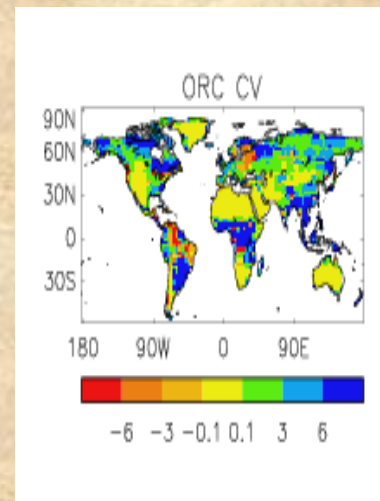# Vegetation Response to Drought
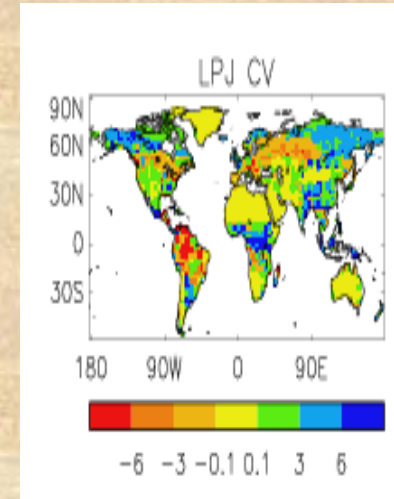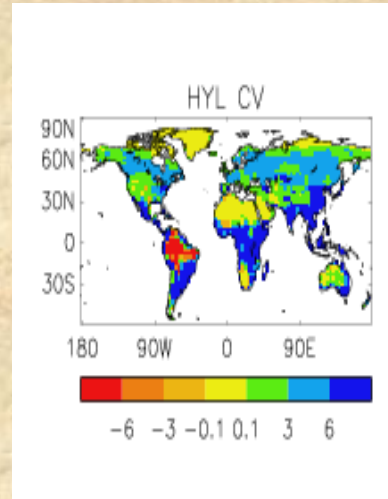
David Galbraith – University of Edinburgh

JULES MEETING, EXETER
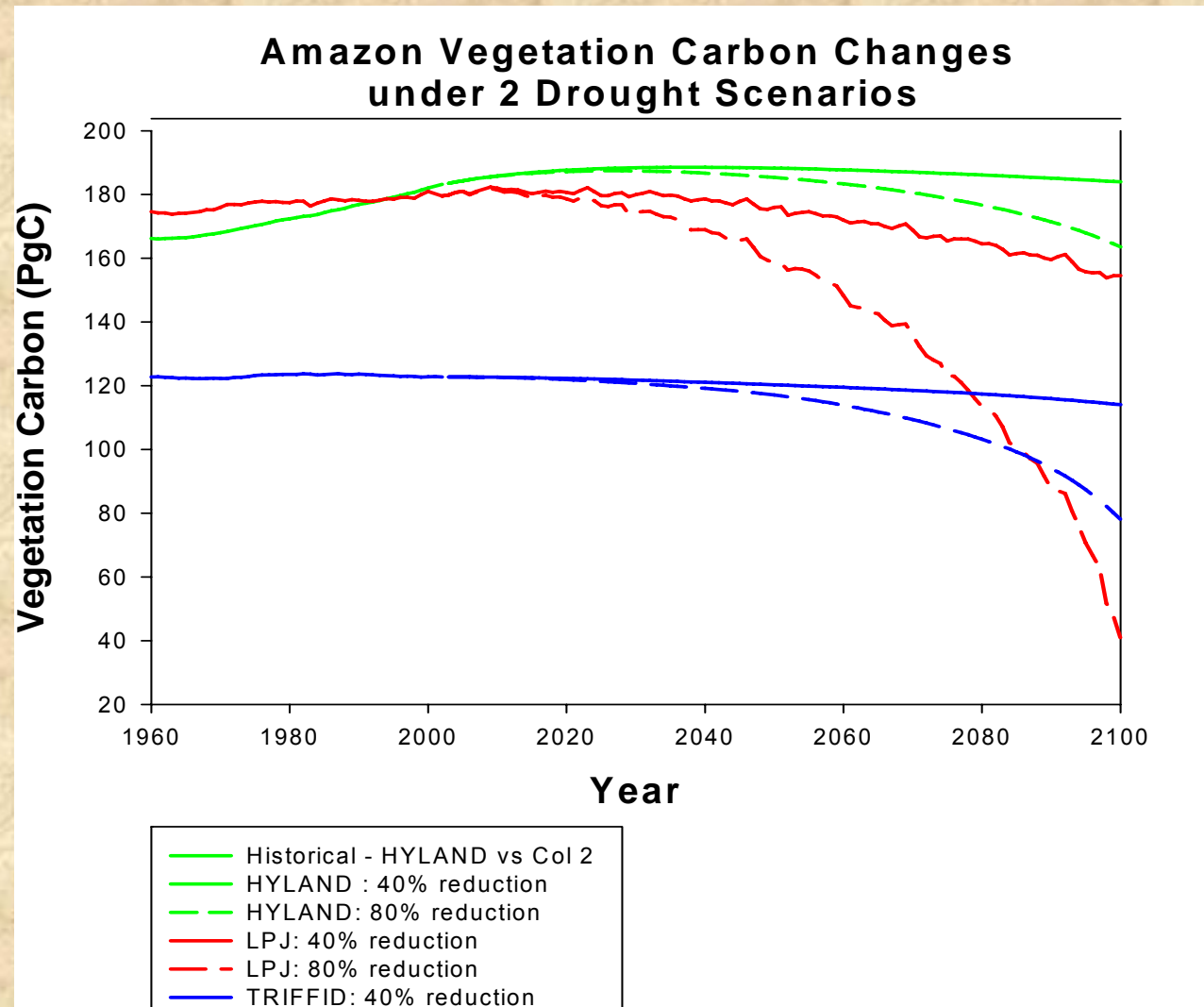
Importance of Vegetation Drought Response in DGVMs
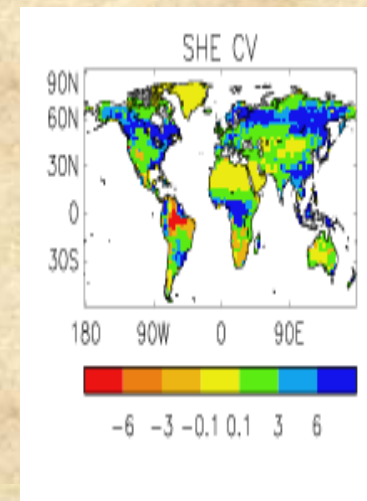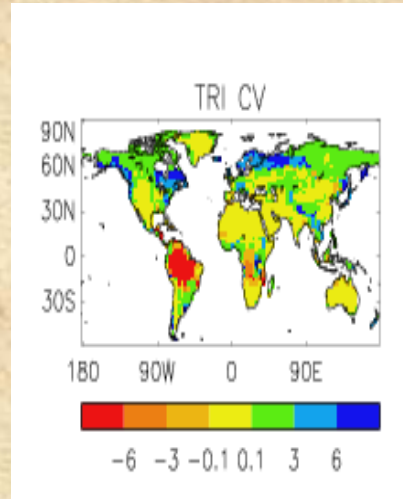
Sitch et al, submitted

Behaviour of Droughted Forests in DGVMs (1)

Amazon Vegetation Carbon Changes under 2 Drought Scenarios

Legend:
- Historical - HYLAND vs Col 2
- HYLAND : 40% reduction
- HYLAND: 80% reduction
- LPJ: 40% reduction
- LPJ: 80% reduction
- TRIFFID: 40% reduction

Behaviour of Droughted Forests in DGVMs (2)
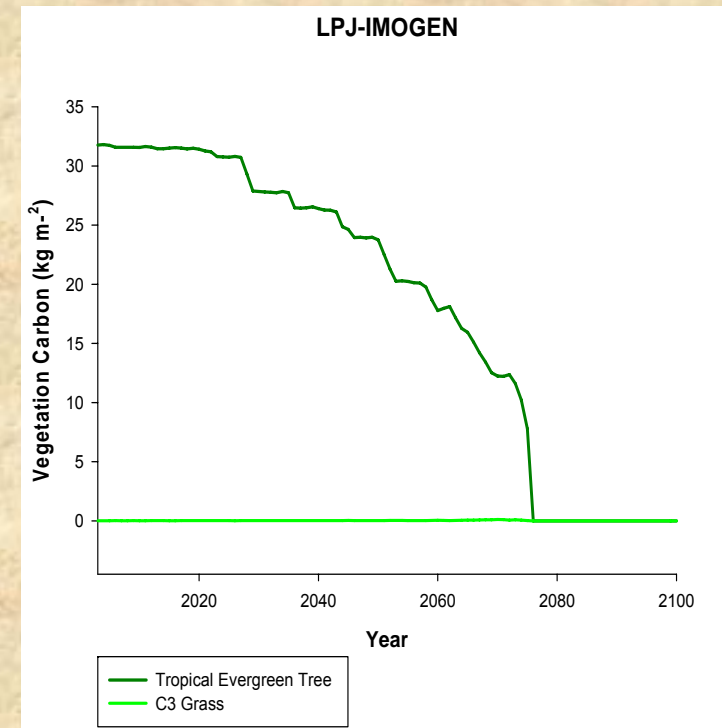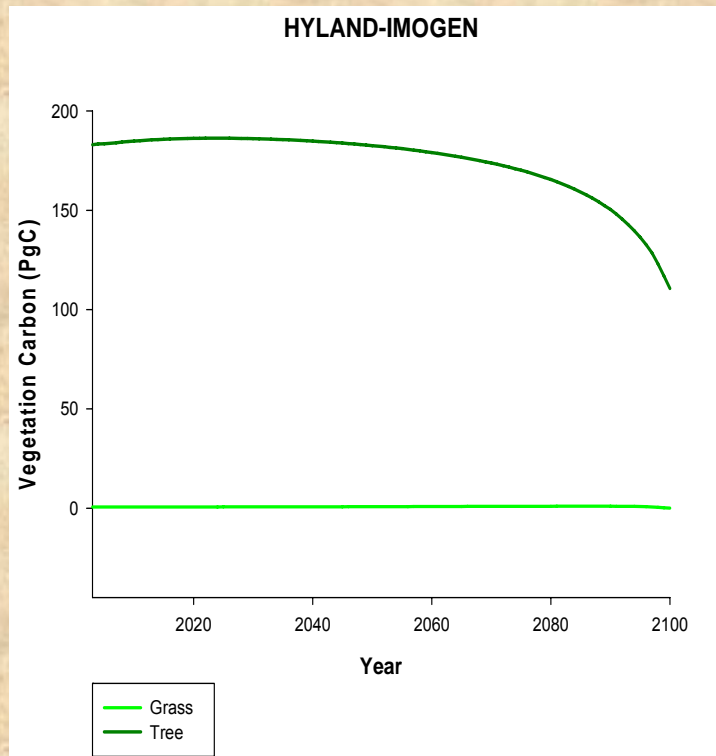
Soil moisture dependencies in JULES

$$A = \frac{g_s}{1.6RT}(c_c - c_i)$$
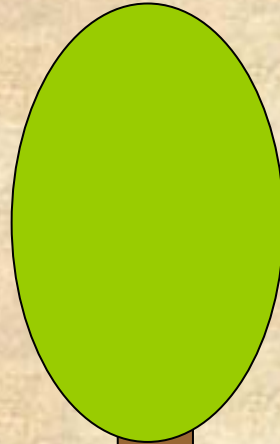
$$A = A_p \beta$$
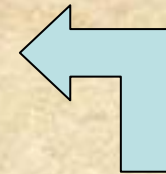
$$R_s = k_s C_x f_\theta f_T$$

$$\beta = \frac{\theta - \theta_w}{\theta_c - \theta_w}$$

$$e_k^0 = \frac{r_k \beta_k}{\sum_k r_k \beta_k}$$

Time-scales of drought response

- 1) Short-term ecophysiological processes (plant hydraulics, stomatal conductance, photosynthesis,etc.)
- 2) Mid-term: rooting depth, root strategies, etc.
- 3)Long-term: reproductive dynamics, competition among PFTs, drought-fire synergisms

Short-term responses (1)

$$\frac{d\Psi_l}{dt} = \frac{\Psi_s - hd - E(R_a + R_b) - \Psi_l}{C(R_a + R_b)}$$

FIG. 1. Representation of pathways of water transport in the soil, plant and atmosphere. Sites of phase change, liquid to vapour, are distinguished by the symbol ⊗.
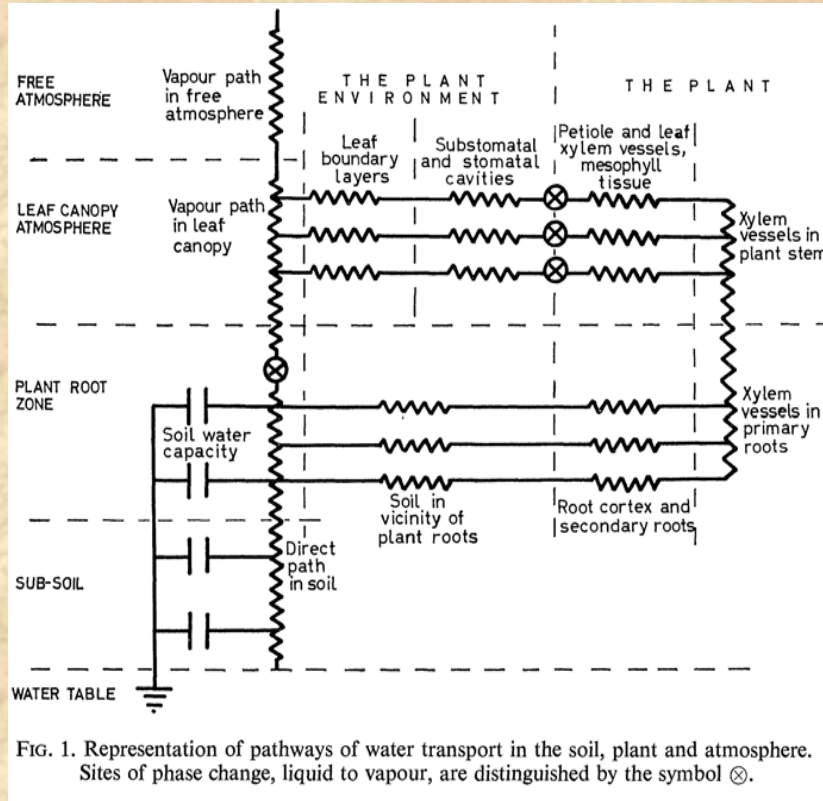
Cowan 1964
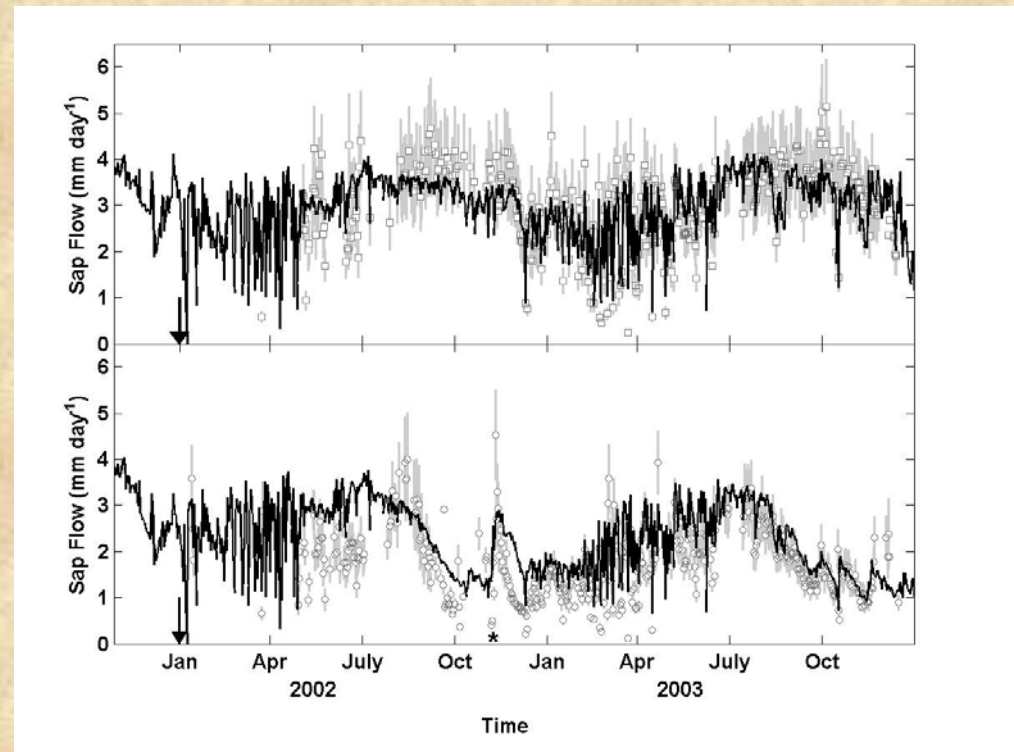
Fisher et al., submitted

Short-term responses (2)

- **Hickler (2006)**

$$E_{su} = \frac{-\Delta P}{(R_r + R_s + R_l)/(a_1 + a_2 \cdot T)}$$

$$k_s = k_{s\_max} \cdot e^{-\left[\frac{-\Psi_{sr}}{\Psi_{50}}\right]^c}$$

$$A_l/A_s = k_{la.sa} - (a \cdot k_{la.sa} \cdot h) - (b \cdot [1 - \omega_a] \cdot h)$$
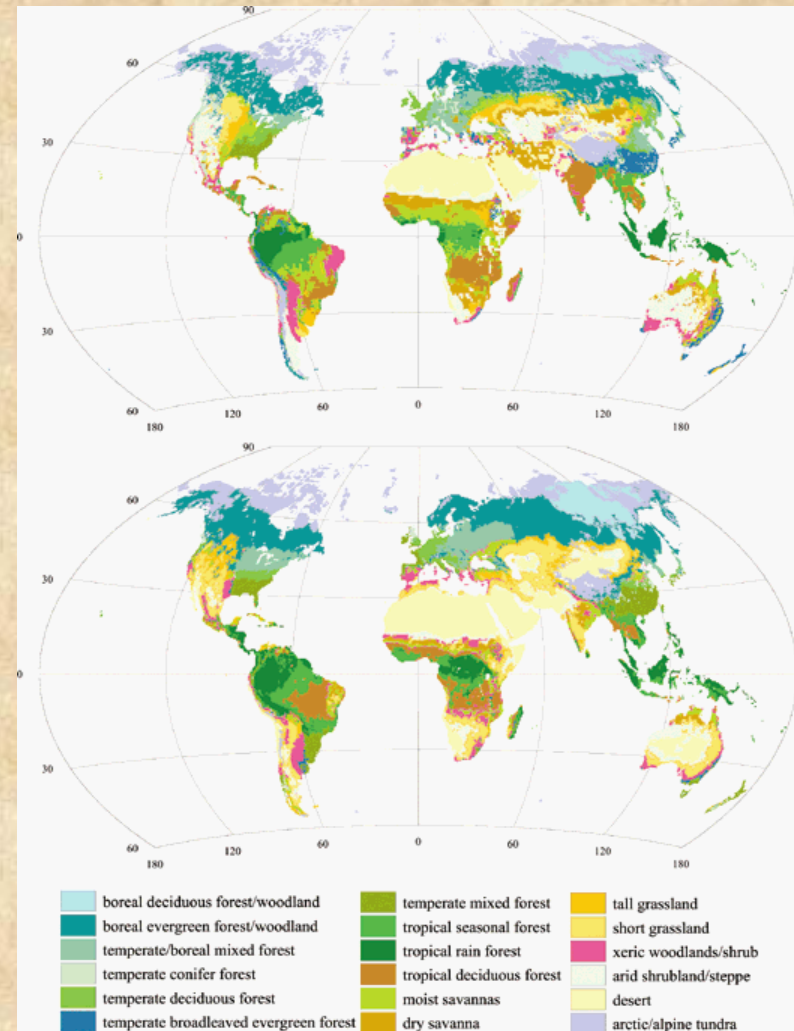

boreal deciduous forest/woodland
boreal evergreen forest/woodland
temperate/boreal mixed forest
temperate conifer forest
temperate deciduous forest
temperate broadleaved evergreen forest

temperate mixed forest
tropical seasonal forest
tropical rain forest
tropical deciduous forest
moist savannas
dry savanna

tall grassland
short grassland
xeric woodlands/shrub
arid shrubland/steppe
desert
arctic/alpine tundra

Mid-term responses (1)

- **Many mechanisms:**
- **Hydraulic redistribution**
- **Stem water storage**
- **Increased water uptake through leaves**
- **Root morphology changes**
- **Access to deep water storage, etc.**

Tropical rain forest

Tapajós National Forest km83, Brazil

0.4 0.42 0.44 0.46 0.48 0.5 0.52 0.54 0.56
Volumetric soil moisture (m3 m-3)
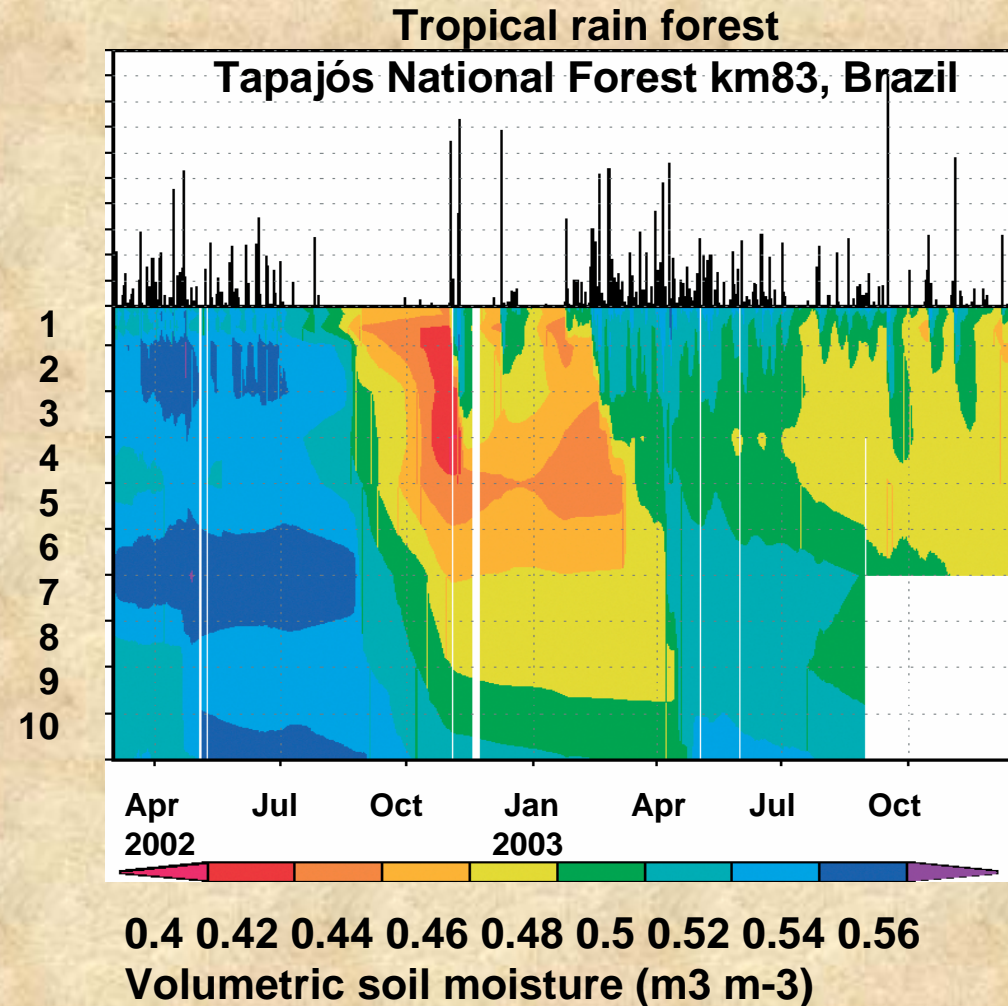
Mid-term responses (2)

- Incorporation of dynamic rooting depth?
- Predictive model:

   - f (soil depth, max PFT rooting depth, seasonal water deficit, soil bulk density)
- Dynamical Root Water Uptake?
- - uptake not so closely tied to root fraction?
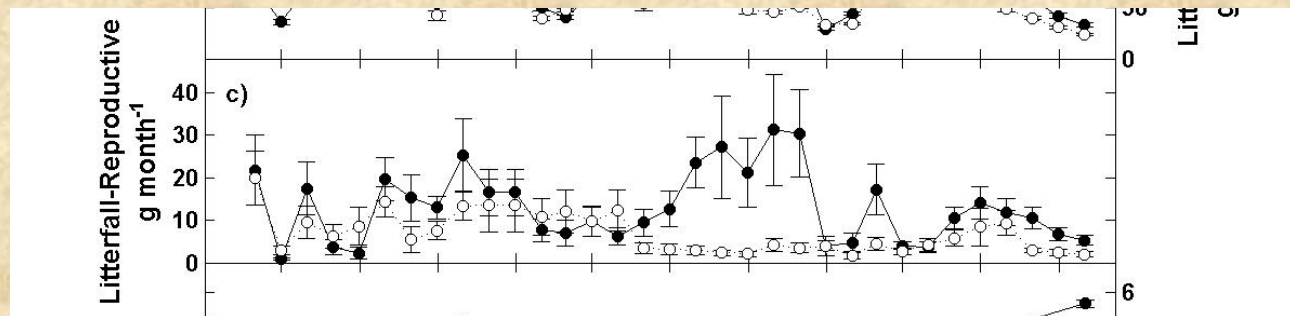- - flexible rooting profiles (with PFT-specific plasticity functions)?
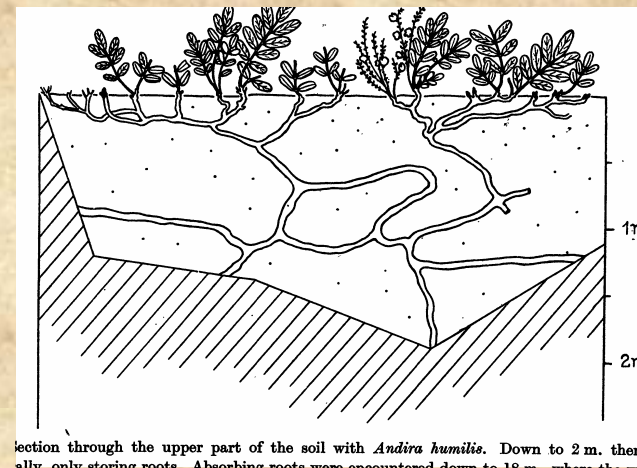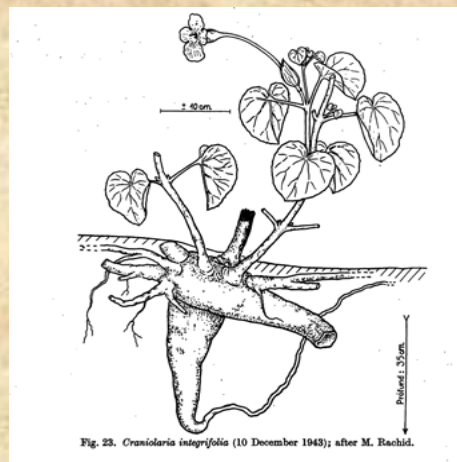
Long-term responses (1)

Tapajos - Cuiaba Transect
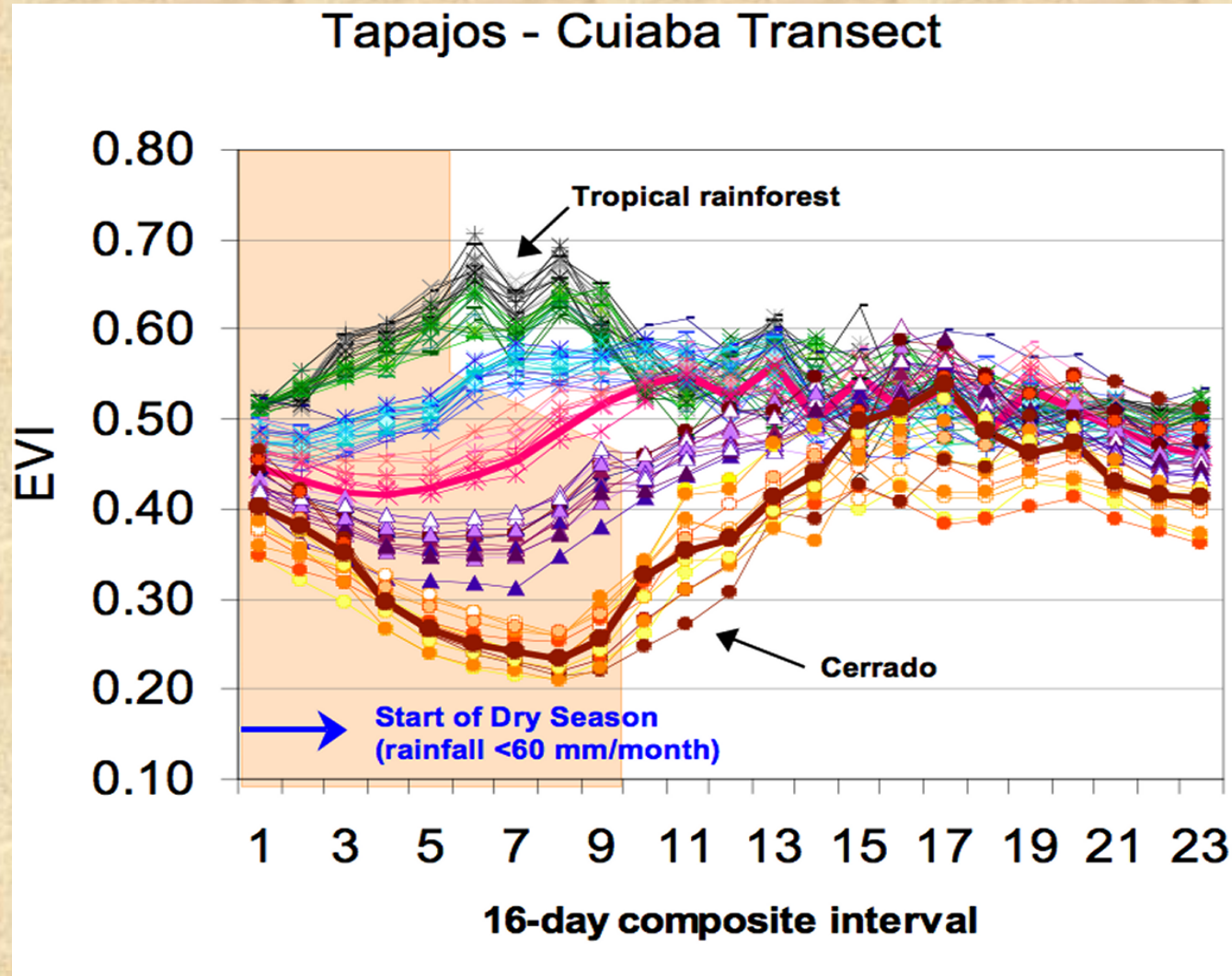
Ratana 2006

Biome Shifts (2): Mechanisms

Drought effects on plant reproduction (figure from Patrick Meir)

- Competition for water resources – root strategy differences?

Fig. 23. *Craniolaria integrifolia* (10 December 1943); after M. Rachid.

section through the upper part of the soil with *Andira humilis*. Down to 2 m. there ally, only storing roots. Absorbing roots were encountered down to 18 m. where the

Rawitscher 1948

Next Steps

- **Continue Intercomparison and Sensitivity Analysis (Default v. Amazonia-calibrated models)**

- **Short-term ecophysiology: validation against seasonal fluxes and drought experiments**

- **Mid and long-term processes: model development + eventual validation against transect data?**