
- Desertification vulnerability, serious
- Desertification vulnerability, moderate

Sources: Natural Resources Conservation Service, Plan Bleu, Times Atlas of the World

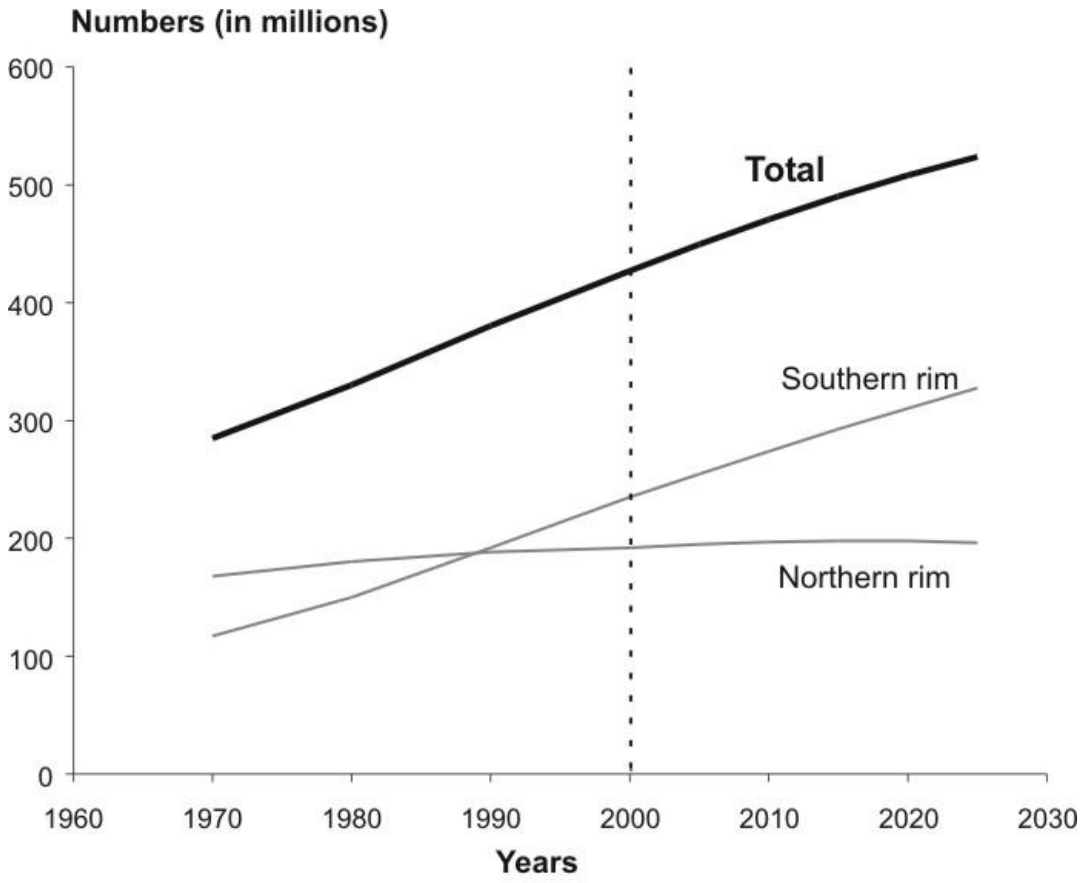
medsec

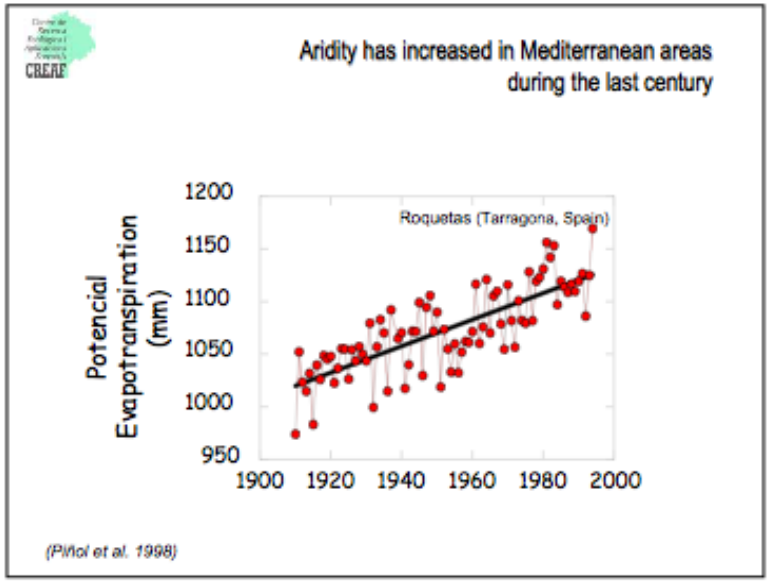
More than half of the region affected by the desertification

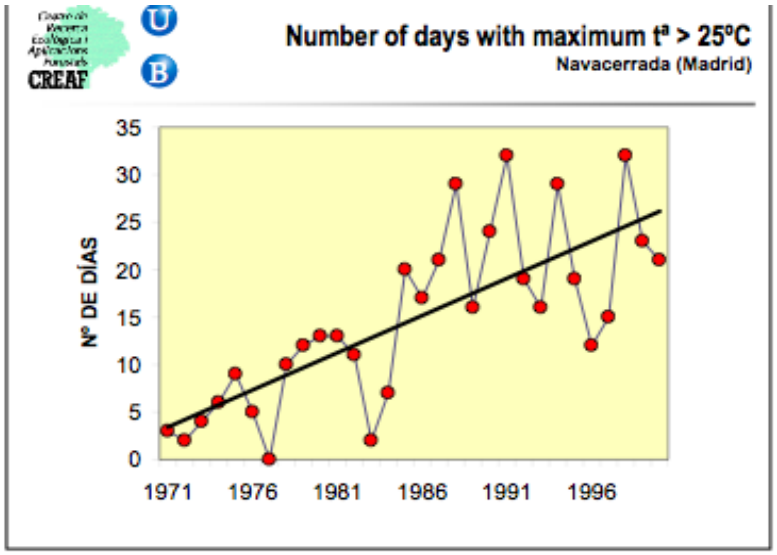
Rapid population growth

Population on southern rim **has almost doubled** over the last 30 years

246 millions of tourists/year



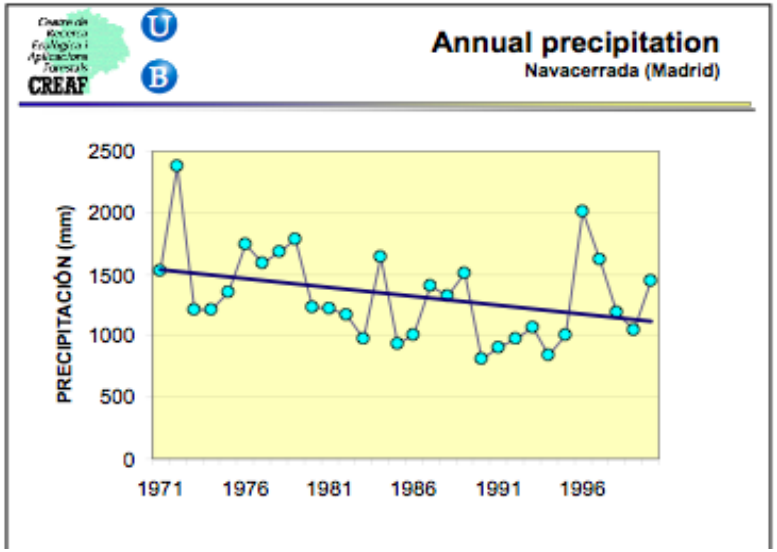


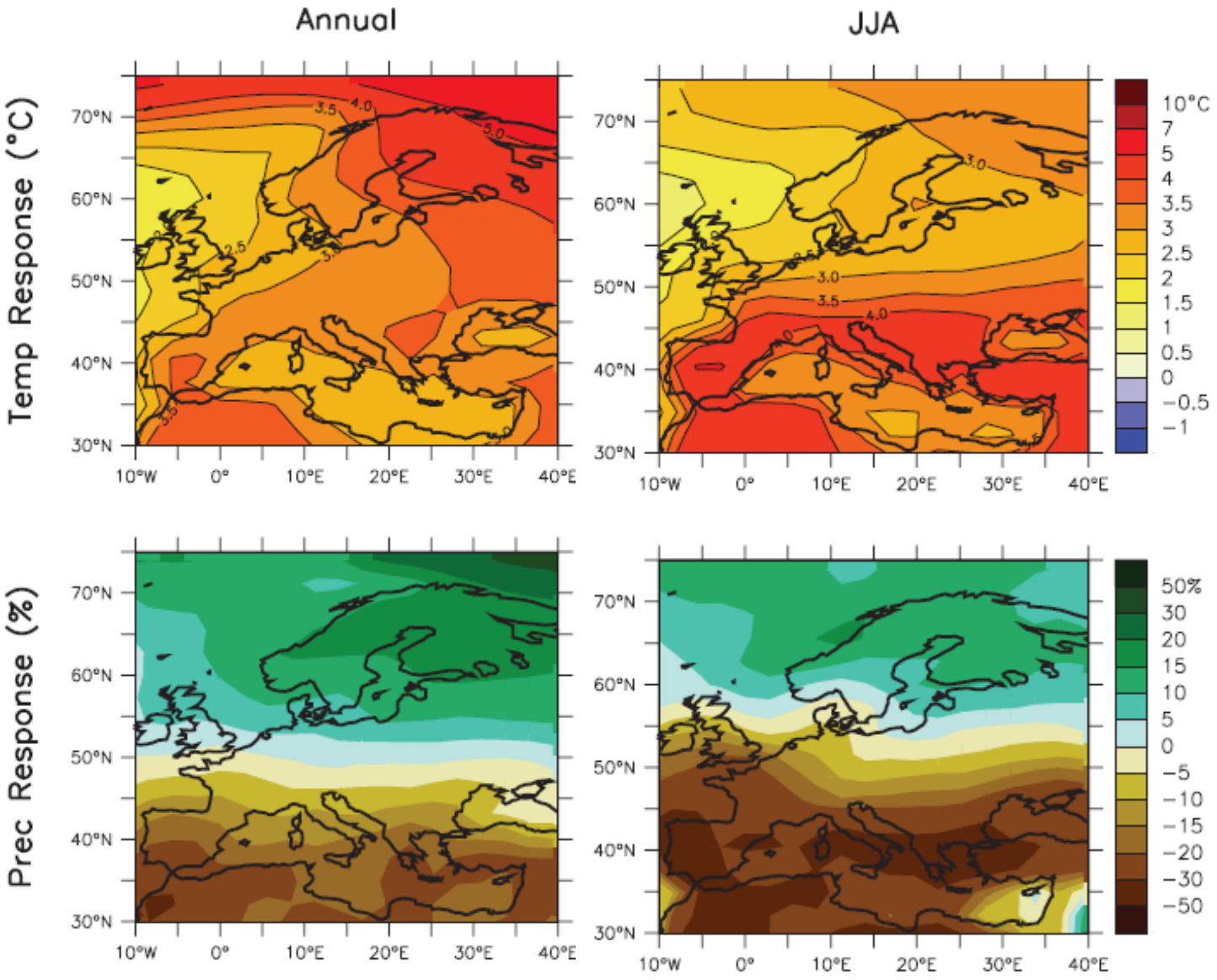


✓Temperature increment
Global scale: 0.76 ° C (1859-99 to 2001-05)
Mediterranean: 1.5- 2° C (1971-2000)

✓Rainfall decrease
Up to 20%

✓**Frequency of extreme events**





Mediterranean region:
4ºC more and
20-50 % less precipitation in summer months

IPCC, 4th Assessment report, 2007

Forests and forestry in the Mediterranean region

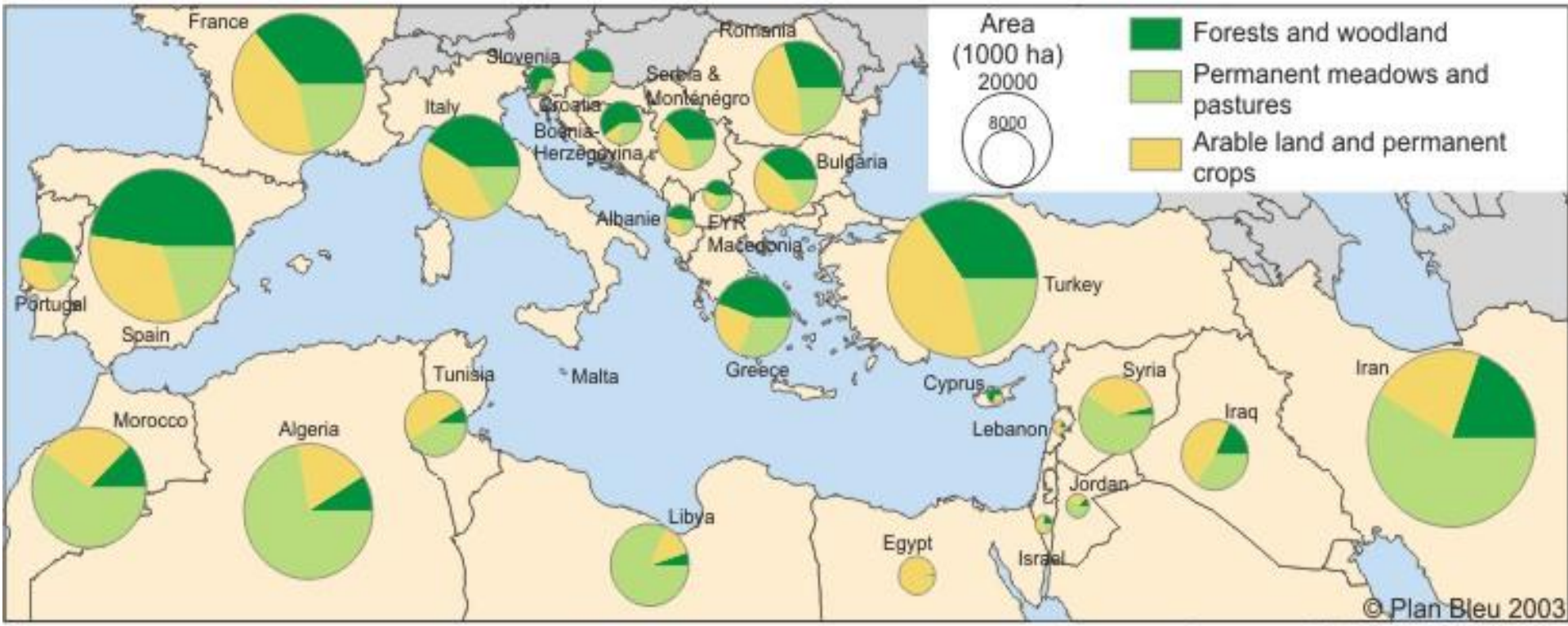
Mediterranean forests: the most important ecological infrastructure of the region

- ✓ High **biological diversity**, 25,000 species of vascular plants
- ✓ Impacts on the most strategic resources: **water and soil**
- ✓ High relative importance of **non-wood products and non-market services**

Their sustainability is threatened by climate and land use changes

Land-use patterns and forest resources in the Mediterranean Region

Landuse



Source : FAOSTAT database

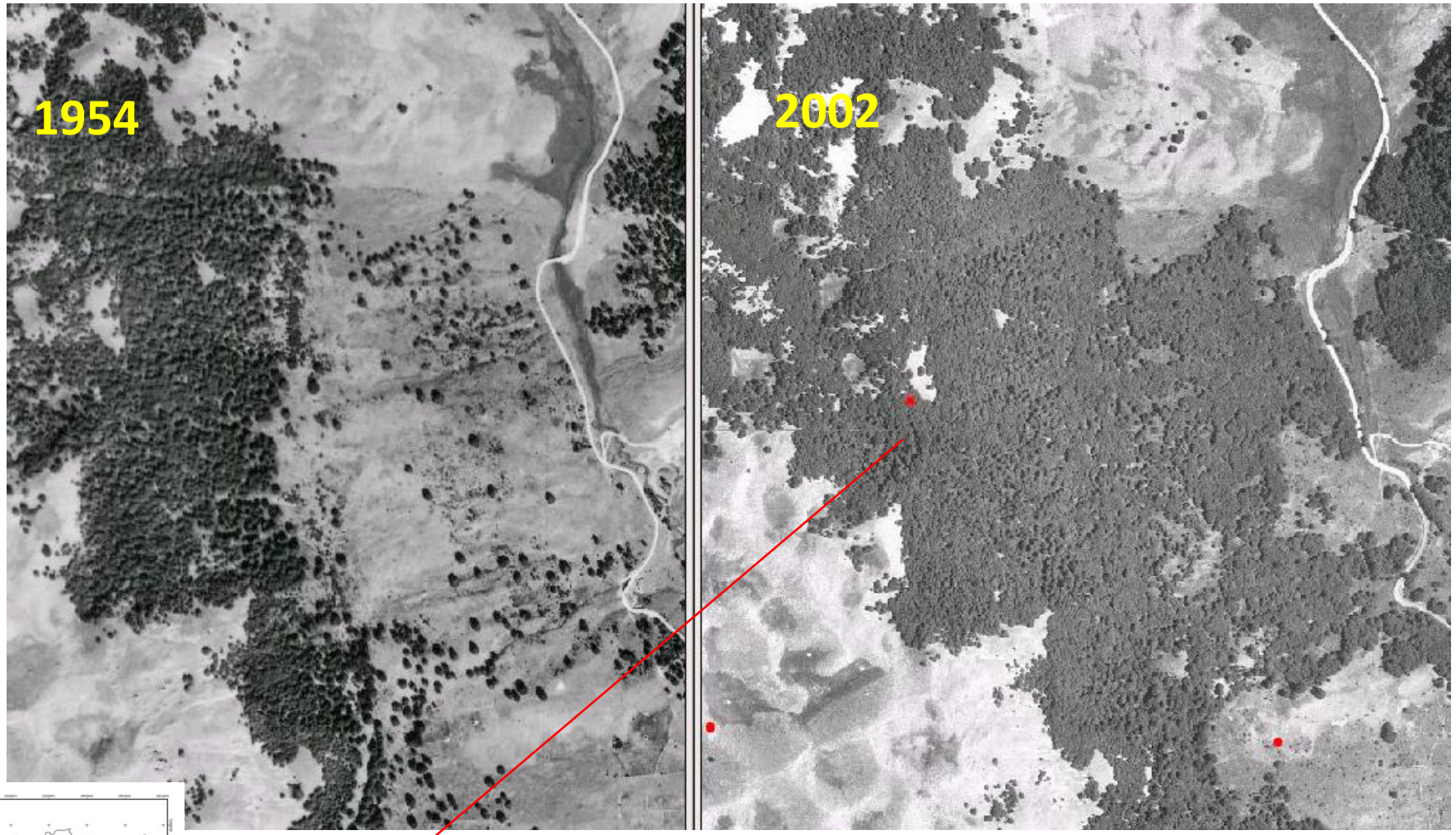
Forest abandonment (north) versus overexploitation (south)

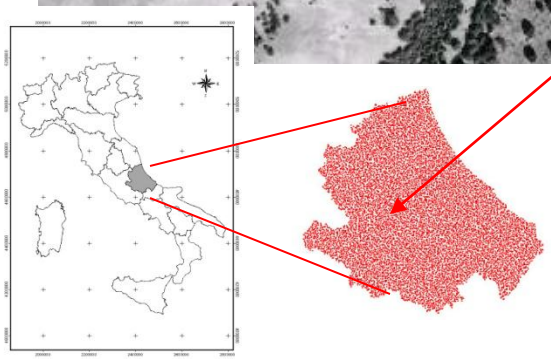
Private forests (north) versus public forests (south)

Forest abandonment (north) versus overexploitation (south)

Private forests (north) versus public forests (south)

E.Pompei, P. Corona, G. Scarascia Mugnozza





Newly formed secondary forests in the last 50 years in the region Abruzzo (central Italy)

0.6% yearly increase of the forest surface

Forests and forestry in the Mediterranean region: **Some conclusions**

- ✓ Management models and policies to address
  - ✓ multifunctionality
  - ✓ interrelations with other land-uses
  - ✓ impacts of climate change & risks

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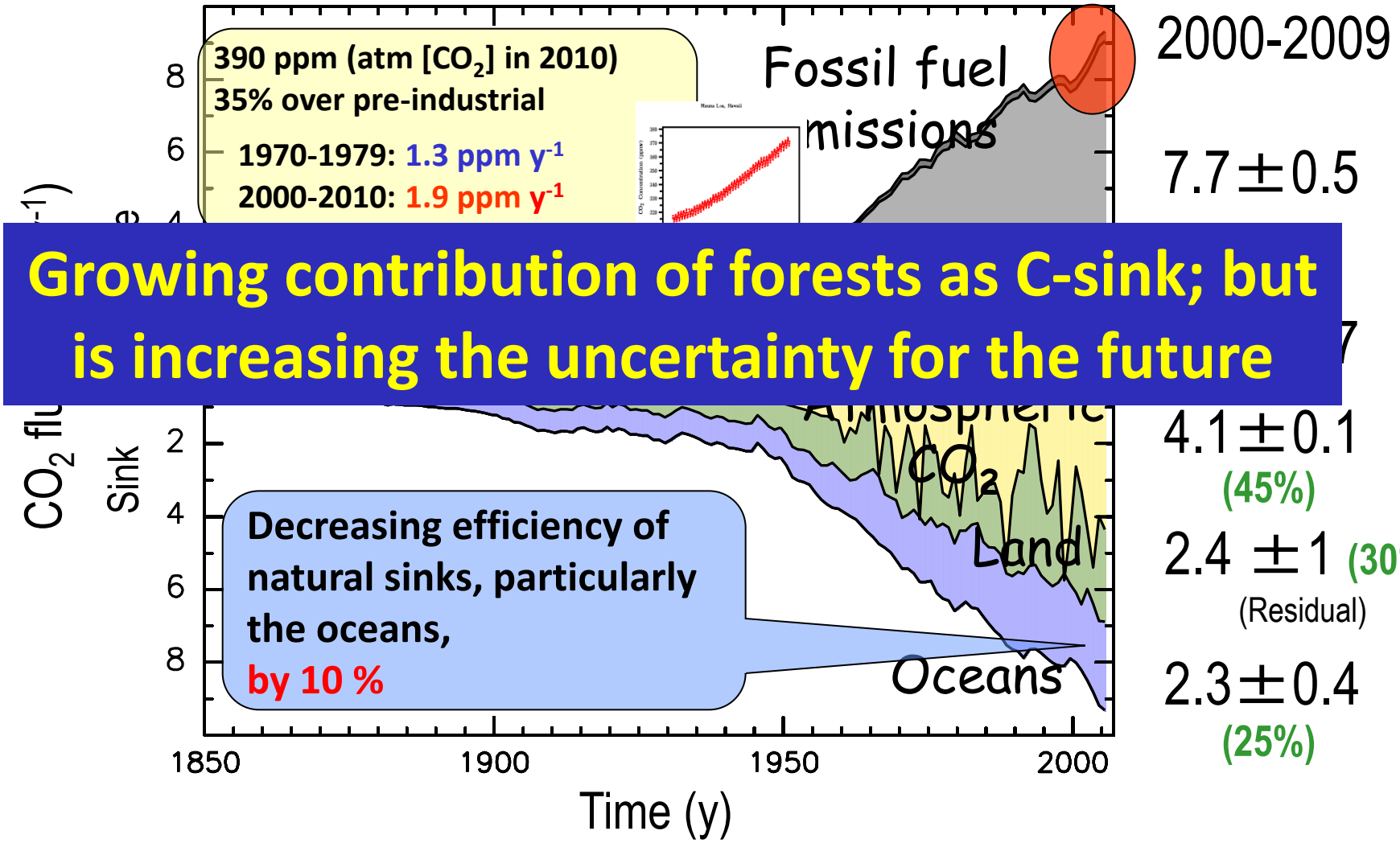
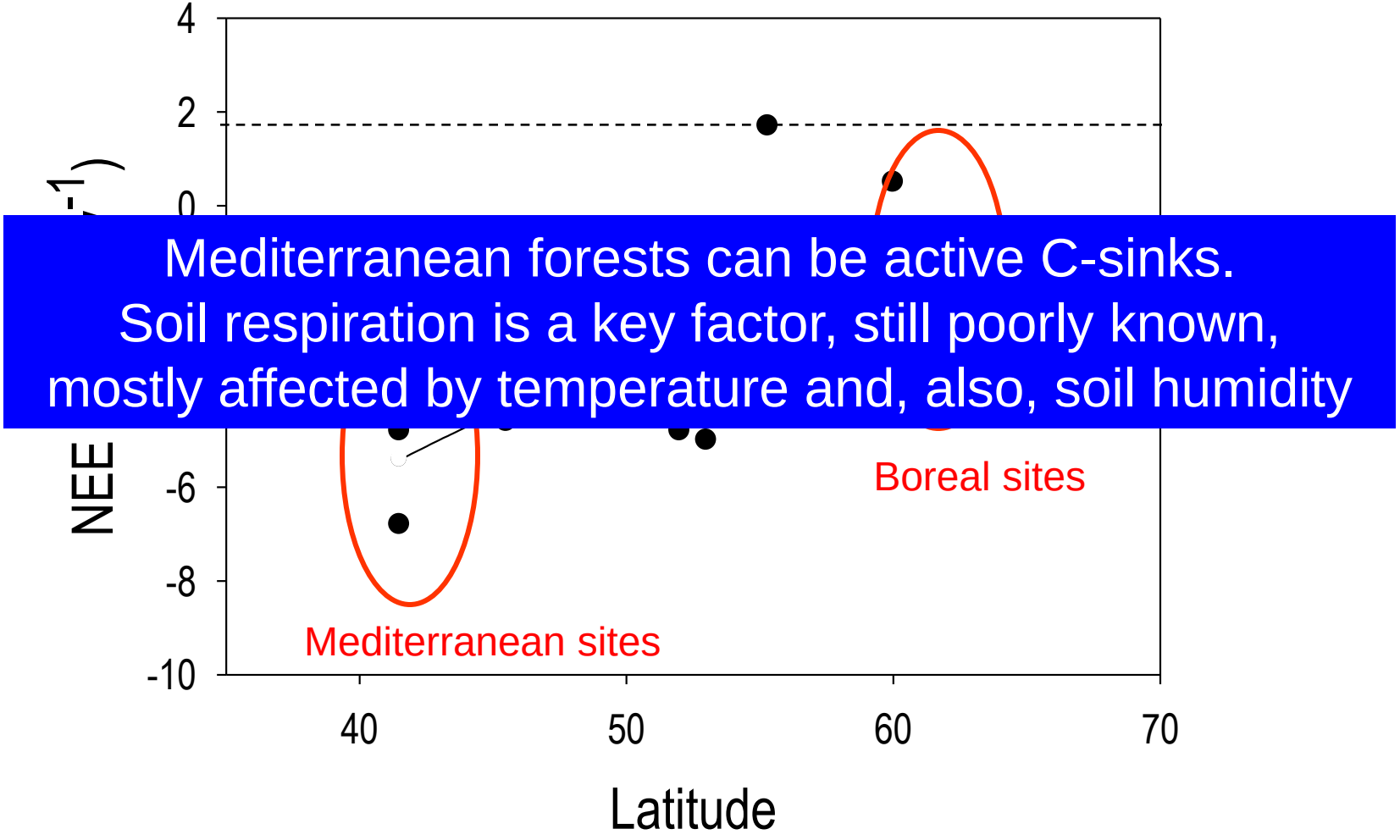
Human perturbations of global C-budget (1850-2009)



(Global Carbon Project 2010; Updated from Le Quéré et al. 2009, Nature Geoscience; Canadell et al. 2007, PNAS)

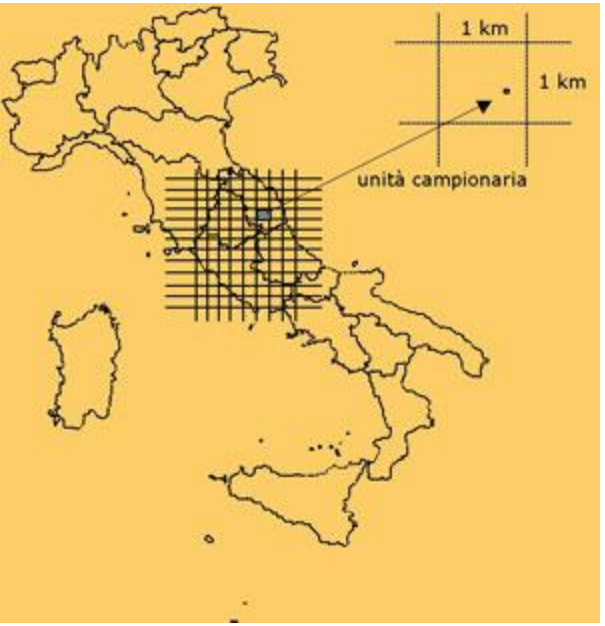
Data from CarboEurope

NEE vs. latitude (Valentini et al. 2000)

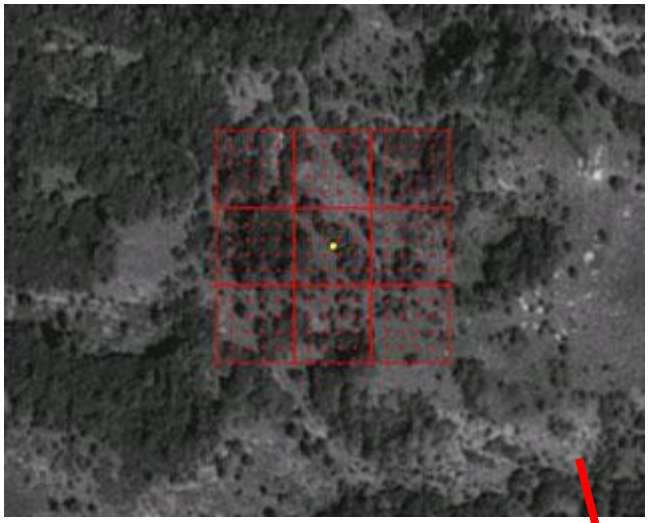


Mediterranean forests can be active C-sinks.
Soil respiration is a key factor, still poorly known,
mostly affected by temperature and, also, soil humidity

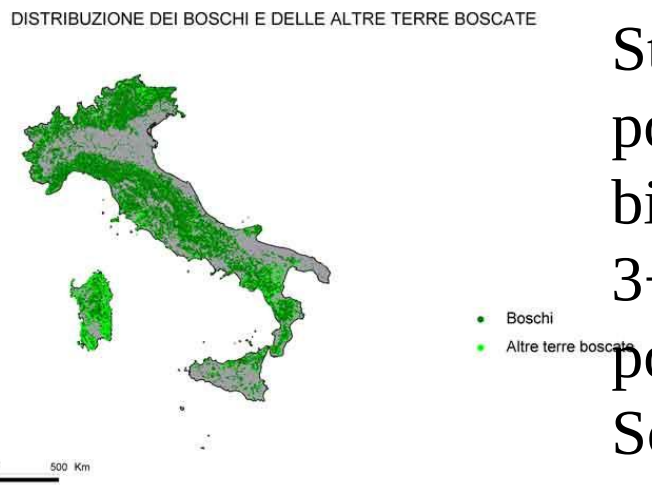
Italian Inventory of Forests and Carbon-INFC



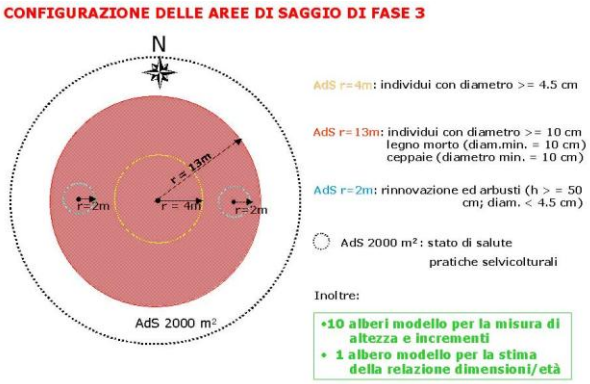
Step 1
300,000
points



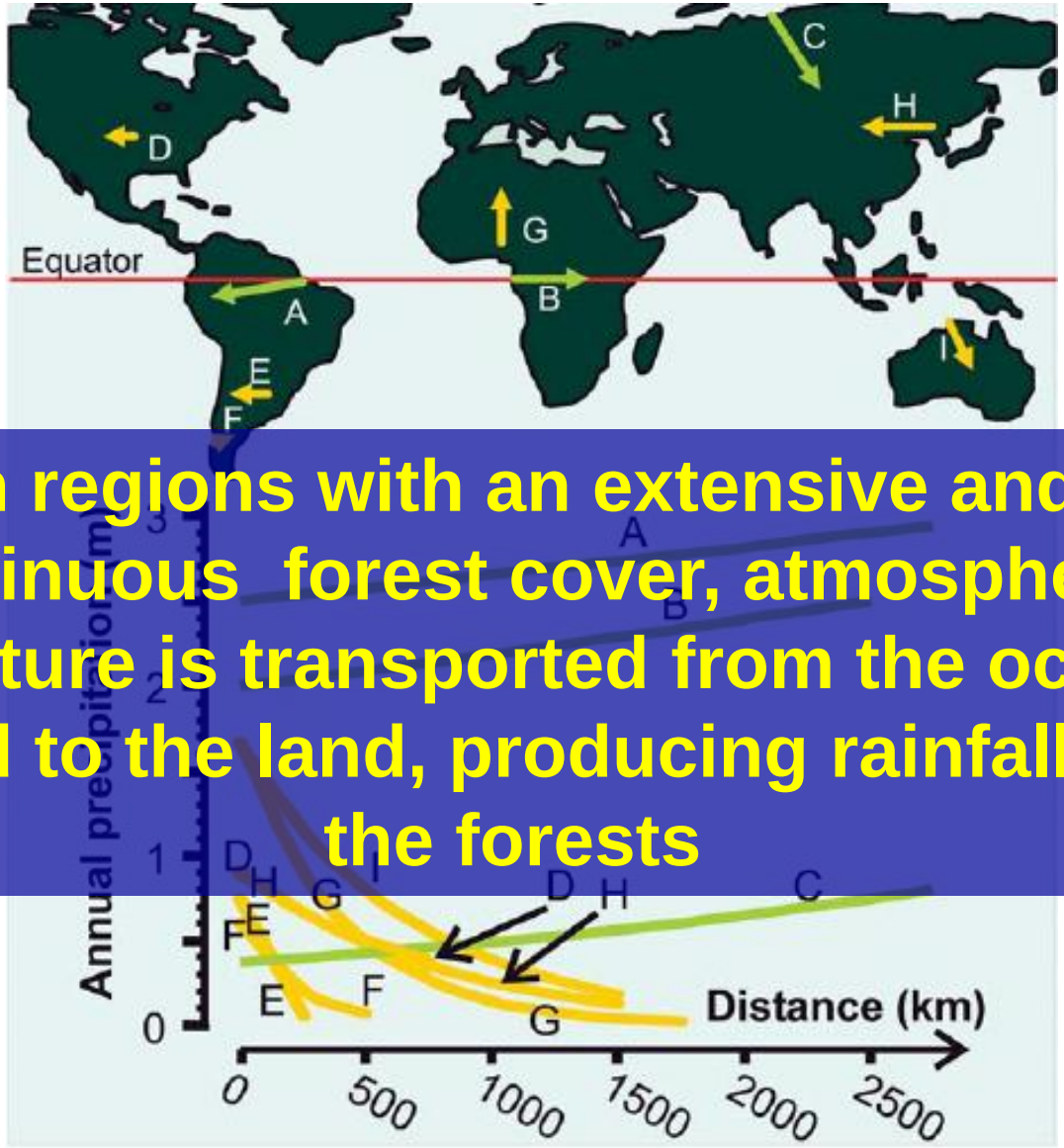
Step 2
30,000
points



Step 3: 7,000
points on
biomass (step
3+ 1,700
points on
Soil-C)



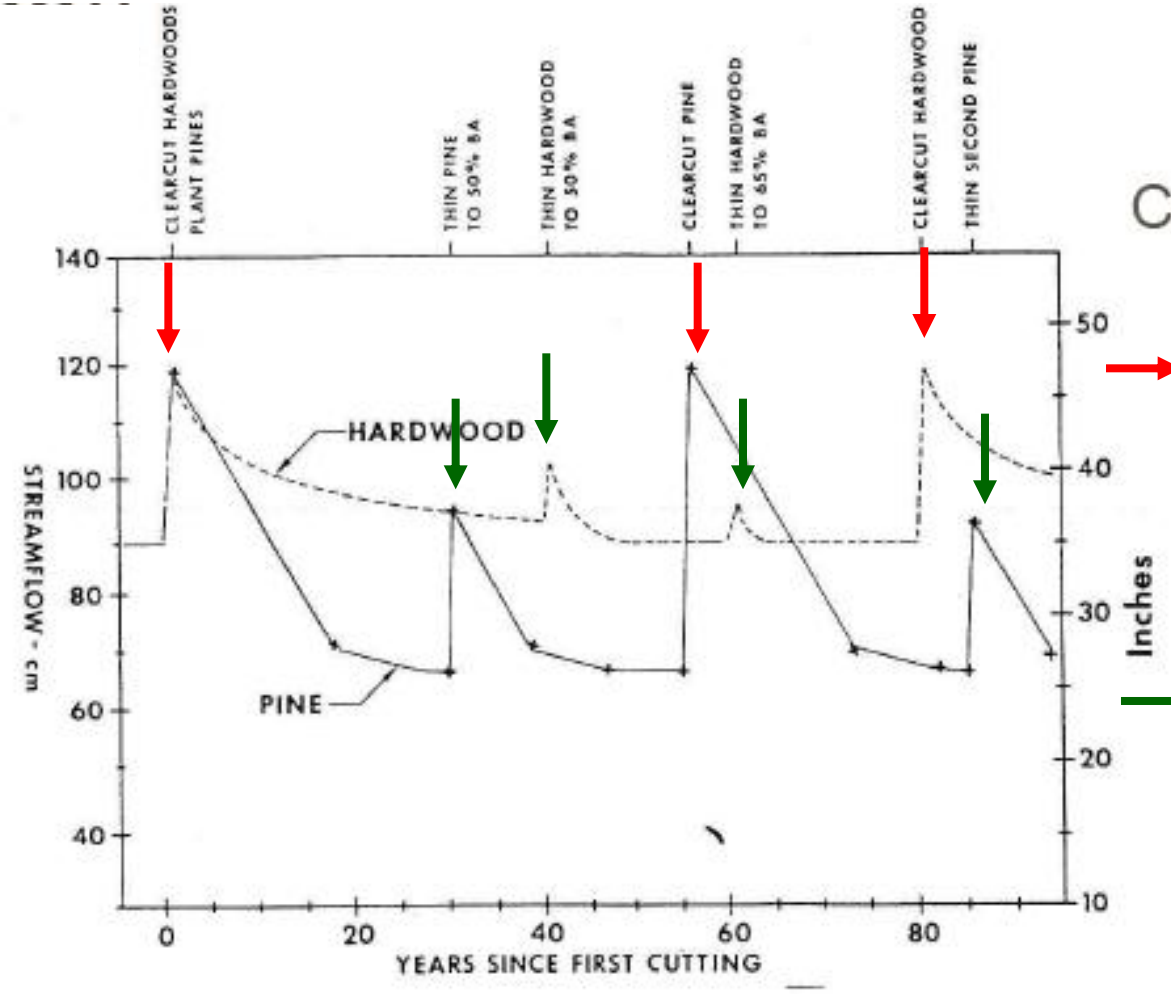
Forest and precipitations: the Biotic Pump



In regions with an extensive and continuous forest cover, atmospheric moisture is transported from the ocean inward to the land, producing rainfall over the forests

Sheil and Murdiyarso, 2009 (from concepts and data of Makarieva and Gorshkov, 2007)

Forest management affects runoff in conifers vs. deciduous watersheds

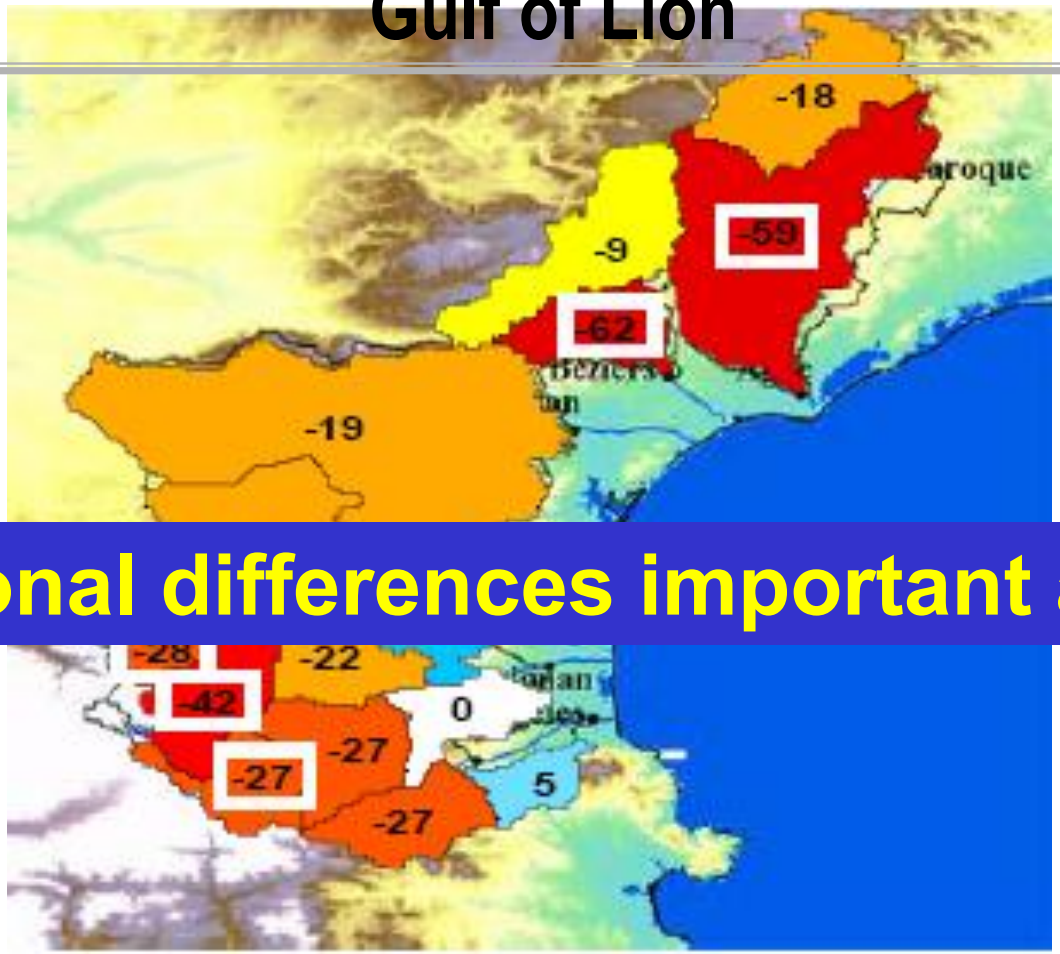


clearcuts

thinnings

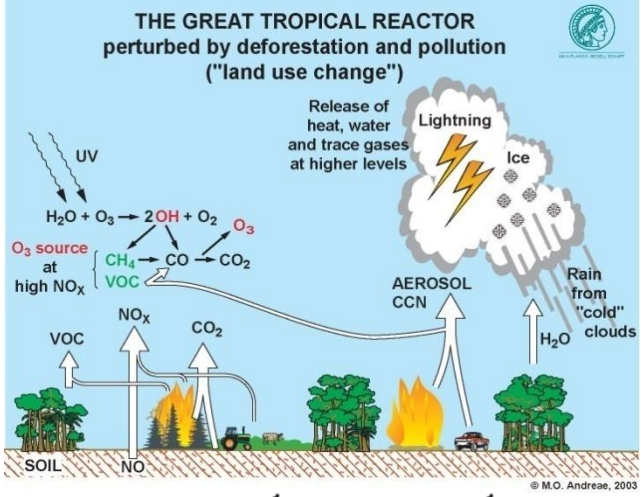
Source: Swank & Crossley, 1988 *Forest Hydrology and Ecology at Coweeta*

Regional H_2O balance: 1965 – 2004 variations
Gulf of Lion



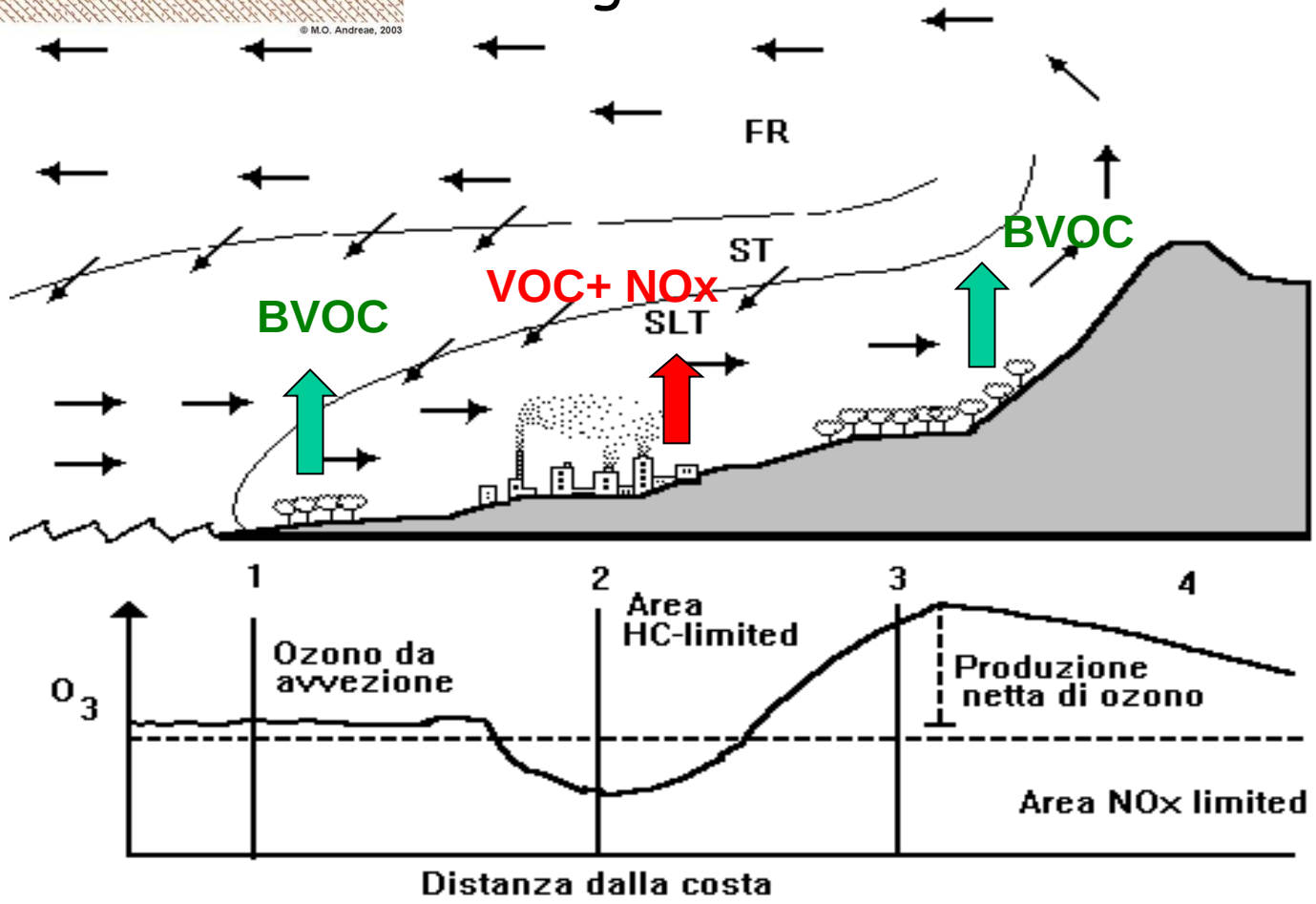
… regional differences important as well

- **Annual water deficits: +20%**
- **Monthly deficits increased in march and late summer because of longer growing seasons**



why the Mediterranean is a "hot spot" for photochemical pollution and for Volatile Organic C…

….along the coasts



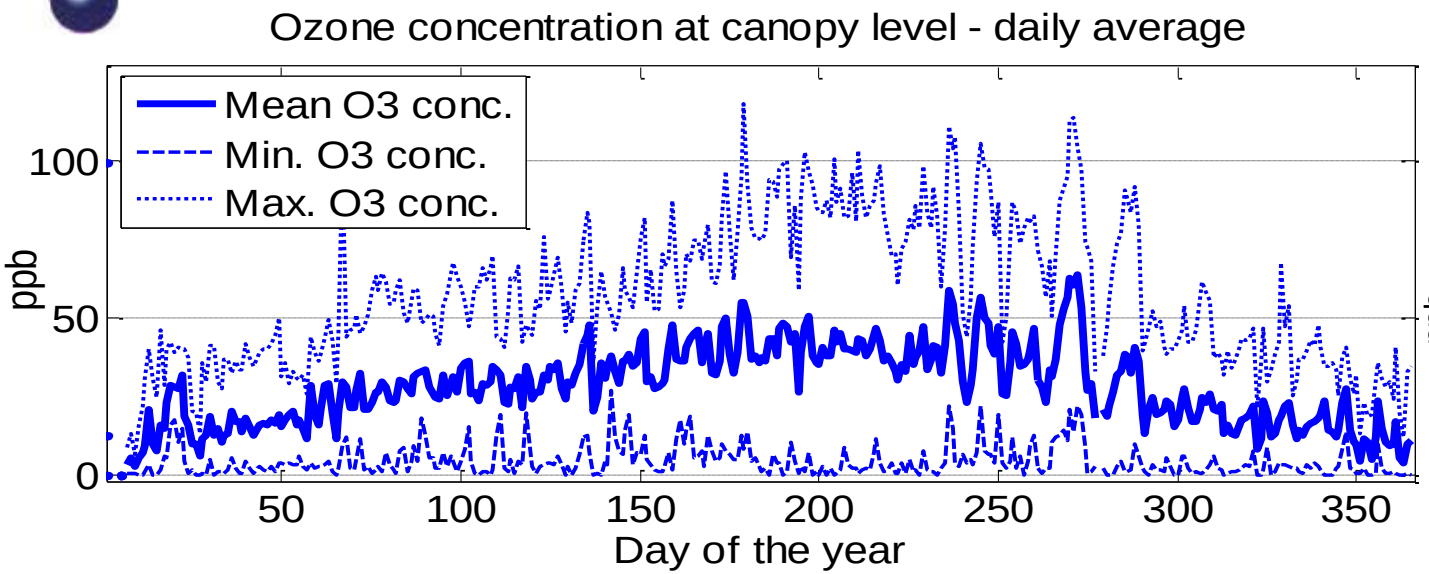
Evidences of significant (non-stomatal) ozone removal in a Pine forest ecosystem

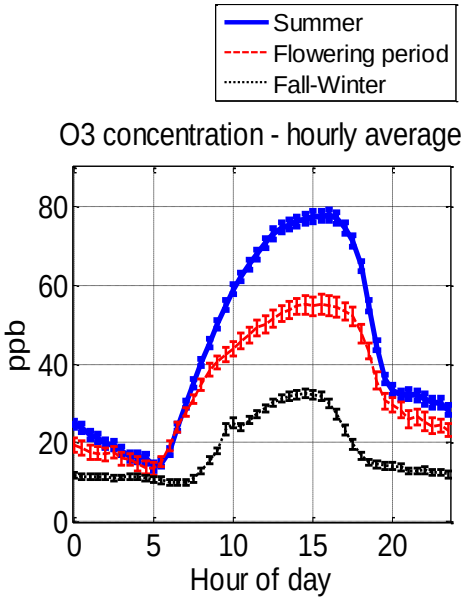
Continuous measurements of ozone fluxes from 2001 to 2007

(Fares et al. 2012)

Ozone concentrations

Fares et al. Env. Poll. 2012

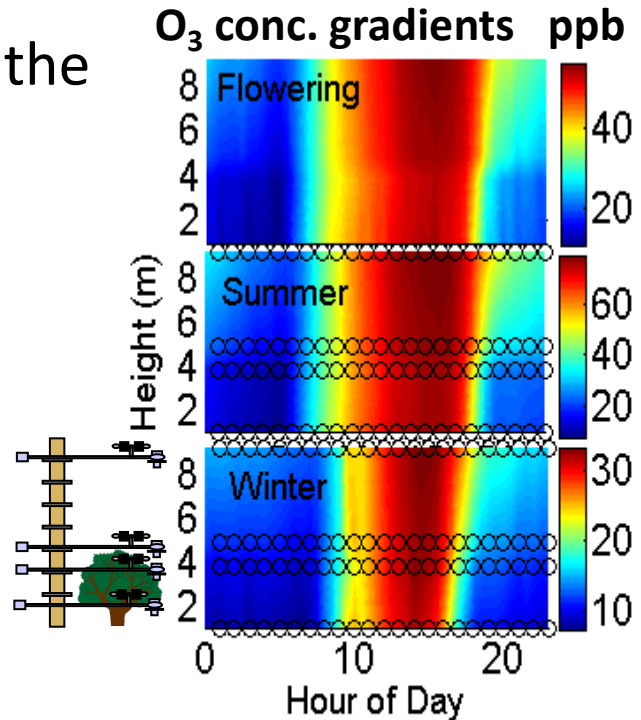




In summer time high temperatures maximize the photochemical production of ozone

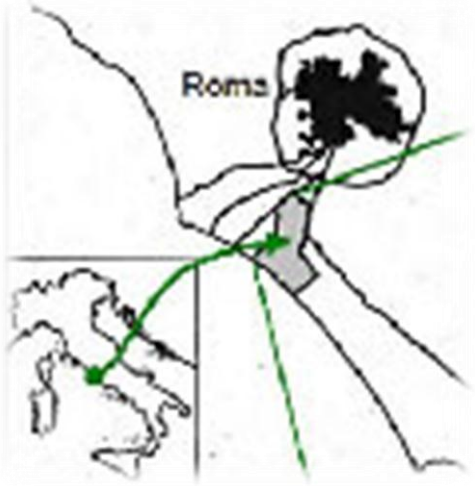
Summer levels of ozone may largely exceed phytotoxic thresholds for trees!

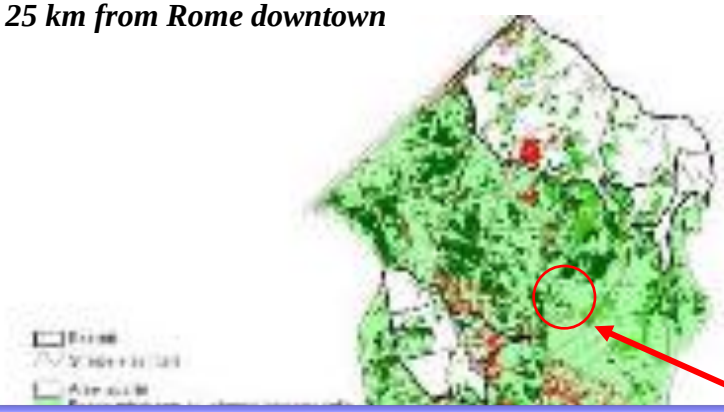
Positive gradients of ozone concentration from the atmosphere to the ground suggest that ozone deposition processes take place in this tree canopy



Castelporziano, a “Urban” forest

~ 6000 ha, 25 km from Rome downtown





Atmospheric pollution removal is being measured also in a Mediterranean “urban” forest around Rome

Dune coastal site in 2007 field campaign

Biogeosciences

The ACCENT-VOCBAS field campaign on biosphere-atmosphere interactions in a Mediterranean ecosystem of Castelporziano (Rome): site characteristics, climatic and meteorological conditions, and eco-physiology of vegetation

S. Fares[1,2], S. Mereu[3], G. Scarascia Mugnozza[1], M. Vitale[3], F. Manes[3], M. Frattoni[4], P. Ciccioli[4], G. Gerosa[5], and F. Loreto[1]

Mediterranean forests: hotspots of biodiversity

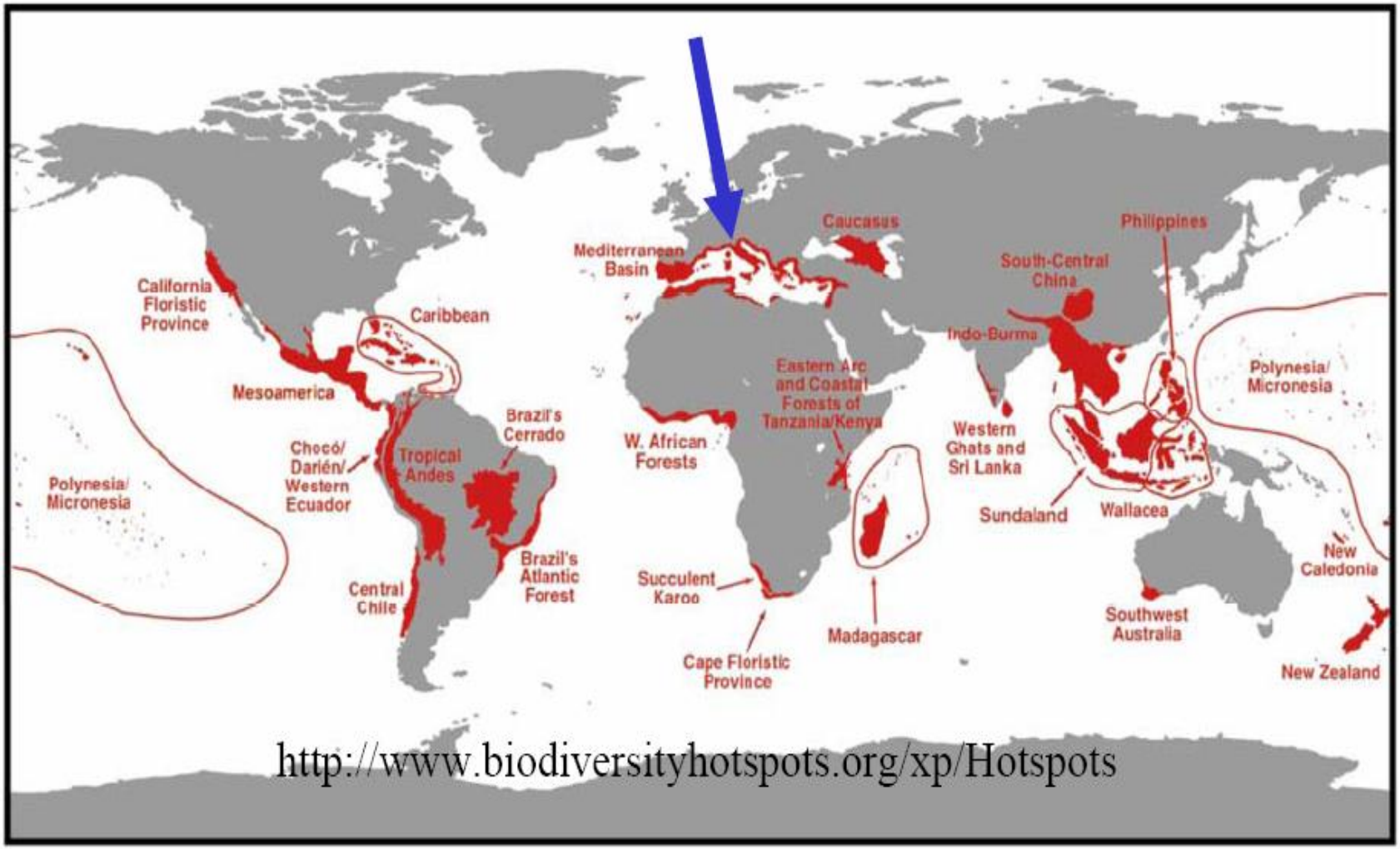


Figure 1 The 25 hotspots. The hotspot expanses comprise 30–3% of the red areas.

Myers N. *et al.*(2000) *Nature* **403**: 853-858

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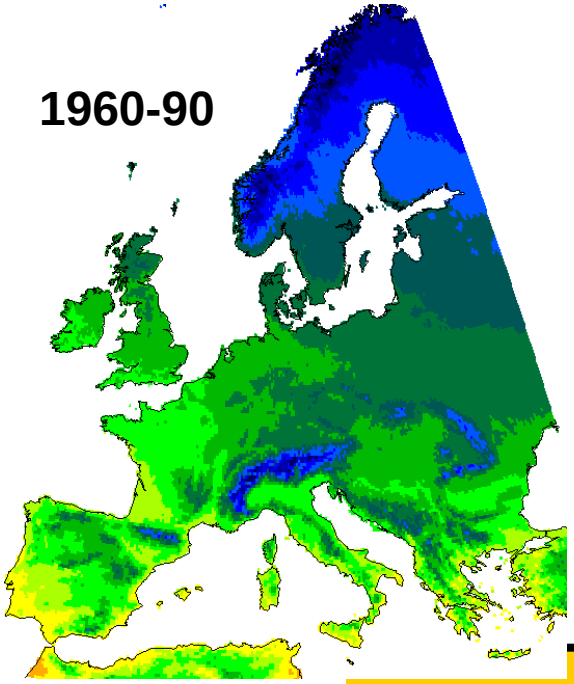
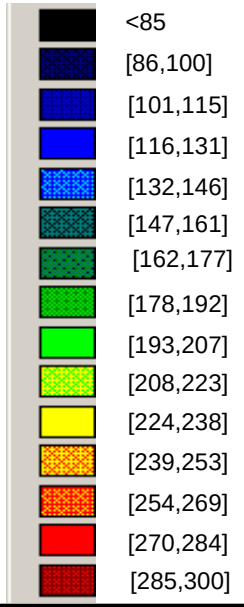
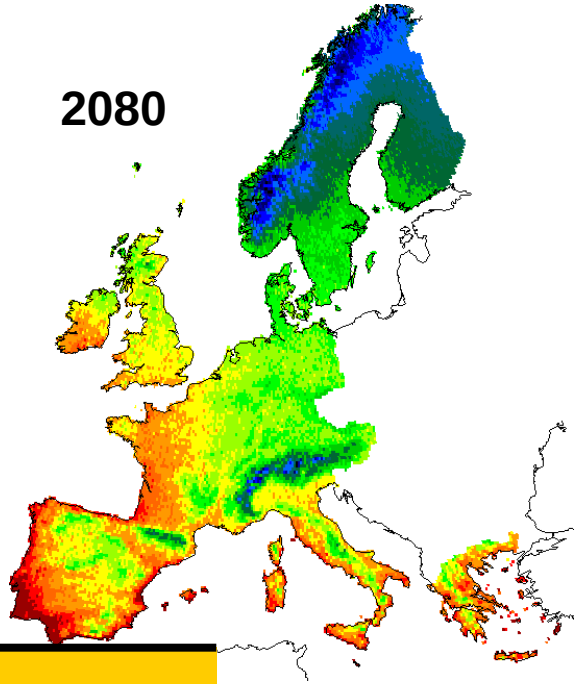






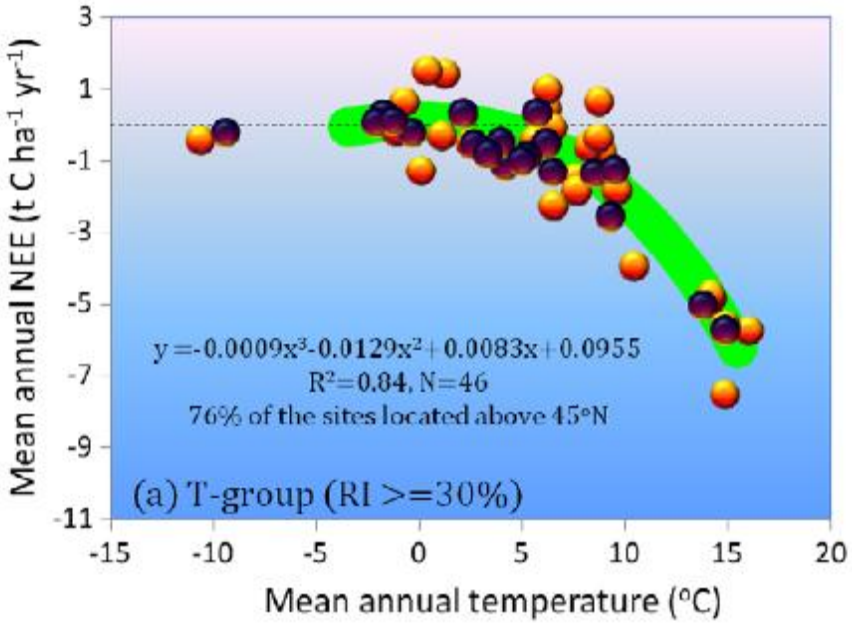
SIMULATED LENGTH OF THE GROWTH PERIOD (days)
A2_HadCM3

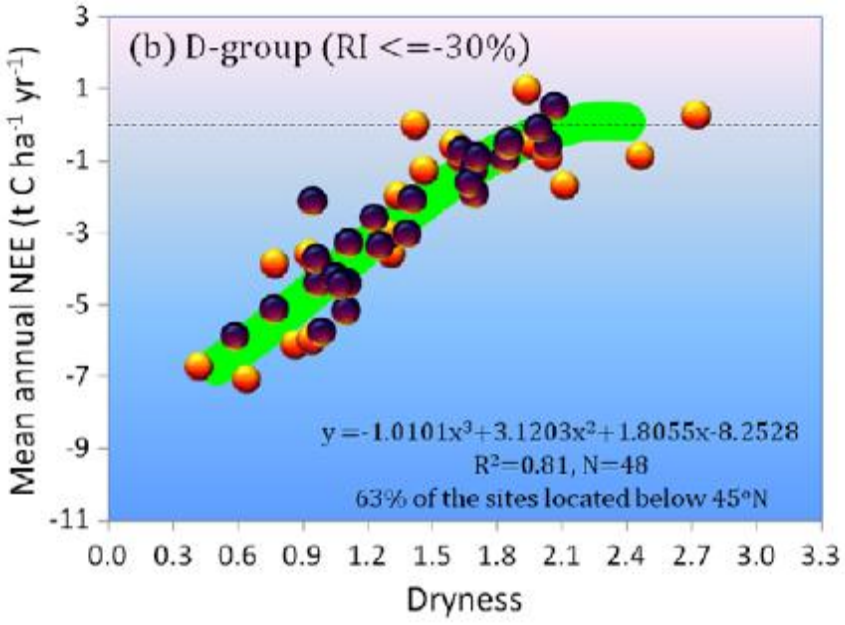
	1960-1990	2020	2050	2080
Norway	124	129	130	155
Finland	128	133	142	160
Sweden	135	138	143	165
Italy	190	198	207	228 + 38
Spain	201	213	222	245
Greece	205	219	223	250
Portugal	218	238	251	279 + 61
Europa	169	176	184	205

increased demand for water

Source: C. Gracia, Y. Birot

Ecophysiology, phenology and productivity



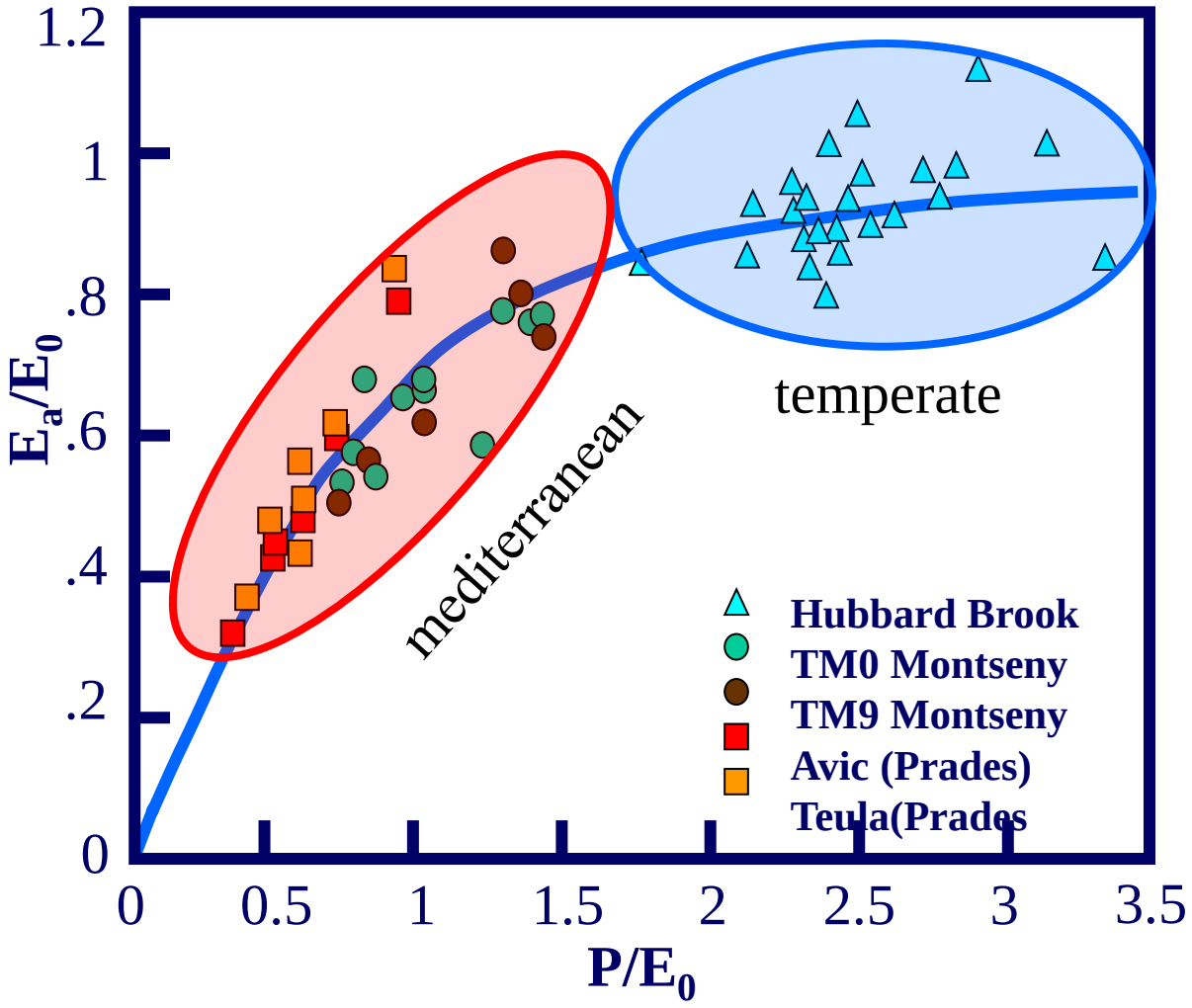


76% of sites above 45°N

63% of sites below 45°N

Yi et al., 2010 ERL

Looking at water/forest relations from a Mediterranean perspective



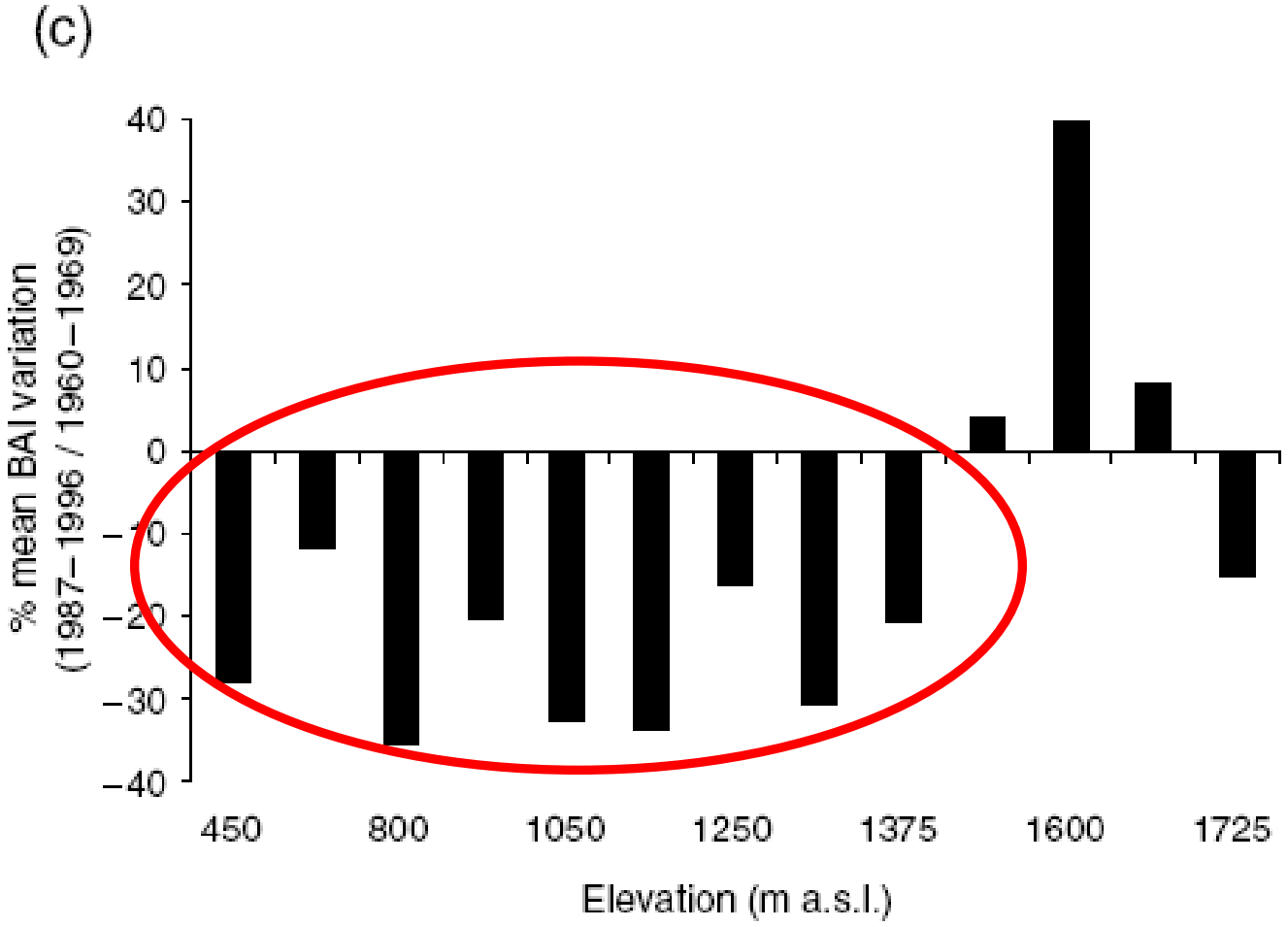
The ratio actual ET to PET (Ea/Eo) is highly dependent on the ratio precipitation / PET (P/Eo).

In a typical Mediterranean forest, actual ET can reach up to 90% of annual precipitation.

The forest grows under an almost permanent water deficit which will be aggravated under the predicted climate changes for the region.

Source: C. Gracia

Long term effects of climate variation on growth: natural beech forests in Italy



(Piovesan et al, 2008 GCB)

Changes in Primary Production 1982-1999

Nemani et al, Science, 2003

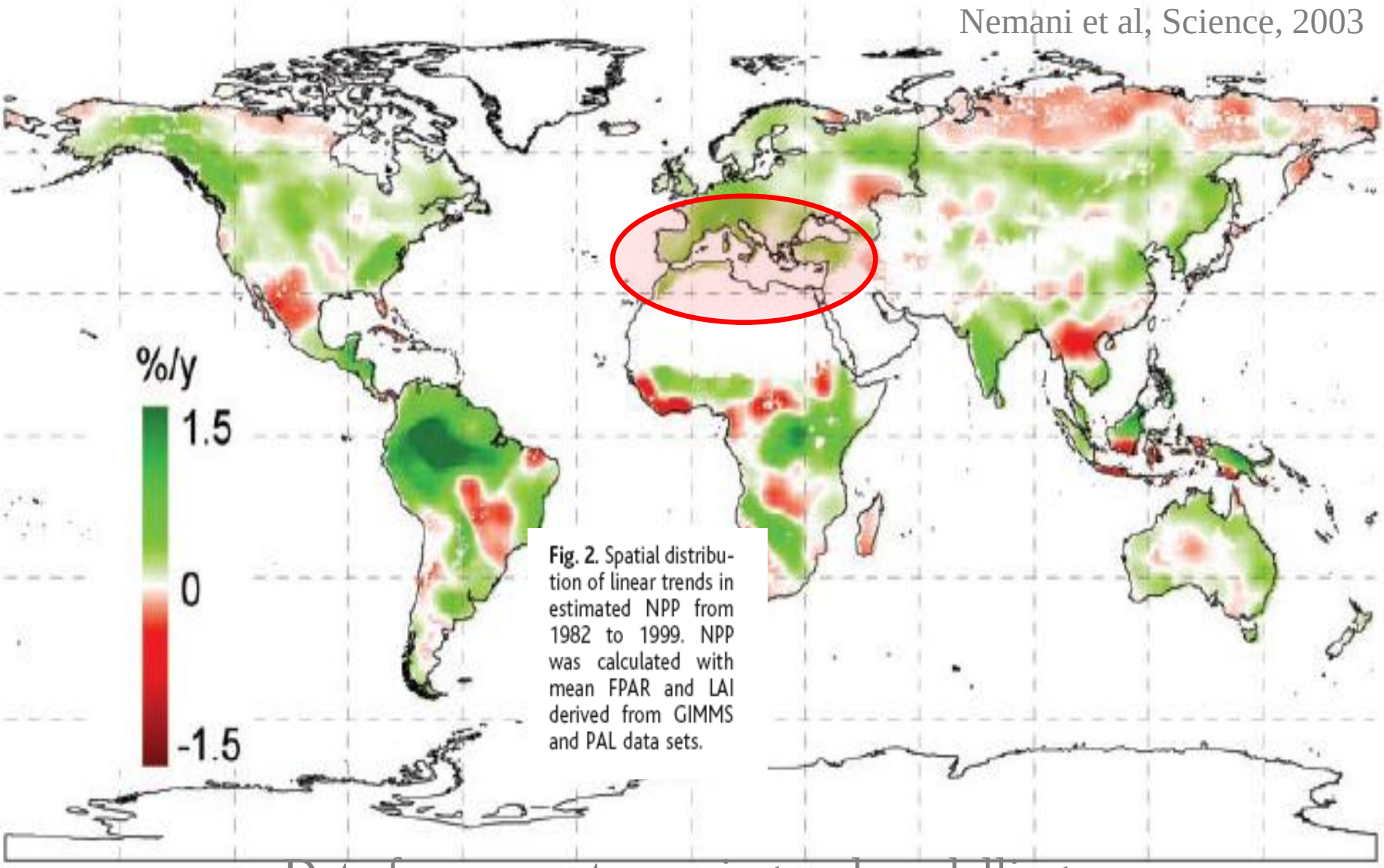
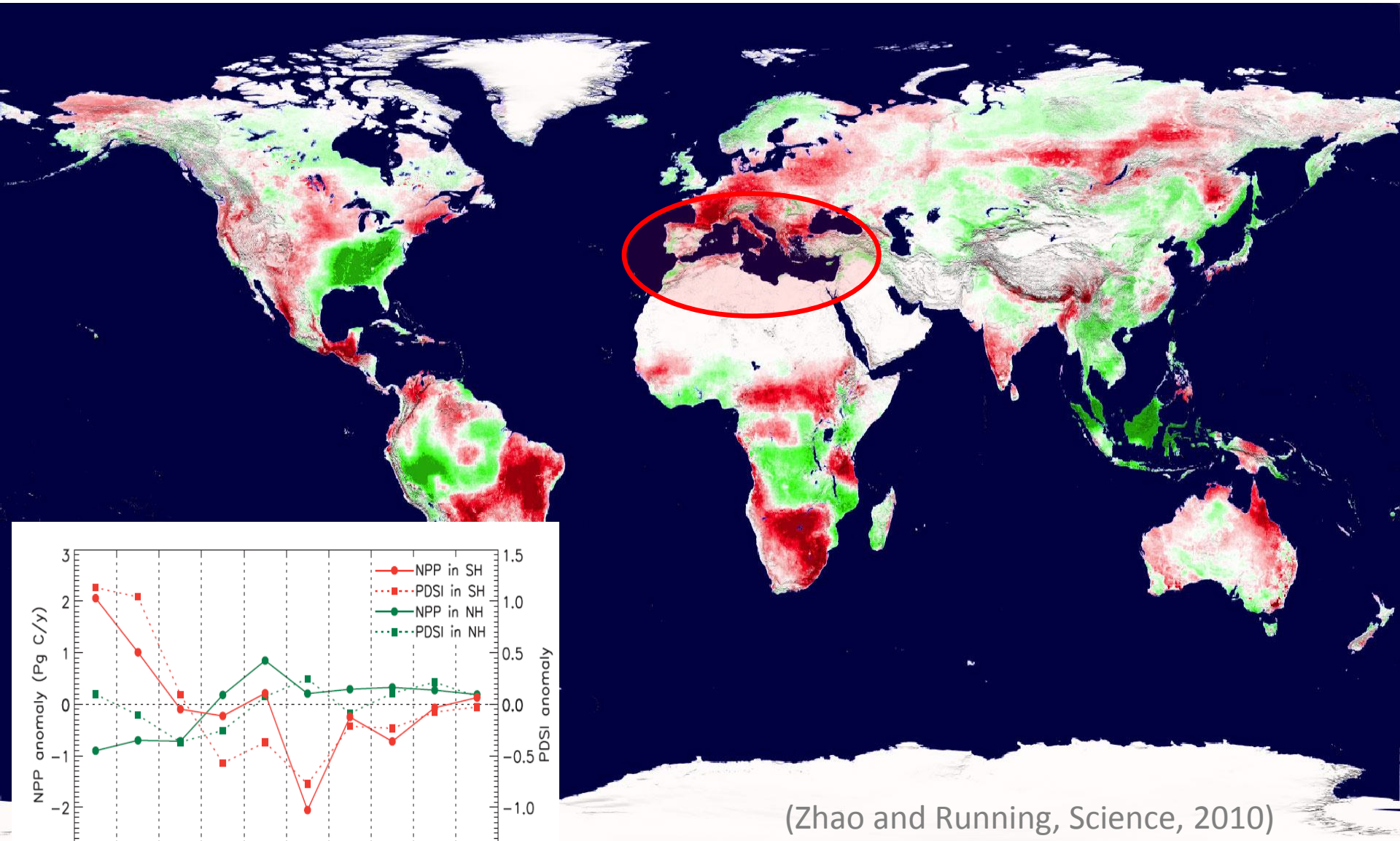


Fig. 2. Spatial distribution of linear trends in estimated NPP from 1982 to 1999. NPP was calculated with mean FPAR and LAI derived from GIMMS and PAL data sets.

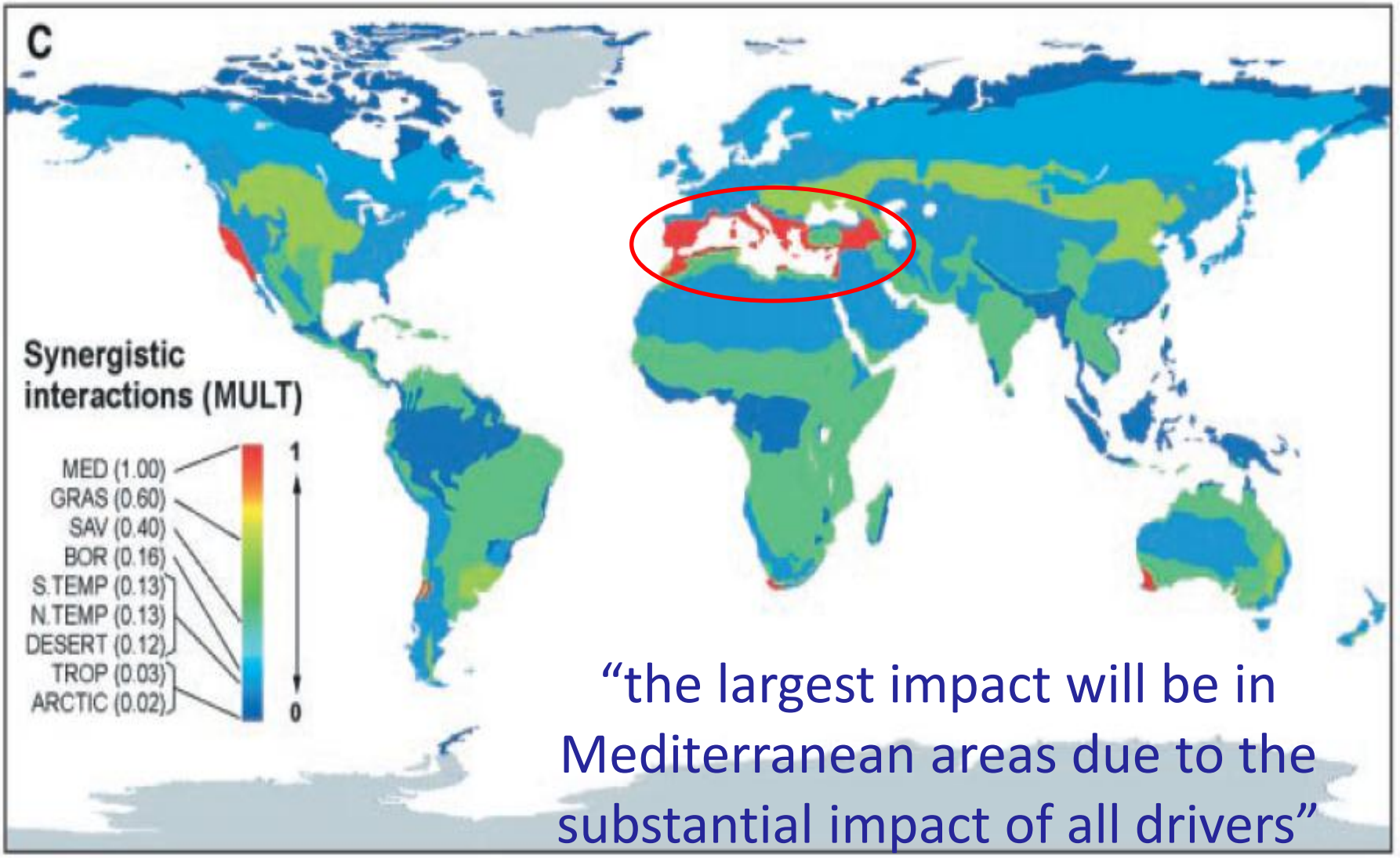
Data from remote sensing and modelling

Changes in Primary Production 2000-2009



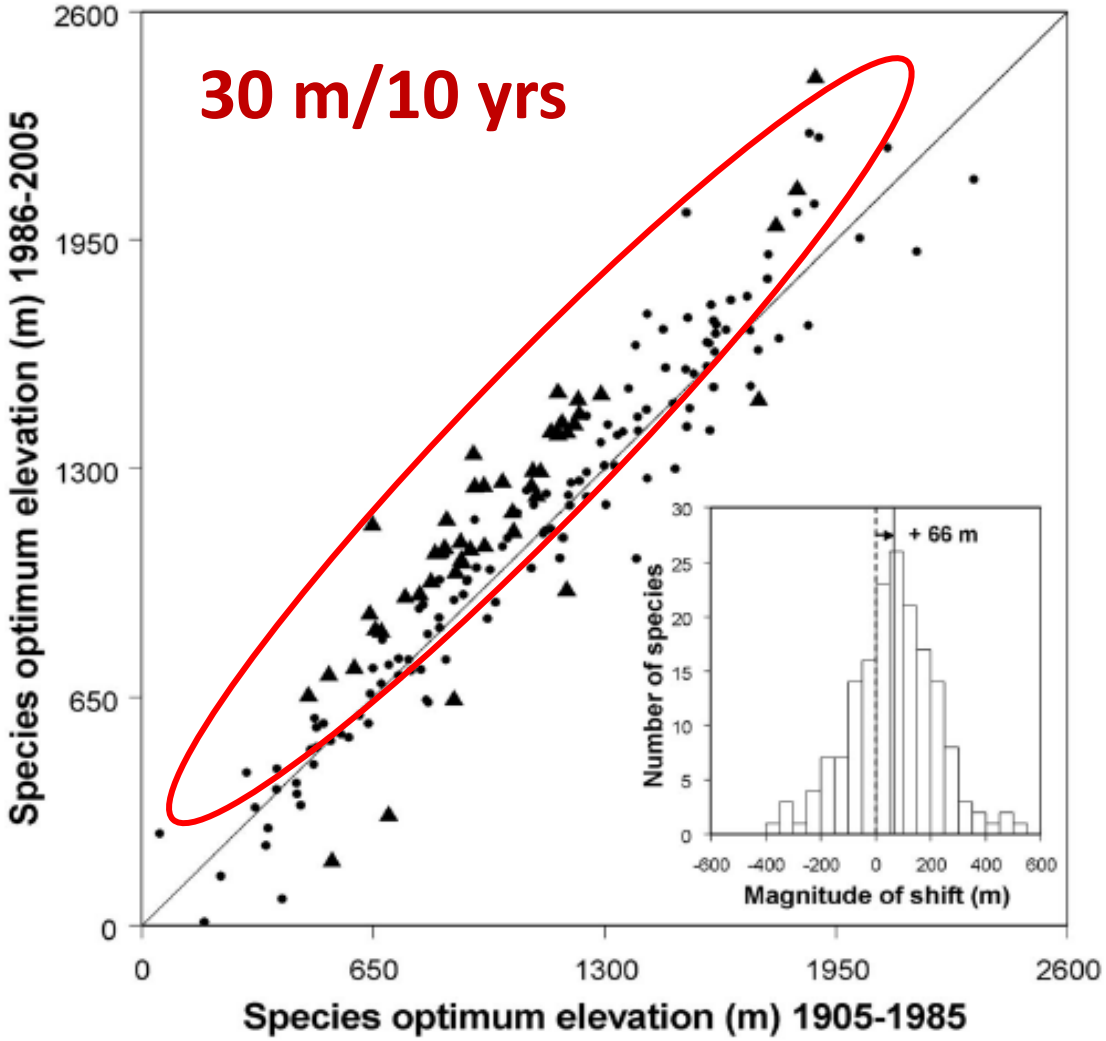
(Zhao and Running, Science, 2010)

Dieback, degradation and distribution of forest ecosystems



"the largest impact will be in Mediterranean areas due to the substantial impact of all drivers"

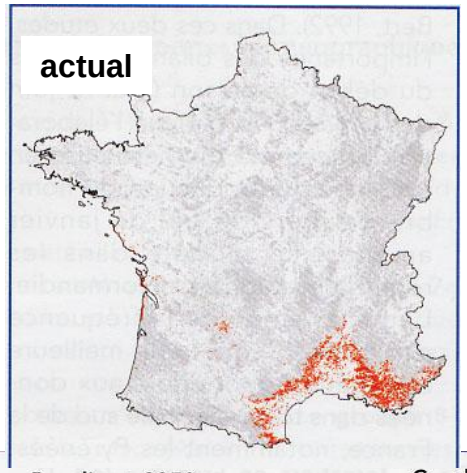
France: upward shift of vegetation in the last 20 yrs

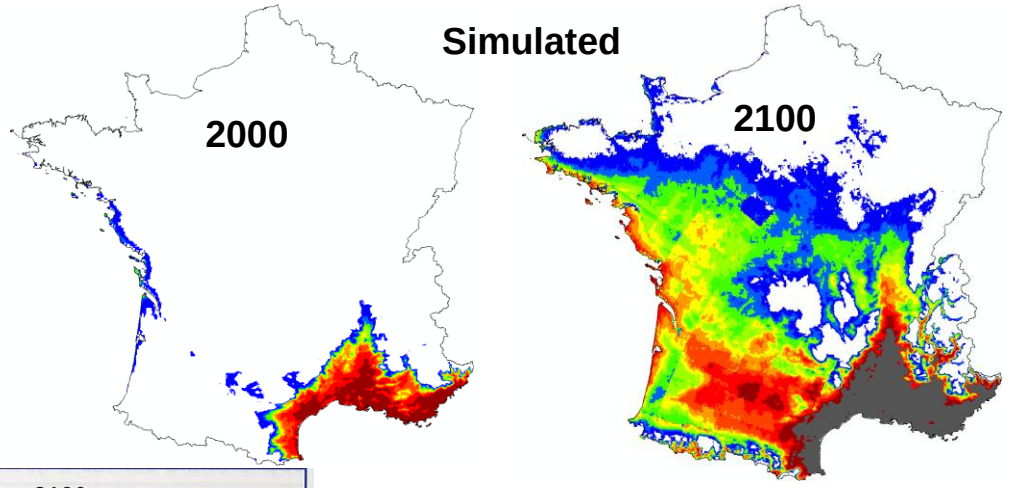


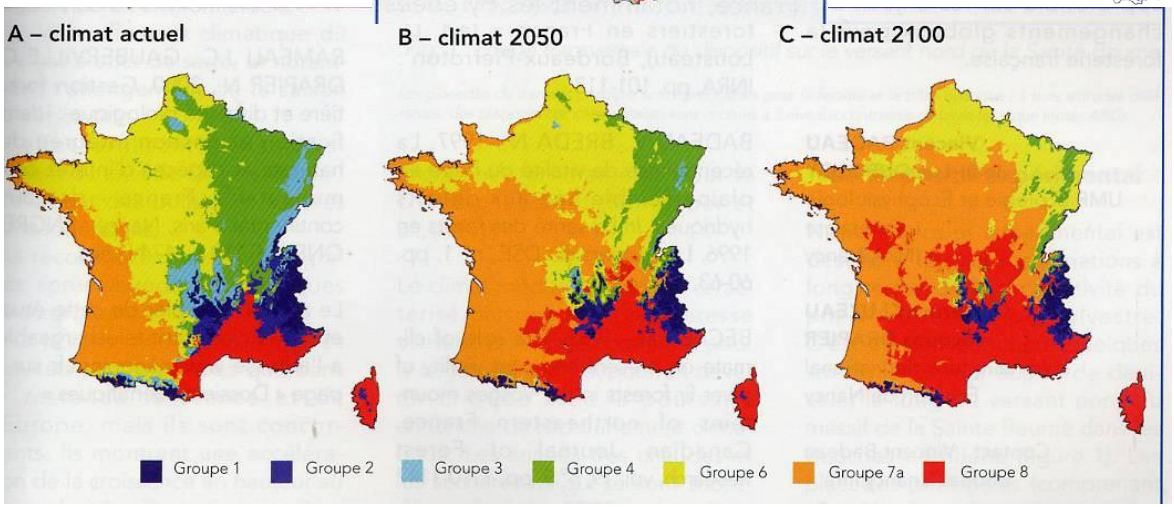
(Lenoir et al, 2008 Science)

Expansion of Mediterranan climatic conditions (Badeau et al., 2007)

Climatic areas for holm oak (*Quercus ilex*)







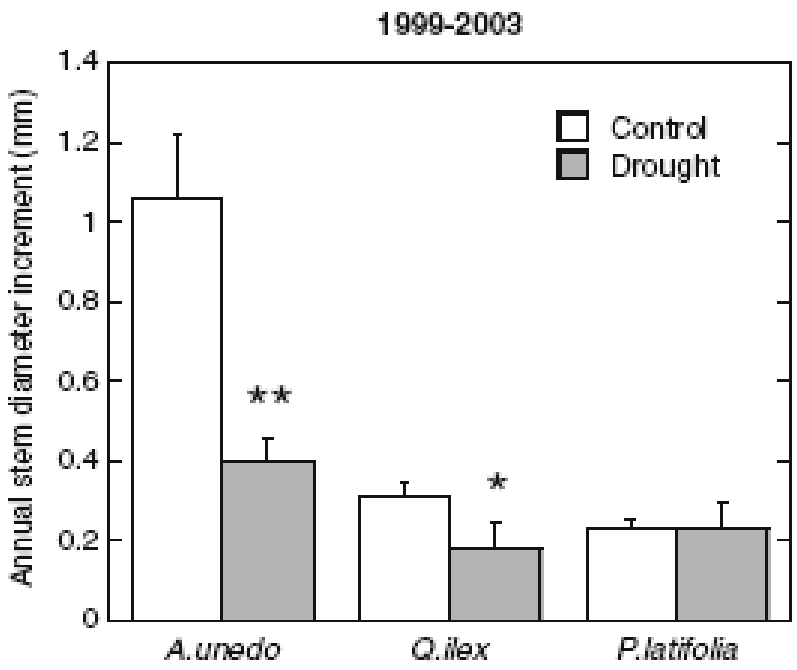
Probability (from **10%** to above **90%**) of *Q. ilex* occurrence in relation to a set of climate variables. Projection in 2100 ibased on the ARPEGE model (Meteo-France) using a scenario with an increased mean temperature of 2.5 ° C. In dark grey: climatic conditions are beyond those suited for *Q.ilex*. Extrapolation to other Mediterranean tree species

Geographic distribution of 7 biogeographic groups (plants) estimated by discriminant analysis based on simple climatic variables (PET, temp.) and then associated to a high resolution meteorological grid/ (good fit with phytogeography). > projections with climatic models

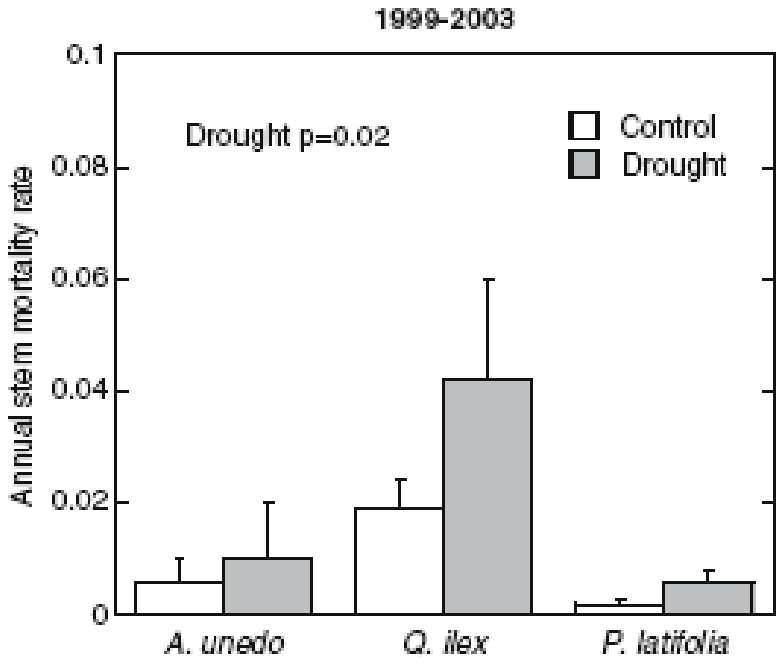
Med: from 9% to 28% of France's territory

Birot, 2008

Effects of prolonged experimental drought on Mediterranean tree species



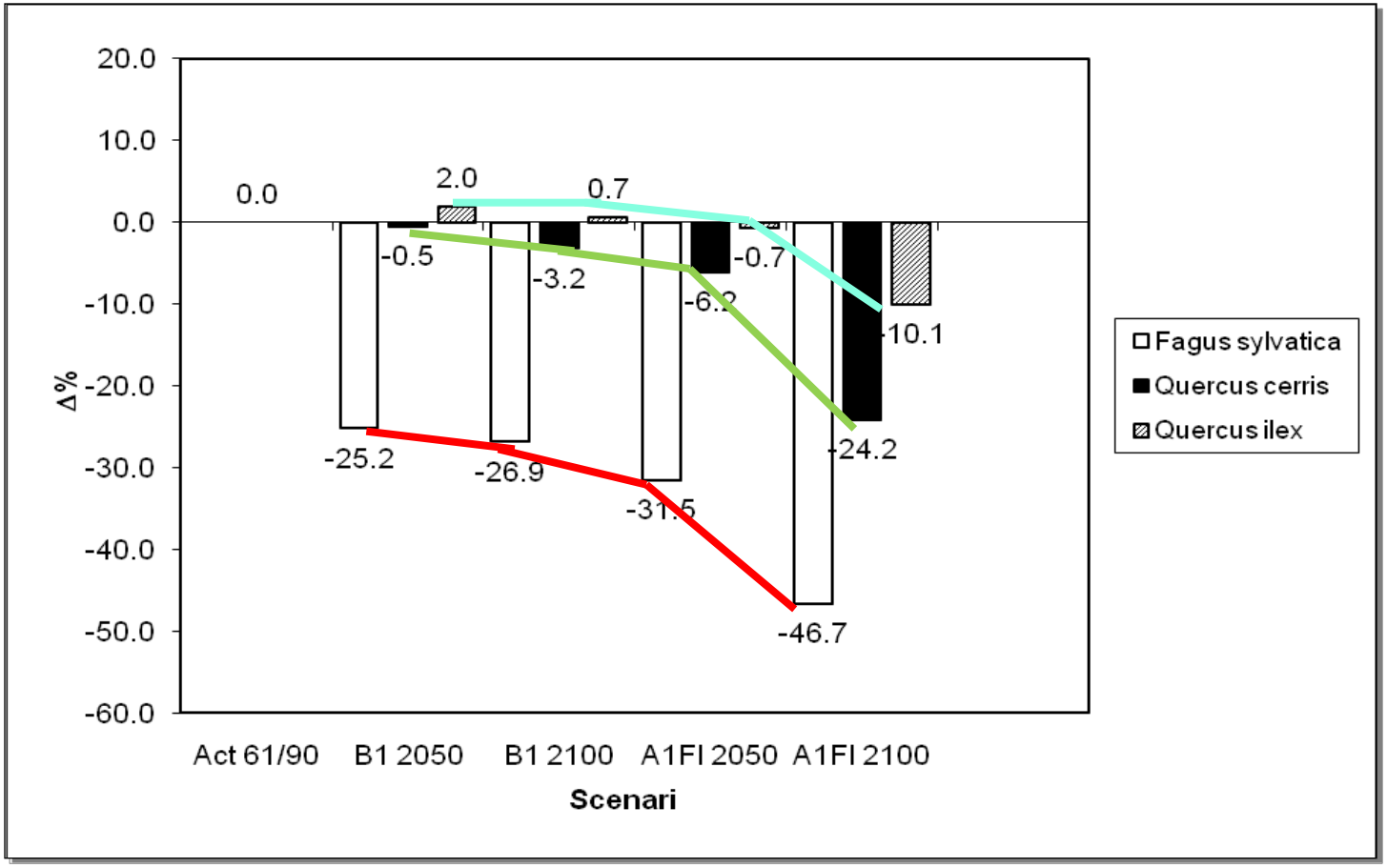
Tree growth



Tree mortality

(Ogaya and Penuelas, 2007 Plant Ecology)

Changes in forest productivity under future scenarios



Fagus sylvatica

Quercus cerris

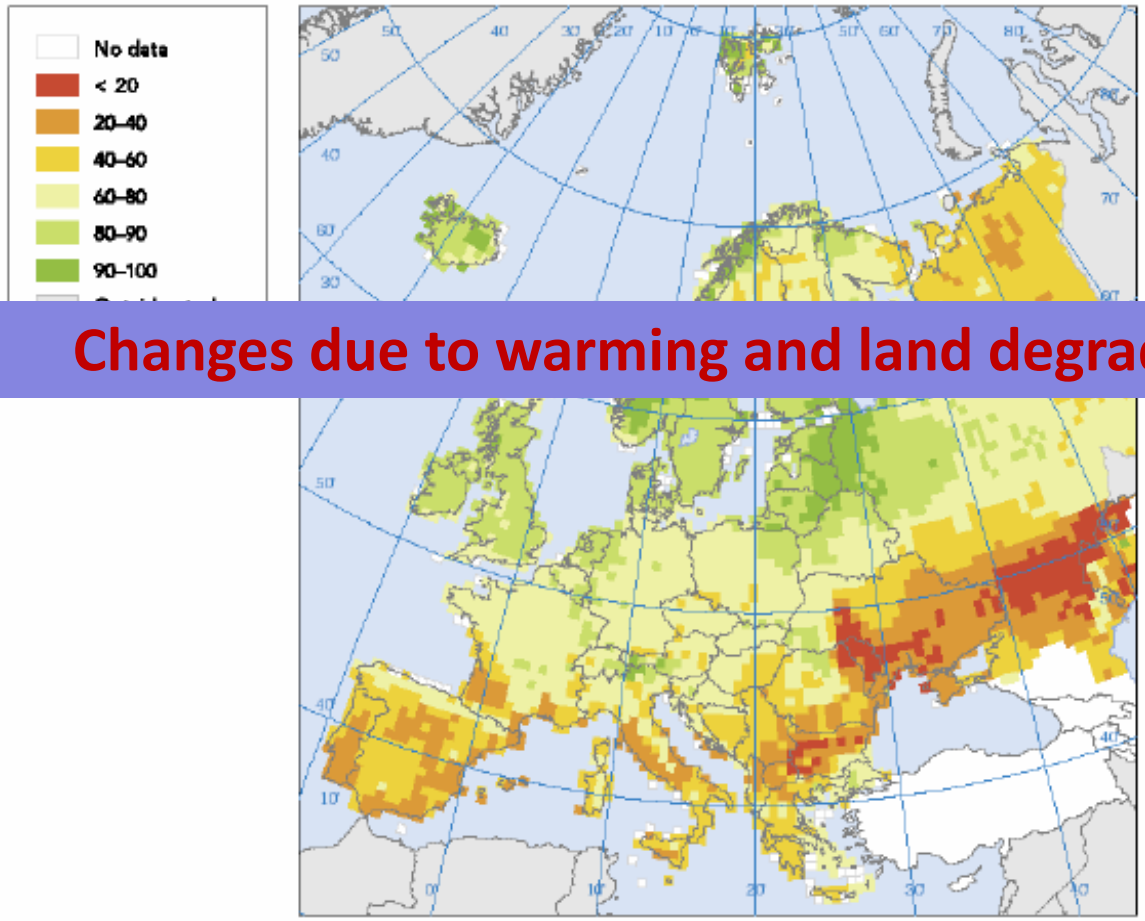
Quercus ilex

(Mancini, 2011, PhD Thesis; Vitale et al., 2011, submitted)

Effects of future climate scenario on the potential and effective distribution of forest ecosystems and tree species

Stable species: 2100 vs. 1990

Map 3.8 Share of stable species in 2100, compared with 1990



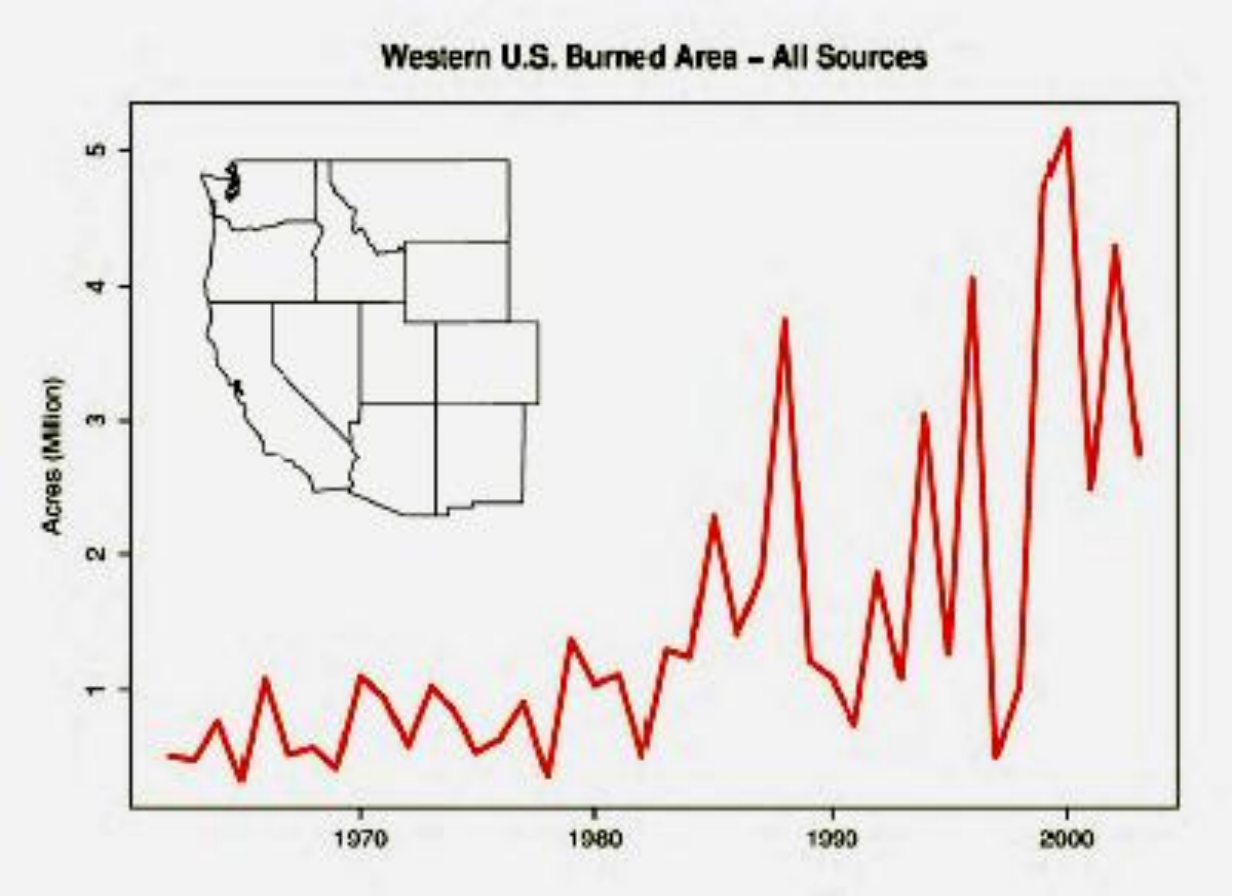
Changes due to warming and land degradation

Note: Percentage of total number of species in 1990. The climate scenario used is a modest climate change scenario (global warming by 2100 is 3 °C and European warming is 3.3 °C).
Source: Bakkenes *et al.*, 2004.

Thomas et al Nature 2004

Forest fires are increasing all over the world

In western USA increased by 4 in 30 years



Source: Westerling et al. 2006

3 main structural causes of fires

A Conflicts or problems at the wildland/rural interface related to: rural abandonment, inconsistent policies on land management (fire use and grazing), and the designation of protected areas for nature conservation

B Conflicts or problems at the wildland/urban interface related to: increased and uncontrolled urbanization in wildland areas; recreational use and poor waste management practices

> Room for better integrated policies *(section3)*

C Unbalanced management or exclusion-suppression vs. fuel management

> Create « Fire-smart » forest stands & landscapes

Photos Cemagref

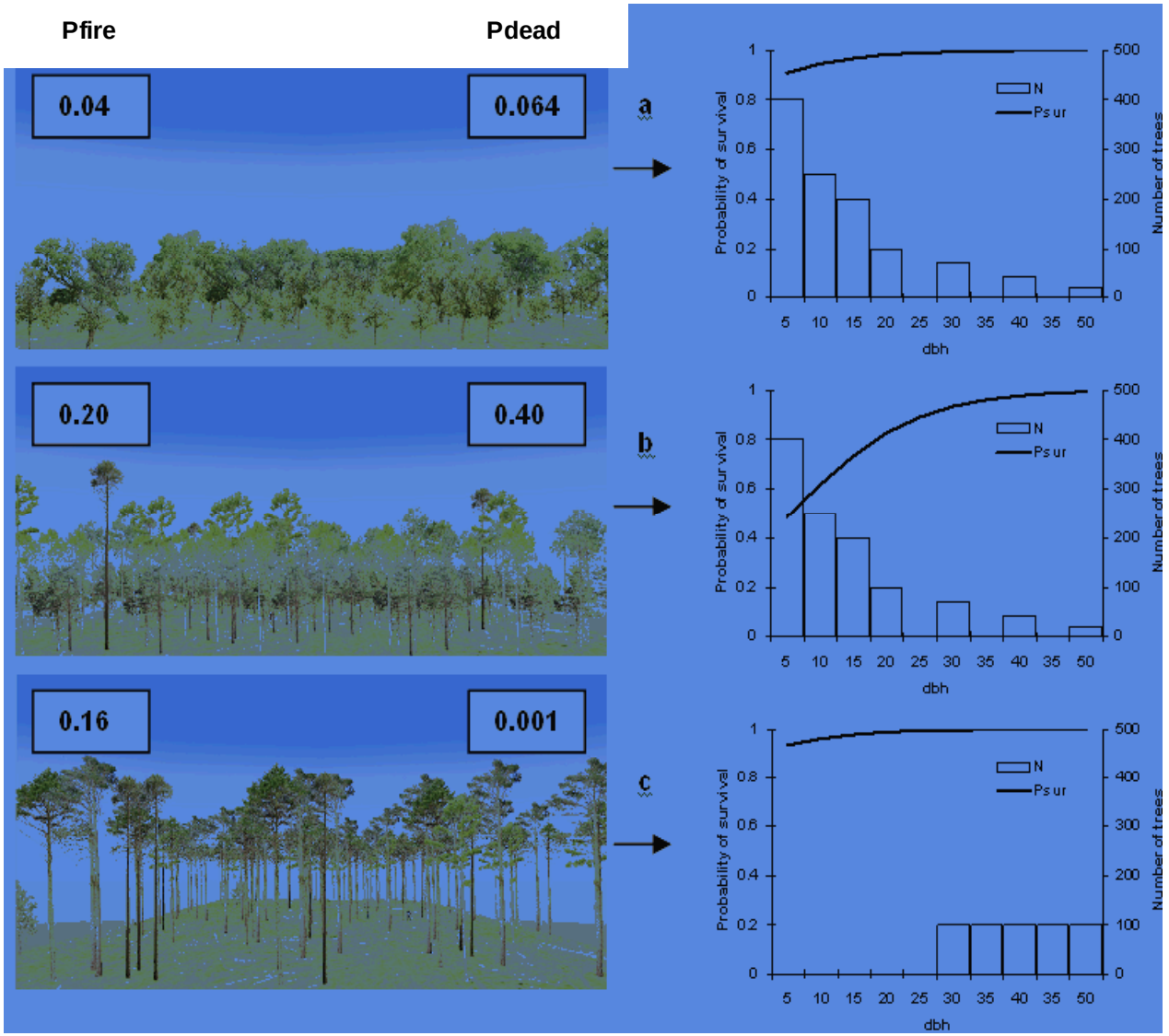
Birot, 2008

Fire risk depends on stand structure and composition

Simulation: fire probability & damage
(altitude 700 meters and slope 12%)

A: representation of different forest stands and their predicted probability of fire occurrence (Pfire) and damage in proportion of dead trees (Pdead).

B same stands with their diametric distribution (N, number of trees per diameter class) and their survival probability (Psur).



A B

(Gonzalez et al. 2007)

Birot, 2008

Summary

- Mediterranean environment and green infrastructures: the forest ecosystems
- Forest ecosystem services: C-sequestration, H_2O production, remediation, biodiversity
- Impact of climate change on forest structure and functions
- Which role for management and research?

Building capacities in Mediterranean forest research

FORESTERRA project:

Coordination of forest ecosystem research between

EU, North-Africa, Near-East and other Med countries

- Joint research calls
- Common infrastructures

A new generation of Mediterranean scientists

Group picture during the field trip in Anopolis

Strengthening Mediterranean Forest Research through an ERANET scheme

EU Research Framework Programme

The objective of the ERA-NET scheme is
to step up the cooperation and coordination of research activities carried out at national level through:

- ✓networking of research activities
- ✓mutual opening of national research programmes

Improving the coherence and coordination across Europe and enable to take on tasks collectively that would not have been able to tackle independently

What can we do?

- Sustainable management and protection

- Restoration treatments
  - ✓ to improve fire and drought resilience
  - ✓ to prepare for warmer and drier conditions and increased likelihood of fires and insect outbreaks
  - ✓ to reduce habitat fragmentation

- Strategies for conserving biological diversity will need to incorporate consideration of climate change

- Proactive action for future adaptation
  - ✓ mixed stands of diverse structure
  - ✓ nursery planning: species more suited to changing climate
  - ✓ Improve ecosystem connectivity (species migration)

Conclusions and perspectives

✓ Mediterranean forests are key-ecosystems, rich in biodiversity, providing important services

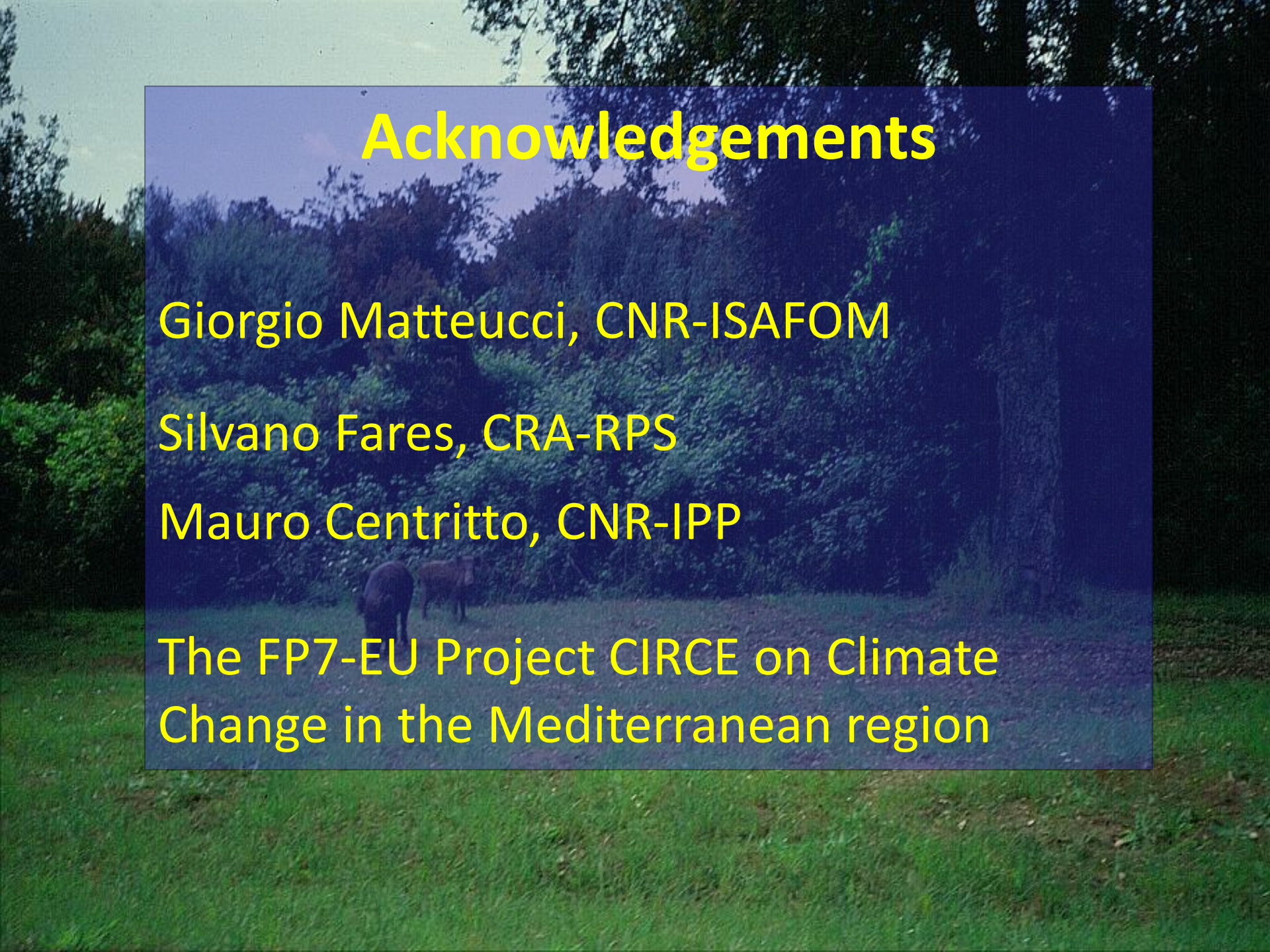
✓ Risks of biodiversity loss and ecosystem degradation

✓ Water availability plays a crucial role in C balance of Mediterranean forests

✓ Climate is changing too rapidly for ecosystem to adapt

✓ Needs of protection, sustainable management for adaptation, resistence and resilience

✓ Needs for long-term research, modelling, monitoring and interaction with stakeholders



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