Scaling up individual metabolism to ecosystem fluxes

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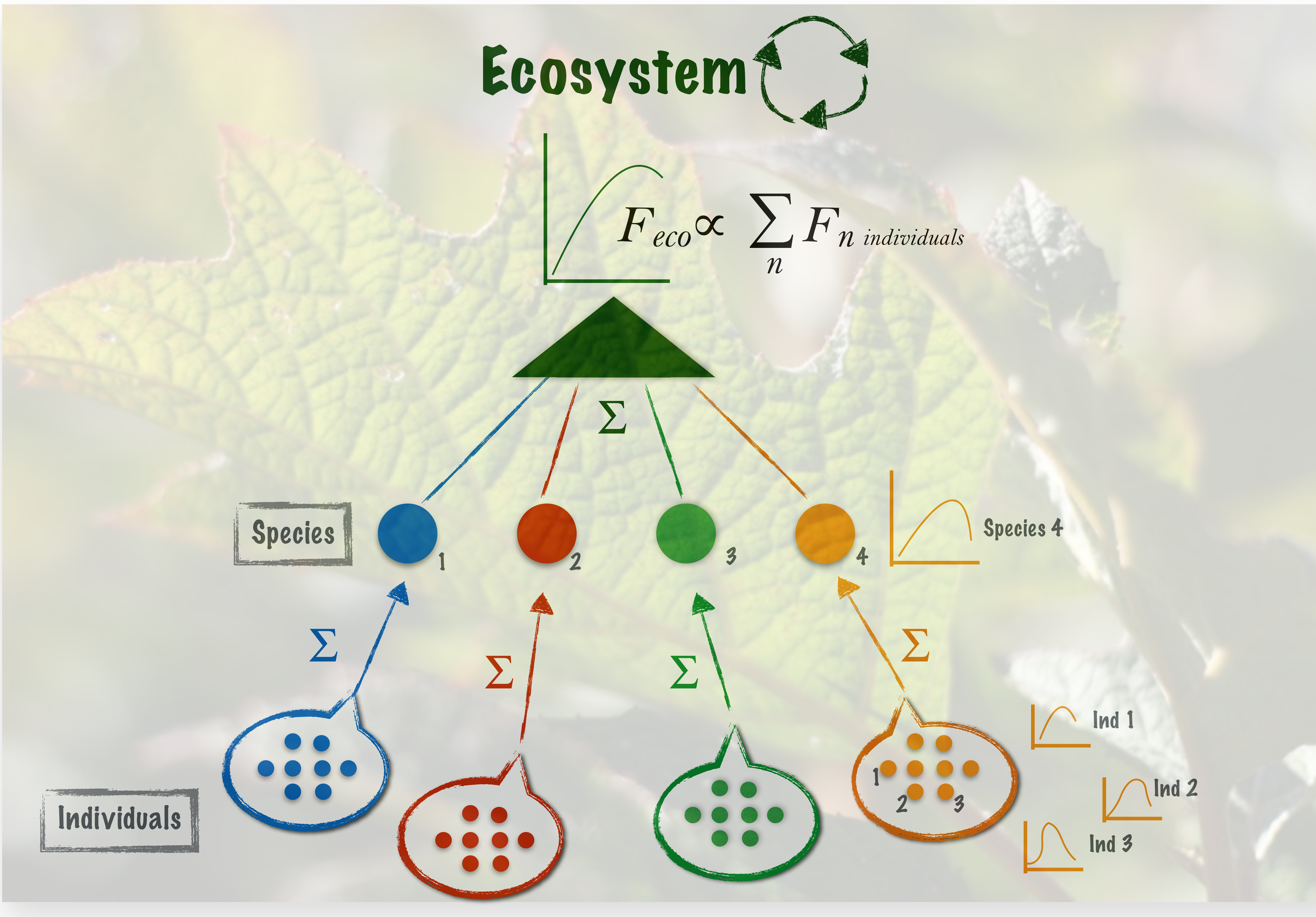
Do species-level thermal performance curves (TPCs) scale up to ecosystem fluxes?



Previous studies assume that the temperature dependence of ecosystem function is a simple scaling up of all the component species' thermal responses. In this case, predicting the effects of climatic warming or cooling on ecosystem function would be a relatively straightforward task.

Data

We combine new theory and data on the temperature dependence of key metabolic traits (photosynthesis and respiration rates) at both:

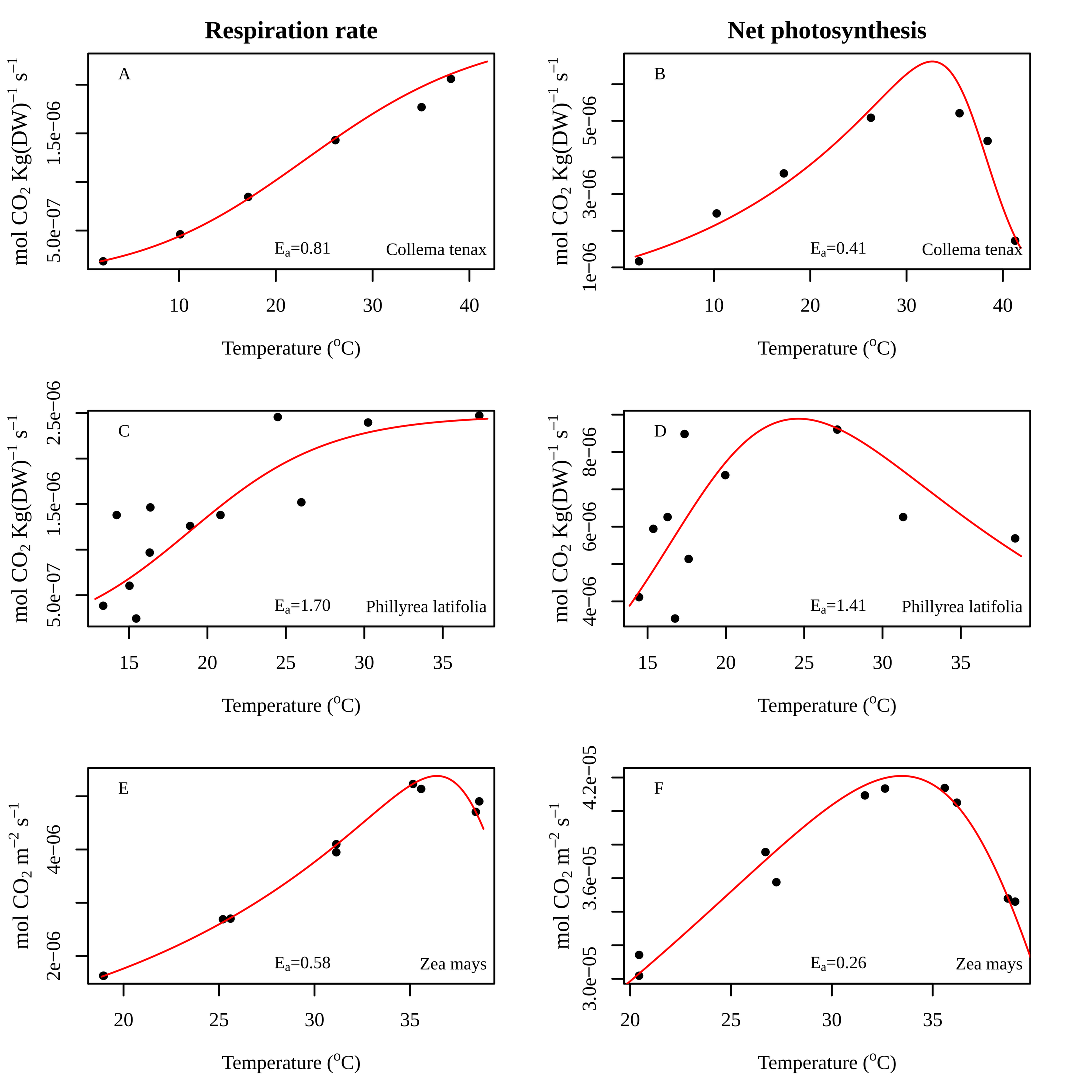
- *Species level:* more than 300 different species of terrestrial plants (*Biotraits Database*)
- *Ecosystem level:* 118 local terrestrial ecosystems across the world (*Fluxnet Database*)

We ask...

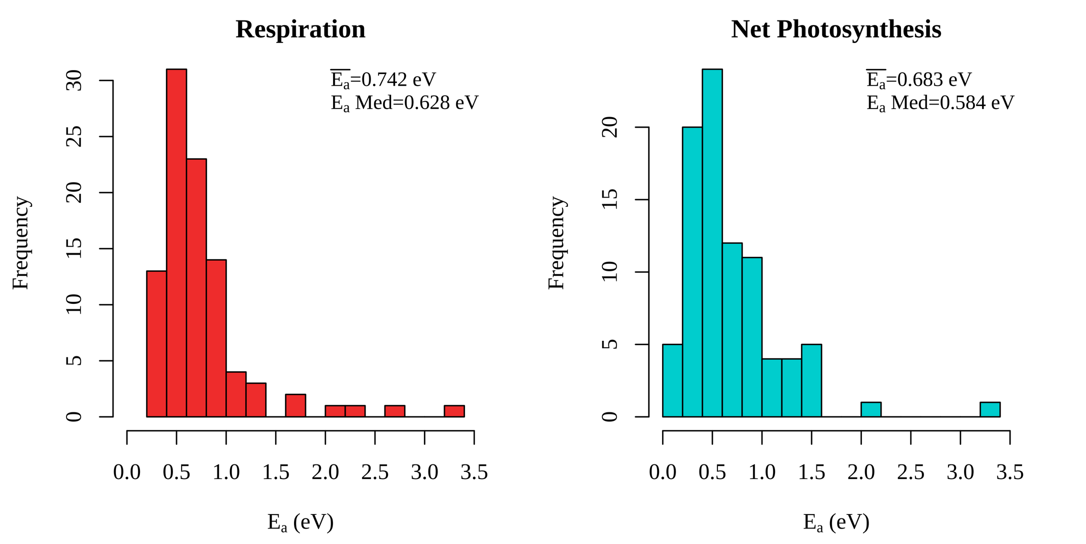
- Are differences in species-level temperature-dependence of photosynthesis and respiration reflected in the ecosystem thermal response?
- Do the full unimodal thermal responses of metabolic rate matter for mapping individual TPCs to ecosystem-level fluxes?
- Is a simple scaling from species-level TPCs sufficient to predict ecosystem-level responses?

We present a preliminary analysis of instraspecific data, to get the patterns necessary for parameterizing a model, and ecosystem flux data for validation.

Parametrization



Representative set of individual-level plot pairs for R (left) and NP (right). Each pair of R-NP corresponds to the same experiment and species. These species are associated to temperate regions.



Distributions of intraspecific activation energies for R and NP.

Model

As ecosystem flux is essentially dependent upon the difference in biomass production (P) and loss (R) of individuals, a simple equation to map individual metabolism to ecosystem flux on a daily scale is:

$$F = F_0\Big(\sum_{i=1}^{k} x_i\left(t_d f_P(m_i) g_P(T) - t_n f_R(m_i) g_R(T)\right) - \sum_{i=1}^{j} x_i t f_R(m_i) g_R(T)\Big)$$

where:

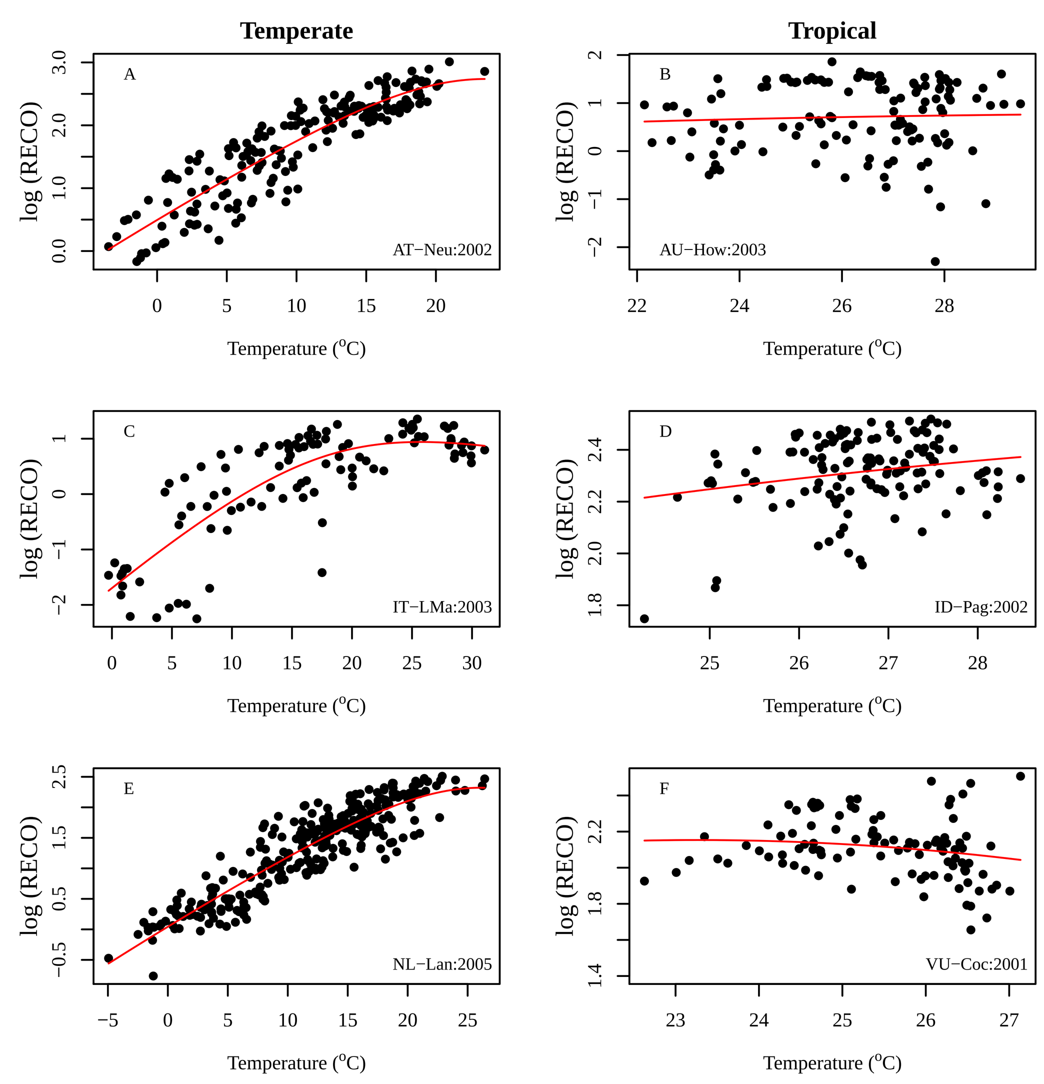
- k is an autotroph and j is a heterotroph species
- $\sum_{i=1}^{k} x_i$ is the total biomass of the ecosystem
- m_i is species' size
- $g(T)$ is contribution of temperature (T) dependence
- F_0 captures sources of variation in ecosystem fluxes that cannot be attributed to either body masses or TPCs
- t_d and t_n are the day and night components in a 24-hr cycle for the ecosystem $(t_d + t_n = t)$

A general form for the distribution of biomasses across species is:

$$x_i = h(m_i)$$

that is, x_i is a function h of the body mass of the species.

Validation



Representative set of ecosystem flux responses to temperature for different sites from tropical and temperate regions. Y axis show respiration in log scale.

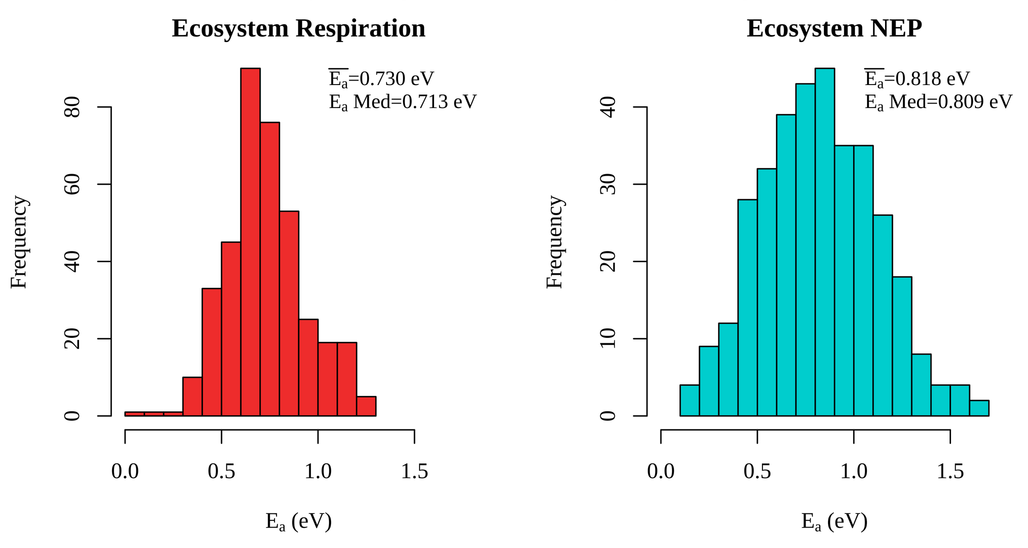


Figure 1: Distributions of activation energies for Reco and NEP at ecosystem level.

Summary

- At the intra-specific level, E_a and T_{peak} for R are usually higher than for P.
- T_{peak}'s are usually much higher than the "characteristic" adaptive environment of the organism, so the full unimodal thermal response doesn't matter for mapping individual TPCs to ecosystem-level fluxes.
- Ecosystem responses strongly depend on the temperature fluctuations of each ecosystem regime.

Ongoing

- What role might acclimation of intraspecific TPCs play on the ecosystem response?
- What is an appropriate distribution for species-level biomass abundances x_i?
- Which is the effect of non-linear interactions between species?

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