

Fagus grandifolia and Acer Saccharum, two types of water use strategies in response to soil moisture deficit

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INTRODUCTION

In the coming years, an increase in the duration and severity of soil moisture deficits is expected in temperate forests of North America.

Soil water deficits induce several effects in plant species, ranging from reduced growth to plant mortality over the short or long term.

Plant species have developed strategies in response to soil moisture deficits, and strategies across the isohydric/anisohydric spectrum are based on stomatal regulation during soil moisture deficits.

In parallel to climate change, temperate forests in southern Quebec (Canada) are seeing a shift in composition, with understory proliferation of American beech (Fagus grandifolia) saplings in sugar maple (Acer saccharum) in the last fifty years. This understory proliferation could lead to increased competition for water, amplifying the effects of soil moisture deficit on sugar maple.



OBJECTIVES

- 1) Compare the water use strategy of Acer saccharum for two ontogenetic stages (sapling vs mature tree)
- 2) Compare the water use strategy of Fagus grandifolia and Acer saccharum saplings to soil moisture deficit.

METHODOLOGY:

- **Experimental design:**
 - 2 sites with Fagus proliferation and 3 sites without Fagus proliferation
 - For each site: 1 plot with rainfall exclusion treatment and 1 control plot
- **Sapflow density measurement:**
- **Heat pulse sapflow sensor (Implexx Industry)**
- **Sap flow density monitoring from early June to August mid-September 2024**
- Nacer tree: 24, Nacer sapling: 13 and Nfagus tree: 10
- **Monitoring of atmospheric and soil conditions**
 - **Estimation** of relative extractable water from volume water content (VWC, m ³m⁻³)

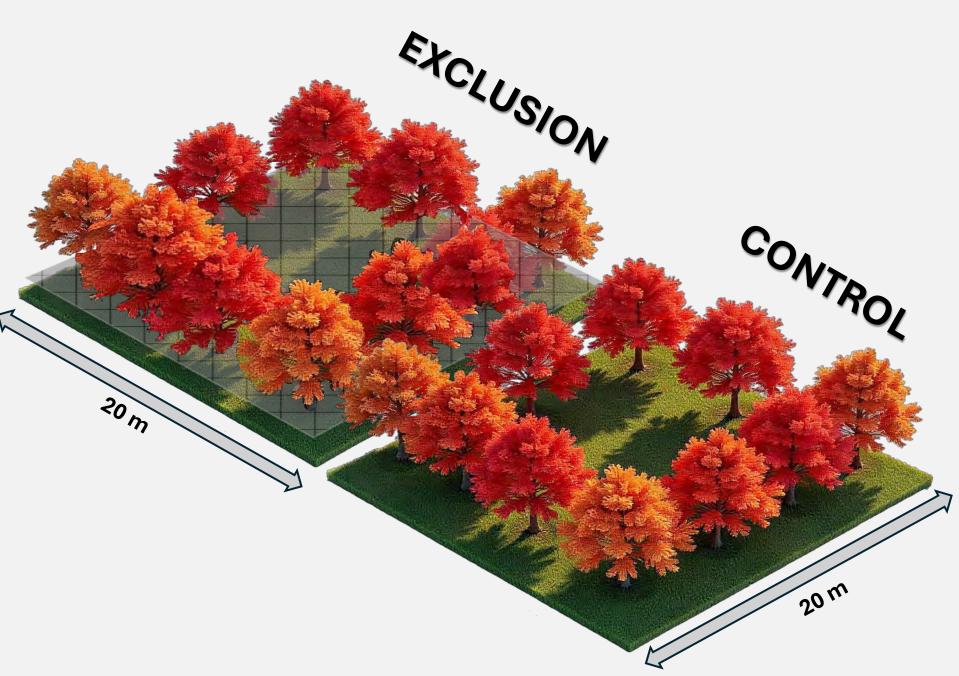
$$REW = \frac{VWC - PWP}{FC - PWP}$$

- **Where FC is the Filed Capacity and PWP is the Permanent Wilting Point**
- Soil VWC measurements taken several times during the summer at a depth of 12 cm
- **Canopy conductance (Gc) estimation :**
 - Estimation of canopy conductance using the equation (Flo et al., 2021)

$$G_c = \frac{115.8 + 0.4236 \, T \, Fd}{VPD} \, \eta \, \frac{T_0}{(T_0 + T)} e^{-0.00012h}$$

Where To is the temperature (°C), Fd is the sapflow density (en kg m⁻² s⁻¹), η is equal to 44.6 mol m⁻³, T is equal to 273 K and h the altitude of each site (m).

Experimental design



- **Leaf water potential:**
- Measurements made with a pressure chamber (model 615 of PMS instrument entreprise)
- For each plot, pre-dawn and midday leaf water potential was measured for 4 saplings (Acer or Fagus) and 3 trees (Acer) on 3 occasions in the summer 2024

Soil moisture deficit

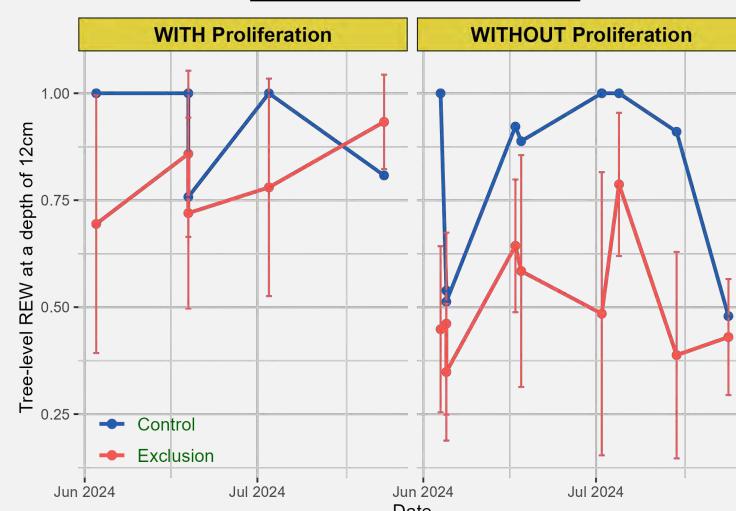


Figure 1: Evolution of relative extractable water (REW) during the summer of 2024 in rainfall exclusion plots and control plot, with and without Fagus grandifolia proliferation. Statistical analysis by Generalized Linear Mixed Model. Values are mean \pm sd.

The results show an absence of soil moisture deficit at a depth of 12 cm in sites with Fagus proliferation. They also show the presence of a soil moisture deficit at a same depth in exclusion plots without Fagus proliferation sites, compared to the control plots. However, this deficit does not intensify over time.

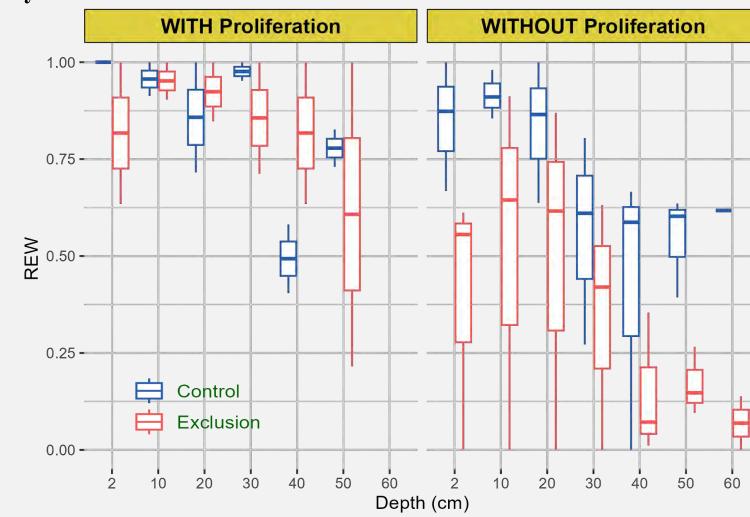


Figure 2: Soil vertical variation of relative extractable water (REW) of rainfall exclusion and control plots, with and without Fagus grandifolia proliferation. Statistical analysis by Generalized **Linear Mixed Model.**

The vertical profile of REW shows that the soil moisture deficit is noticeable at depth.

Response of canopy conductance to soil moisture deficit

The results show that when the soil water availability decreases, Fagus grandifolia saplings regulates transpiration by closing its stomata, while Acer saccharum saplings and Acer saccharum trees keep their stomata open.

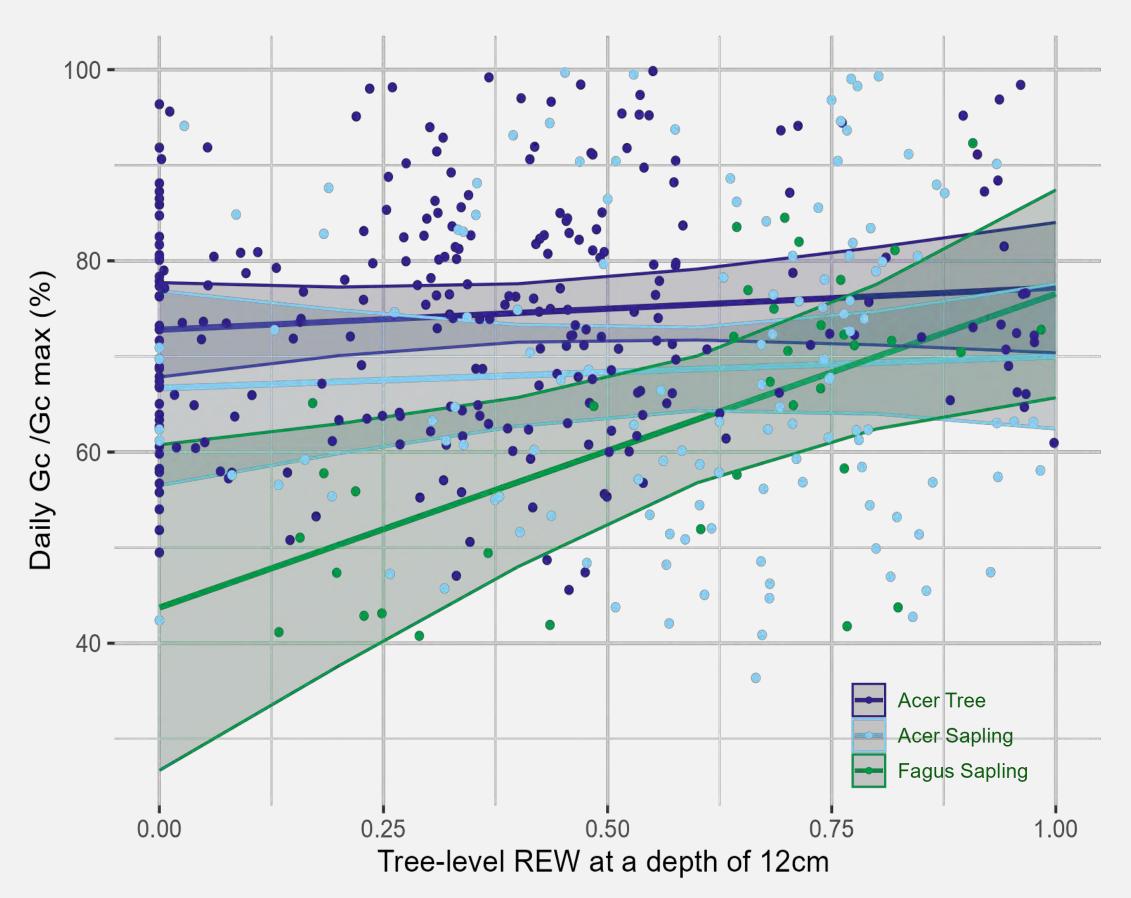


Figure 3: Response of Acer saccharum (Sapling and mature tree) and Fagus grandifolia saplings canopy conductance to soil moisture deficit. Gc max corresponds to the seasonal maximum value of daily Gc at the 90th percentile. Statistical analysis by Generalized Linear Mixed Model. Dot: observed values.

Response of leaf water potential to soil moisture deficit Acer Tree Acer Sapling Fagus Sapling MP

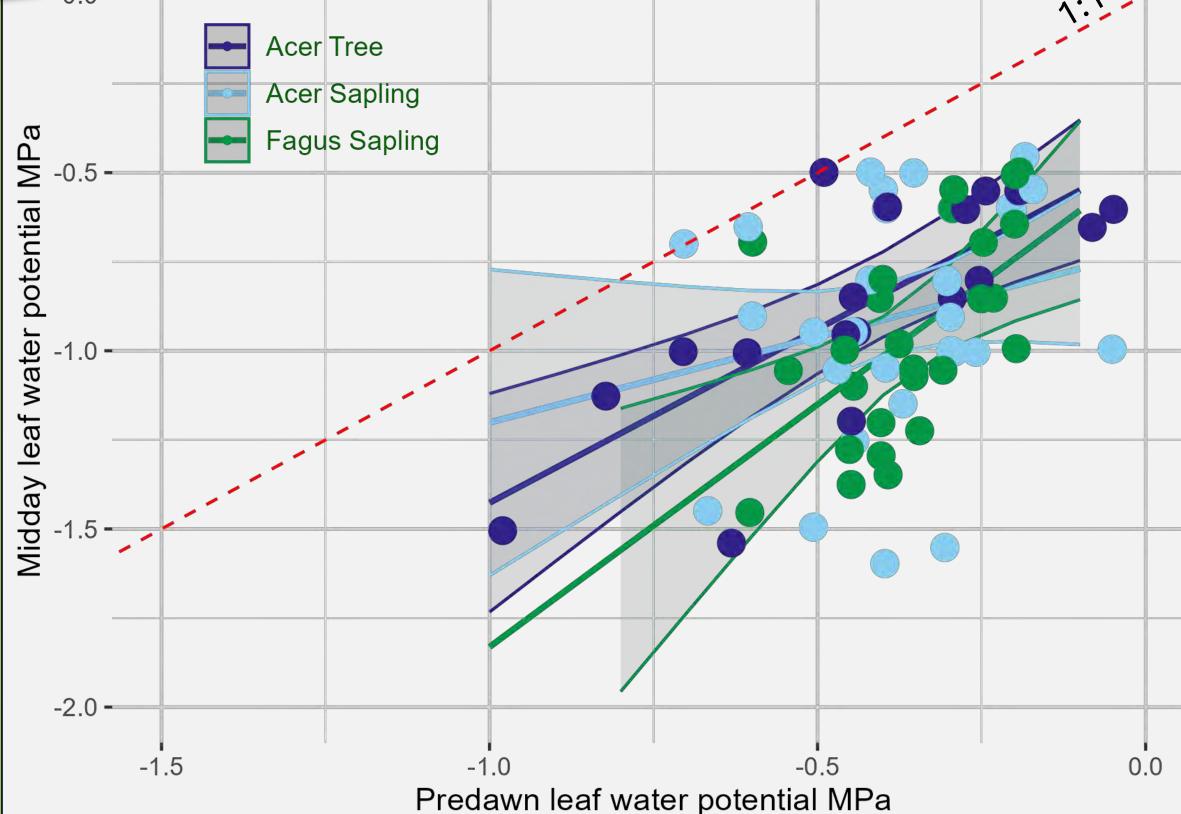


Figure 4: Response of Acer saccharum (Sapling and mature tree) and Fagus Grandifolia saplings leaf water potential to soil moisture deficit. Statistical analysis by Generalized Linear Mixed Model. Dot: observed values.

The results show that the soil moisture deficit on the measurement days was not strong enough to induce a response in leaf water potentials.

In the absence of a soil moisture deficit perceived by the individuals, water use strategies are identical between species.

CONCLUSION AND PERSPECTIVE:

In our study, the results show that in response to a surface soil moisture deficit (12 cm depth), Fagus grandifolia saplings regulate their transpiration, whereas Acer saccharum (sapling and mature tree) do not. Moreover, Acer saccharum's water use strategy remains unchanged between sapling and mature stages. Our study has also highlighted the importance of using different methods to classify species along the iso-anisohydric spectrum.

The findings of our study will contribute to a better understanding of how these species will respond to climate change, and therefore of future changes in forest composition.





