Water cycling (pools and movement) through an enclosed tropical forest in response to drought.

B11O-9712 B11O-9712

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Water movement through trees

- Currently research on water movement through trees and how they can resist environmental pressures strongly focusses on leaf stomatal control of the water balance (Isohydric vs. an-isohydric responses).
- Tree stems, depending on their size, can represent a large store of water, especially in the tropics where low wood density and annual precipitation cycles are common.

Aims of this study

- determine the water balance of the tropical tree species in the B2 rainforest
- assess the influence of stored water on tracer movement
- determine how these are affected by changes in precipitation

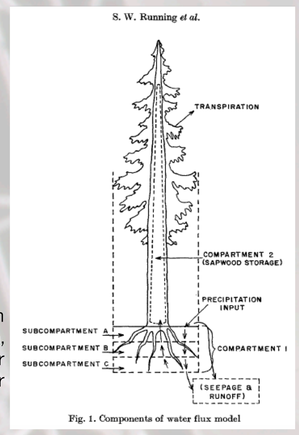
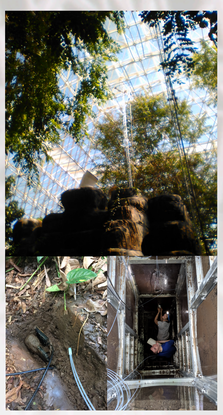


Fig. 1. Components of water flux model

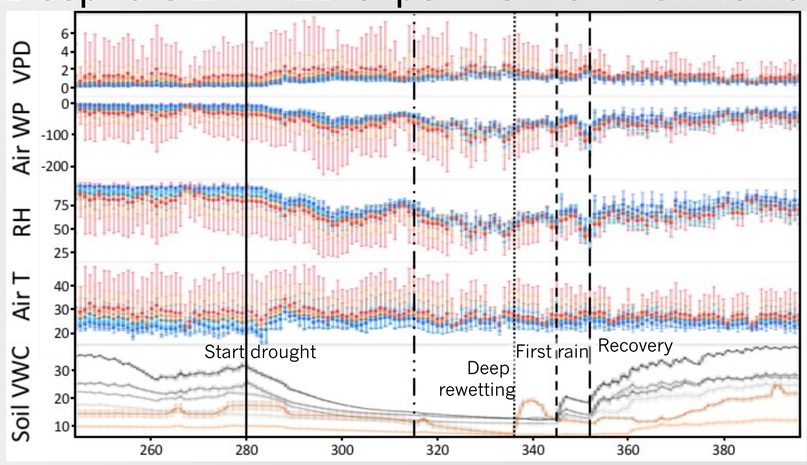
Conceptual drawing from Running et al. 1975 (Oecologia, 18, 1-16) depicting the water balance of Douglas fir

Site and Methods



- The Biosphere 2 tropical forest, constructed and planted in 1989-1991, consists of ~95 plant species, of which 32 are tree species.
- Rainforest temperature and humidity were monitored along four profiles with sensors at 1, 3, 7, 13, and when possible 20m above the soil surface soil was constructed in two layers: a bottom granite gravel overlain with one meter of topsoil (~one third each sandy loam, Wilson pond soil, and peat moss) with a bulk density on ~1.6 g/cm3, carbon content ~2% and nitrogen content of ~0.1%.
- In July of 2019, we installed soil moisture (SMT100, Truebner, Germany), water potential (Meter Group, USA), and soil gas exchange probes (custom made) into soil pits at 5*, 10*, 20*, 50, 100, 200, 300#cm (*only depths with water potential, #when soil was deep enough).
- We installed 16 sap flow sensors (Edaphic, Australia) and 12 TDR water content (Acclima, USA) sensors in selected trees (below right).
- All sensors were monitored at a 15 minute timeframe using CR1000 dataloggers (Campbell Scientific, USA).
- We started drought by closing off all rain water pipe valves
- Deep rewetting: 22,000 liters of rain water to bottom of pits and subsoil drainage pipes.

Biosphere 2 WALD experiment environmental conditions

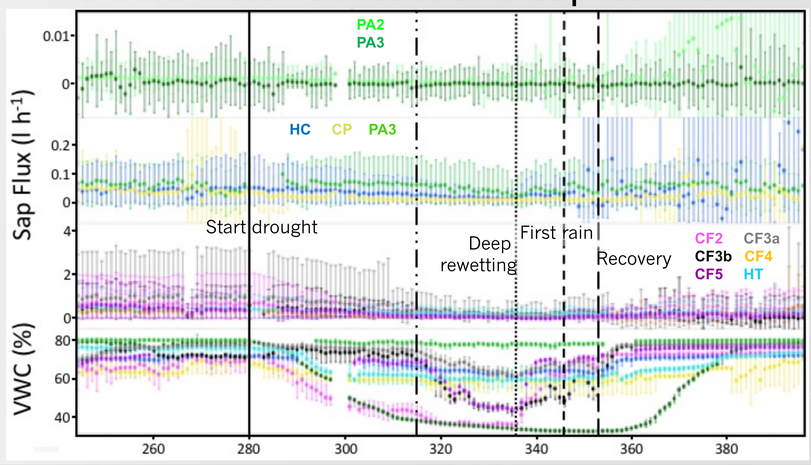


- Relative to pre-drought vapor pressure deficit (VPD) mostly increased at he lower canopy levels
- Drought mainly the result of lower relative humidity (RH)

below 4m Sensor heights
4-9m
9-15m
15-20m
above 20m

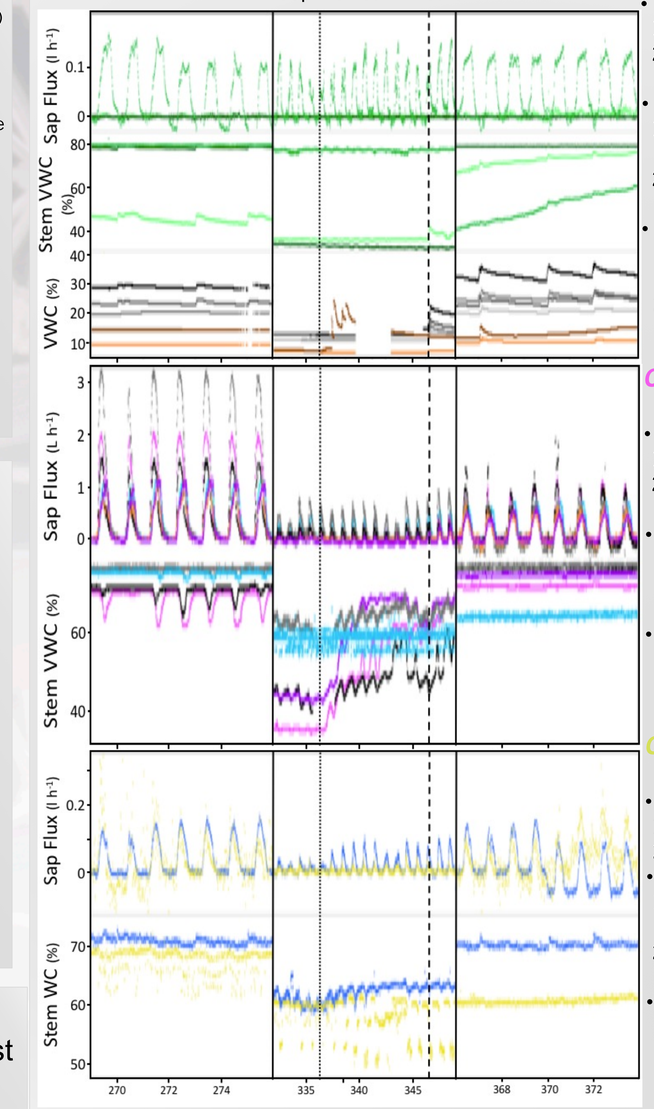
- Shallow depths (black/dark grey) respond to rainfall
- Deep rewet: only deep soil (brown) responds
- Line colors denote different depths

Tree bole water content and sap flow rate



- Stem volumetric water content and its response to drought is highly variable, between and within species
- Sap fluxes vary by three orders of magnitude and depend on species (high flow in *Clitoria faichildiana* (hot pink, grey, purple and black, bottom sap flux panel) and *Hibiscus tilliaceus* (light blue)
- Strongest response to deep rewetting in *C. fairchildiana*

Three types of stem water response



Pachira aquatica

- **Small trees:**
  1. constant sap flux
  2. stem water tied to shallow soil water
- **Big tree:**
  1. reduced sap flux end of drought
  2. little water content change
- **Rewet response:**
  1. fast response sap flux big tree
  2. slow response small trees only after start rain

C. fairchildiana
H. tilliaceus

- **Pre-drought:**
  1. large sap flux,
  2. variable draw from stem storage
- **End-drought:**
  1. strongly reduced sap flux and water content
- **Rewet & recovery:**
  1. refill stem storage prioritized (CF only)
  2. slow rise sap flow

Ceiba pentandra
Hura crepitans

- **Pre-drought:**
  1. constant sap flux
  2. stem WC constant
- **End-drought:**
  1. strongly reduced sap flux
  2. WC reduced and changeable
- **Deep rewet:**
  1. Rapid rise **HC** sap flow, both recover
  2. WC **HC** recovers quick, **CP** slow

Final words

- internal water dynamics of tropical forest trees are highly variable and can show strong drought responses
- Species identity and size appear to play a strong role in determining the response

Acknowledgements
Funding for the B2_WALD project and this study was provided by ERC-Grant VOCO #647008, Biosphere 2, the Philecology Foundation, and Susan and Daniel Warmack.
The authors are immensely grateful for unrelenting and cheerful technical and physical support from the B2 staff, in particular Jason Deleeuw and Tim McMullin.

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