Present and future role of forest resources in the socio-economic development of rural areas

Rome, 23rd June 2011
Parallel Session

Parallel Session 3

Strategies for mitigation of and adaptation to climate change.

How are net primary productivity and water use of Italian tree species affected by climate change?

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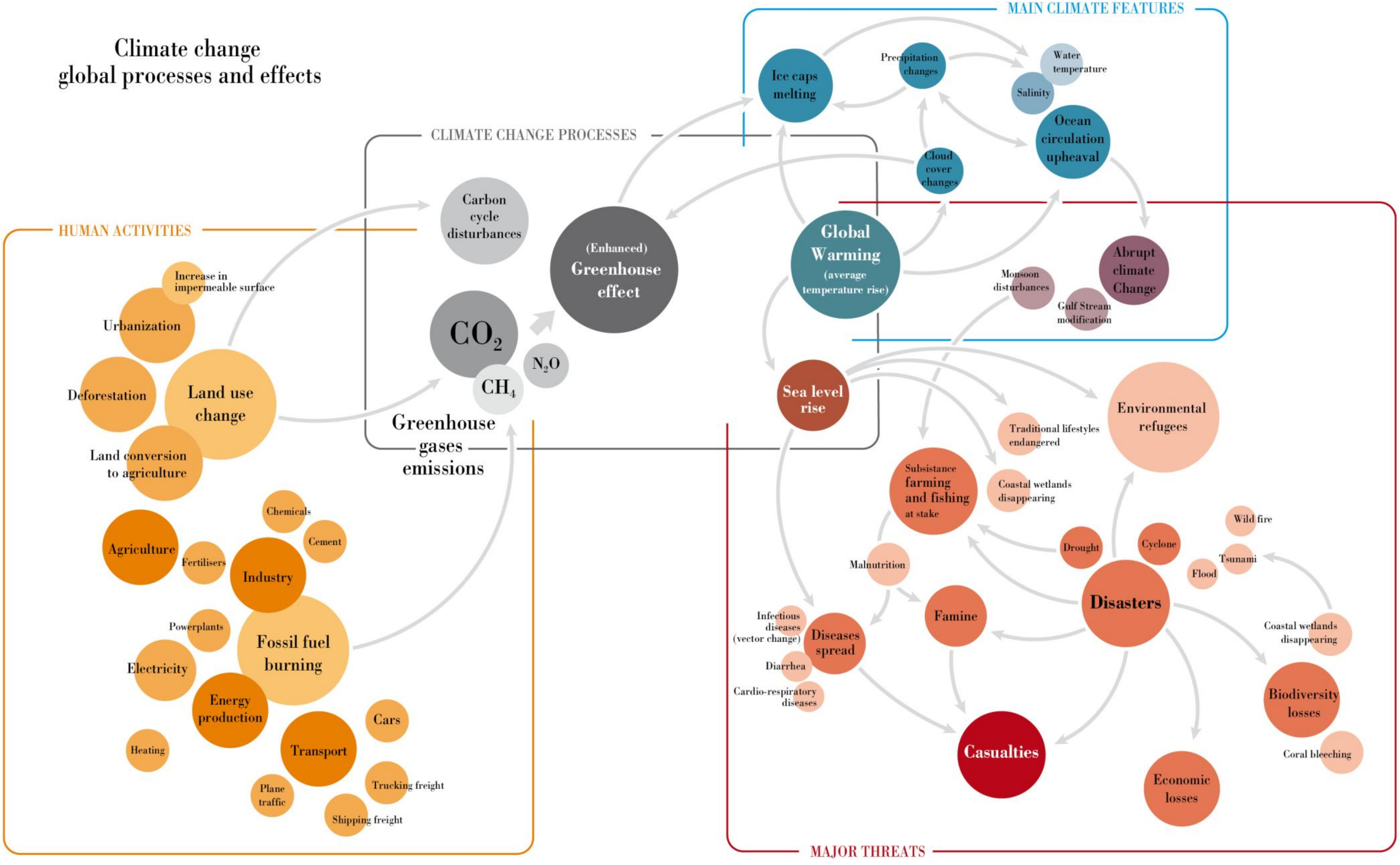
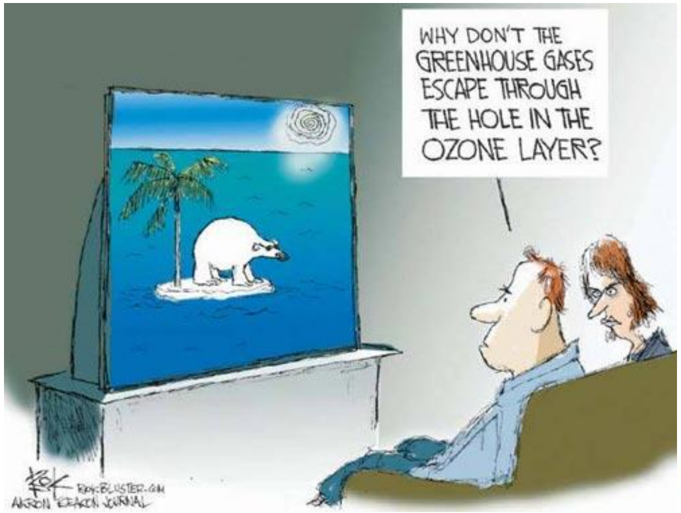
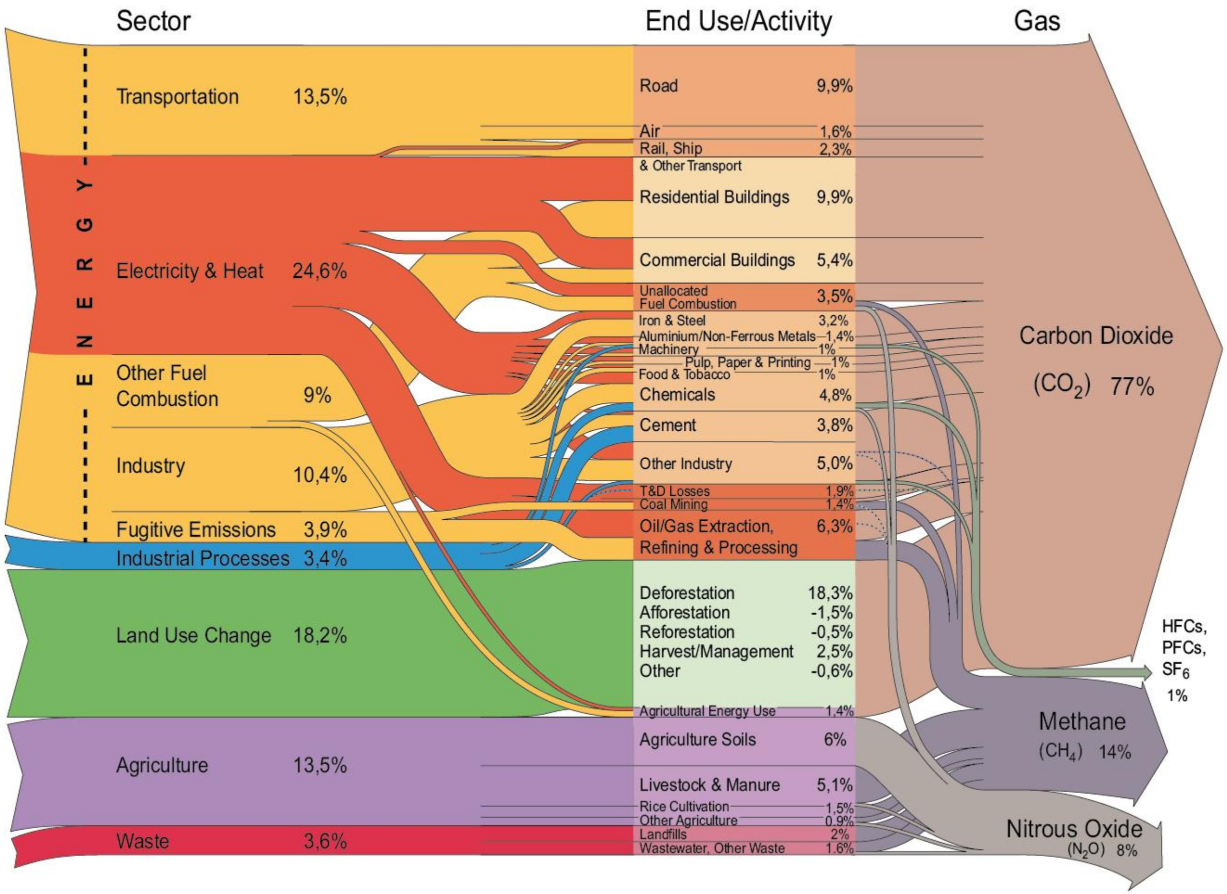


Source: Kick the Habit: A UN Guide to Climate Neutrality (2009)
http://maps.grida.no/go/graphic/climate-change-global-processes-and-effects1



World Greenhouse gas emissions by sector

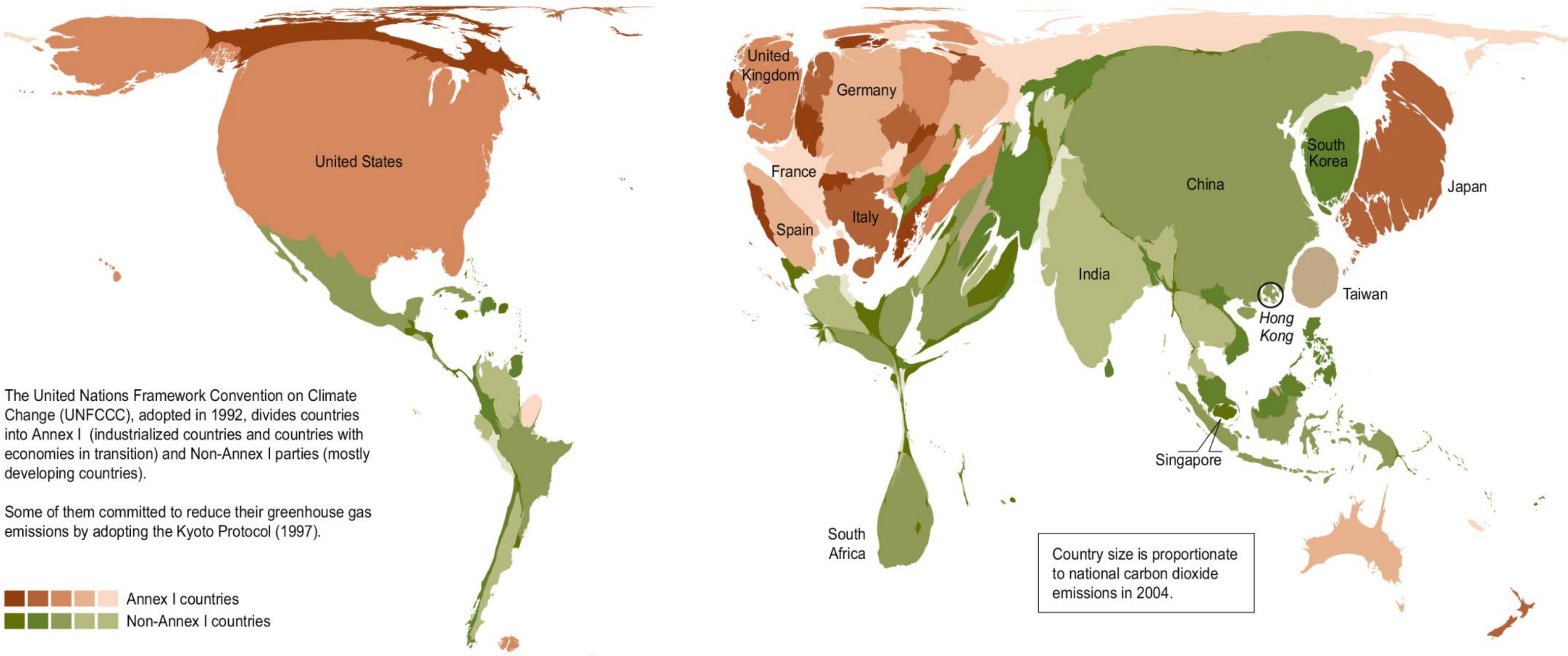


All data is for 2000. All calculations are based on CO_2 equivalents, using 100-year global warming potentials from the IPCC (1996), based on a total global estimate of 41 755 $MtCO_2$ equivalent. Land use change includes both emissions and absorptions. Dotted lines represent flows of less than 0.1% percent of total GHG emissions.

Source: World Resources Institute, Climate Analysis Indicator Tool (CAIT), Navigating the Numbers: Greenhouse Gas Data and International Climate Policy, December 2005; Intergovernmental Panel on Climate Change, 1996 (data for 2000).

Total CO_2 emissions

from fossil-fuel burning, cement production and gas flaring

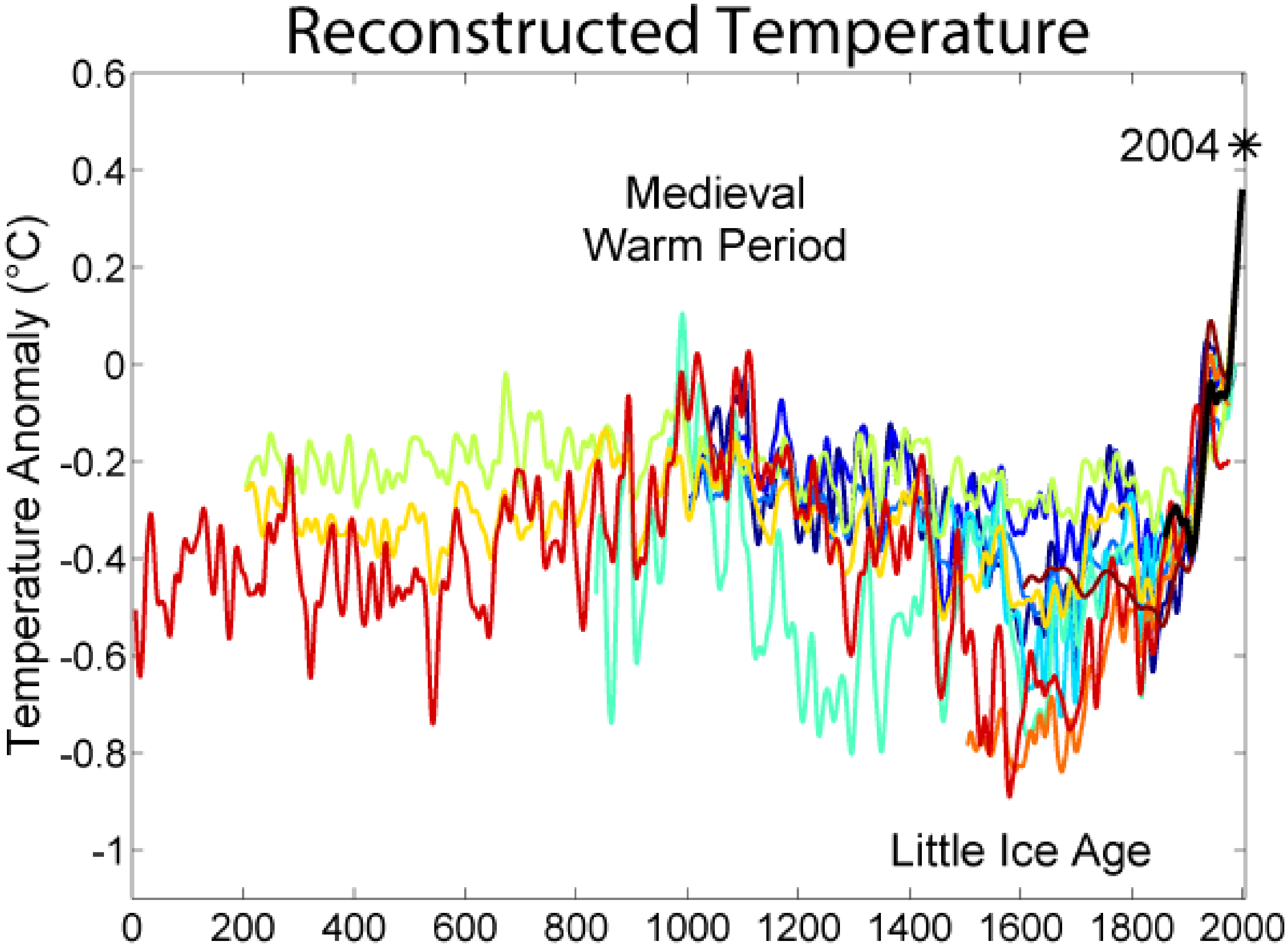


The United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992, divides countries into Annex I (industrialized countries and countries with economies in transition) and Non-Annex I parties (mostly developing countries).

Some of them committed to reduce their greenhouse gas emissions by adopting the Kyoto Protocol (1997).

Country size is proportionate to national carbon dioxide emissions in 2004.

Cartography: SASI Group, University of Sheffield; Mark Newman, University of Michigan, 2006 (updated in 2008), www.worldmapper.org.
Data source: Gregg Marland, Tom Boden, Bob Andres, Oak Ridge National Laboratory. Please note that data for Norway is inaccurate.



It is clearly visible that there is an un-normal rise in the average temperature on the earth 1800 and 2000.
This Abnormal rise in temperature has /is happening because of the so called Green House Effect.

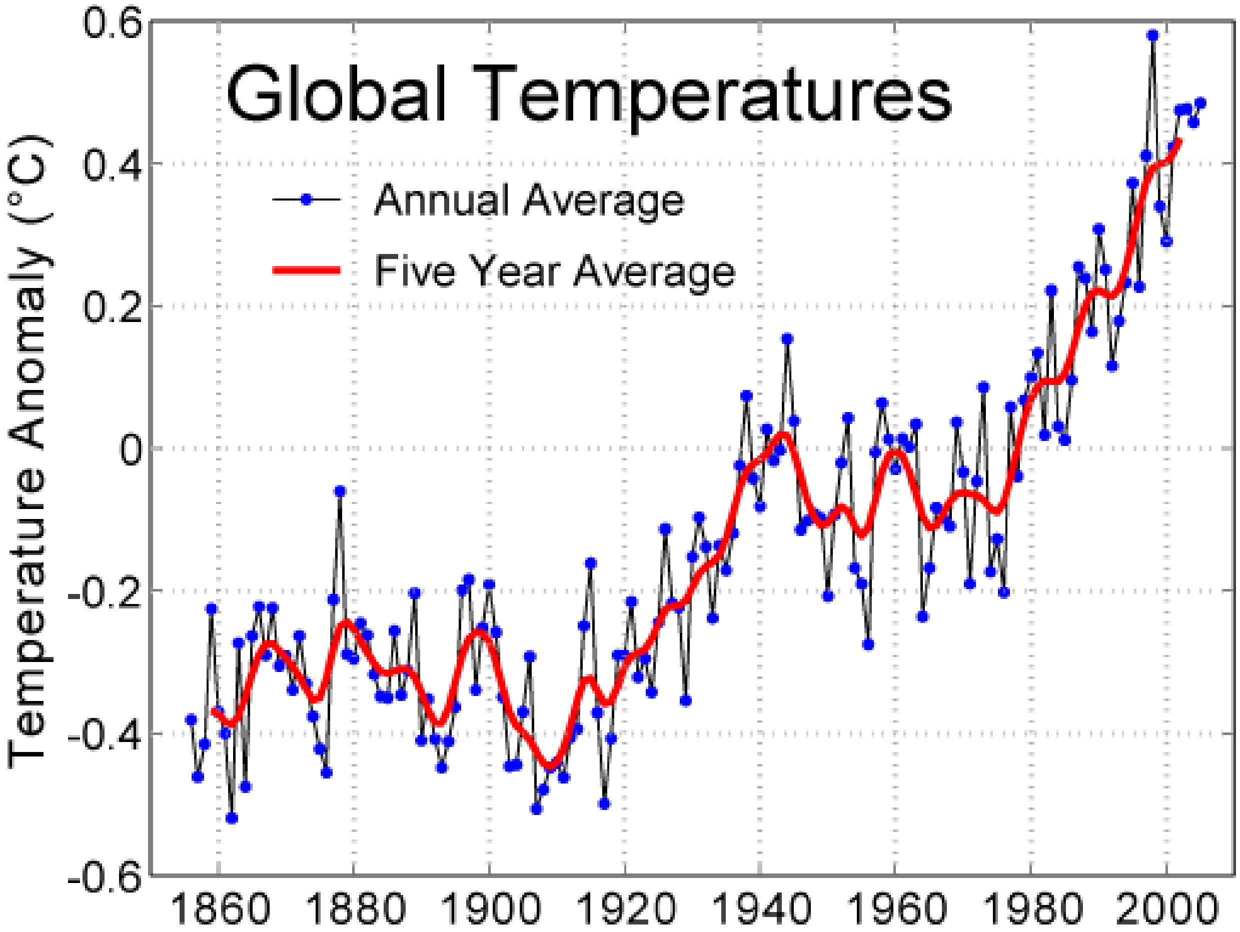
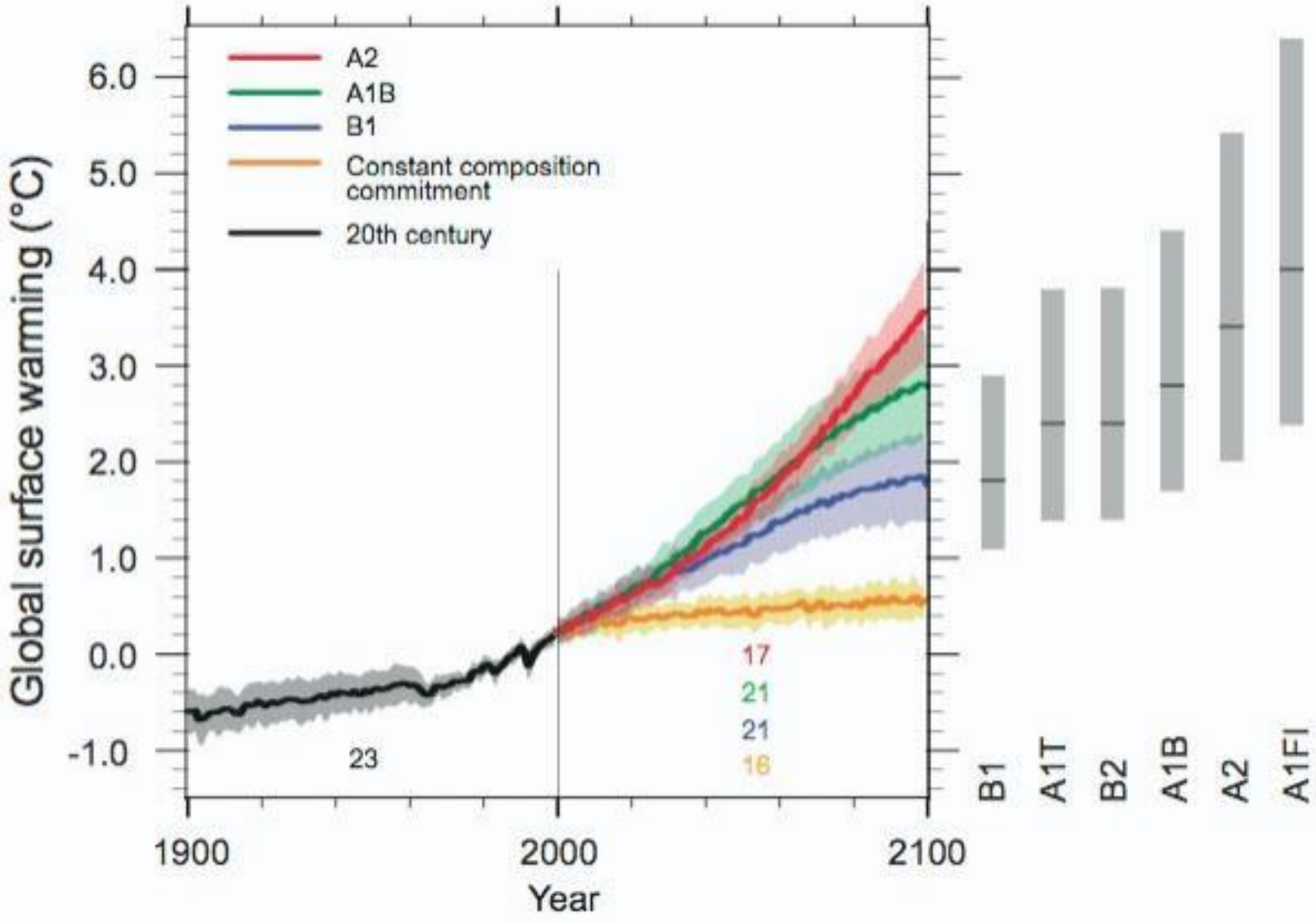
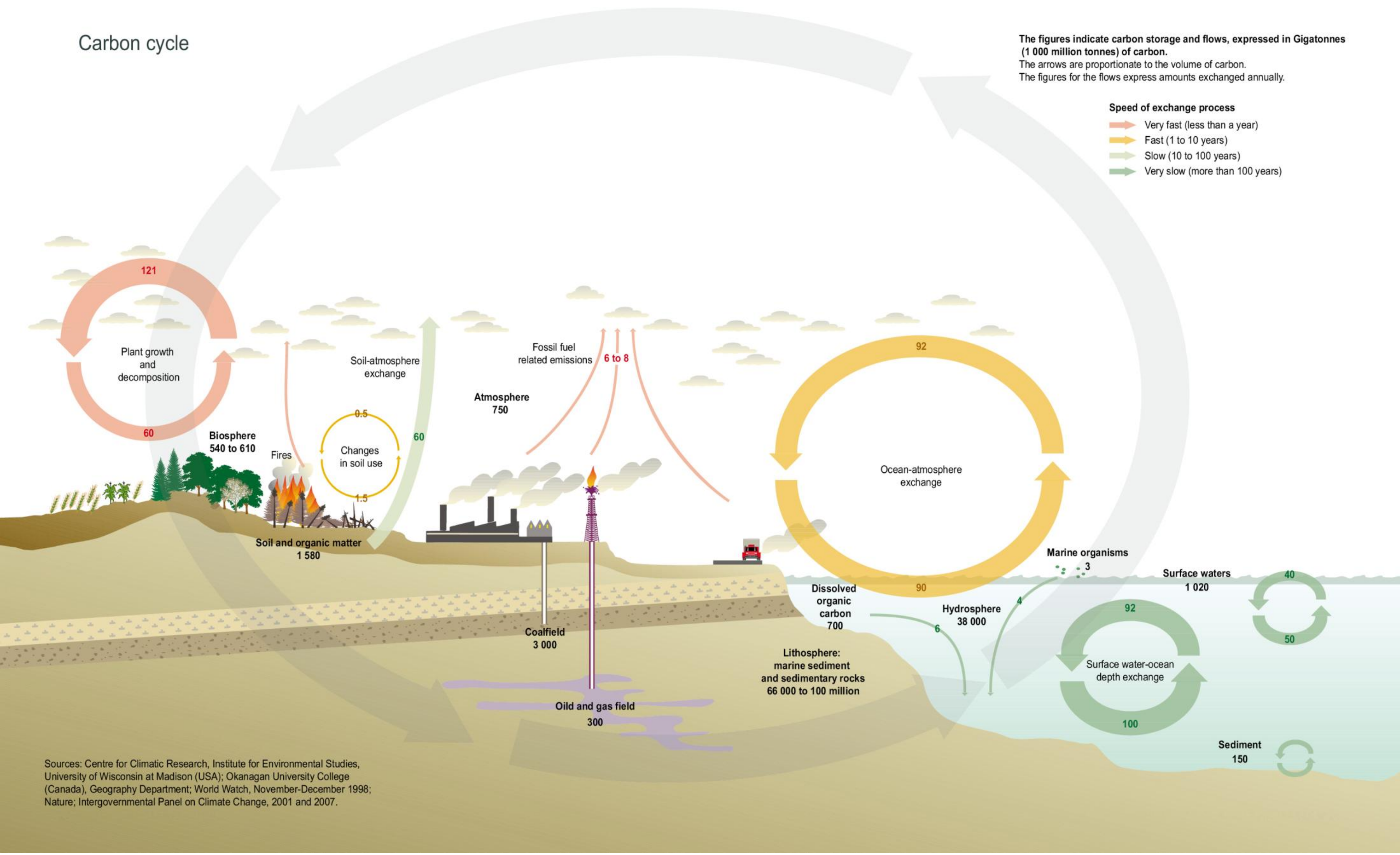


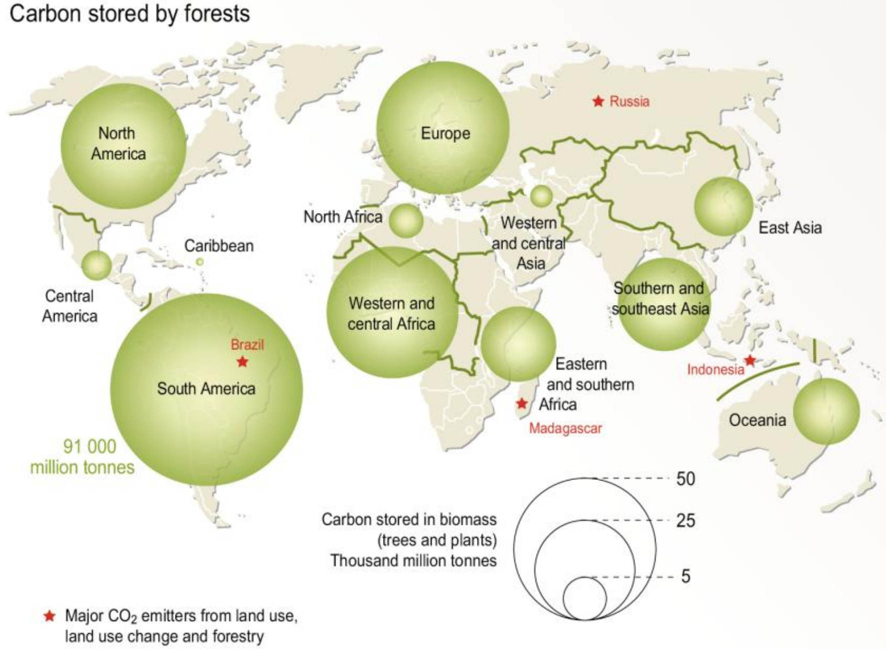
Image: Andrzeg Krause

Global air temperatures have increased by 0.7 °C during the 20th century and are predicted to increase by between 1.1 and 6.4 °C during the 21st century, with the greatest increases expected to occur at more northerly latitudes (Fourth Assessment Report 2007).



The predicted temperature rise by 2100 is between 1.8 and 4.0°C. This is based on models representing a variety of emissions scenarios and an uncertainty of one standard deviation (grey shading). The orange line is a model where greenhouse gas concentrations were held constant at year 2000 values (Graphic: IPCC)

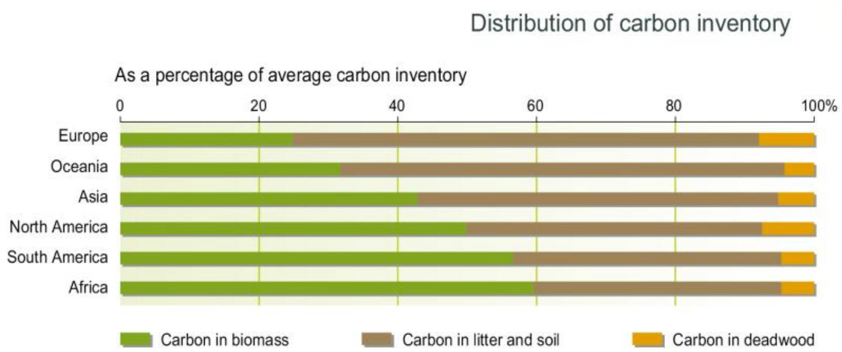

Carbon cycle
The figures indicate carbon storage and flows, expressed in Gigatonnes (1 000 million tonnes) of carbon.
The arrows are proportionate to the volume of carbon.
The figures for the flows express amounts exchanged annually.
Speed of exchange process
Very fast (less than a year)
Fast (1 to 10 years)
Slow (10 to 100 years)
Very slow (more than 100 years)
121
Plant growth and decomposition
60
Biosphere 540 to 610
Fires
Soil-atmosphere exchange
0.5
Changes in soil use
1.5
60
Soil and organic matter 1 580
Fossil fuel related emissions
6 to 8
Atmosphere 750
Coalfield 3 000
Oild and gas field 300
92
Ocean-atmosphere exchange
90
Marine organisms 3
Surface waters 1 020
40
50
Dissolved organic carbon 700
Hydrosphere 38 000
4
6
92
Surface water-ocean depth exchange
100
Lithosphere: marine sediment and sedimentary rocks 66 000 to 100 million
Sediment 150
Sources: Centre for Climatic Research, Institute for Environmental Studies, University of Wisconsin at Madison (USA); Okanagan University College (Canada), Geography Department; World Watch, November-December 1998; Nature; Intergovernmental Panel on Climate Change, 2001 and 2007.

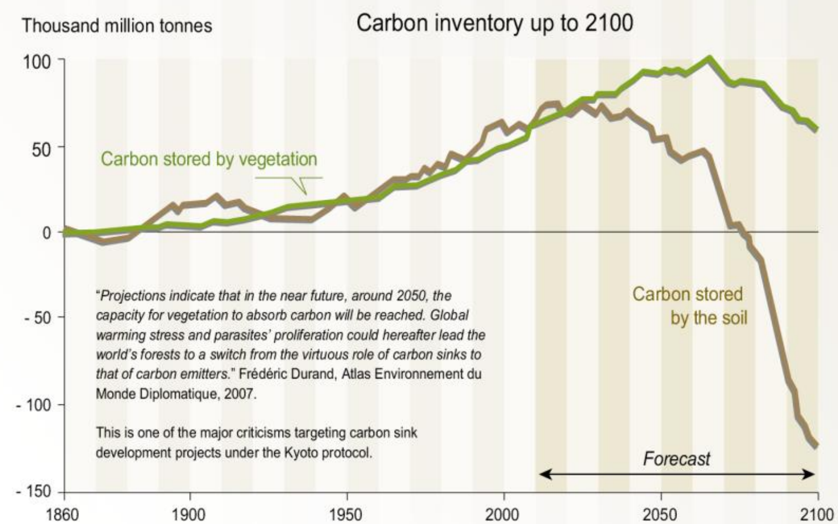


Carbon inventory

"Forests play a vital role in the global carbon cycle, storing roughly half of the world's terrestrial carbon (Millennium Ecosystem Asessment, 2005). When forests grow, they withdraw carbon dioxide from the atmosphere and sequester it in trees and soil. When they are destroyed or degraded, much of this carbon is released, either immediately if the trees are burned or more slowly if the organic matter decays naturally."
EarthTrends Update, April 2008.

Sources: *Atlas Environnement du Monde Diplomatique*, 2007; *Global Forest Resources Assessment 2005*, United Nations Food and Agriculture Organization (FAO); Hadley climate research unit, 2007; World Resources Institute (WRI), *EarthTrends Environmental Information Portal*, 2008; World Resources Institute, *Climate Analysis Indicators Tool*, 2008.





Scientific findings

Forests will have to adapt to changes in mean climate variables but also to increased variability. The responses of plant productivity and other ecosystem processes to climate change are quite variable and increases, decreases, or no change at all have all been reported.

(Rustad et al. 2001; Peñuelas et al. 2004)

However, there seem to be some regularities such as a greater positive response of aboveground plant productivity to warming in colder ecosystems.

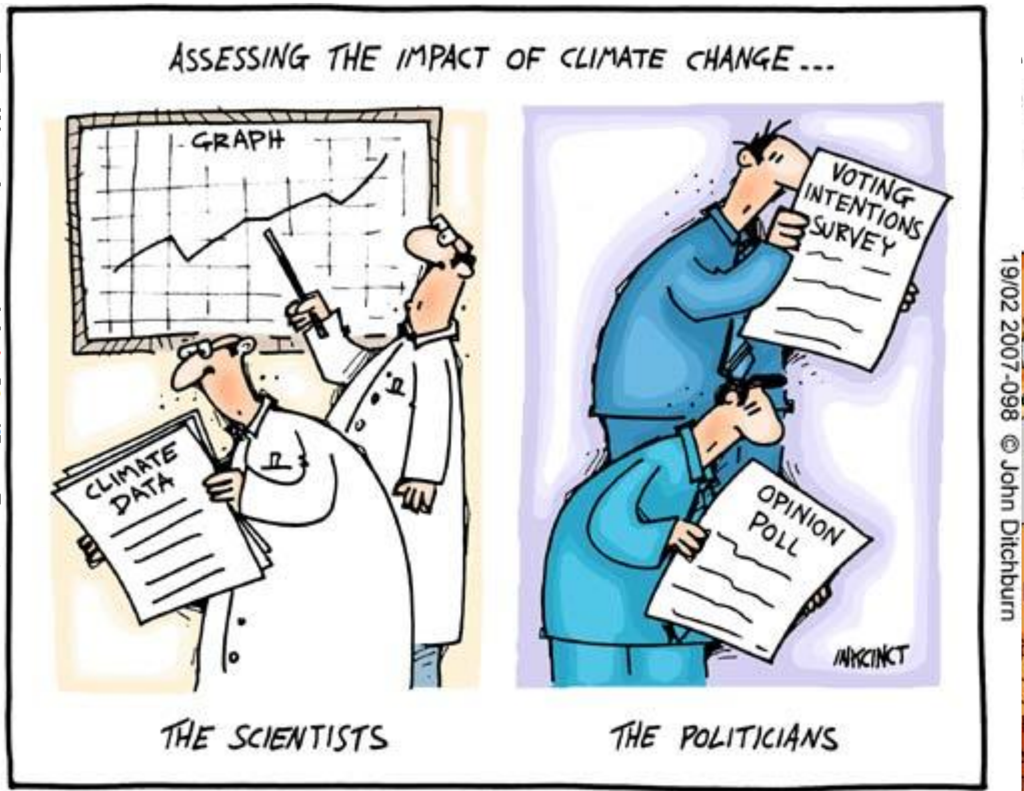
(Rustad et al. 2001)

Furthermore, there is a large body of observational, satellite, and atmospheric data regarding plant species and ecosystems that shows clear biological responses to warming such as extended growing seasons and altitudinal and northward movement of species' distributions in both northern and southern, cold-wet and warm-dry ecosystems.

(Myneni et al. 1997; Peñuelas et al. 2002; Walther et al. 2002; Parmesan, 2007; Parmesan & Yohe 2003; Peñuelas & Boada 2003; Menzel et al. 2006)

The Mediterranea
low precipitation i
decrease in moist

If the dry season lasts t
water deficits may neg
capacity for carbon ass
result of lower photosy
leaf areas (or shorter li
plants) induced by wat



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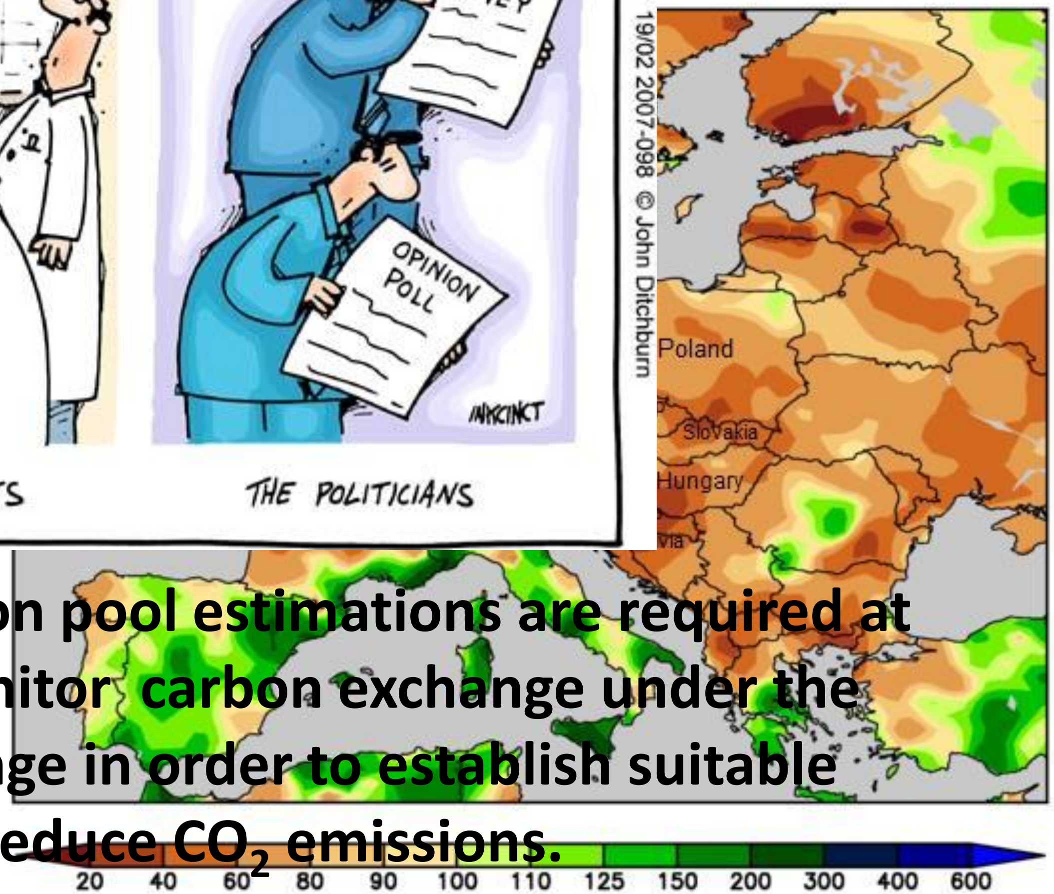
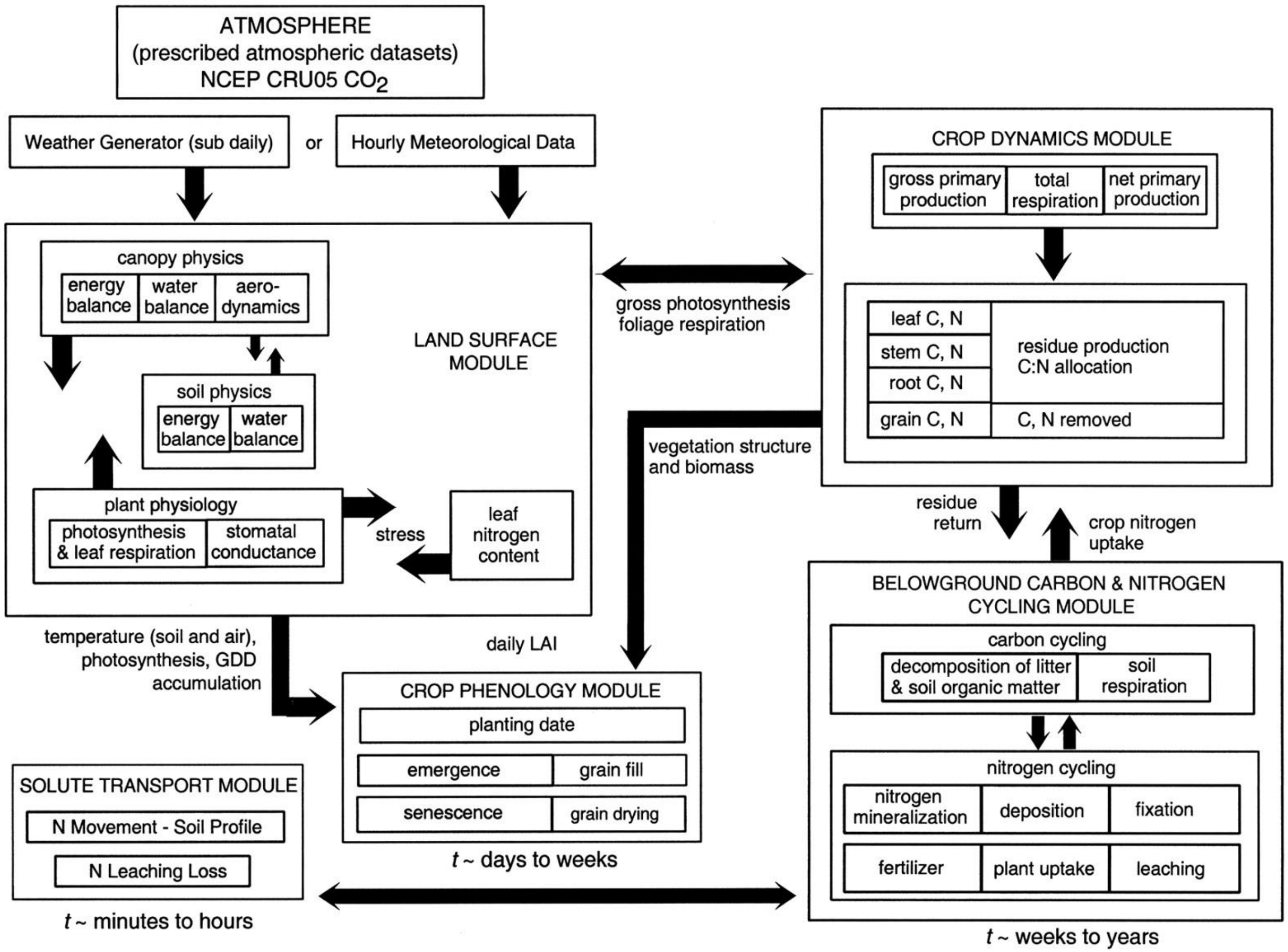
Analysis
10 April 2011



As a consequence, carbon pool estimations are required at a regional level to monitor carbon exchange under the ongoing climatic change in order to establish suitable polices to reduce CO_2 emissions.

Serious drought worries in Europe. Top wheat, barley, rapeseed countries affected

The interest in C exchange modelling reflects the growing attraction in using models as vehicles to integrate knowledge, research activities, experimental results, and to test hypothesis, and as the most feasible tools to address how climate change will affect the process-based forest functionality.



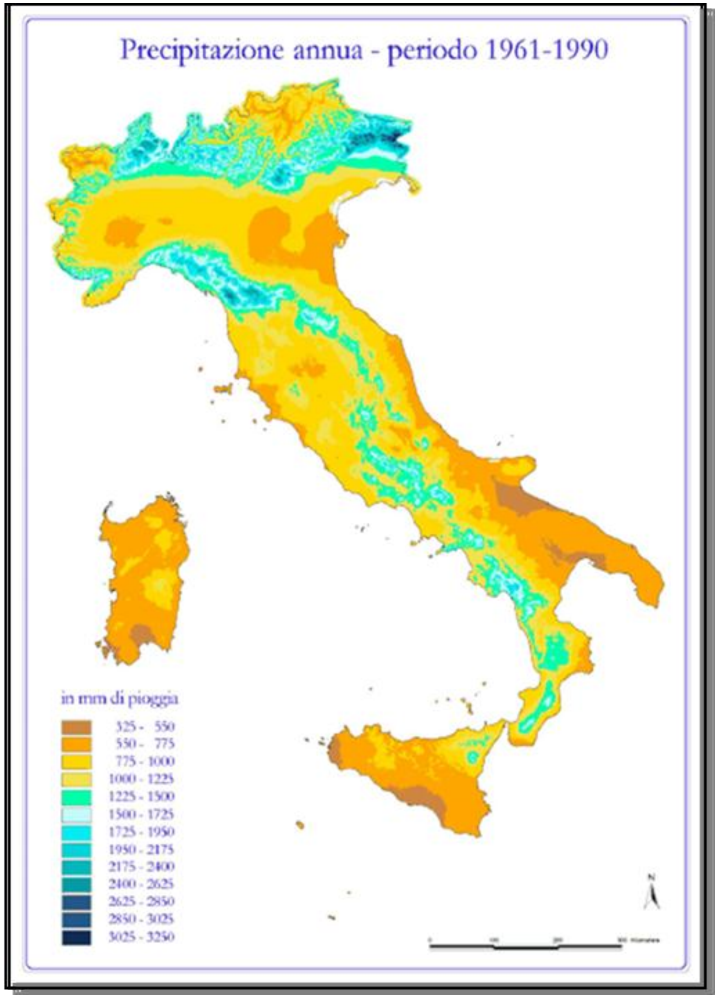
AIM

Simulations of net primary production and transpiration for tree species as *Fagus sylvatica*, *Quercus cerris* and *Quercus ilex*, forming widely diffused forest-types in the Mediterranean area, under <u>two climatic scenarios</u> representing low and high emission trajectories: <u>B1</u> (stabilization at 550 ppm atmospheric CO_2) and <u>A1FI</u> (no stabilization of atmospheric CO_2) storylines, and for <u>two temporal frames</u>: <u>2031-2060</u> and <u>2071-2100</u>.

Consequences on primary productivity and distribution patterns of these tree species will be discussed.

METHODS

Universal kriging and covariates



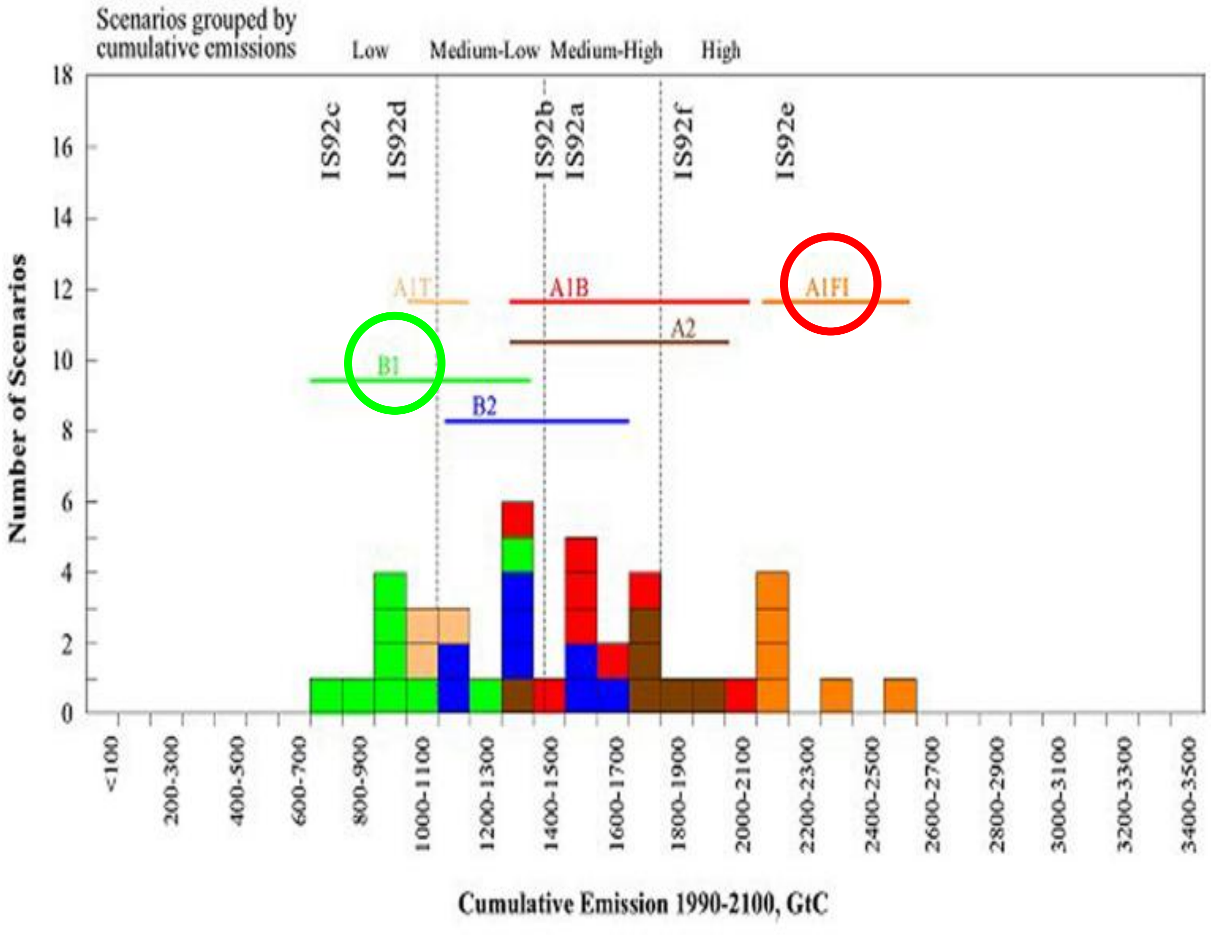
Network of meteorological stations
(900 thermometric stations and 1600 pluviometric stations) Time period lasting from 1961 to 1990

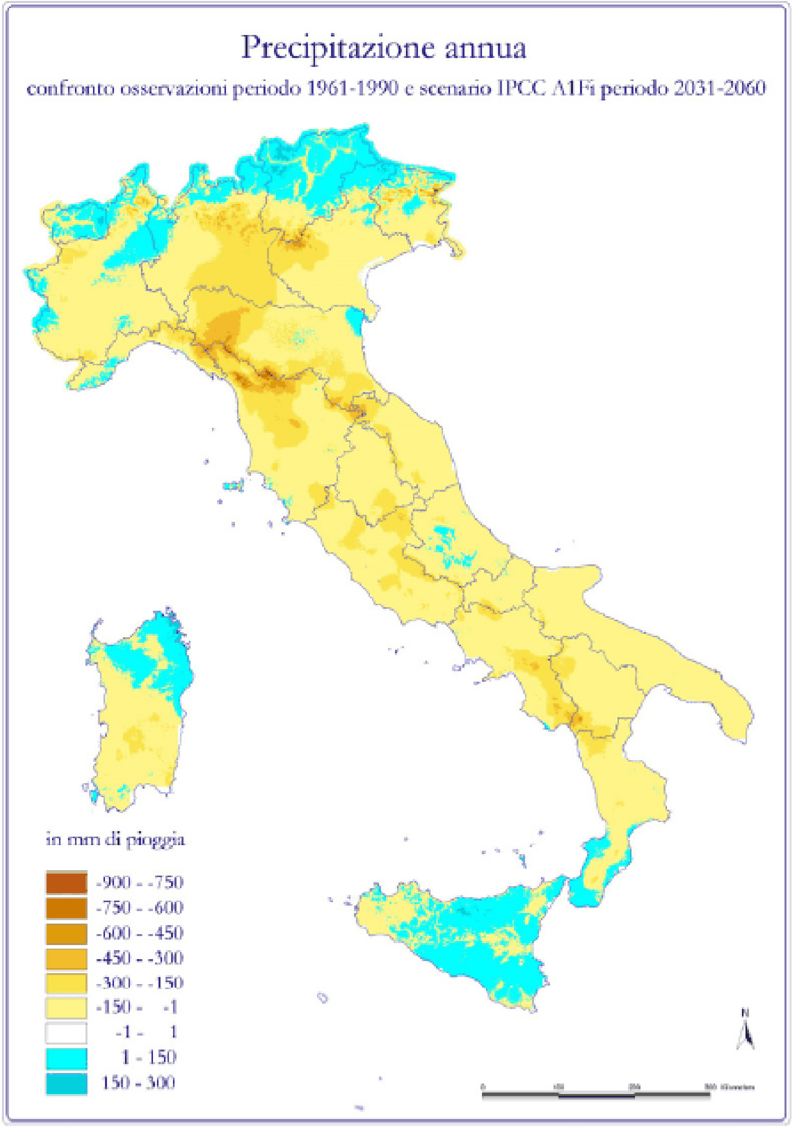
Climate Change

- Two IPCC scenarios:
  B1 e A1FI

(*Tyndall Centre for Climate Change Research* : HadCM3 model)

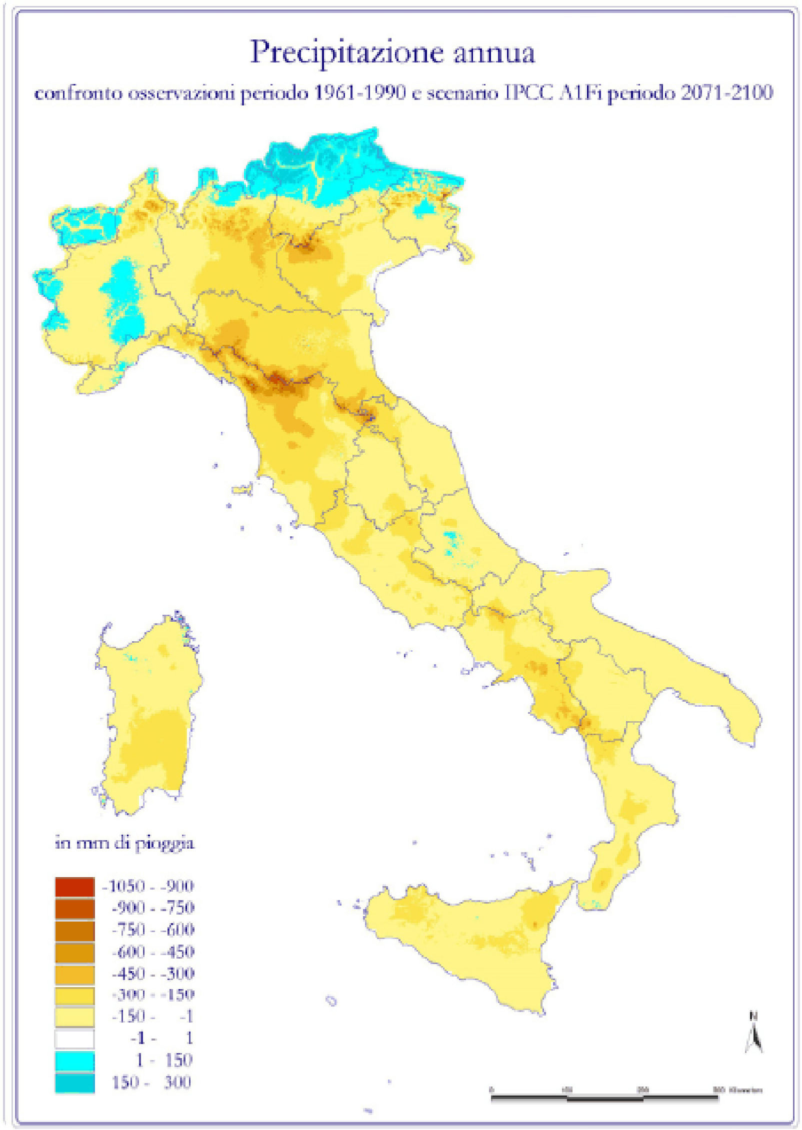
- Two temporal frames
  2031 – 2060
  2071 – 2100





A1Fi

B1

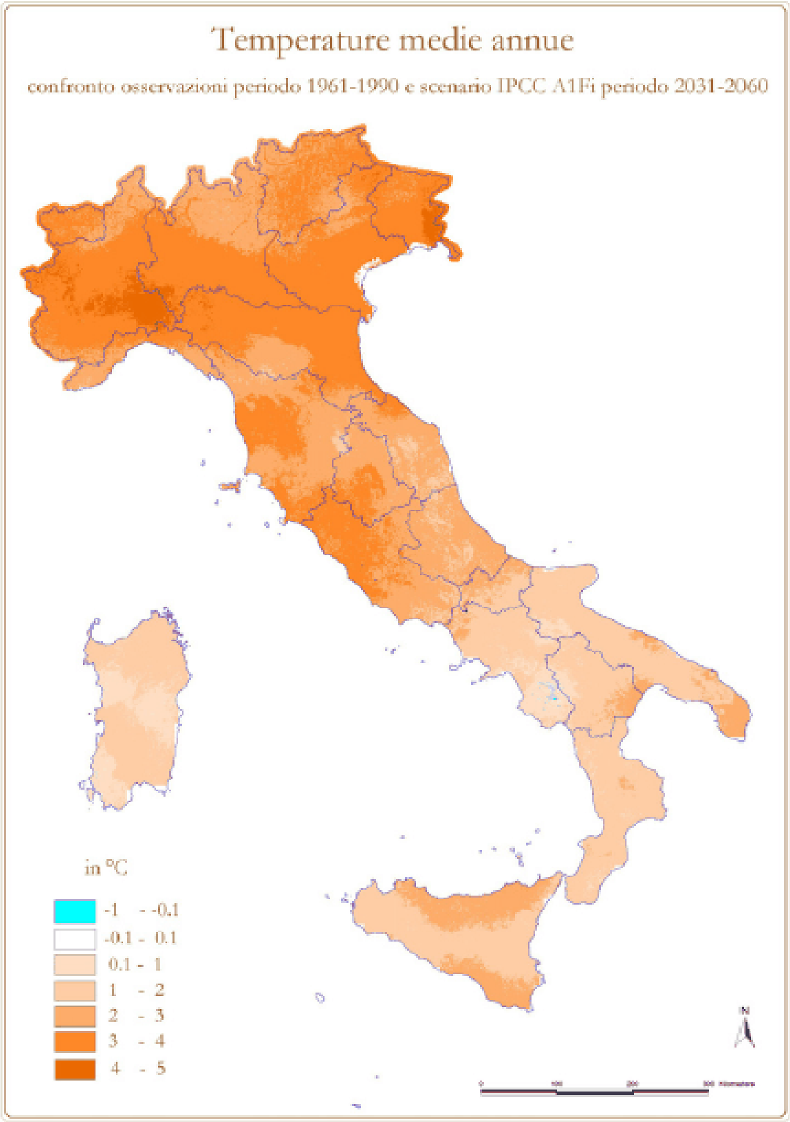


METHODS

2031 - 2060

2071 - 2100

Rainfall distributions: future scenarios



AB11Fi

METHODS

2031 - 2060

2071 - 2100

Temperature distributions: future scenarios

Database IN.DE.FO (1995) State Forestry Department

(Investigation of the Decay of Forests 3547 forest plots)

Importance Value (IV) of a species *x*:

$$IV_x = [(diam._x / diam.tot) \times 100 + (num._x / num.tot) \times 100]$$

Forest data

Climatic data

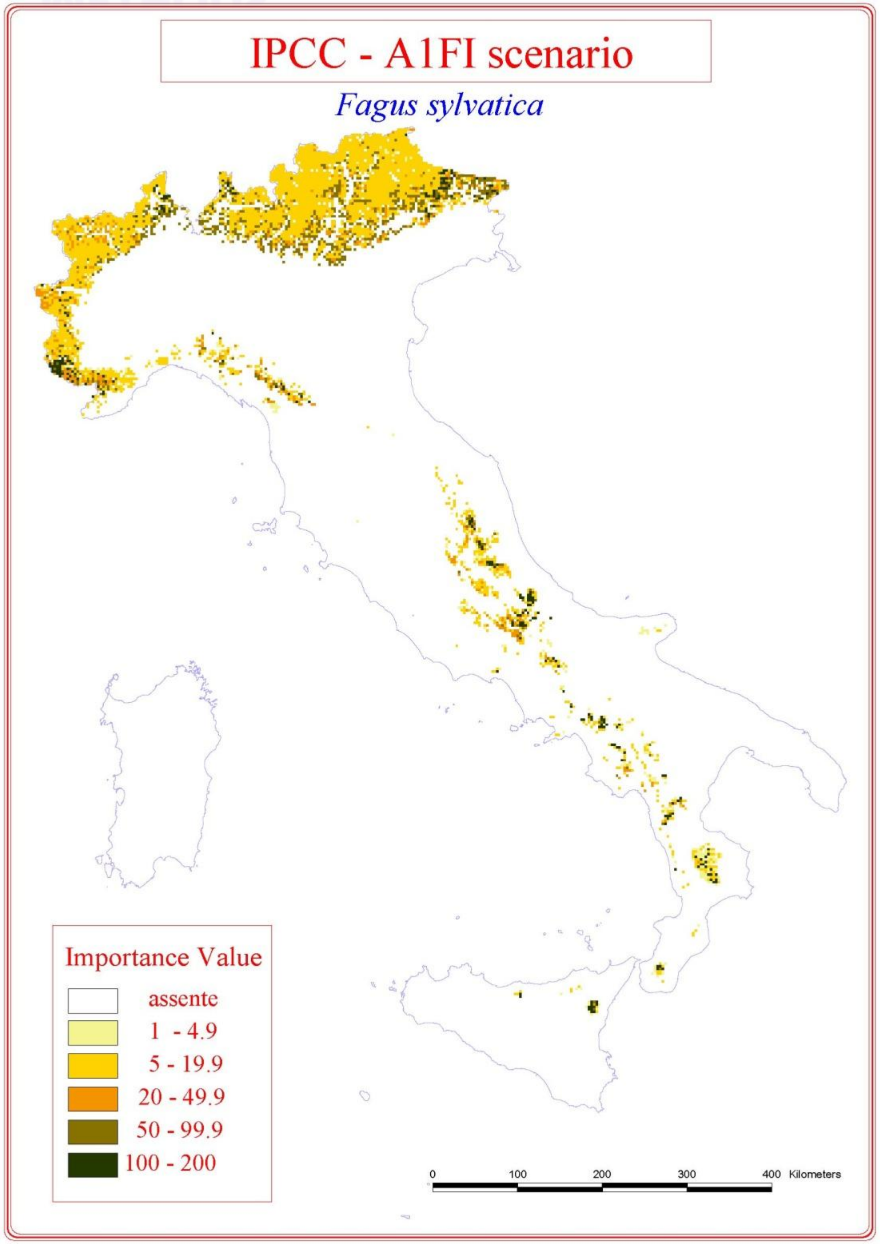
Environmental data

→ Matrix of 30840 plots placed at the top of a 3 km x 3 km grid

→ Suitability index made on the basis of Corine Land Cover ←

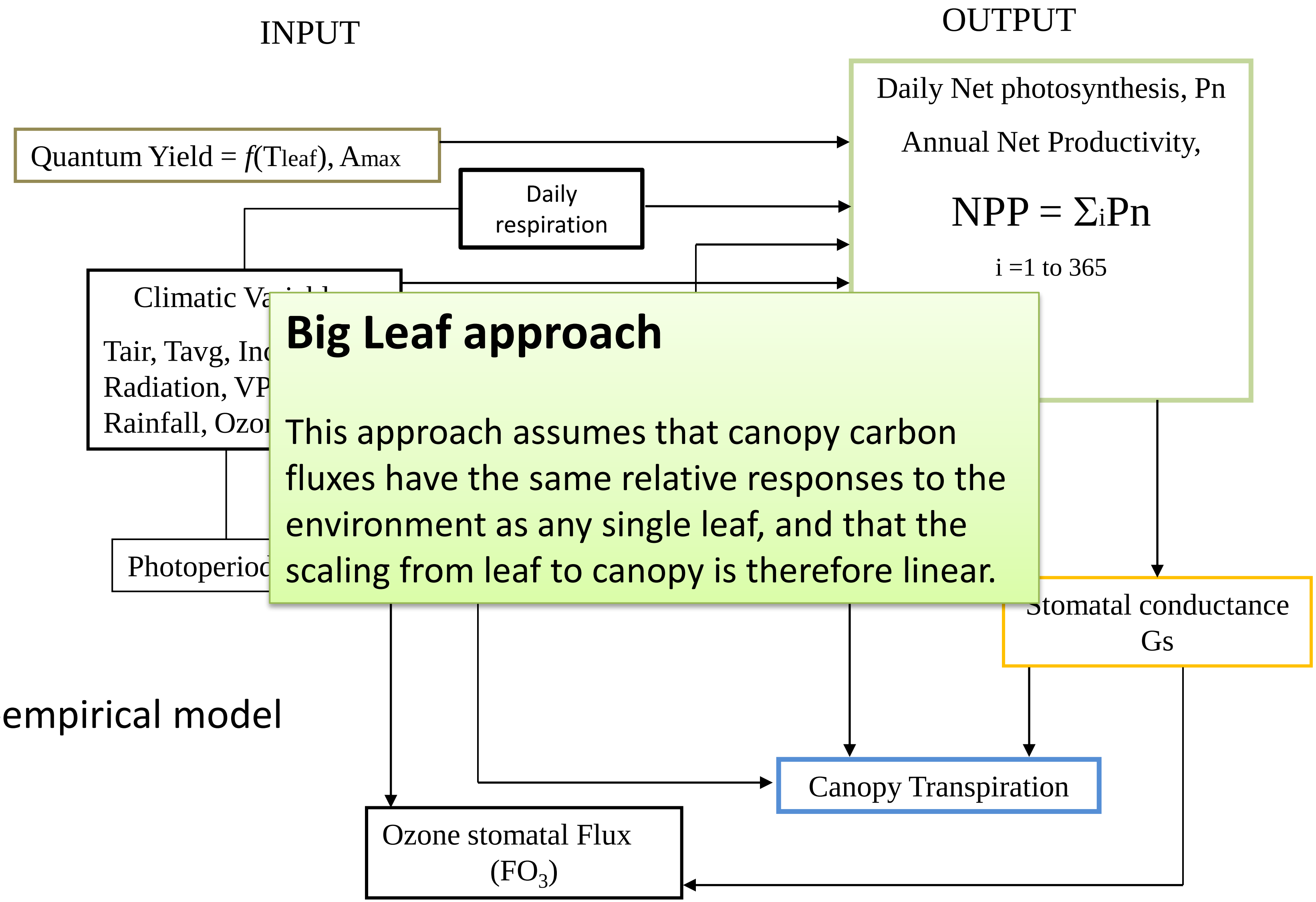
Random Forest statistical approach → <u>current and future potential distribution of tree species in Italy</u>: *Fagus sylvatica*, *Quercus cerris*, *Quercus ilex*

METHODS



Fagus sylvatica
Quercus cerris
Quercus ilex

MO.C.A. (Model for Carbon Assessment)



Big Leaf approach

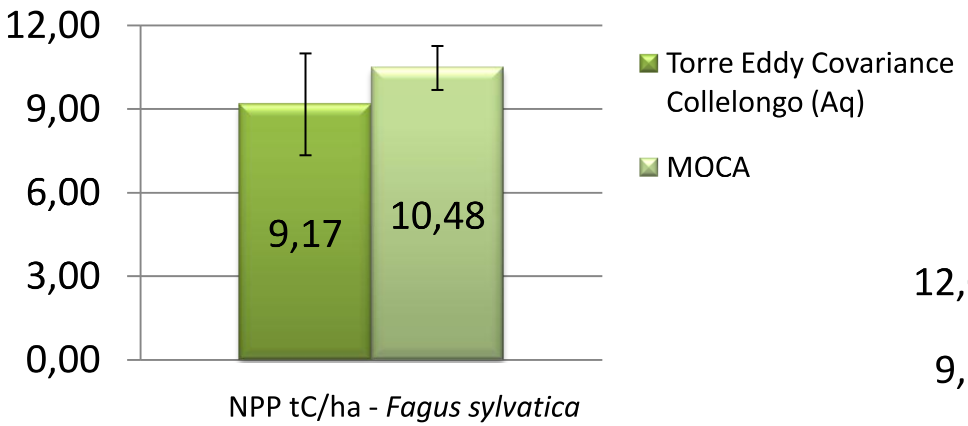
This approach assumes that canopy carbon fluxes have the same relative responses to the environment as any single leaf, and that the scaling from leaf to canopy is therefore linear.

Semi-empirical model

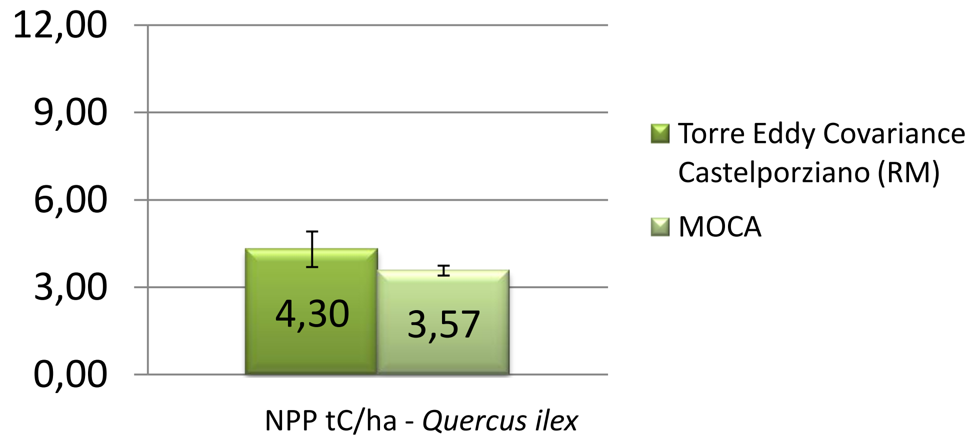
METHODS

Validation

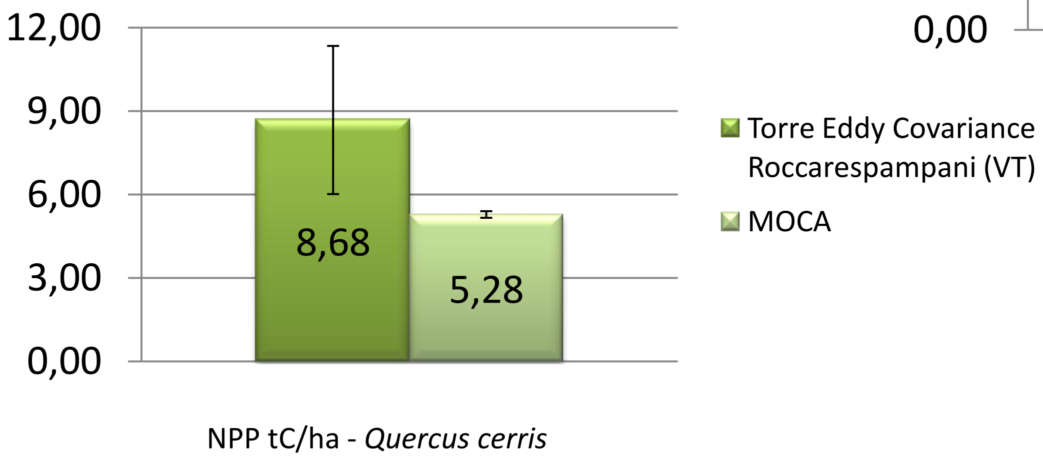
Torre Eddy Covariance Collelongo vs MO.C.A.



Torre Eddy Covariance Castelporziano vs MO.C.A.

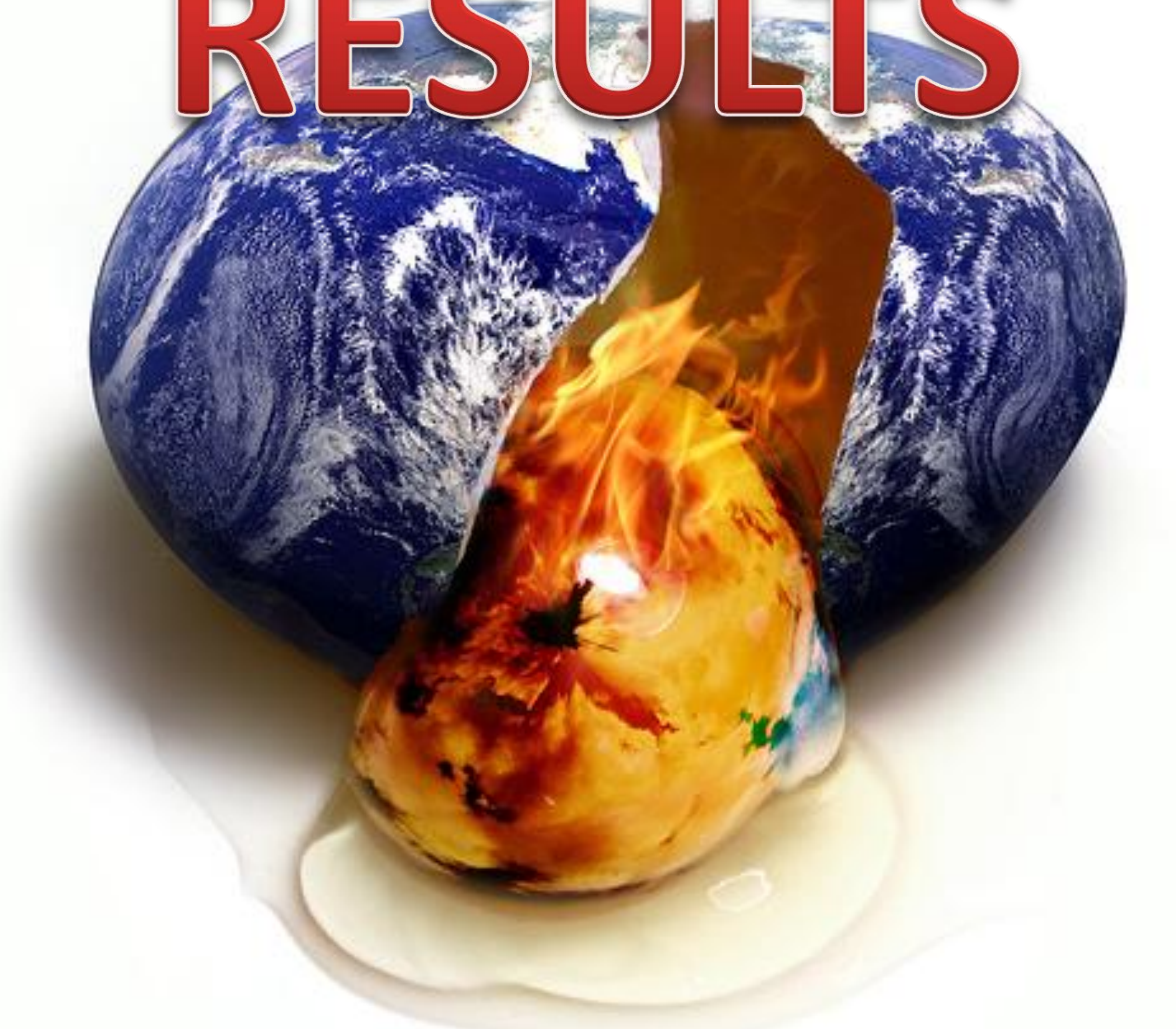


Torre Eddy Covariance Roccarespampani vs MO.C.A.

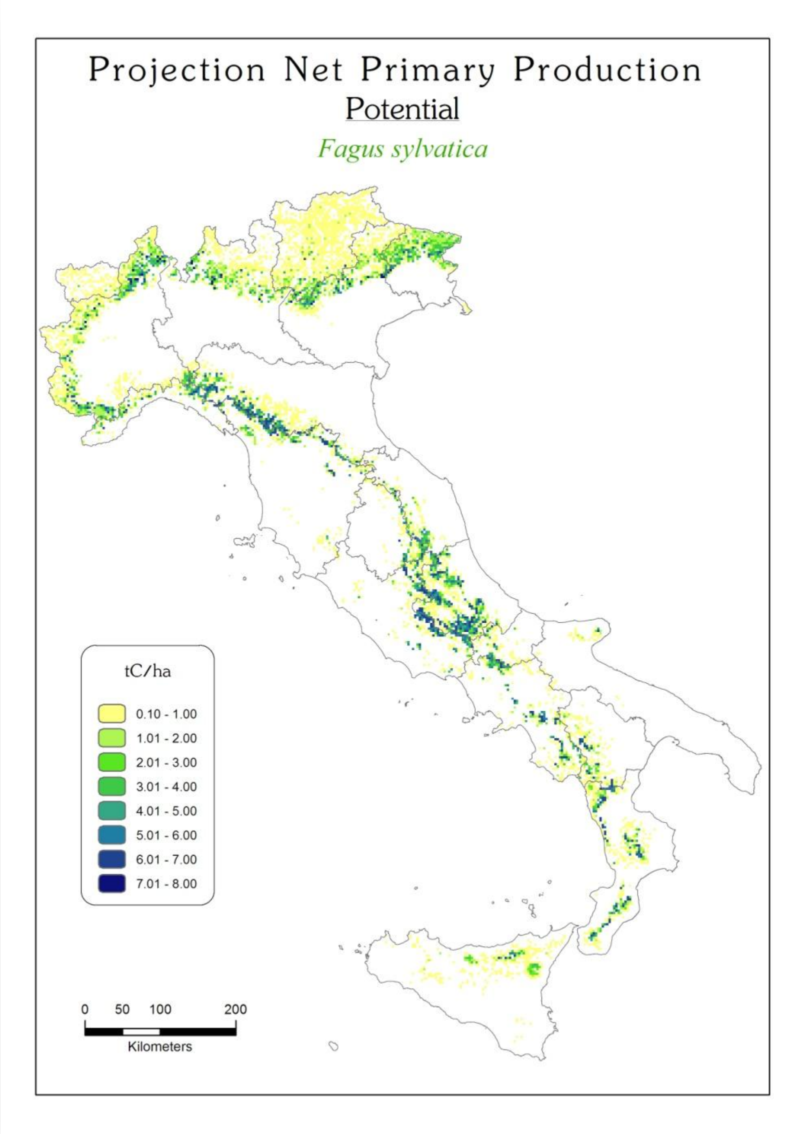


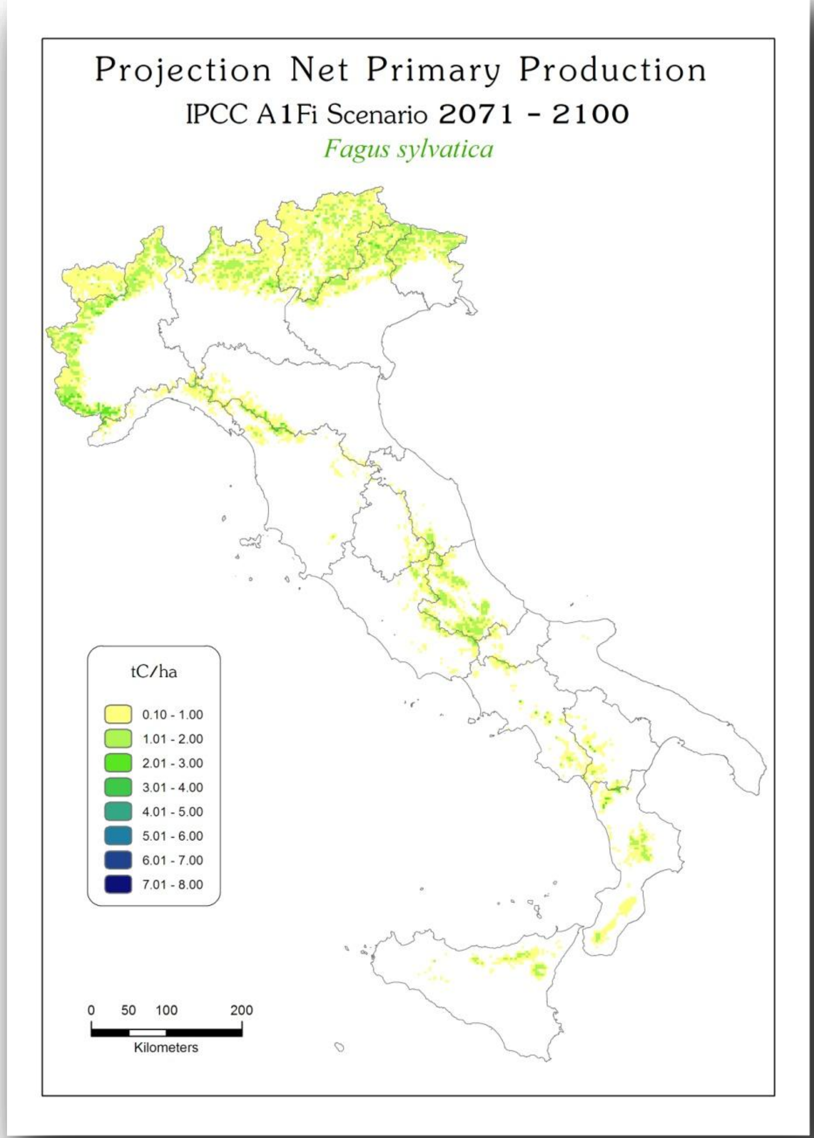
Time Range:
2000 - 2005

RESULTS

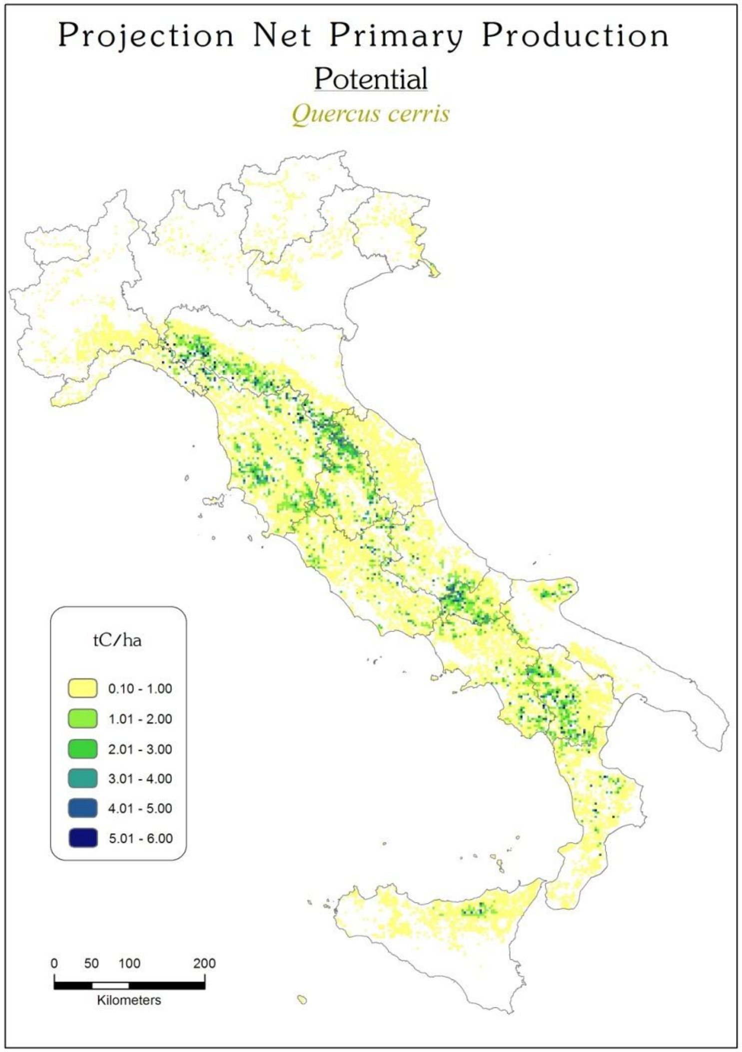


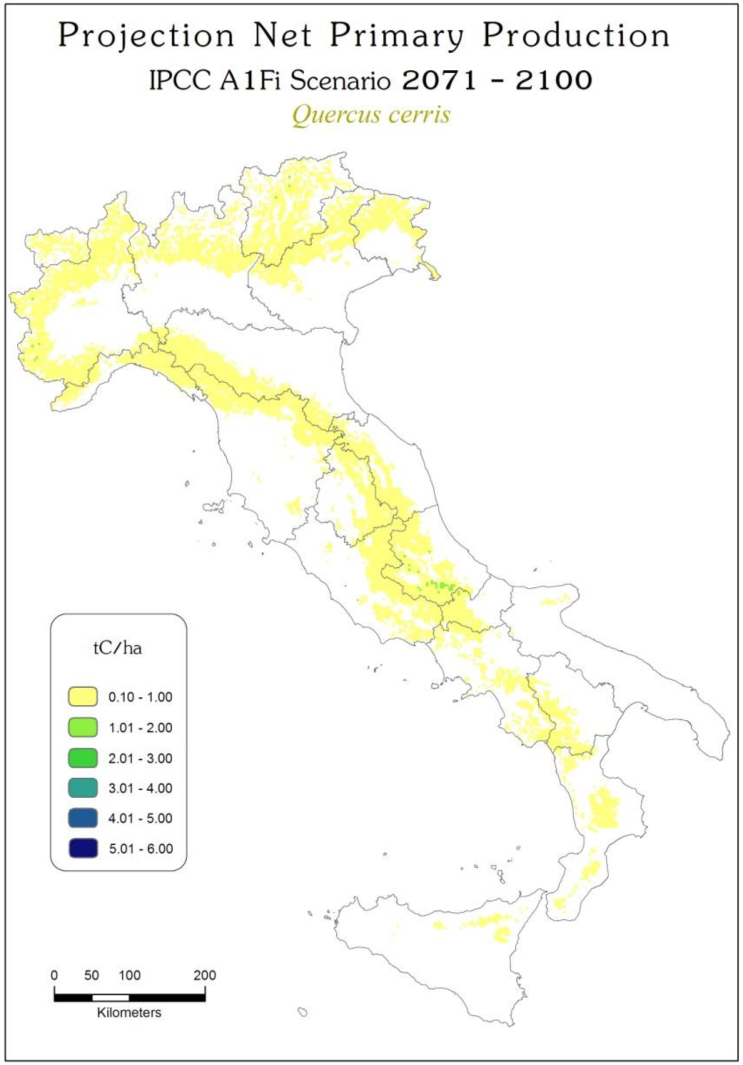
NPP distribution maps current and future scenarios



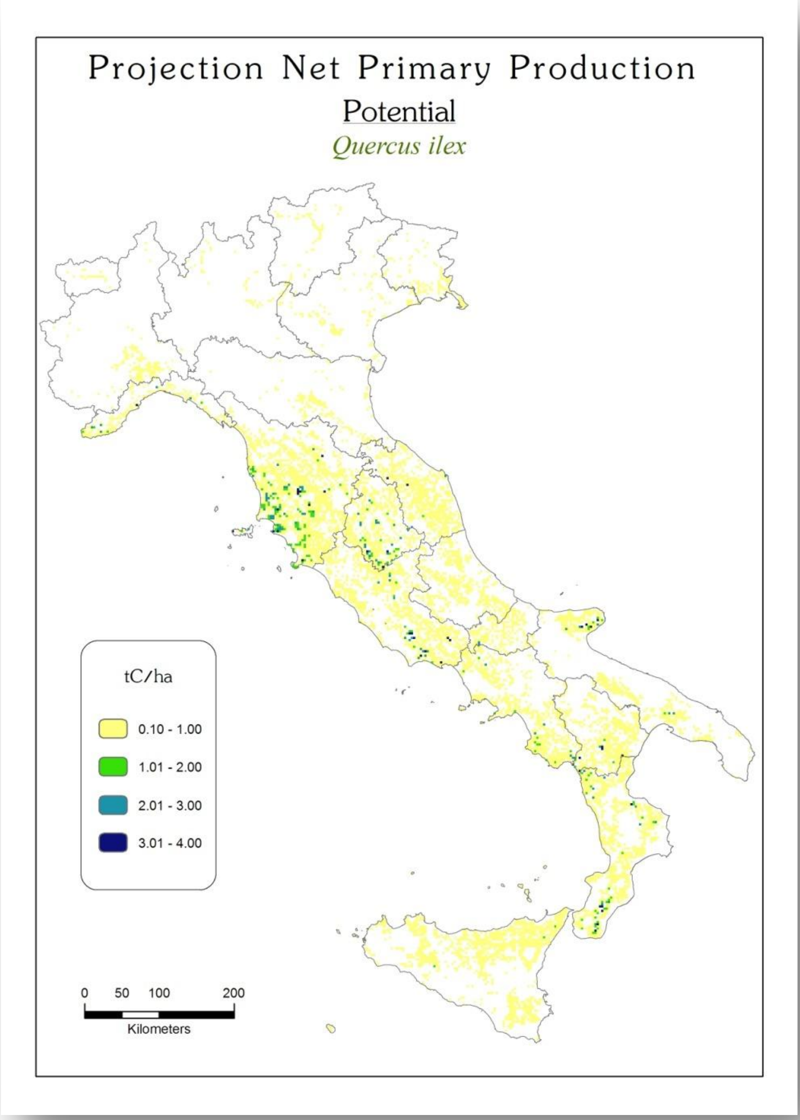


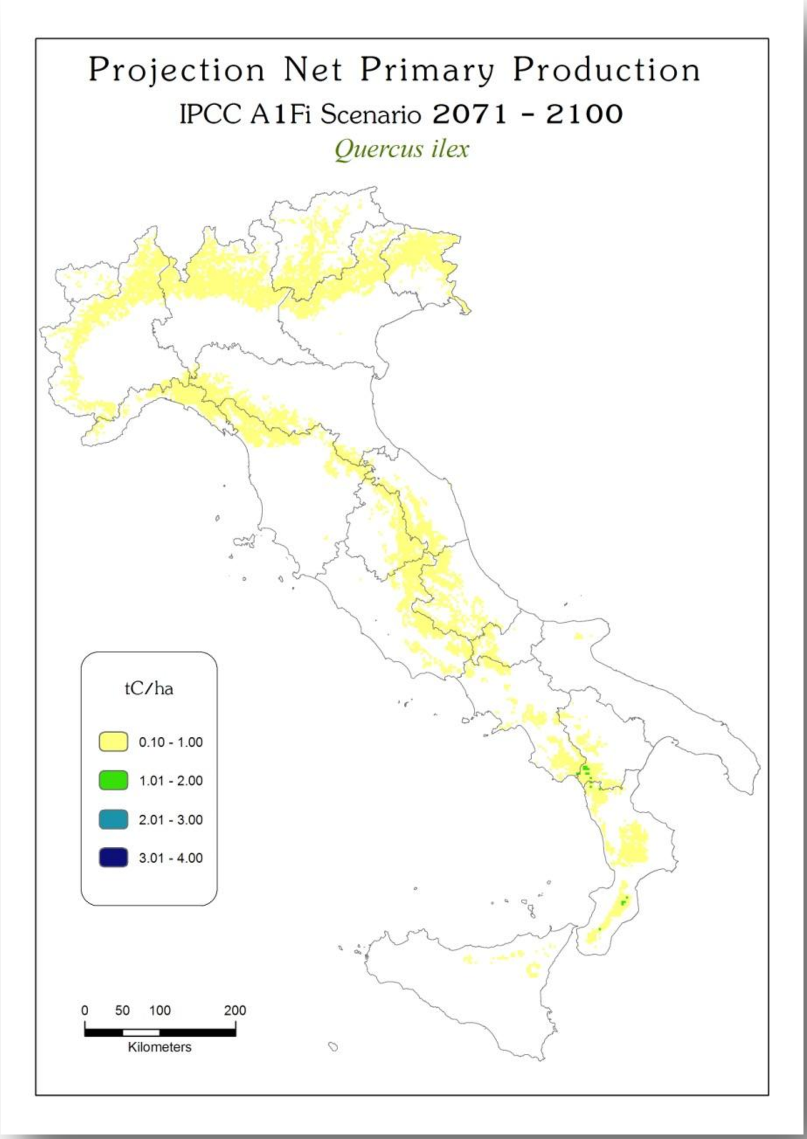
NPP distribution maps current and future scenarios

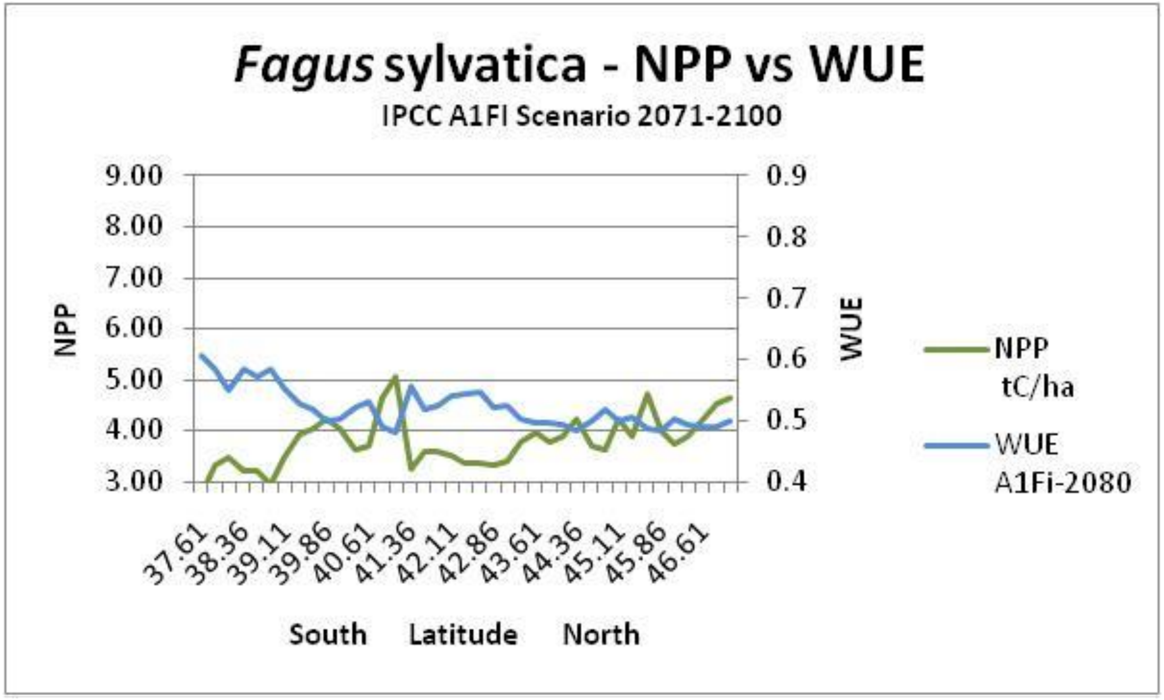




NPP distribution maps current and future scenarios

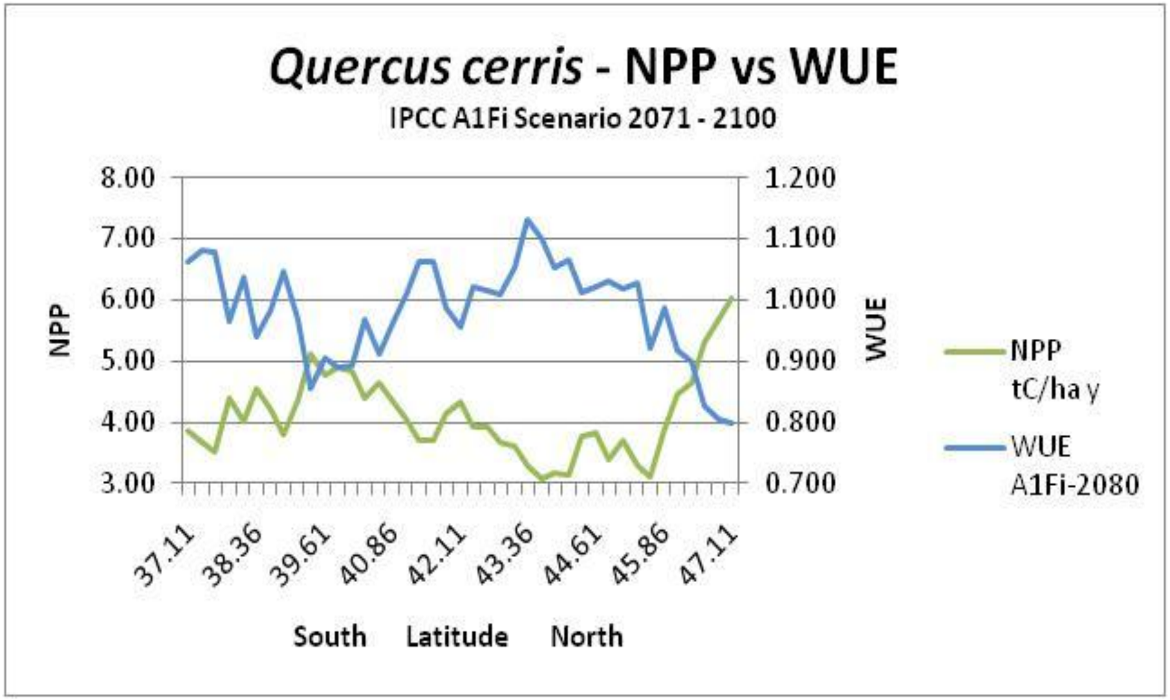






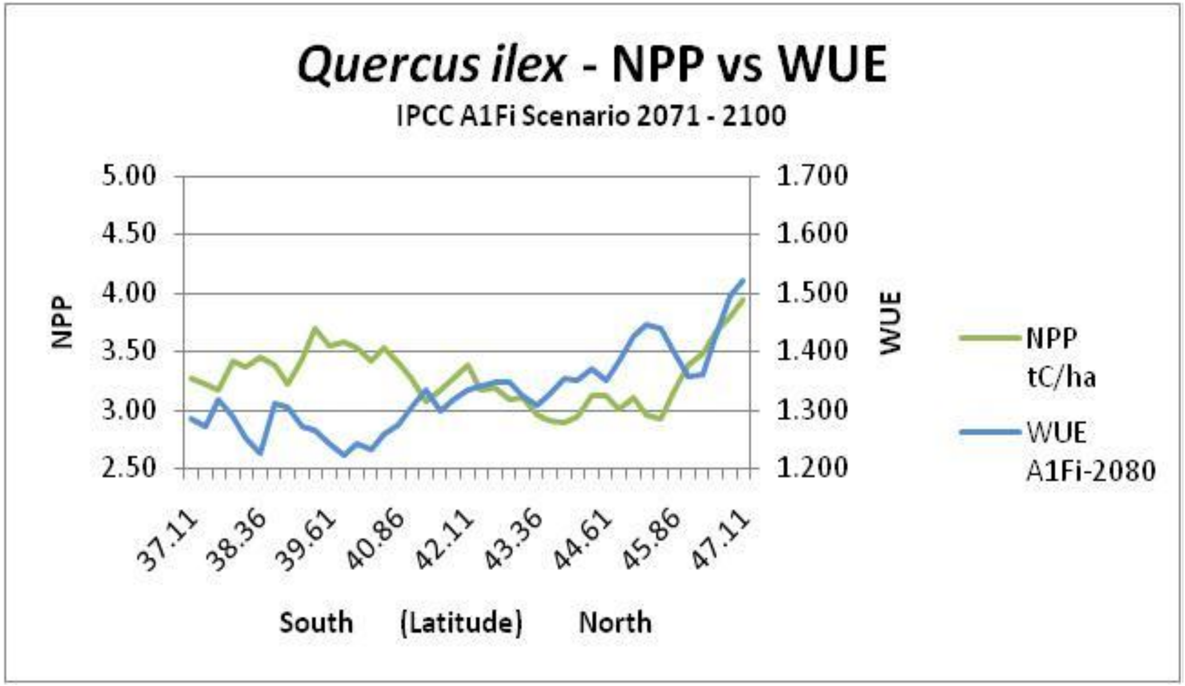
The difference percentages calculated between 1961-90 and 2071-2100 B1 scenario range from -40% to -25%, showing greater reduction in the pre-Alps areas (-41%) and northern Apennines (-37%).

Similar values have been calculated for difference between 1961-90 and 2071-2100 A1FI scenario.



Quercus cerris shows increasing difference percentages of WUE in the 2017-2100 B1 scenario with respect to the 1961-90 one. The most representative frequency class ranges between 7% and 15% and it is characterizing the northern and central Apennines, whereas in the southernmost part of Apennines the difference percentages range from -5% to 3%.

The increasing trend of the difference percentages appears also under the 2071-2100 A1FI scenario with the most representative frequency class ranging from 25% to 30% and similar geographical localizations to the B1 climatic scenario.



The difference percentages calculated for *Quercus ilex* between 1961-90 and 2071-2100 B1 scenarios range from -8% to -2%, showing greater reduction in the central and southern Apennines.

However, these differences remain at similar values for the 2071-2100 A1FI scenario, although they are higher than the difference between the 2071-2100 B1 and 61-90 scenario, ranging between -4% and 6%.

Q. ilex was the best adapted to drought stress among plant species considered here. The higher drought resistance of *Q. ilex* is based on a <u>drought-tolerant water-saving strategy</u>, due to the morpho-anatomic characteristics of the sclerophyllous leaves and their longer physiological functioning in time, to low transpiration rates, and to the root system which is able to adapt and to resist to dehydrated soils.

(Levitt, 1980; Manes et al. 2006

Furthermore, the higher WUE values of *Q. ilex* under limiting climatic scenarios with respect to the other two species point out a well adapted functional mechanism to maintain a positive carbon gain by the activation of "alternative ways" to dissipate the excess of incoming radiant energy, such as the increase of photorespiration rates.

(Zaragoza-Castells et al. 2008; Rennenberg et al. 2006)

Q. cerris showed a progressive reduction of NPP and transpiration rates under limiting scenarios, due to the closure of stomata which are sensitive to change of evaporative demand between plant and atmosphere.

However, under water stress the stomatal closure could be due to the reduction of the stem/root hydraulic conductance and to the variation of soil water availability.

(Cochard et al. 1996, 2000; Nardini et al. 1999; Bréda et al. 1993)

An integrated mechanism seems to be involved for the limitation of water loss when soil water dehydration becomes more intense; high evaporative demand becomes just as important as the state of dehydration of the soil which directly affects the root ability to water uptake.

(Manes et al. 2006)

However, WUE values do not increase in the B1 and A1FI scenarios, pointing out a <u>non conservative water strategy</u>. This could affect the distribution pattern of *Quercus cerris* and, in turn, its ability to fix carbon under limiting conditions.

F. sylvatica, shows different adaptive abilities to counteract the climate change, adopting a water spender strategy, that is typical for species growing in mesophilous environments, but it could represent a risk for survival of plant populations when environmental conditions extremely change.

It is worth to note that remaining surface area under the 2017-2100 A1FI scenario is 65% with respect to 1961-90, pointing out a scarce possibility to shift to higher altitudes.

(Attorre et al. 2011)

As a consequence, *F. sylvatica* may be seriously threaten by climate change in Italy, being also subjected to a strong reduction of NPP.

Final remark

It seems that in a warmer and drier environment, as the one projected for the Mediterranean areas for the following decades, the performance of the dominant species, as *F. sylvatica* and *Q. ilex*, could be less competitive with respect to the other more drought and heat resistant species such as the co-dominant *Pistacia latifolia* for *Q. ilex*; as a general rule, the temporal dynamics of progressive physiological adjustments counteracting the environmental limiting factors (high temperature and drought increase) seem to play a fundamental role for determining competitive abilities against other co-occurring plant species under Mediterranean limiting conditions, affecting thus the final distribution patterns of plant species.

Thank you for your attention !