Yujie's First Committee Meeting

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Proposal Aims

- Improve gas exchange model;
- Test the model;
- Make predictions of forest health.

Photosynthesis Optimization Model

Cowan and Farquhar (1977)

$$\int \delta E dt \geq 0; \int \delta A dt = 0 \tag{1}$$

$$\frac{\delta E}{\delta A} = \lambda \; if \; (\frac{\delta E}{\delta A})_0 \leq \lambda \tag{2}$$

$$A = A_0; E = E_0 \; if \; (\frac{\delta E}{\delta A})_0 \geq \lambda \tag{3}$$

The disadvantage is the definition of λ, and there is no details of what λ should be.

Empirical Model

Ball, Woodrow and Berry (1987)

$$g_{sw} = k \cdot A \cdot \frac{h_s}{c_s} \tag{4}$$

Model was improved by implementing more practical equation, but there is no physiological concern.

Hydraulic Model

Sperry and Love (2015)

$$\Delta P = \Delta P' \cdot \frac{(dE/dP)'}{(dE/dP)_{max}} \tag{5}$$

Stomatal control is defined by supply and demand functions: regulated P_{canopy} is regulated by hydraulic loss if no regulation applies.

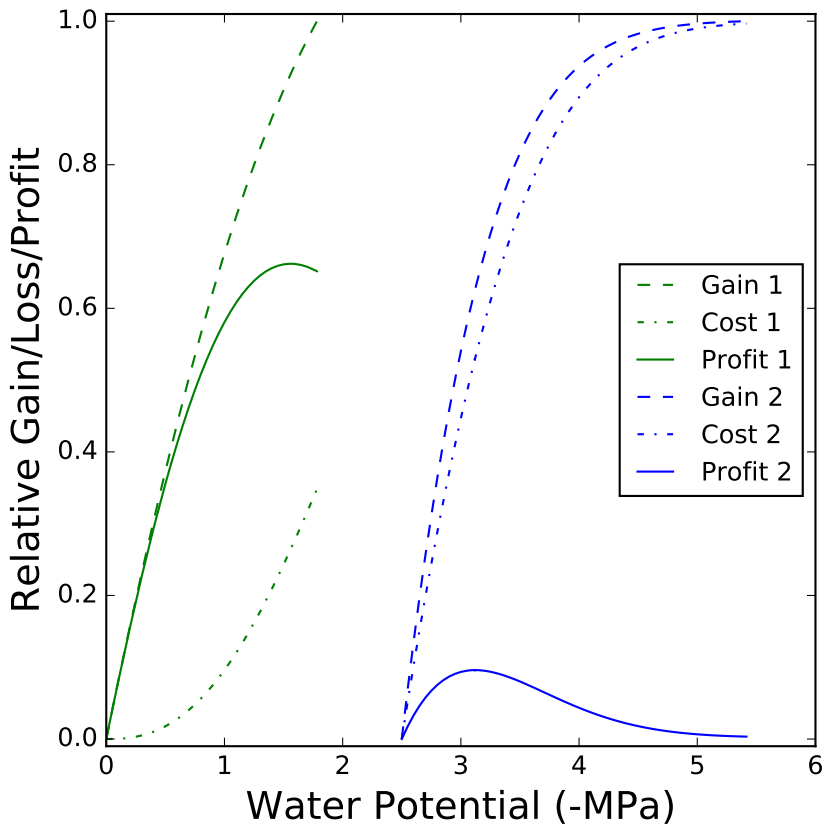
Photosynthetic-Hydraulic Trade-off Model

Sperry et al. (2016)

$$gain = \frac{A}{A_{max}} \quad (6)$$

$$cost = 1 - \frac{dE/dP}{dE/dP_{max}} \quad (7)$$

$$profit = gain - cost \quad (8)$$



Summary of Models

Table 1: Summary of the basic parameters in each model.

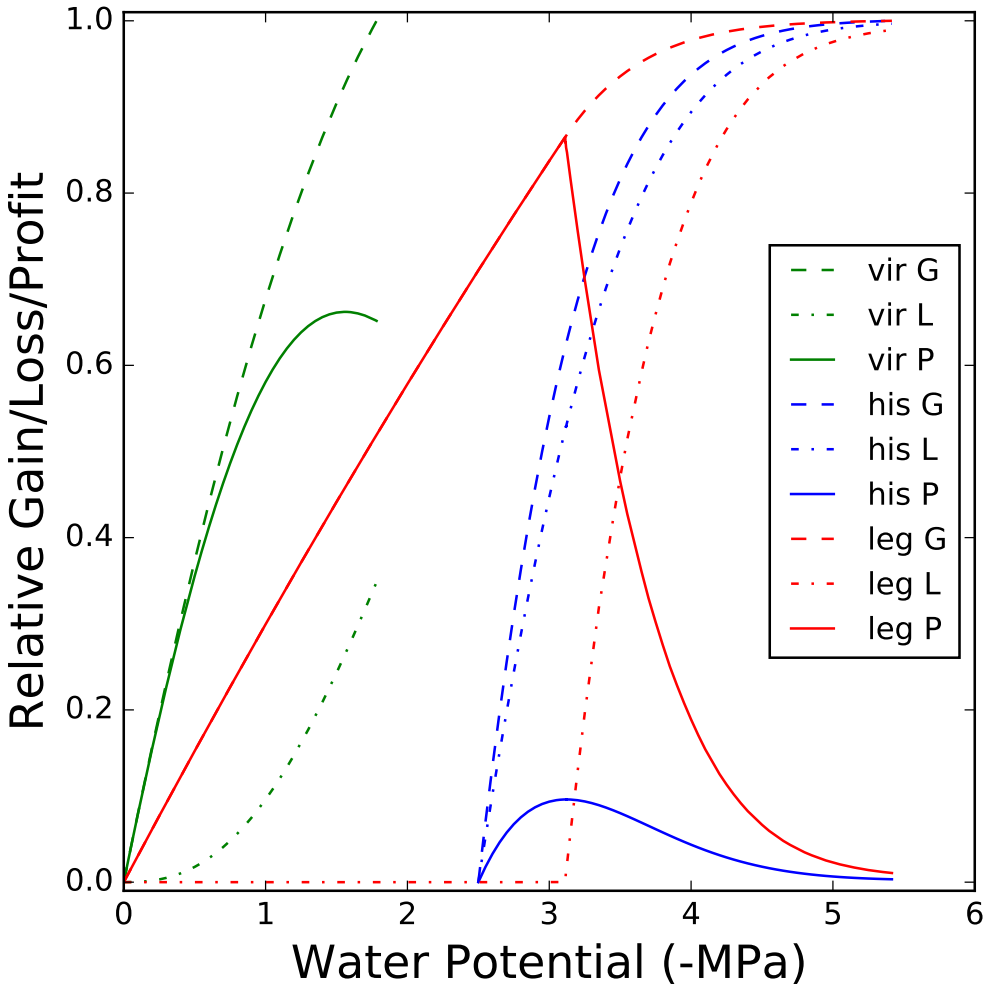
Model	Light	CO_2	VPD	Soil	VC
PO1977	Yes	Yes	Yes	No	No
EM1987	Yes	Yes	Yes	No	No
HO2015	No	No	Yes	Yes	Yes
TO2016	Yes	Yes	Yes	Yes	Yes

Aim 1: Improve the model

- Post-drought physiology;
- Optimal leaf investments;
- Leaf shedding and Rubisco activity.

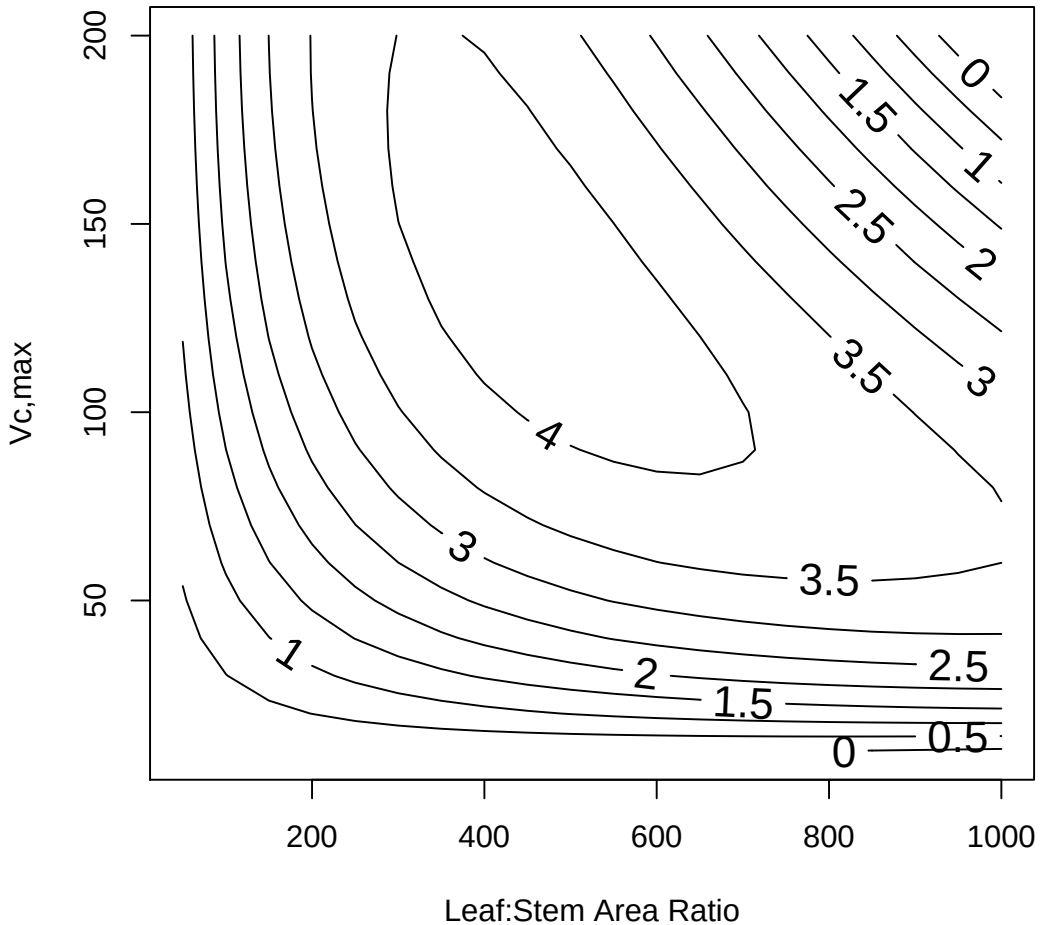
Post-drought Physiology

- Drought history;
- Xylem refill;
- Rubisco activity shift;
- Abscisic acid tempo.



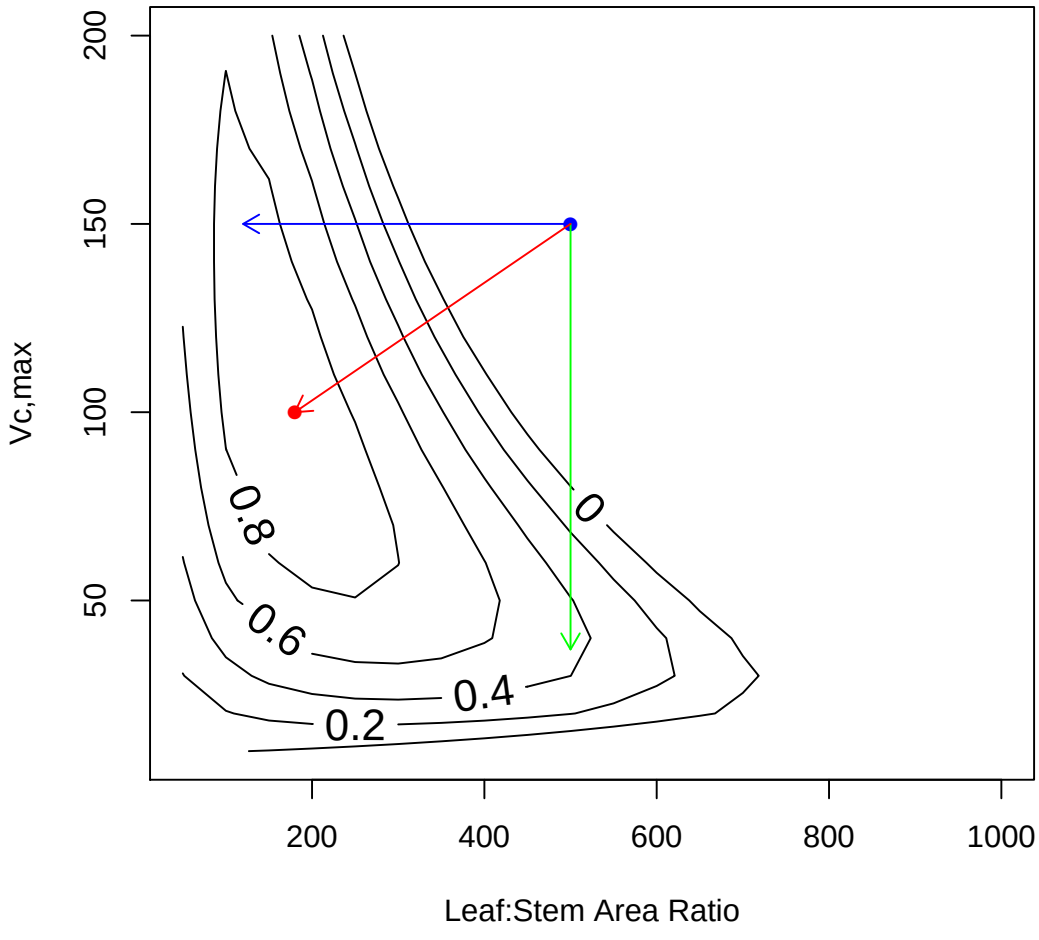
Optimal leaf investment

- Leaf photosynthesis benefit;
- leaf respiration cost;
- Leaf construction cost;
- Root and Stem respiration;
- Nutrient limitation.



Leaf shedding and Rubisco activity

- Drought stress;
- Drought time;
- Opportunity cost;
- Leaf shedding;
- Rubisco activity shift.



Aim 2: Test the model

- Response curves of VPD, [CO_2], Light, Soil Moisture;
- Post-drought physiology;
- Leaf investment strategy;
- Leaf shedding strategy.

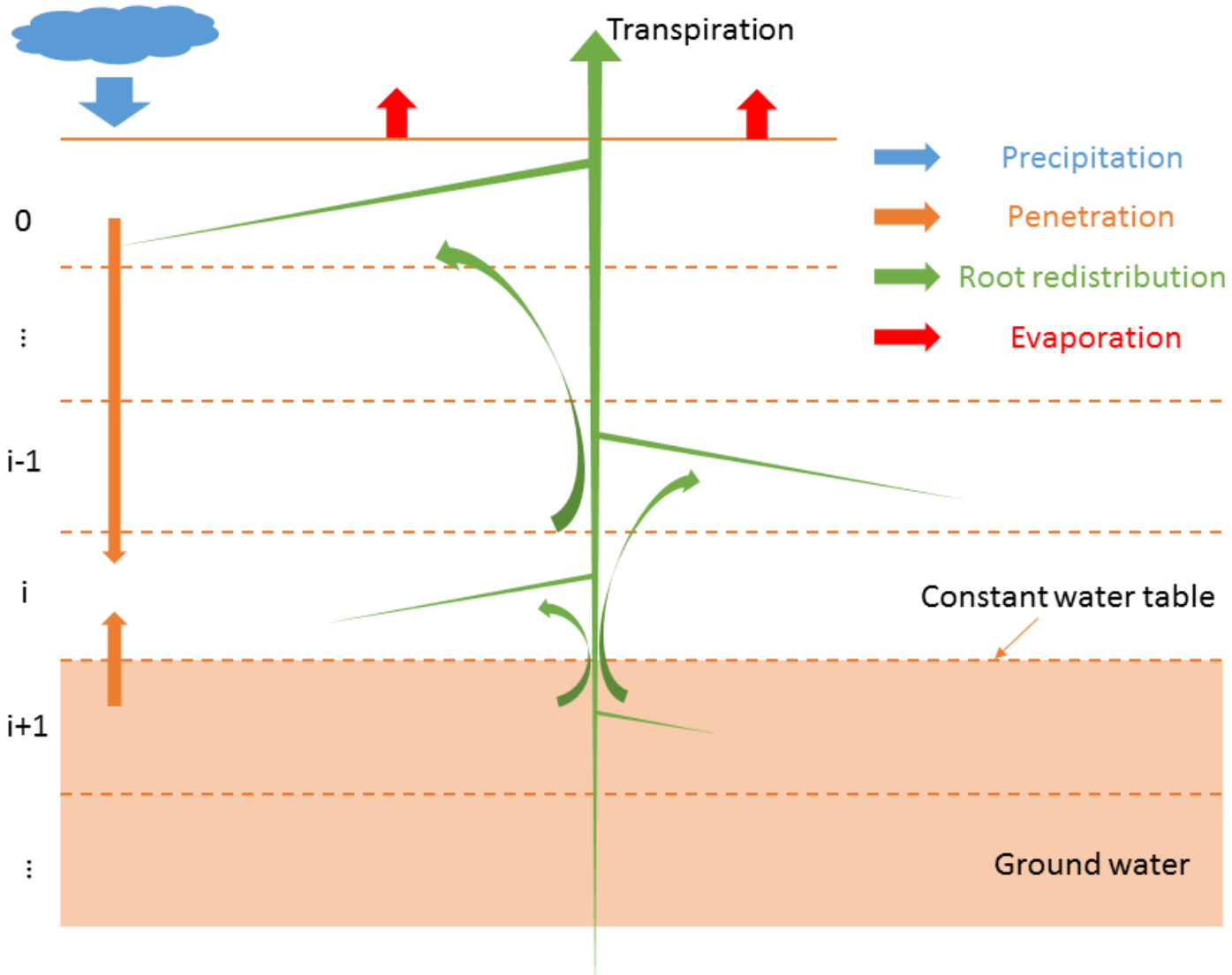
Aim 3: Predict forest health

- Implement climate and hydrology;
- Correlate mortality, productivity with drought index;
- Predict the forest health and species mortality.

Climate and Hydrology

- Climate: VPD, temperature, wind, precipitation, light, $[CO_2]$;
- Hydrology: top soil evaporation, soil type, soil layers, ground water;
- Forest: forest composition, tree distribution, root distribution, leaf shedding.

Diagram


Transpiration
Precipitation
Penetration
Root redistribution
Evaporation
0
i-1
i
i+1
Constant water table
Ground water

Forest health

- Correlate drought index and forest health with data collected from real forest stands;
- Make a library of different climate, hydrology, and forest composition; and run simulations of the library;
- Make predictions of forest health and species mortality in each stand.

Thanks!