Forest vulnerability and tree mortality in the Mediterranean: Impacts and Opportunities

מכון ויצמן למדע
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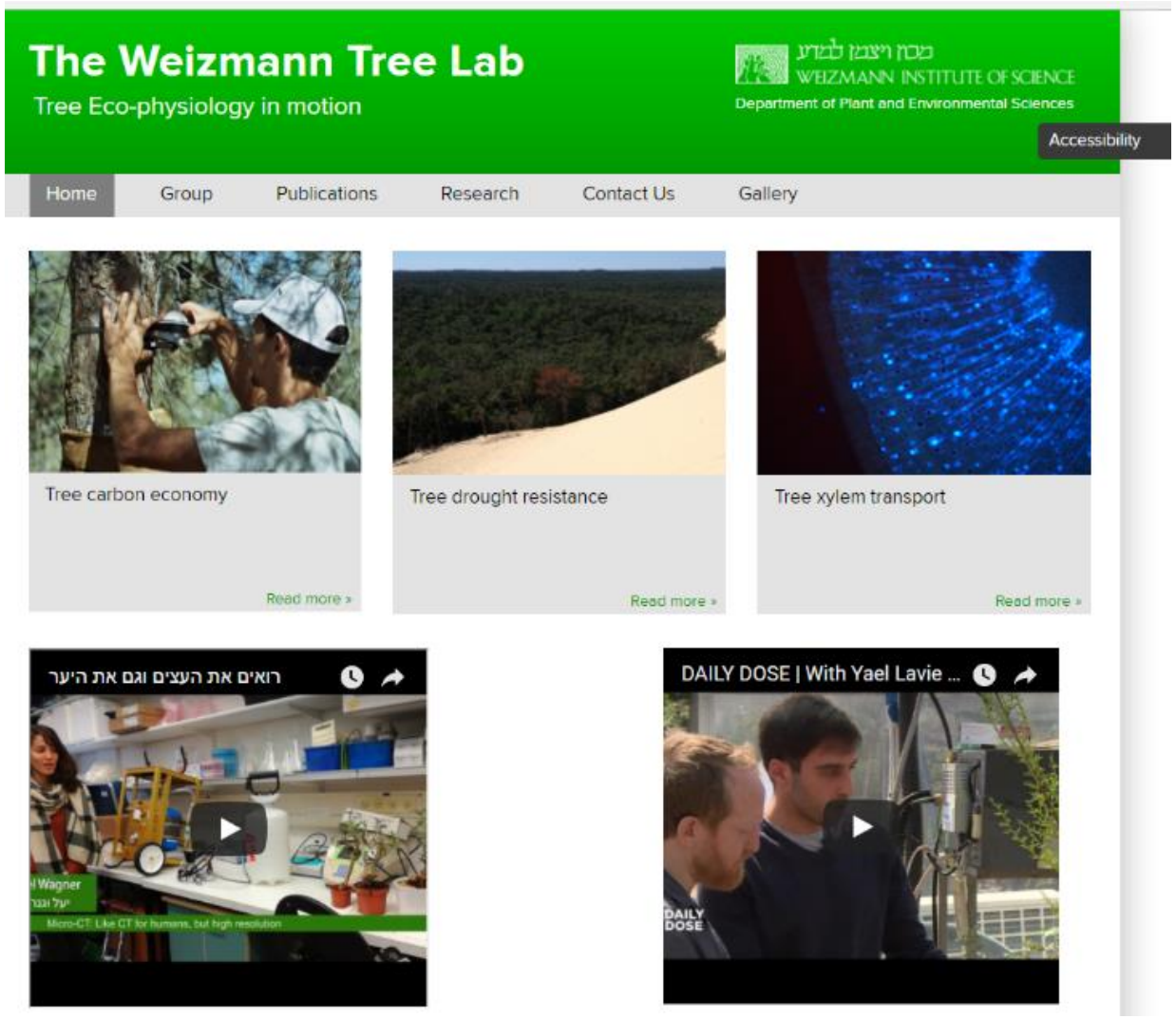
Tamir Klein and research partners

The Mediterranean basin: special considerations

1. A mosaic of human and natural landscapes
2. A long history of anthropogenic disturbance
3. Ongoing warming, expected drying

1. What are the impacts?
2. What can we do?

A seven-decade tree mortality study across Israel, the first nation-scale survey



We combined remote sensing (satellite) data with forest monitoring data along 1948-2017, to cover the entire forest area across Israel.

We asked:

- Is tree mortality increasing?
- Are recent mortality events related to climate change?
- Which tree species are the most affected?

Klein et al. 2019 FEM

What kills trees in Israel?

Deforestation and windstorm are negligible

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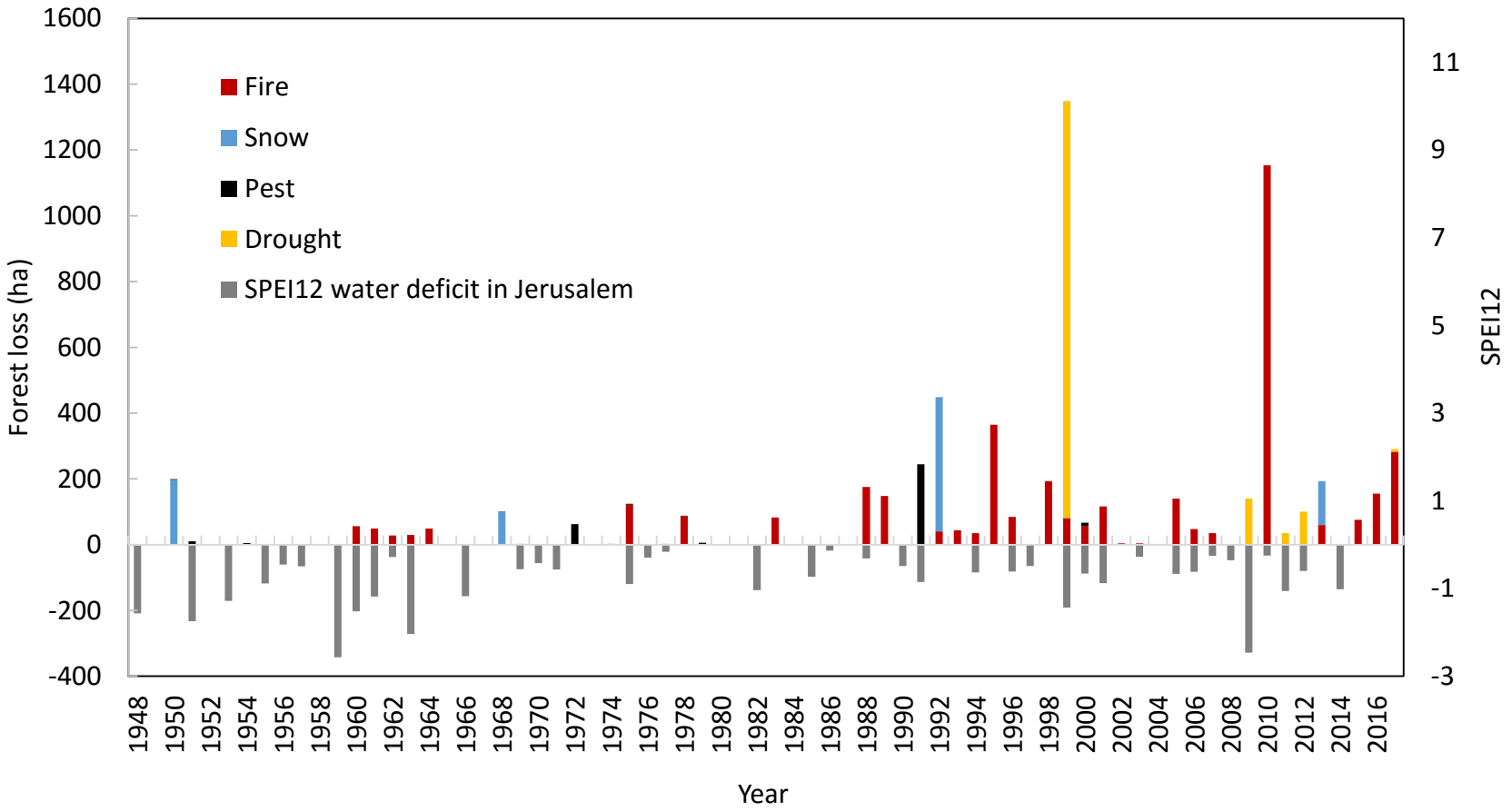
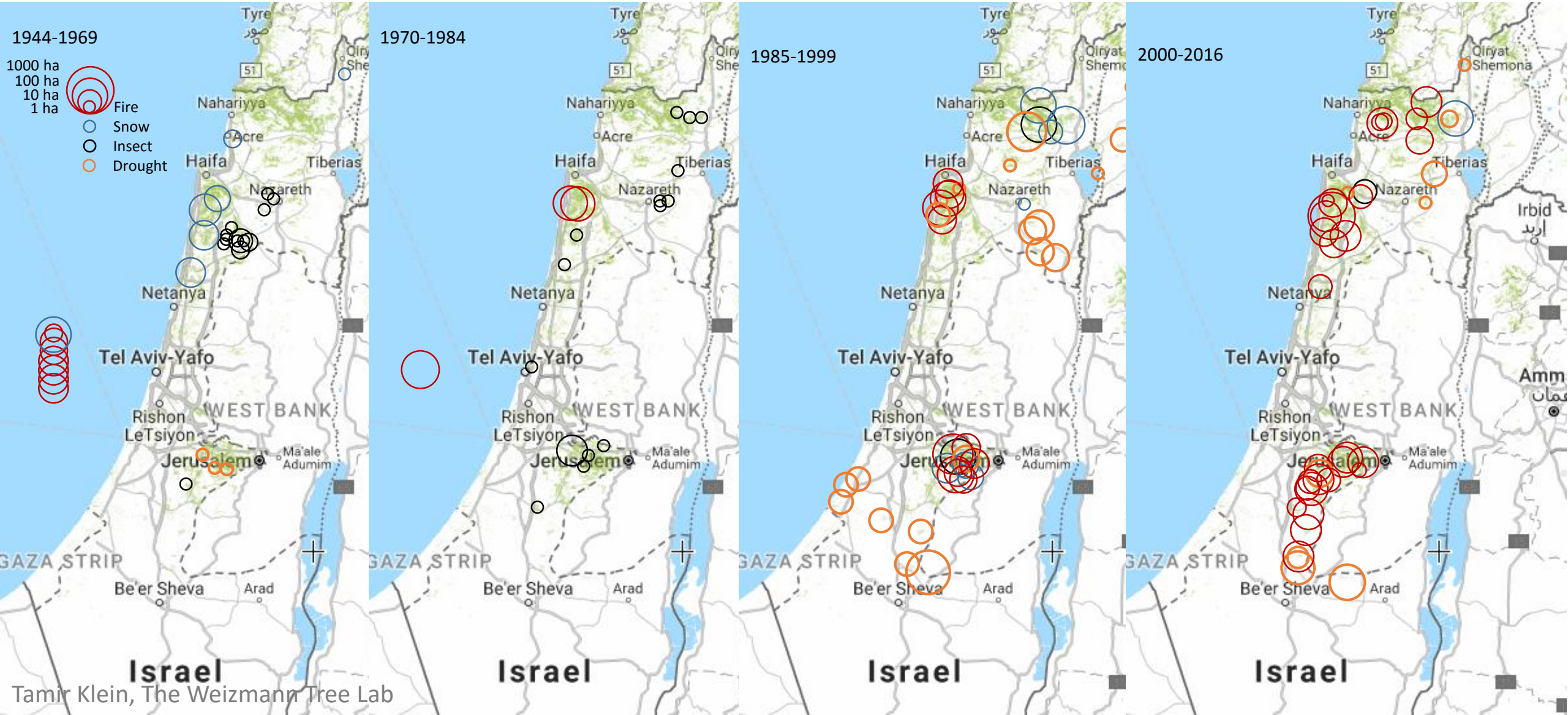
Tree mortality events have been increasing significantly since 1991 and correlated well with drought



42% and 31% of the loss were in the 1990s and 2010s, respectively, whereas other decades had only 3-8% of the loss. Overall, 24% of the loss was directly related to drought, and 58% to fire.

Tree mortality events have expanded northward and southward since the 1980's. The most affected species was Aleppo pine (*Pinus halepensis*).



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Aleppo pine, the single most important forest tree species in the region

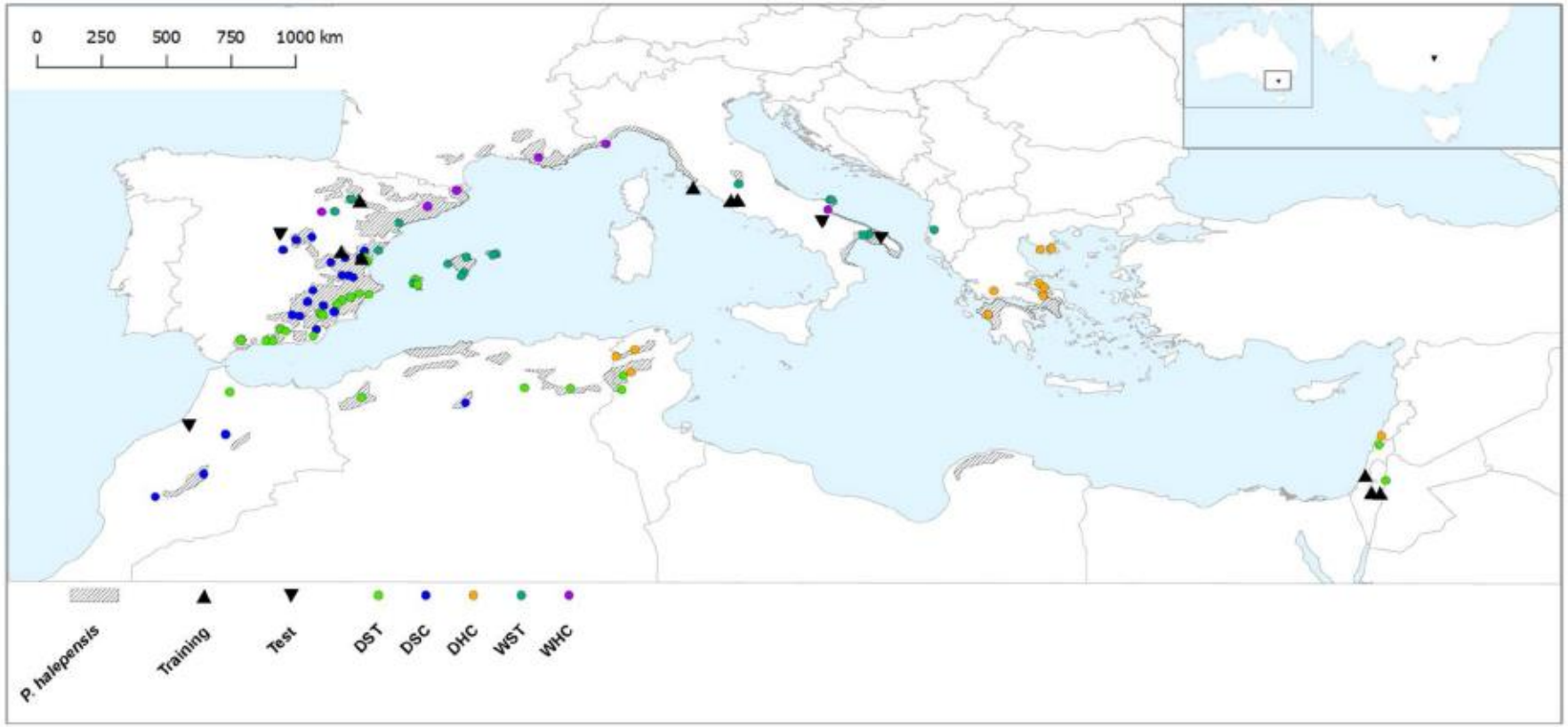


Fig. S4. Distribution range of *Pinus halepensis* identified with hatching. Populations evaluated in the multi-environment trial are shown with dots and trials with black triangles. The dot colour denotes a particular ecotype as identified in the dendrogram of Fig. S5. Validation trials in Australia (inset), Italy, Morocco and Spain are depicted with black inverted triangles.

Aleppo pine has been grown for decades in common garden plots of provenances from around the region. We performed a synthesis of these long-term results.

Aleppo pine height increases with precipitation, and, to lesser extent, with temperature

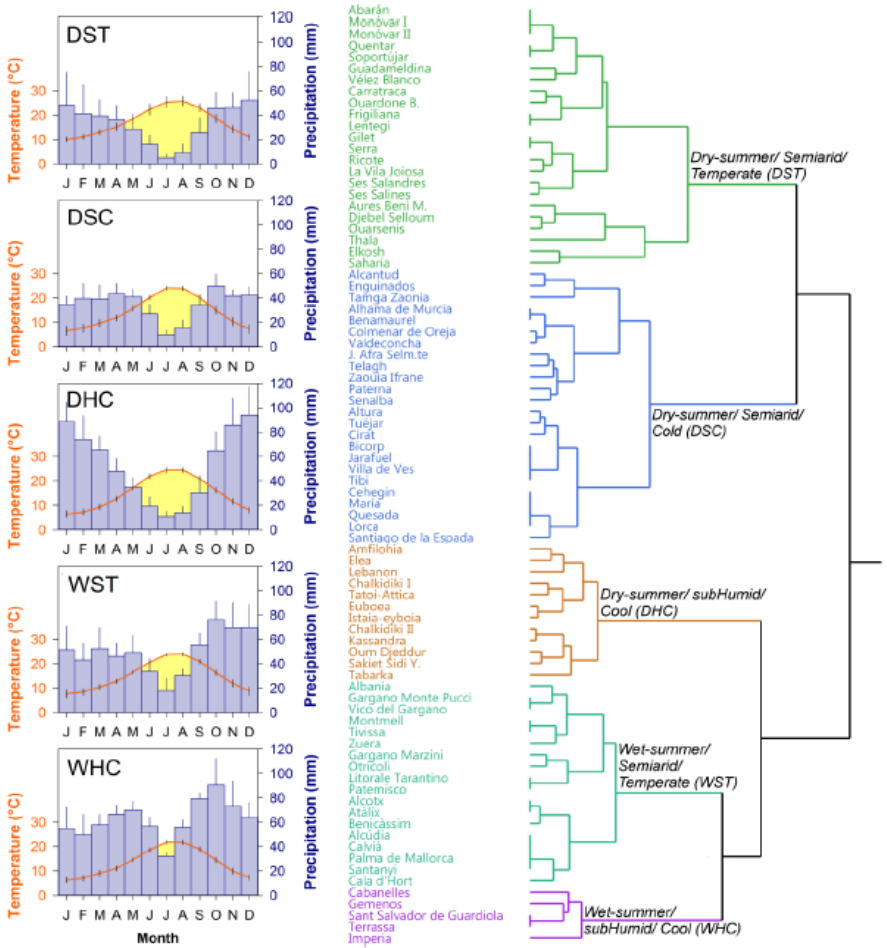
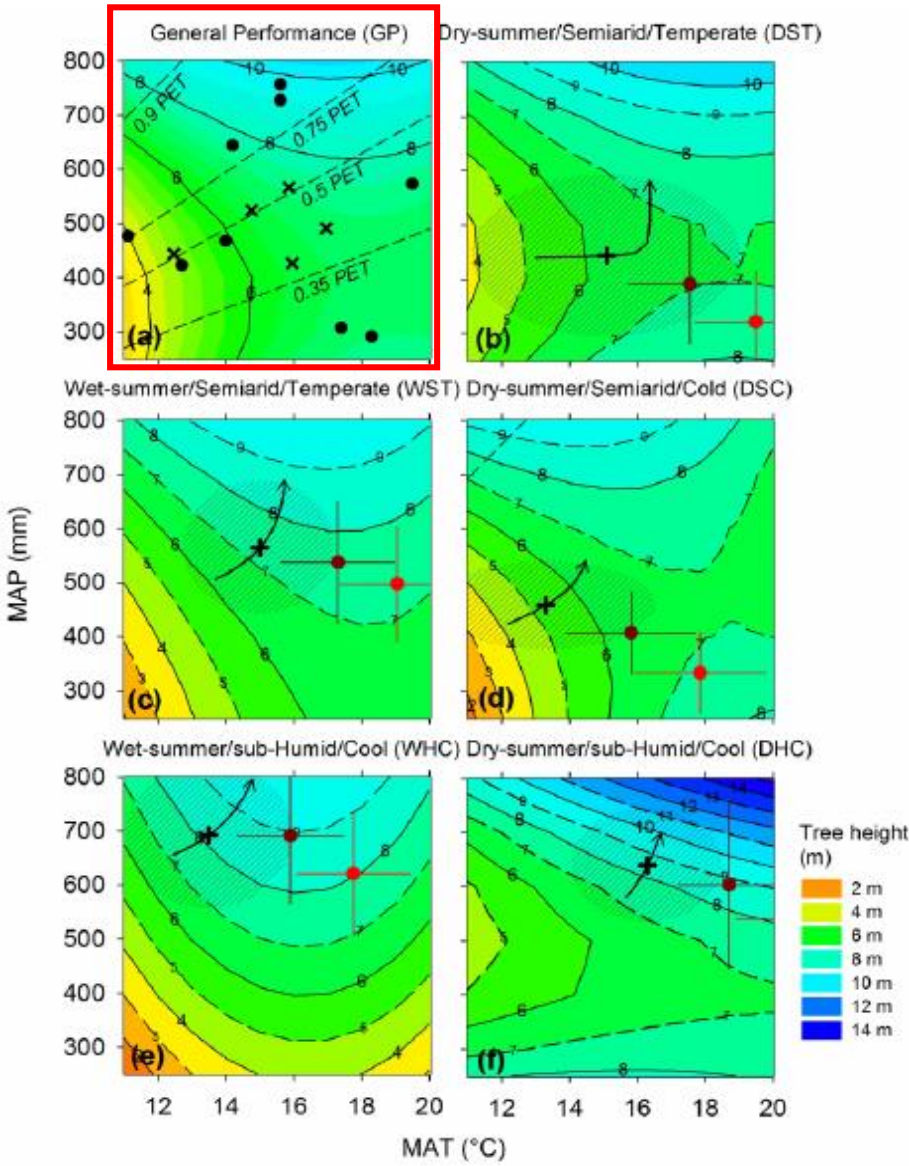


Fig. S5. Dendrogram of the 82 populations of *Pinus halepensis* used as training dataset for factorial regression modelling of tree height at age 15. Clustering was based on climate characteristics at origin. For more details see *SI Appendix 1*, Section 1C.

Eighty-two populations were divided into five major ecotypes (left).

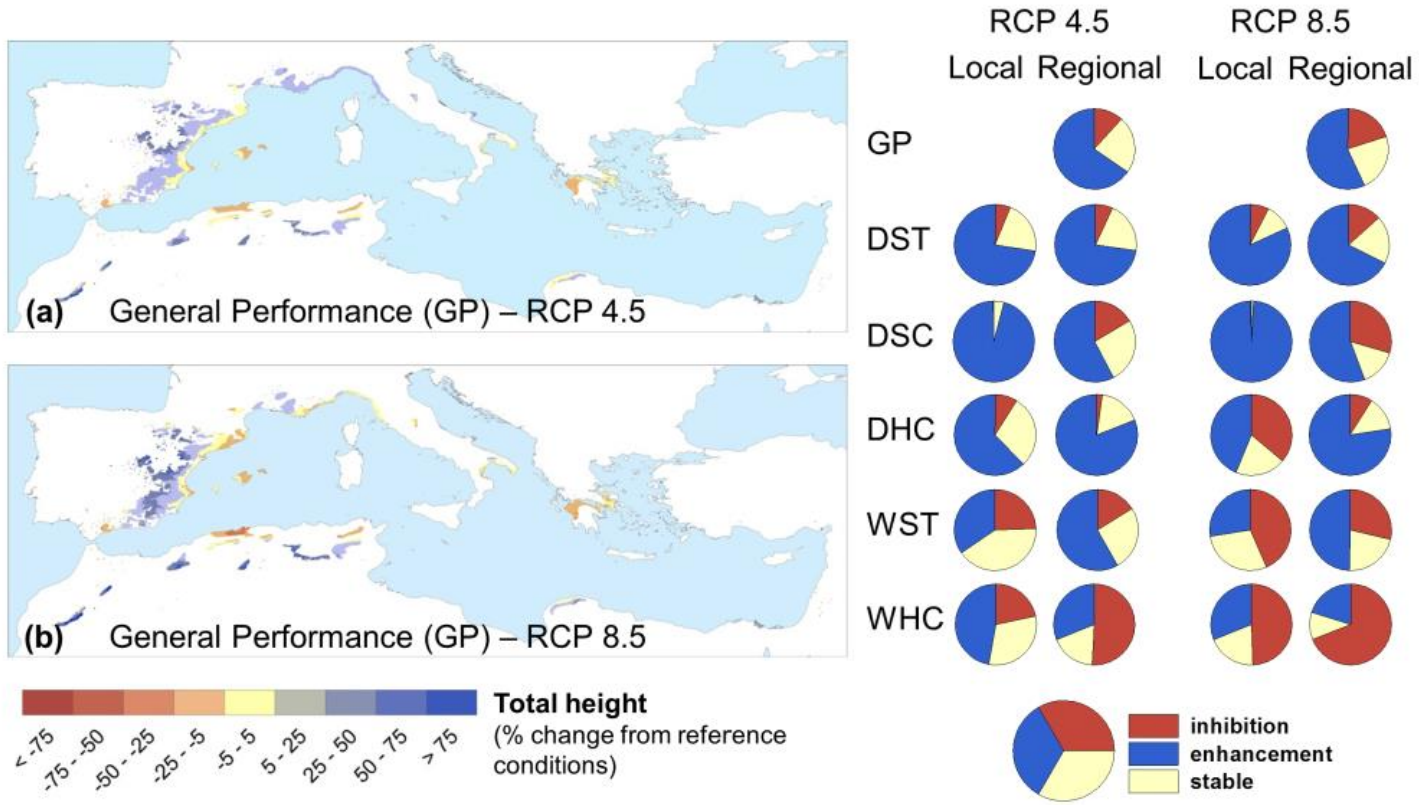
Height growth information from the provenance trials was used to produce temperature and precipitation growth sensitivity profiles (right; the general trend in a red box)

Patsiou et al. NPH under review



Climate growth sensitivity profiles were applied on future climate maps.

We predict a potential expansion northward, but substantial growth reduction in coastal areas of France, Greece, Spain, and northern Africa



What can we do?

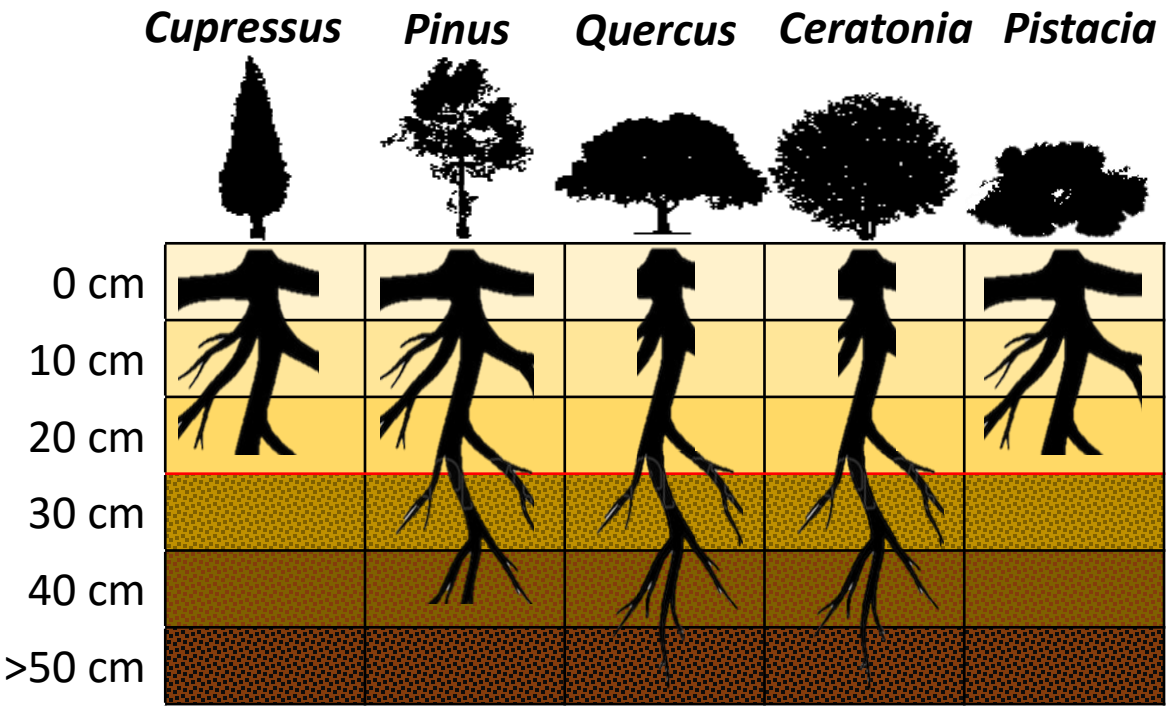
(1) Ecotypes matter! Selecting the right ecotype for future afforestation can make a difference between survival and mortality.

Areas in blue = future growth increase; Areas in yellow/red = future growth reduction.

Pie charts are for specific ecotypes under specific climate scenarios.

What can we do?

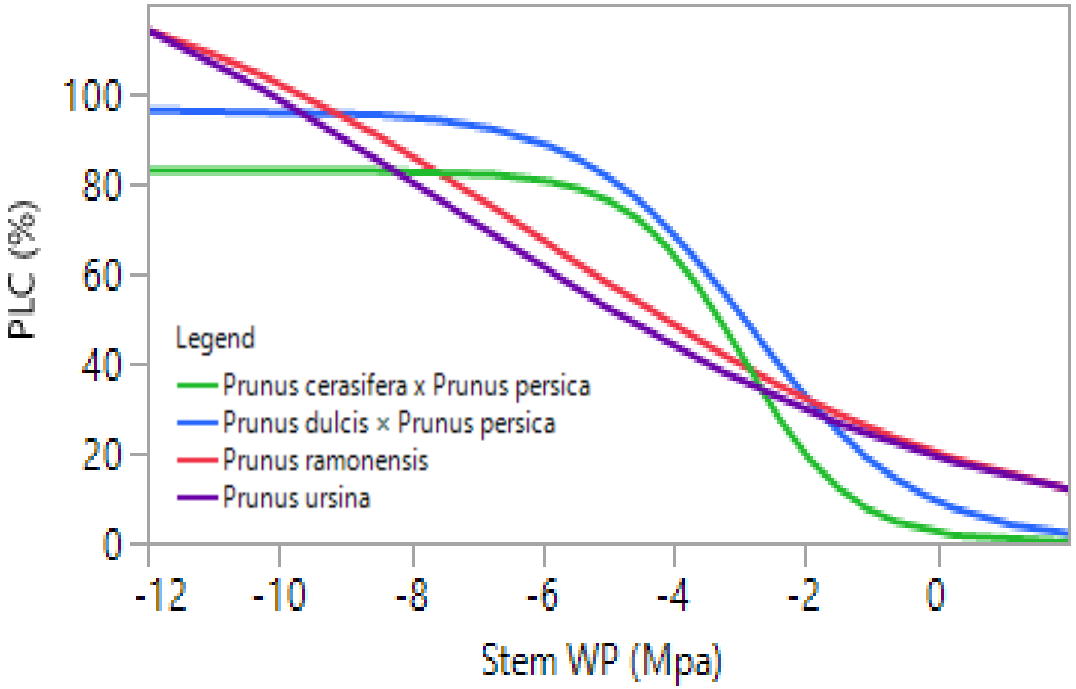
(2) Mixed forests, with native broadleaf and conifer species coexisting, have high resilience, thanks to interspecific niche partitioning

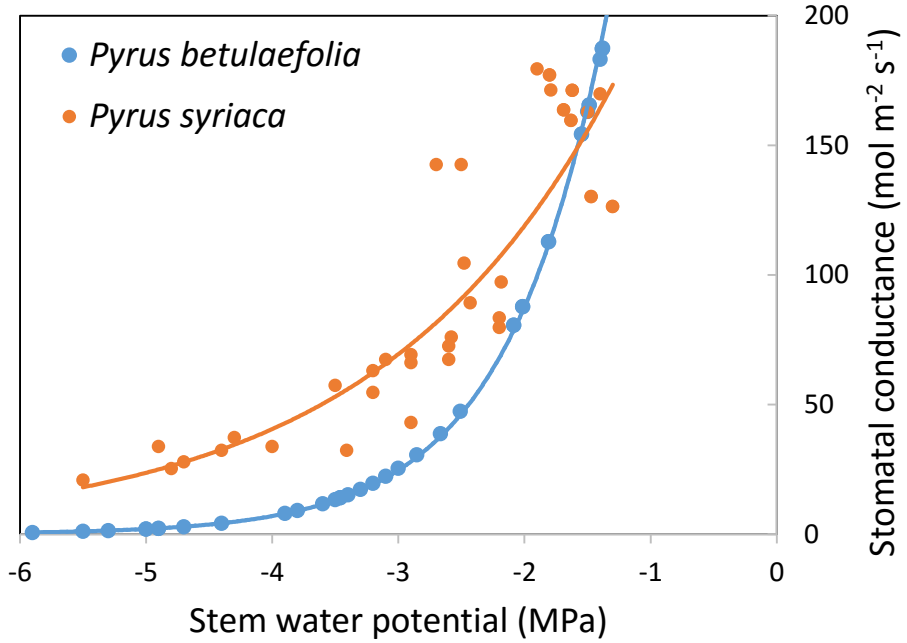


Interspecific differences in rooting depth and stomatal behavior contribute to decreased competition in an evergreen, mixed, Mediterranean forest. ***Rog et al. in prep.***

What can we do?

(3) Native fruit trees have higher drought resistance than their cultivated relatives, and should be protected and integrated into local agriculture

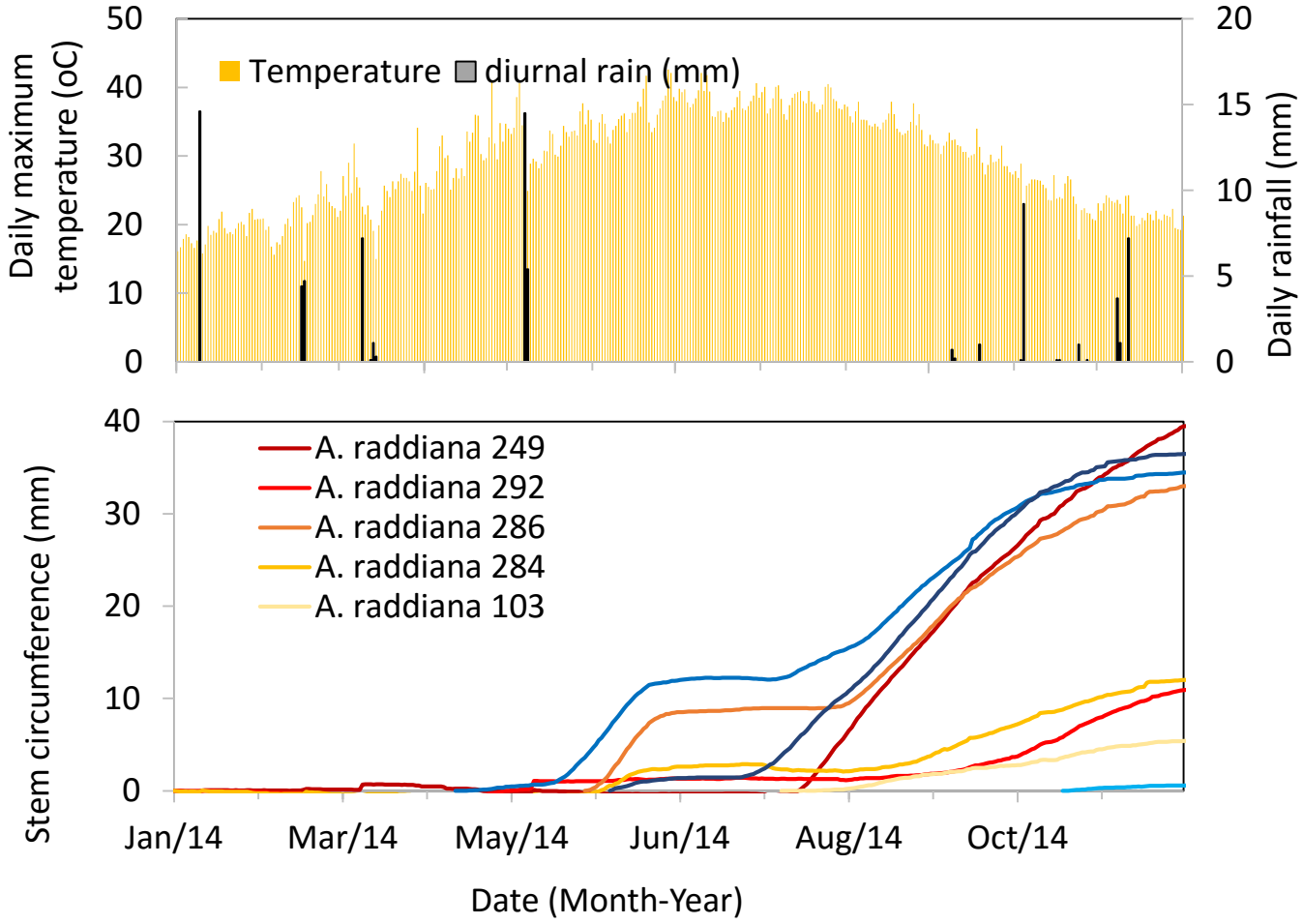




Endemic wild almond and plum species growing in Israel have lower xylem vulnerability to embolism than currently used rootstocks (left). Endemic wild pear has higher stomatal conductance at decreasing water potential than the rootstock. ***Paudel et al. 2019 EEB; Tree Phys***

What can we do?

(4) Native savannah trees from the southern fringes of the region are becoming more important, and offer new resilience strategies



Acacia species grow during the hot, dry summer days, in spite of the harsh desert conditions.

Winters et al. 2018 Oecologia

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Conclusions:

1. Large-scale tree mortality is already occurring and is drought-related
2. Mortality and reduced growth will exacerbate as warming and drying continue
3. There is a lot to do: selecting the right ecotypes; mixing contrasting species; and using native species with high drought resistance in orchards and afforestations

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