

# An experimental test of the range-limiting drivers of *Cedrus libani* suggests an unexpectedly wide altitudinal range and a likely high resilience to future climate warming



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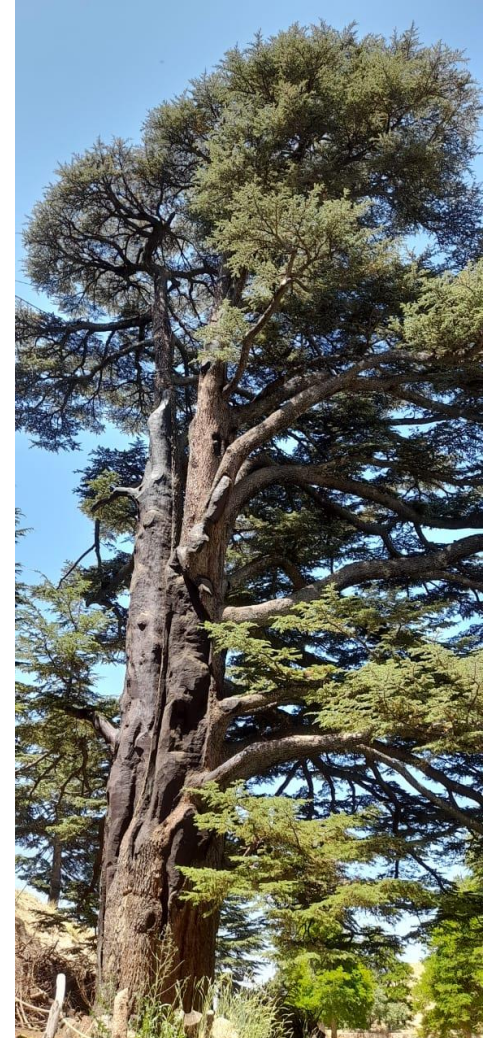
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# Background: species' niche limits and the expected impact of climate change

Distribution models used to predict species range shifts induced by climate warming are often based on climatic limits observed under natural conditions.

However, other factors influencing range boundaries introduce uncertainties regarding species' response to climate variables

For improving predictions of climate change impacts on species distribution, it is essential to gain a better understanding of the causes behind species range limits



# Aim

**To assess the climatic niche of a relict endangered tree species, the Cedar of Lebanon, with transplant experiments located inside and beyond its altitudinal range**

- Assess the species' altitudinal range limits in natural conditions, both at lower and higher elevations.
- Assess the size of the species' fundamental niche during the juvenile stage by an experimental approach extending beyond both the cold and warm margins of its natural range.
- Explore the influence of warm temperatures, water stress and competition in driving the species range edges.



# Methodological approach: Field plots and transplant experiments

1241 field plots  
carried out between  
100 et 2960 m



Cedars' Presence/absence  
over the altitudinal gradient



**Altitudinal range**

**and**

Set-up of 8  
transplants sites  
distributed  
between 110 et  
2320 m



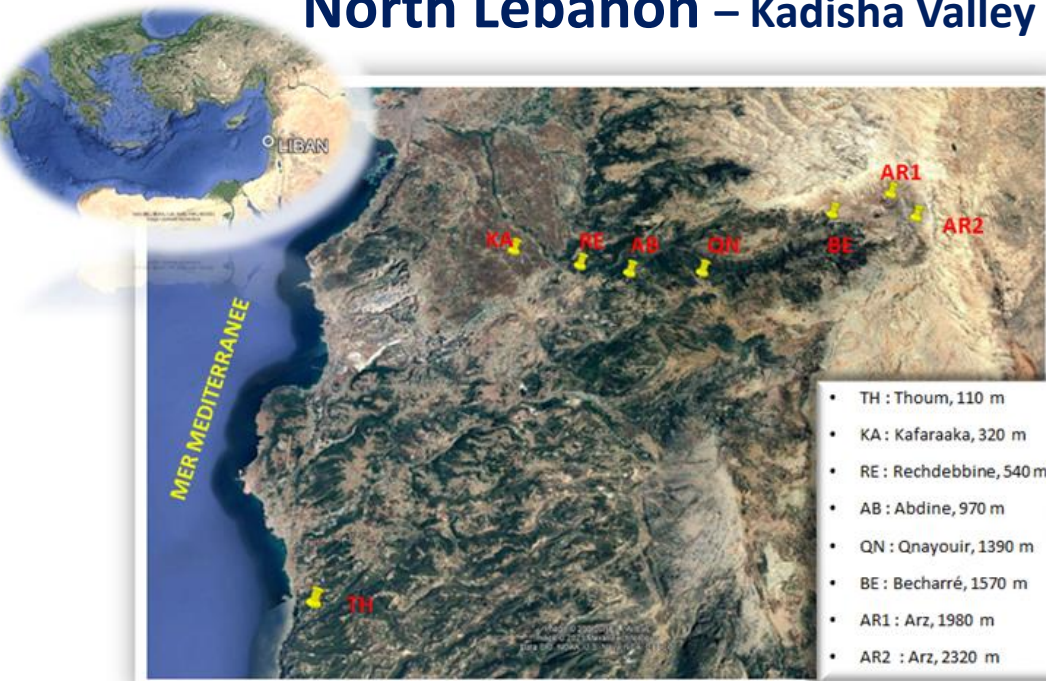
Cedar survival and growth  
within and outside its range



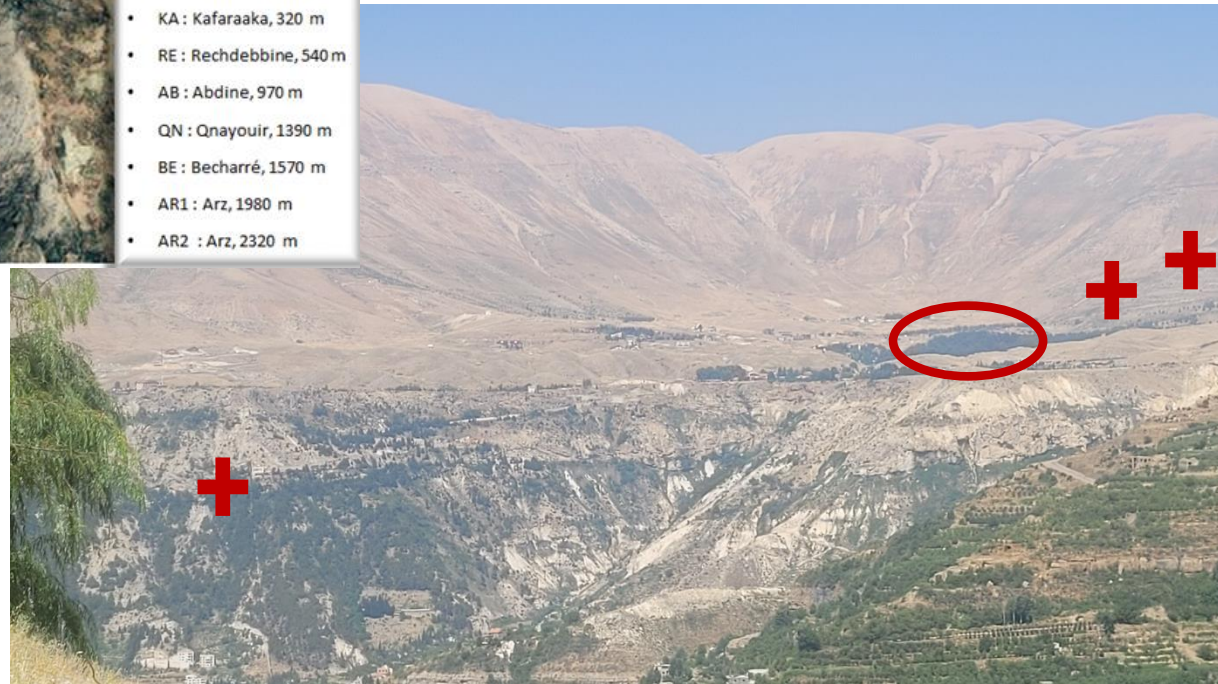
**Niche Breadth and  
limit drivers**

# Study area

## North Lebanon – Kadisha Valley



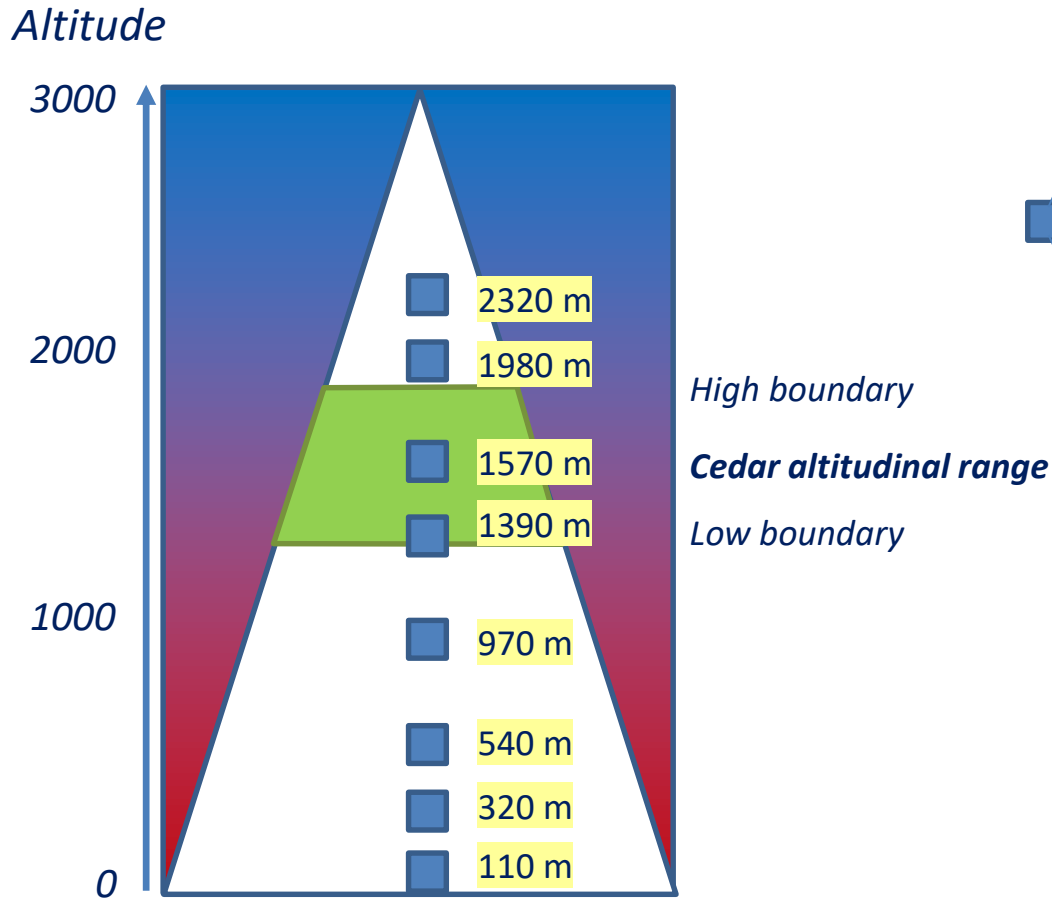
8 experimental sites systematically distributed across an altitudinal range 110 to 2320 m



- The Cedars of God, a relict forest located in the Kadisha Valley
- + Location of the 3 uppermost experimental sites

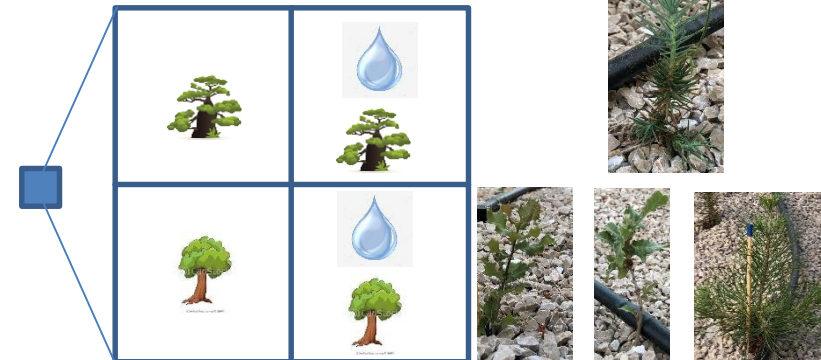
# Experiment tranplant set-up

## Experimental set-up 8 sites



## Experimental site

36 Ind./spec./modal.



Consistent seedlings allocation: equal number of seedlings from low, medium and high altitude planted at each site

# Optimal conditions for non climatic factors



Soils preparation:  
All soils selected have  
high fertility and water  
storage capacity

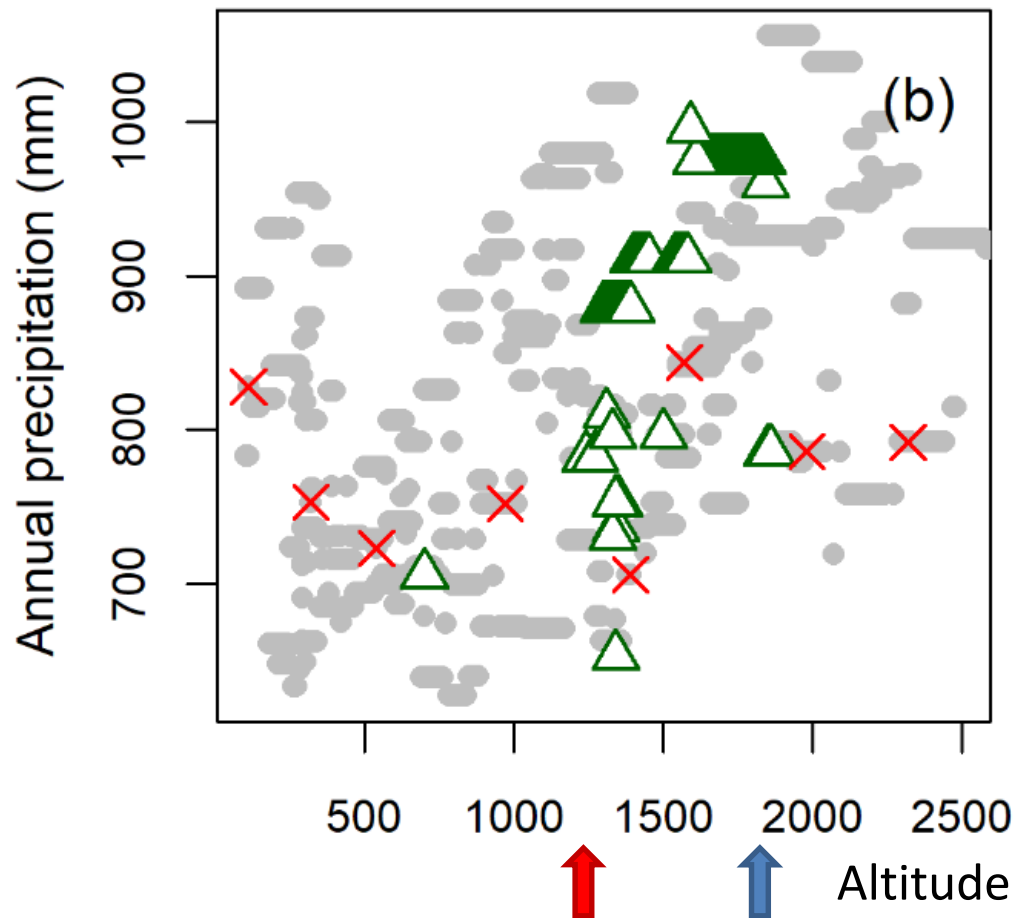
All experiments  
conducted in  
locations with full  
light exposure



Controlling of  
browsing and  
herbaceous  
competition



# Altitudinal distribution of the Cedar in the Lebanon forests



- Plot without Cedar
- △ Plot with Cedar
- × Experimental site

Cedar was observed in **74** plots over 1241 plots carried out.

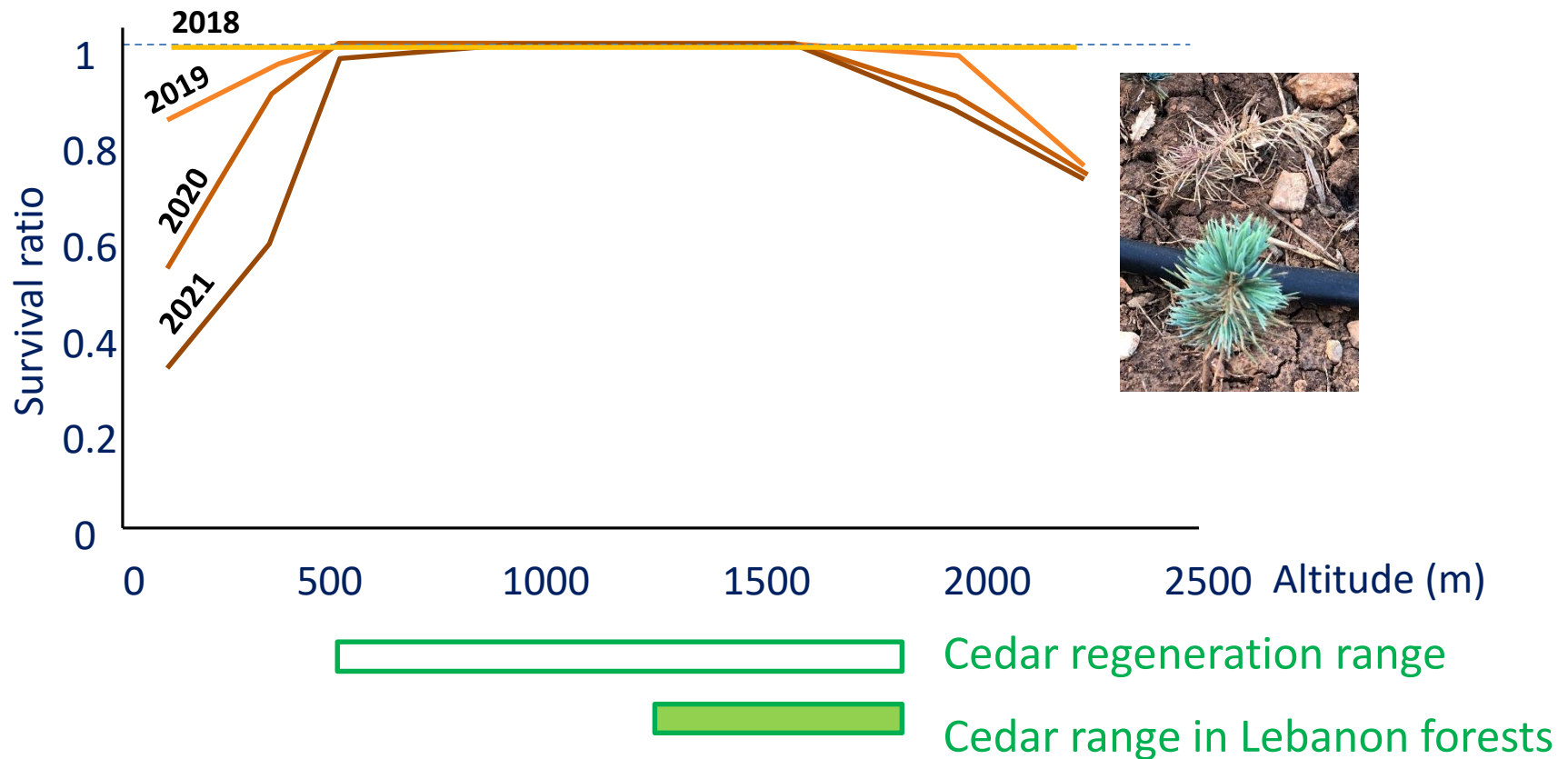
1310m – Low altitudinal range limit (5th centile)

1830m – High altitudinal range limit (95th centile)

Cedar has an altitudinal **range of 500 m under natural conditions**



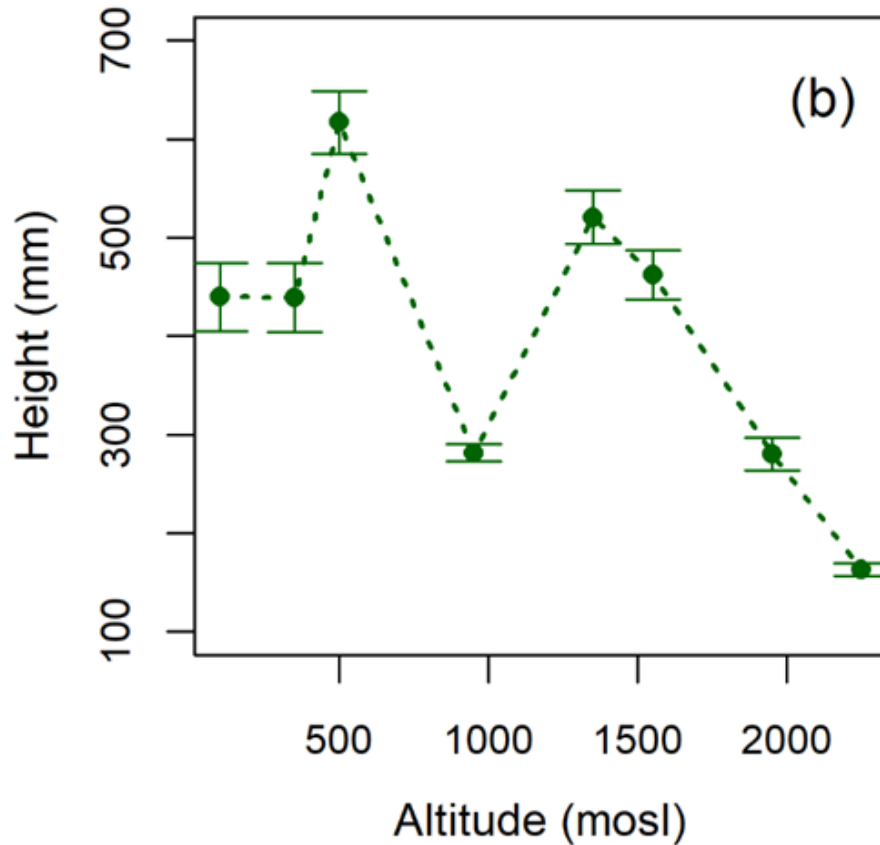
# Evolution of cedar survival over 3 years



- The species' survival decreases at both high and low altitudinal extremes
- The range of maximum survival rate extends from 500 to 1800 m
- The regeneration range is more than **twice** the range encountered in the field, primarily extending toward lower altitudes

**How to explain the discrepancy between the regeneration and adult ranges ?**

# Cedar growth over the altitudinal gradient



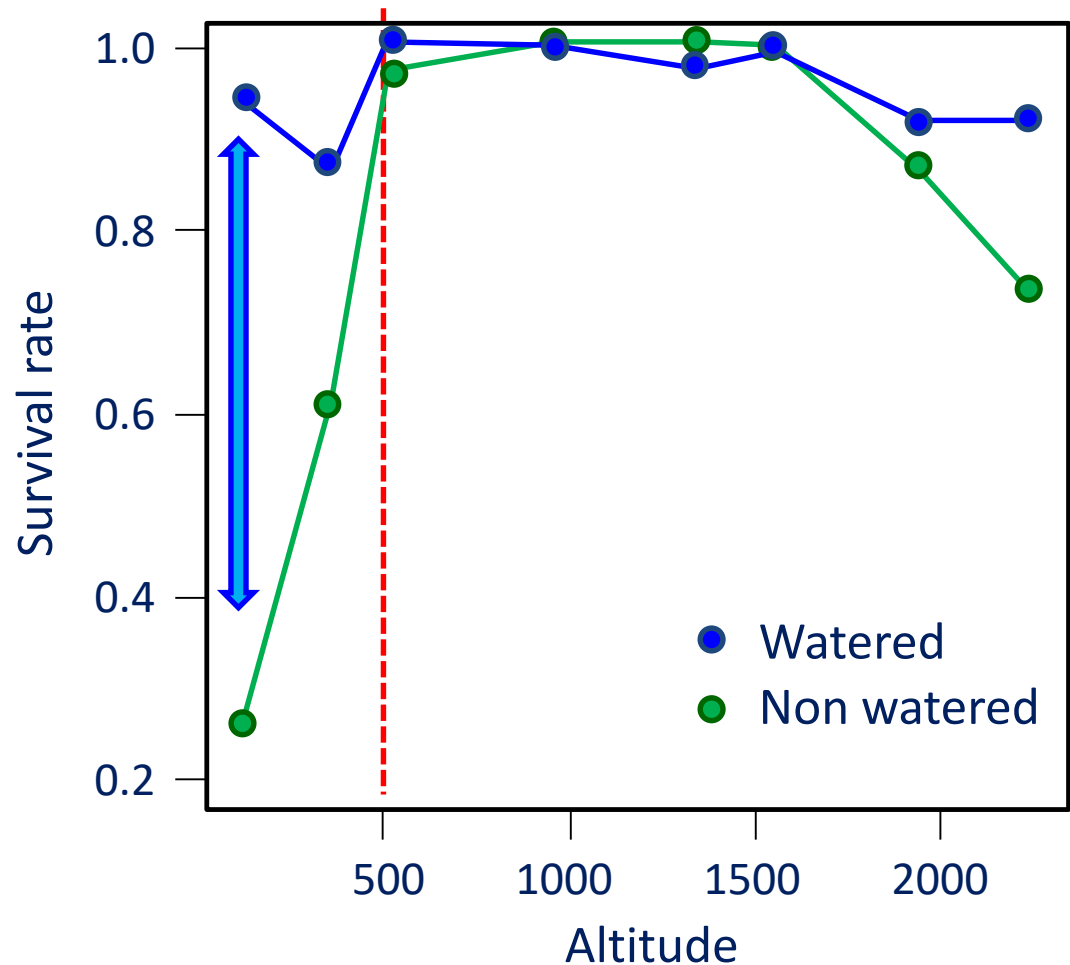
The cedar growth is high from 500 to 1800m.

The significant growth at low altitude confirms the presence of a large regeneration niche, as observed through survival analysis

# Drivers of the Cedar's low elevation limit - I

Water availability strongly influences cedar survival below 500 meters

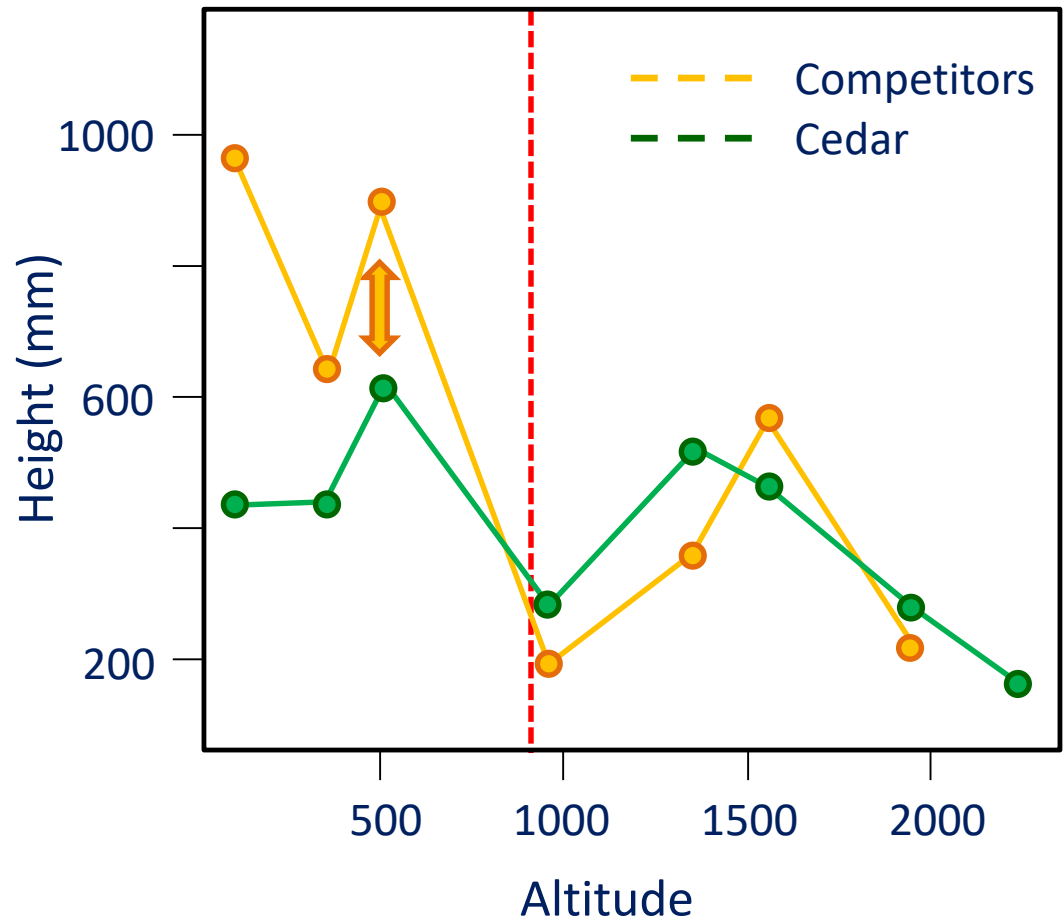
Drought is the driver of Cedar's **fundamental niche** at very low altitude



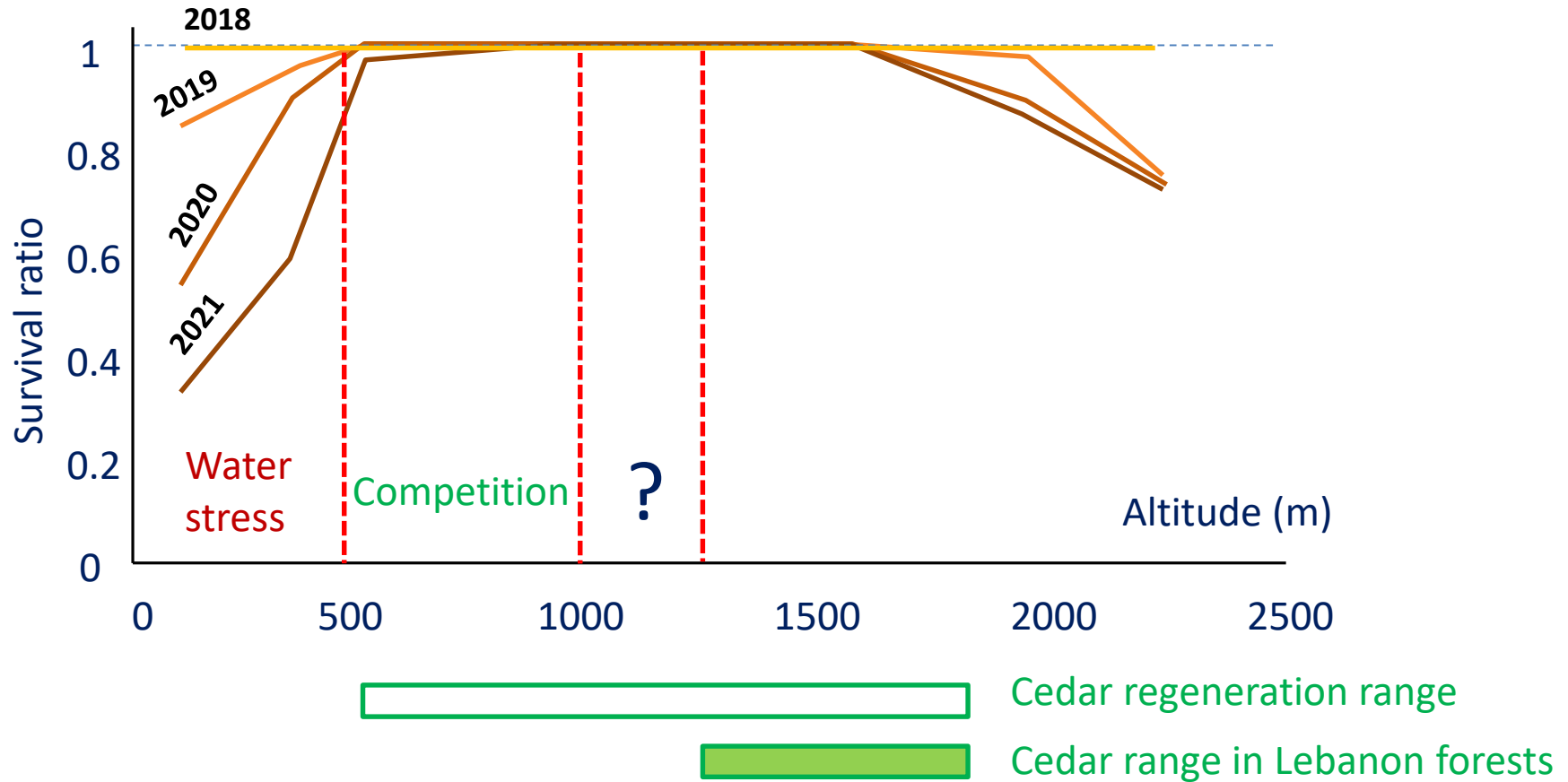
## Drivers of the Cedar's low elevation limit - II

Competing species are taller than Cedar below 1000m altitude

Competition is likely the driver of Cedar's **realized niche** below 1000 m altitude



# Drivers of the Cedar's low elevation limit - III



How to explain the absence of Cedar between 1000 and 1300 m?

# Anthropogenic exploitation

- Palynological studies showed that Cedar thrived in the Bekaa valley at an altitude of 900 meters approximately 2000 years ago
- Many antiques attest evidence of an extensive use of the Cedar wood over several millennia by the great civilizations of Assyria, Egypt and Babylon
- Low altitude Cedar stands were more accessible than high altitude ones for boat transportation

**The absence of cedar below 1300 meters is likely a result of historical anthropogenic exploitation**



Transporting Lebanese cedar by boat.  
Bas relief, palace of Sargon II (king of Assyria)  
-713-716 (Louvre, Paris, photo : Louvre)



Photo: P. Pinto

Sarcophagus of Ramses 2 (-1304—1213) in Cedar wood

# Conclusions

## Niche size

- Field observations indicate that the Cedar's fundamental niche is over twice the size of the estimated niche based on field data.
- This difference is primarily observed below the species' warm limit.
- The warm edge of the Cedar range is influenced by a combination of factors acting at incremental altitude levels: drought, competition, and historical anthropogenic exploitation

## Implications

- The study demonstrates the potential for expanding the distribution of Cedar towards lower altitudes than its low range limit
- These findings raise doubts about extinction models for relict mountain species facing climate change when they are based solely on their realized niche

Questions ?

