*Universidad de Alcalá*

# *Impactos, Vulnerabilidad y Adaptación de los bosques ibéricos al cambio climático*

***Miguel Angel de Zavala***

*Grupo de Ecología y Restauración Forestal*

**SEMINARIOS DEL PLAN NACIONAL DE ADAPTACIÓN AL CAMBIO CLIMÁTICO**
**INTEGRACIÓN DE LA ADAPTACIÓN AL CAMBIO CLIMÁTICO EN LA PLANIFICACIÓN Y LA GESTIÓN DE LAS ÁREAS PROTEGIDAS EN ESPAÑA**

**Centro Nacional de Educación Ambiental (CENEAM)**

**Valsaín, 4 y 5 de abril de 2016**

# Impactos, Vulnerabilidad y Adaptación de los bosques ibéricos al cambio climático

- **Contexto: Evolución histórica y situación actual.**
- **Evidencias desde la investigación.**
- **Los bosques y la biodiversidad frente al cambio climático:** Impactos, Vulnerabilidad y Adaptación en España**. Informe de Evaluación**

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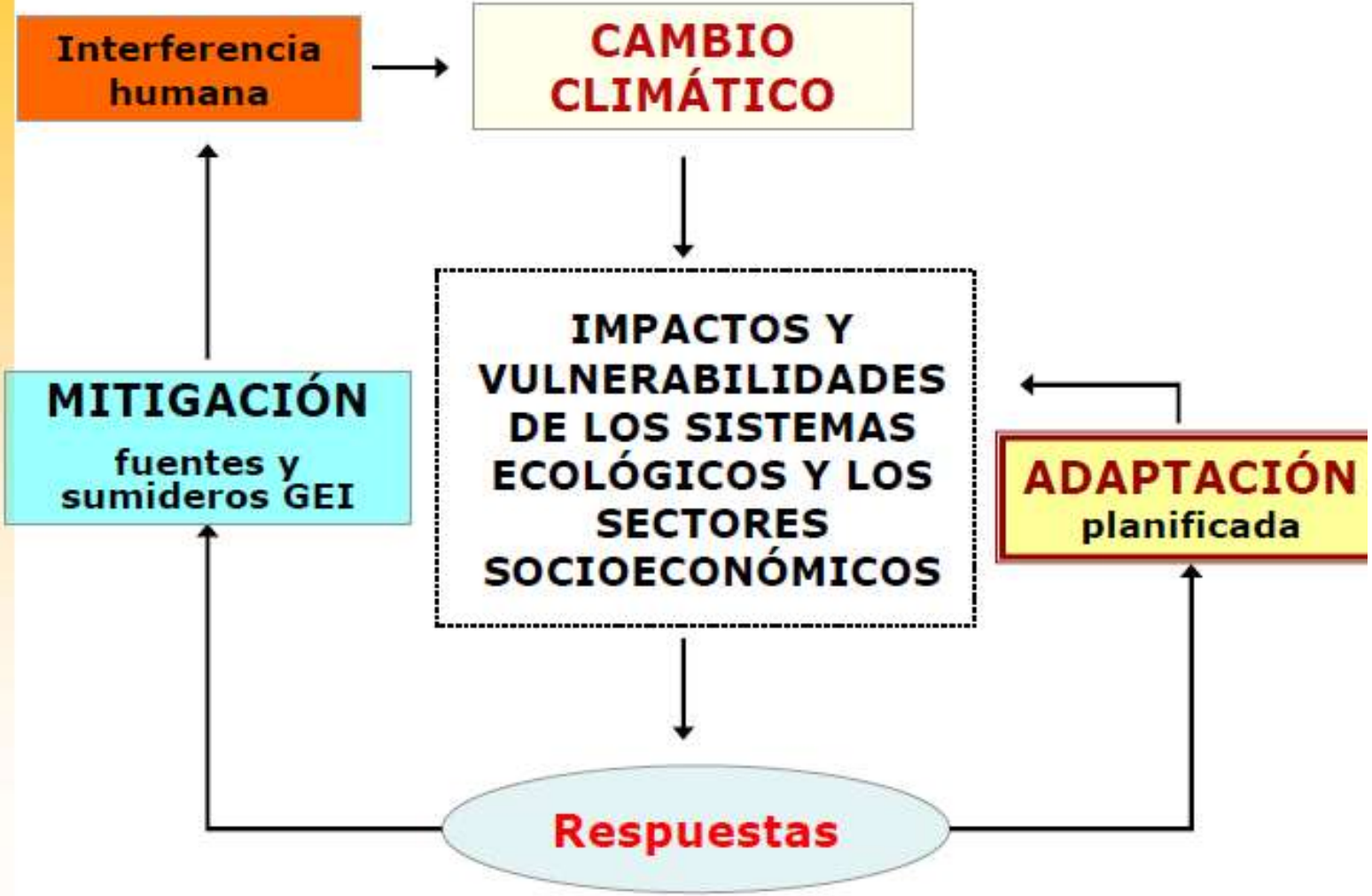
MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO

Ciclo de Seminarios de Análisis y Prospectiva

I Seminario 2009 / 26 de Febrero

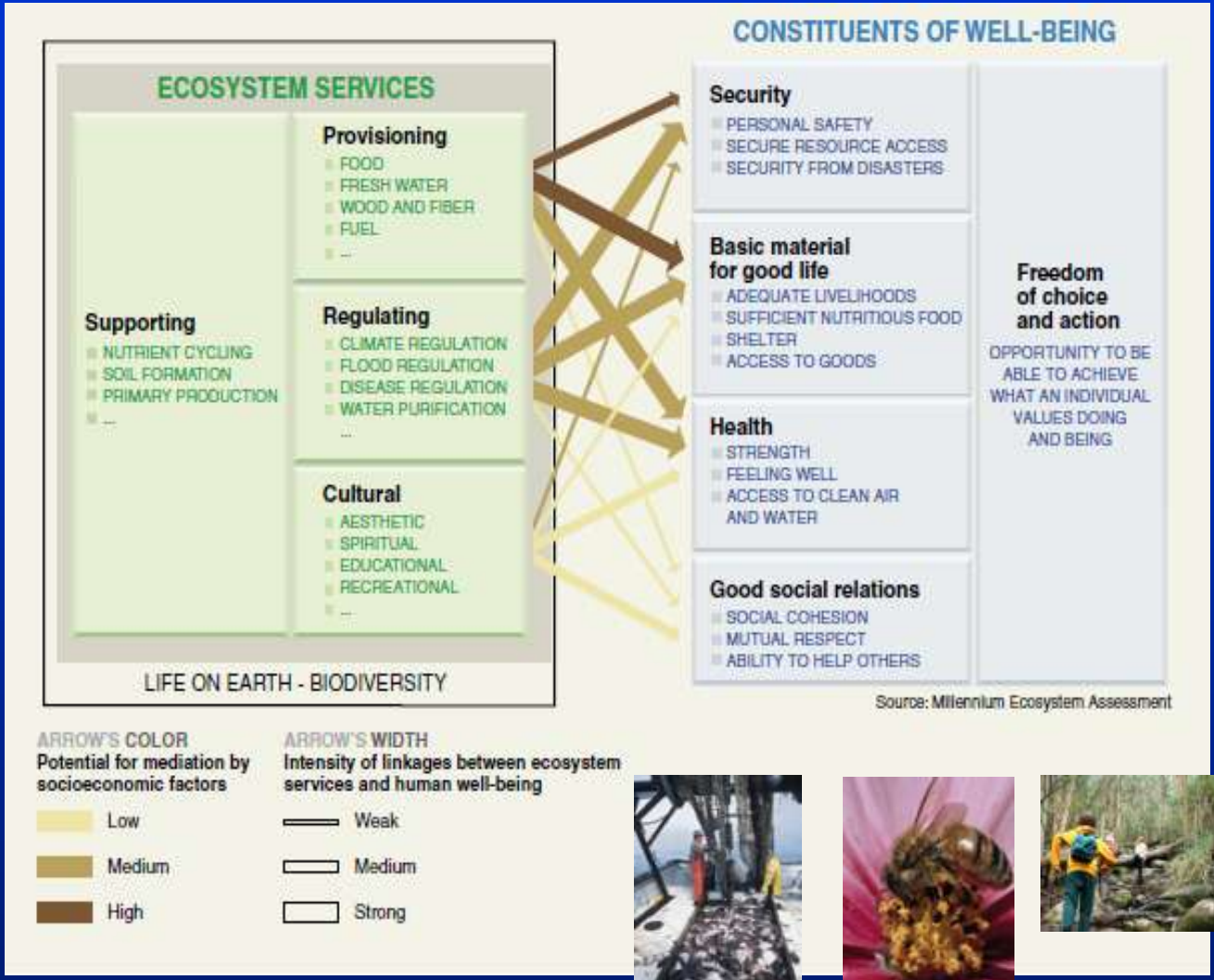
Implicaciones del Cambio Climático sobre el medio ambiente, el medio rural y el medio marino

# EL CAMBIO CLIMÁTICO COMO PRINCIPAL RETO AMBIENTAL




oecc

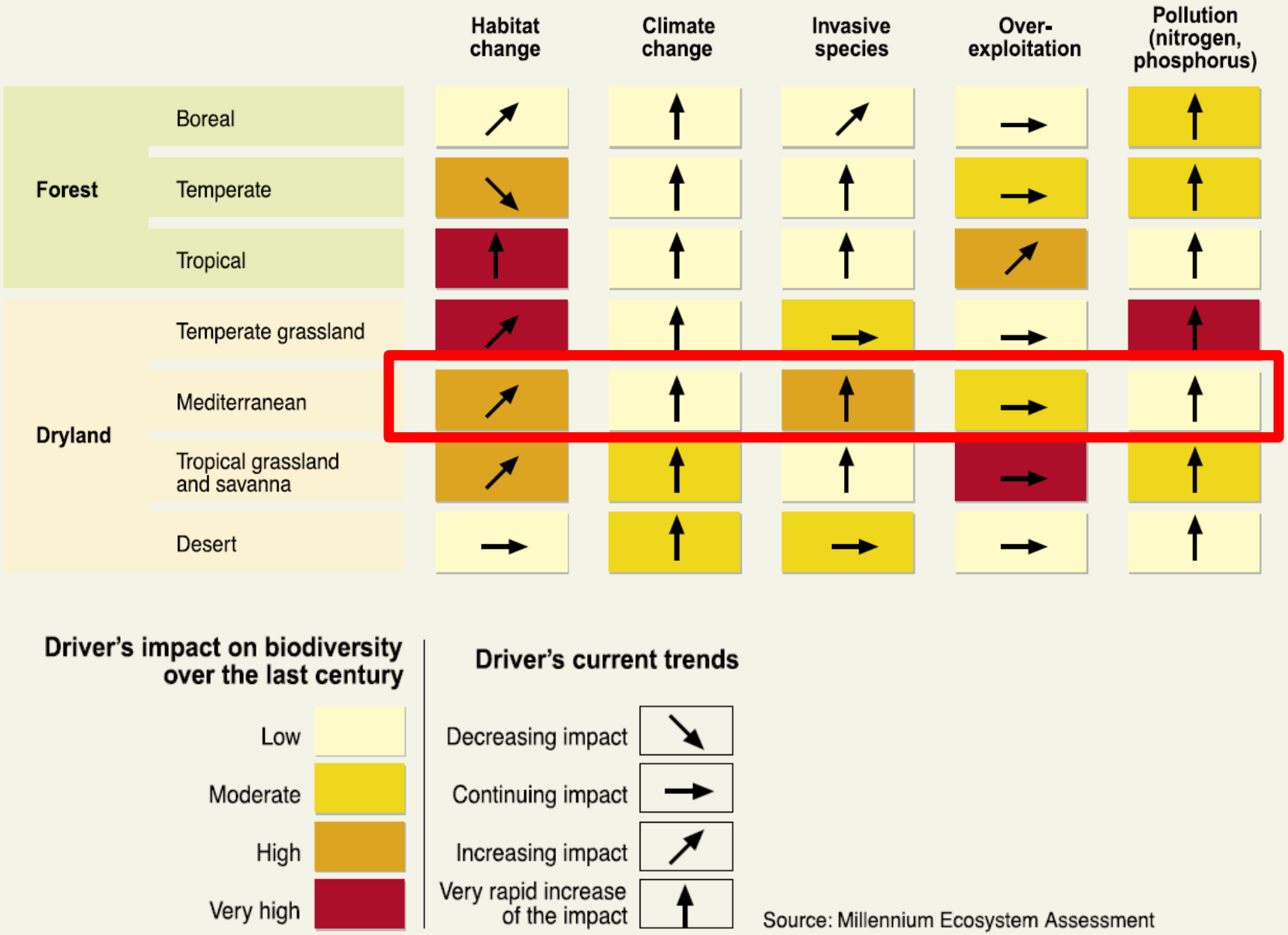
# ¿Por qué los bosques?



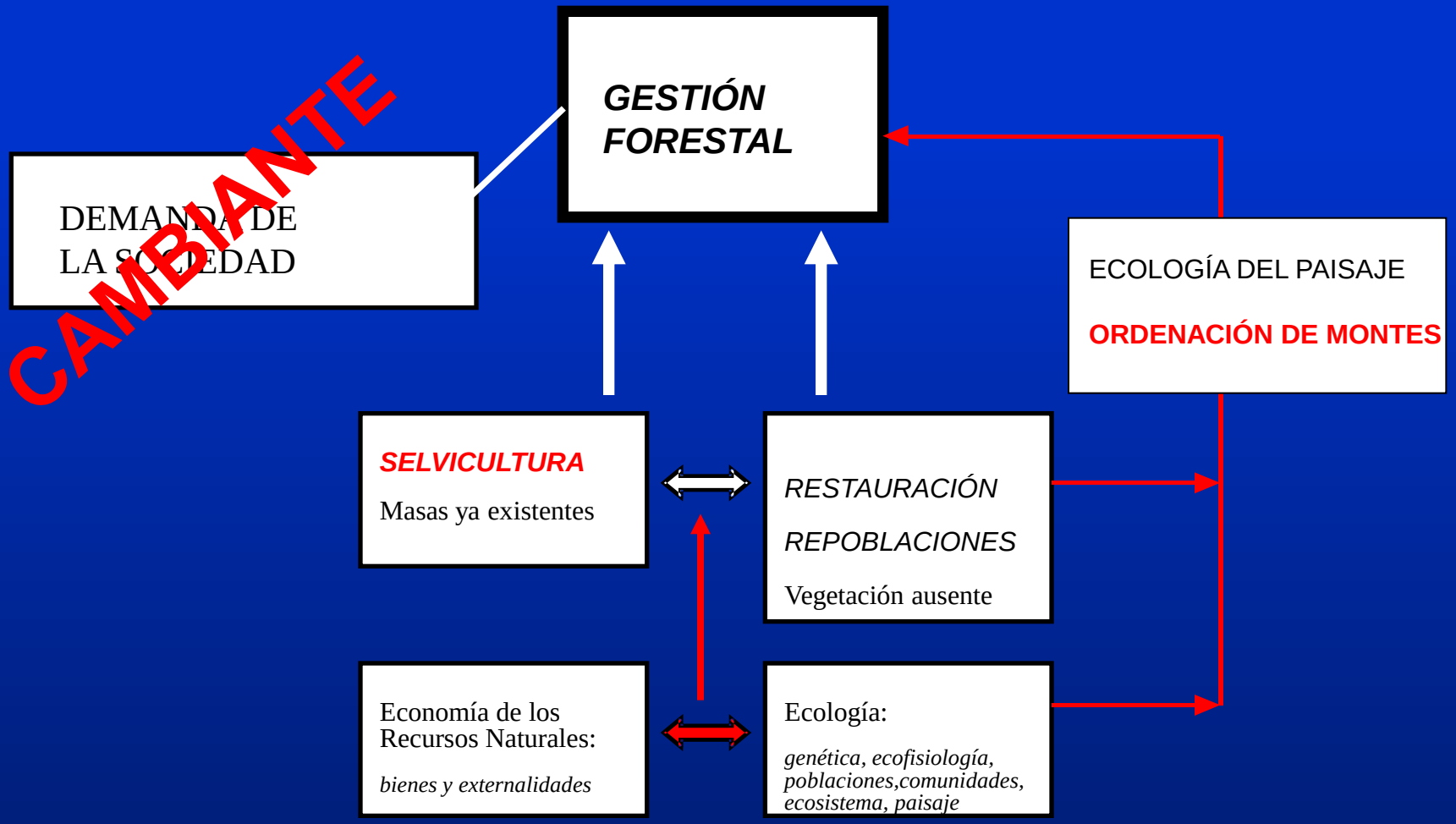







http://www.youtube.com/watch?v=MaKKKdoLc2g


GESTIÓN FORESTAL
DEMANDA DE LA SOCIEDAD
CAMBIANTE
ECOLOGÍA DEL PAISAJE
ORDENACIÓN DE MONTES
SELVICULTURA
Masas ya existentes
RESTAURACIÓN
REPOBLACIONES
Vegetación ausente
Economía de los Recursos Naturales:
bienes y externalidades
Ecología:
genética, ecofisiología, poblaciones,comunidades, ecosistema, paisaje

Visión financiera

Multifuncional

Sostenibilidad


DEMANDA
TIPO DE GESTIÓN
Bienes
Selvicultura clásica
Bienes
Servicios
Multifuncionalidad
Bienes
Servicios
Funciones ecosistémicas
Sostenibilidad
Bienes
Servicios
Funciones ecosistémicas
Resiliencia al Cambio Global
Adaptación
Mitigación

*"Cuando creíamos que teníamos todas las respuestas, de pronto, cambiaron todas las preguntas".*

*Mario Benedetti*

# Impactos, Vulnerabilidad y Adaptación de los bosques ibéricos al cambio climático

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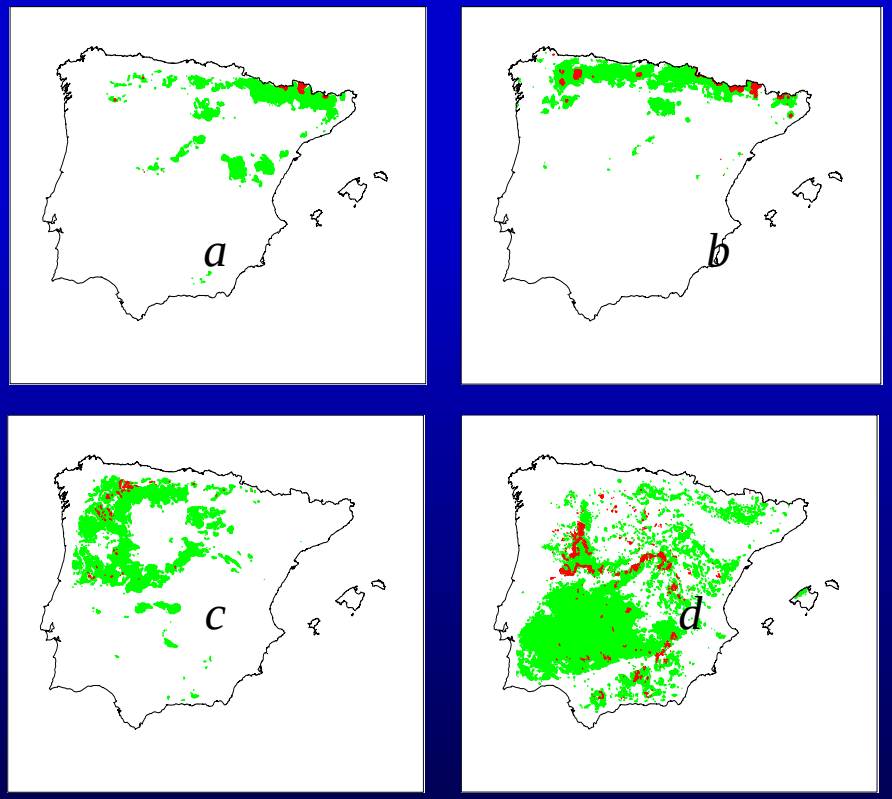
# Classical Species Distribution Models (SDM)

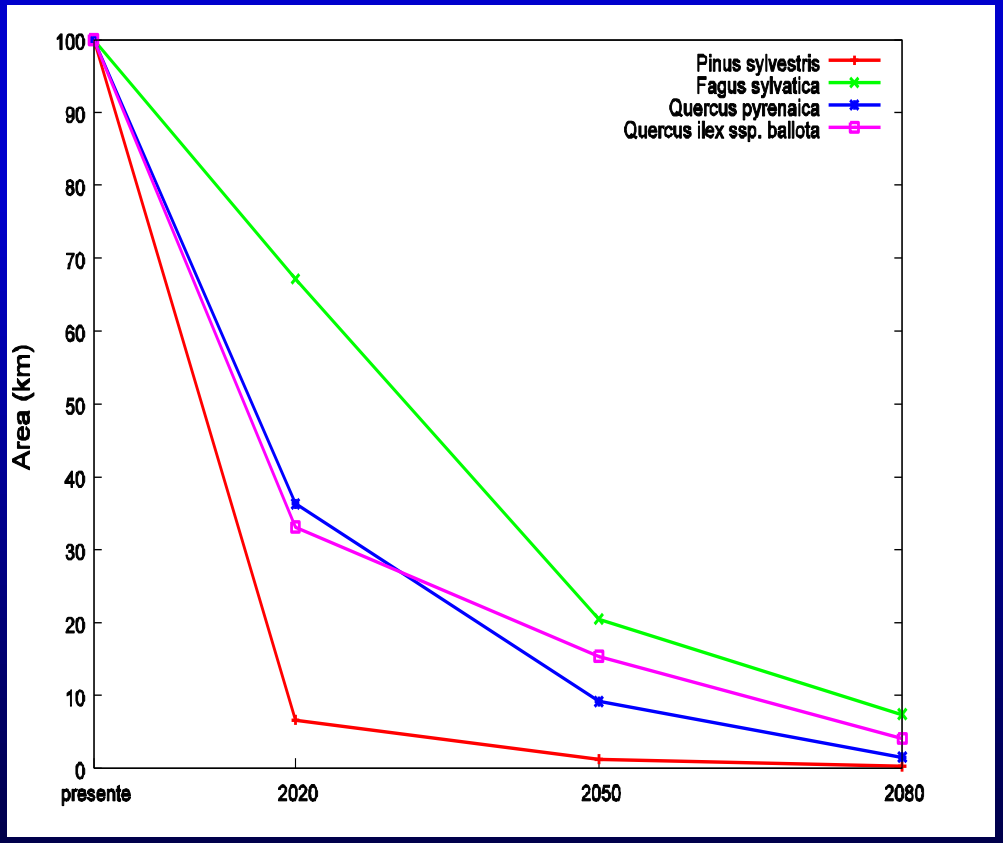
# **Vulnerability to climate change:** potential tree species distributions




Source *Benito Garzón et al.* 2009

Changes in potential distribution of tree species; current (green) and 2080 (red) under scenario A2 CSIRO-Mk2 for *Pinus sylvestris* (a), *Fagus sylvatica* (b), *Quercus pyrenaica* (c) and *Quercus ilex* subsp. ballota (d)

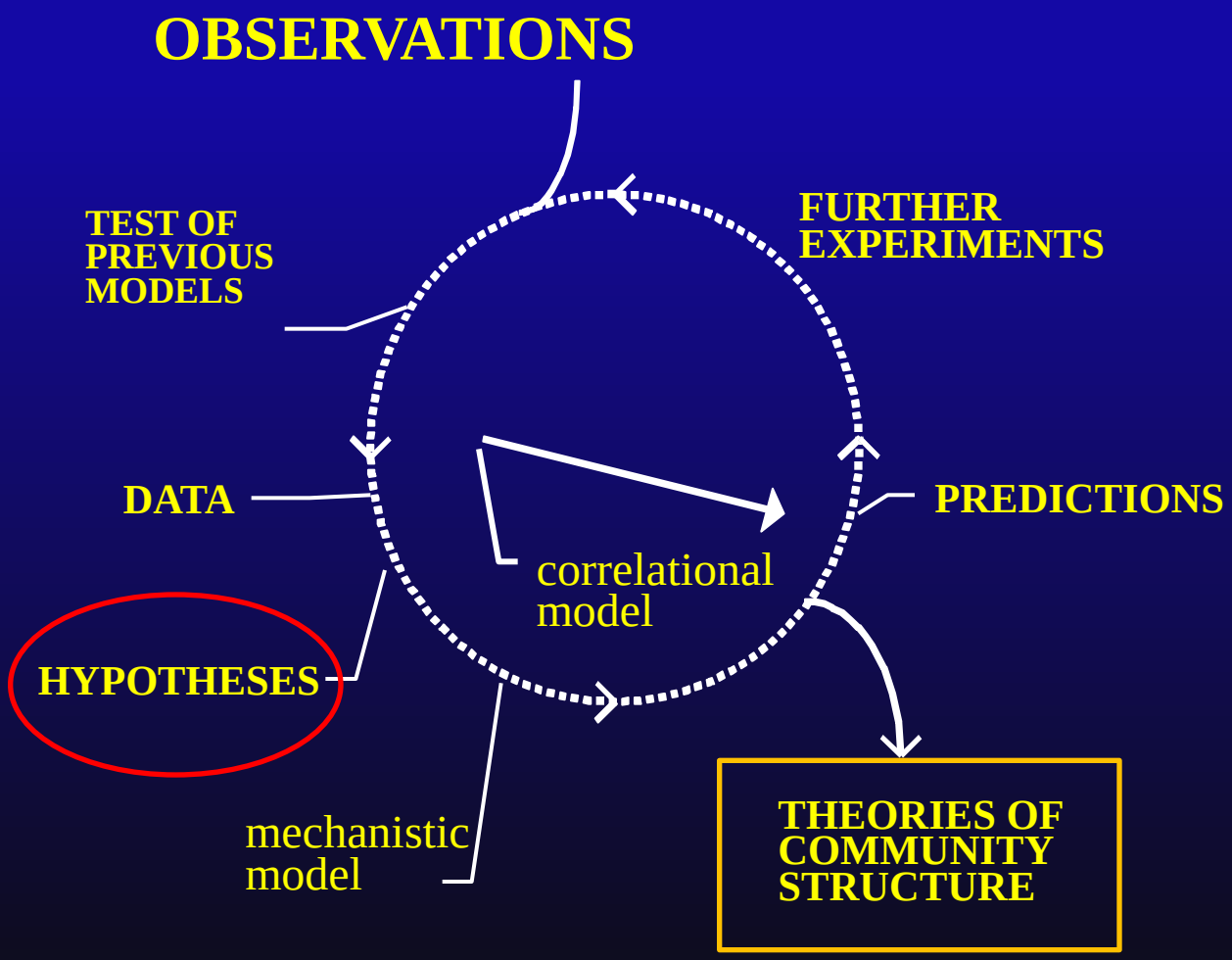
# **Vulnerability to climate change:** potential tree species distributions

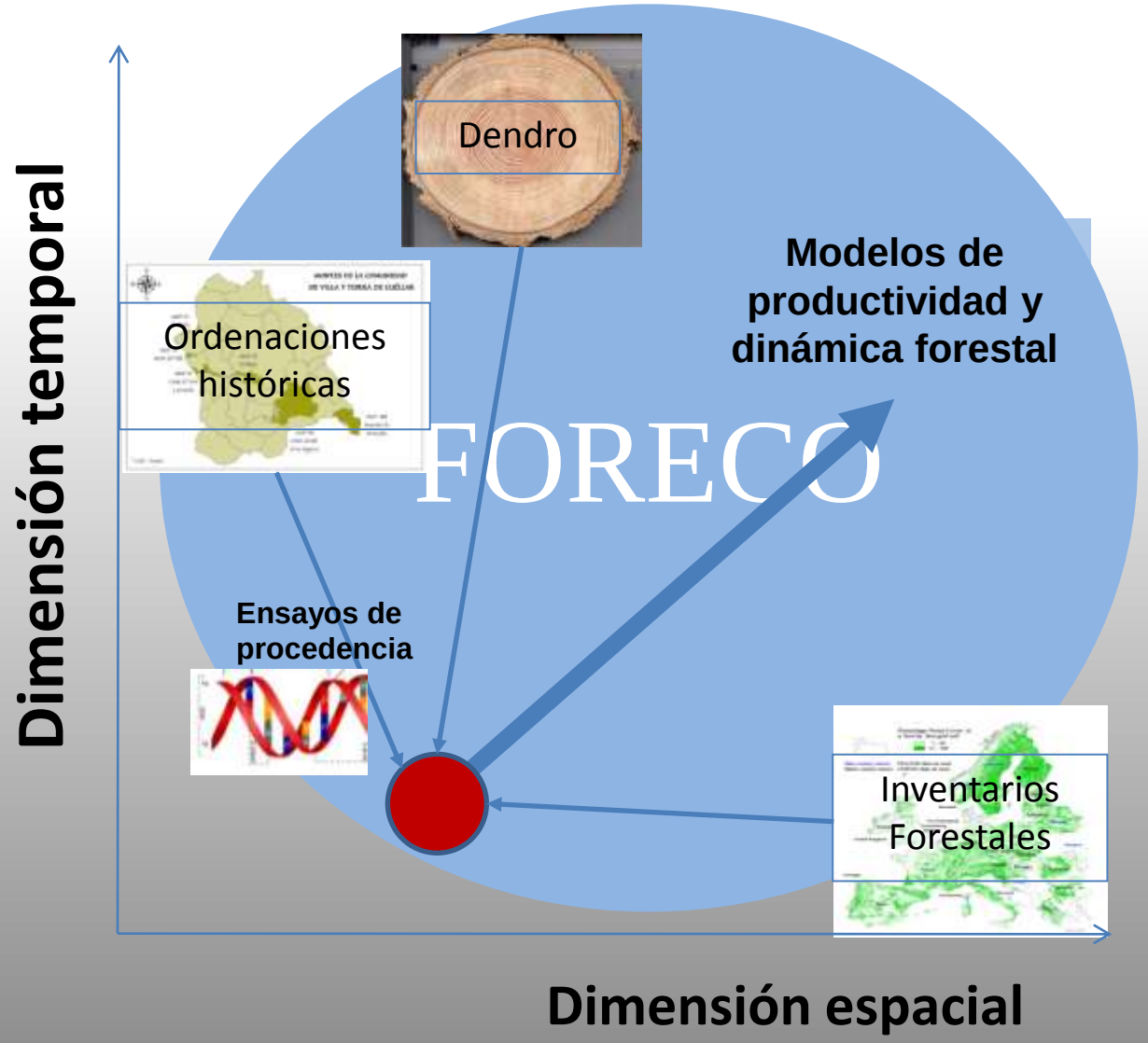



Source *Benito Garzón et al.* 2009

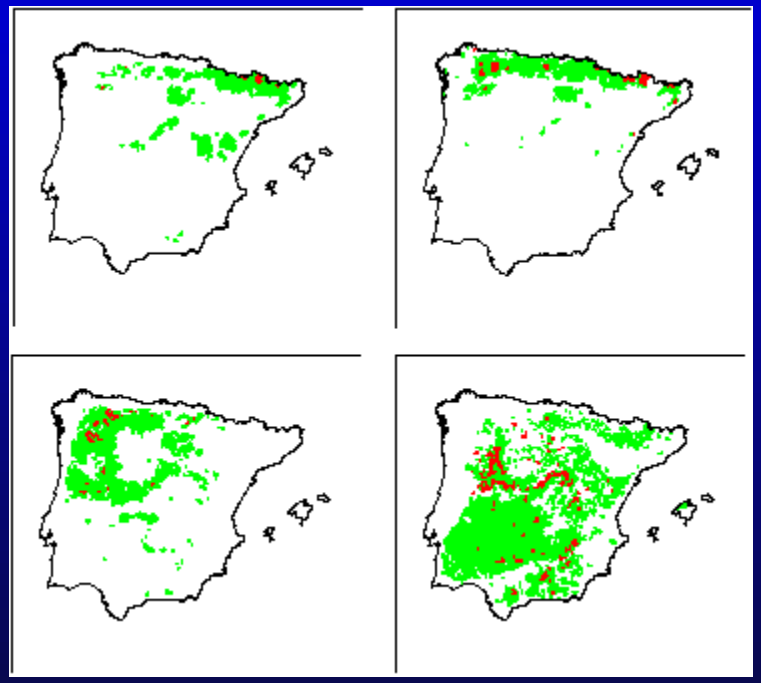
Changes in potential distribution of tree species. Current = 100%. Potential area decreases according to A2 CSIRO-Mk2 for 2020, 2050 and 2080.

# The Role of Models in Global Change Research




Dendro
Ordenaciones históricas
Modelos de productividad y dinámica forestal
FORECO
Ensayos de procedencia
Inventarios Forestales
Dimensión temporal
Dimensión espacial

# Including ecological and adaptive mechanisms in vulnerability models.

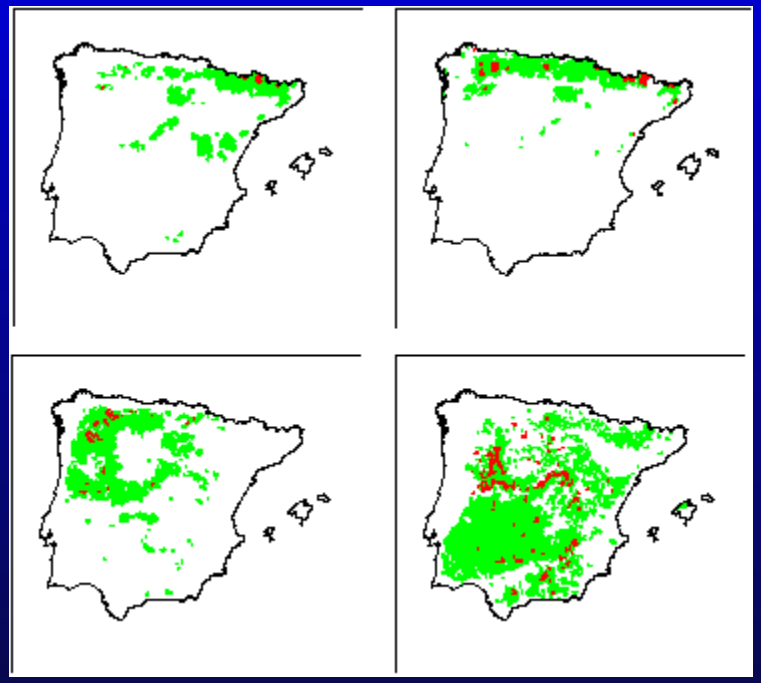


**Genes & organismic**
Epigenesis.
Evolution/Local adaptation
Plasticity

**Population and communities**
Demographic compensation
Migration (dispersal)
Diversity/Stabiilty

**Ecosystem & landscape.**
$CO_2$ fertilization
Land use governance

# Including ecological and adaptive mechanisms in vulnerability models.



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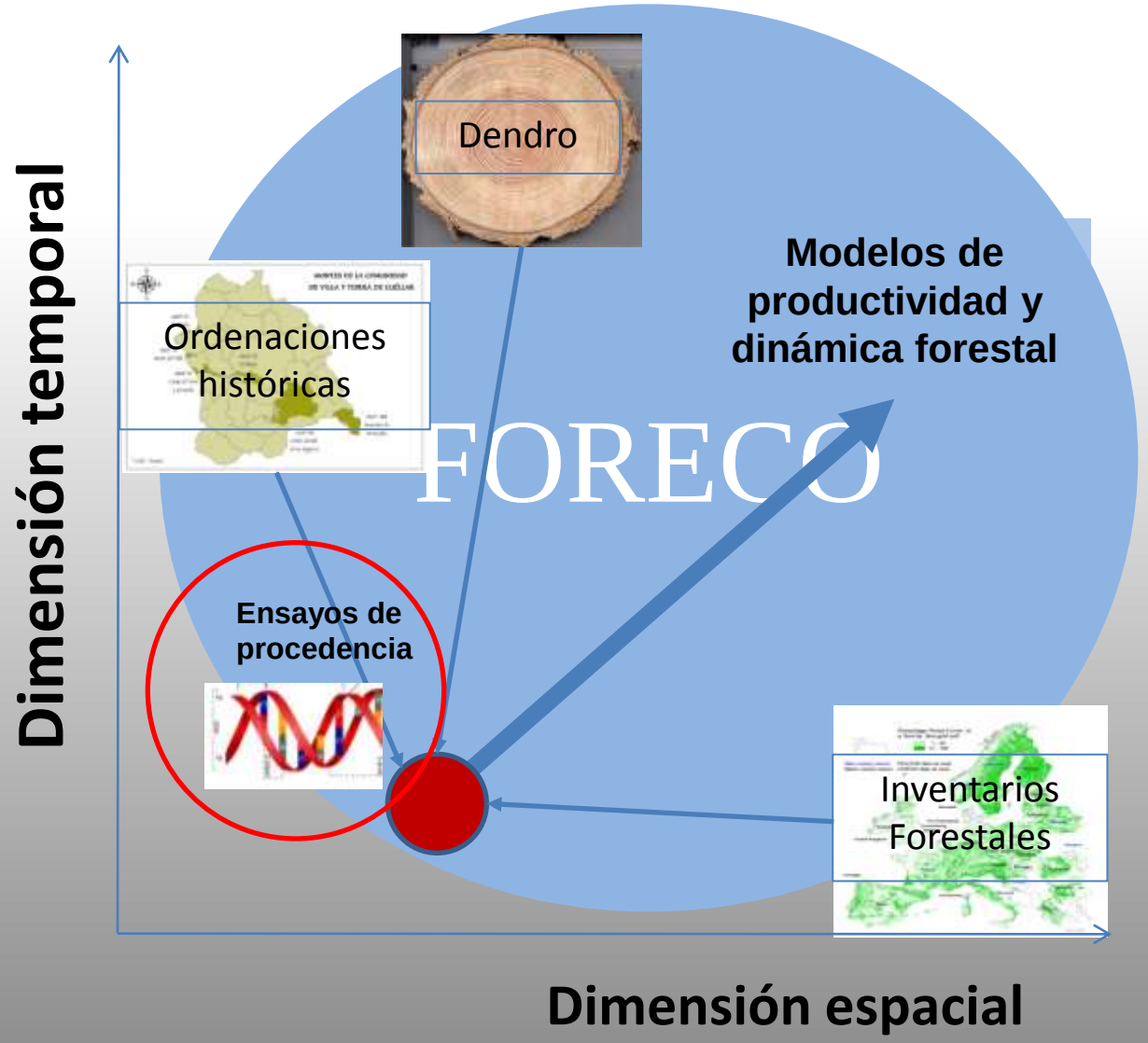
Dendro
Ordenaciones históricas
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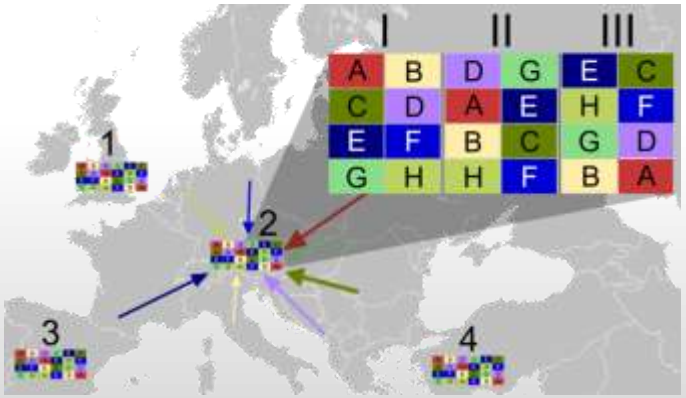
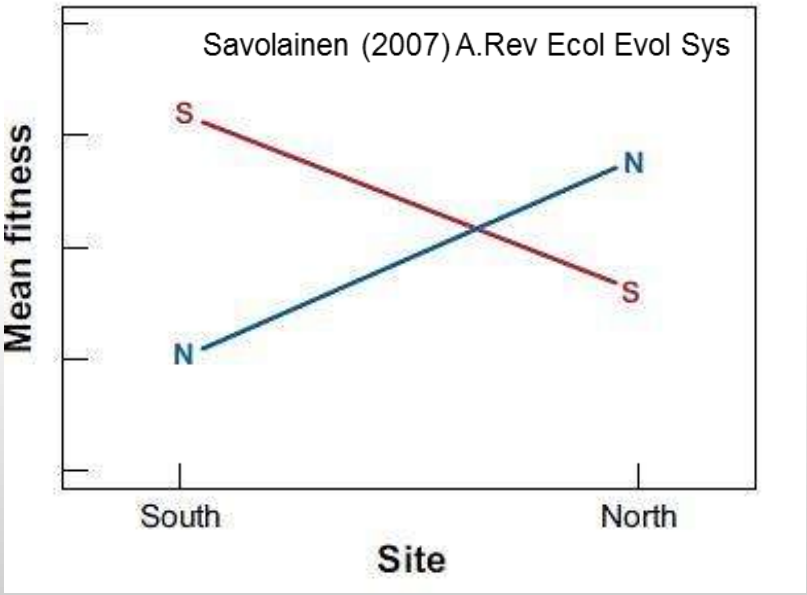
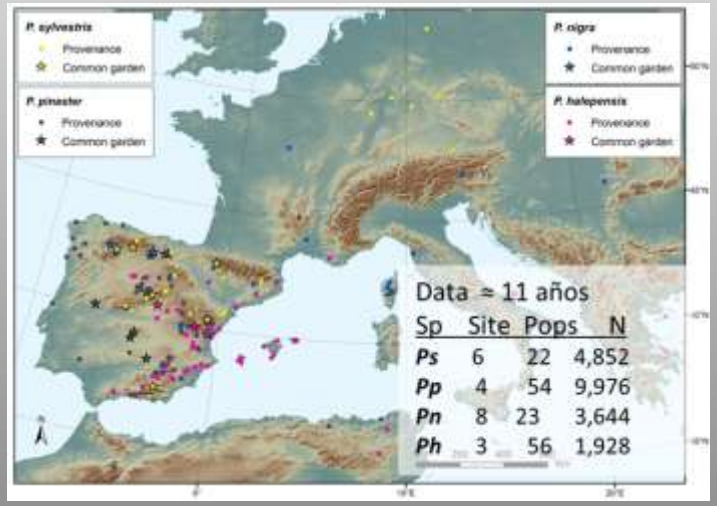
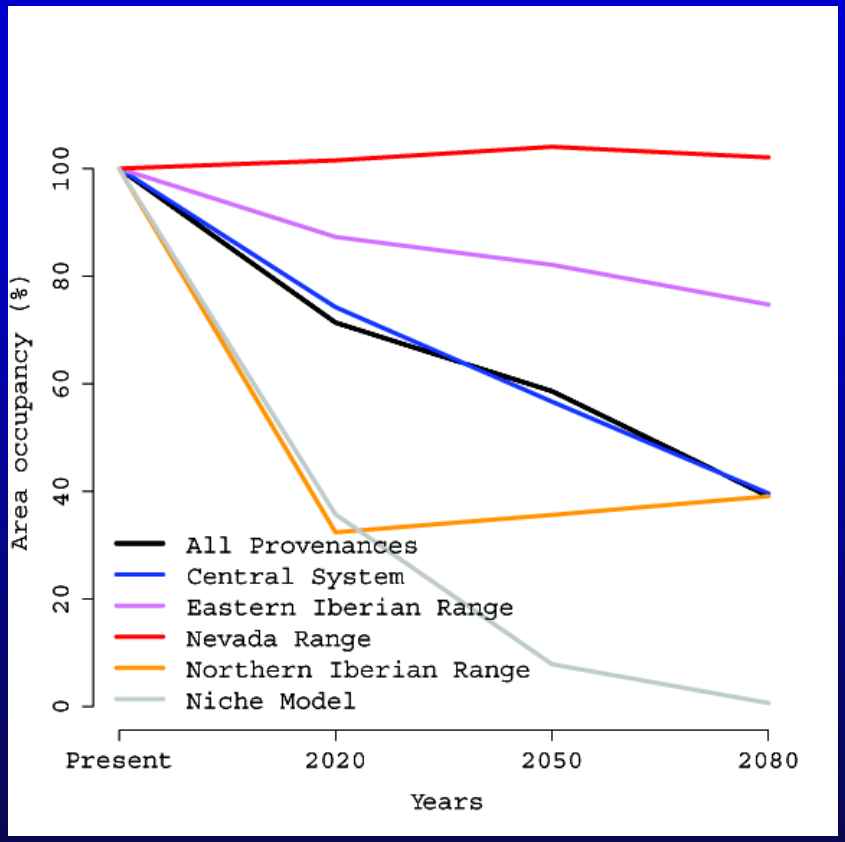

I
II
III
A B D G E C
C D A E H F
E F B C G D
G H H F B A
1
2
3
4


Savolainen (2007) A.Rev Ecol Evol Sys
S
N
N
S
Mean fitness
South
North
Site

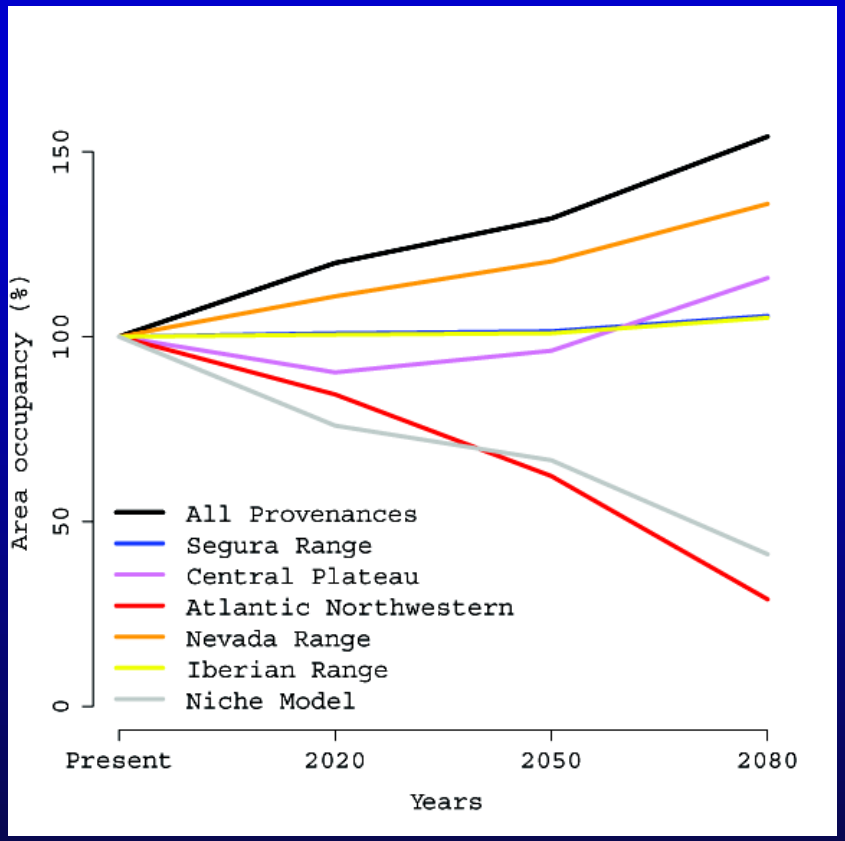

P. sylvestris
Provenance
Common garden
P. nigra
Provenance
Common garden
P. pinaster
Provenance
Common garden
P. halepensis
Provenance
Common garden
Data ≈ 11 años
Sp Site Pops N
Ps 6 22 4,852
Pp 4 54 9,976
Pn 8 23 3,644
Ph 3 56 1,928


P. halepensis
Aleppo pine
P. nigra
Black pine
P. pinaster
Maritime pine
P. sylvestris
Scots pine

# c) SDM: genetic variation



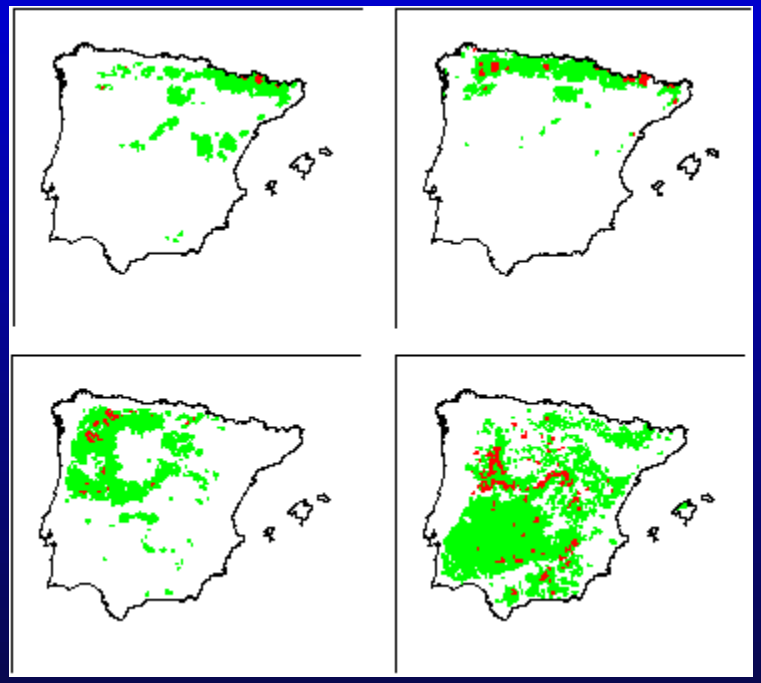

*Pinus sylvestris*




*Pinus pinaster*

Benito-Garzón *et al.* 2011. *Global Ecology & Biogeography* 20: 766–778.

# Including ecological and adaptive mechanisms in vulnerability models.



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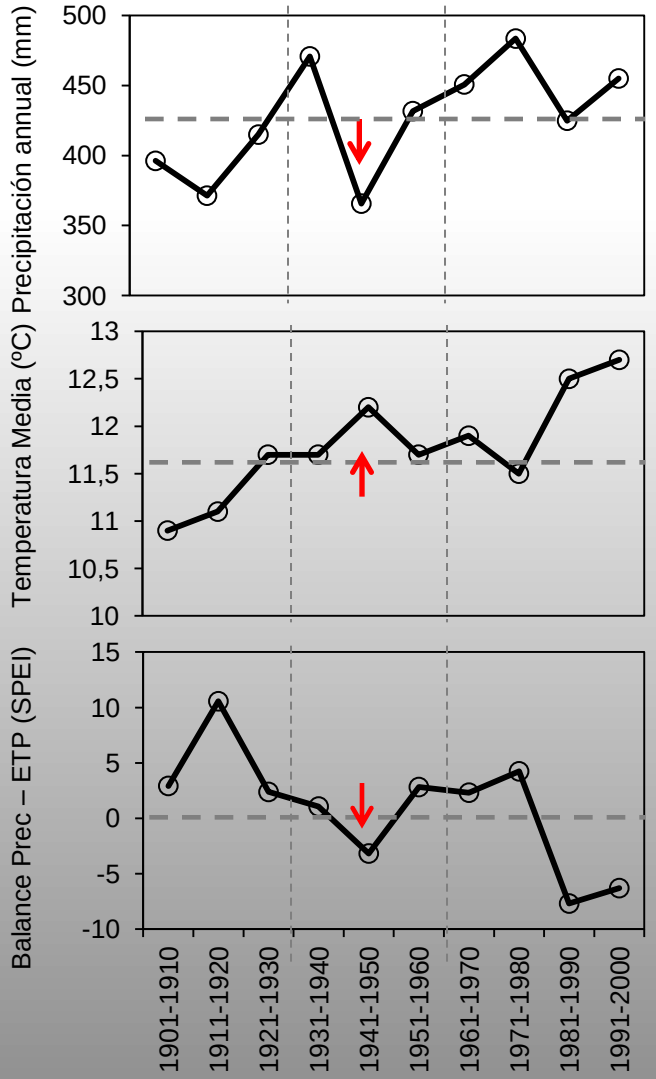
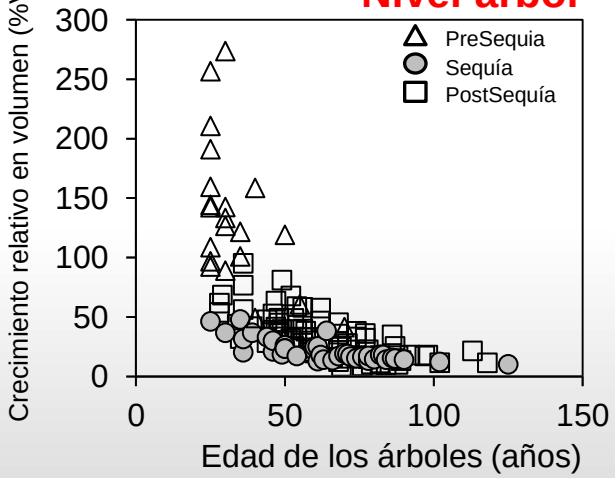
Land use governance

# Resilience to long-term drought in a water limited forest: from tree growth responses to principal forest demographic rates

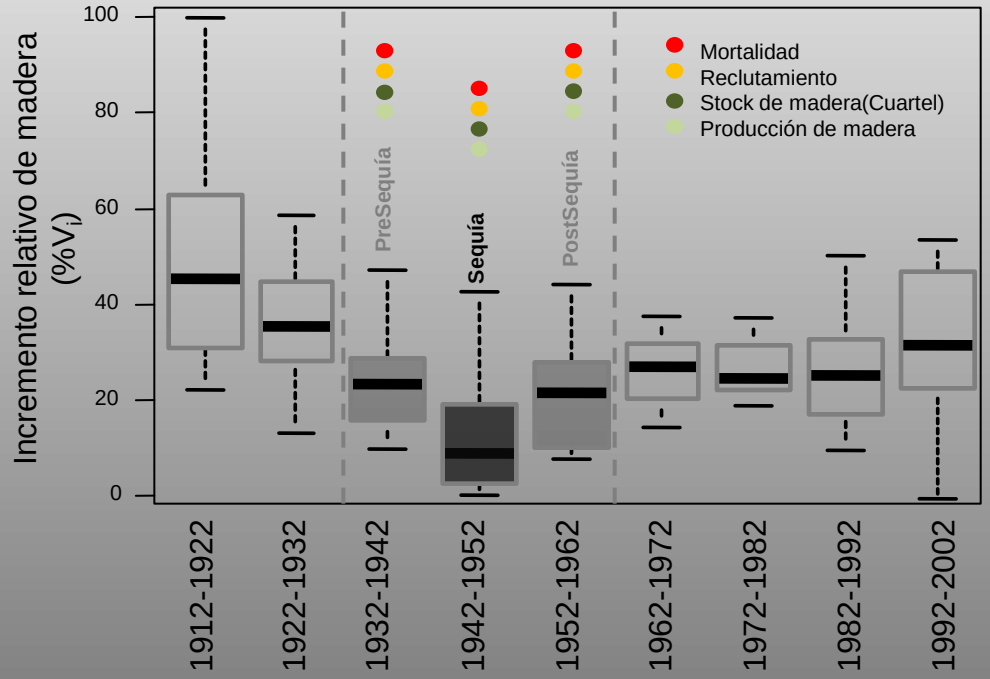
(Madrigal-González et al. en prep)




## Nivel árbol




## Nivel Bosque



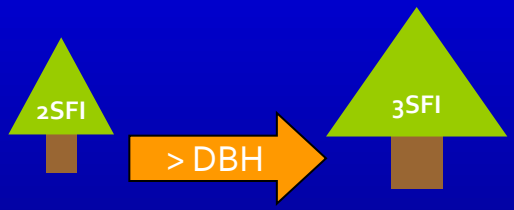
# Recruitment, growth & mortality

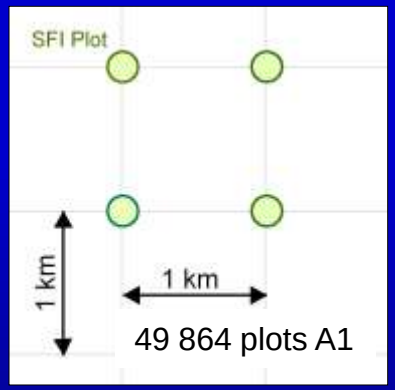

Villaescusa & Díaz, 1998
Villanueva 2004

**2SFI:** Segundo Inventario Forestal (1986-1996)

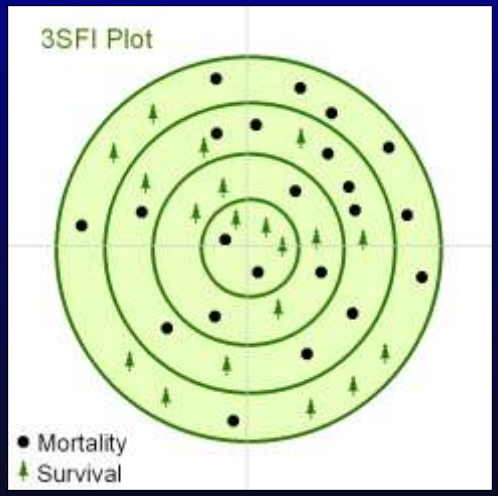
**3SFI:** Tercer Inventario Forestal (1997-2007)

Crecimiento

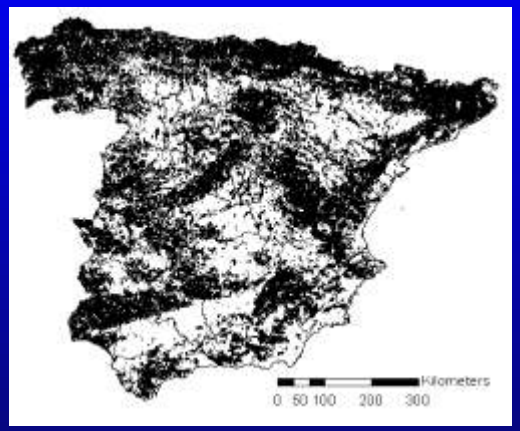


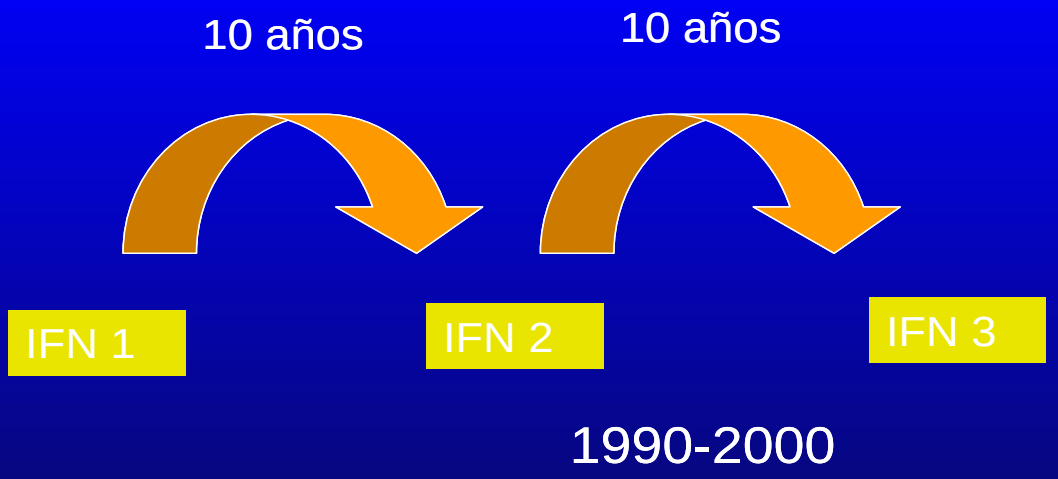







# Temporal **sampling**




Forest plot distribution IFN (89365 plots) in continental Spain (1 plot per $Km^2$).

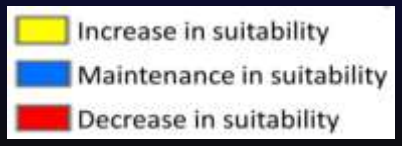
Benito-Garzón et al. (2013). Inter-specific differences in tree growth and mortality responses to climate determine potential species distribution limits in Iberian forests. Global Ecology and Biogeography). DOI: 10.1111/geb.12075

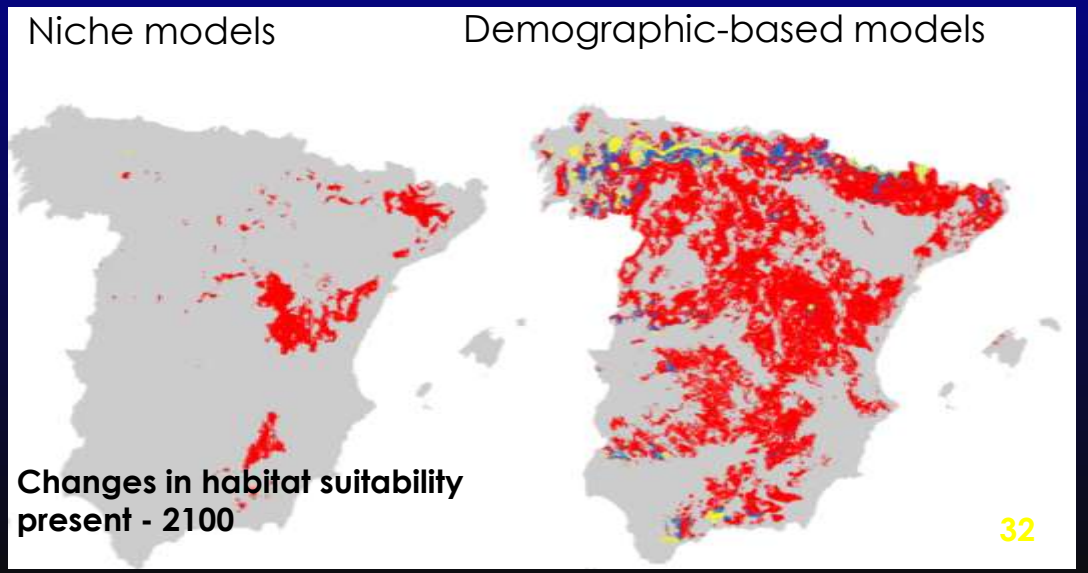
| Species | Growth | Mortality |
|---|---|---|
| *Pinus halepensis* | ↗ | ↗ |
| *P. pinea* | ↗ | ↗ |
| *P. pinaster* | ↗ | ↗ |
| *P. nigra* | ↗ | ↗ |
| *P. sylvestris* | ↗ | ↗ |

| Species | Growth | Mortality |
|---|---|---|
| *Quercus suber* | ↗ | ↘ |
| *Q. petraea* | ↘ | ↗ |
| *Q. robur* | ↗ | ↗ |
| *Abies alba* | ↗ | ↗ |
| *Castanea sativa* | ↗ | ↗ |
| *Fagus sylvatica* | ↗ | ↗ |

Compare to classical niche models

- Habitat reductions: Rear-edge Iberian Peninsula
- Habitat expansion: Mediterranean species

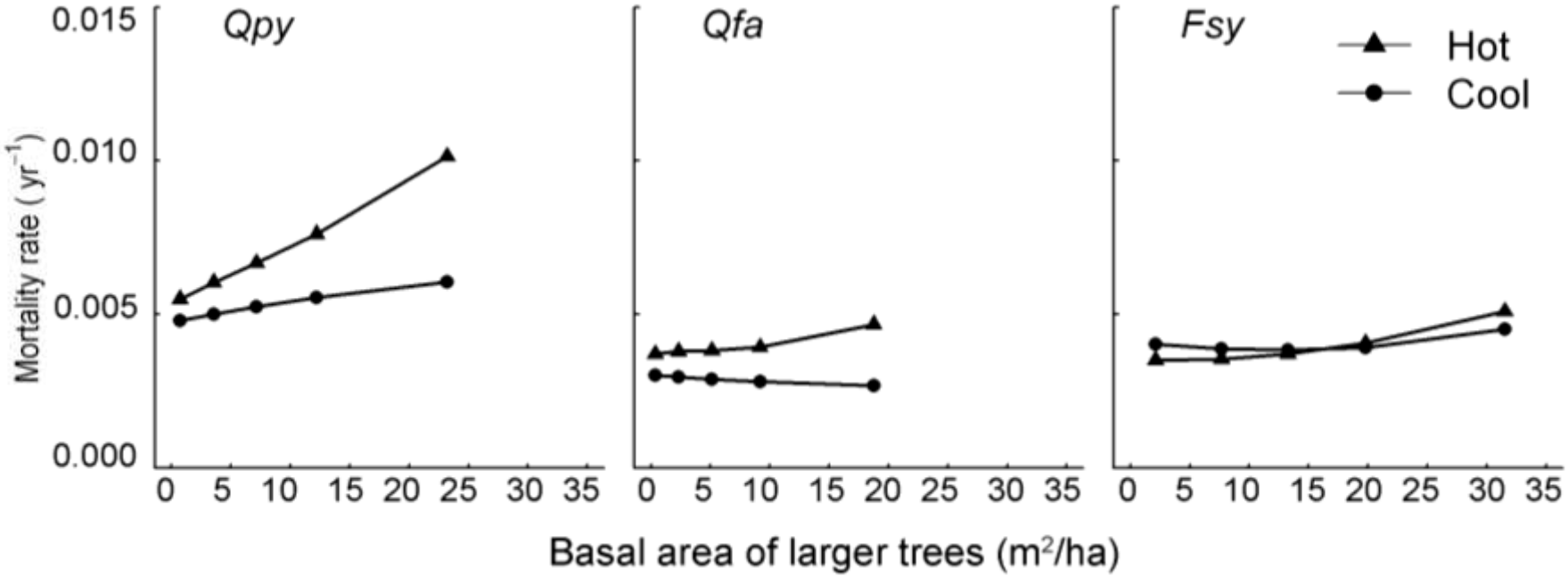



**Changes in habitat suitability present - 2100**

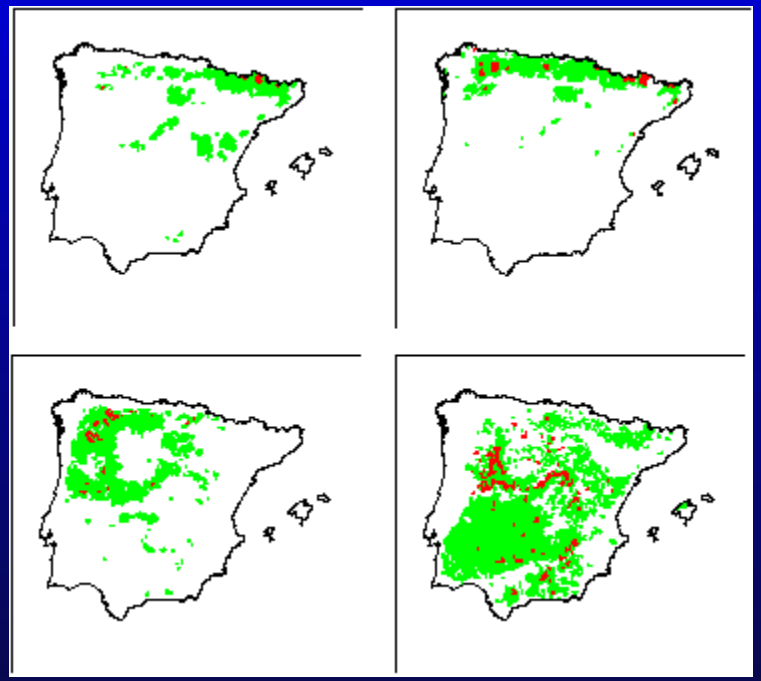
**Ruiz-Benito et al (2013). Patterns and drivers of tree mortality in Iberian forests: climatic effects are modified by competition. PLoS ONE 8: e56843. doi: 10.1371/journal.pone.0056843 .**

# ↑ mortality rates in hot sites at high competition levels




*Pinus halepensis*
*Pinus pinea*
*Pinus pinaster*
*Pinus nigra*
*Pinus sylvestris*
*Pinus uncinata*
*Quercus ilex*
*Quercus suber*
*Quercus pyrenaica*
*Quercus faginea*
*Fagus sylvatica*

# Including ecological and adaptive mechanisms in vulnerability models.



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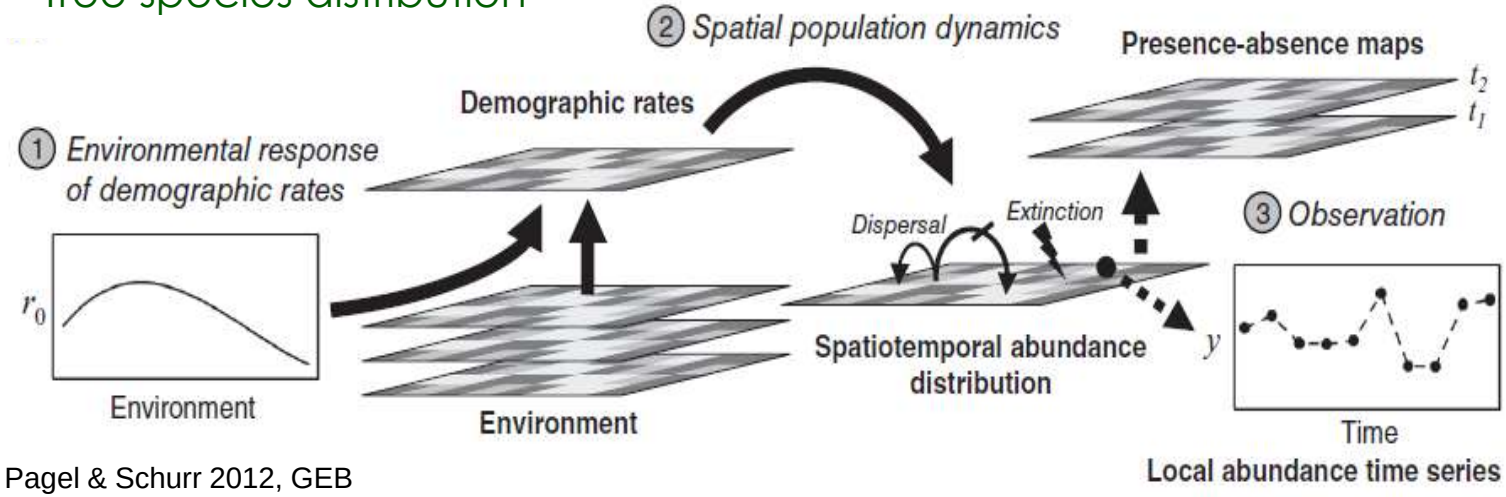
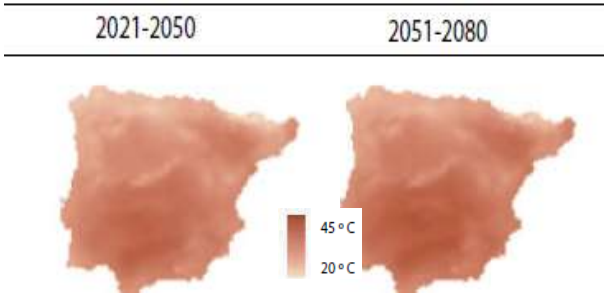
# **Hypothesis:** *"Source-sink dynamics"*

Tree species distribution



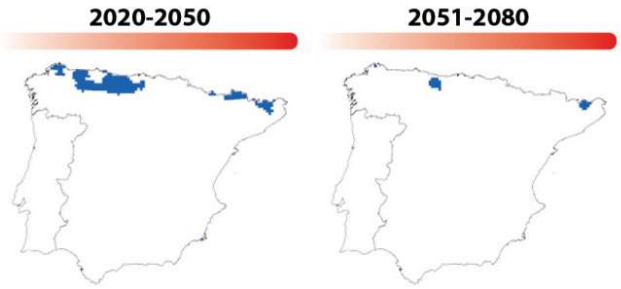

Pagel & Schurr 2012, GEB

***CLIMATE***

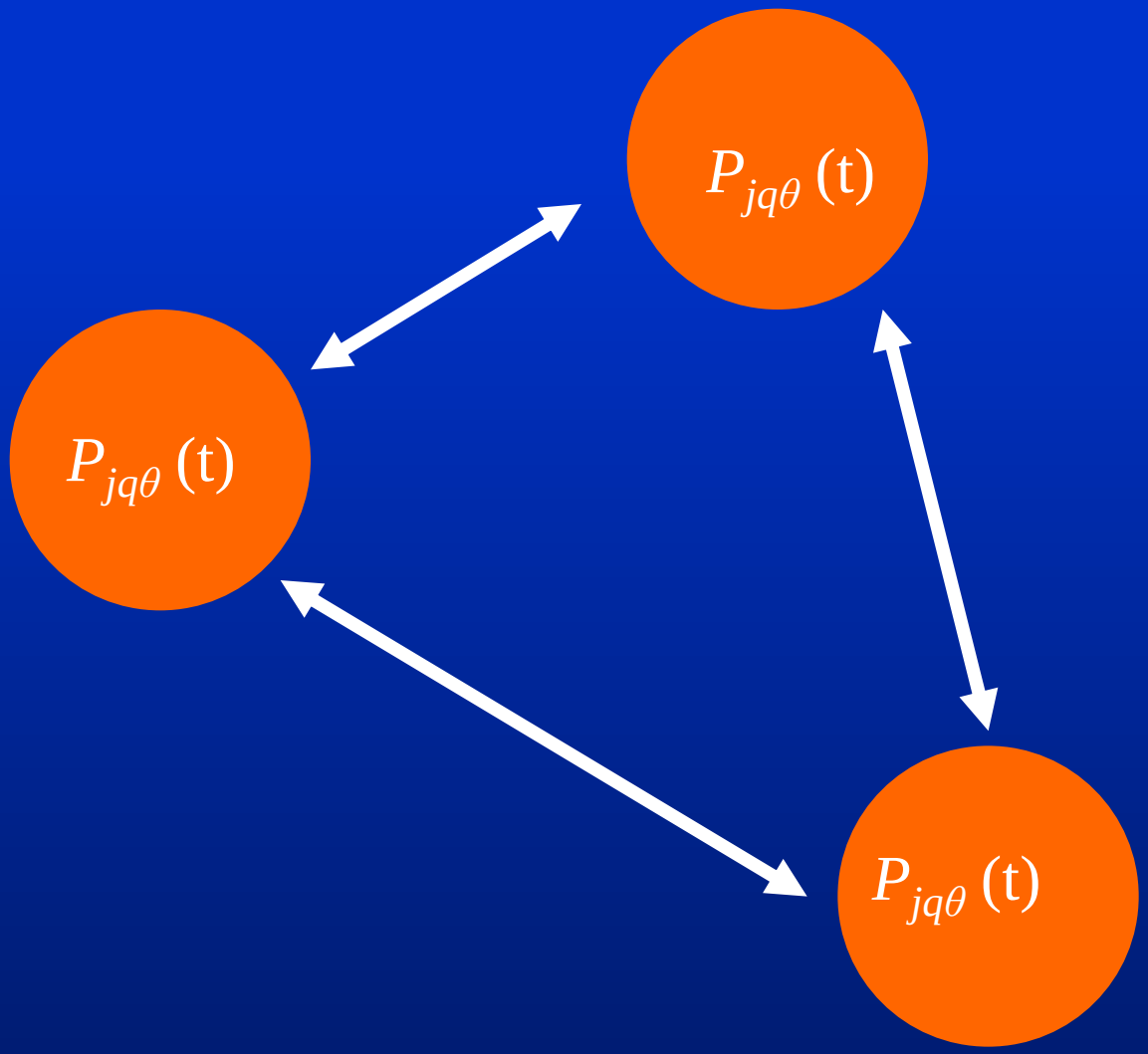



Classical Species Distribution Models (SDM)

***SPECIES DISTRIBUTION (presence-absence)***

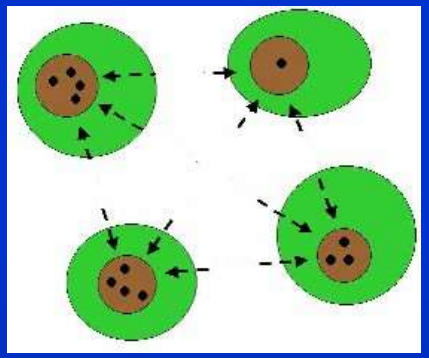


# *SPOM ("Stochastic Patch Occupancy Model")*



# Vulnerability to Climate Change

## Model fitting

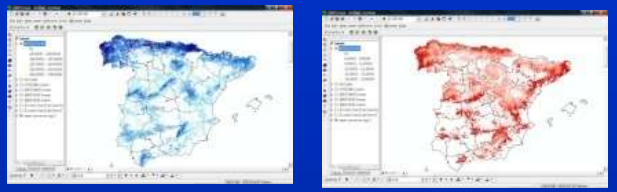


1990 2000 inside the forest

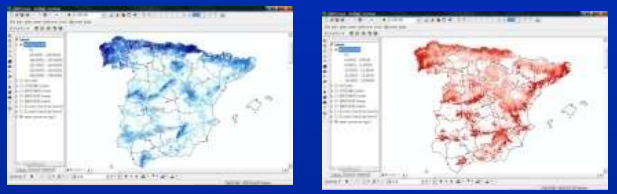
*Quercus robur*

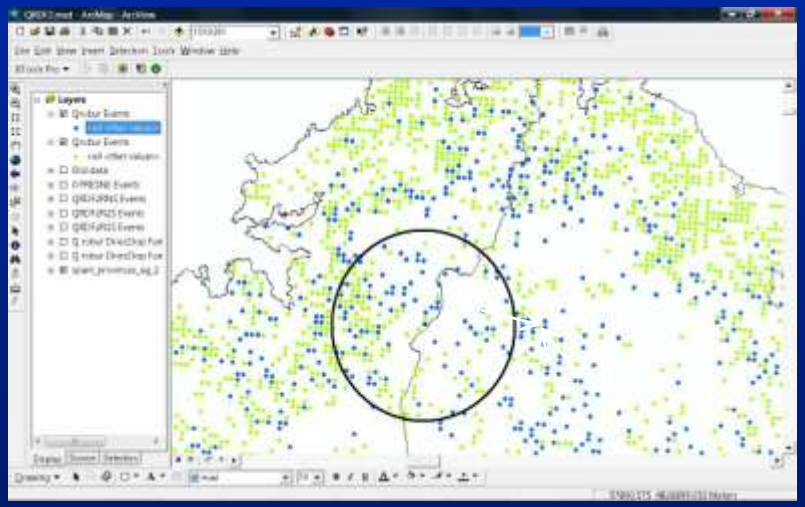
0 → 1
1 → 0

$P_{j,q,\theta}$ (1→0) = f (P, T)



$P_{j,q,\theta}$ (0→1) = f (P, T, DistF, DistSp)





Neighborhood

Random dispersal - Mediated dispersal

# SPOM ("Stochastic Patch Occupancy Model")

$$P\left[z_{j,i}(t+1) \mid z_{j,i}(t)\right] = \begin{cases} \phi_i & \text{if } z_{j,i}(t)=1 \text{ and } z_{j,i}(t+1)=0 \\ 1-\phi_i & \text{if } z_{j,i}(t)=1 \text{ and } z_{j,i}(t+1)=1 \\ 1-(1-\alpha_{j,i})^{S_{j,i}(t)} & \text{if } z_{j,i}(t)=0 \text{ and } z_{j,i}(t+1)=1 \\ (1-\alpha_{j,i})^{S_{j,i}(t)} & \text{if } z_{j,i}(t)=0 \text{ and } z_{j,i}(t+1)=0 \end{cases}$$

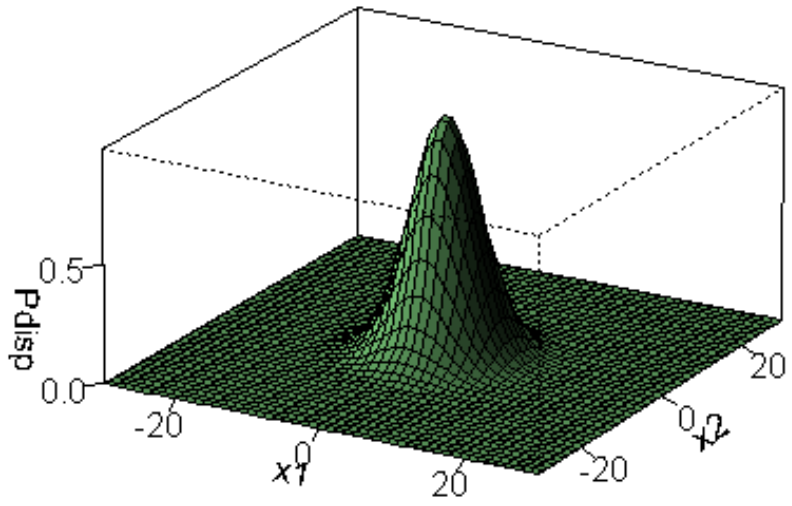
1) Distance to seed source.

2) Post-fire genet mortality.

Purves, D., M. A. Zavala, K. Ogle, F. Prieto, y J.M. Rey Benayas. 2007. Environmental heterogeneity, bird-mediated directed dispersal, and oak woodland dynamics in Mediterranean Spain. Ecological Monographs 77:77–97.

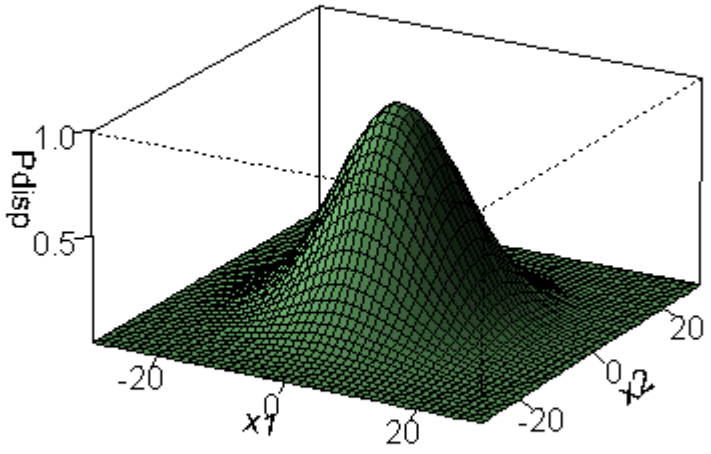
# Vulnerability to Climate Change

**Pinus sylvestris dispersal kernel**



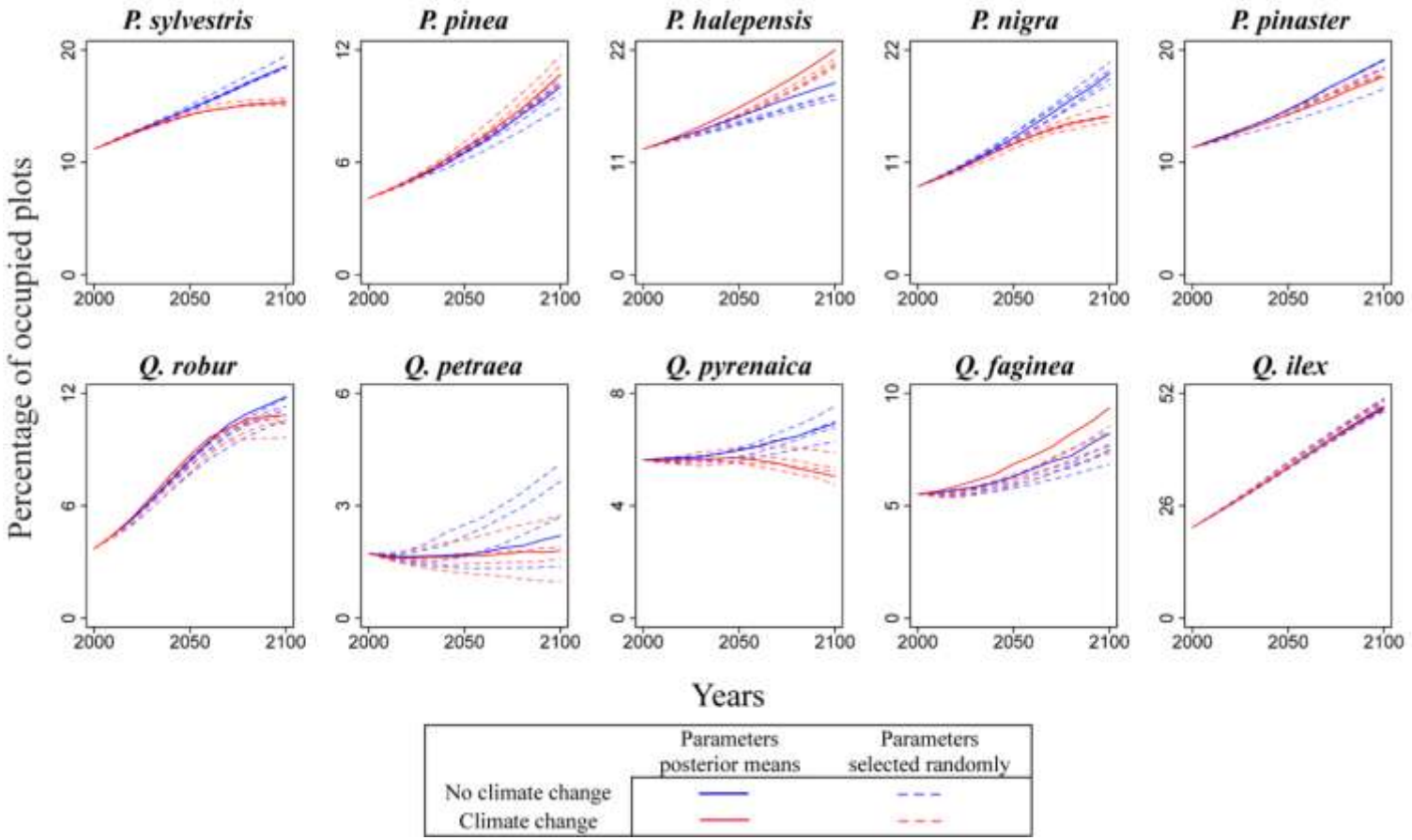

$$f(\mathbf{x}) = \exp\left(-\left[\frac{\sqrt{x1^2 + x2^2}}{\sigma}\right]^2\right) \qquad \sigma = 6.19$$

**Quercus faginea dispersal kernel**




$$f(\mathbf{x}) = \exp\left(-\left[\frac{\sqrt{x1^2 + x2^2}}{\sigma}\right]^2\right) \qquad \sigma = 12.54$$

# Vulnerability to Climate Change



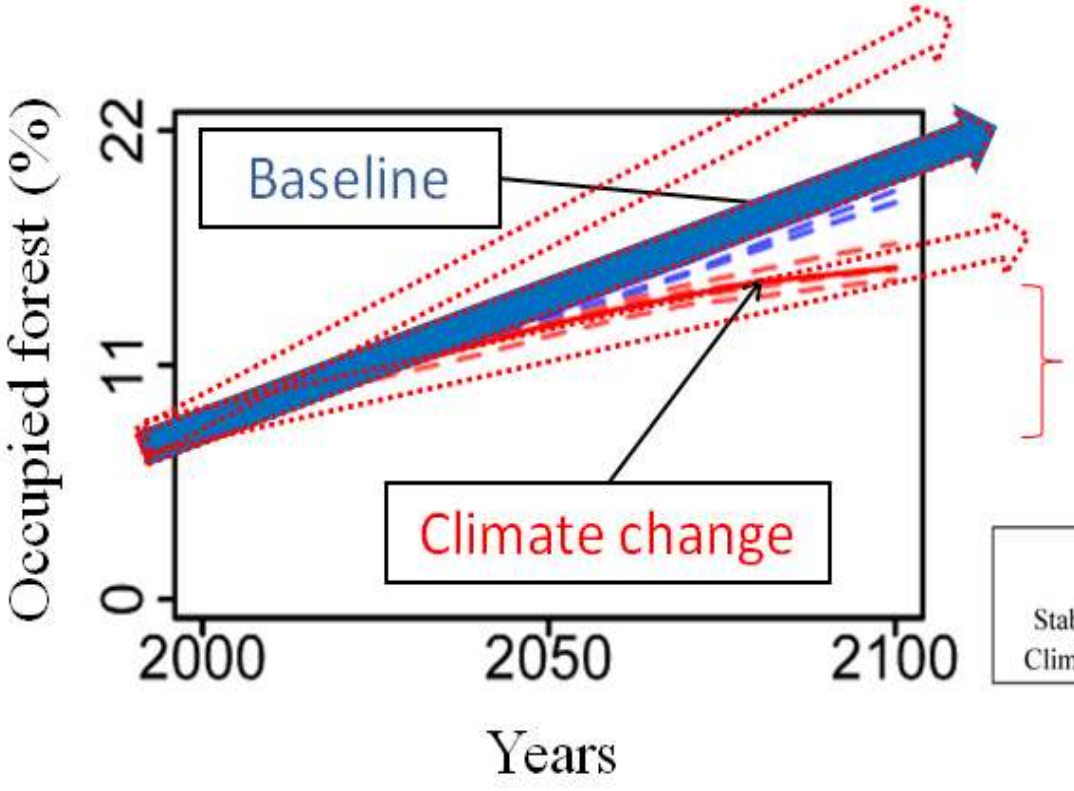

Species fraction of occupied plots from year 2000 to year 2100. One simulation using the posterior means for the parameter values, and four simulations using parameter sets drawn randomly from the samples generated by the MCMC algorithm.

García-Valdés, R., **M. A. Zavala**, M. B. Araújo & D. W. Purves. 2011. Chasing a moving target: projecting non-equilibrial tree species responses to climate change .Journal of Ecology 2013).

# Non-equilibrium and climate change

*Pinus nigra*

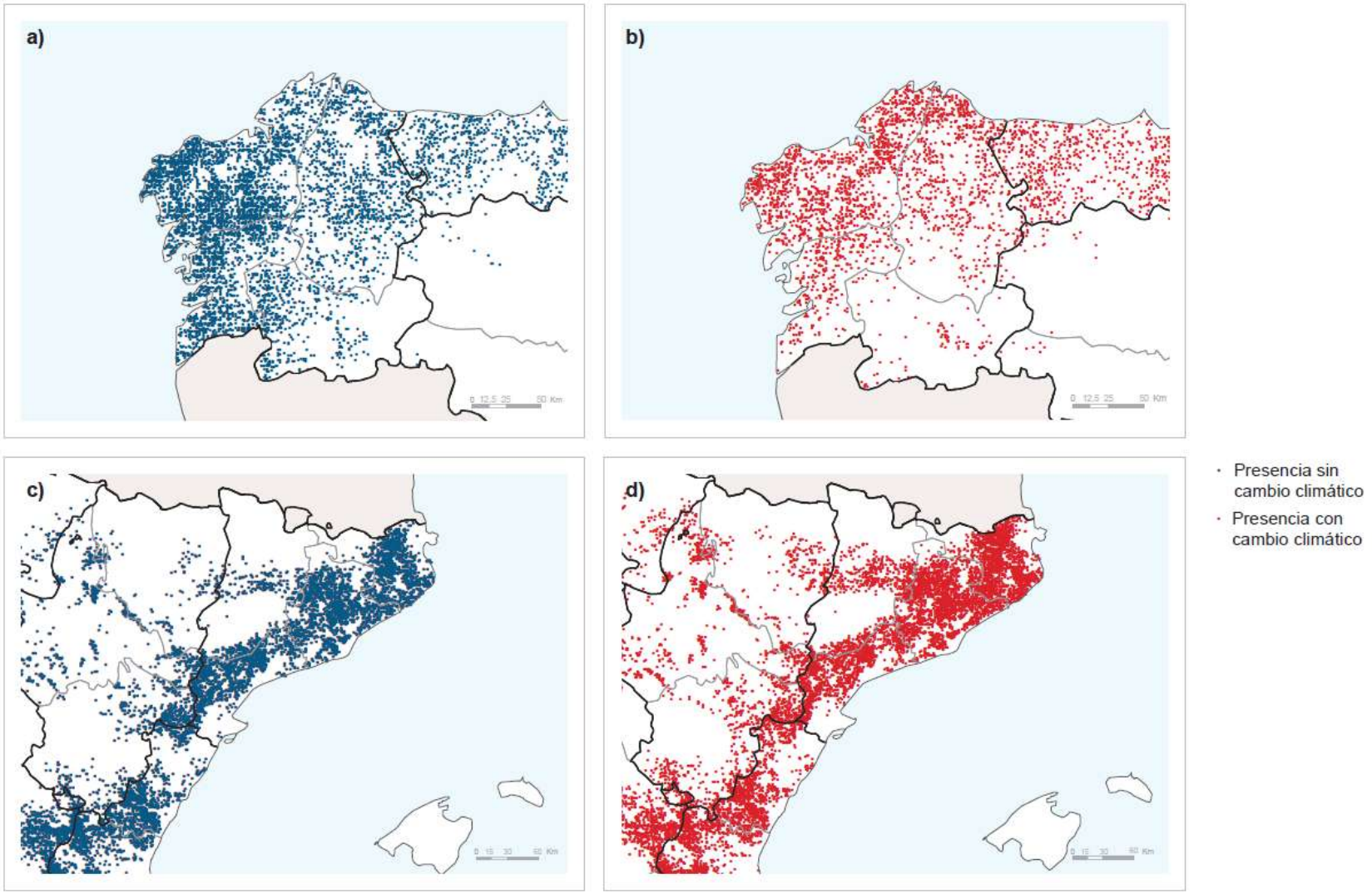
## Simulation results




| | Parameters posterior means | Parameters selected randomly |
|---|---|---|
| Stable climate | — | - - - |
| Climate change | — | - - - |

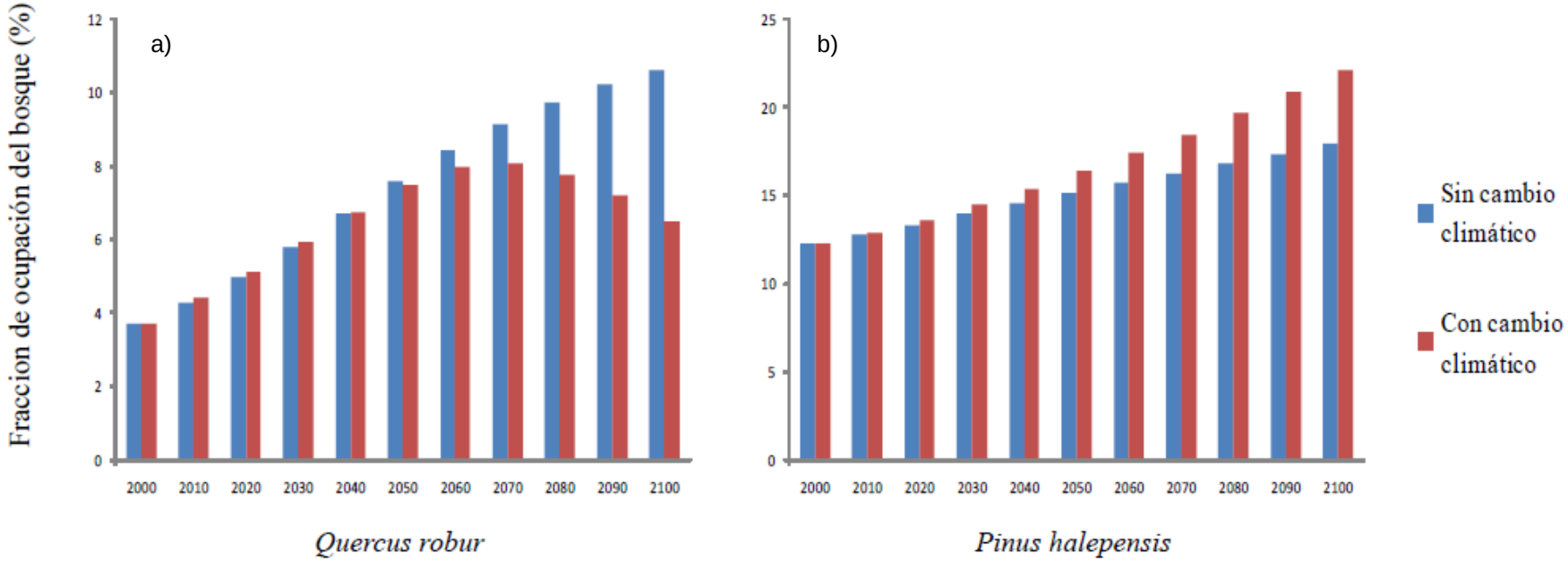
**Error propagation**

# Proyecciones de la fracción de ocupación del bosque de *Q. robur* en 2100 sin y con cambio climático (a y b respectivamente) y para el *P. halepensis* (c y d respectivamente).




**Fuente: Elaboración OSE a partir de García-Valdés et al. (2010)[18]. Nota: las Islas Baleares no se incluyeron en el análisis.**

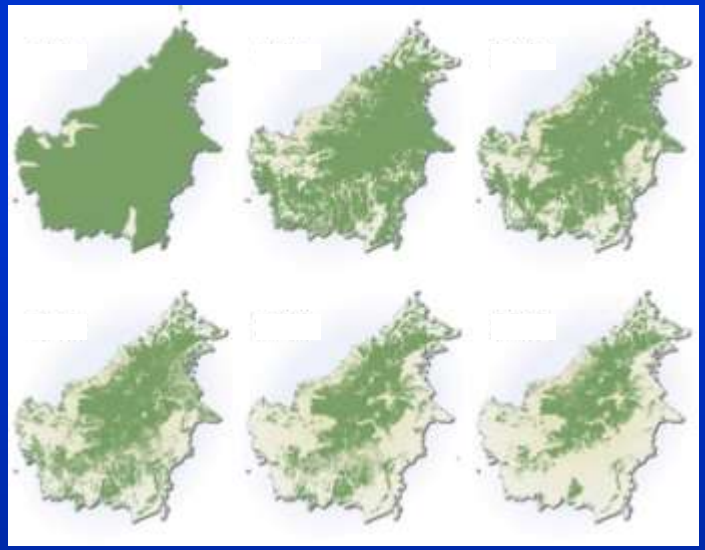
# Vulnerability to Climate Change



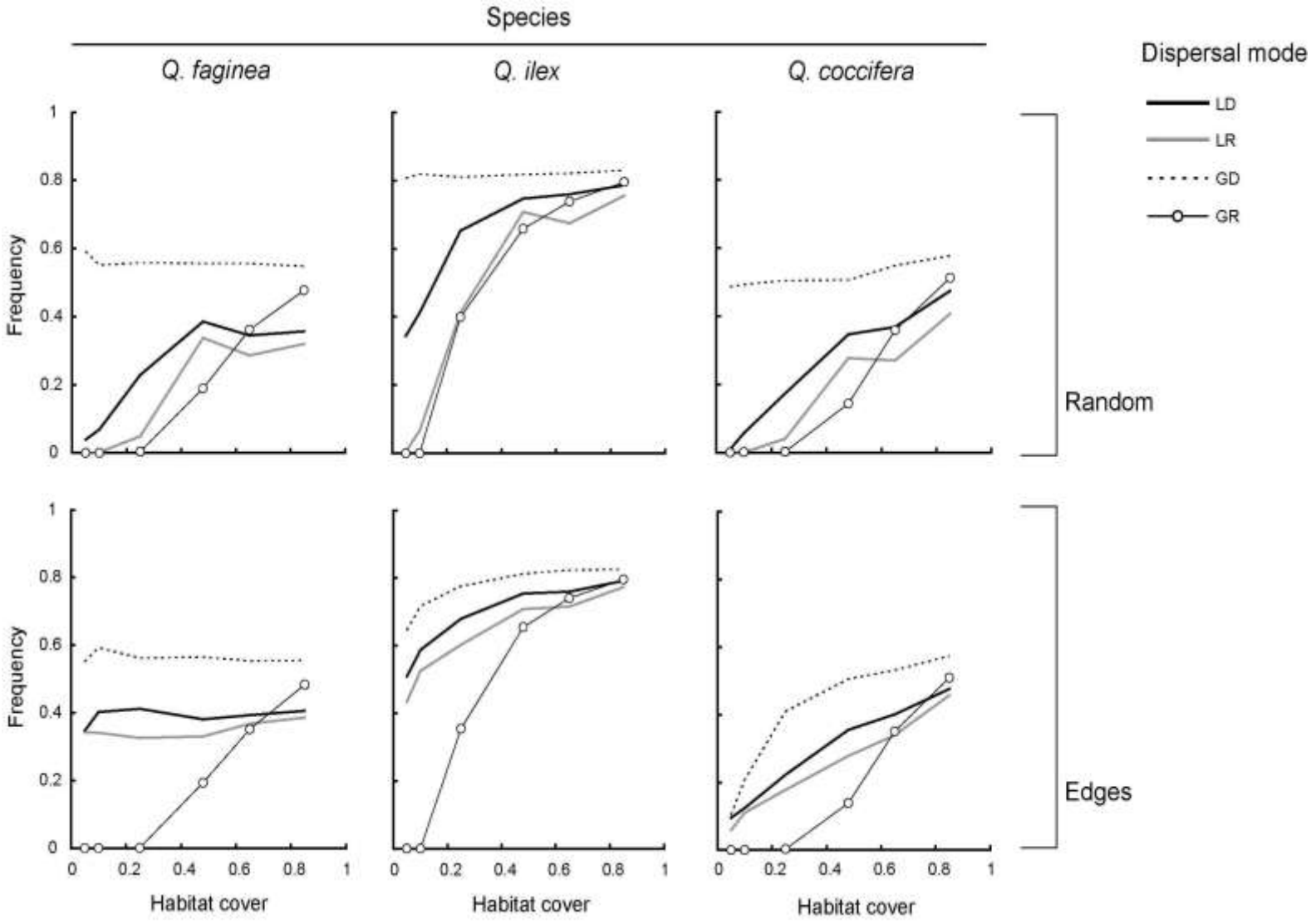

Proyecciones de la fracción de ocupación del bosque, número de parcelas en las que está presente la especie respecto al total de parcelas de bosque, en 2100 con y sin cambio climático para (a) el roble común (*Q. robur*) y (b) el pino carrasco (*P. halepensis*)

**Fuente: Elaboración OSE a partir de García-Valdés *et al.* (2010).**

# Vulnerability to habitat change

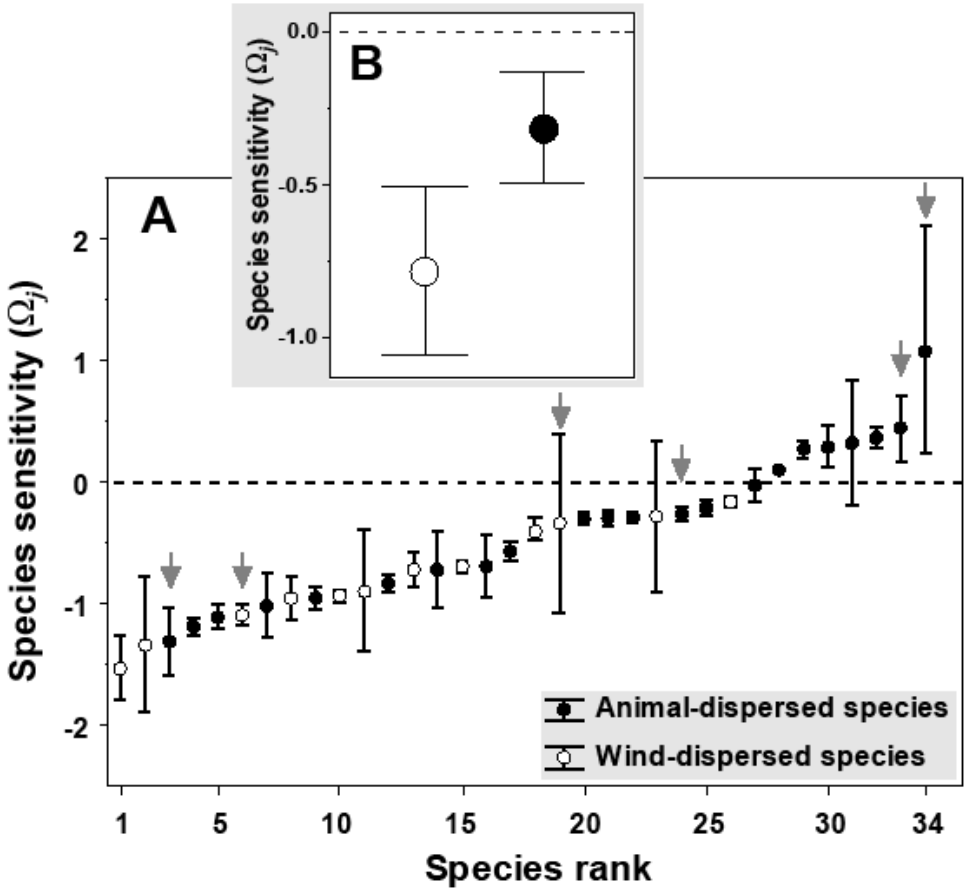


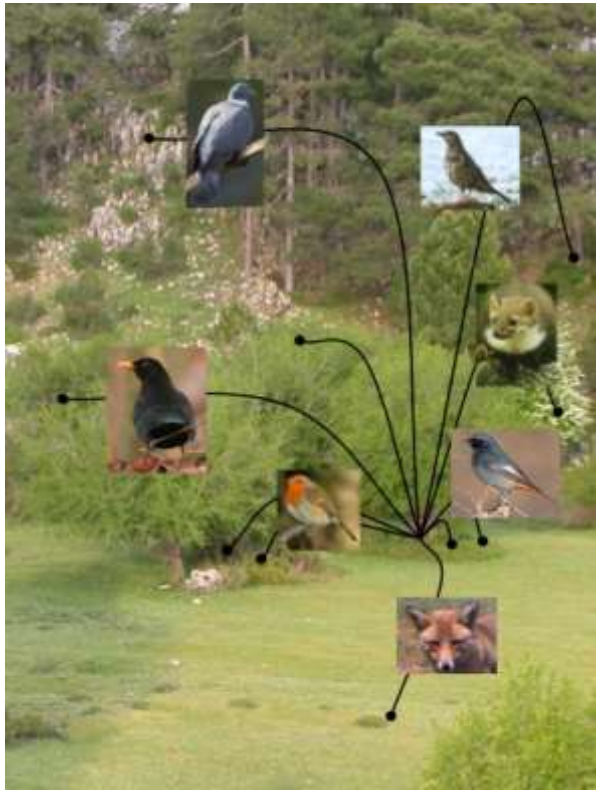

# Vulnerability to habitat change




Purves, et al. 2007. Ecological Monographs 77:77–97.

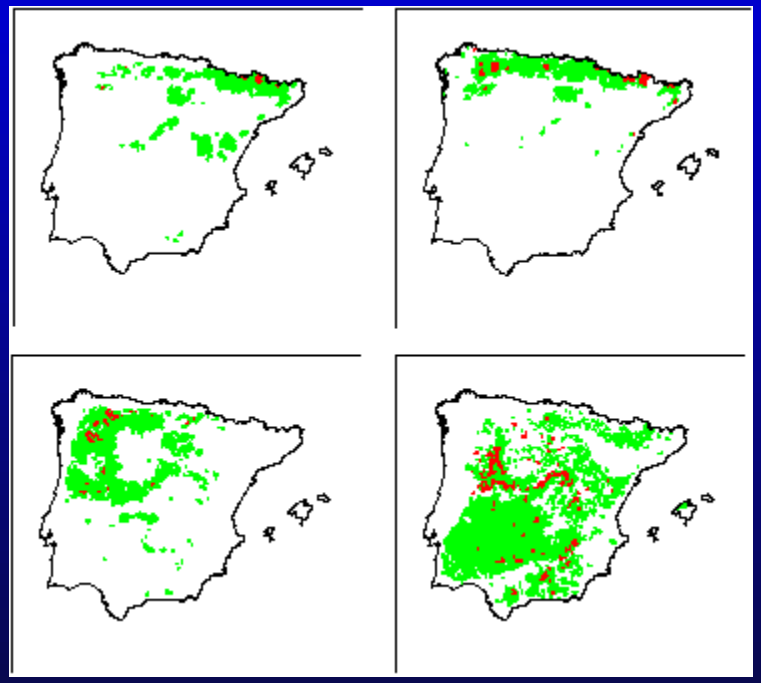
# Vulnerability to habitat change



Montoya et al. (*Science* 2008)

# Including ecological and adaptive mechanisms in vulnerability models.



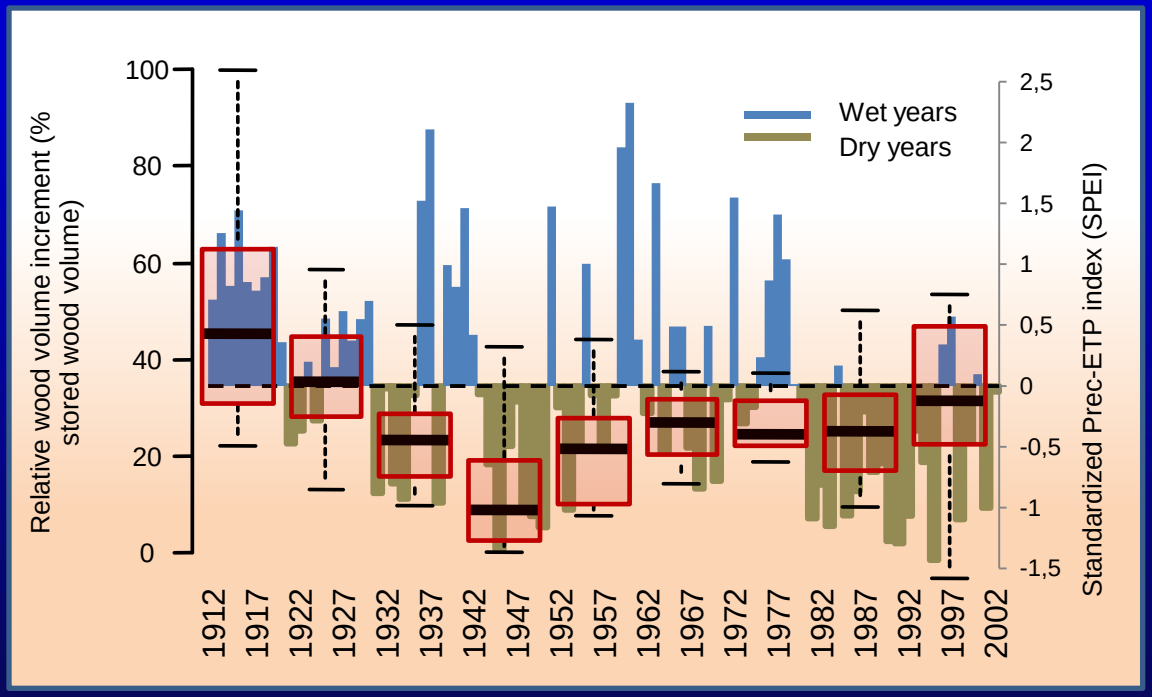
Fuente: *Elaborado a partir de Benito Garzón et al.* 2009

**Genes & organismic**
Epigenesis.
Evolution/Local adaptation
Plasticity

**Population and communities**
Demographic compensation
Migration (dispersal)
Diversity/Stabiilty

**Ecosystem & landscape.**
$CO_2$ fertilization

# Can carbon fertilization buffer drought impacts on forest carbon storage in water-limited areas? evidence from 90 year inventory data




**Boxplot of observed relative biomass storage along the 20th century superimposed on annual values of drought (SPEI index, Vicente-Serrano et al. 2010)**

UNIVERSIDAD DE ALCALÁ

CARBO Extreme

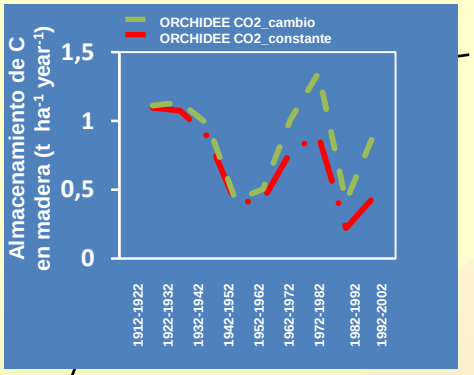
**Climate Extremes and Biogeochemical cycles**

**Open Science Conference, Seefeld (Austria), 2-5 April 2013**

# Long-term wood production in water-limited forests: evaluating potential CO2 fertilization along with historical confounding factors

(Madrigal-González et al. 2015. *Ecosystems*)

**Simulaciones ORCHIDEE con y sin aumento en $CO_2$**




**El aumento en $CO_2$ atmosférico puede conducir a un proceso de fertilización por carbono y reducir así el impacto de la sequía**

**Procesos**

modelización

experimentos

**Modelos basados en procesos (ORCHIDEE)**

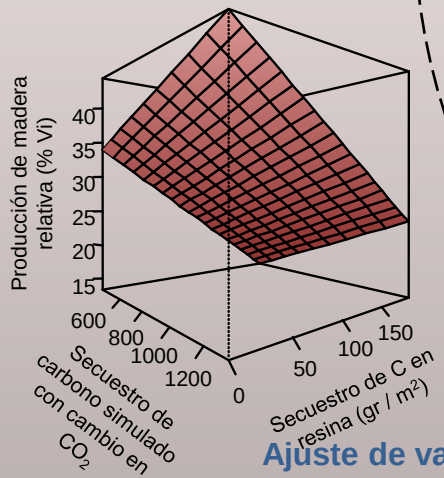
Hipótesis

validación

**Patrones**

Hipótesis (pseudo-experimento)

Modelo estadístico

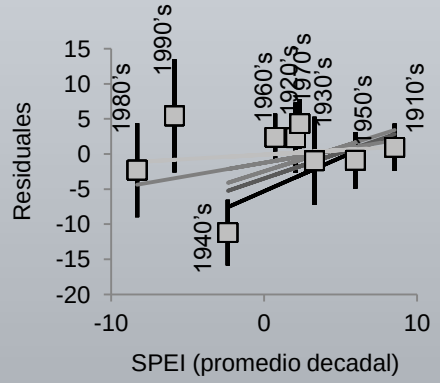



**Ajuste de valores observados a valores simulados (mejor con cambio en $CO_2$)**

Modelo Estadístico

**Observación** (datos históricos)

**Pérdida de sensibilidad a la sequía a finales del s XX**



# **Los bosques europeos:**
# un componente esencial de nuestras sociedades

http://www.youtube.com/watch?v=MaKKKdoLc2g

# LOS BOSQUES Y LA BIODIVERSIDAD FRENTE AL CAMBIO CLIMÁTICO: IMPACTOS, VULNERABILIDAD Y ADAPTACIÓN EN ESPAÑA

## Informe de Evaluación