LRU – a theoretical approach

- The problem: LRU = *f*(PAR, species, ...) ???

- Current approaches to represent LRU above the leaf scale
  - The constant value: 1.6 or 1.5, etc.
  - Measured LRU from collocated leaf chambers
  - Diagnosed from model output, e.g., SiB3

- LRU –> constant, when PAR > a certain threshold (say, 1000 μmol m^{-2} s^{-1}). But why do we expect LRU to behave like this?

Sun and Seibt, manuscript in prep.

Deriving an equation for LRU

- Let's see what the LRU function *should* look like from the basic knowledge of stomatal conductance

The bread and butter:

- Ball–Berry stomatal conductance equation

$$g_{\mathrm{s,W}} = m \frac{A_{\mathrm{n}}}{\chi_{\mathrm{s,C}}} h_{\mathrm{s}} + b$$

- Leaf OCS uptake as a function of conductance terms (Stimler et al., 2010; Berry et al., 2013)

$$F_{\mathrm{S}} = -g_{\mathrm{s,S}} \left(\chi_{\mathrm{s,S}} - \chi_{\mathrm{i,S}} \right) = -g_{\mathrm{m,S}} \left(\chi_{\mathrm{i,S}} - \chi_{\mathrm{CA,S}} \right)$$
$$= -\frac{V_{\mathrm{max,CA,S}}}{K_{\mathrm{m,S}}} \cdot \chi_{\mathrm{CA,S}}$$

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After cranking out the math …

1. Express the OCS uptake F_S in terms of stomatal conductance, internal conductance, and ambient OCS concentration
2. Taylor expansion and neglecting higher order terms of $g_{s,W}$ / $g_{i,S}$, assuming $g_{i,S} >> g_{s,W}$
3. Substitute $g_{s,W}$ with the Ball–Berry equation

…

$F_S = F_S(A_n$, m, internal conductance, OCS/H_2O diffusivity ratio)

Sun and Seibt, manuscript in prep.

Finally, LRU = ...

Ratio of OCS/H_2O diffusivity

$$\mathrm{LRU} = \frac{m}{R_{\text{W-S}}^2} \cdot h_s \left(-\frac{1}{g_{i,S}} \cdot m \frac{h_s}{\chi_{s,C}} A_n + R_{\text{W-S}} \right)$$

Internal conductance of OCS

Furthermore, approximating A_n with a typical light response curve, for example,

$$A_n = \frac{\mathrm{PAR}}{\mathrm{PAR} + K_{\mathrm{PAR}}} P_m - R_d$$

We get an explicit expression of LRU vs PAR and RH,

$$\mathrm{LRU} = \frac{m}{R_{\text{W-S}}^2} \cdot h_s \left(R_{\text{W-S}} + \frac{1}{g_{i,S}} \cdot m \frac{h_s}{\chi_{s,C}} R_d - \frac{1}{g_{i,S}} \cdot m \frac{h_s}{\chi_{s,C}} \frac{\mathrm{PAR}}{\mathrm{PAR} + K_{\mathrm{PAR}}} P_m \right)$$

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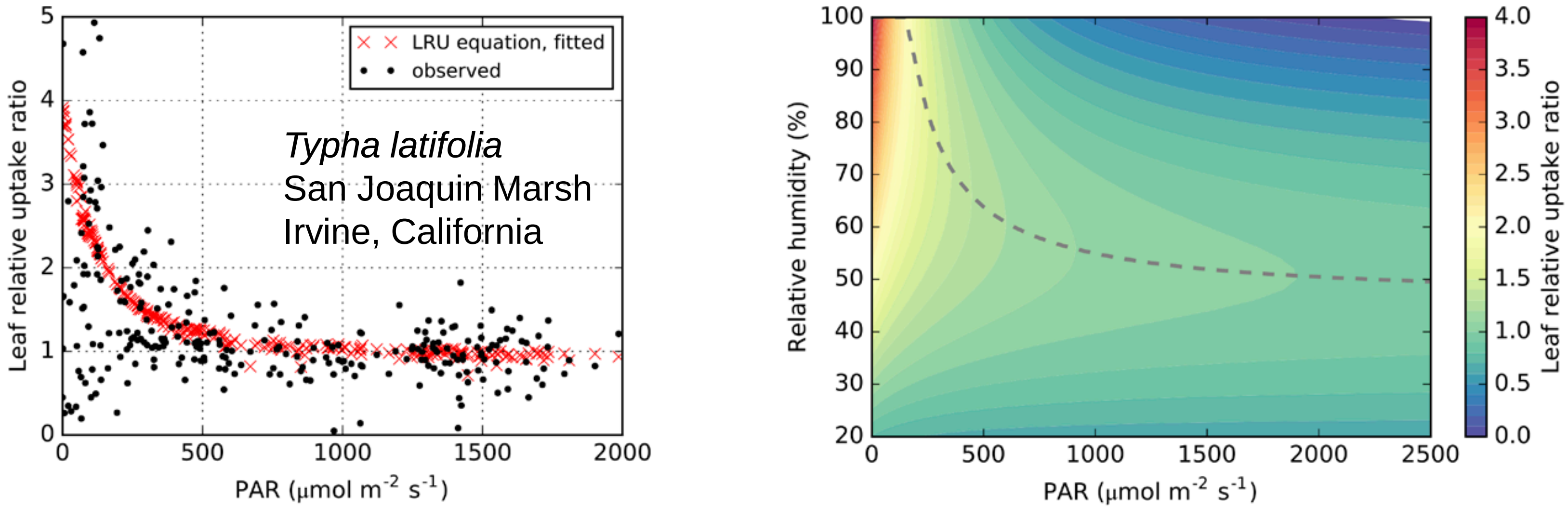
- The LRU equation
  - tells us how LRU responds to PAR and RH
  - allows us to derive physiological parameters controlling g_s and photosynthesis by fitting leaf-level data to the equation
  - is useful for extrapolating LRU to the canopy level



- However, the equation does *not* guarantee LRU to converge to a universal constant value at high light …
- Our observations at high light: 1.3 in a semi-arid oak woodland, and 1.0 in a freshwater marsh

Sun and Seibt, manuscript in prep.