**Title:** Thermal sensitivity across forest vertical profiles: patterns, mechanisms, and ecological implications

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# Appendix S1. Methods for NEON vertical profiles

S1 Note:

It is noteworthy that leaf and branch temperatures often differ substantially. For instance, exposed tropical tree bark can be much warmer than leaves (Pau *et al.*, 2018; Johnston *et al.*, 2020; Still *et al.*, 2021). Thus, vegetation temperature () measured using sensors that integrate across both leaves and woody vegetation (e.g., infrared sensors for at NEON sites, Fig. 2h) does not always equal , particularly in settings where leaf area is low relative to woody vegetation (*i.e.*, low-LAI ecosystems and understories). Recent advances in modeling (see “Scaling across Space and Time”) will enhance our understanding of large scale vertical patterns (Still *et al.*, 2021; Maclean & Klinges, 2021)

METHODS ON NEON ANALYSIS GO HERE.

see [Issue 2](https://github.com/EcoClimLab/vertical-thermal-review/issues/2) , [issue 20](https://github.com/EcoClimLab/vertical-thermal-review/issues/20)

# Appendix S2. Methods for leaf energy balance modeling

Energy balance for a typical overstory sun leaf and understory shade leaf were modeled in the R package *Tleaves* (Muir, 2019), parameterized for *Quercus rubra* L. leaves at Harvard Forest, MA, USA (\*\*GEOGRAPHIC COORDINATES). Parameters are presented in Table S1.

*Describe where you came up with all the parameters:*

* micromet from NEON (explain exactly what you used)
* leaf characteristic dimension, was measured on *Quercus rubra* sun and shade leaf,
* stomatal conductance measurements were referred from Tleaves typical sun and shade measurements (Muir, 2019)

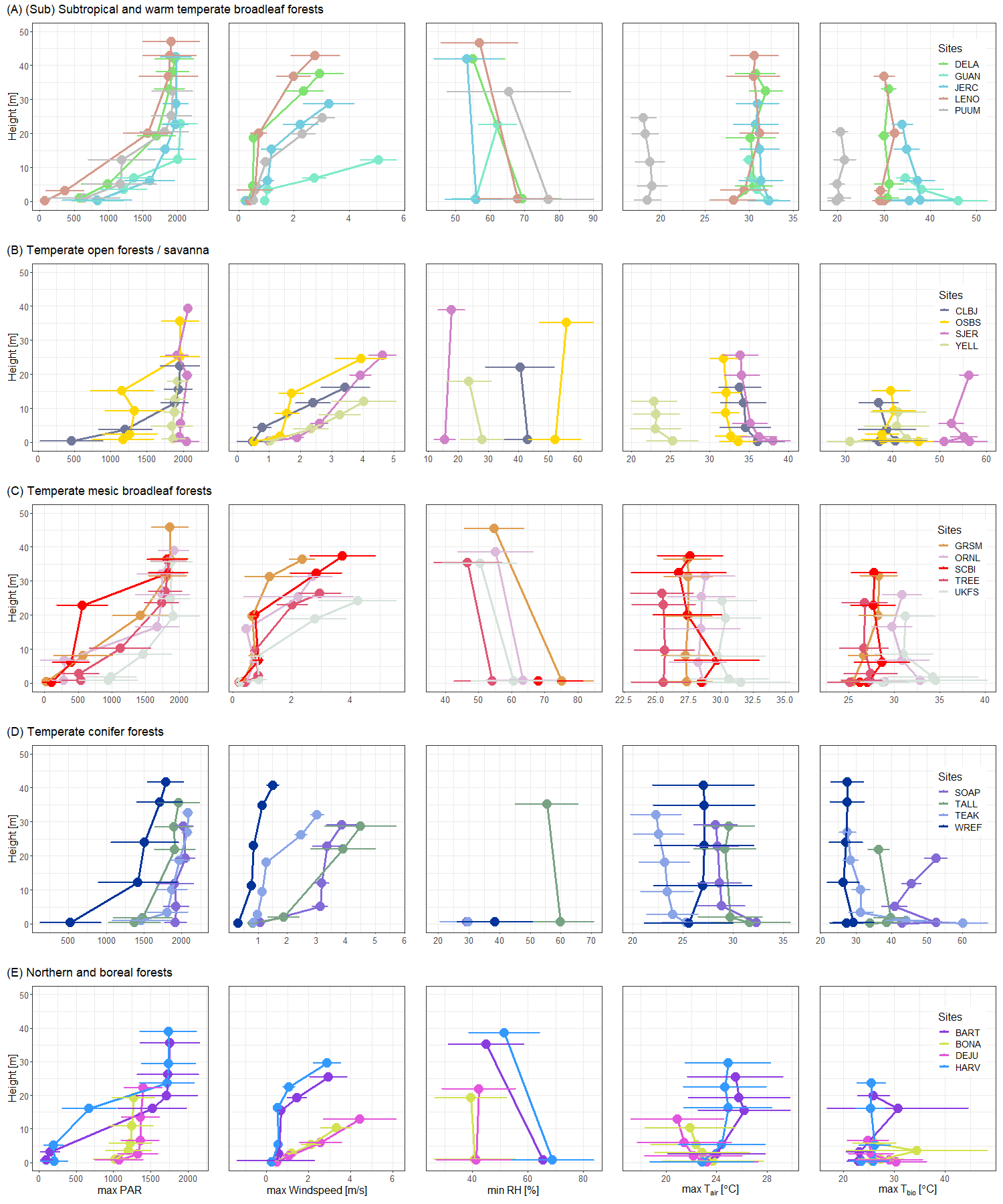
For drought scenario, biophysical variables were parameterized similar to normal scenario using Harvard NEON data. Overstory drought PAR values reflect maximum observed Harvard NEON PAR and understory drought reflect 50% increased PAR of understory normal value. Leaf trait measurements for leaf width is the same as normal scenario, stomatal conductance is kept constant at a minimum value of 0.01 umol/m^2/s/Pa for both positions. In each visual, all variables are constant (Biophysical Constants table) except for the independent variable that represents minimum - maximum range.

# Table S1. Tealeaves parameters

Make a table from this: <https://github.com/EcoClimLab/vertical-thermal-review/blob/master/NEON_height_profiles/HARV_neon_stats.csv>

| verticalPosition | month\_num | max\_mean | min\_mean | max\_sd | min\_sd | norm\_height | month\_char | var |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 10 | 7 | 0.24 | 0.06 | 0.05 | 0.02 | 0.43 | July | windSpeedMean |
| 20 | 7 | 0.58 | 0.16 | 0.09 | 0.04 | 0.87 | July | windSpeedMean |
| 30 | 7 | 0.53 | 0.13 | 0.10 | 0.04 | 1.30 | July | windSpeedMean |
| 40 | 7 | 1.07 | 0.19 | 0.28 | 0.11 | 1.74 | July | windSpeedMean |
| 50 | 7 | 2.88 | 0.67 | 0.67 | 0.37 | 2.17 | July | windSpeedMean |
| 0 | 7 | 96.83 | 68.92 | 4.81 | 14.75 | 0.00 | July | RHMean |
| 60 | 7 | 90.81 | 51.48 | 10.98 | 12.83 | 2.61 | July | RHMean |
| 10 | 7 | 22.86 | 17.37 | 4.11 | 3.95 | 0.43 | July | tempSingleMean |
| 20 | 7 | 24.44 | 17.73 | 3.49 | 3.05 | 0.87 | July | tempSingleMean |
| 30 | 7 | 24.92 | 17.01 | 3.51 | 3.19 | 1.30 | July | tempSingleMean |
| 40 | 7 | 24.66 | 17.01 | 3.30 | 3.19 | 1.74 | July | tempSingleMean |
| 50 | 7 | 24.92 | 17.64 | 3.45 | 2.98 | 2.17 | July | tempSingleMean |
| 0 | 7 | 23.62 | 17.09 | 2.44 | 2.38 | 0.00 | July | bioTempMean |
| 10 | 7 | 25.93 | 17.42 | 3.10 | 2.37 | 0.43 | July | bioTempMean |
| 20 | 7 | 26.20 | 17.31 | 3.10 | 2.47 | 0.87 | July | bioTempMean |
| 30 | 7 | 25.37 | 17.12 | 2.85 | 2.68 | 1.30 | July | bioTempMean |
| 40 | 7 | 25.56 | 16.72 | 2.87 | 2.75 | 1.74 | July | bioTempMean |
| 10 | 7 | 203.69 | -0.35 | 189.70 | 0.38 | 0.43 | July | PARMean |
| 20 | 7 | 196.60 | -0.14 | 132.86 | 0.14 | 0.87 | July | PARMean |
| 30 | 7 | 677.82 | -0.12 | 367.77 | 0.86 | 1.30 | July | PARMean |
| 40 | 7 | 1,723.45 | 8.48 | 372.42 | 25.92 | 1.74 | July | PARMean |
| 50 | 7 | 1,741.65 | 0.01 | 368.16 | 0.18 | 2.17 | July | PARMean |
| 60 | 7 | 1,738.48 | 0.67 | 378.96 | 8.87 | 2.61 | July | PARMean |
| 0 | 7 |  |  |  |  | 0.00 | July | SWIR |
| 60 | 7 | 868.40 | -3.89 | 184.67 | 1.12 | 2.61 | July | SWIR |

# Figure S1. Vertical gradients in micrometeorological conditions for all forested sites in the National Ecological Observatory Network (NEON)



**Figure S1. Vertical gradients in micrometeorological conditions for all forested sites in the National Ecological Observatory Network (NEON)**. Shown are height profiles in July mean ± 1 standard deviation for maximum photosyntehtically active ratiation (PAR), maximum wind speed, minimum humidity, maximum , and maximum biological temperature, . Sites are grouped into the following categories: (A) (sub)subtropical and warm temperate broadleaf: …, (B) temperate open/ savanna forests: …, (C) temperate mesic broadleaf forests: …, (D) temperate conifer forests: …, (E) northern and boreal forests: … [Issue #35](https://github.com/EcoClimLab/vertical-thermal-review/issues/35).

## References

**Johnston M, Andreu A, Verfaillie J, Baldocchi DD, Moorcroft PR**. **2020**. What Lies Beneath: Vertical Heterogeneity in Vegetation Canopy Temperatures. **2020**: B088–03.

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