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

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Water movement through trees

- Currently research on water movement through trees and how they can resist environmental pressures strongly focuses on leaf stomatal control of the water balance (isohydric vs. anisohydric 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.

Site and Methods

- The Biosphere 2 tropical forest, constructed and planted in 1990–1991, 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, and 13 m, and when possible 20 m above the soil surface.

- Soil surface soil was constructed in two layers: a bottom granite gravel over lain with one meter of loess (one third each sandy loam, Wilson pond soil, and peat moss) with a bulk density of ~1.6 g/cm3, carbon content ~2% and nitrogen content ~0.1%.

- In July 2019, we installed soil moisture sensors (SMT100, Truber, Germany), water potential (Meter Group, USA), and soil gas exchange probes (custom made) into soil pits at 5, 10, 20, 50, 100, 150 cm, 200 cm (only depths with water potential, when soil was deep enough).

- We installed 16 sap flow sensors (Edaphic, Australia) and 12 TDR water content (Acrroma, 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: 20,000 liters of rain water to bottom of pits and subsoil drainage pipes.

- Deep soil rewetting: 80% of field capacity, 30% above canopy.

- Pre-drought: ~1 liter sap flux.

- End drought: ~1 liter sap flux.

- Recovery: ~1 liter sap flux.

- The Biosphere 2 WILD experiment environmental conditions

- Soil VWC, RH, AWP, VPD

- Temperature, humidity, and water potential

- Soil water content

- Sap flow rate

- Tree bole water content and sap flow rate

- Stem volumetric water content and its response to drought is highly variable, between and within sapwood.

- Sap fluxes vary by three orders of magnitude and depend on species (high flow in Ceiba pentandra (red), black, top sap flux panel) and Hibiscus tiliaceus (light blue).

- Strongest response to deep rewetting in C. pentandra.

- Sap flow both recovers 2 WC, HC slow.

- Three types of stem water response

- Pre-drought: ~1 liter sap flux.

- End drought: ~1 liter sap flux.

- Recovery: ~1 liter sap flux.

- Small trees: 1. constant sap flux

- Big tree: 2. strong sap flow

- Big tree: 3. shallow soil water

- Small trees: 2. little water content change

- Rewet response: 1. fast response sap flux big tree

- Slow response small trees only

- After start rain C. fairchildiana

- H. tiliaceus

- 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)

- Slow rise sap flow

- Ceiba pentandra

- Hura crepitans

- Pre-drought: 1. constant sap flux

- 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.

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