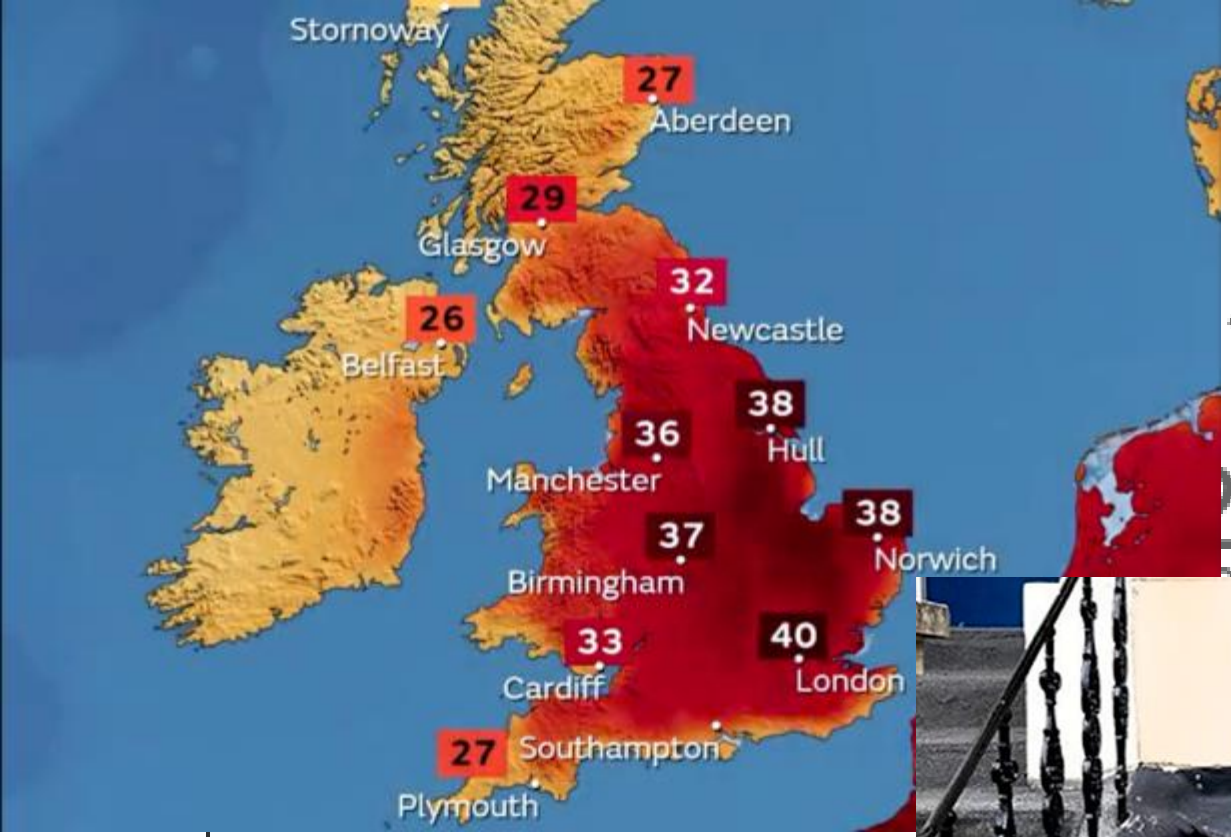
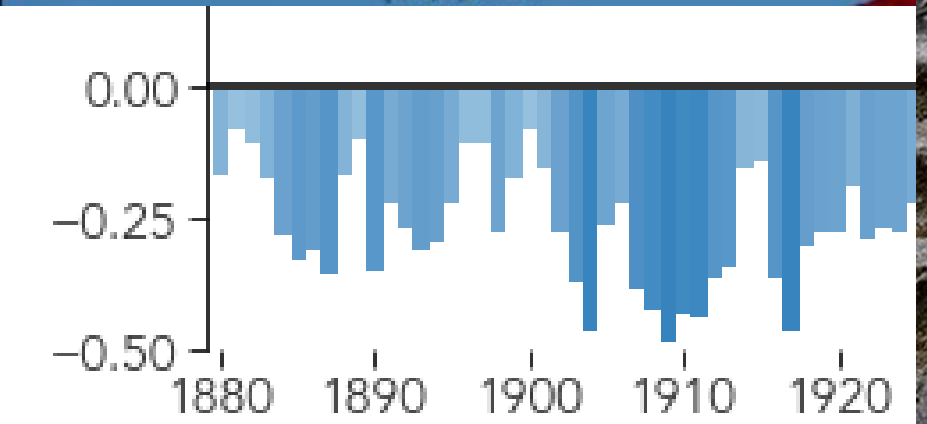
What do warmer temperatures mean for trees?

Dr Jon Banks and Christopher Percival



1951-1980 average)

2022

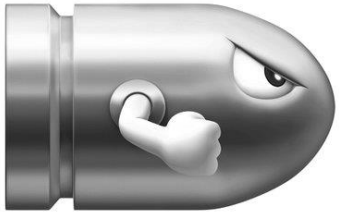



Moisture Meter
Mineral
TOO DRY
on - read
off - menu
DELTA-T DEVICES

Heat + Drought.

- Combinations have a greater effect than each individually.
- Transpirational heat loss and water content are reduced during drought, so leaves are in-turn greater affected by heat stress.

What can we do about that?



It is becoming increasingly important to consider heat and drought tolerance when selecting trees.

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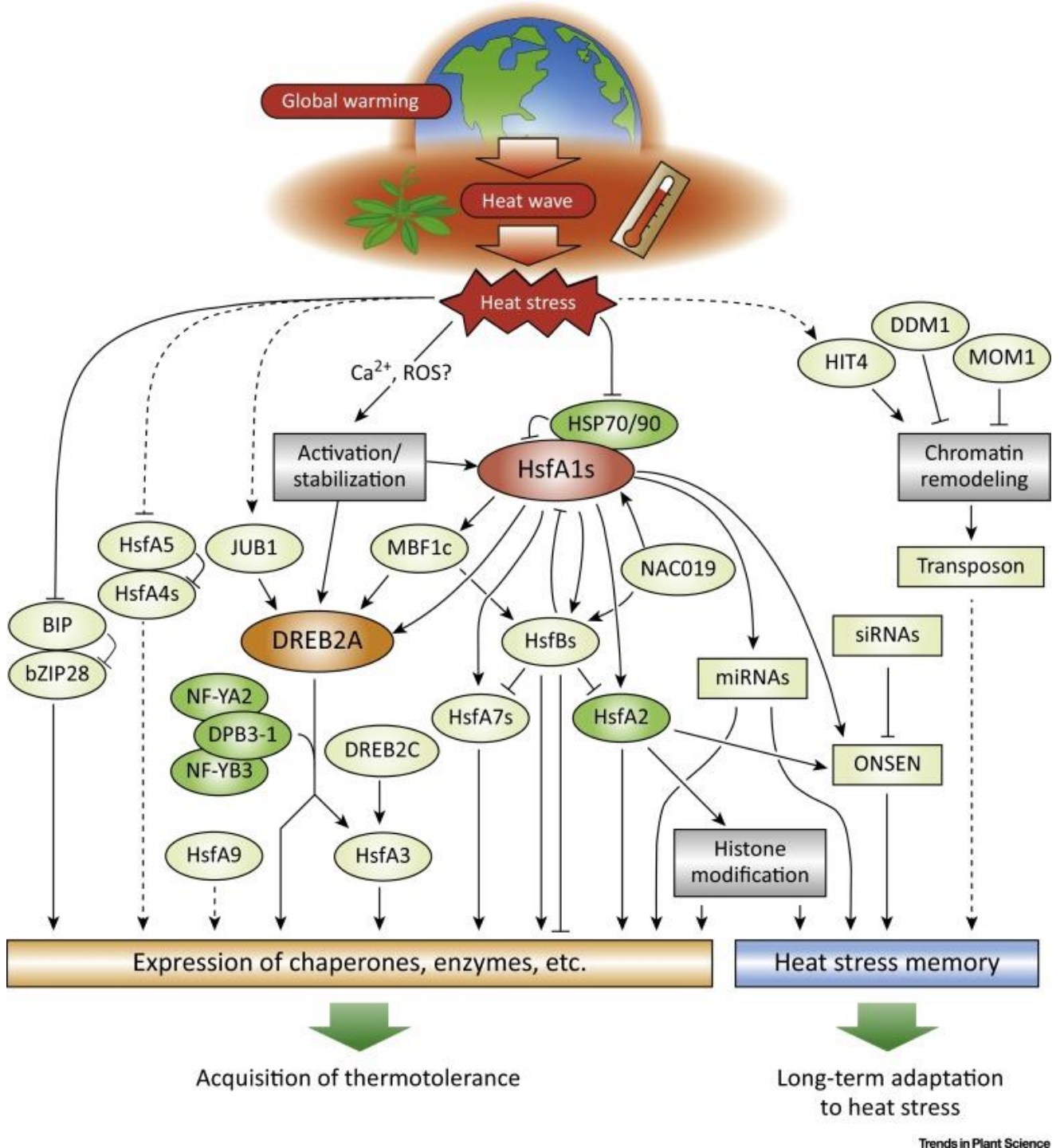
- (Exogenous application: sugars, ABA, phosphates, fertilisers)

Heat + Drought.

- Physiologically they can affect plants differently but do overlap.
- ..Why should you care?



Heat + Drought.

- Drought tolerance is now easier to measure and select for.

- But heat tolerance is still Very difficult!

Abies grandis (Grand fir)

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Tree Selector: Use potential | Mature size | Crown form | Crown density | Environmental tolerance | Ornamental qualities

Use potential
Park

Tree size and crown characteristics
A massive tree capable of exceeding 80m in favourable environments. >25M
Conical to columnar form.
A dense crown.

Natural habitat
A late-successional tree found in the mixed conifer forests of the Pacific Northwest. It is a key species in the temperate rainforest, but can be found from British Columbia down to the Coast, Cascade and Sierra Nevada mountains of northern California. Its preferred climate is humid and cool to cold with average annual temperatures of 6-10°C. Typically found on slopes between 1400-2135m in its southern range but will grow from near sea level to over 1000m farther north. Prefers mildly acid, moist, free draining soils.

Environmental tolerance
Tolerant to shade.
Moderately sensitive to drought.
Moderately sensitive to waterlogging.

Ornamental qualities
Flowers in early summer, fairly inconspicuous. EARLY SUMMER
Large (5-10cm) upright cones mature in early autumn. EARLY AUTUMN
Evergreen conifer with needle leaves.
Single-stemmed

Issues to be aware of
Capable of becoming an extremely large tree so requires plenty of space. In oceanic climates, *Abies grandis* can self seed and is potentially invasive.

Notable varieties
Some 'dwarf' varieties are available for use in *small garden* situations.

Notes
- Young trees are sensitive to weed competition (including turf), require humidity and ample soil moisture.
- When well established it can grow very quickly (around 1m per year).

The tree and its features

Left: Shade tolerance allows *Abies grandis* to develop well amongst other trees. © Duncan Slater
Right: A semi-mature *Abies grandis* in an open park. © Duncan Slater

Light green young growth contrasts starkly with the darker needles from previous years. © Henrik Sjöman

Reminder:

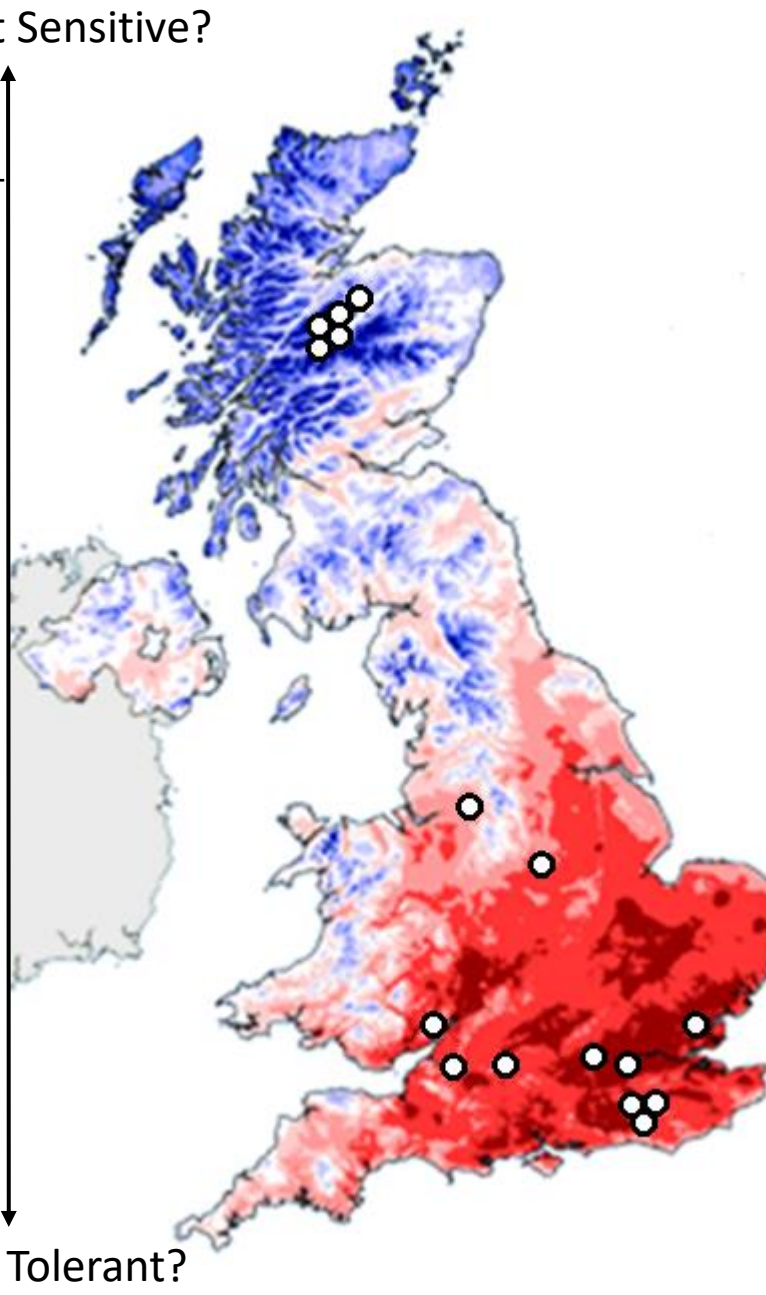
- Both may cause greater susceptibility to other pests and diseases. (mites, canker, wood borers, aphids etc.)

Selection by location and a rapid screening technique for heat tolerance.

Initial look into tree selection by location.

- Acorns collected from 16 different locations across the UK.
- 10 plants of each block randomised.

Location	Latitude
Grantown on Spey	57.33
Loch Pityoulish	57.20
Loch Pityoulish (S)	57.20
Aviemore	57.19
Inverdruie	57.17
Manchester	53.48
Derby	52.92
Maldon	51.72
Chepstow	51.63
Henley	51.54
Twickenham	51.44
Savernake	51.40
Bath	51.36
West Hoathly	51.08
West Hoathly (S)	51.08
Lindfield	51.02

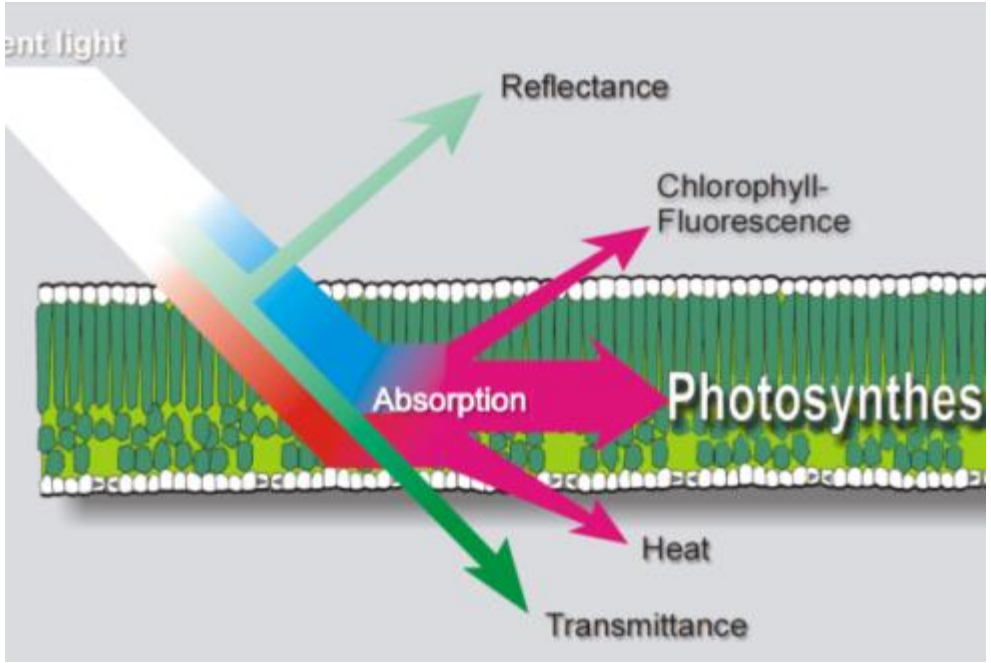


Critical Temperature

- Leaves have a critical temperature T_{crit} after which point photosystem II efficiency begins to decrease.
- This indicates the temperature at which the photosynthetic electric transport and carbon metabolism systems begin to break down.
- Usually between 40 and 45 degrees C
- Varies largely due to many different factors.
  - Species/Cultivar.
  - External product applications.
  - Heat acclimatization.
  - Other stresses.

Chlorophyll Fluorescence as a measurement for heat stress.

- Method used to measure photosynthetic efficiency.
- Photosynthetic systems are the first to be affected by heat stress.
- Meaning chlorophyll fluorescence is an ideal method to acquire an initial view of how heat stress is affecting a plant.

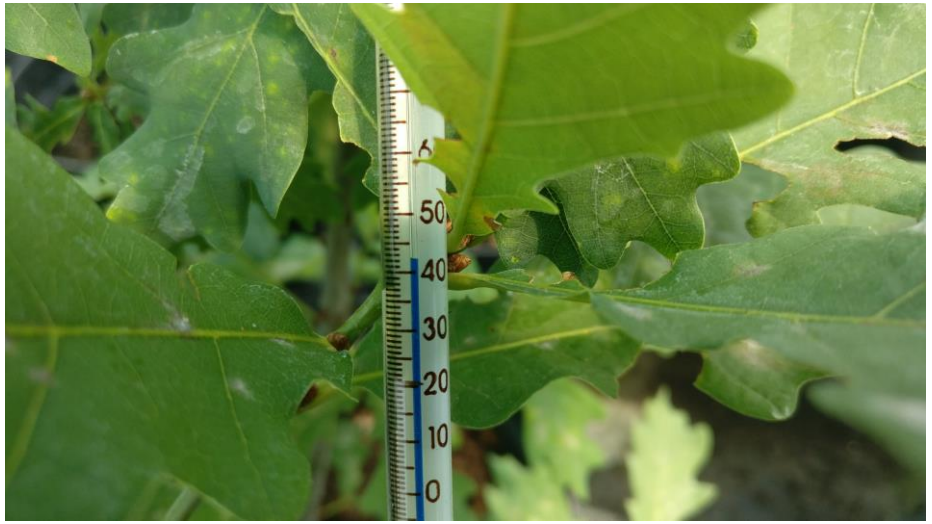


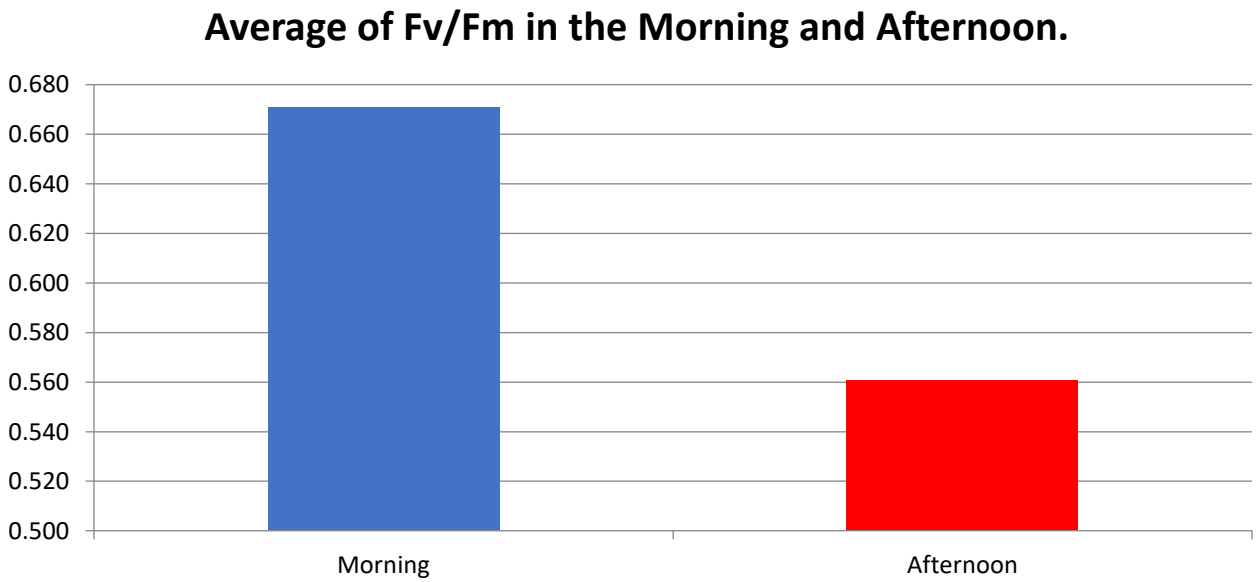
UK Heatwave 2022

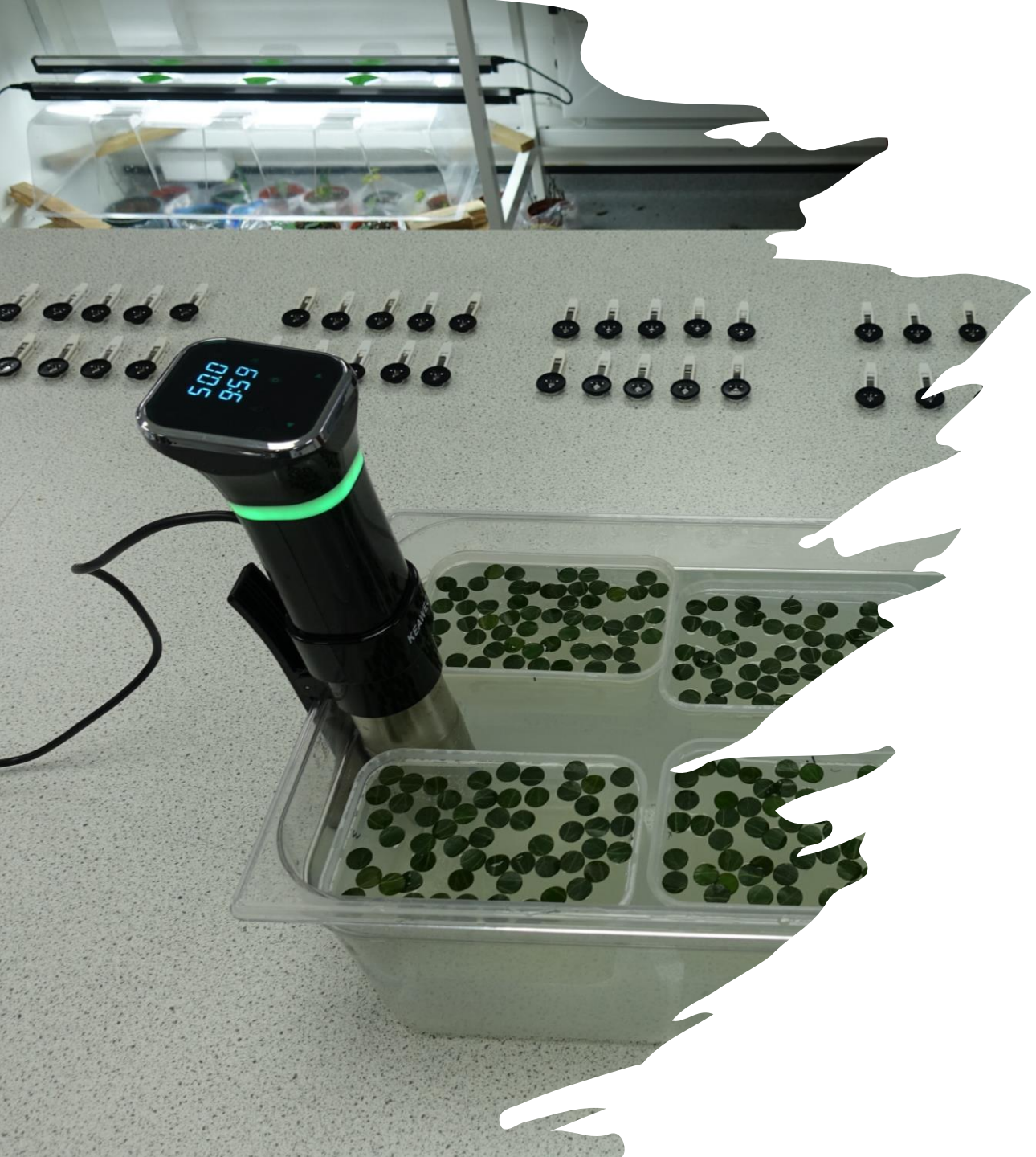
- Average UK July daily temperature ~20°c
- 19th July (Hottest day of the year and hottest on record UK)
  - Reached temperatures of up to 40.3°c
- Damage due to heat stress occurs generally between 40-45°c.
- Damage more likely to occur at lower temperatures if the plant is also under drought stress.

Subjected to Heat (In-Situ).

- Subjected to torturous heat.
- Measured in the morning then again in the afternoon.
- Temperature around plants reached 44°c.







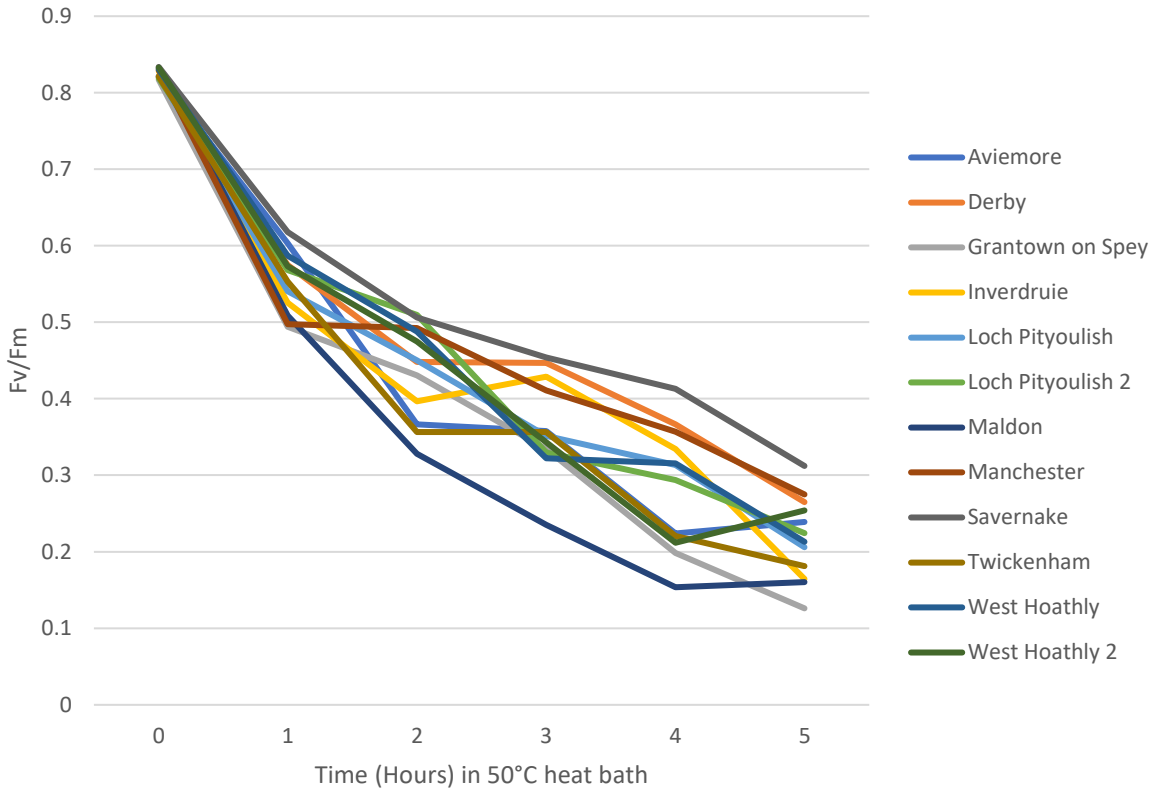
Subjected to more heat (Lab environment).

- Some provinces had to be dropped from this due to mortality/ limited number.
- Placed on a 50°c water bath to induce heat stress but not drought stress.
- Less inclusive than measuring on the plant.
- Easily replicable conditions for accurate comparisons and non-destructive to the plant.

Initial Results – Lab environment

- Two groups significantly different in heat tolerance but no significant relationship to latitude/longitude.

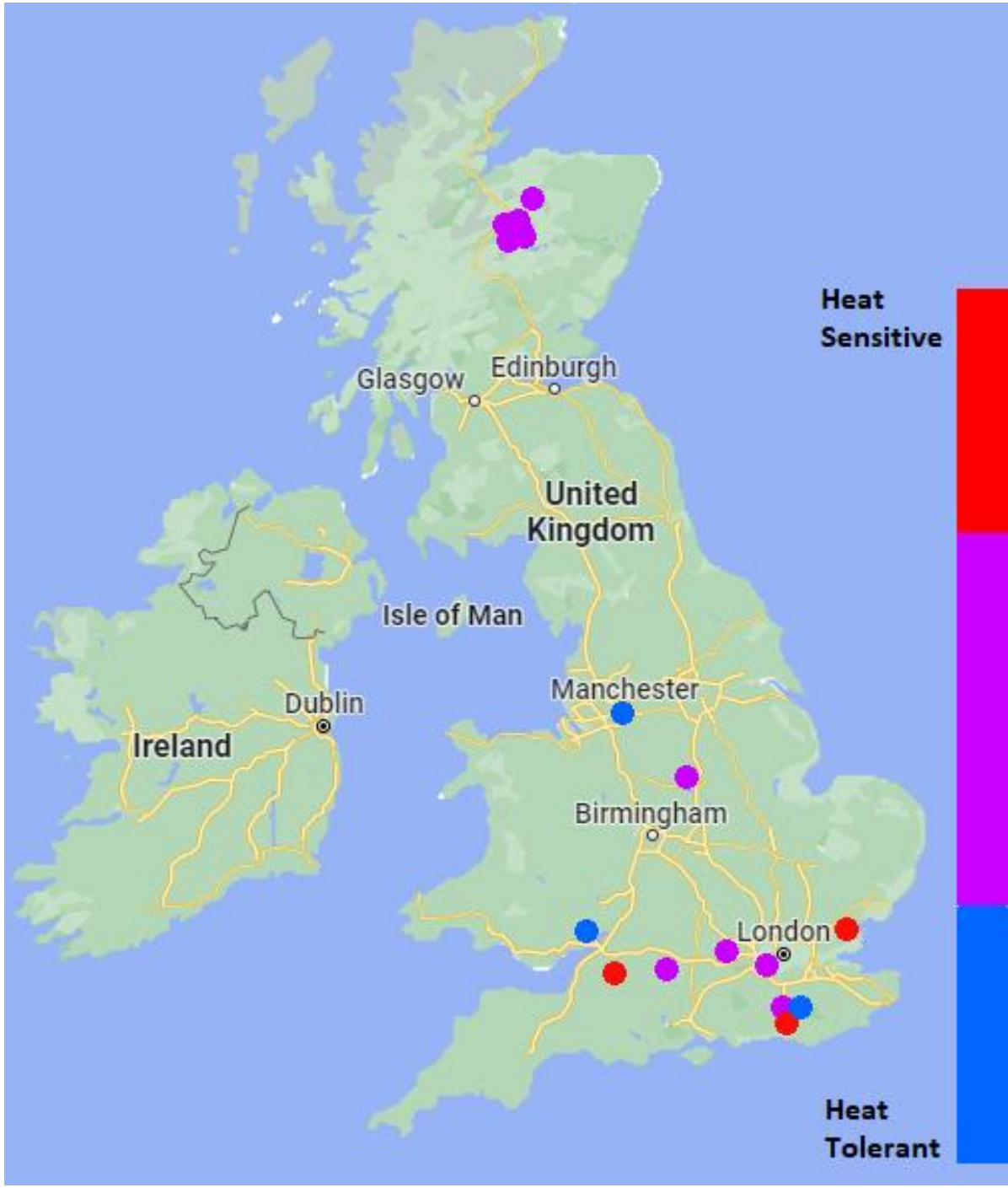
Province	Significantly different groups (Fv/Fm)		Percentage Change
	0 Hours	4 Hours	
Savernake	a	a	-50.48%
Derby	a	ab	-55.39%
Manchester	a	ab	-57.01%
Inverdruie	a	ab	-59.65%
Loch Pityoulish	a	ab	-61.85%
West Hoathly	a	ab	-62.01%
Loch Pityoulish 2	a	ab	-64.16%
Aviemore	a	ab	-72.74%
Twickenham	a	ab	-73.16%
West Hoathly 2	a	ab	-74.59%
Grantown on Spey	a	b	-75.72%
Maldon	a	b	-81.55%



Initial Results – In-Situ

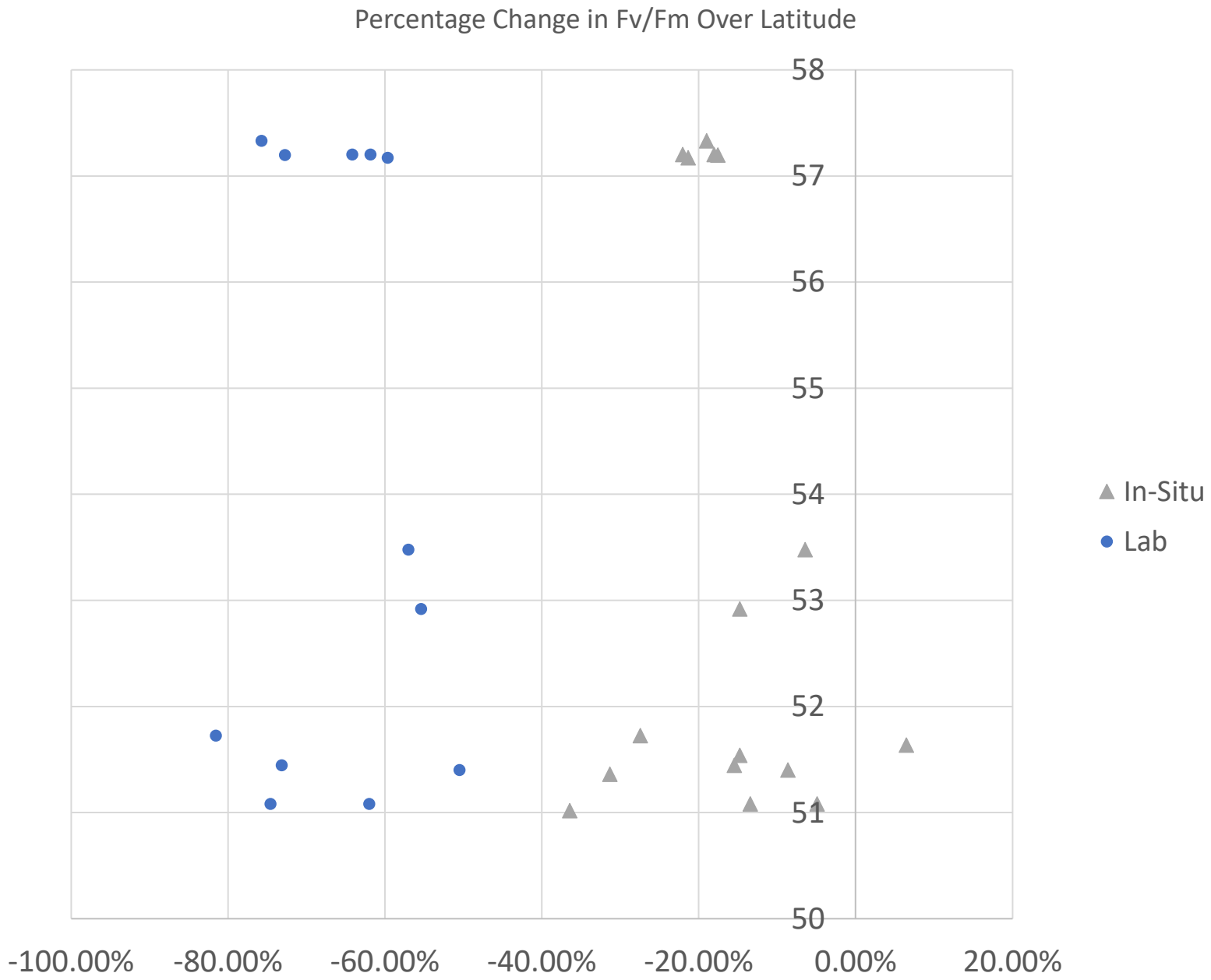
- Again, significant differences by location but not a significant relationship to latitude from hotter to colder areas of the UK.

Province	Significantly different groups (Fv/Fm)		Percentage Change
	Morning	Afternoon	
Chepstow	a	a	6.48%
West Hoathly	a	a	-4.90%
Manchester	a	a	-6.43%
Savernake	a	ab	-8.63%
West Hoathly 2	a	ab	-13.42%
Henley	a	ab	-14.75%
Derby	a	ab	-14.76%
Twickenham	a	ab	-15.48%
Aviemore	a	ab	-17.56%
Loch Pityoulish 2	a	ab	-18.04%
Grantown on Spey	a	ab	-18.98%
Inverdruie	a	ab	-21.33%
Loch Pityoulish	a	ab	-22.06%
Maldon	a	b	-27.44%
Bath	a	ab	-31.33%
Lindfield	a	b	-36.46%



Rapid screening vs In-Situ.

- Results from the heat bath method correlate with results from In-Situ
- We can use this method as a non-destructive rapid screening technique.



Conclusion

- Selecting the right trees for the future is important.

- Preliminary results show:
  - Some locations produce significantly more heat tolerant trees than others.
  - Tolerance does not seem to be linear based on latitude/longitude or warmer vs colder locations. (At-least not at a difference of the length of the UK)
  - A larger study is needed.
  - Laboratory method can be used as a non-destructive rapid screening process for heat tolerance.

Future Work

- We are looking for people to send us acorns.
- Please send us acorns. (Especially if you live in Scotland.)
- *Quercus Robur* please.
- Thanks!

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Summer student ??