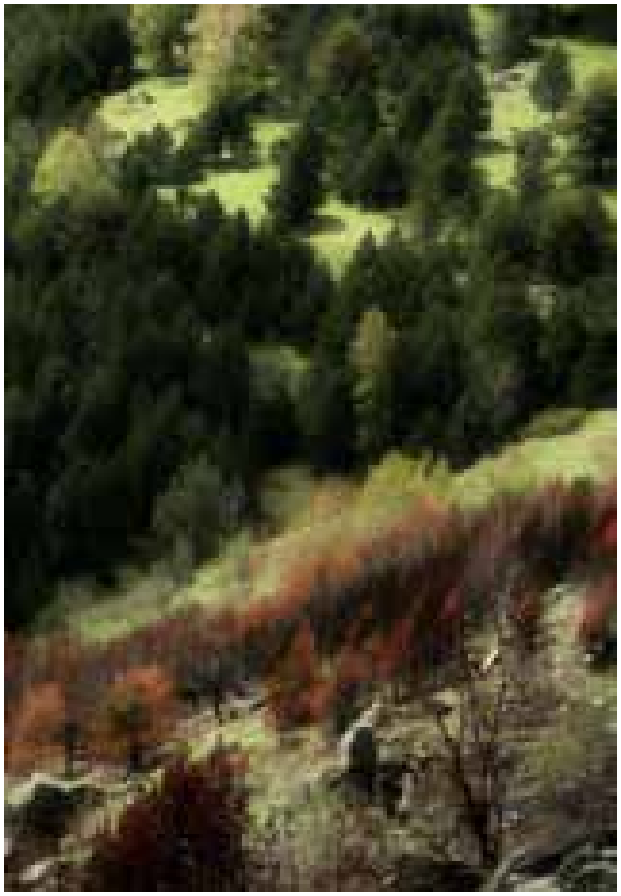
Climate change impacts on water availability. Adaptive options.

Eduard Pla and Diana Pascual, CREAF

ForClimAdapt Seminar

Solsona, 15th October 2012

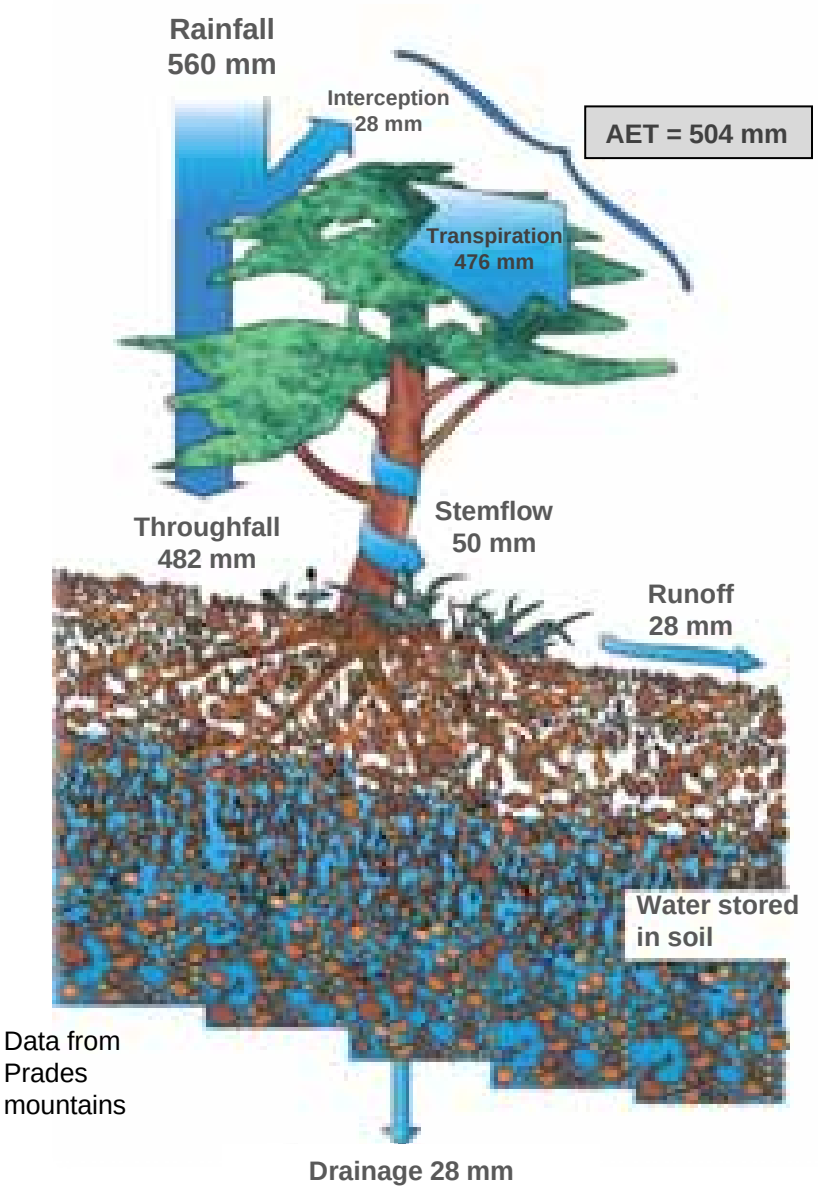


- Global Change impacts in the Mediterranean basin
- Results of previous water related projects
- Suggestions for forest adaptive options

- Global Change impacts in the Mediterranean basin

Impacts in the Mediterranean basin

Water balance in a Mediterranean forest

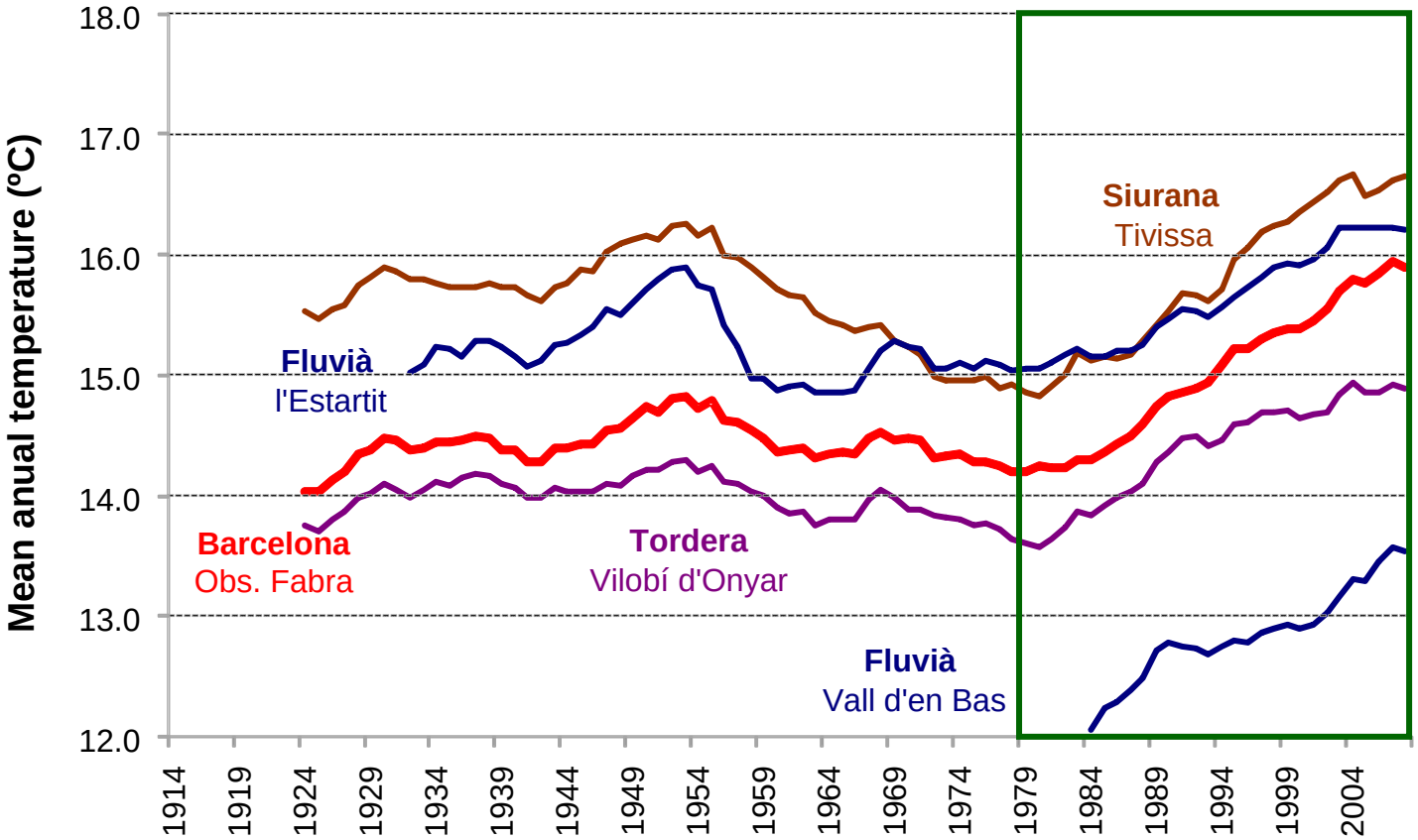


In the Mediterranean forests, **Actual Evapotranspiration** (AET) could represent **80-90%** of annual precipitation

Source: Gracia *et al.* 2008

Impacts in the Mediterranean basin

Observed temperature trends (1914-2008)

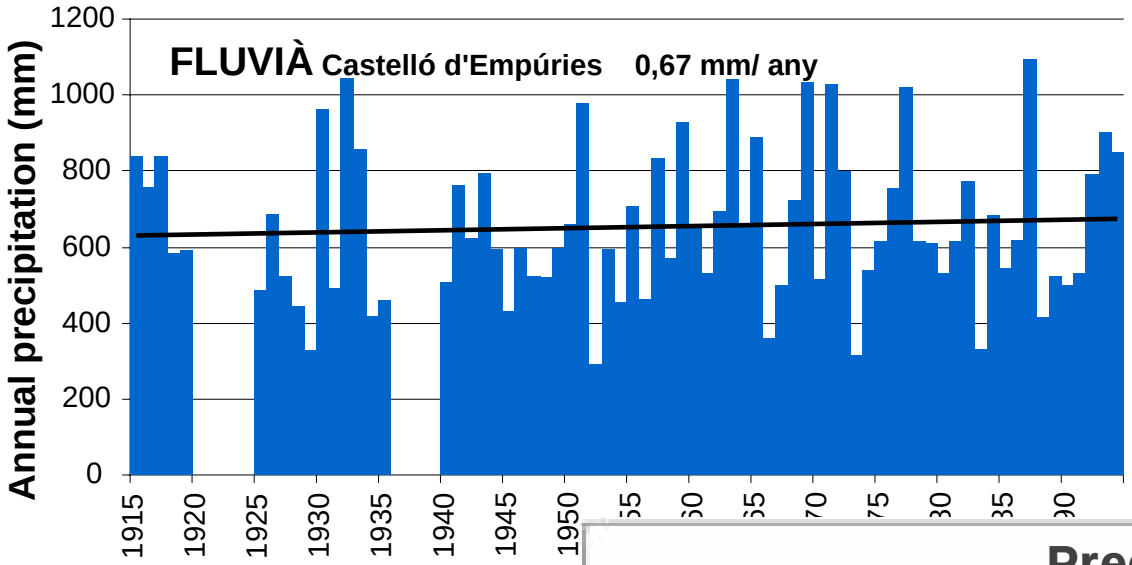


A **1.9 ºC** temperature increase since **1979** has been monitored at three watersheds in Catalonia

Source: ACCUA project. SMC and NESATv2 data base from Climate Change Research Group. Universitat Rovira i Virgili.

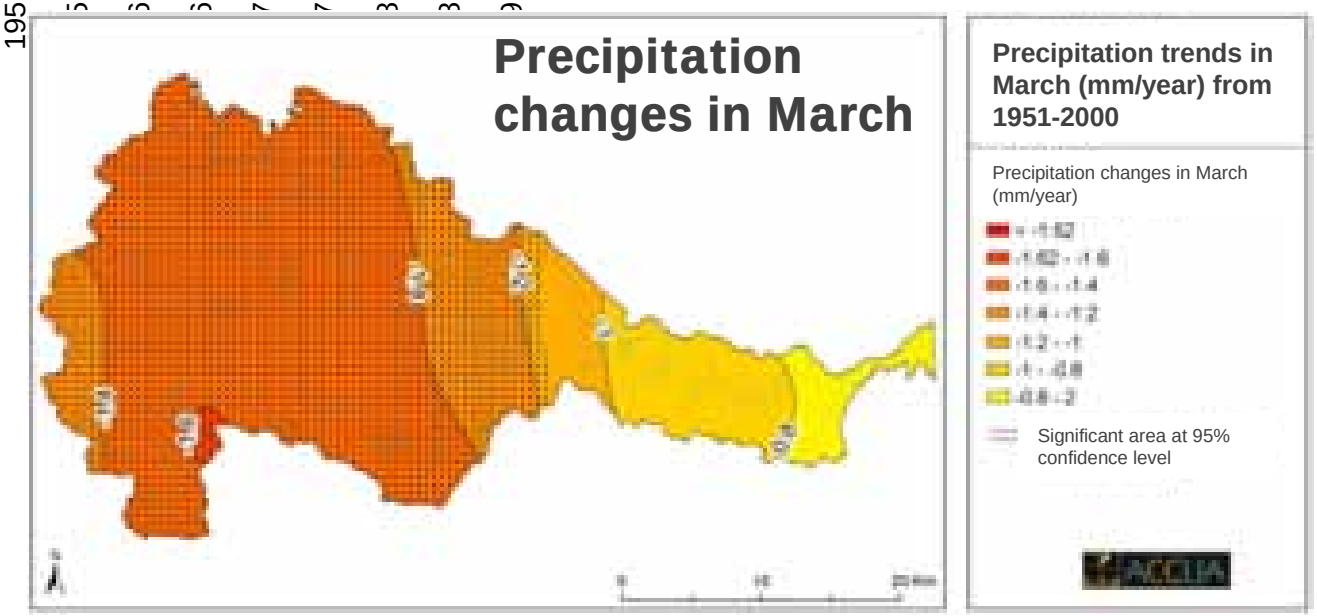
Impacts in the Mediterranean basin

Observed precipitation trends



No significant **changes** in annual precipitation...

...but **significant** changes in certain **months**

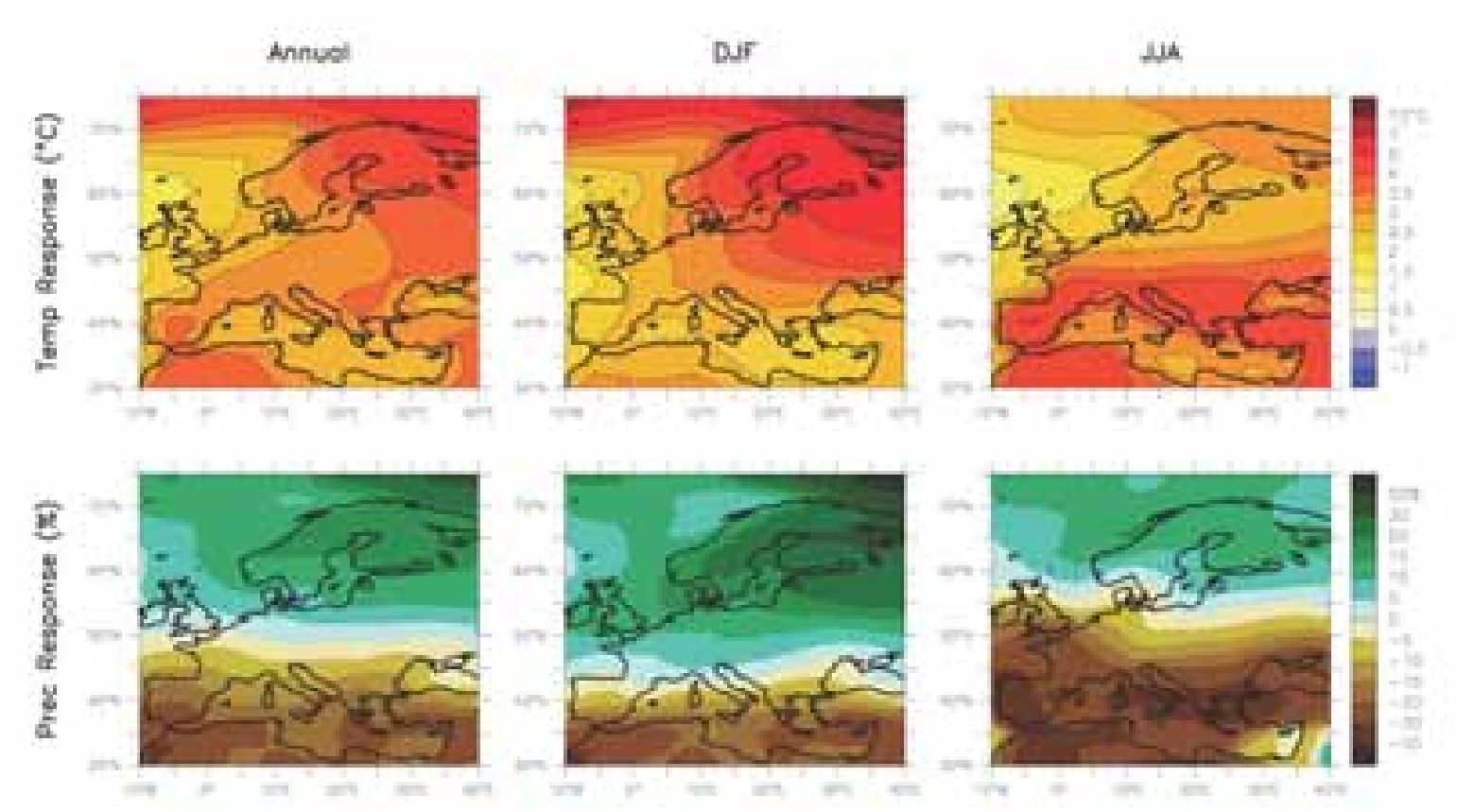


Impacts in the Mediterranean basin

Future climate: temperature and rainfall projections

Annual mean, DJF and JJA temperature change between 1980 to 1999 and 2080 to 2099, averaged over 21 models (A1B scenario)

Annual mean, DJF and JJA fractional precipitation change between 1980 to 1999 and 2080 to 2099, averaged over 21 models (A1B scenario)



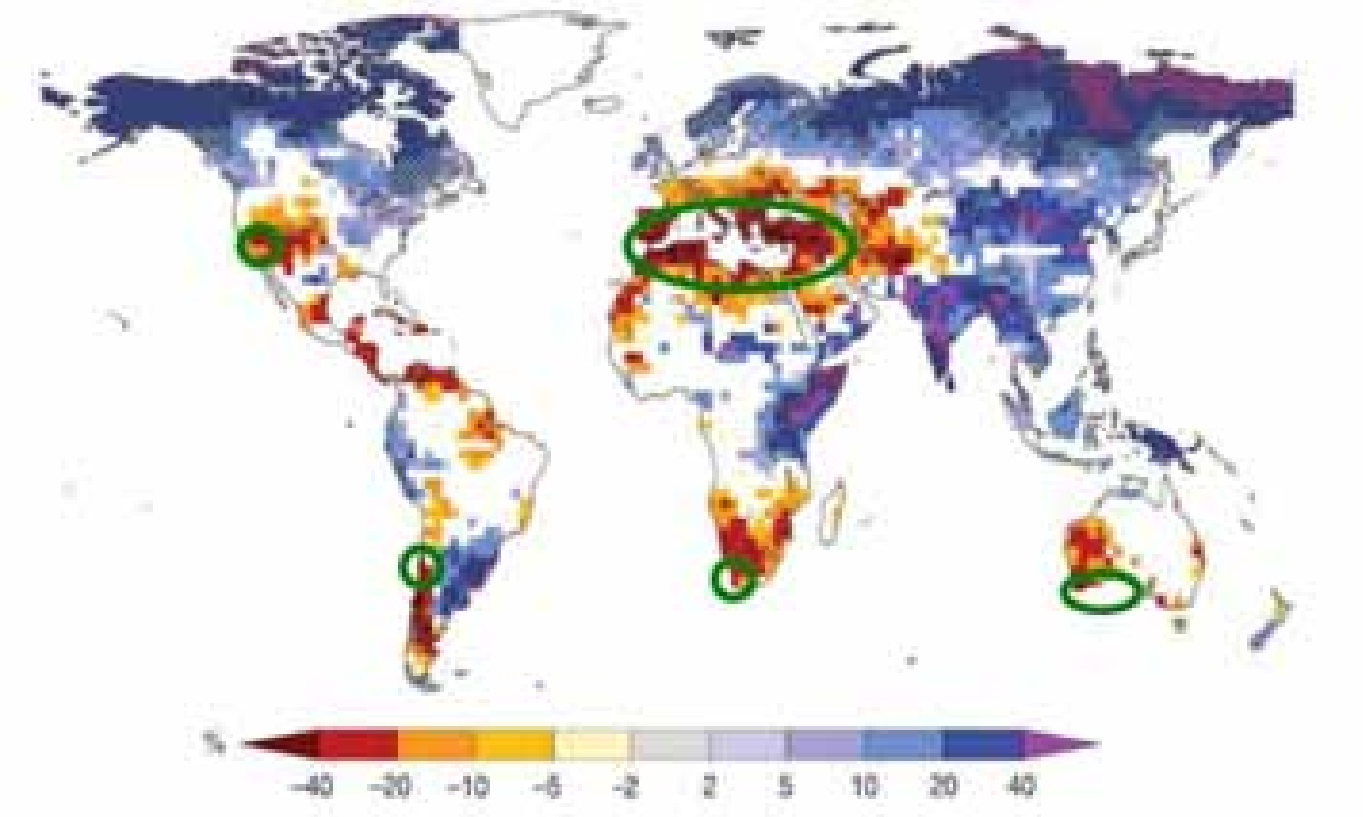
Mediterranean basin could become one of the **most vulnerable areas** to climate change in Europe

Source: Climate Change 2007
Fourth IPCC Assessment Report

Impacts in the Mediterranean basin

Changes in water resources

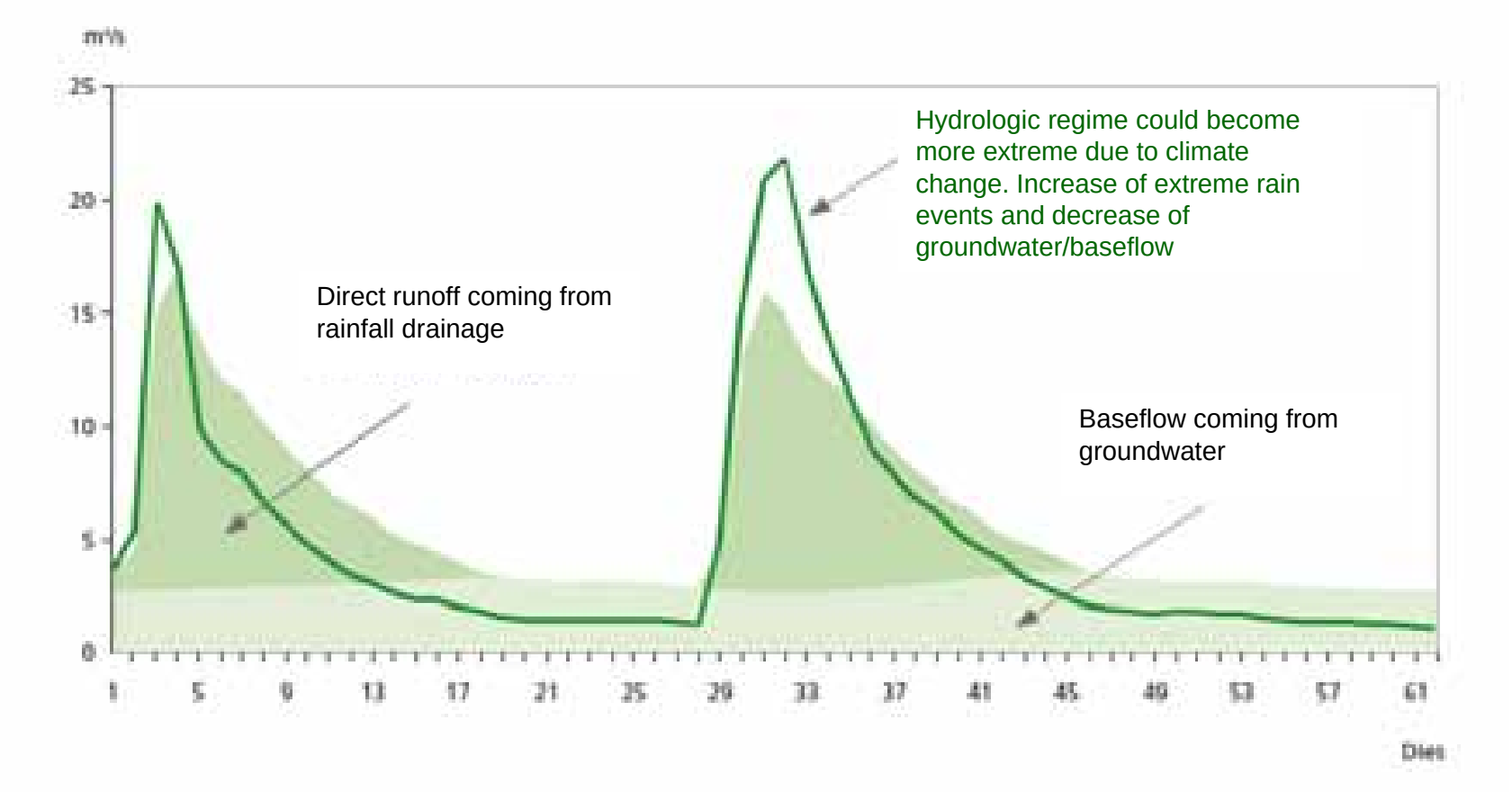
Changes in **annual runoff** for 2090-99 period, relative to 1980-99



Source: Climate Change and Water 2008. IPCC Technical Paper VI

Impacts in the Mediterranean basin

Expected changes in stream flow pattern



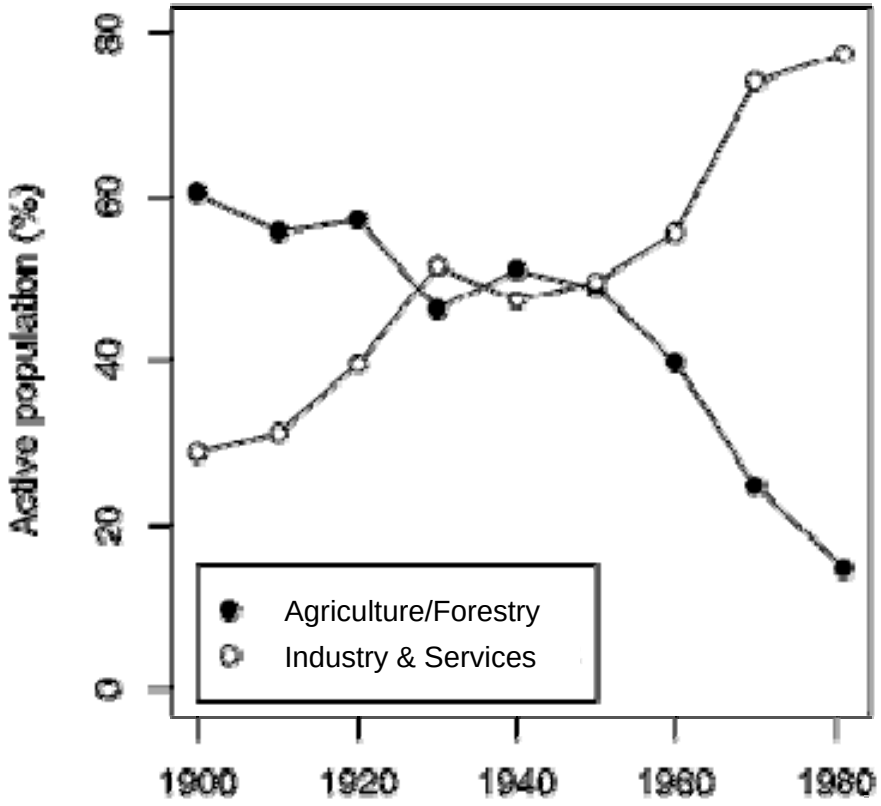
Source: ACA 2009

Impacts on Mediterranean basin

There are also important land use changes in the North rim

Agricultural land abandonment

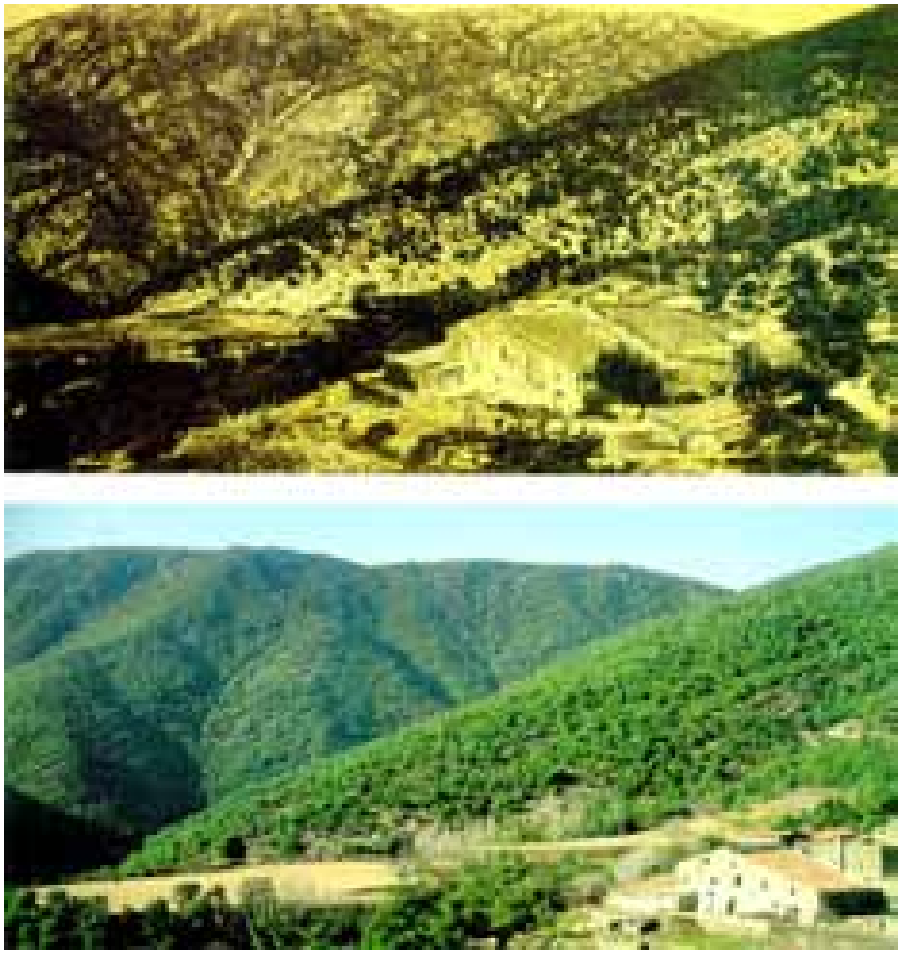
Forest management changes



Impacts in the Mediterranean basin

Changes which imply a forest surface increase

MONTSENY (CATALONIA)

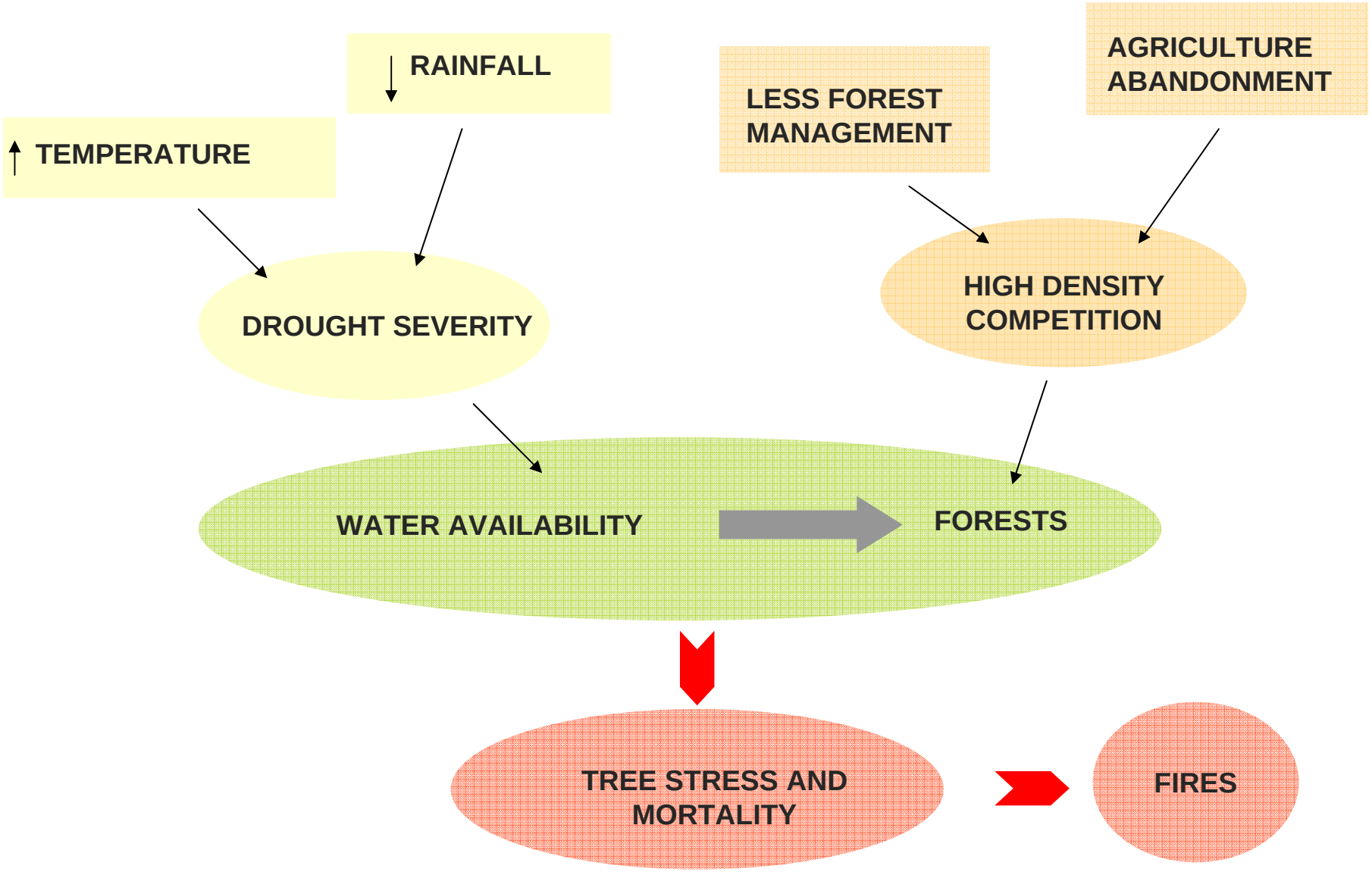


BEFORE

NOW

Impacts in the Mediterranean basin

Forest decline and fire are the main threats

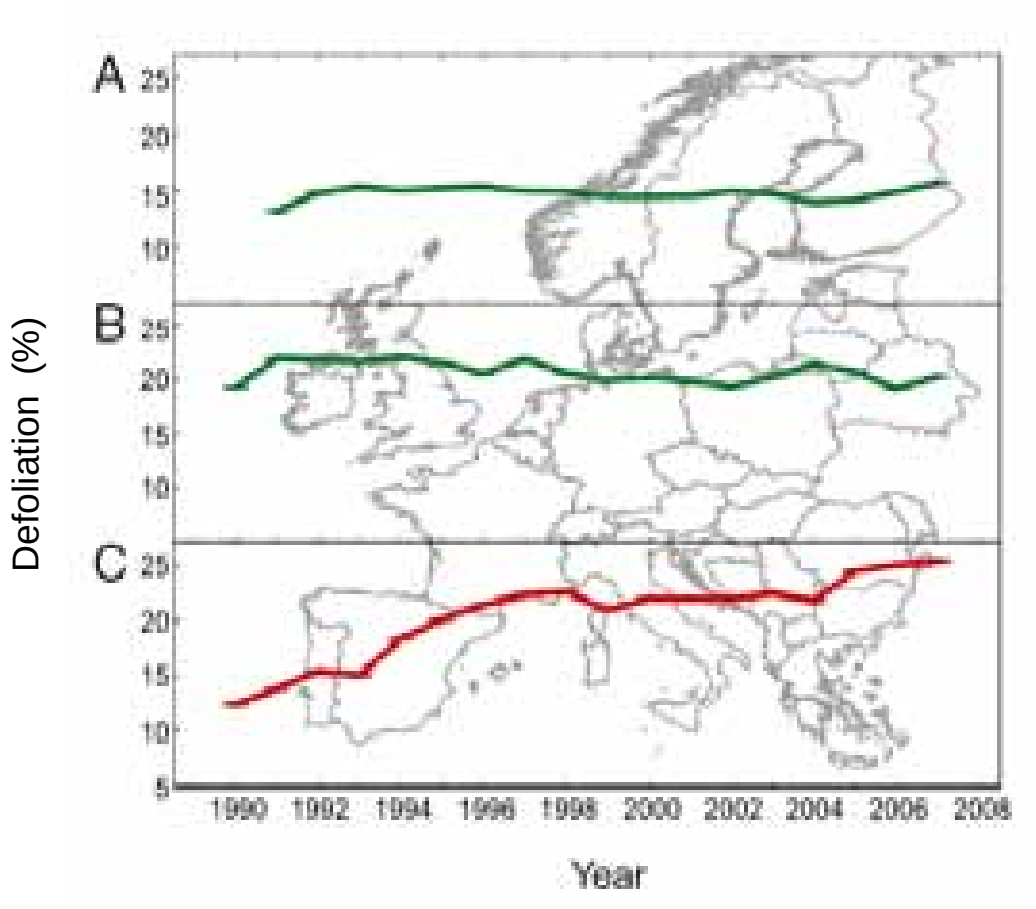


Impacts in the Mediterranean basin

Tree mortality

Impacts in the Mediterranean basin

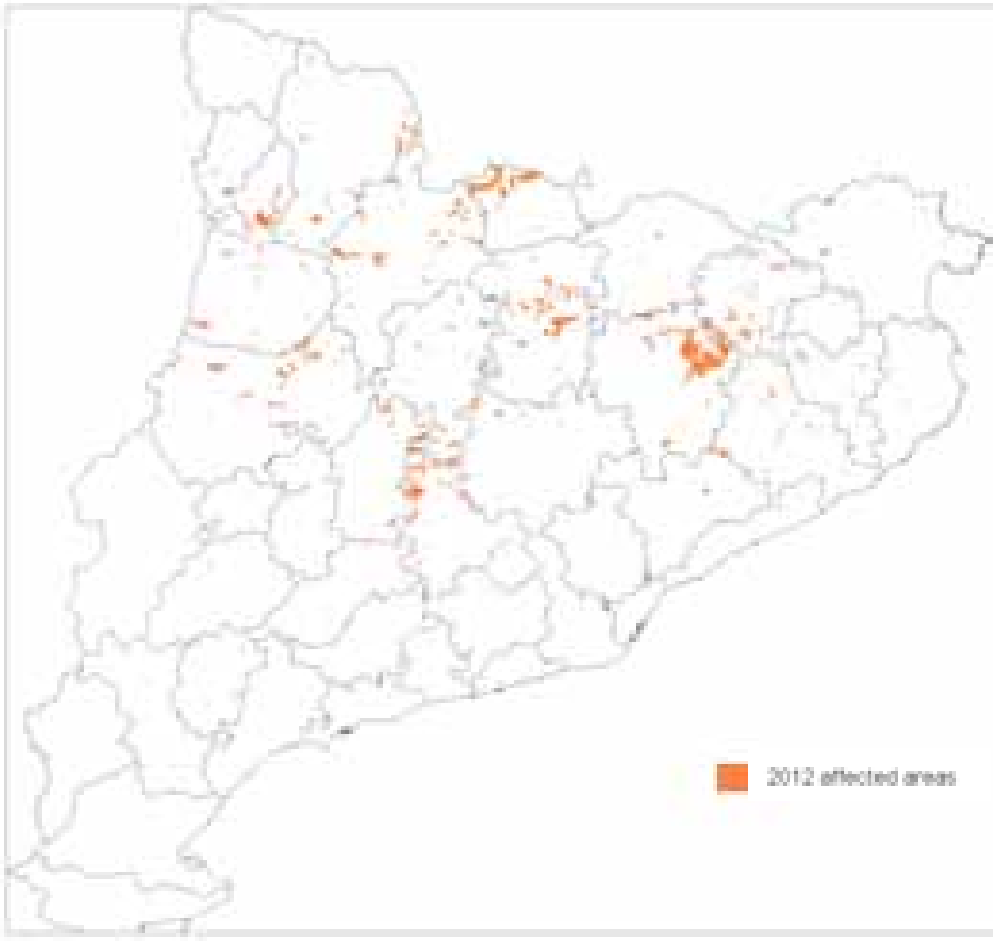
Forest decline



Source: Carnicer *et al.* (2011)

Impacts in the Mediterranean basin

Forest decline in Catalonia



Forest decline:
Areas (> 3 ha)

with ≥5% of tree mortality

and/or

≥ 50% of defoliation/discoloration

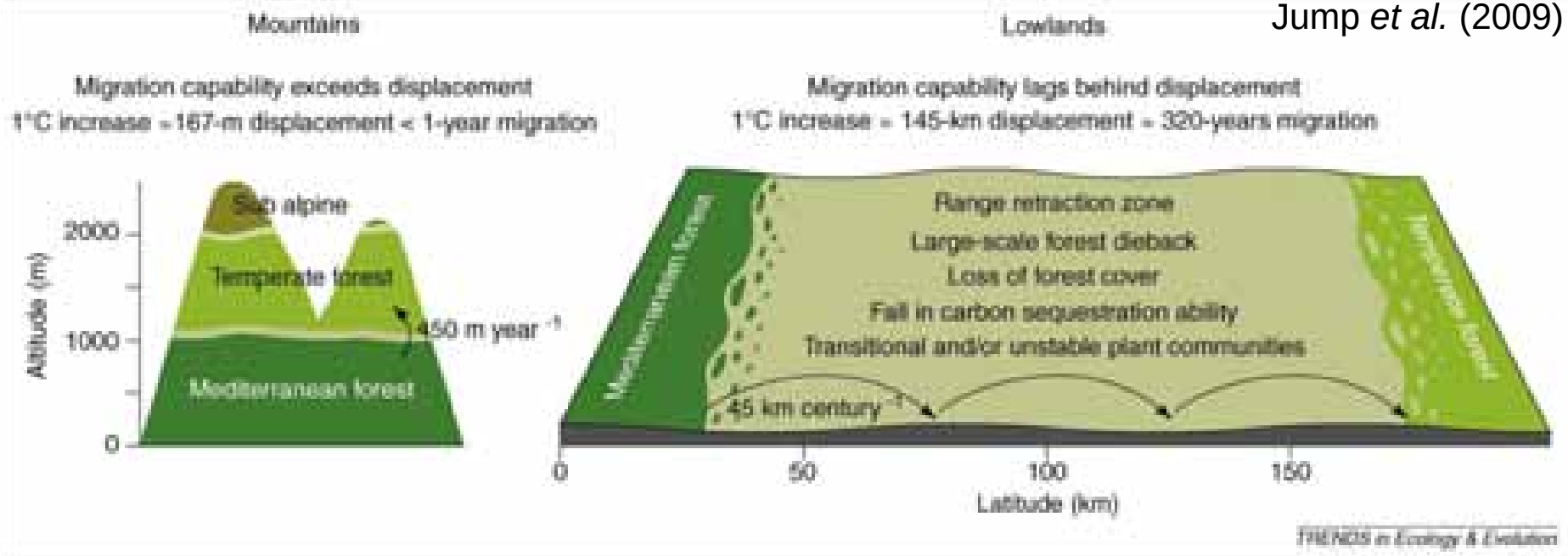
It represents the **3.05%** of the forest area

Source: DeBosCat Project (2012). Direcció General de Medi Natural. Generalitat de Catalunya

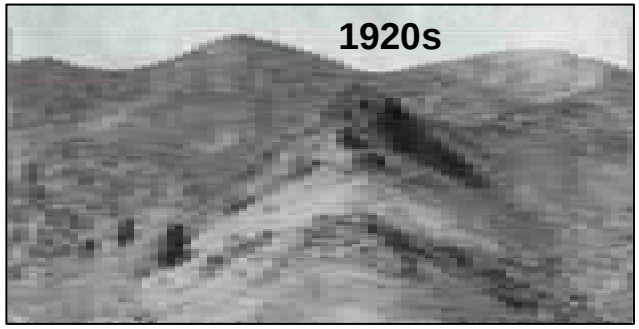
Impacts in the Mediterranean basin

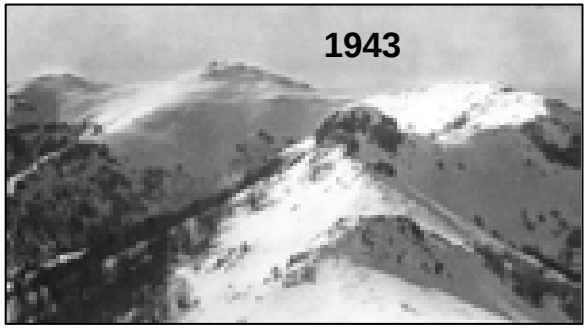
Altitudinal and latitudinal shifts

Jump *et al.* (2009)



Beech at Montseny (Barcelona)

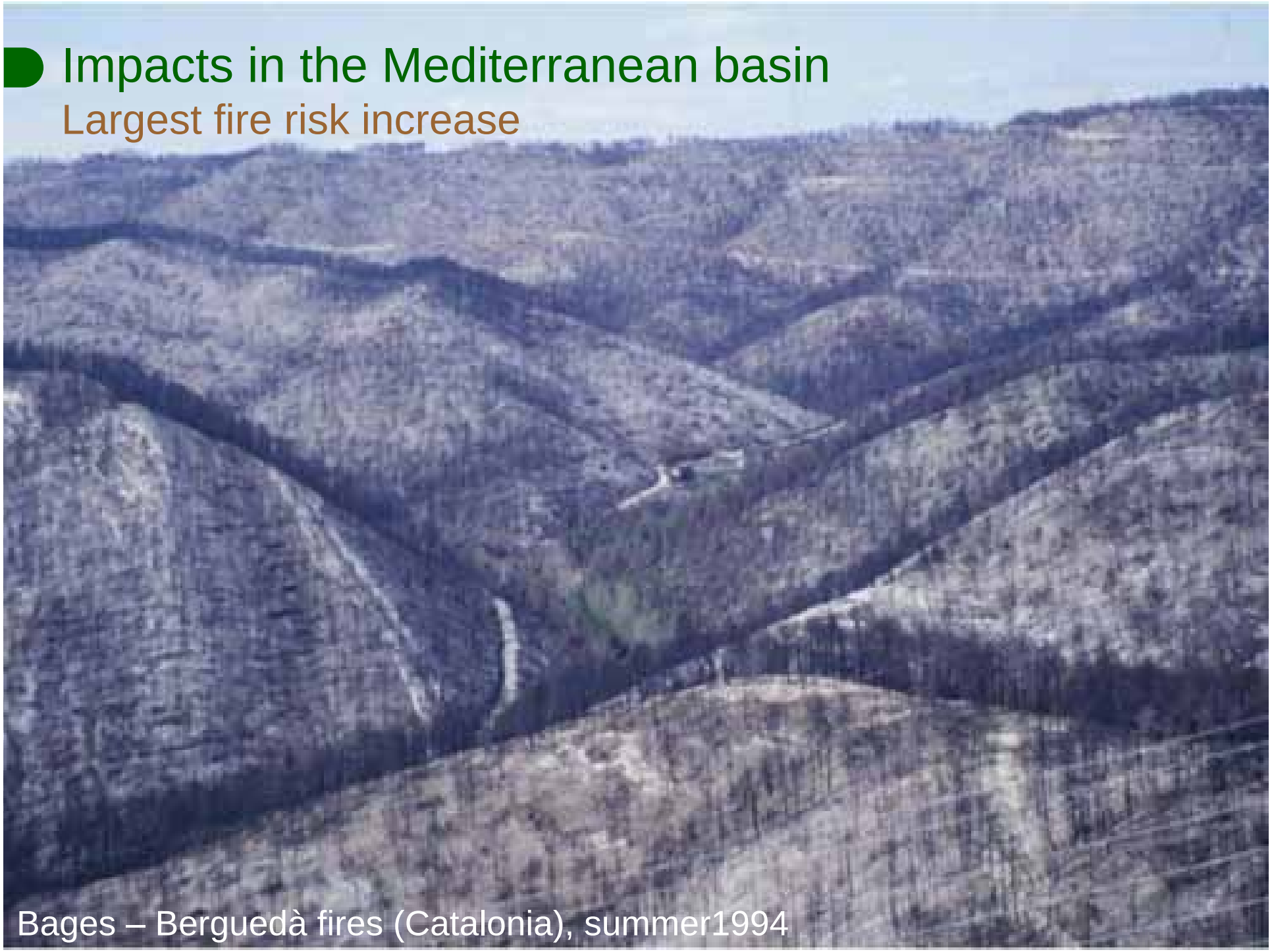




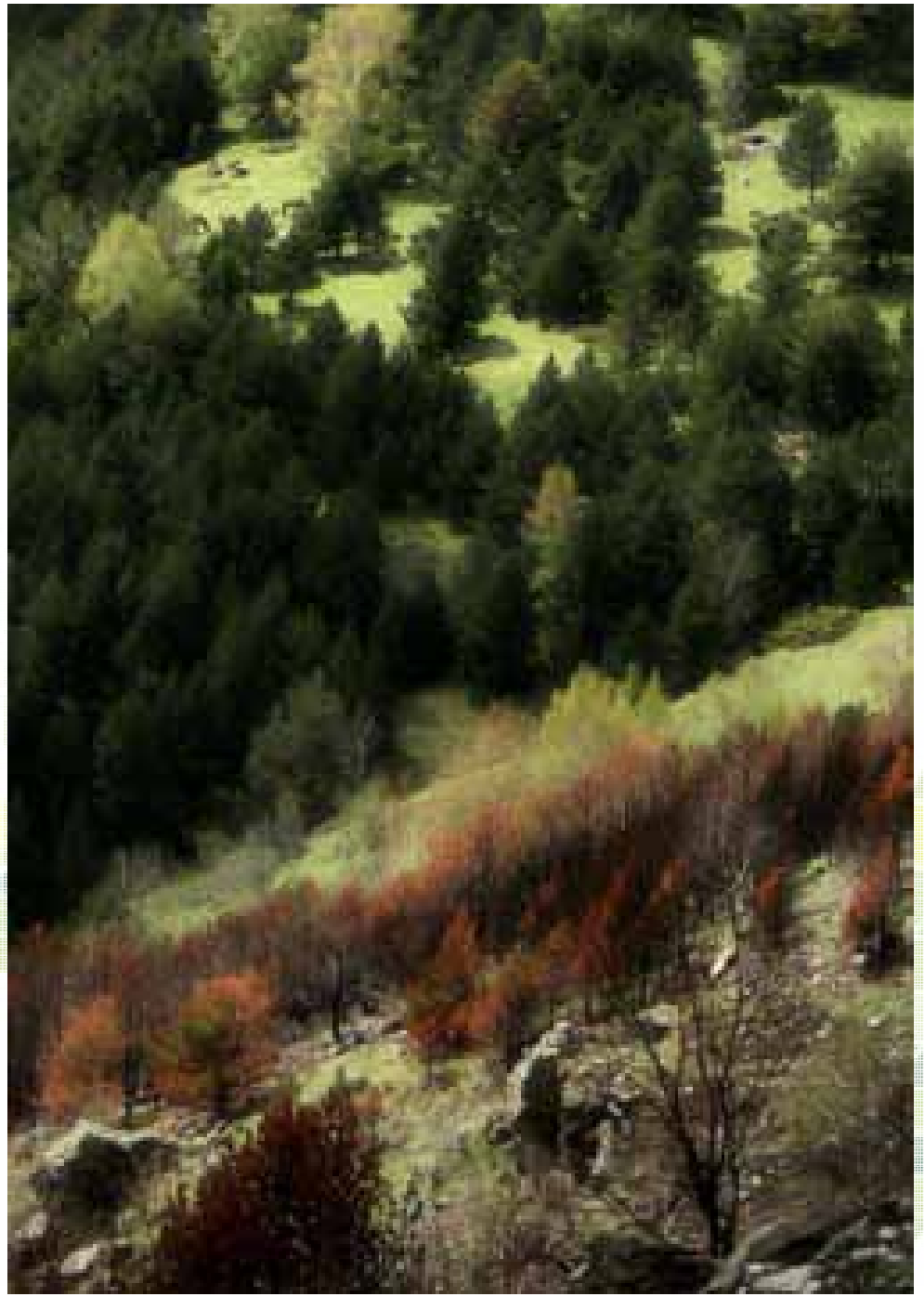
Peñuelas *et al.* (2007)

Impacts in the Mediterranean basin

Largest fire risk increase



Bages – Berguedà fires (Catalonia), summer1994



Results of previous water related projects

- ACCUA
- CLICO
- IFN2-IFN3 comparation

ACCUA project

Impacts on water bodies

RELATIVE STREAM FLOW CHANGES FROM 2006-2030 RESPECT 1984-2008 (%)

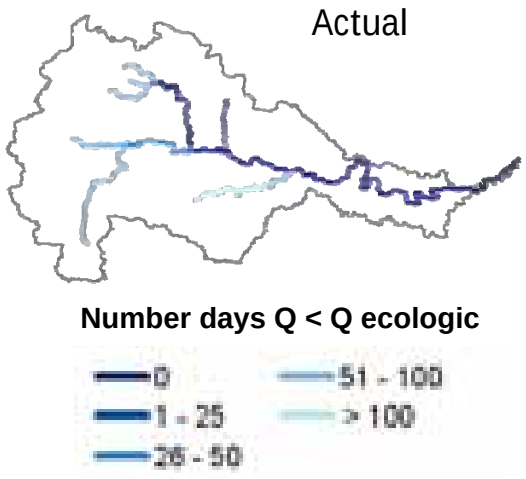
Stream flow variation at the headwater				Stream flow variation at river mouth			
- 8	- 5	+ 9	%	- 5	- 3	- 4	%
-11	- 5	+11	%	- 5	- 2	- 8	%
-20	-11	-11	%	-13	-15	-25	%
-20	-11	-10	%	-13	-14	-29	%
Fluv	Tord	Siu		Fluv	Tord	Siu	

- Generalized **stream flow reduction**, more severe at A2 scenario

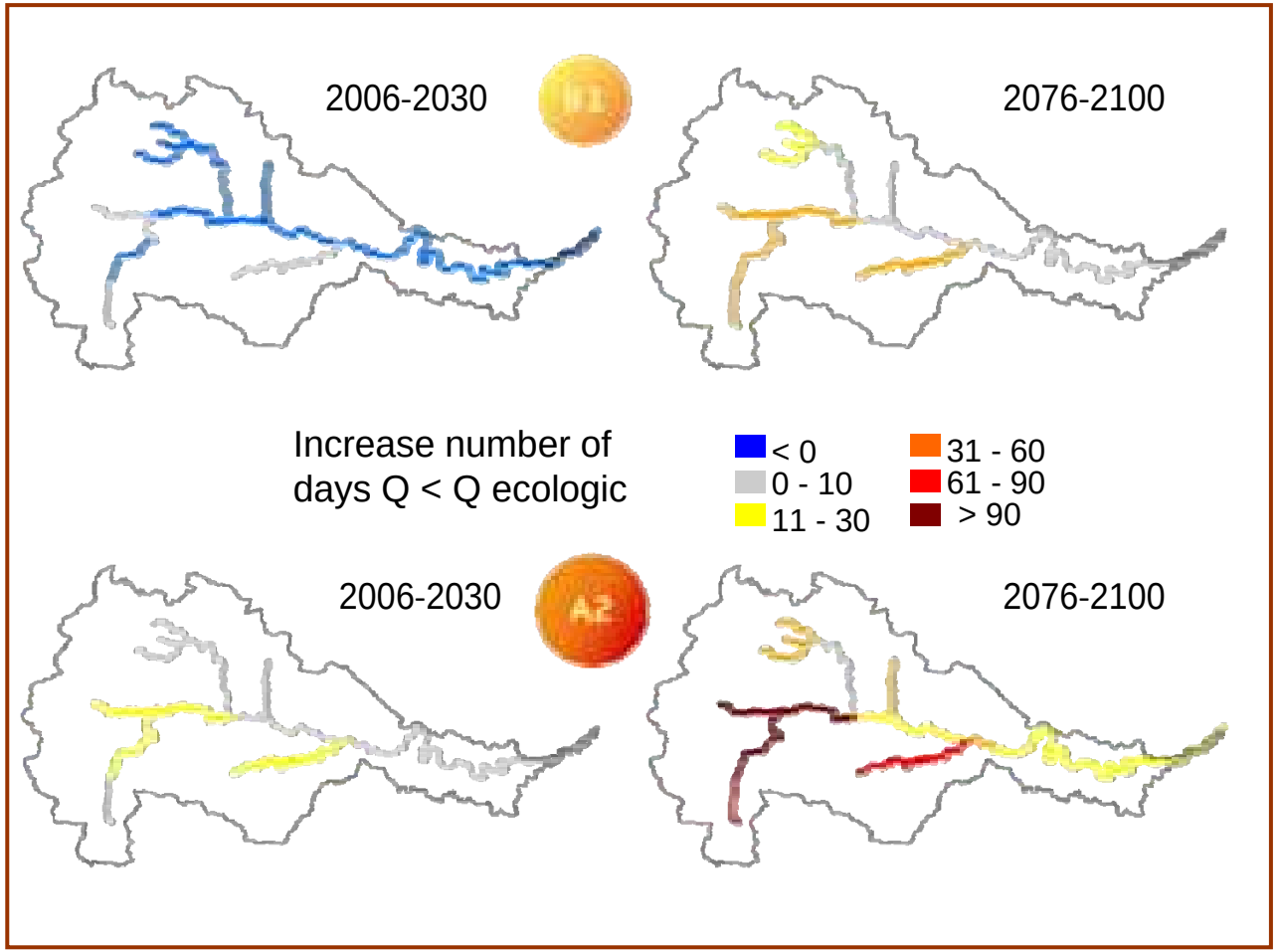
- In Fluvià and Tordera, the **socioeconomic scenarios** (changes in land and water use) **are not relevant** in water balance → Strong effect of **forests** in water balance
- In Siurana, land use change **amplify** water availability decrease
- In Fluvià, the highest reductions are expected in the **headwater**

ACCUA project

Ecological flow variation



- At the end of the Century, the **number of days** per year with stream flow lower than ecological flow **will increase** (more than **90** days in A2)

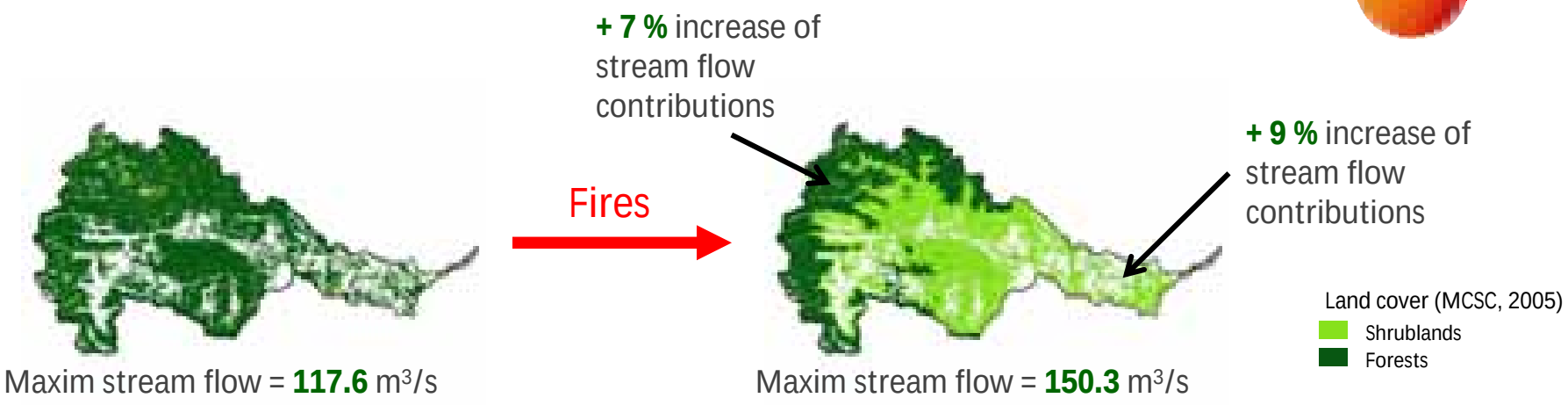


ACCUA project

Disturbance effects on water balance: simulation experiment

WHAT WILL HAPPEN IF FOREST SURFACE IS REDUCED TO THE HALF BY 2030?

A2



The **reduction** of **forest** surface and the **increment** of **shrublands** will imply:

- **Increase** of the **superficial stream flow contributions** along the watershed due to the reduction of actual evapotranspiration and infiltration.
- Increase of the **maxim stream flow**, increasing the **flood risk**
- Increase of the **flow variability**, tending to more extreme situations → **Forest** as water balance **regulators**.

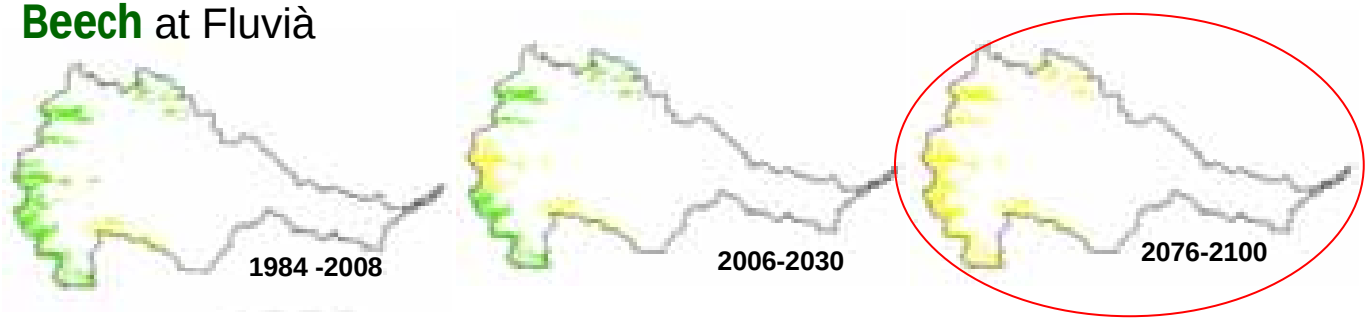
ACCUA project

Forest species suitability

CHANGES IN BIOCLIMATIC SUITABILITY OF FOREST SPECIES

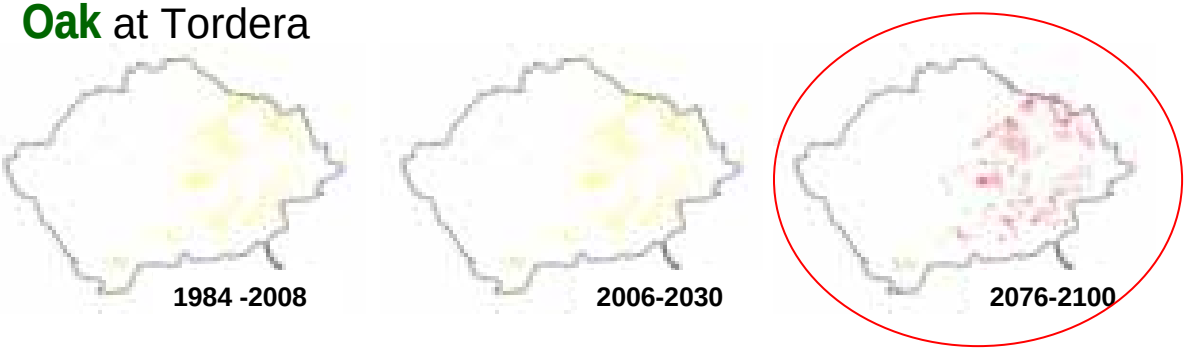
A2

Beech at Fluvià



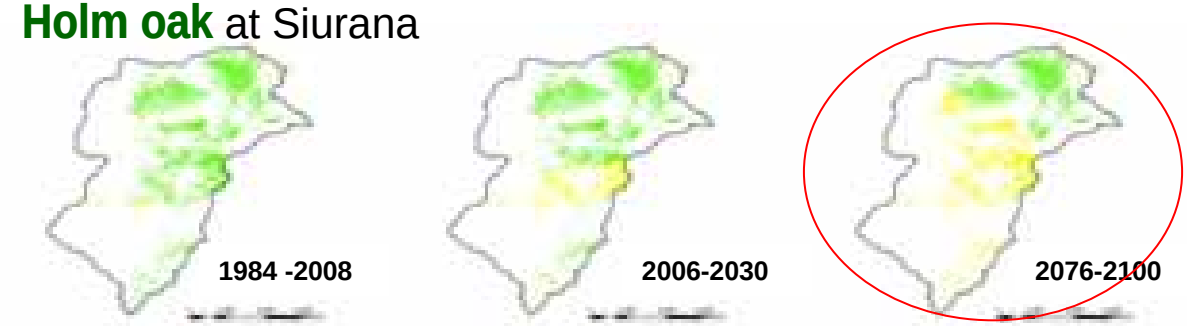
- Species from **humid areas** (beech, oak, scots pine) trend to **marginal conditions**.

Oak at Tordera



- These same species in **currently marginal areas** may be compromised their **viability**.

Holm oak at Siurana



- **Sclerophylls** and **evergreen** species (holm oak, aleppo pine) extend their **suitability to higher areas**

Unsuitable
Marginal
Suitable

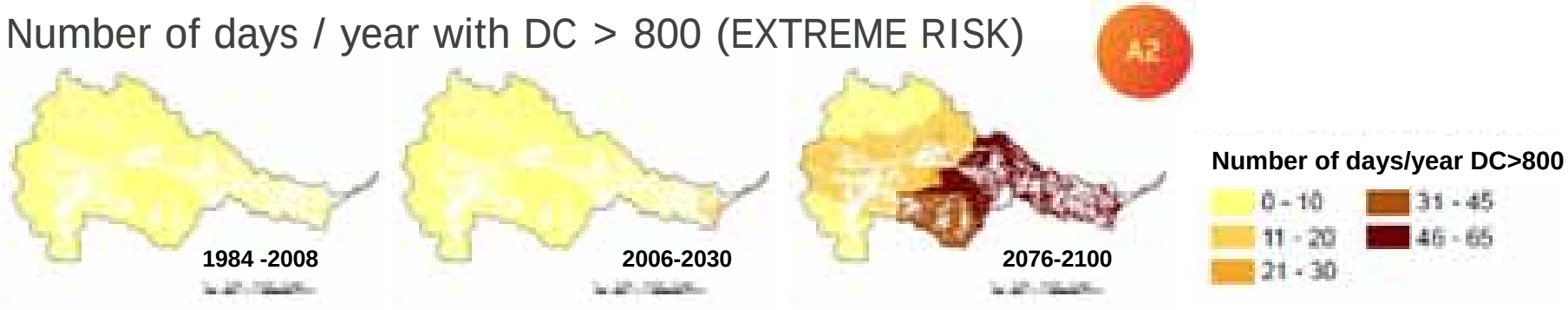
Source: BIOCLIM model

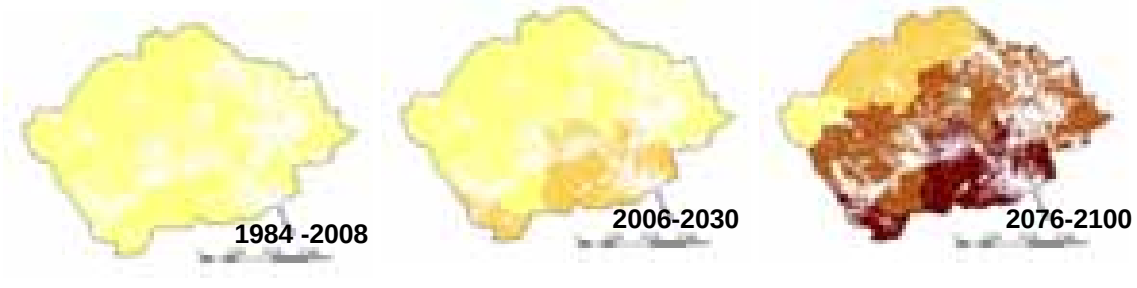
ACCUA project

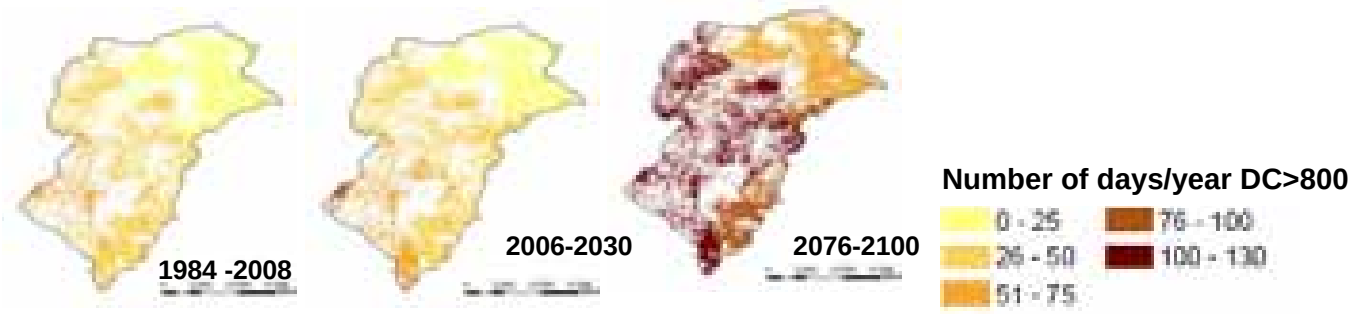
Forest fire risk

FIRE RISK (DROUGHT CODE. CANADIAN METEREOLOGIC INDEX)

Number of days / year with DC > 800 (EXTREME RISK)





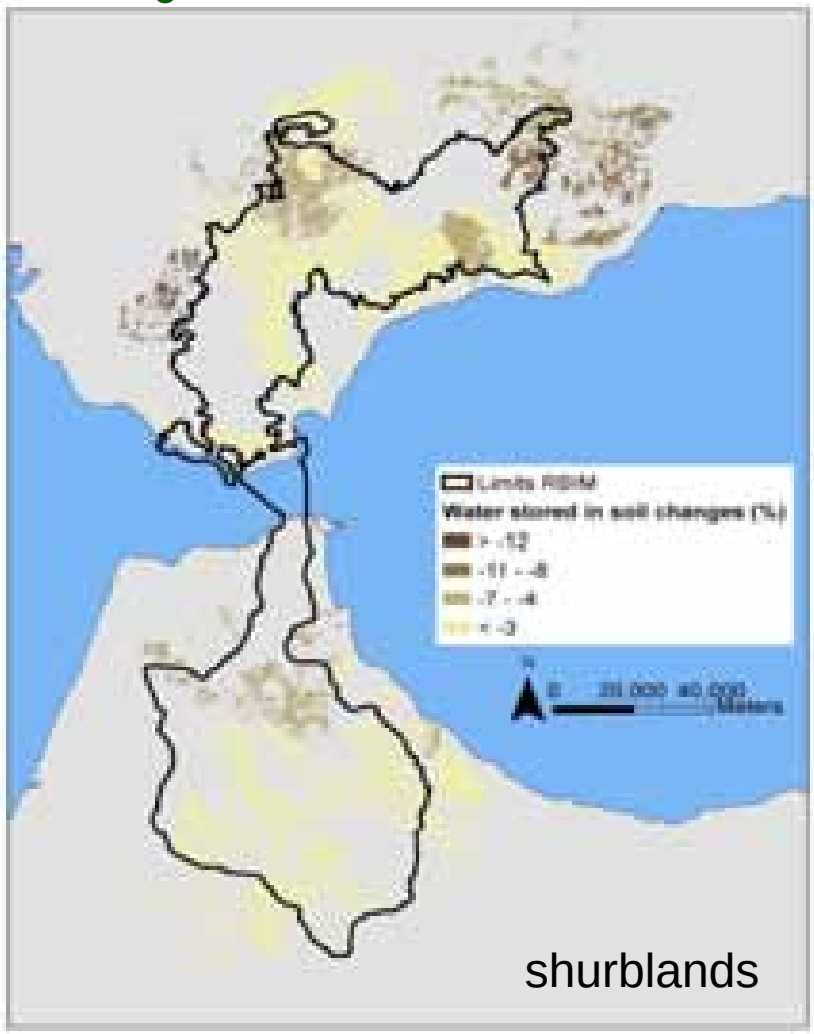


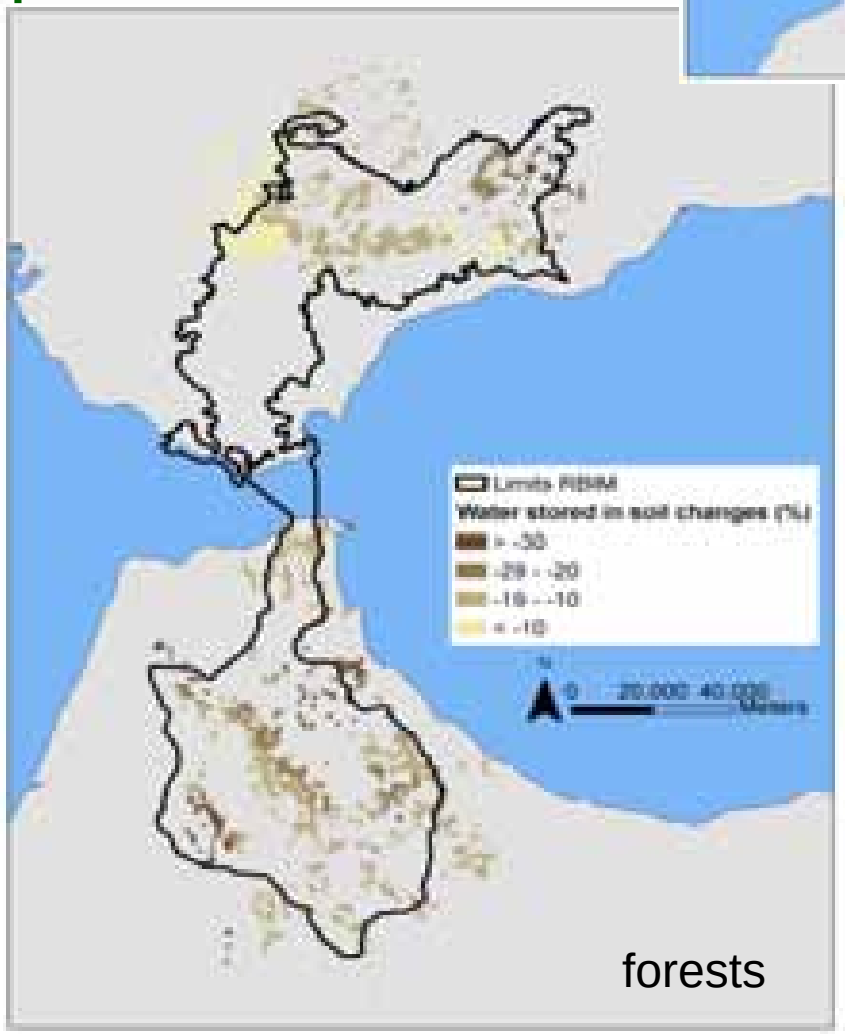
Risk fire increase may aggravate forest **vulnerability**

CLICO project

Intercontinetal Biosphere Reserve of the Mediterranean

Changes in water in soil: 2041-2070 period vs 1961-1990

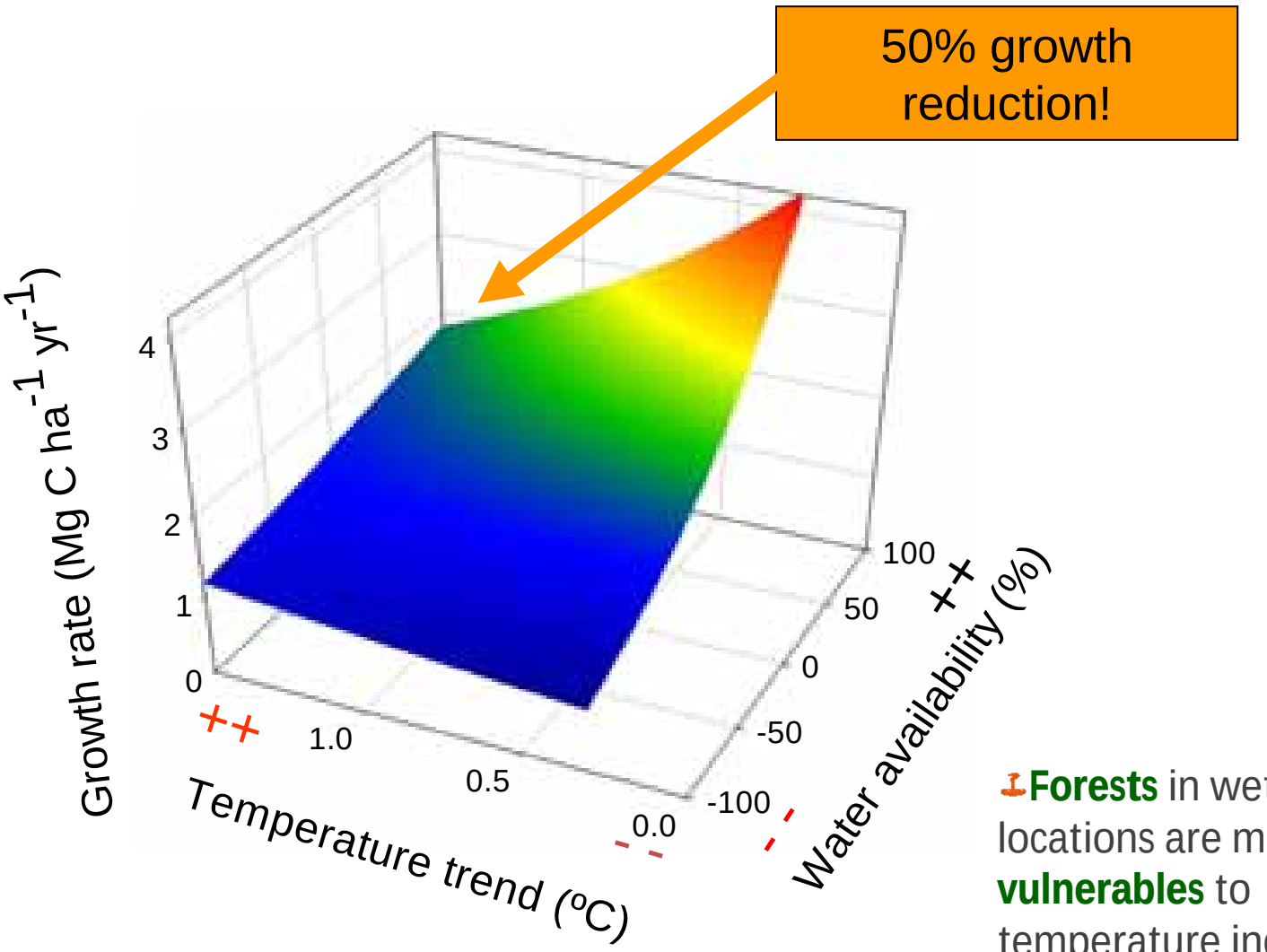




Source: Pascual *et al.* 2012

Forest inventories comparison

Impacts of recent climate change trends in Spanish forests



Forests in wet locations are more **vulnerables** to temperature increase

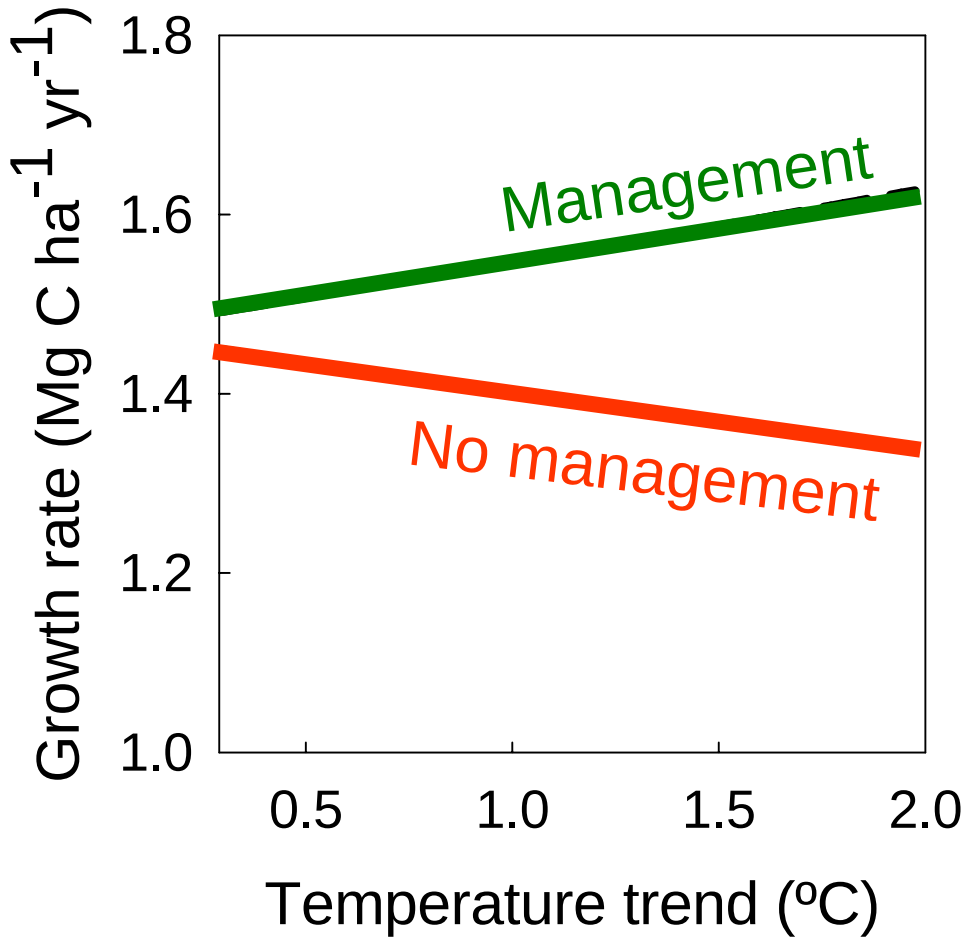
Source: Vayreda et al 2012

Adaptive measures

Forest inventories comparison

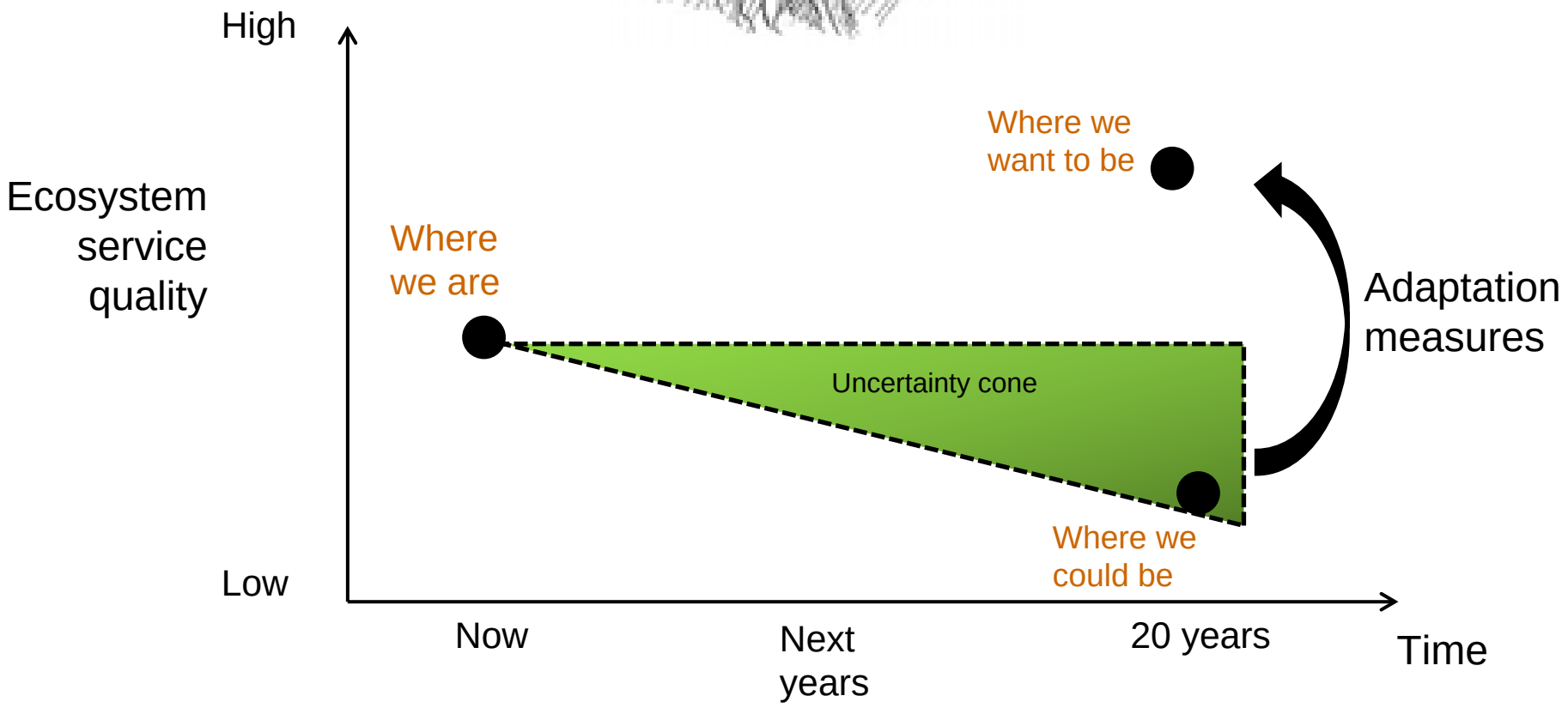
Impacts of recent climate change trends in Spanish forests

Forest management moderates the negative impacts of warming in Spain



Source: Vayreda et al 2012

The uncertainty

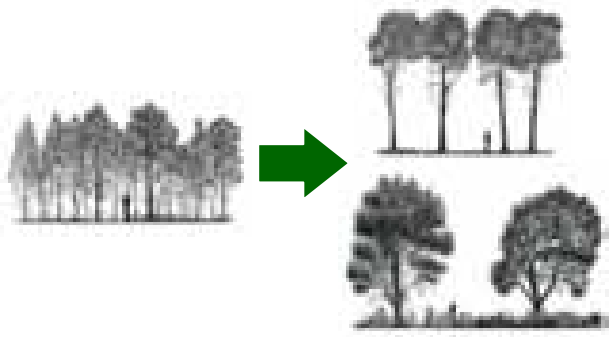


Source: WaterChange project (CETaqua)

Adaptive measures

Forests and shrublands

- **Forest management** promoting health forest structures, fire and water stress resistance: **Reduction of trees density** and promotion of **big trees**



- Identification of **more vulnerable** species to global change in order to **manage** and **guaranty** its viability.

- Promotion of trees and shrublands species **more adapted** to future **new conditions.**

- Recovery and maintenance of the **agro-forest mosaic**

Adaptive measures

Forest management results in Catalan forests

Prades Mountains

FLUVIÀ
Boscos
escenari climàtic
A2 smc
sense escenari
socioeconòmic

Cobertes arbòries de la conca

3 Vulnerabilitats

Intercanvi de carboni als boscos

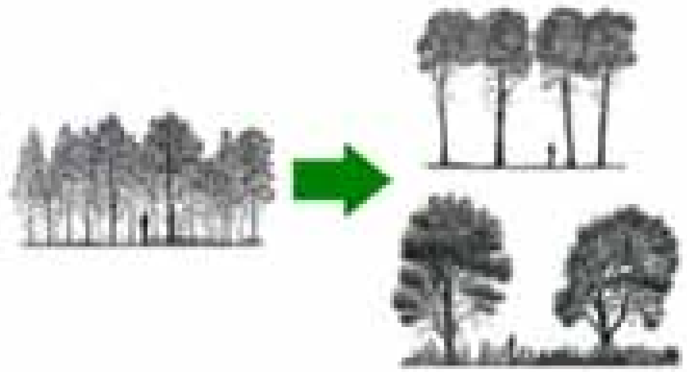
Idoneïtat climàtica de les espècies

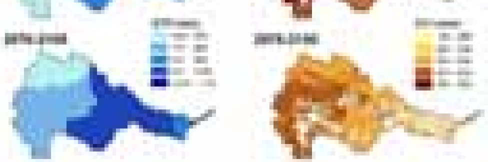
Risc d'incendi

4 Adaptacions

Gestió forestal orientada cap a estructures més sanes, més resistents al foc i amb menys estrès hídric

1. Espècies **més vulnerables** que s'haurien de **gestionar prioritàriament** per garantir la seva viabilitat:
   - Castanyer i faig als trams mitjos i baixos
   - Roure i castanyer als trams baixos
2. **Reduir densitats** i potenciar estructures amb **arbres grans** a través de la gestió
3. Després d'una pertorbació, identificar espècies sensibles i potenciar aquelles **espècies més resistents a les noves condicions.**
4. Recuperació i manteniment del **mosaic agroforestal**





Conclusions

✓ **Drought and warming** impacts are **increasing** their frequency and intensity in the Mediterranean region and this trend will be stronger in the future. There is a synergic effect of temperature increase with rainfall changes.

✓ Nowadays, Mediterranean forests are in a **changing stage**, linked to climate and forest management changes.

✓ At mid term, important **vegetation changes** are expected in the Mediterranean region. They will affect **forest distribution** and **forest species suitability**.

✓ Forest **adaptation measures** can moderate the negative impacts of climate change, but in some cases impacts will be unavoidable.

Thank you!

www.creaf.uab.cat