A (dendro)climatological perspective on fungal ecology

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COST Action FP1203
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Zagreb, Croatia, February 18, 2015

Main research interest(s)

How did and does climate change?

&

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How did and does climate change?

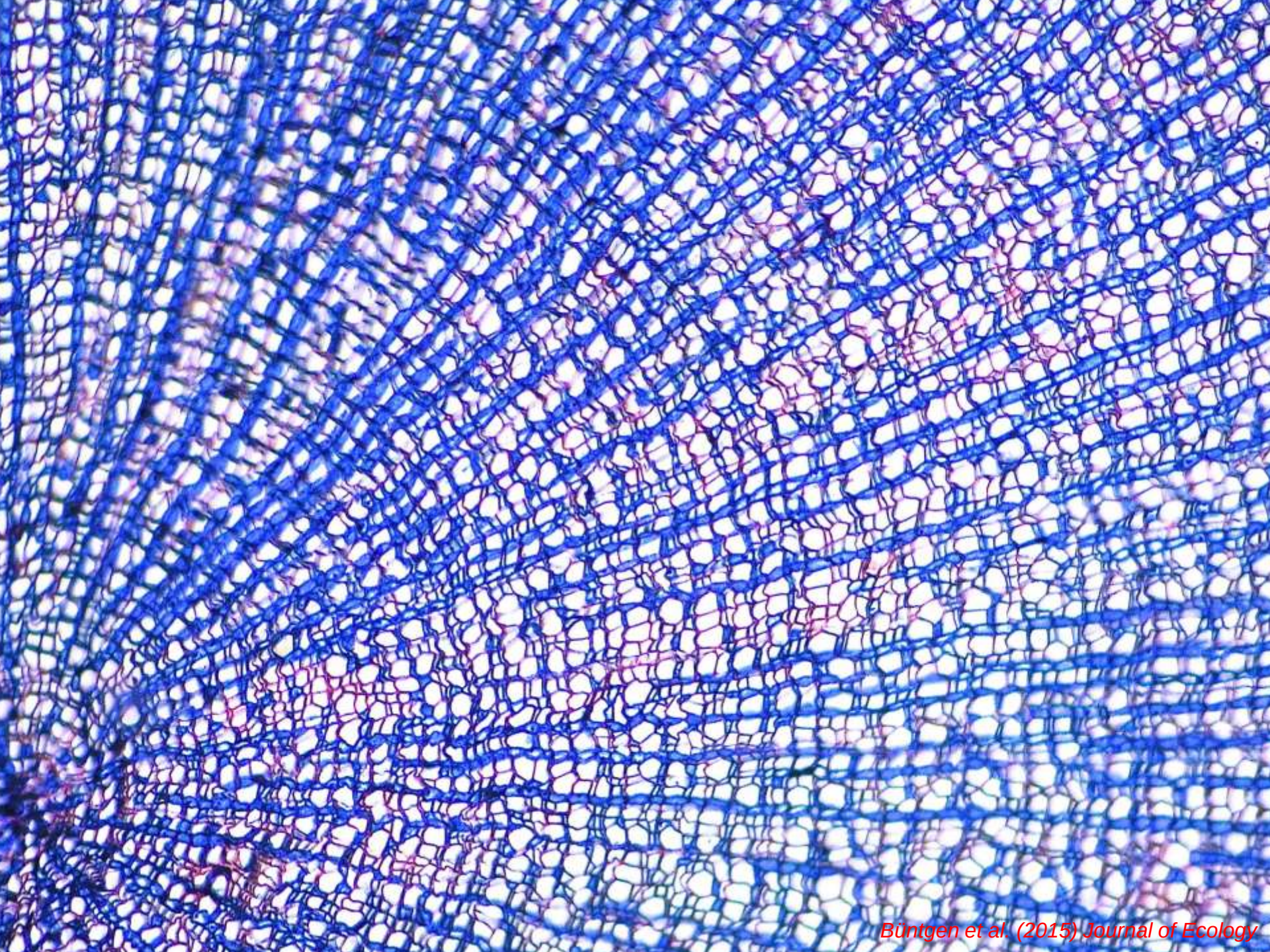
&

How did and do ecosystems respond to such changes?

Büntgen et al. (2015) Journal of Ecology

Büntgen et al. (2015) Journal of Ecology

Büntgen et al. (2015) Journal of Ecology



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A (dendro)climatological perspective on Alpine ibex

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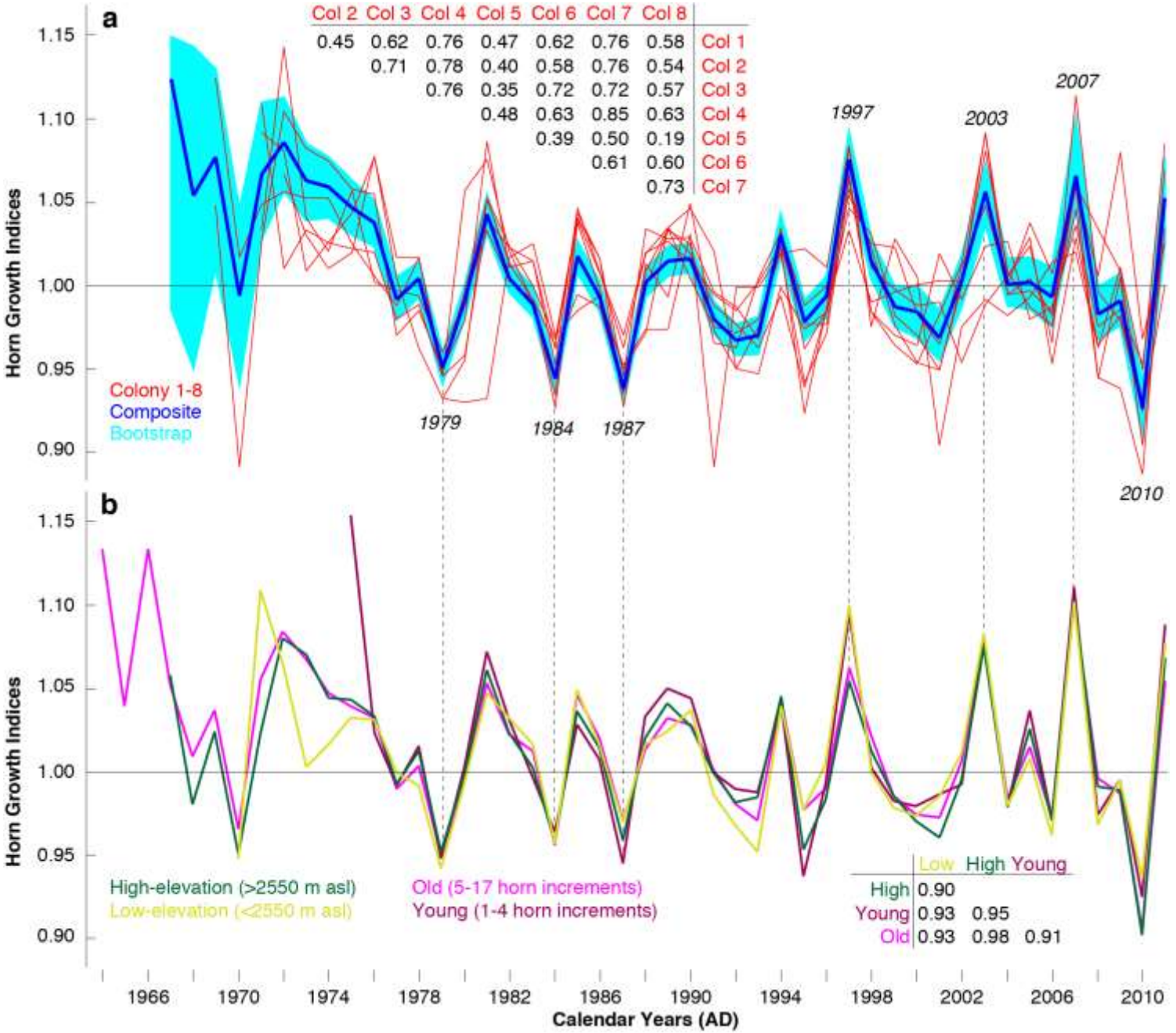
Ibex horn growth variability



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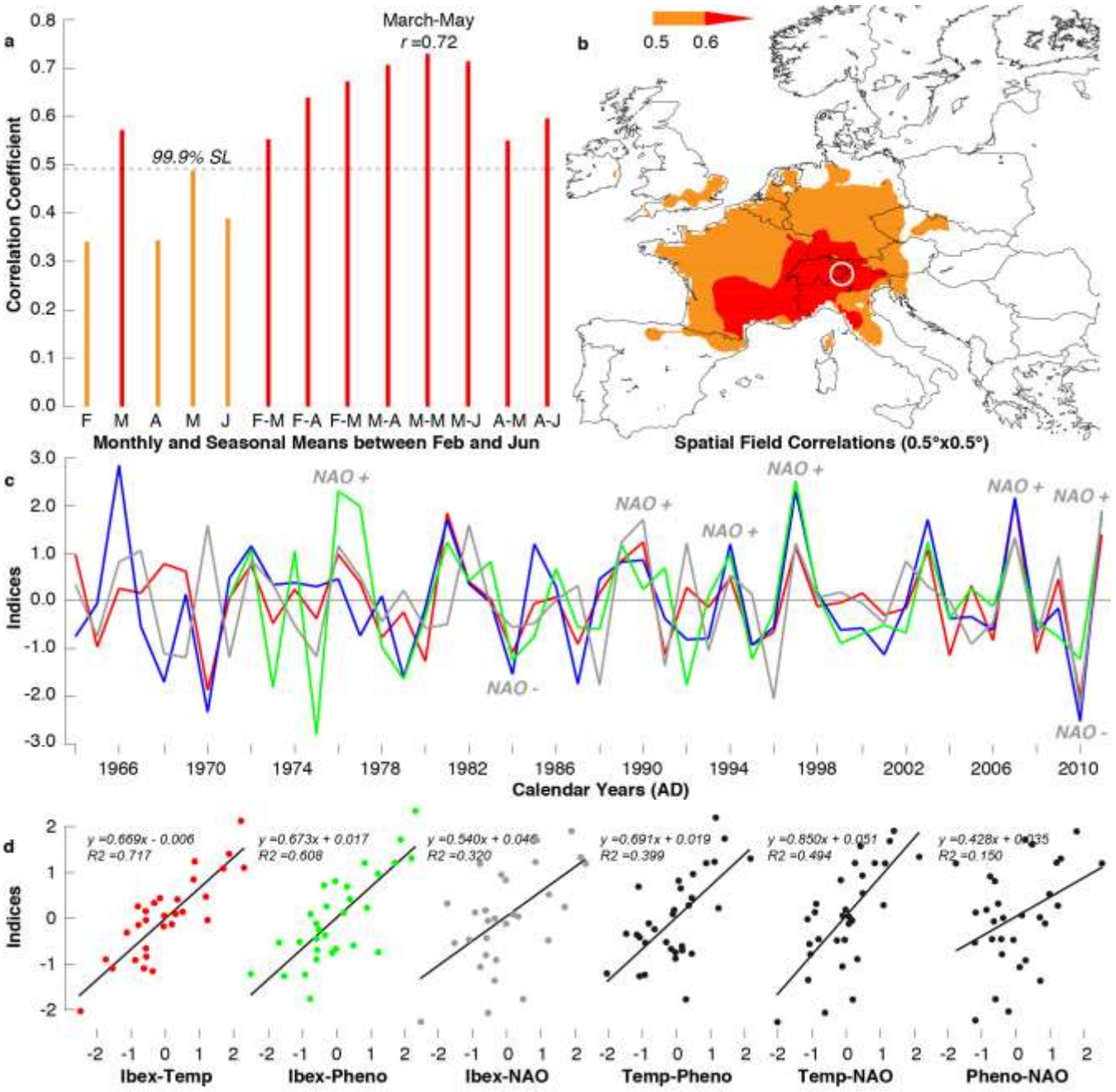
Temperature controls on horn growth



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A (dendro)climatological perspective on fungal ecology

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Outline

Illuminating the dark world of truffles

Tuber melanosporum research in Spain

Tuber aestivum research in Switzerland and Germany

Linking fungal ecology with climate variability

Long-term changes in the phenology, productivity and diversity of Spanish mushrooms

Long-term changes in the phenology, productivity and diversity of Swiss mushrooms

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Outlook

Illuminating the dark world of truffles

Tuber melanosporum research in Spain

Tuber aestivum research in Switzerland and Germany

Tuber melanosporum

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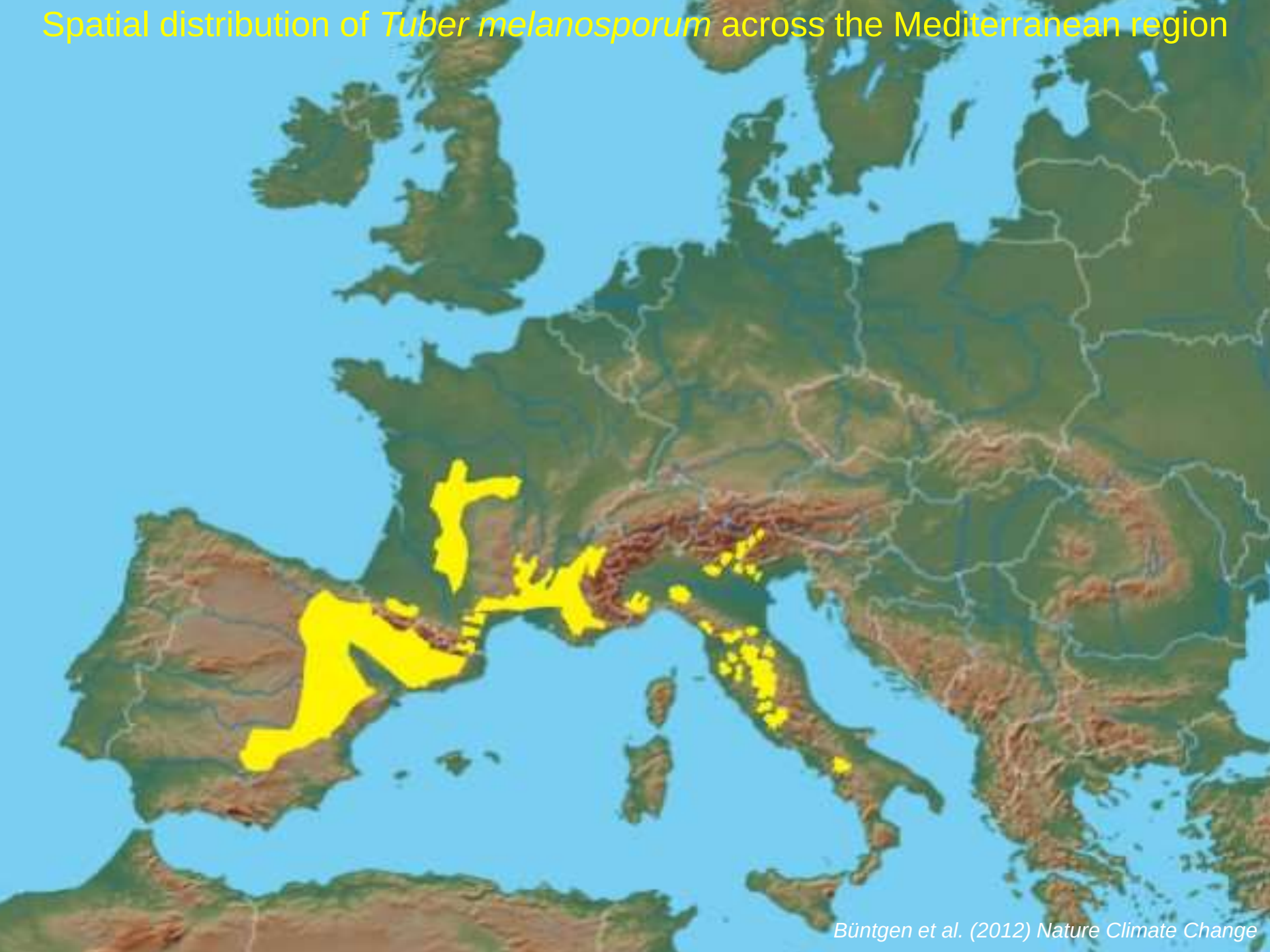
Spatial distribution of *Tuber melanosporum* across the Mediterranean region



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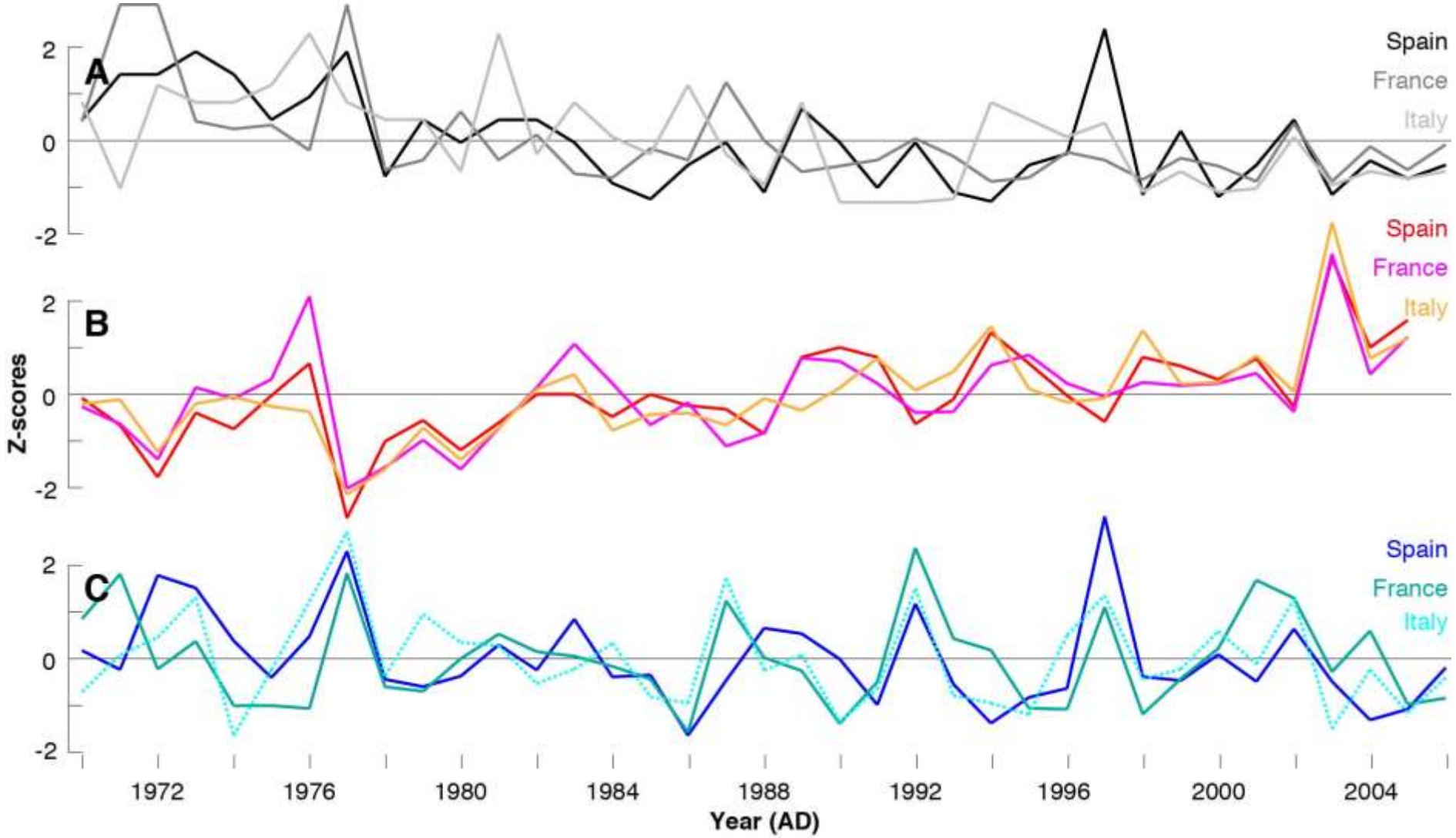
Spatial synchrony in truffle productivity and climate variability



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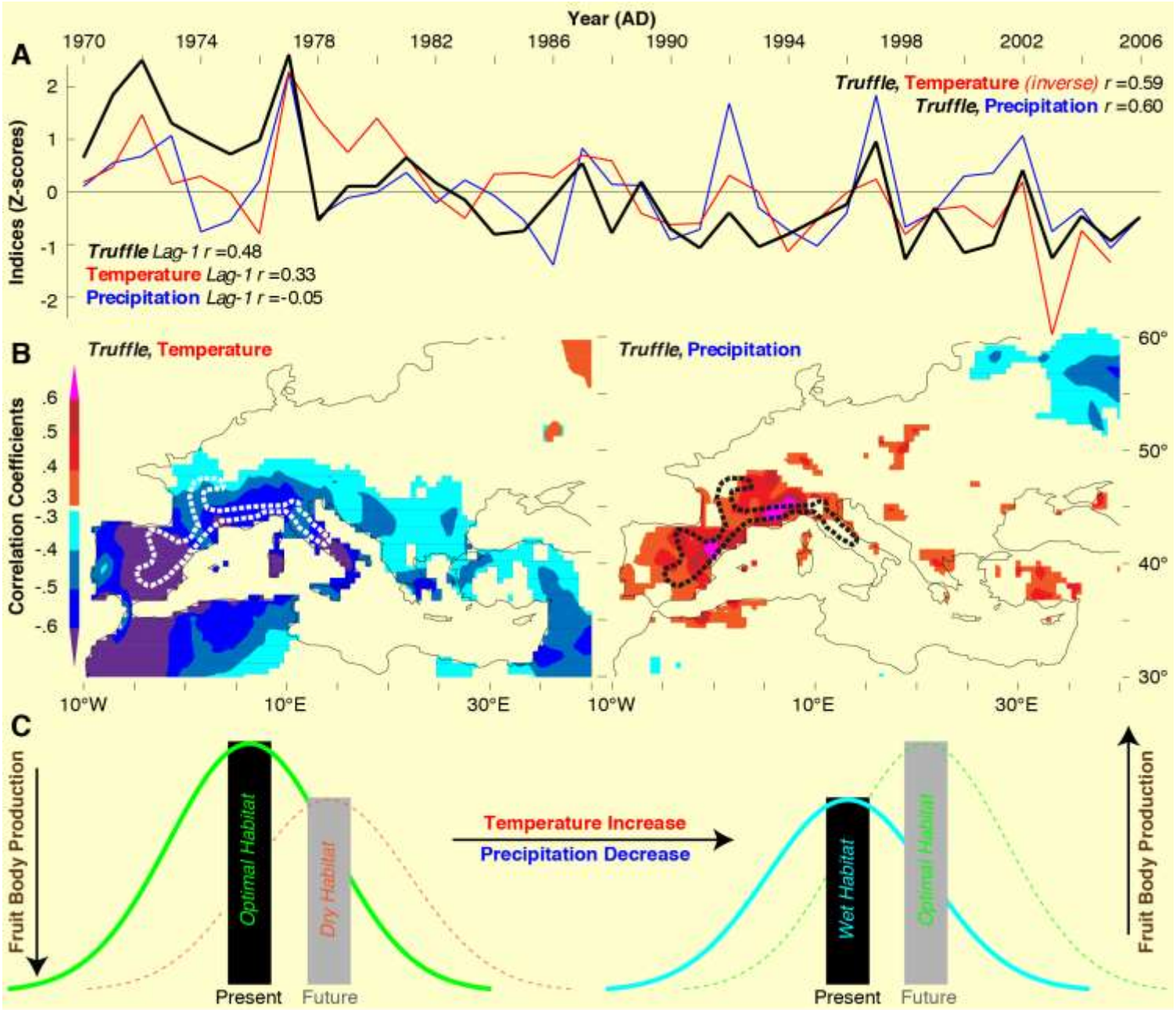
Drought-induced Mediterranean truffle decline



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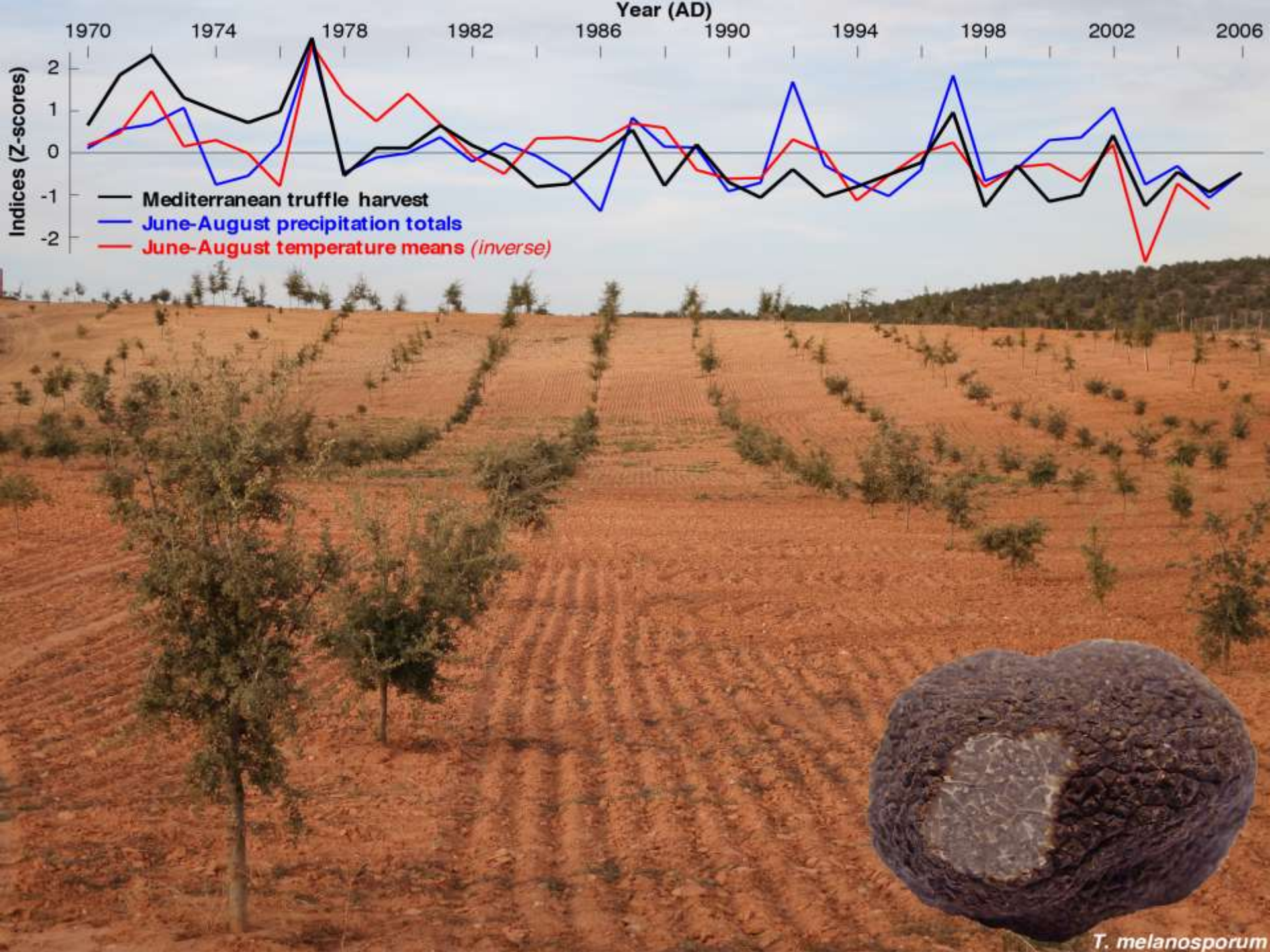
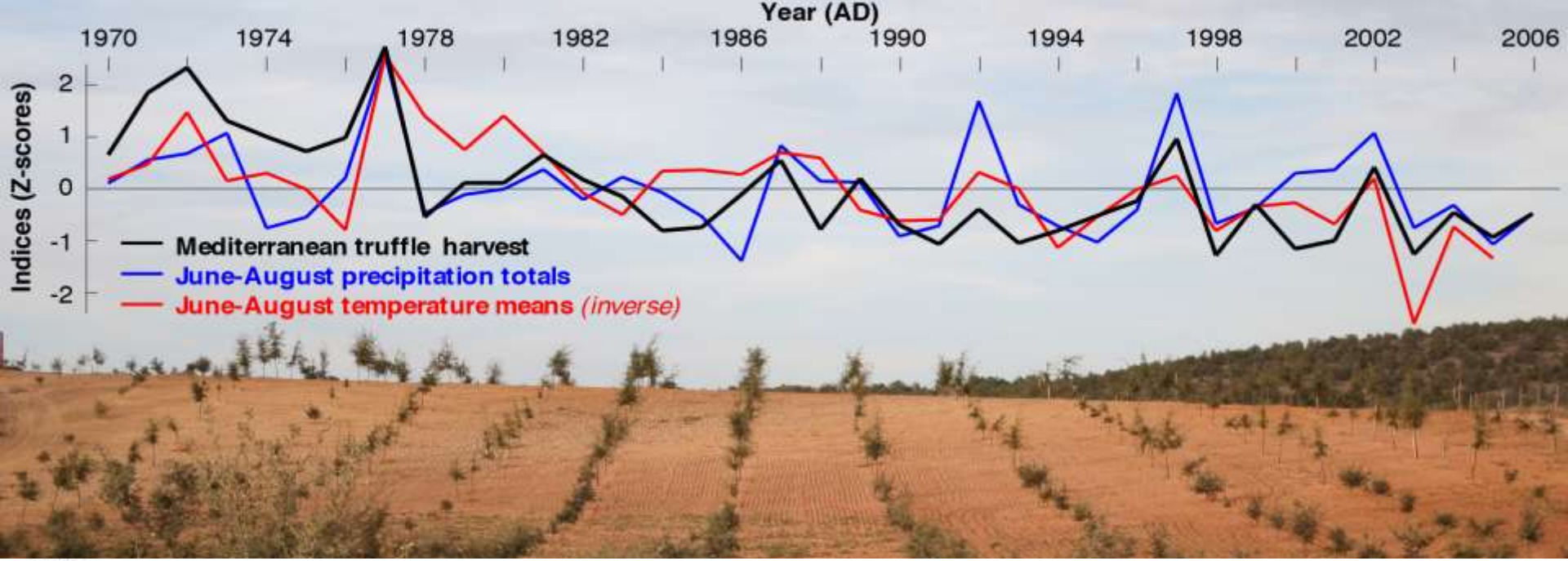

Year (AD)
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Indices (Z-scores)
2
1
0
-1
-2
Mediterranean truffle harvest
June-August precipitation totals
June-August temperature means (inverse)
T. melanosporum


Year (AD)
1970
1974
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1998
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2
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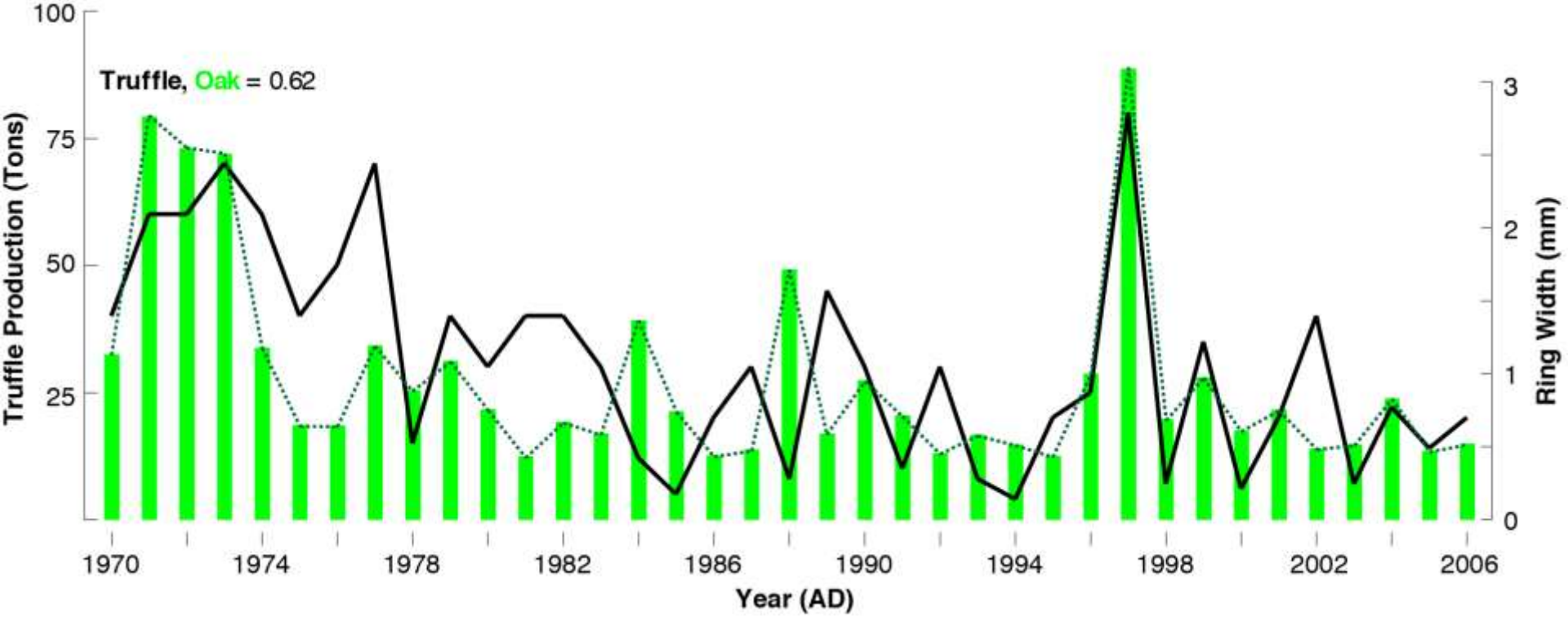
Mediterranean truffle harvest
June-August precipitation totals
June-August temperature means (inverse)


Truffle, Oak = 0.62
Truffle Production (Tons)
100
75
50
25
Ring Width (mm)
3
2
1
0
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Year (AD)

Long-term irrigation effects on Spanish holm oak growth and its black truffle symbiont

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The World’s largest truffle plantation – 600ha near Soria

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The World’s largest truffle plantation – 600ha near Soria

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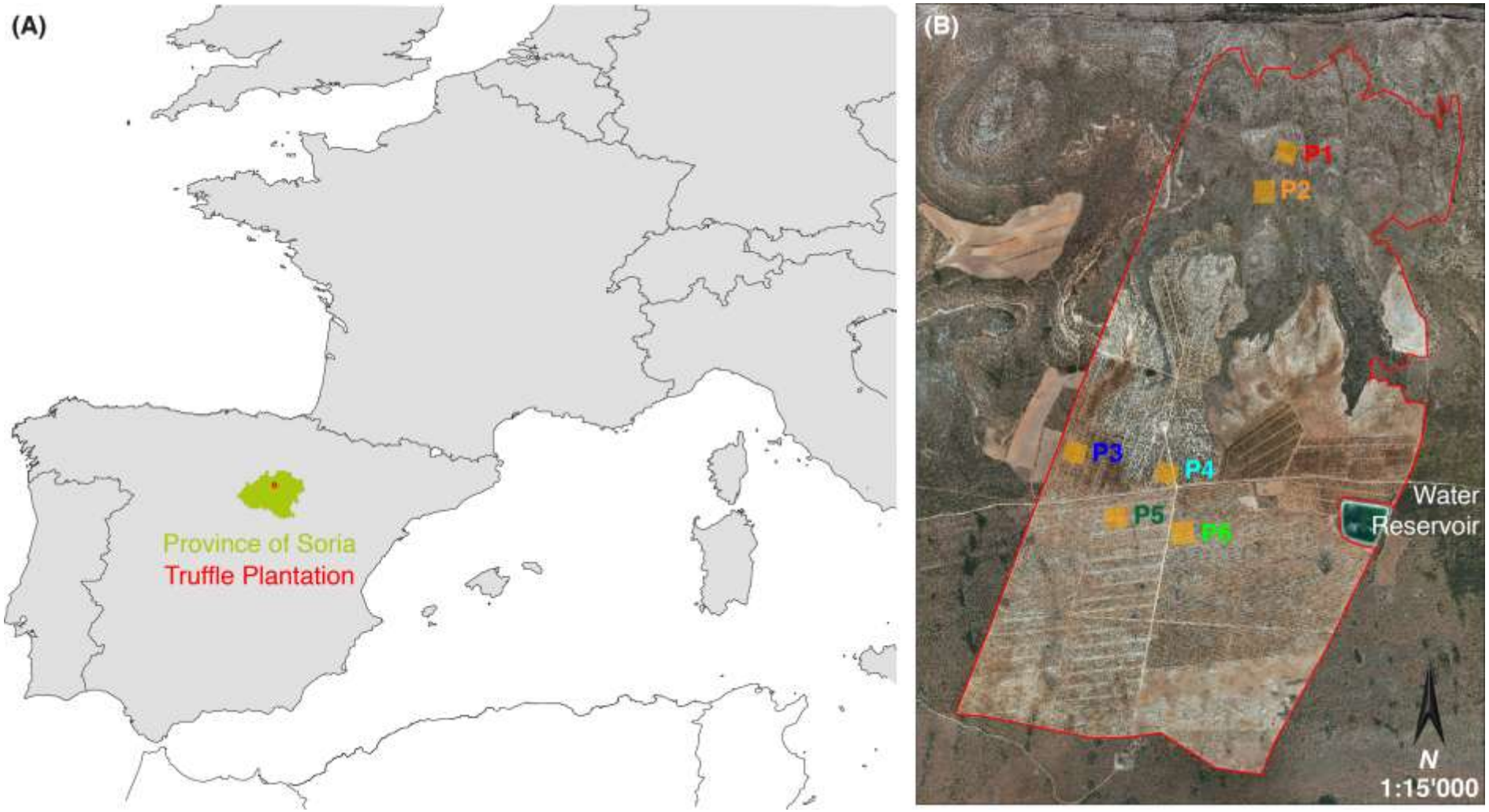
Location of the Arotz plantation



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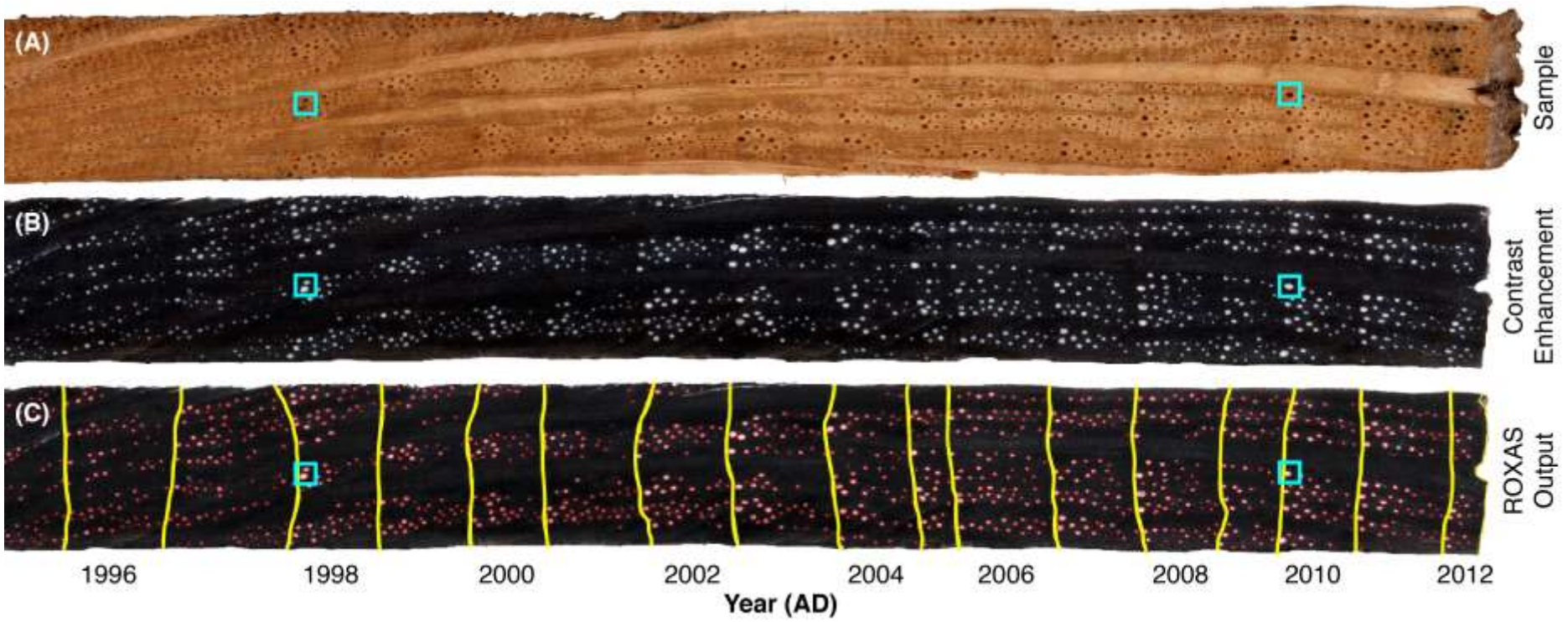
Dendrochronological and wood anatomical features of *Quercus ilex*



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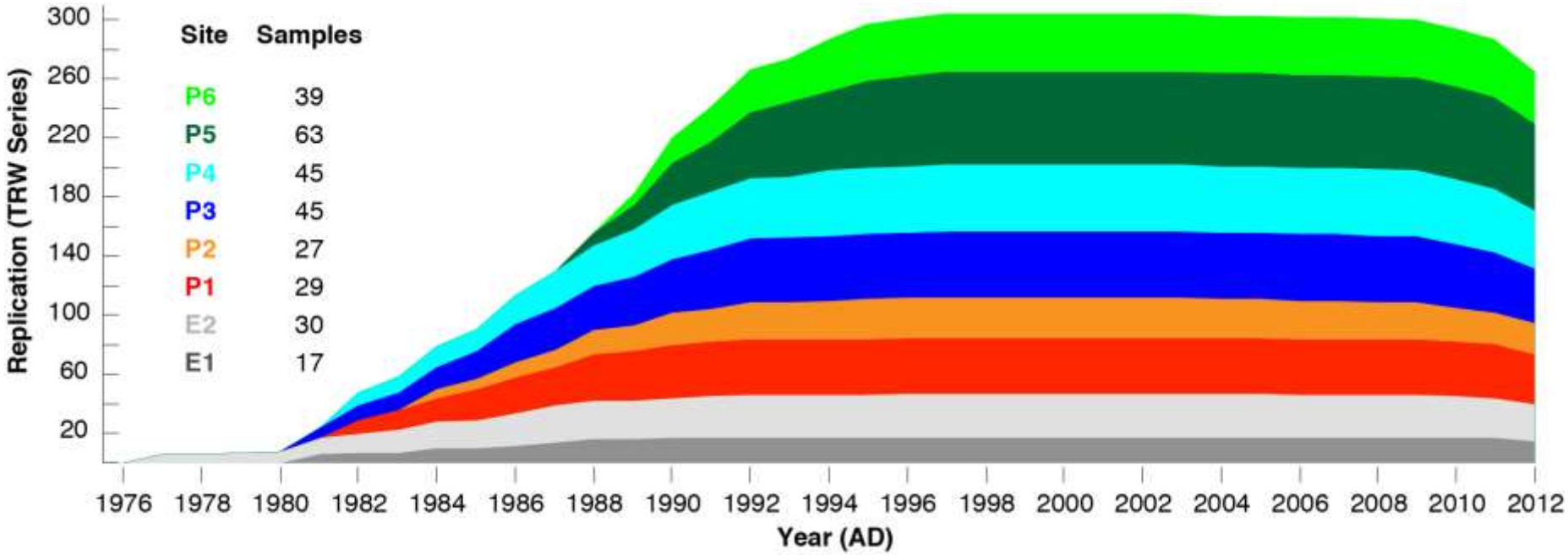
Tree-ring sample replication



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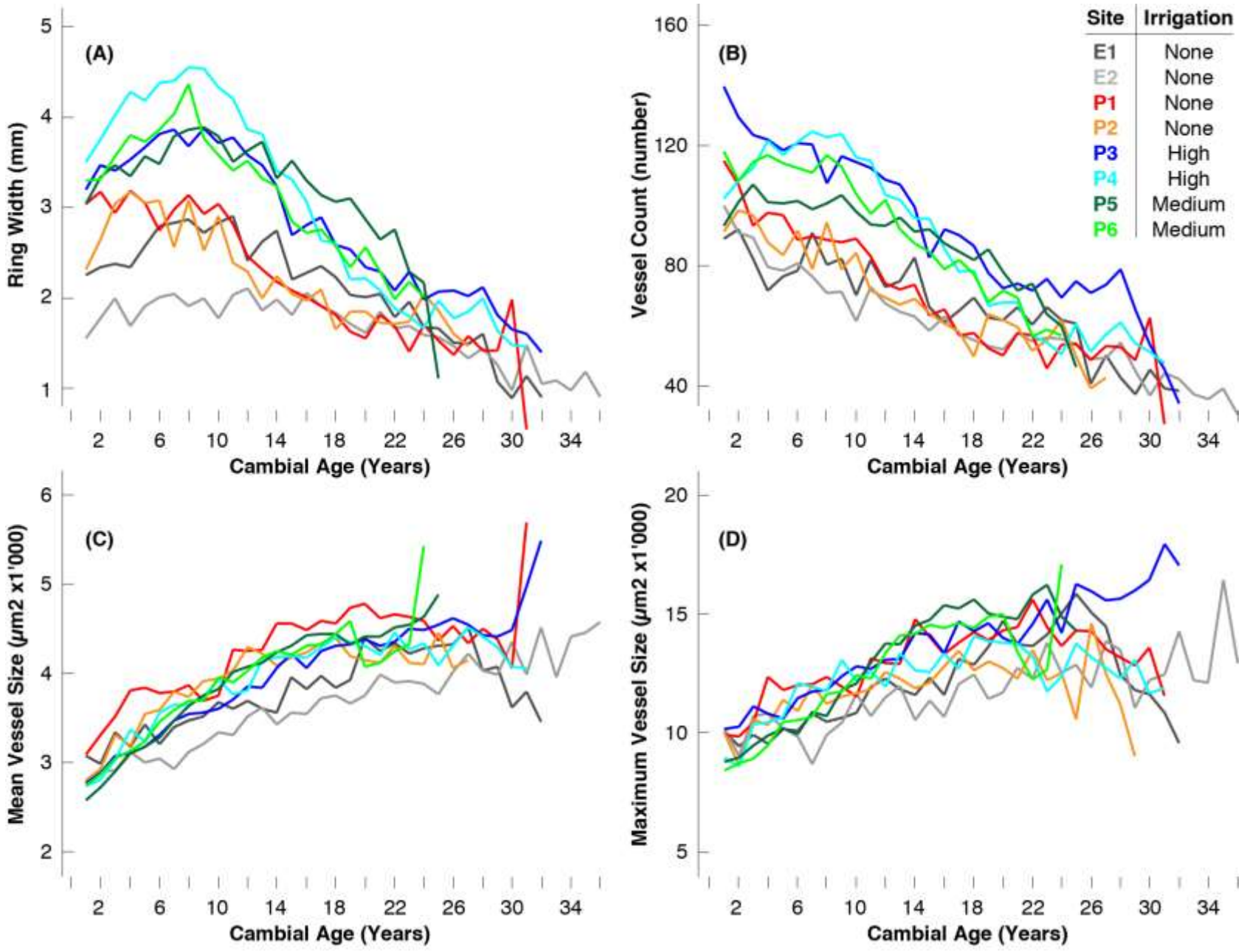
Parameter-specific age trends



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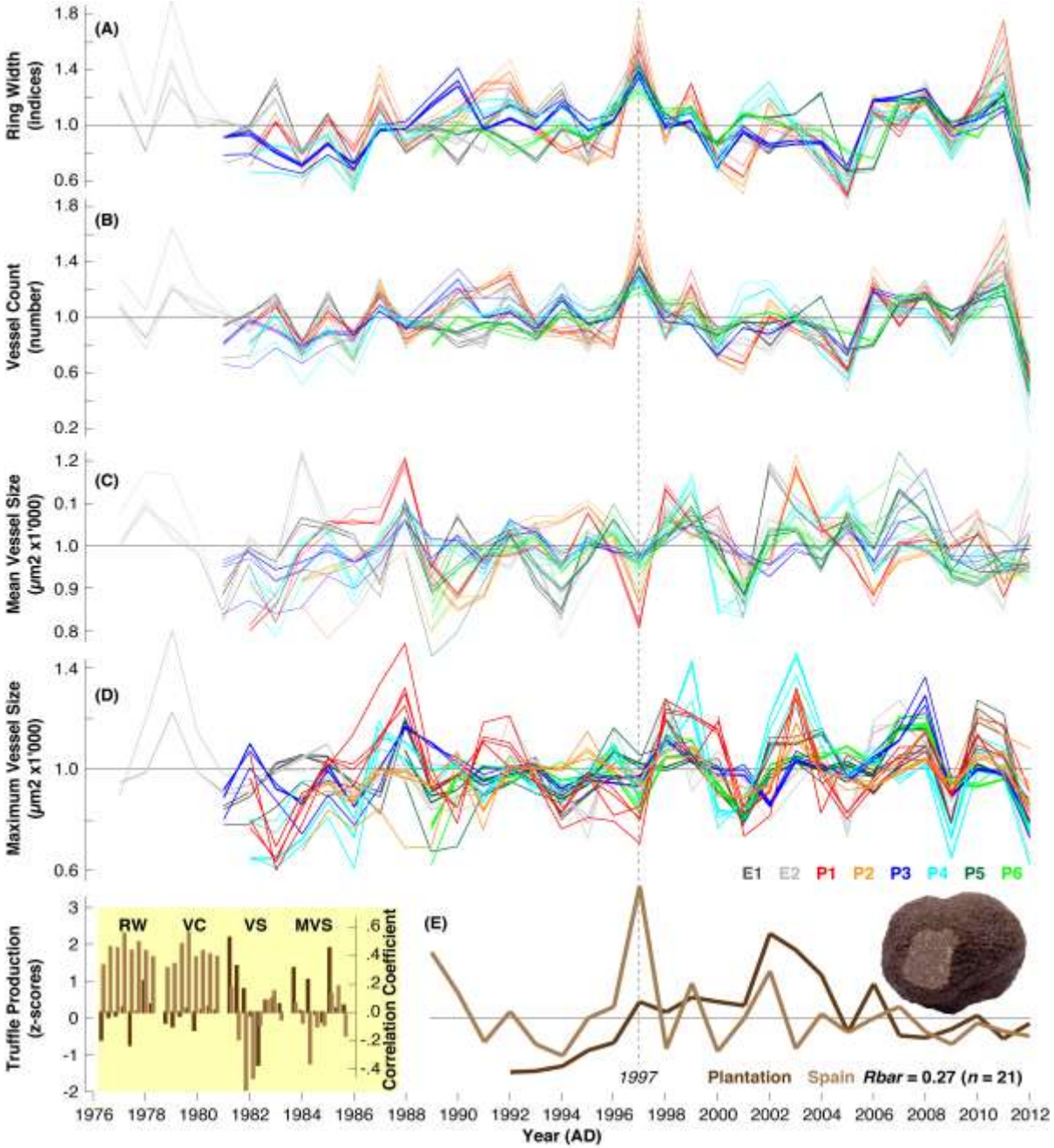
Oak growth variability and truffle productivity



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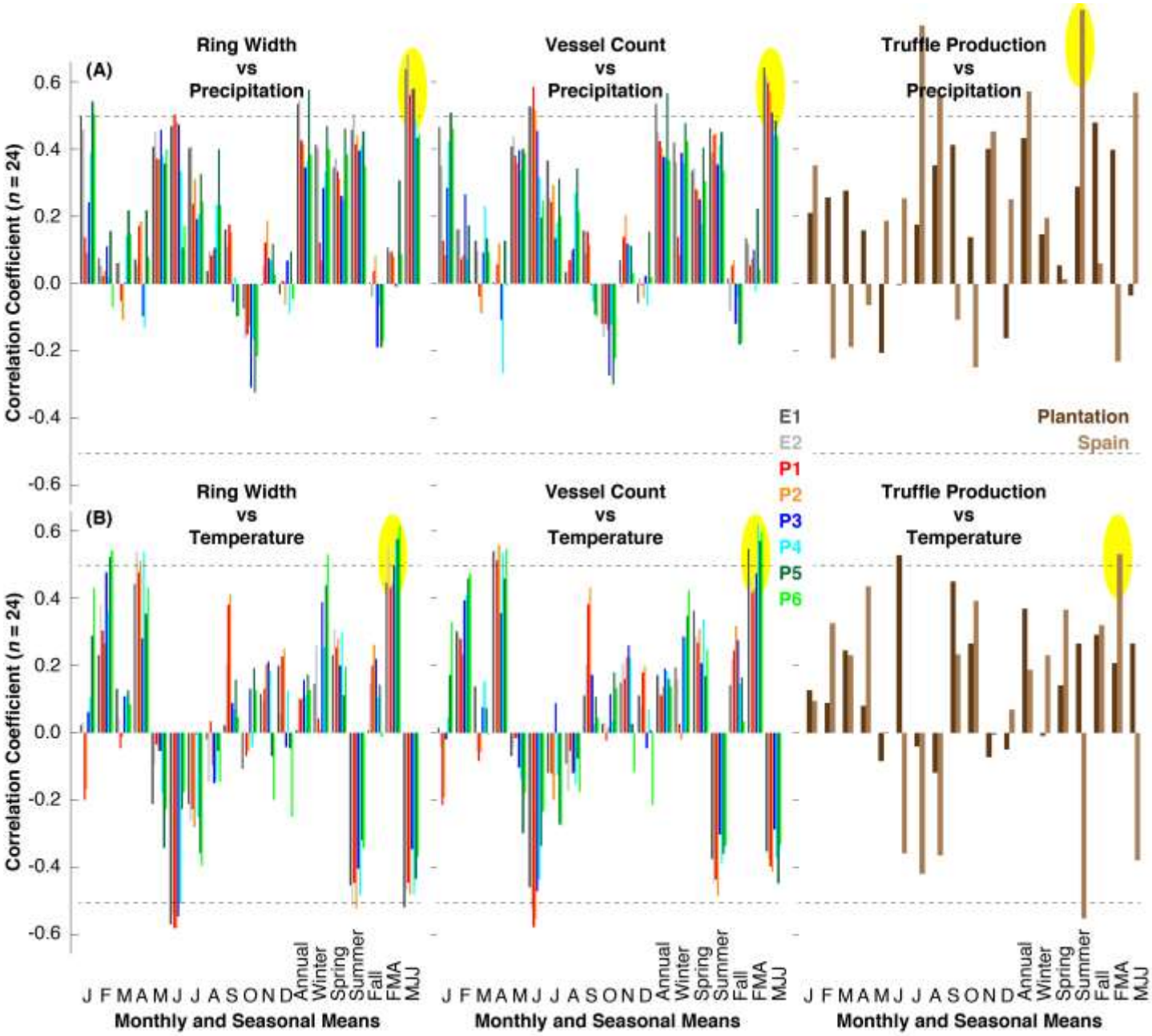
Growth-climate sensitivity



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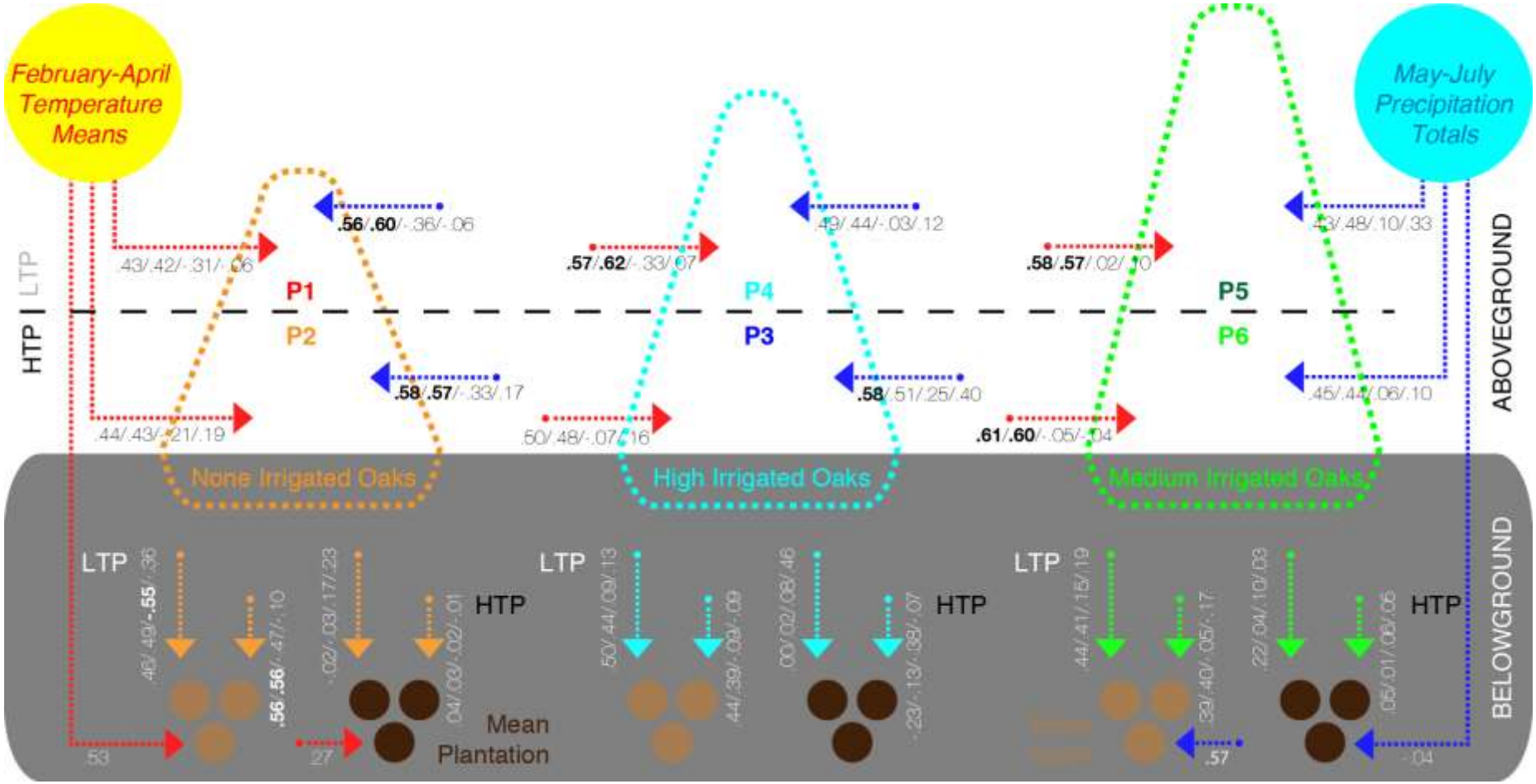
Conclusions



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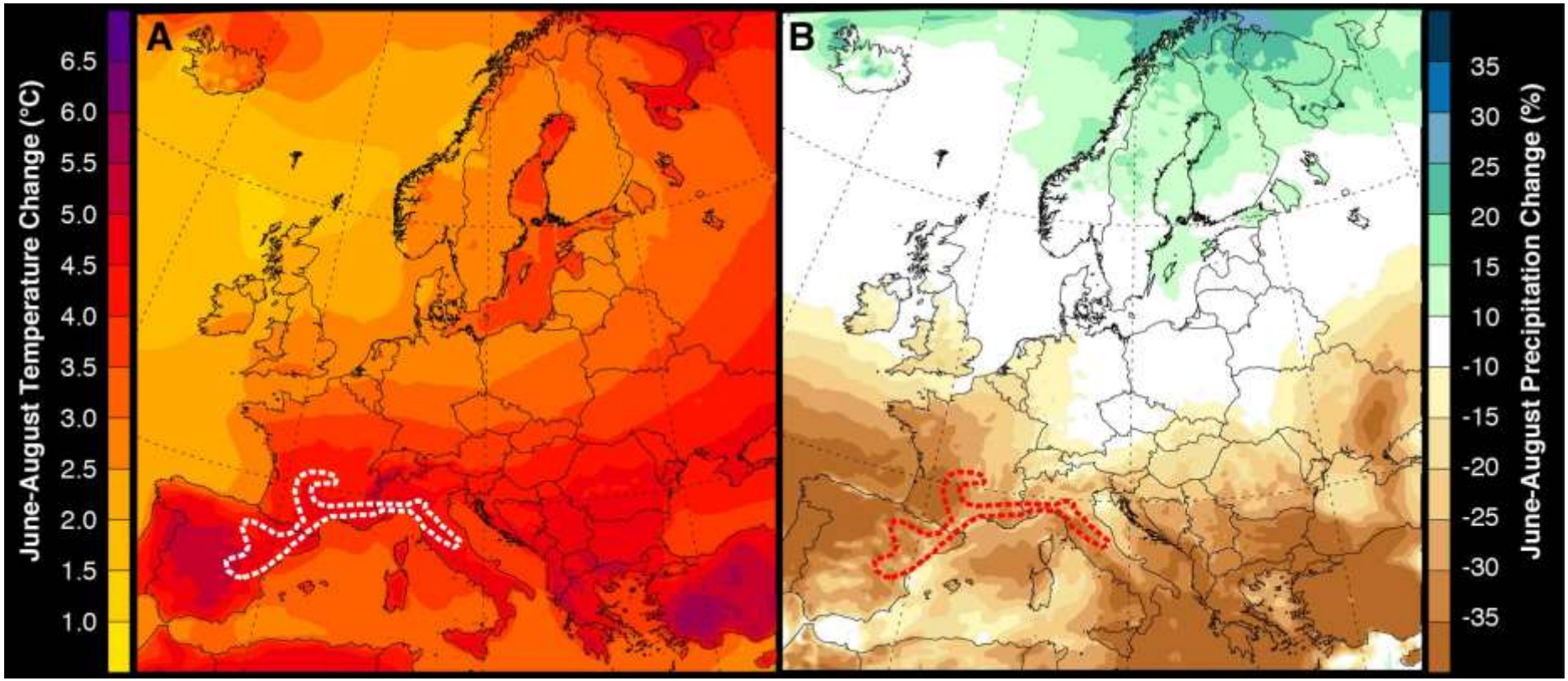
Outlook

Projected Mediterranean drying



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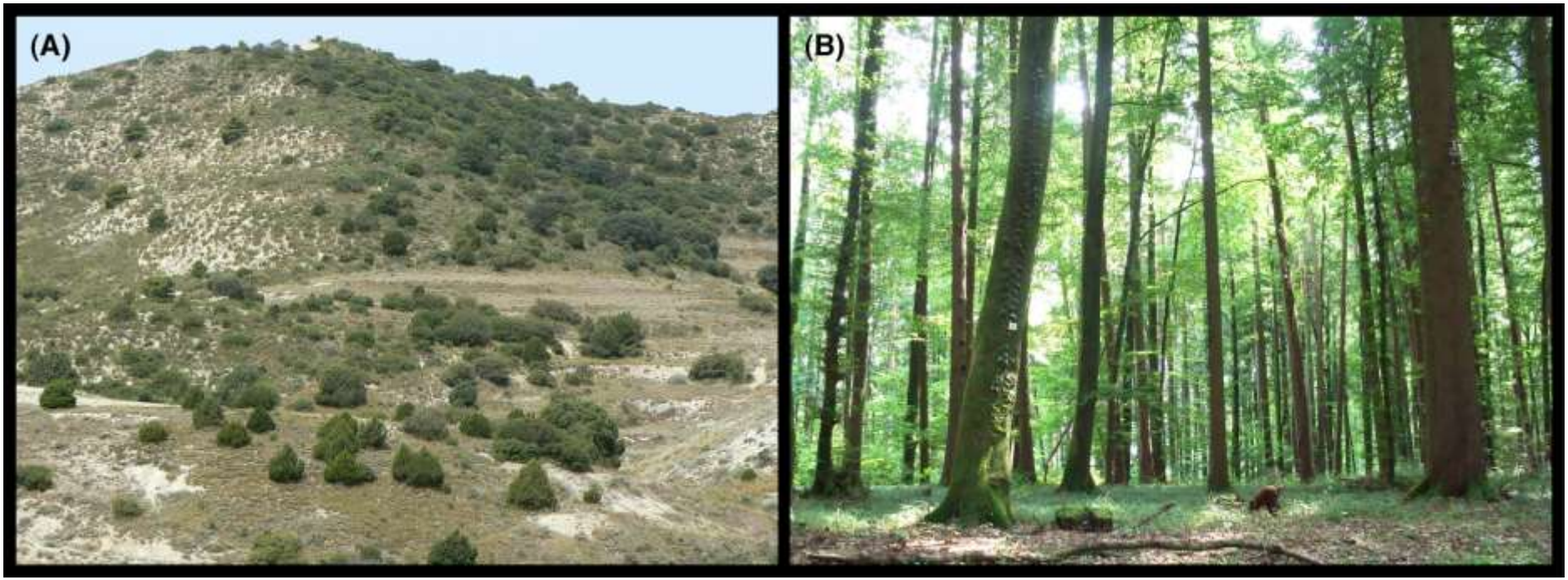
First indication for the possibility of a climate induced biome shift?



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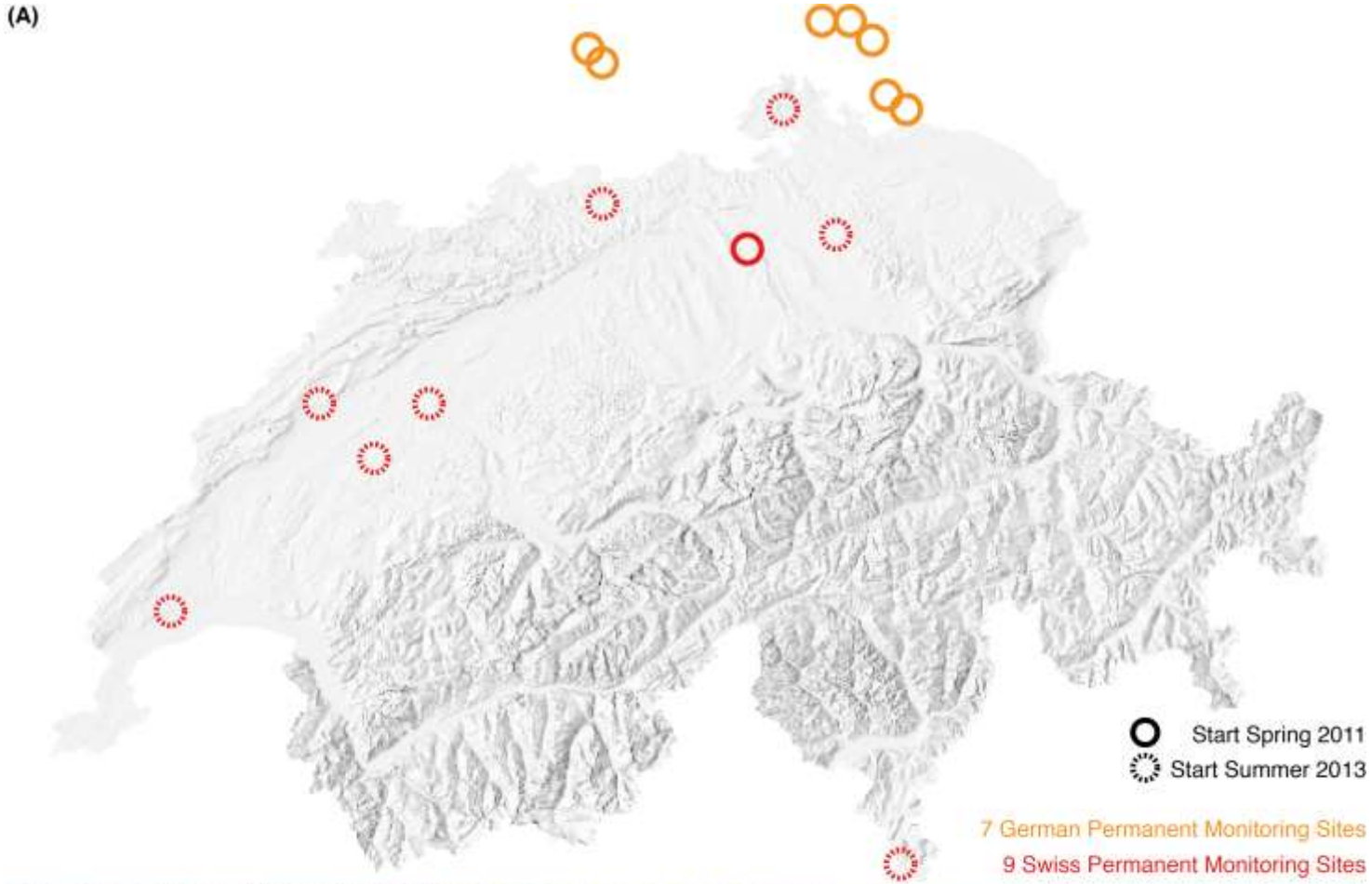
Swiss-German *Tuber aestivum* monitoring network



Tracing putative fungi-host linkages

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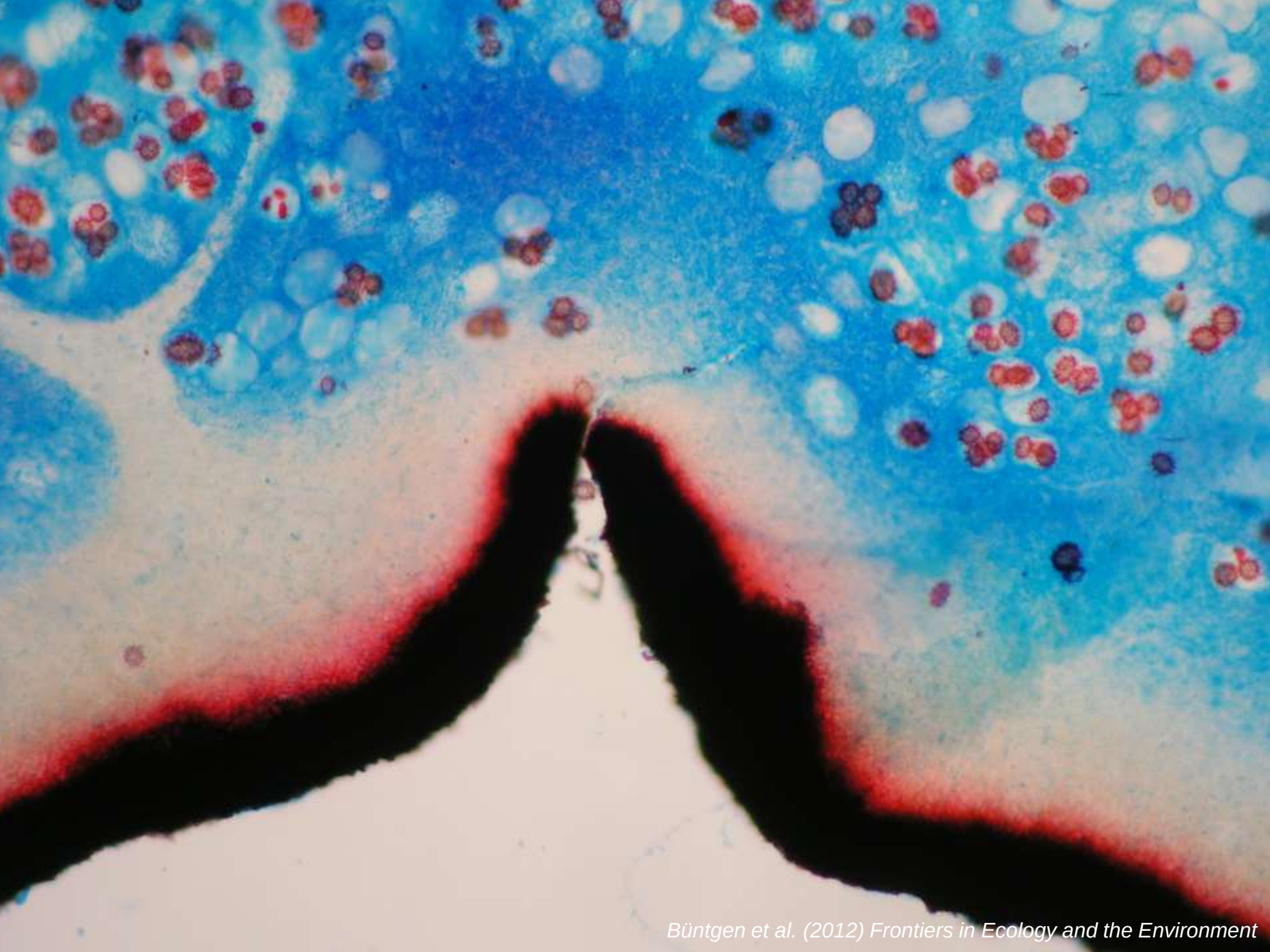
Büntgen et al. (2012) Frontiers in Ecology and the Environment



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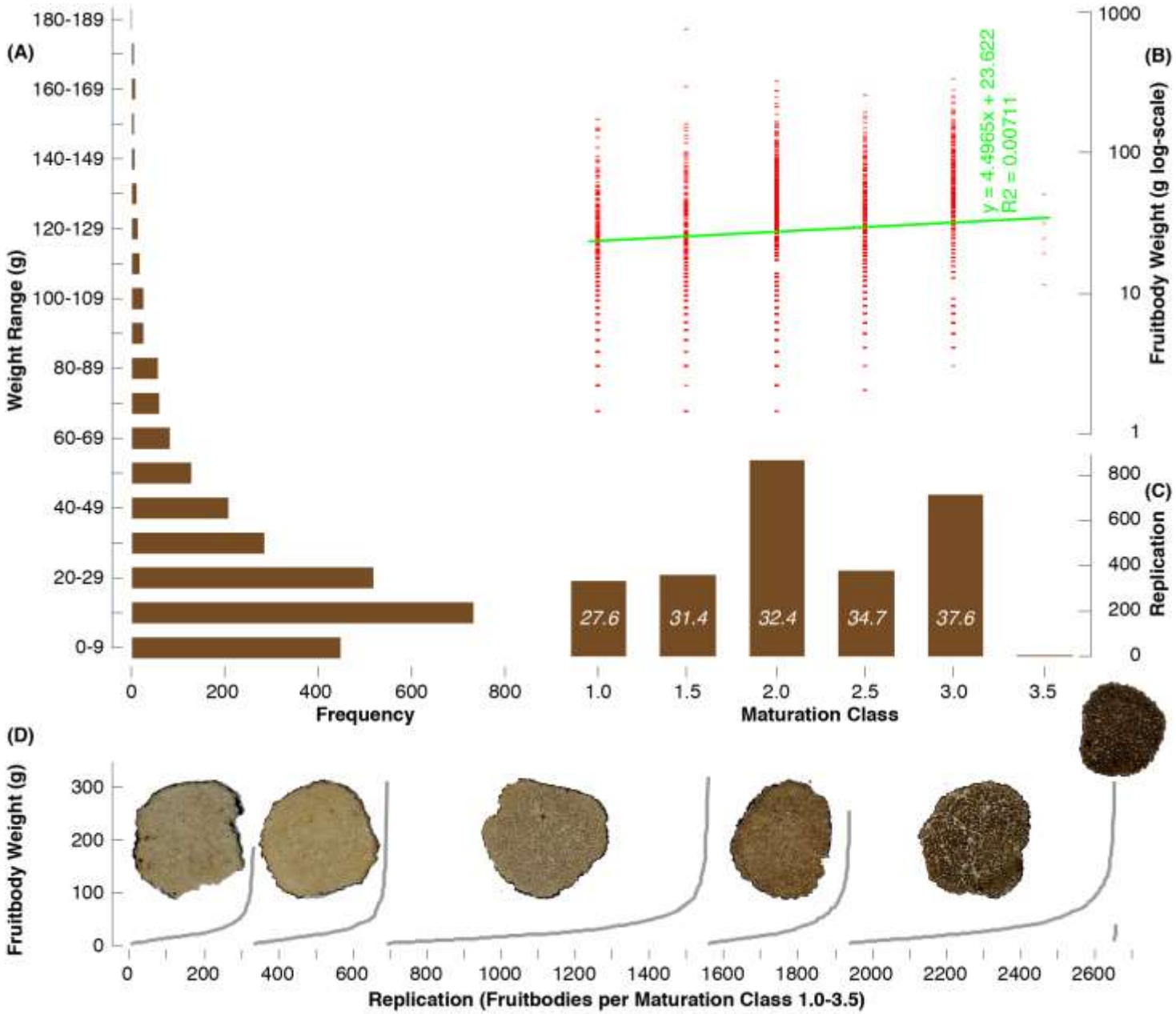
Does truffle maturation coincide with fruitbody formation?



Büntgen et al. (in prep)

Linking fungal ecology with climate variability

Long-term changes in the phenology, productivity and diversity of Spanish mushrooms

Long-term changes in the phenology, productivity and diversity of Swiss mushrooms


The Pinar Grande *Pinus sylvestris* forest in Soria
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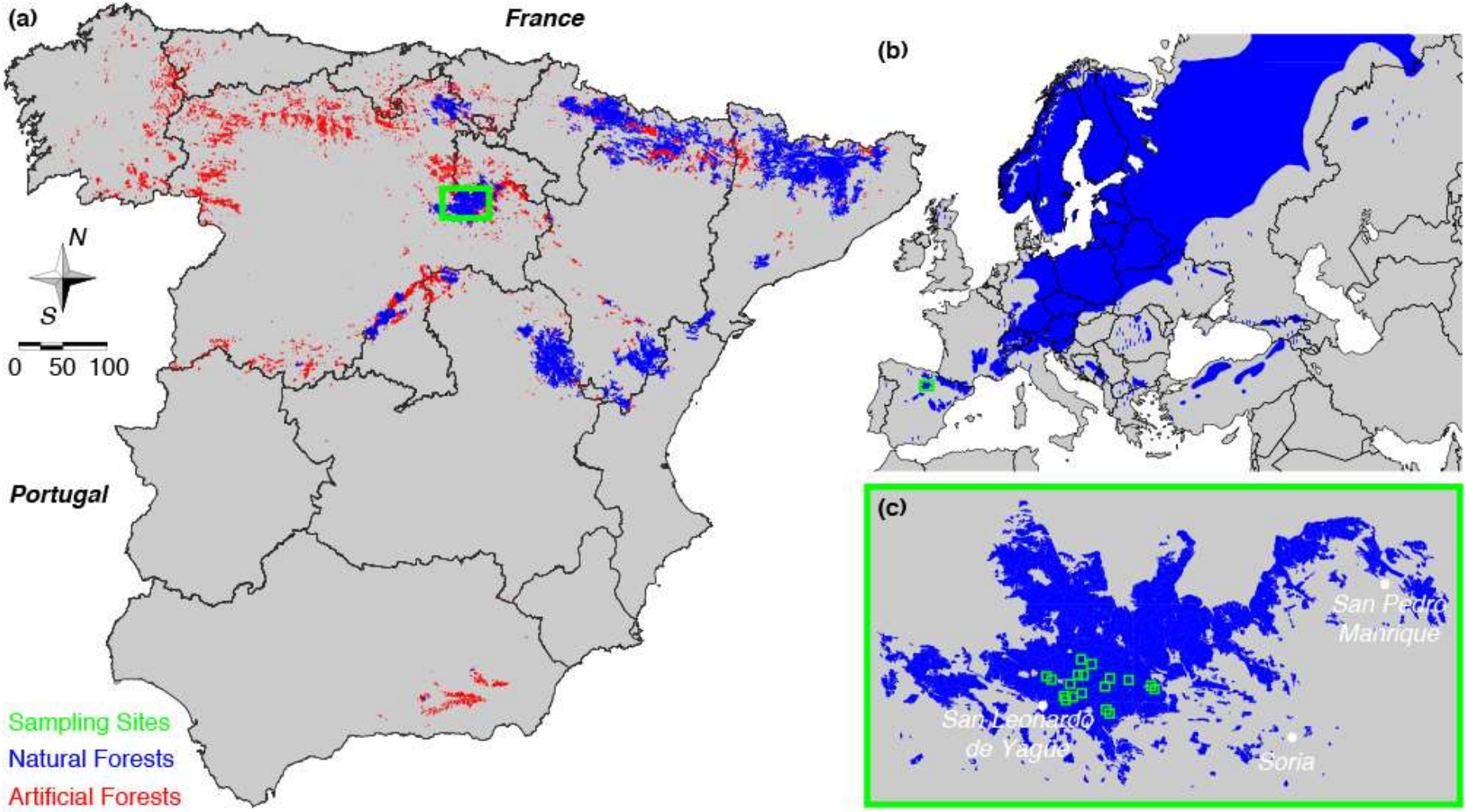
The Pinar Grande *Pinus sylvestris* forest in Soria



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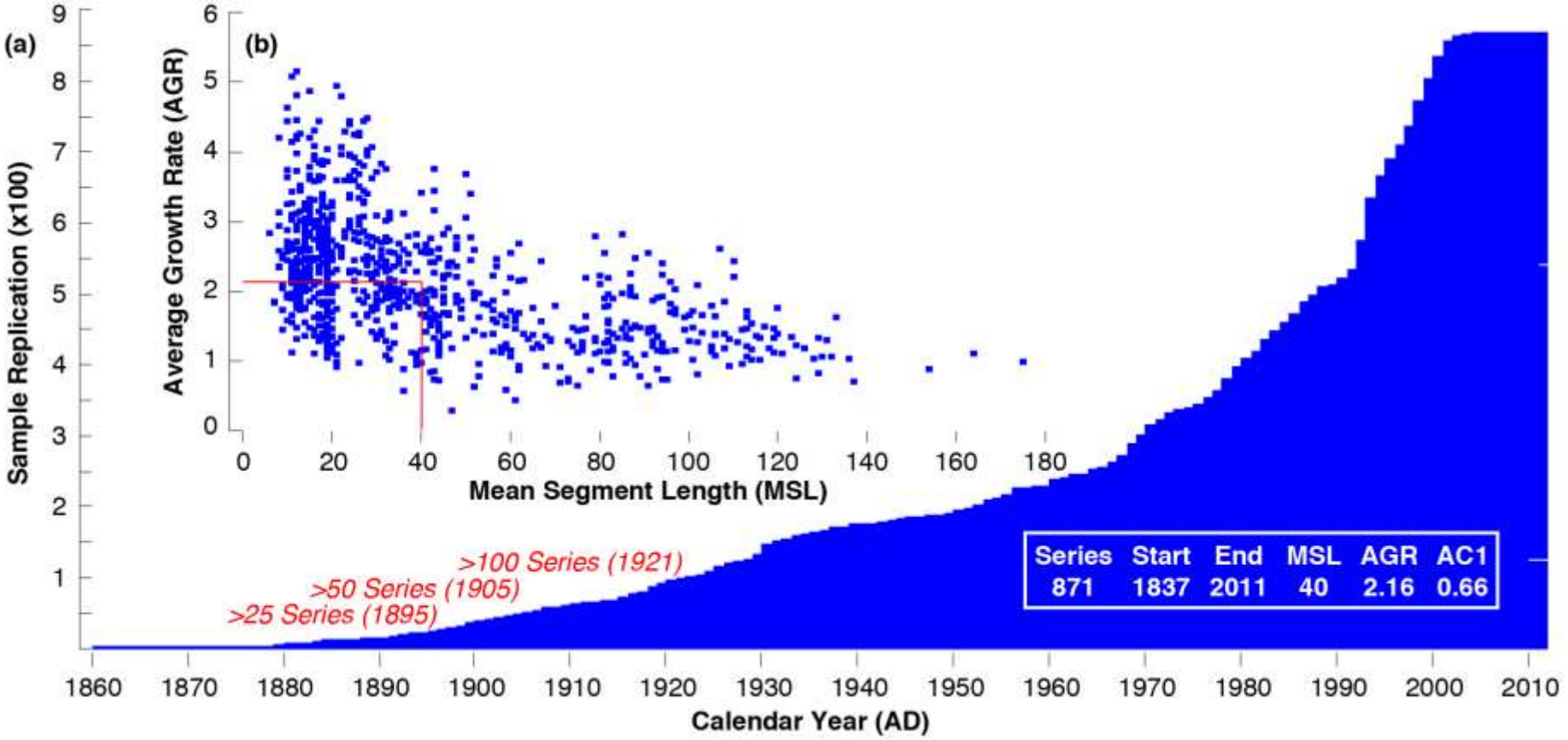
Sample replication



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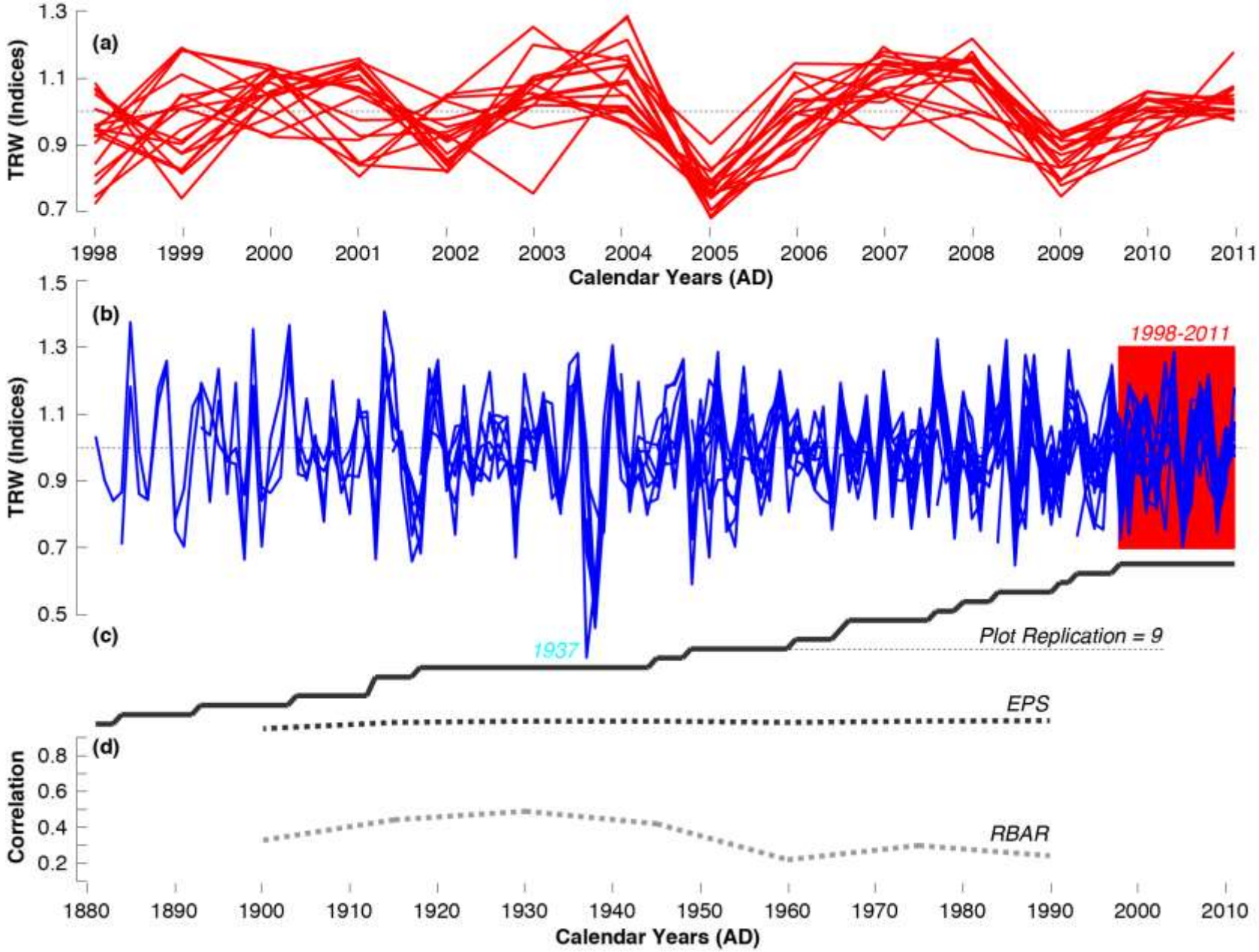
Growth coherency



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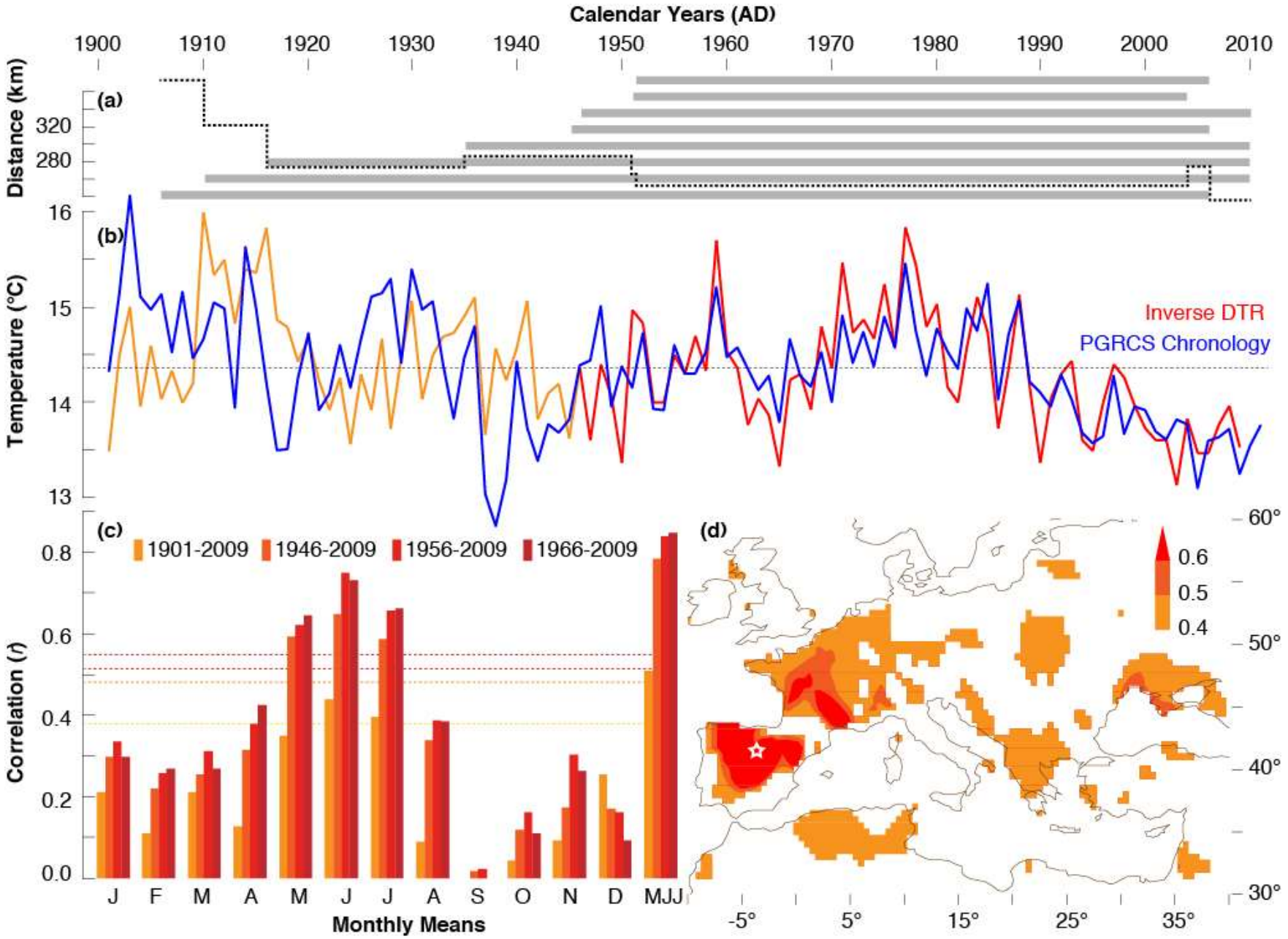
Using the DTR as a hydroclimatic surrogate to reconstruct forest growth

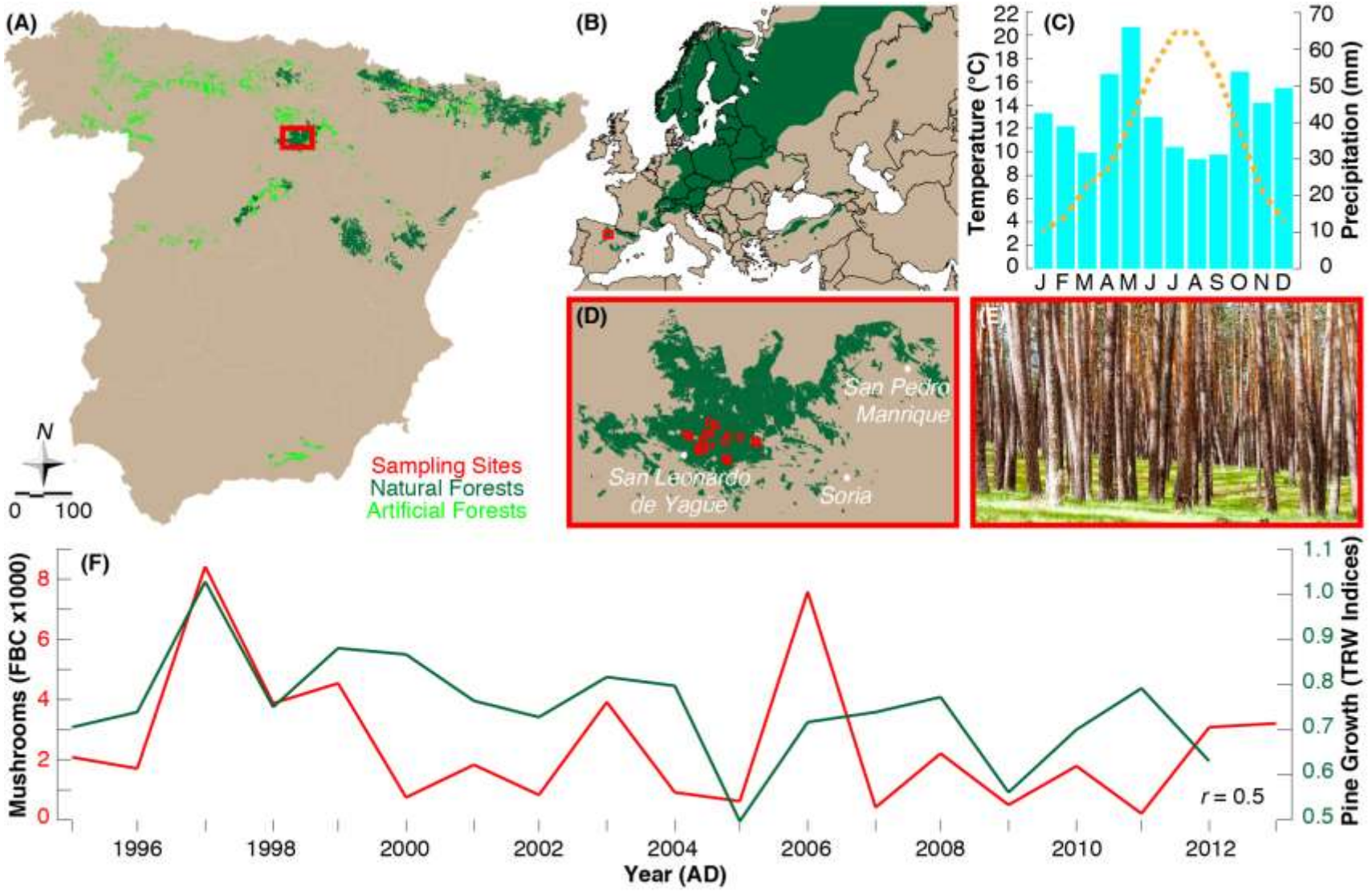


Büntgen et al. (2013) Global and Planetary Change

Drought-induced long-term changes in the phenology, productivity and diversity of Spanish mushrooms

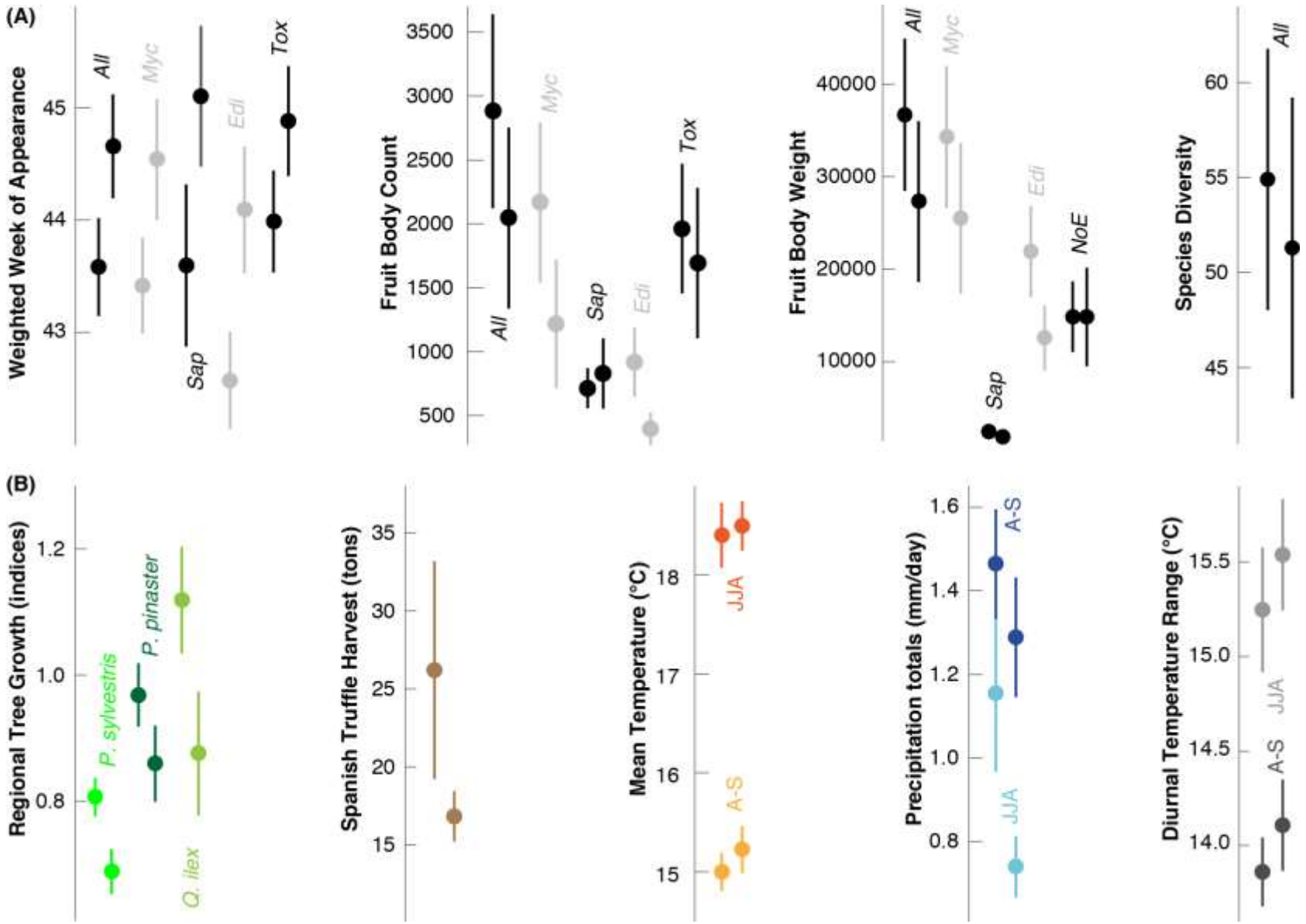
Büntgen et al. (in revision) Fungal Ecology

Drought-induced long-term changes in the phenology, productivity and diversity of Spanish mushrooms



Büntgen et al. (in revision) Fungal Ecology

Linking Spanish fungal ecology with climate variability



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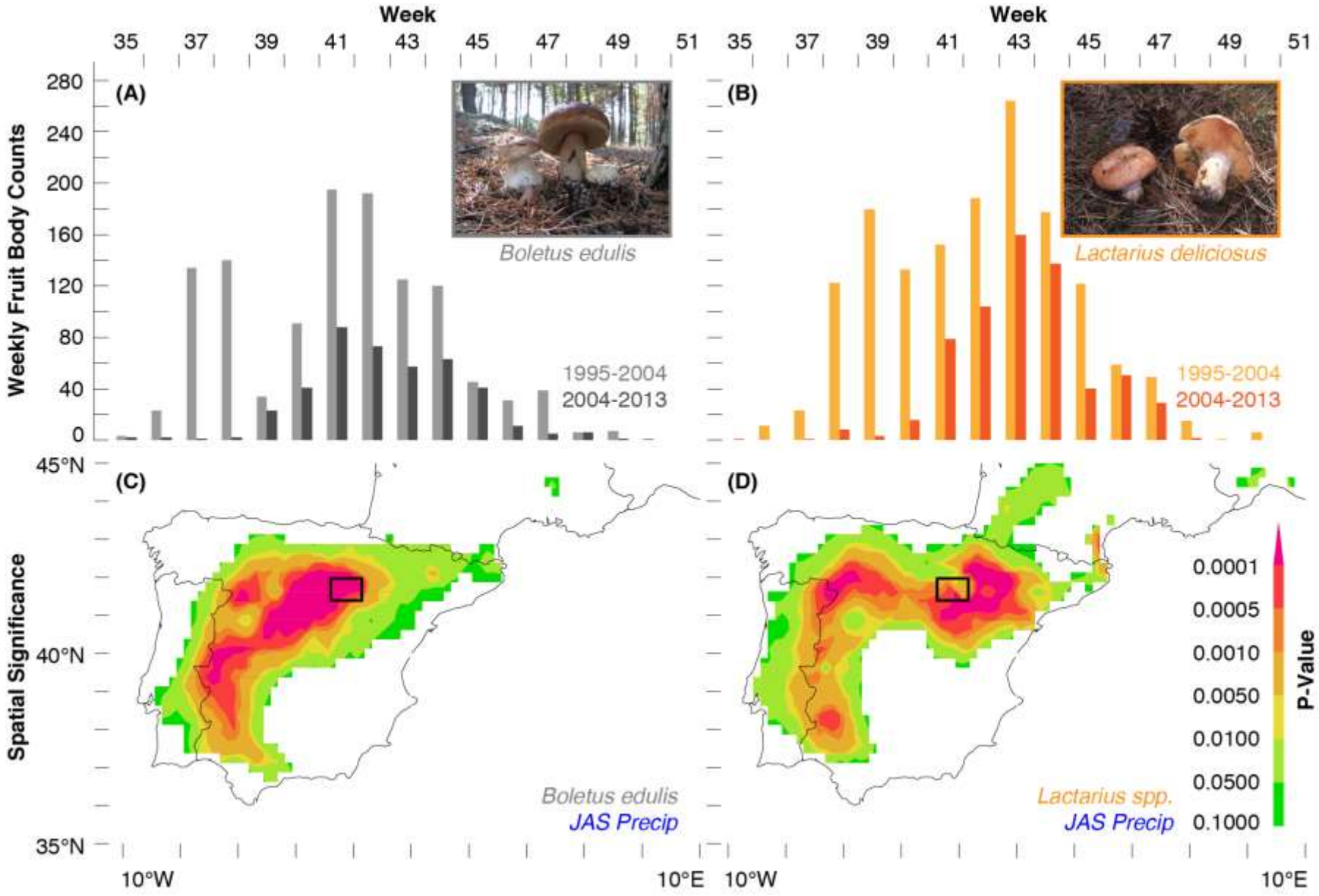
Linking Spanish fungal ecology with climate variability



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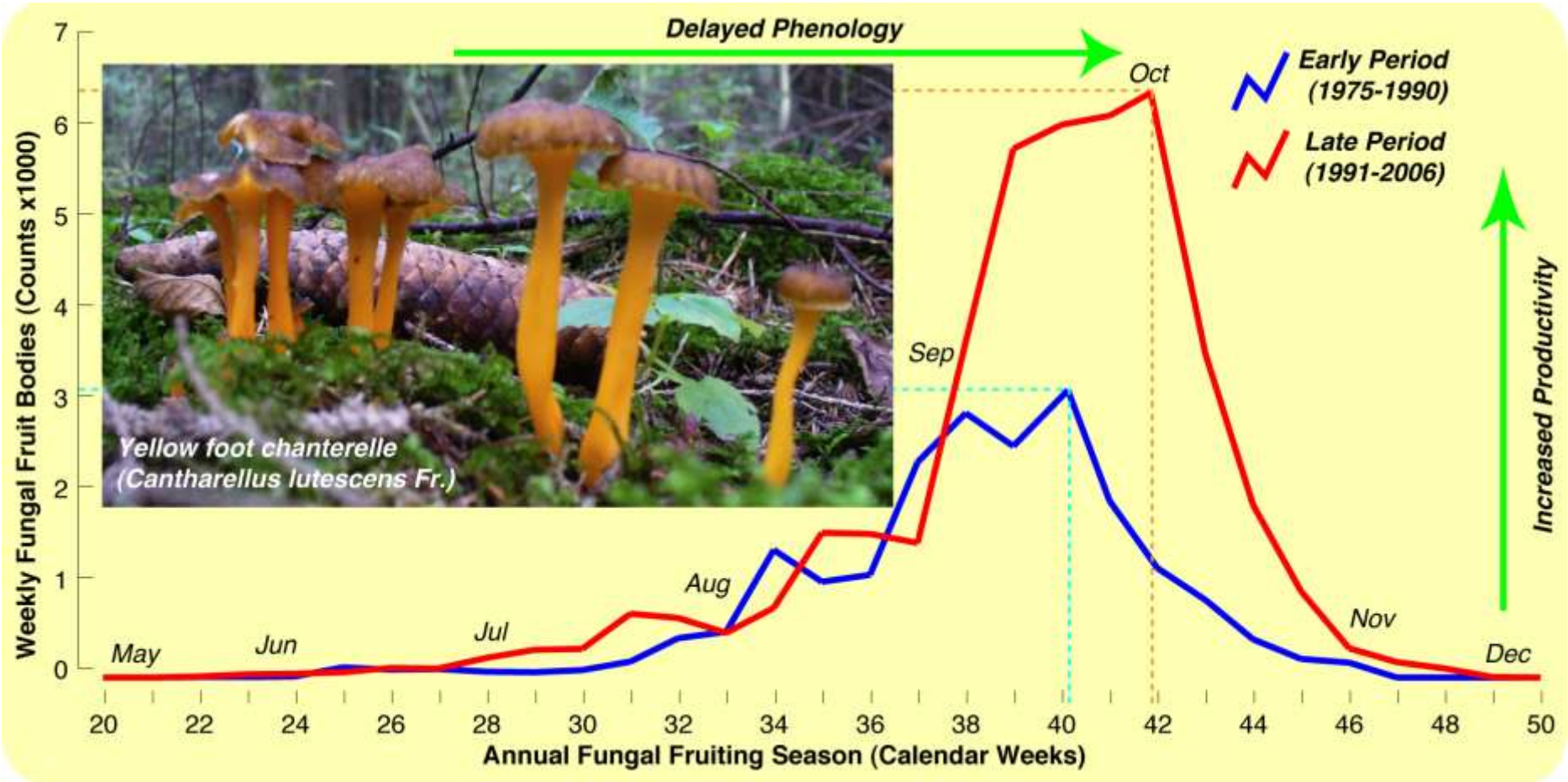
Mushroom phenology and productivity in Switzerland

Mushroom phenology and productivity in Switzerland



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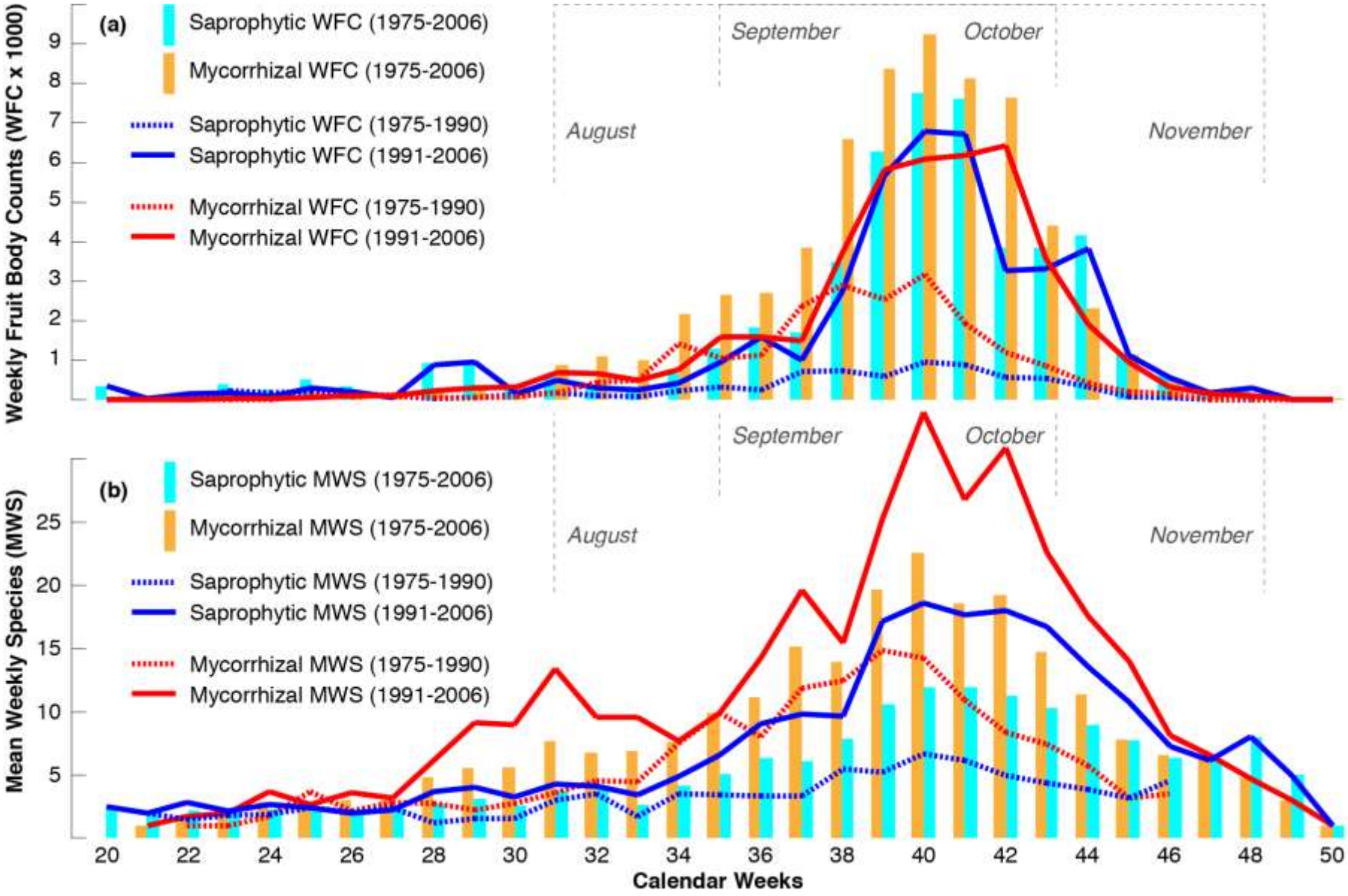
Mushroom phenology and productivity in Switzerland



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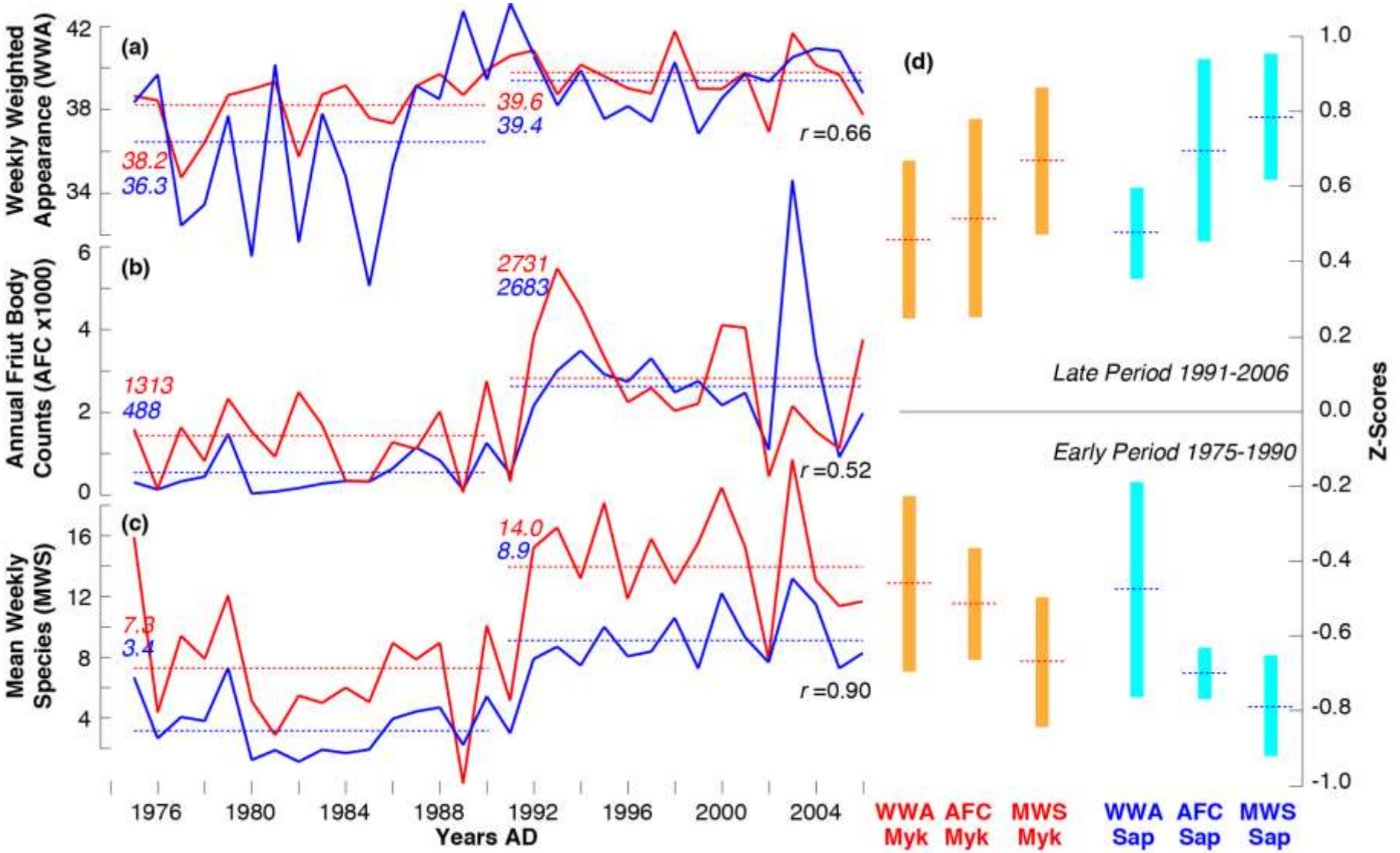
Mushroom phenology and productivity in Switzerland



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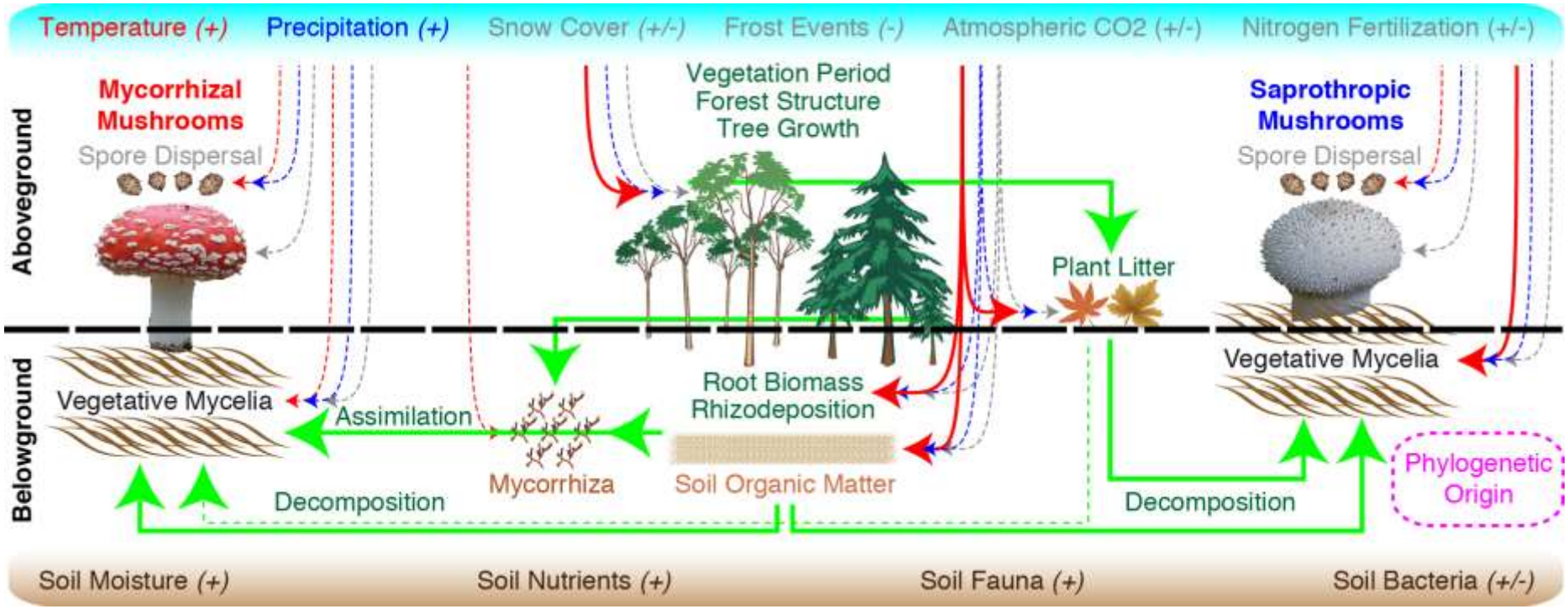
Linking dendroecology with mycology



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Outlook

Breaking new ground at the interface of dendroecology and mycology

New insight on the mycorrhizal fungus-host association, expected to emerge from combining dendrochronology, wood anatomy and mycology, may help to better understanding and disentangling biotic, abiotic and combined edaphic factors of the mutualistic relationship between ectomycorrhizal fungi and their perennial partners.

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A priority list of eight interrelated research avenues (i-iv)

i) Combine continuous high-resolution dendrometer measurements of cell formation and sap flow with mushroom fruiting body observations and mycelial growth patterns to quantify linkages between the phenology and net primary productivity of mycorrhizal fungi webs and their host plants.

ii) Apply isotopic labeling to trace symbiotic carbon, nutrient and water (host-fungi/fungi-host) pathways and fluxes for different species, environments and climates, to better understand the continuum between plant growth and ectomycorrhizal fungus energy capture and partition.

iii) Perform field and greenhouse experiments with model host-fungus pairings to quantify the weight abiotic factors may have in the reciprocal transfer of nutrient, phosphorus, water and carbon in order to predict environmental effects on symbiosis functioning.

iv) Utilize the advent of bioinformatic sensor technologies, such as metagenomic and/or metatranscriptomic analyses or biochemical assays to gauge belowground functional hyphal activity and compare these data with intra-annual tree-ring patterns.

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A priority list of eight interrelated research avenues (v-viii)

v) Develop chronologies of different tree-ring and wood anatomical parameters to reconstruct impacts of forest management on fungi phenology and productivity, including the assessment of truffle orchards in drought-prone Mediterranean habitats.

vi) Test if increased photosynthesis (in tandem with increased vegetation growth) fosters carbon sequestration in ectomycorrhizal ecosystems, such as the boreal zone, or whether better carbohydrates access to ectomycorrhizal fungi improves their competitive ability above saprotrophic species, which will tentatively lead to higher carbon accumulation rates.

vii) Relate long-term mushroom monitoring inventories to tree-ring chronologies and meteorological records to analyze direct and indirect climatic drivers of the productivity and phenology of fruit body production fruiting, even involving ascomycetes.

viii) Extend cross-disciplinary approaches to the vast number of perennial tree and shrub species symbiotic with ectomycorrhizal fungi, and utilize this new perspective to help parameterize and validate the next generation of general ecosystem models.

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Thanks

Thanks

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