  

Respuestas de los bosques mediterráneos al cambio climático: retos científicos y de gestión

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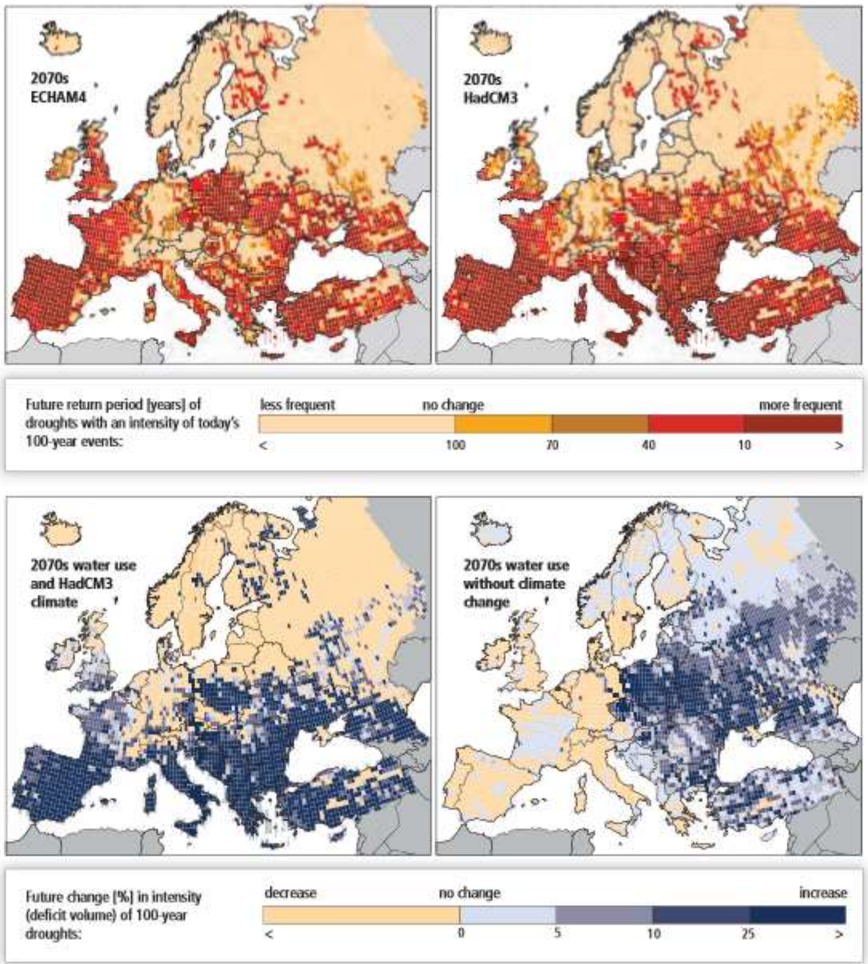
AGUA

Birot y Vallejo 2011. Book chapter

Mayor frecuencia e intensidad de sequías extremas



Adaptado a sequías moderadas

Estrés hídrico

?

⬇ Capacidad de respuesta y aclimatación

⬇ **Resiliencia**

IPCC 2012

Gutschik y BassiriRad 2003. New Phytol
Holling 1973. Ann Rev Ecol Syst

Pocos estudios en condiciones naturales donde se analice alteración funcional de los árboles durante sequías extremas

Disminución del crecimiento y de la conductividad hidráulica

Gran mortalidad

Pinus sylvestris

Martínez-Vilalta y Piñol 2002.
For Ecol and Manage

Defoliación y decaimiento

Incremento eficiencia en el uso del agua

Quercus ilex

Peñuelas et al. 2000. Biol Plant

CAUSAS DECAIMIENTO Y MORTALIDAD

- **Fallo hidráulico**
  - → Ψ muy bajos – pérdida conductividad hidráulica
  - → Umbral de tolerancia – depende de la especie y condiciones ambientales

Martínez-Vilalta et al. 2002. Oecologia
Urli et al. 2013 Tree Physiol

- **Inanición por falta de carbono**
  - → Cierre estomático – consumo carbohidratos almacenados
  - → C almacenado – depende de la especie, edad, tamaño, época del año
  - → Accesibilidad y transporte C durante sequía

Zwieniecki y Secchi 2015. Plant Cell Environ
Sala et al. 2012. Tree Physiol

Bosques mediterráneos: alta resistencia y resiliencia a las perturbaciones

Lloret et al. 2012. Glob Change Biol

Especies
Características sequía

Rasgos funcionales relacionados con la **sequía**

- Hojas esclerófilas
  Salleo y Lo Gullo 1990. Ann Bot
- Incremento ratio raíz/tallo
  Peña-Rojas et al. 2005. Funct Plant Biol
- Osmoregulación
  Meinzer et al. 2014. Plant Cell Environ
- Raíces más profundas
  David et al. 2007. Tree Physiol
- Incremento eficiencia en el uso del agua
  Gulías et al. 2003. Ann Bot
- Resistencia del sistema hidráulico
  McDowell et al. 2008. New Phytol

Respuesta funcional de especies coexistentes con contrastadas estrategias hídricas bajo condiciones de sequía extrema

Mediterranean trees coping with severe drought: avoidance might not be safe

Forner A, Valladares F, Aranda I

Envir Exp Botany (enviado)

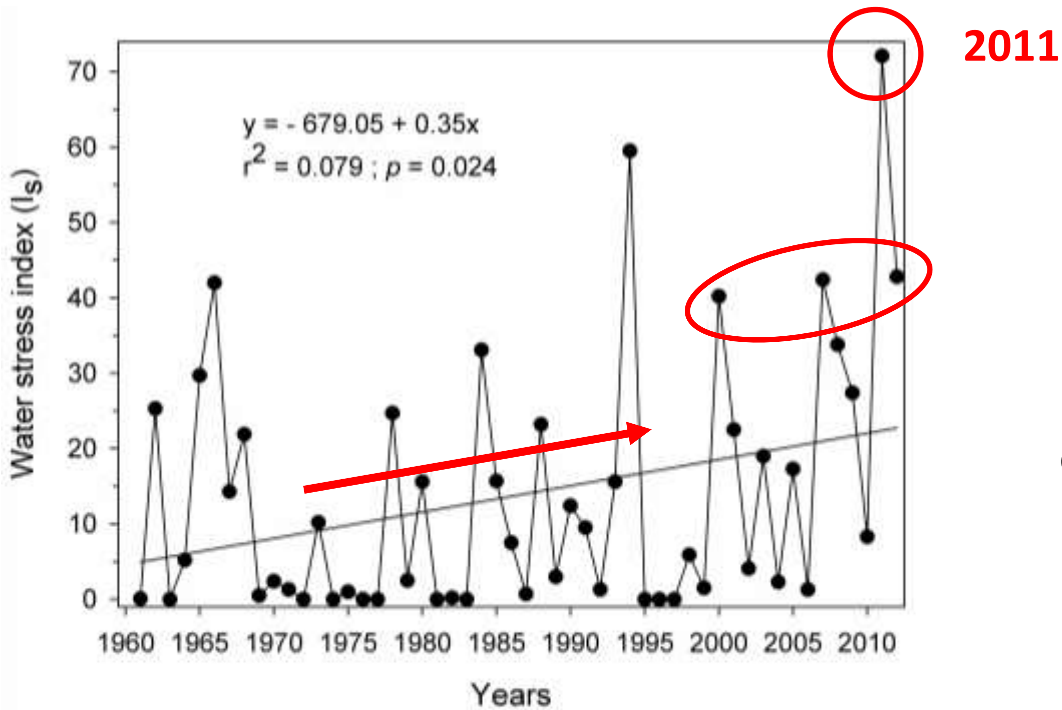
Tree Physiology 00, 1–11
doi:10.1093/treephys/tpy022

Research paper

Extreme droughts affecting Mediterranean tree species' growth and water-use efficiency: the importance of timing

Alicia Forner[1,7], Fernando Valladares[1,2], Damien Bonal[3], André Granier[3], Charlotte Grossiord[4] and Ismael Aranda[5,6]

P. Natural del Alto Tajo



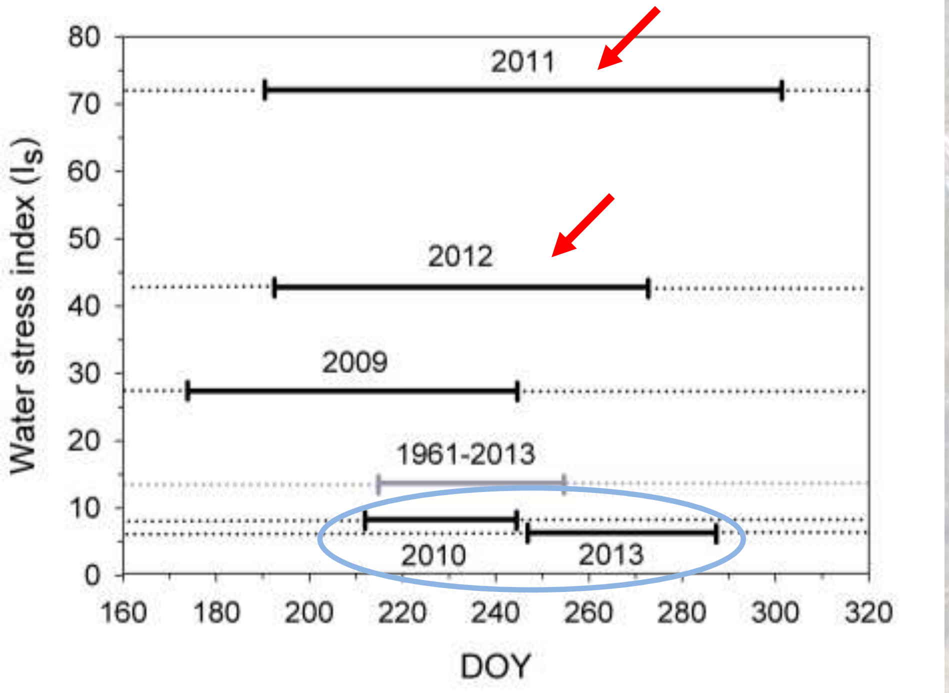
El estrés hídrico ha aumento en los últimos 50 años

La frecuencia de las sequías extremas ha aumentado en la última década

$$REW = \frac{\text{Agua disponible}}{\text{Agua máx. extraíble}}$$

$$I_s = \frac{\text{Suma } (REW - REW_c)}{REW_c} \quad \text{when } REW < REW_c$$

REW_c = 0.4 Estrés hídrico (Granier et al. 1999)

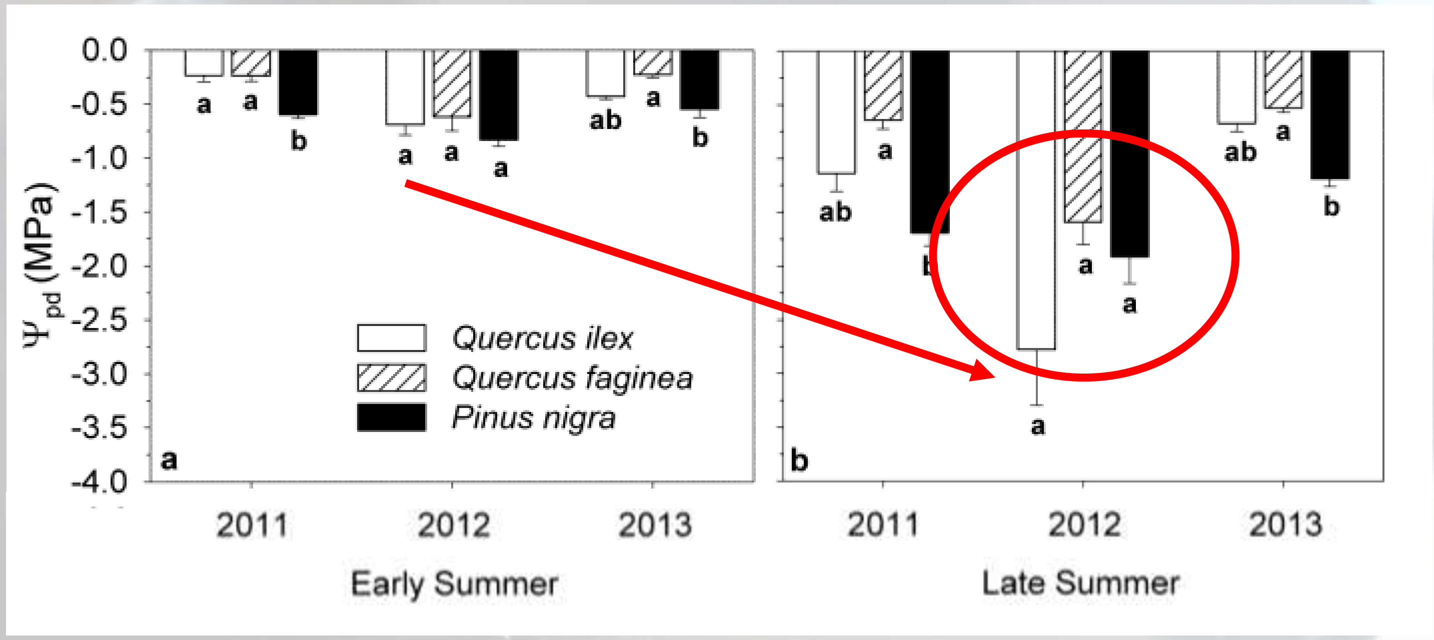


2011 presentó una sequía muy intensa, prolongada y temprana

2010 y 2013 tuvieron I_s inferior a la media

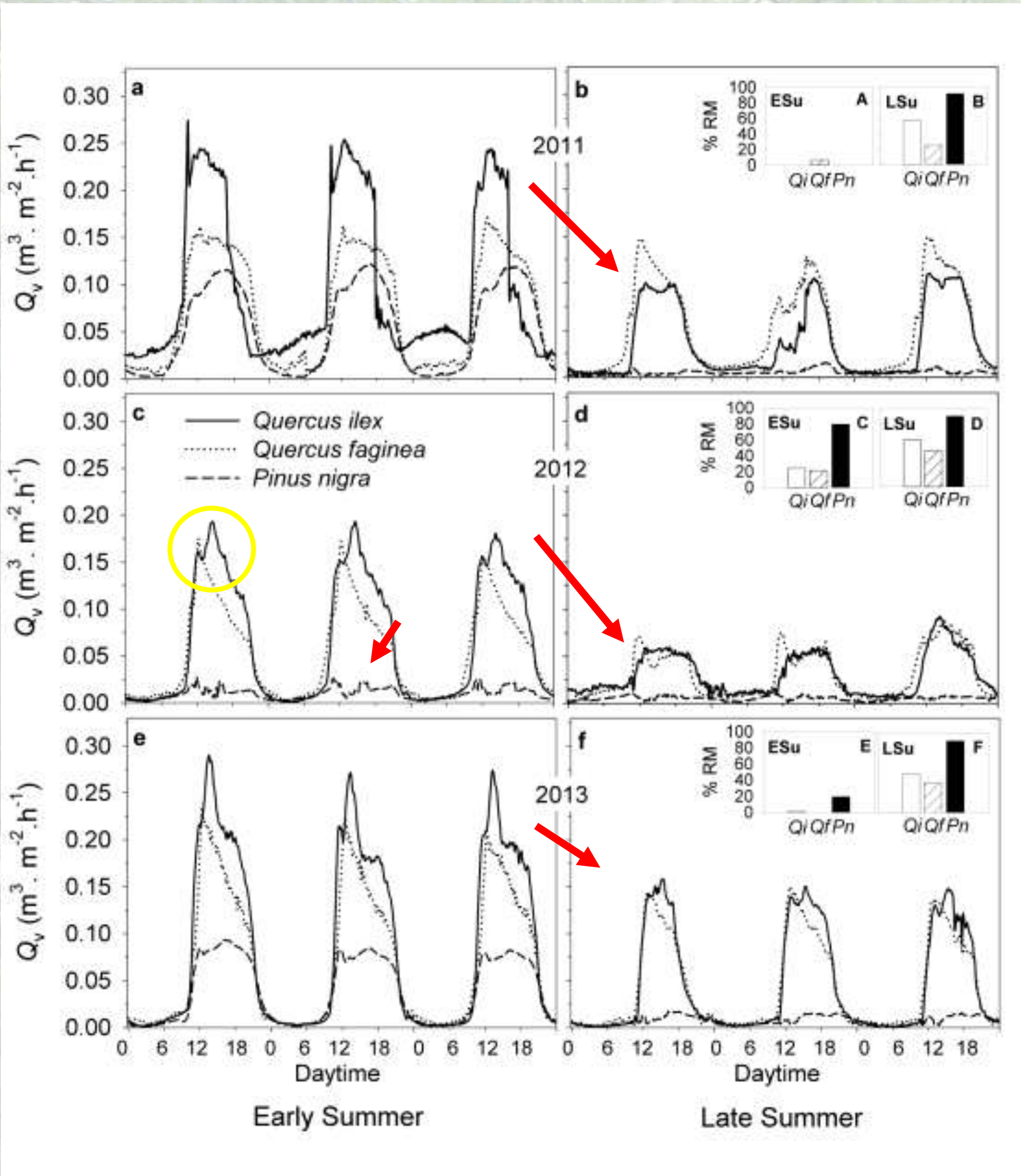
2012 tiene aprox. el triple que la media

Potencial hídrico



Caída potencial hídrico a lo largo del verano (*Q. ilex* en 2012)

General: *P. nigra* < *Q. ilex* ~*Q. faginea*



Flujo de savia

Menores flujos de savia en *P. nigra*

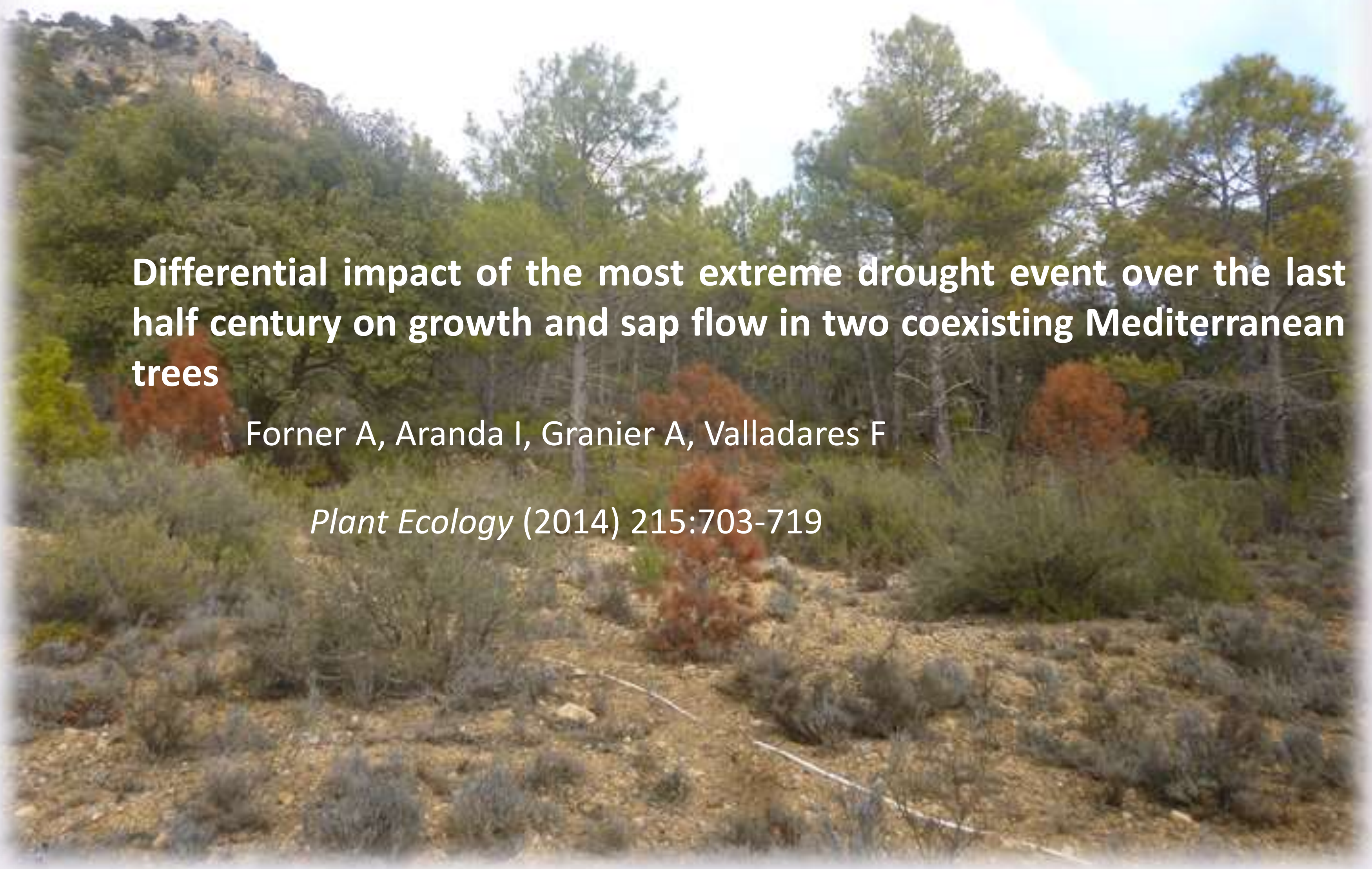
Valores mínimos a finales de verano de 2012

Disminución flujo savia *P. nigra* del 80%

P. nigra ESu 2012 ~LSu 2011/2013

Marcado cierre estomático al mediodía en *Q. faginea*

Papel modulador del microclima en la respuesta ecofisiológica de las especies bajo condiciones de sequía extrema



Al contrario de lo esperado: *P. nigra*, especie evitadora, alcanzó niveles de estrés hídrico cercanos a su umbral crítico

Potenciales hídricos bajos

Fotorespiración

Consumo agua mínimo ya al inicio del verano (Cierre estomático - fijación C mínima/nula todo verano)

Sequía severa 2012 + Acumulación efectos sequía extrema 2011

SIN EMBARGO sin síntomas claros decaimiento ni mortalidad

1- Mayor impacto sequías severas consecutivas que sequías extremas puntuales

2- Alta resiliencia de las especies en el lugar de estudio, aunque ligera pérdida

3- Aunque no muy lejos de su umbral crítico de no retorno

- Estudios a largo plazo
- Medir y entender la recuperación

Ligeras diferencias en la humedad del suelo atenúan efecto sequía extrema

Microclima claro efecto modulador sequías extremas, incluso en 2012

(ej. laderas umbría) Peñuelas et al. 2001. For Sci

- Importante considerar factores locales cuando se comparen diversos ámbitos geográficos

- Posibilidad de gestión local para evitar/paliar efectos sequías extremas

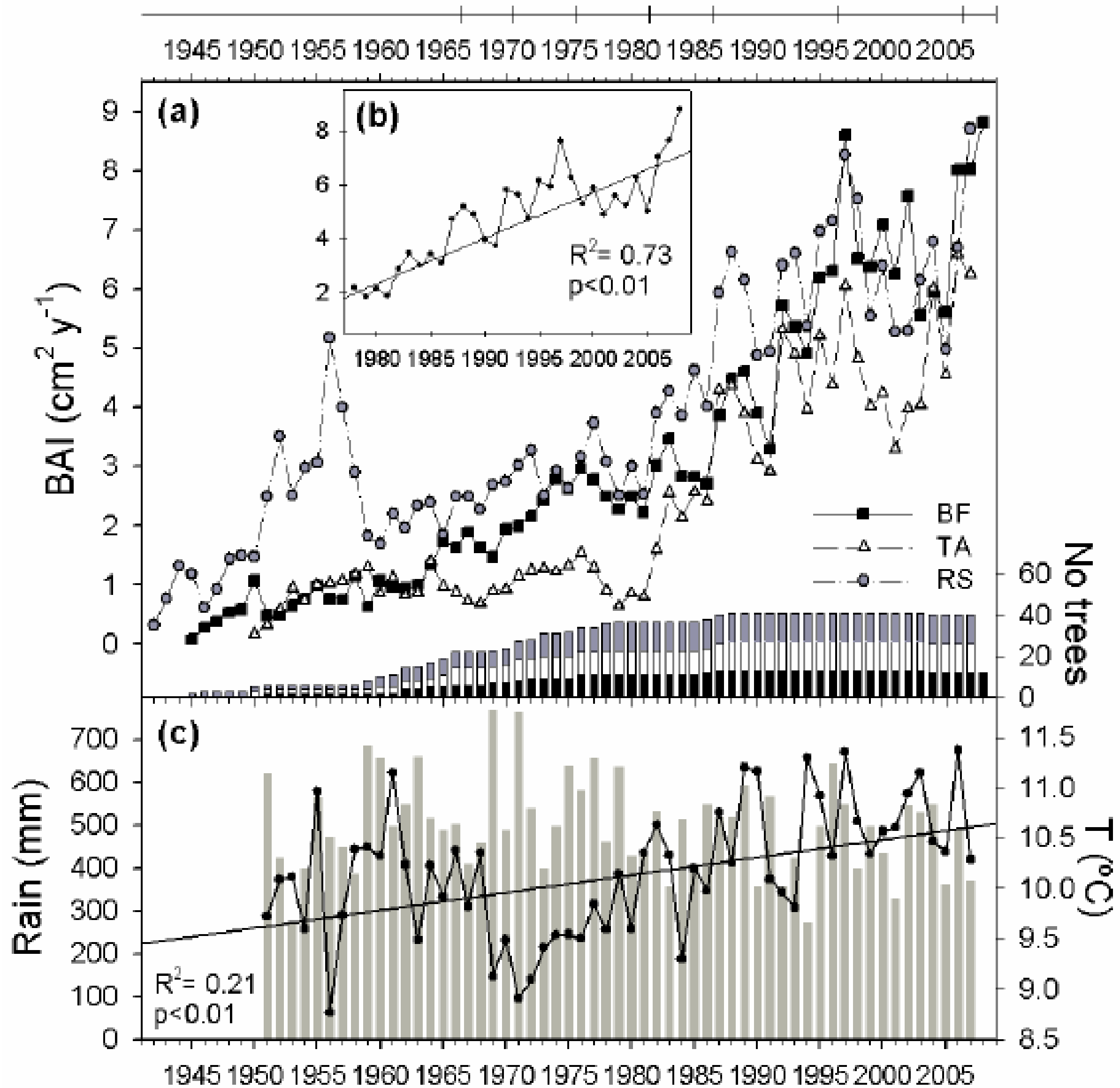
Avila, nevada del 23 de marzo de 2017

Juniperus thurifera

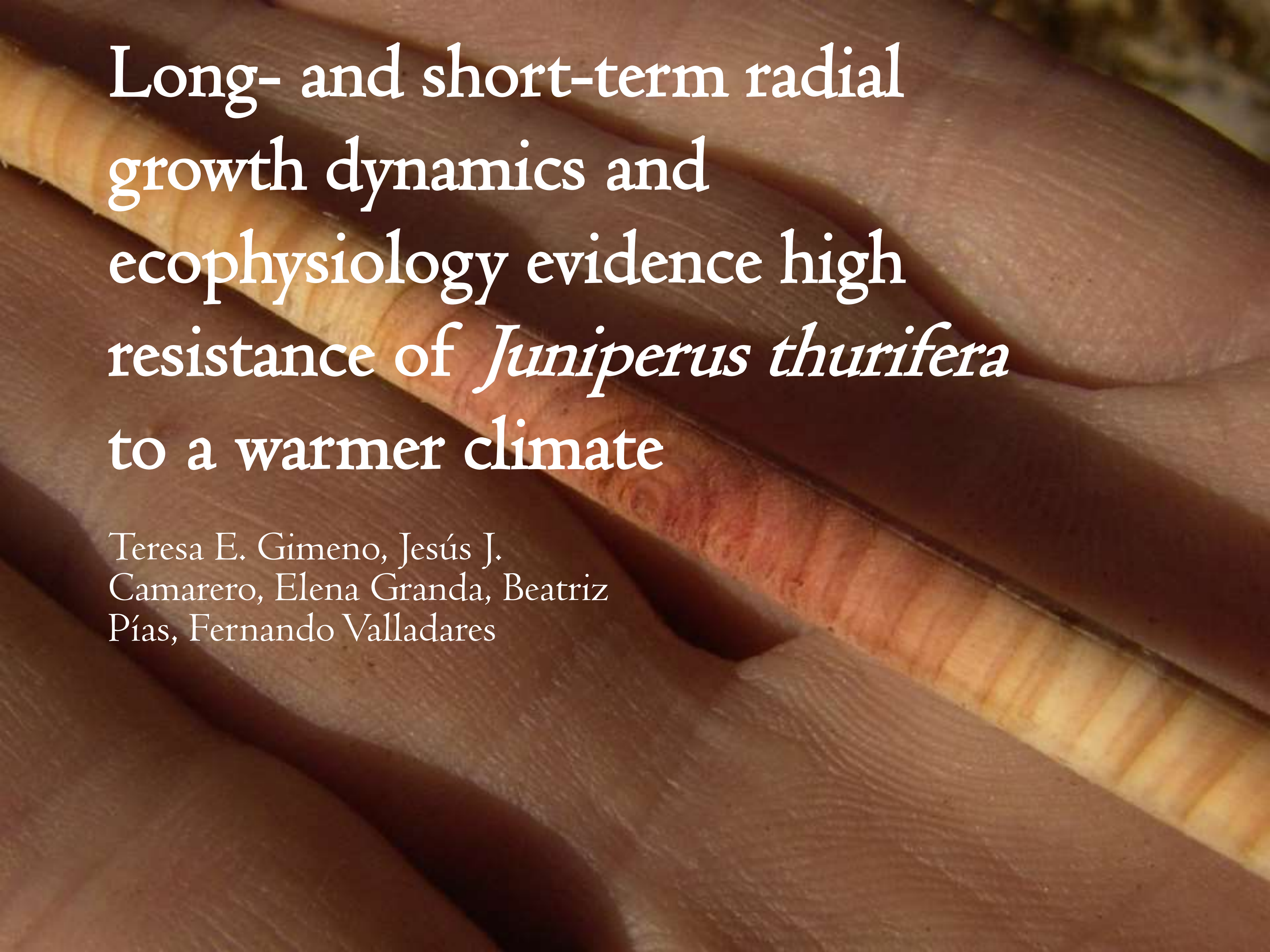
Continental conditions

- Cold in winter (and over night), which adds to heat and drought

Warming temperatures, increased growth



Gimeno, Valladares et al 2010



Long- and short-term radial growth dynamics and ecophysiology evidence high resistance of *Juniperus thurifera* to a warmer climate

Teresa E. Gimeno, Jesús J. Camarero, Elena Granda, Beatriz Pías, Fernando Valladares

For *Juniperus thurifera*:

i. Growth is negatively affected by the increased warming-induced water-stress due to climate change
ii. Males and females differ in their growth dynamics
iii. Seasonal evolution of carbon gain and water use efficiency underlay climate-growth relationships and growth dynamics.

Change in Habitat Use in Mediterranean Continental areas

Forest expansion a special case of habitat change that involves natural woodland expansion into former grasslands and increased tree density in open, partially degraded woodlands

Archer *et al.* 2001, Bonet *et al.* 2004

Spatial pattern and growth of juvenile and adult trees reveal different ecological processes in mature versus expanding Spanish-juniper woodlands

Teresa E. Gimeno, Beatriz Pías, Jesús Martínez-Fernández, David L. Quiroga, Adrián Escudero, Fernando Valladares

Biodiversity

- Species, the bricks of biodiversity, can be seen as a**lternative solutions** to changing challenges.
- Biodiversity also encapsulates the notion of intraspecific variability and population differentiation including, thus, a range of **alternatives on local adaptation and plasticity** that we are just beginning to uncover.

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FOREST ECOLOGY

Positive biodiversity-productivity relationship predominant in global forests

Jingjing Liang,[1*] Thomas W. Crowther,[2,3†] Nicolas Picard,[4] Susan Wiser,[5] Mo Zhou,[1] Giorgio Alberti,[6] Ernst-Detlef Schulze,[7] A. David McGuire,[8] Fabio Bozzato,[9] Hans Pretzsch,[10] Sergio de-Miguel,[11,12] Alain Paquette,[13] Bruno Hérault,[14] Michael Scherer-Lorenzen,[15] Christopher B. Barrett,[16] Henry B. Glick,[3] Geerten M. Hengeveld,[17,18] Gert-Jan Nabuurs,[17,19] Sebastian Pfautsch,[20] Helder Viana,[21,22] Alexander C. Vibrans,[23] Christian Ammer,[24] Peter Schall,[24] David Verbyla,[25] Nadja Tchebakova,[26] Markus Fischer,[27,28] James V. Watson,[1] Han Y. H. Chen,[29] Xiangdong Lei,[30] Mart-Jan Schelhaas,[17] Huicui Lu,[19] Damiano Gianelle,[31,32] Elena I. Parfenova,[26] Christian Salas,[33] Eungul Lee,[34] Boknam Lee,[35] Hyun Seok Kim,[35,36,37,38] Helge Bruelheide,[39,40] David A. Coomes,[41] Daniel Piotto,[42] Terry Sunderland,[43,44] Bernhard Schmid,[45] Sylvie Gourlet-Fleury,[46] Bonaventure Sonké,[47] Rebecca Tavani,[48] Jun Zhu,[49,50] Susanne Brandl,[10,51] Jordi Vayreda,[52,53] Fumiaki Kitahara,[54] Eric B. Searle,[29] Victor J. Neldner,[55] Michael R. Ngugi,[55] Christopher Baraloto,[56,57] Lorenzo Frizzera,[31] Radomir Bałazy,[58] Jacek Oleksyn,[59,60] Tomasz Zawiła-Niedźwiecki,[61,62] Olivier Bouriaud,[63,64] Filippo Bussotti,[65] Leena Finér,[66] Bogdan Jaroszewicz,[67] Tommaso Jucker,[41] Fernando Valladares,[68,69] Andrzej M. Jagodzinski,[59,70] Pablo L. Peri,[71,72,73] Christelle Gonmadje,[74,75] William Marthy,[76] Timothy O'Brien,[76] Emanuel H. Martin,[77]

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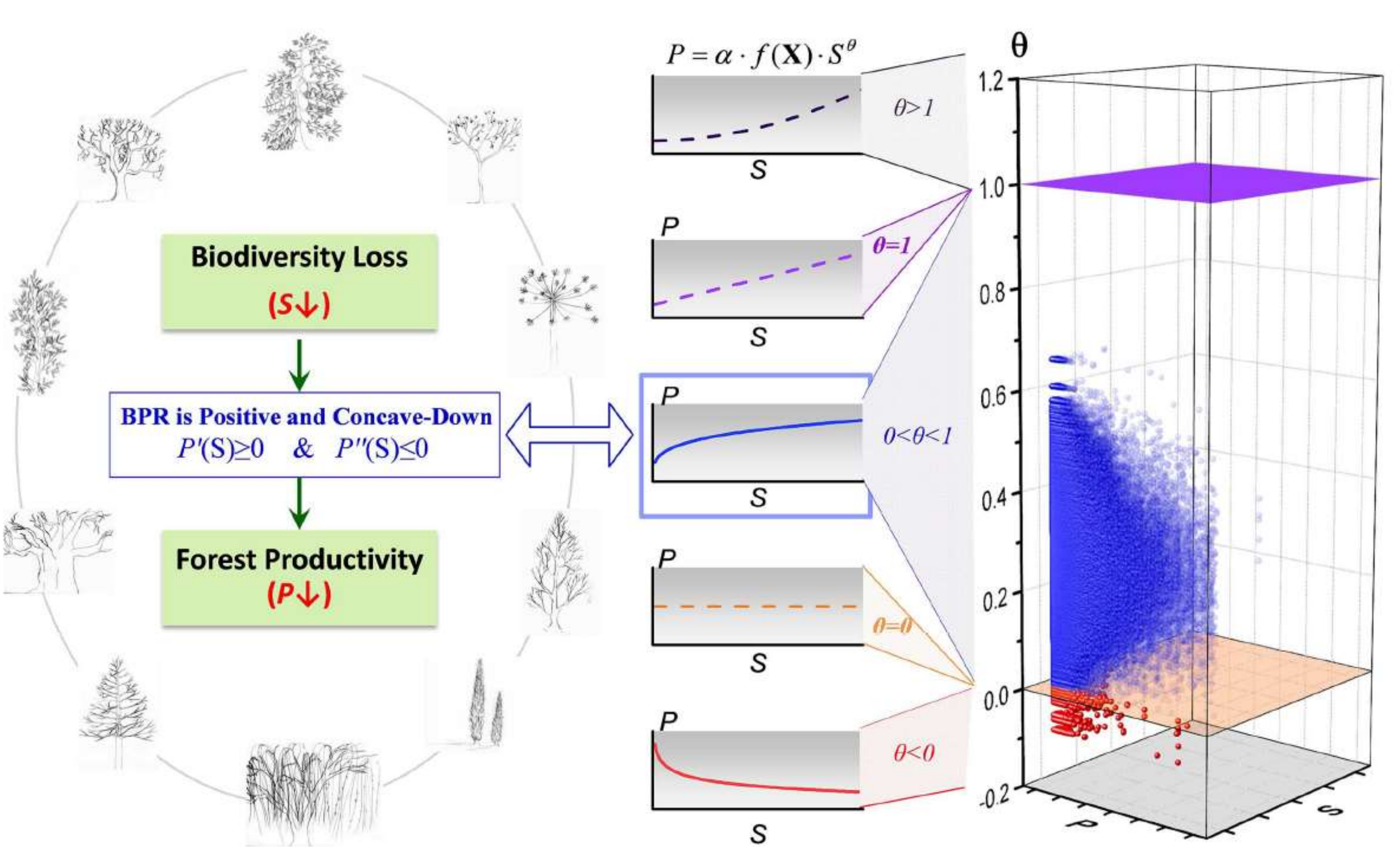

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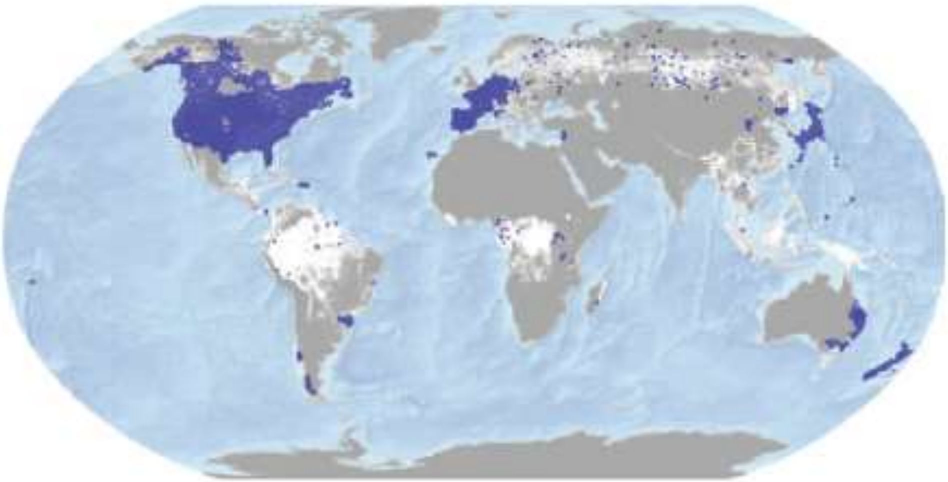
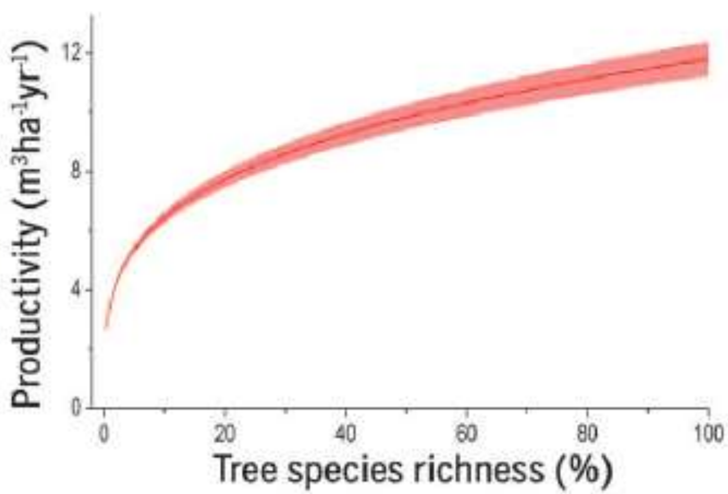
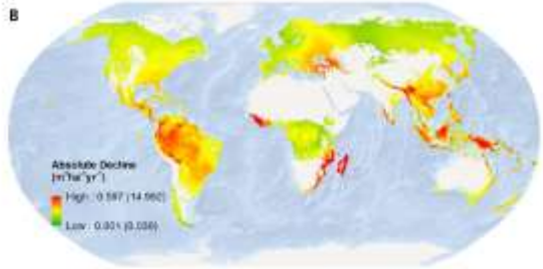




- the opposite to be true – a decline in biodiversity would result in an accelerating decline in forest productivity.



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- Scientists from 90 institutions consolidated field-based data forming one of the largest global forest inventory databases in the history of forestry research.
- Tens of thousands of forestry professionals collected the underpinning data, which extended over a period of 150 years.
- In total, data was collected from more than 770,000 plots consisting of more than 30 million trees across more than 8,700 species.
- The study took into account all major global forest ecosystems across 44 countries and territories. It included some of the most distinct forest conditions on Earth, such as the northernmost in Siberia; the southernmost in Patagonia; the coldest in Oimyakon, Russia; the warmest in Palau, an archipelago in the western Pacific Ocean; and the most diverse in Bahia, Brazil

As forests go, so goes the economy

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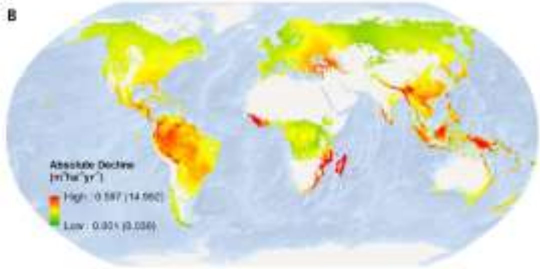
- The amount of loss in productivity that is associated with the loss of tree species richness would have an economic value of up to a $500 billion per year across the world.

- That amounts to **more than double what it would cost to implement effective conservation** for all of Earth's ecosystems on a global scale.

- The strongest economic message of this study is that the economic **benefit of forest species diversity far exceeds the cost of preserving it**, even when we only consider its role in maintaining the global commercial productivity of forests.



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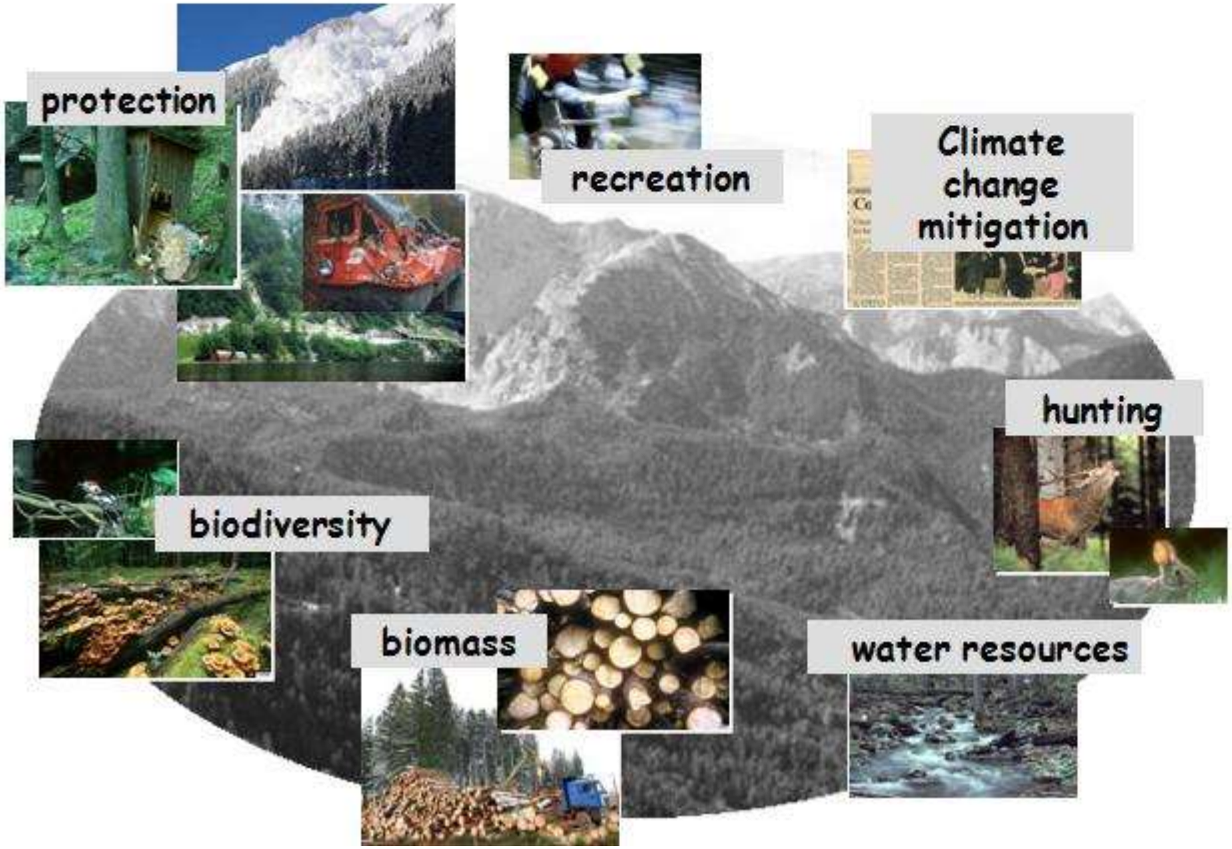
The ongoing species loss in global forests could substantially reduce forest productivity, thereby reducing the absorption of carbon dioxide by forests from the atmosphere.

Therefore, **conserving forest biodiversity** should be one of the important actions on **what we can do about climate change**.

Multifunctionality



In a world with less space for nature, we want ecosystems to do many things for us

What do we know about forest features that confer multifunctionality?

Not much !

Nature Communications March 2016

nature COMMUNICATIONS

ARTICLE

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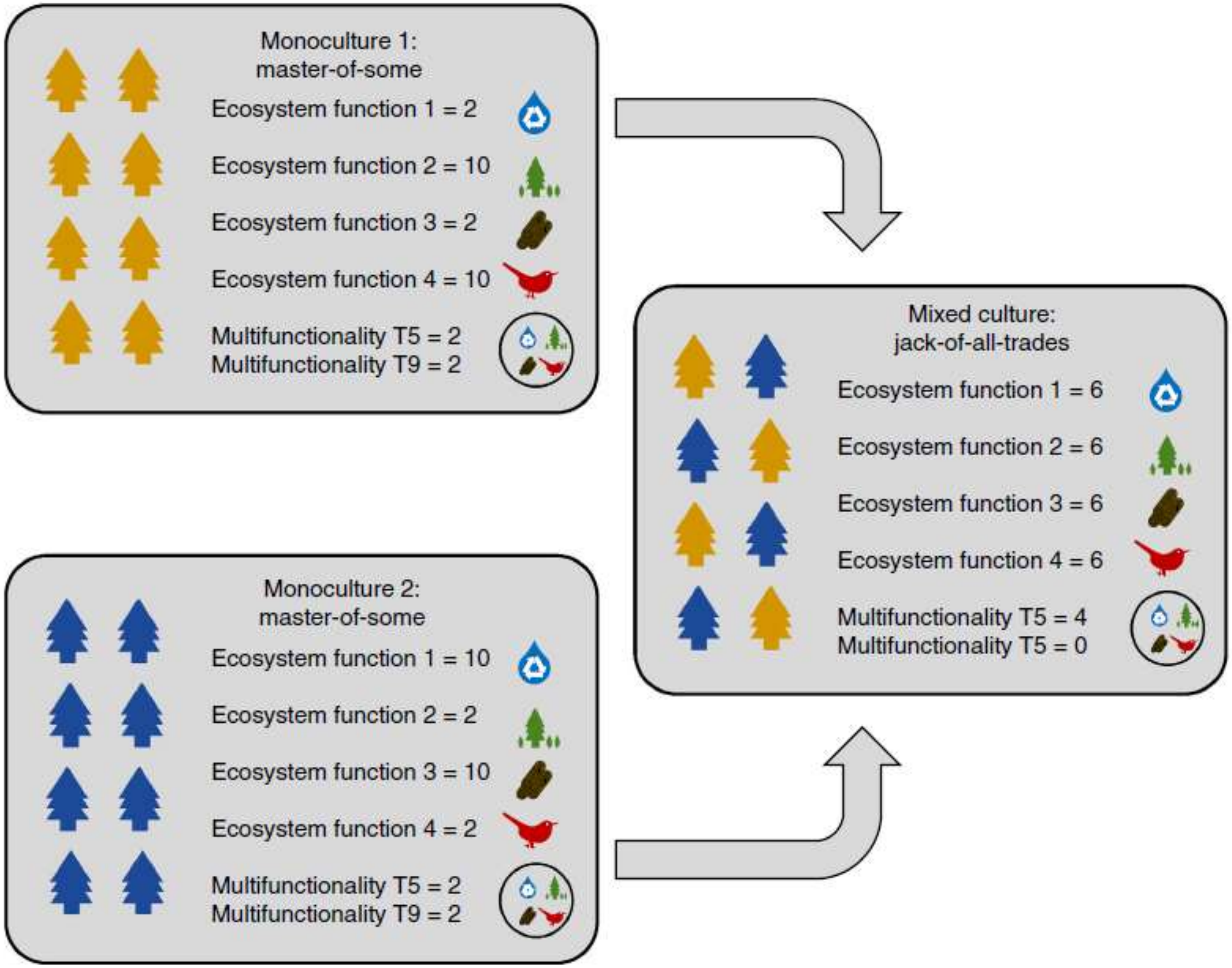
DOI: 10.1038/ncomms11109 OPEN

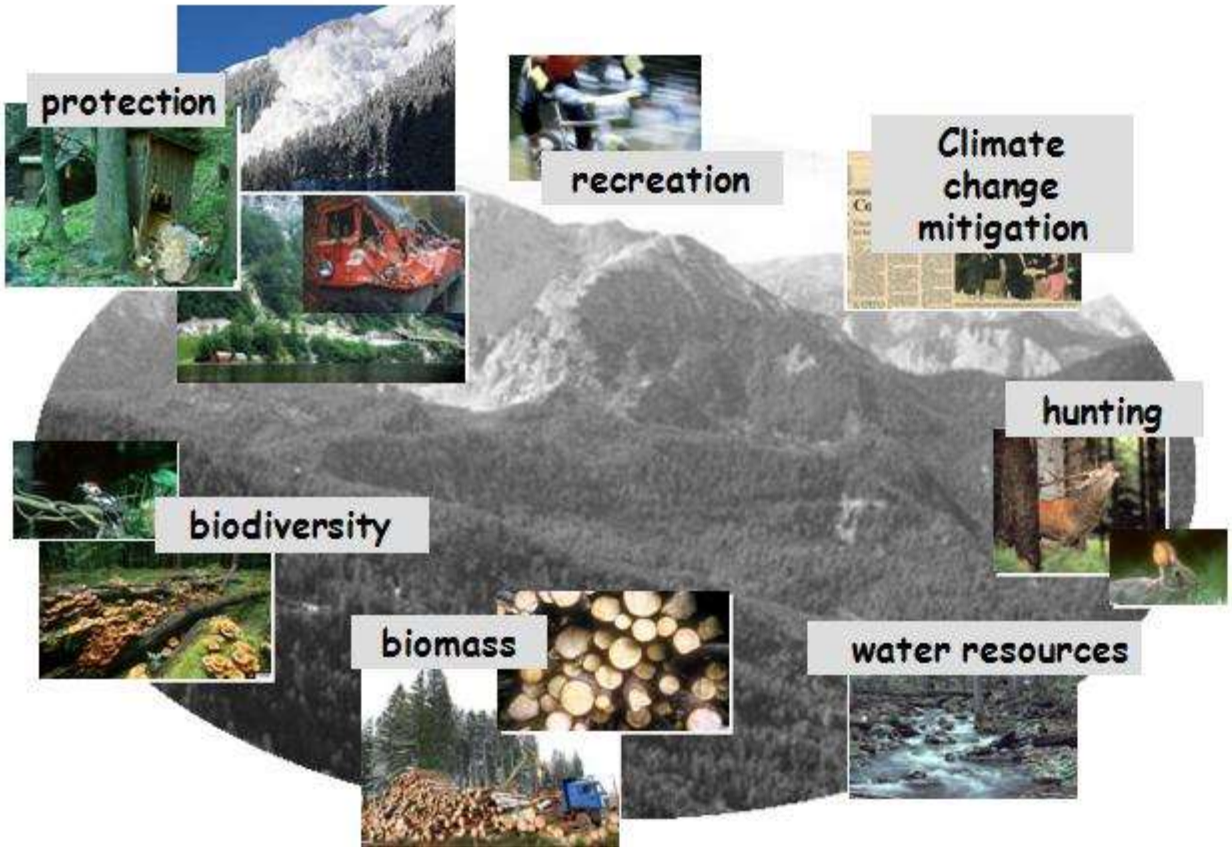
Jack-of-all-trades effects drive biodiversity–ecosystem multifunctionality relationships in European forests

Fons van der Plas[1,2], Peter Manning[1,2], Eric Allan[1], Michael Scherer-Lorenzen[3], Kris Verheyen[4], Christian Wirth[5,6], Miguel A. Zavala[7], Andy Hector[8], Evy Ampoorter[4], Lander Baeten[4,9], Luc Barbaro[10,11], Jürgen Bauhus[12], Raquel Benavides[3], Adam Benneter[12], Felix Berthold[13], Damien Bonal[14], Olivier Bouriaud[15], Helge Bruelheide[6,13], Filippo Bussotti[16], Monique Carnol[17], Bastien Castagneyrol[10,11], Yohan Charbonnier[10,11], David Coomes[18], Andrea Coppi[16], Cristina C. Bastias[19], Seid Muhie Dawud[20], Hans De Wandeler[21], Timo Domisch[22], Leena Finér[22], Arthur Gessler[23], André Granier[14], Charlotte Grossiord[24], Virginie Guyot[10,11,25], Stephan Hättenschwiler[26], Hervé Jactel[10,11], Bogdan Jaroszewicz[27], François-Xavier Joly[26], Tommaso Jucker[18], Julia Koricheva[28], Harriet Milligan[28], Sandra Müller[3], Bart Muys[21], Diem Nguyen[29], Martina Pollastrini[16], Karsten Raulund-Rasmussen[20], Federico Selvi[16], Jan Stenlid[29], Fernando Valladares[19,30], Lars Vesterdal[20], Dawid Zielínski[27] & Markus Fischer[1]

Nature Communications March 2016



Multifunctionality increases with biodiversity



Diverse forests do not maximize any function but performs very well all functions

Jack of all trades, master of none

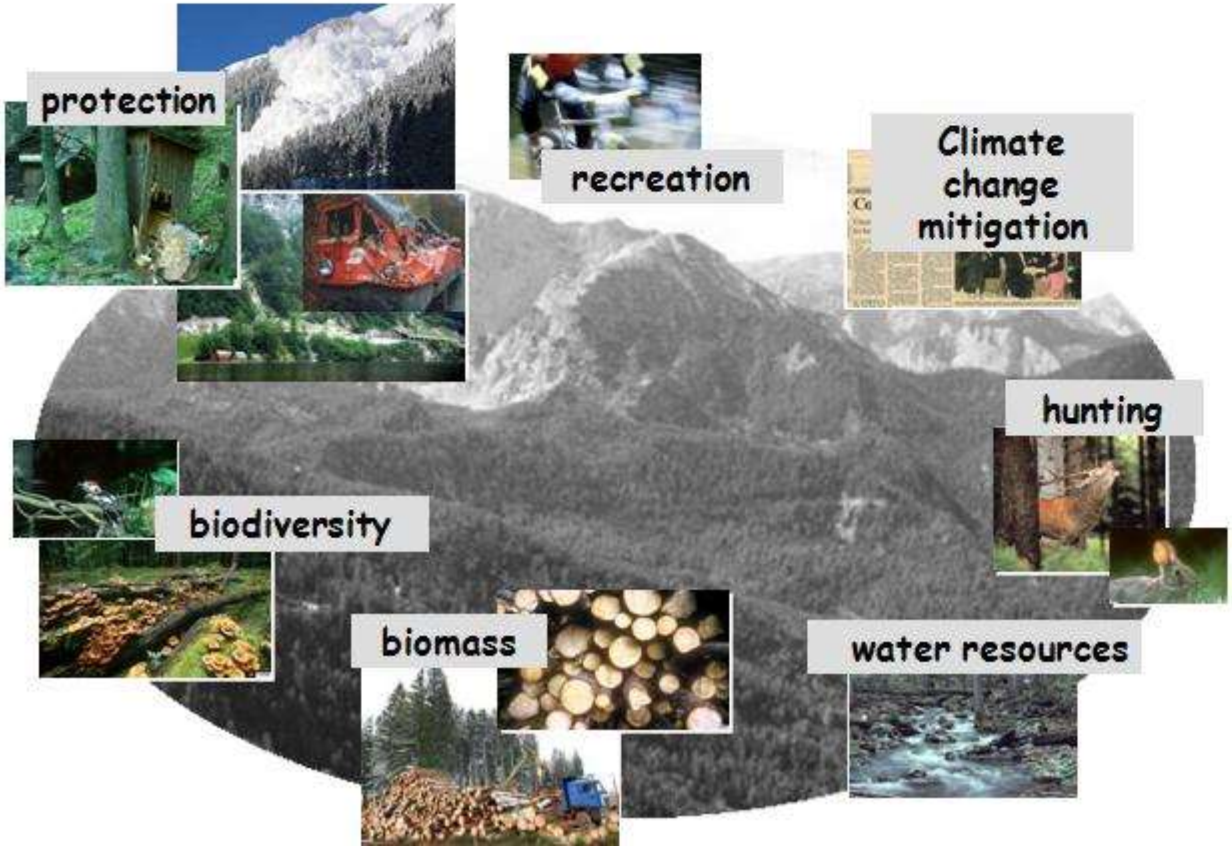
Diverse forests do not maximize any function but performs very very well all functions

The analogy with decathlon

The winner is the one able to do well all 10 sports, not the one being top in one or two

The analogy with decathlon

Multifunctionality increases with biodiversity



So far, three good reasons to preserve forest biodiversity

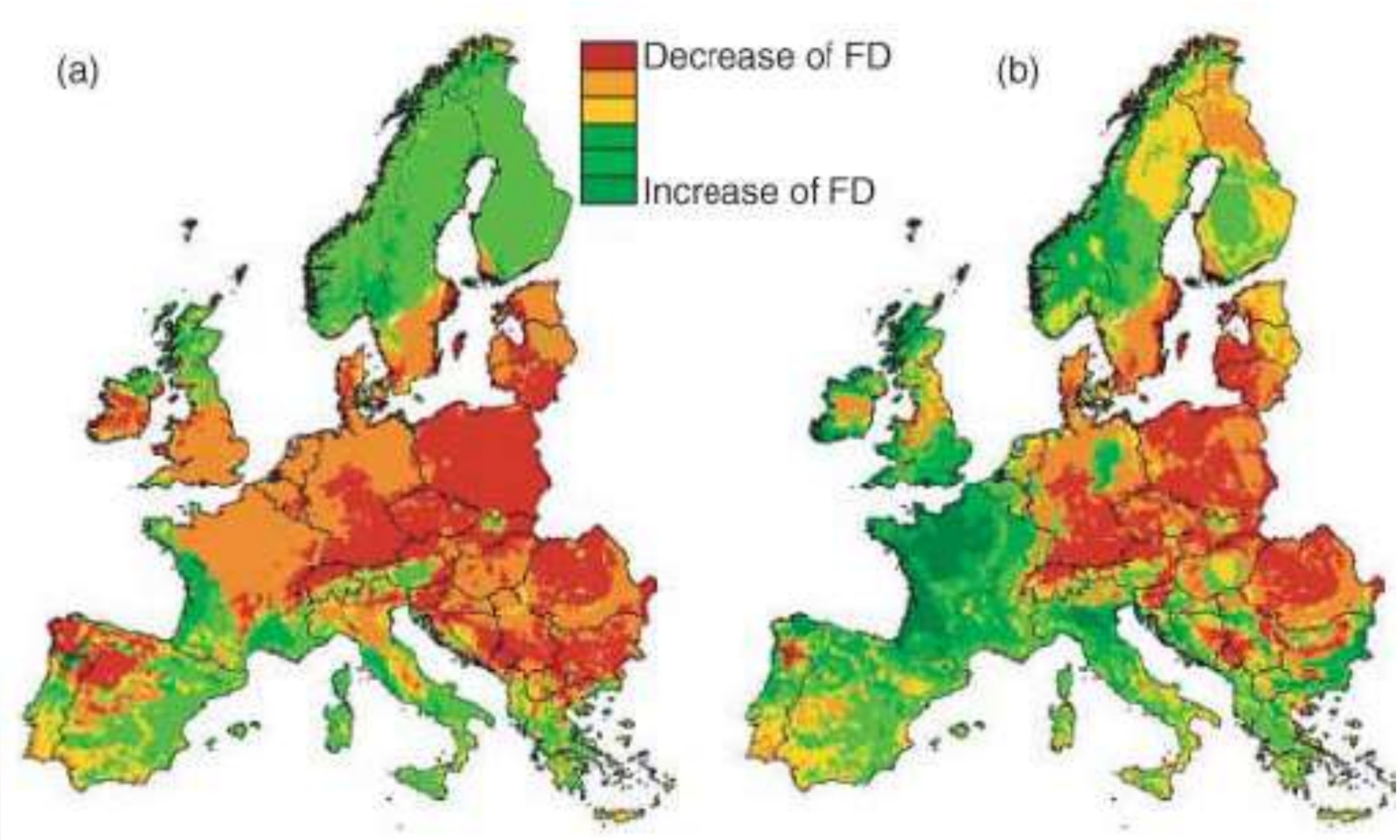
1- It increases productivity

2- Its conservation is more tan paid by productivity

3- It increases multifunctionality

Climate change and functional diversity of European forests

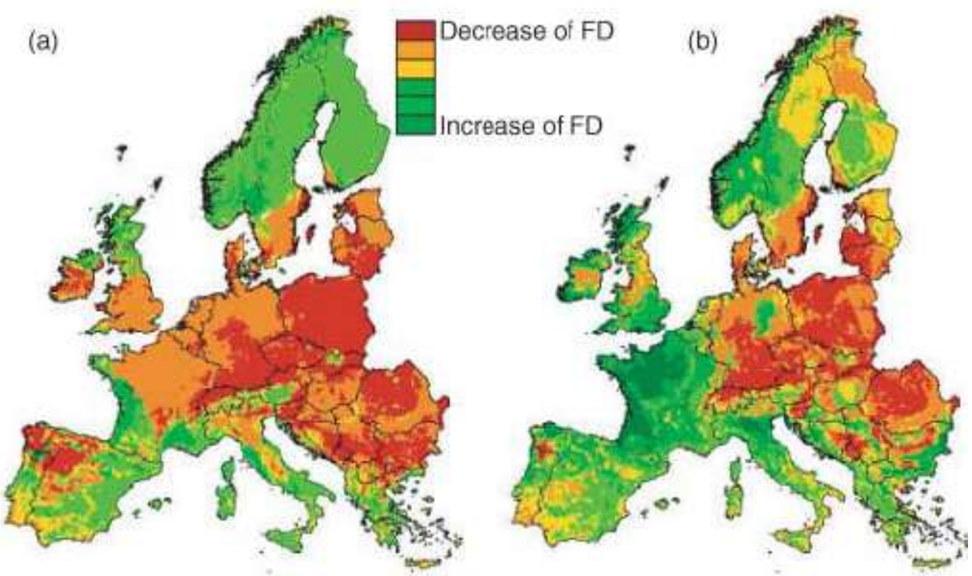
2050 (no dispersal)　　　2050 (with dispersal)

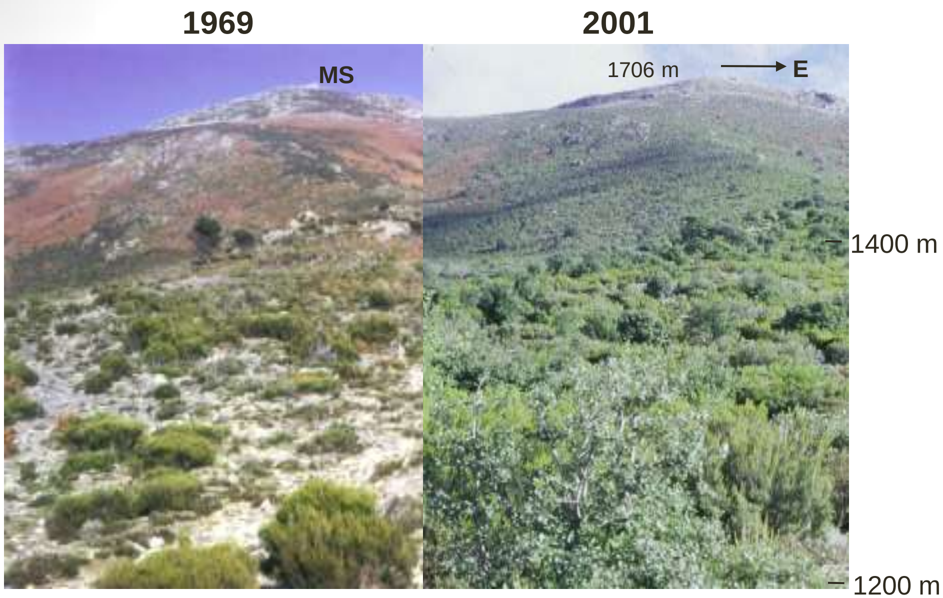


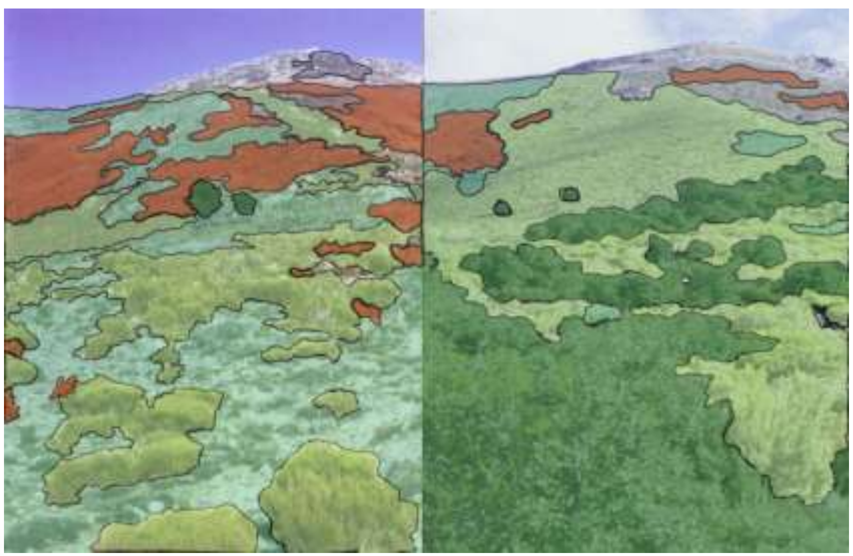
Thuiller et al. 2006

Are these maps realistic?

Is species future distribution simply a projection of current distribution as a function of climate?







Altitudinal shift of Quercus ilex

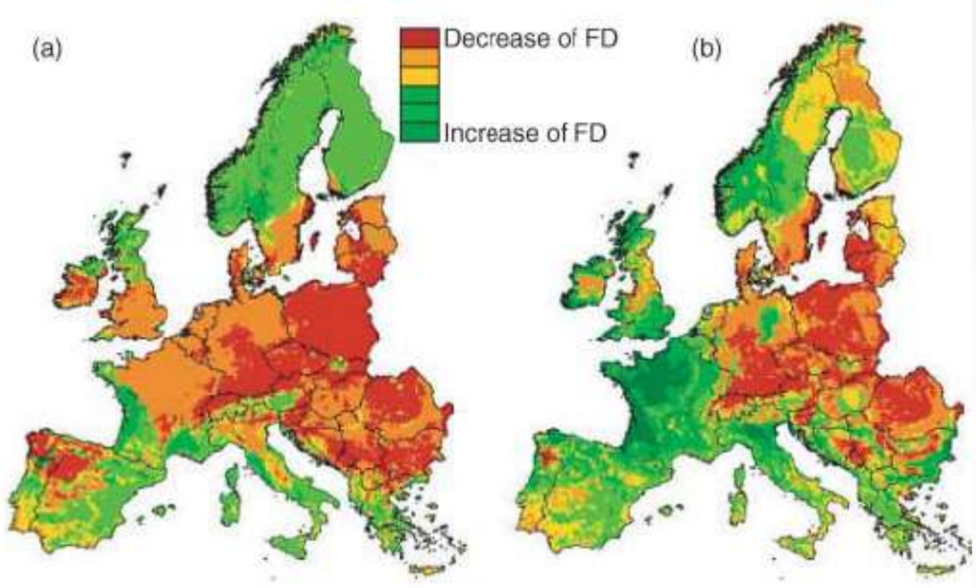
- *Quercus ilex* young forest
- *Erica scoparia* heathland
- *Calluna vulgaris* heathland
- *Pteridium aquilinum* fernland
- Grassland *and Cytisus scoparius*
- **MS** Meteorological station

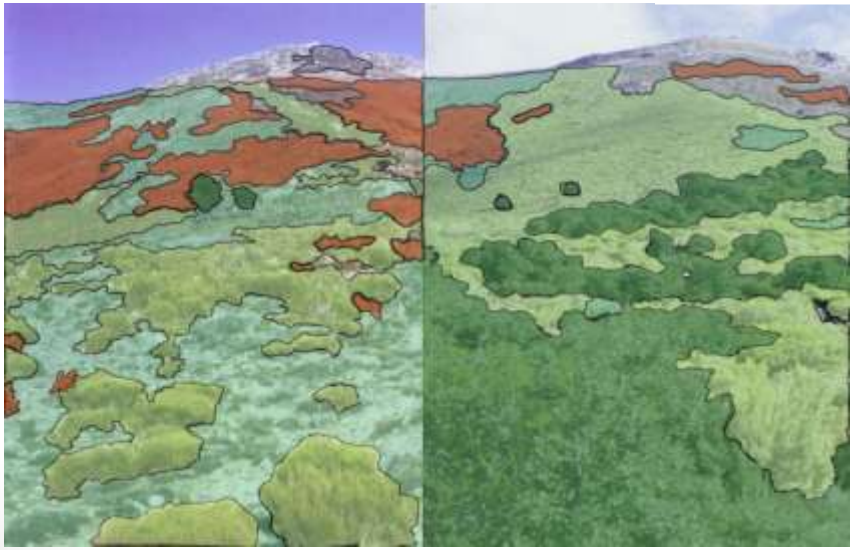
Peñuelas and Boada, 2003 *Global Change Biol*, 9, 131-140

Peñuelas *et al.* 2007 *Ecography,* 30, 830-838

Do these maps match?

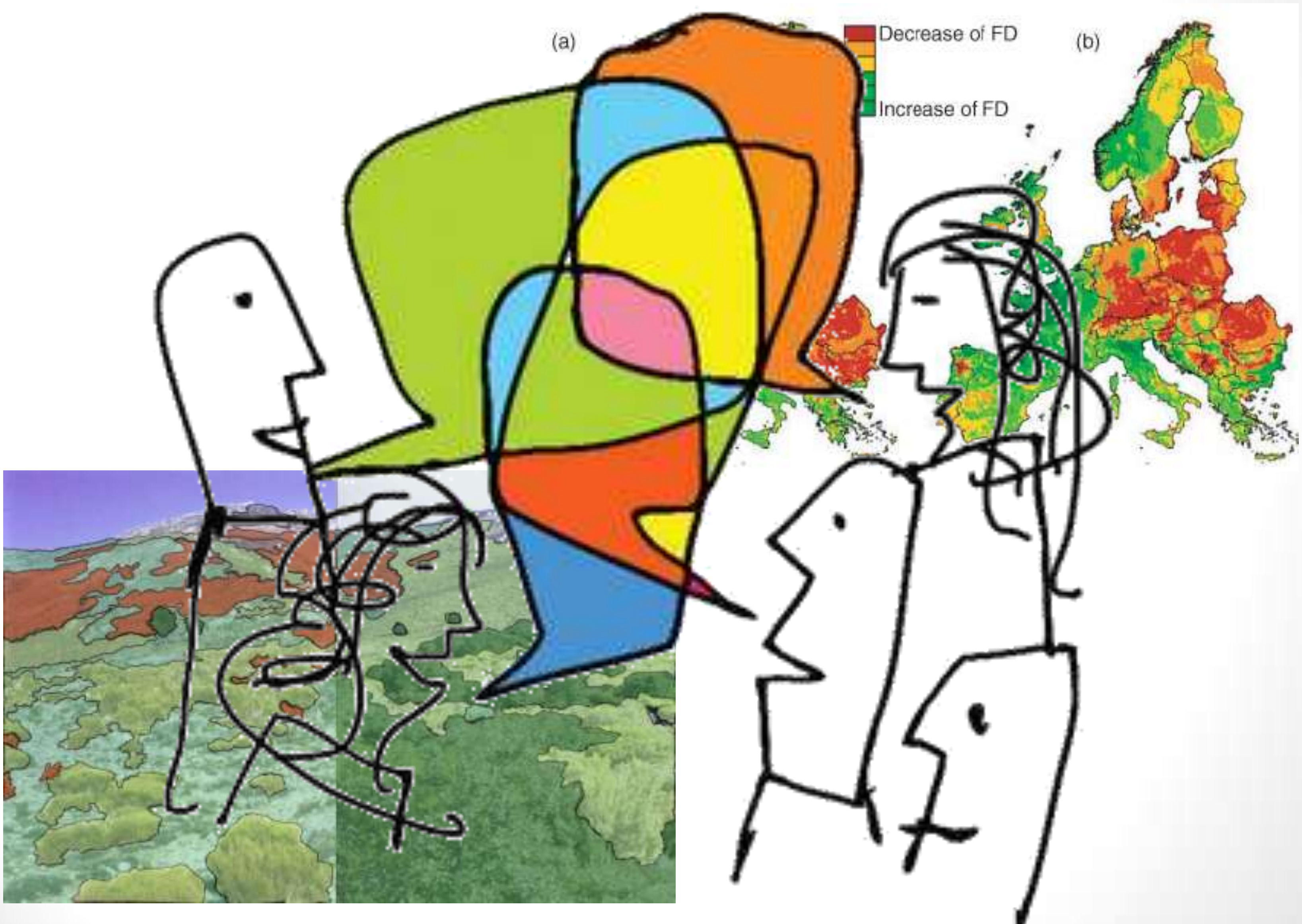
Observation and local/regional maps less pesimistic scenarios than models over large areas





Extinctions that are not seen… movements that are less extreme

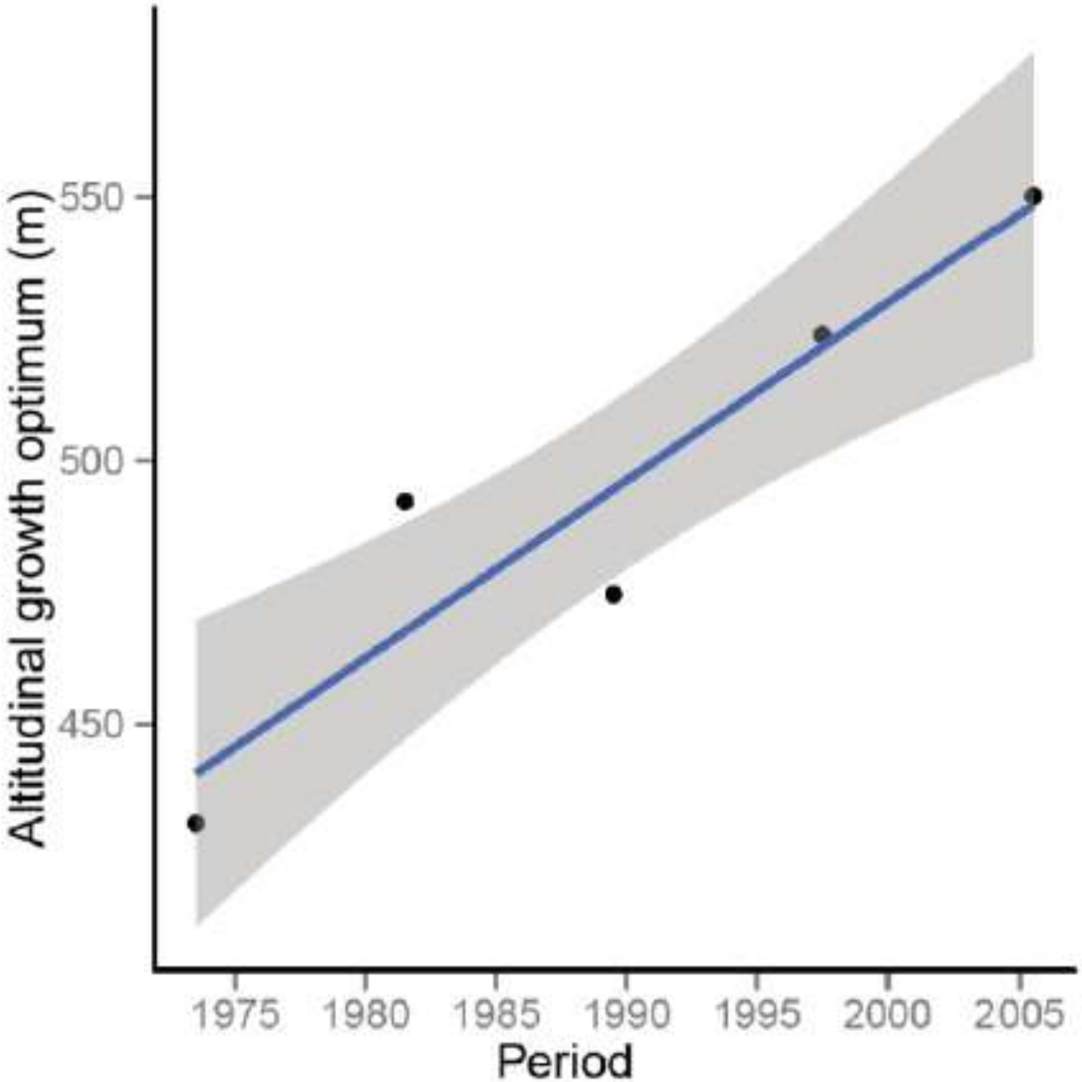
Some reasons for mistmatches



DENDROECOLOGY

Cores along elevation gradients

Beech (*Fagus sylvatica*)

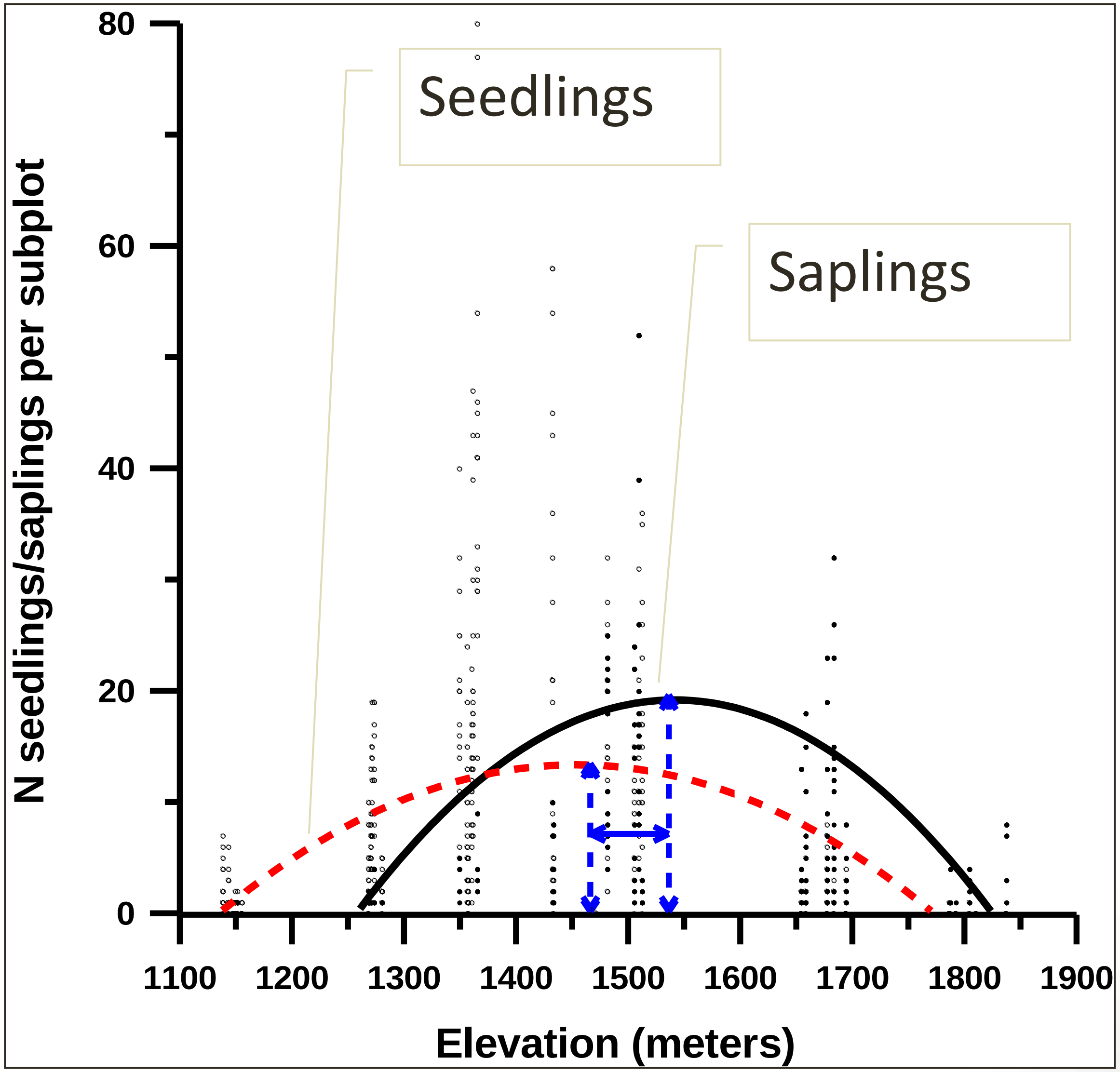


Delzon et al.

DEMOGRAPHY

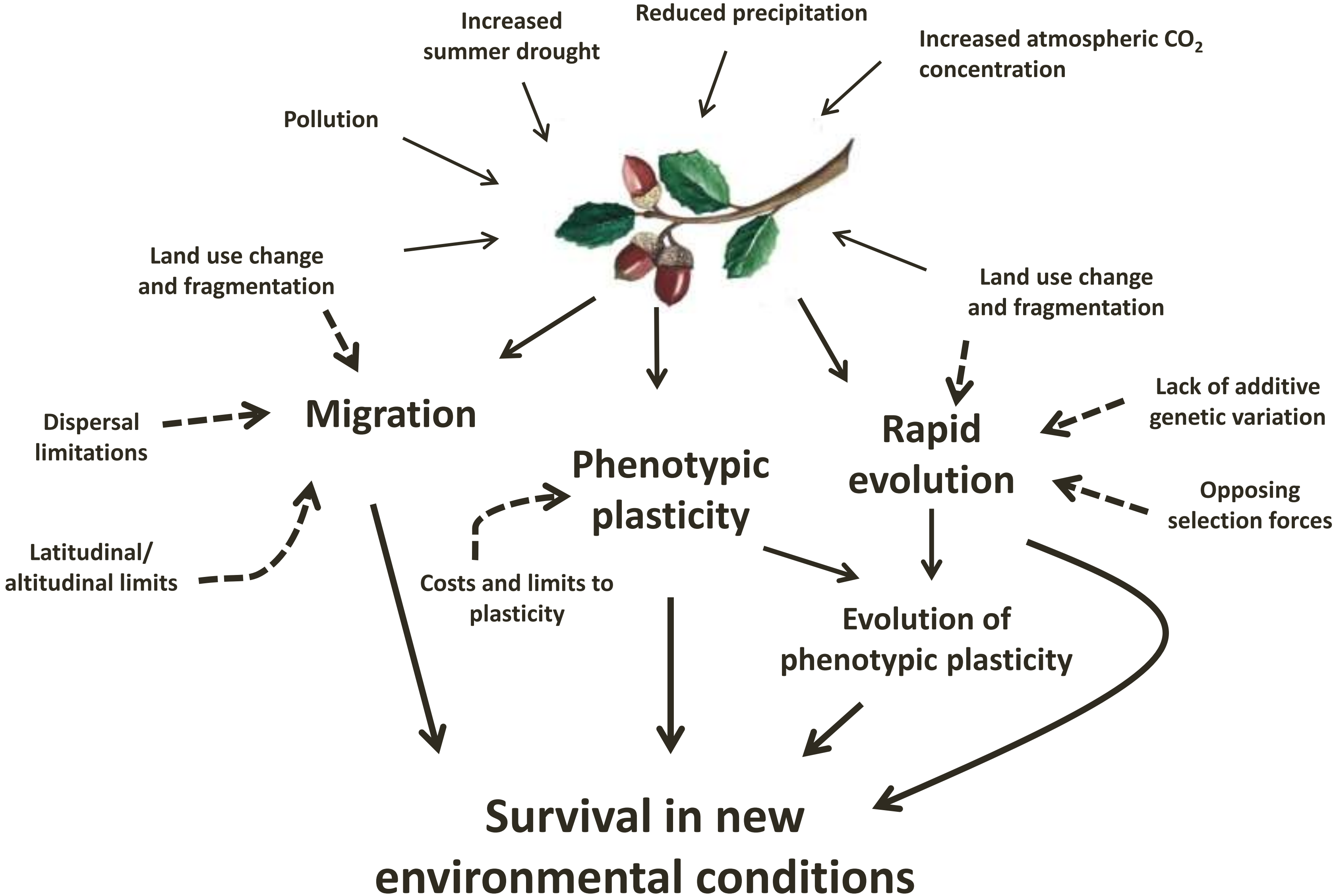
Age classes along elevation gradients

Pinus sylvestris



Benavides et al. 2012

Global change



Matesanz & Valladares 2014 EEB

¿Que podemos hacer?

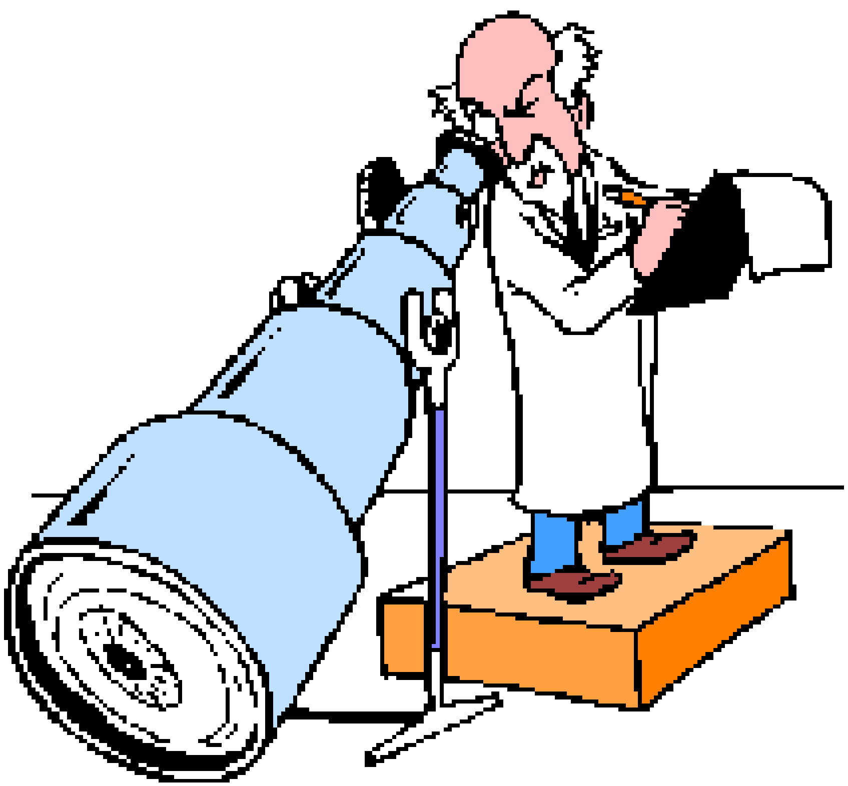
Ganar tiempo

Permite

1. Atenuar impactos
2. Entender mejor
3. Avances tecnológicos
4. Adaptación
5. Evolución

¿Que podemos hacer?

Mientras actuamos… seguir estudiando!



Servicios ecosistémicos alterados

Pérdida de biodiversidad

Valladares et al. 2009. Book Chapter

CAMBIO USO DEL TERRITORIO

Motores de Cambio Global

Doblas-Miranda et al. 2017. Glob Planet Change

CAMBIO CLIMÁTICO

Mayor rapidez e intensidad acción humana

Incremento fragmentación hábitat

Modificación de los paisajes forestales

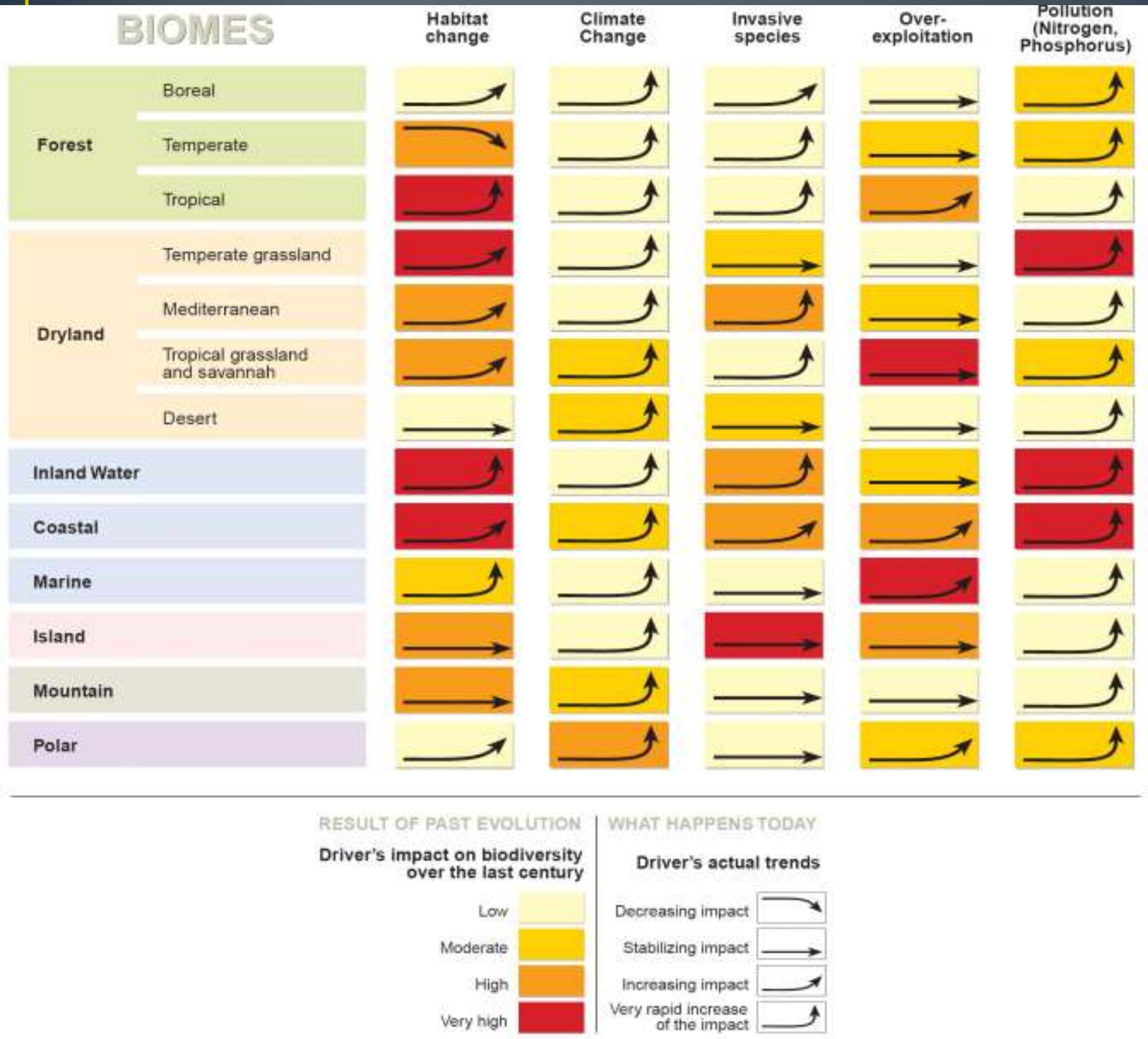
Incremento T

Disminución P

Alados et al. 2004. Landsc Ecol; Millennium-Ecosystem-Assessment 2005

Christensen y Christensen 2003. Nature; IPCC 2014

Los motores de cambio global



- El cambio climático NO ESTA SOLO!!!

Millennium Assessment 2005. UN

Conclusions

1. Mediterranean tree species differ in their sensitivity and responses to climate change but most are still far from their tolerance limits
2. Biodiversity increases ecosystem functions such as productivity and multifunctionality, and quite likely resilience to climate change
3. Our knowledge on genetic diversity, phenotypic plasticity, and ecophysiological performance of key Mediterranean tree species is still very limited
4. Gain time is crucial to allow adaptation, evolution, and scientific and technological knowledge
5. Climate change is not coming alone and our understanding of interactions is poor
6.