Does a Forest's Age Affect it's Response to Seasonal Drought?

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Introduction

The international panel on climate change (IPCC) has projected increasing mean annual temperature and precipitation and more variability in precipitation for North America (NA) (Pachauri, 2008), which can result in more dry spells.

Given the importance of temperate forests as carbon sinks and weather moderators, it is important to learn more about the potential impacts of climate change and extreme weather events such as drought. The variability of forest plantation ages poses the question of whether older or younger stands react differently.

Methods

Study sites

The two white pine stands (*Pinus Strobus* L.), planted in 1939 (TP39) and 1974 (TP74), part of McMaster's Turkey Point Field Station, are located adjacent to one another in Simcoe, ON. Each have an eddy covariance tower system that extends above the canopy.

	TP39	TP74
Stem density (trees/ha)	321±111	1583 ± 118
Tree BA (m^2)	0.12 ± 0.01	0.025 ± 0.002
Tree biomass (kg/tree)	547±170	122±101
Belowground biomass (kg/tree)	99 ± 40	17±14
Foliage (kg/tree)	10.0±8.5	7.0±8.5
Leaf area index (m^2/m^2)	5.5	6.6

Ecosystem flux measurements

•Fluxes of momentum, latent heat (LE), sensible heat, and CO_2 (Fc) have been measured continuously following FLUXNET protocol since 2008 using a closed path eddy covariance system

Supplementary measurements

•Meteorology
•Sapflow (following Granier, 1987)
•Soil (at depths of 2, 5, 10, 20, 50, and 100cm)
•Water table depth at TP39

Results & Discussion

A Palmer Drought Severity Index constructed for the region indicated a **severe drought in the 2012 growing season.** This was reflected by the P-ET balance (figure 1) when compared to the wetter 2013.

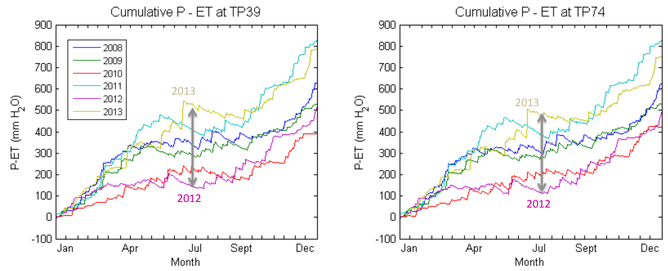

Figure 1: Precipitation minus evapotranspiration water balance

ET had a fairly consistent annual pattern, contrasting with the **variable sapflow velocity (Js)** (figure 2), which shows rate of transpiration (T). TP74 had **longer and lower depressions in Js** during dry periods.

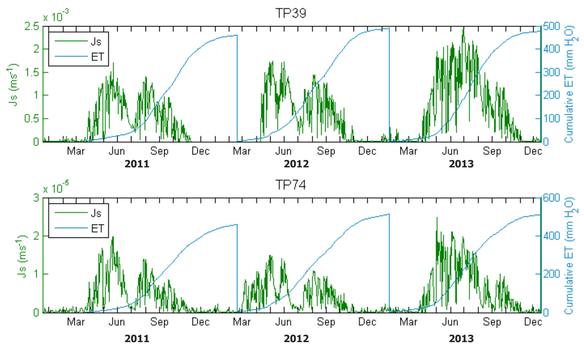

Figure 2: Sapflow velocity (Js) and cumulative evapotranspiration

Soil moisture was consistently lower at TP74 (figure 3), reflecting the high demand that is expected with the stand requiring sufficient water and nutrient intake via fine (<2mm) roots to accommodate foliage growth (Peichl, 2007).

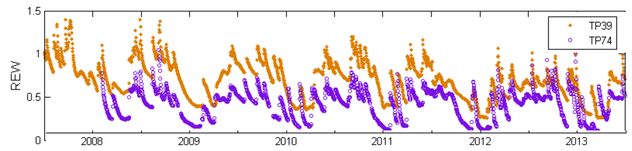

Figure 3: Relative extractable water at 95-105 cm depth

Results & Discussion

Multivariate analysis sought to model bulk surface conductance (*Gs*) using environmental variables to find those of greatest influence both throughout 2008-2013, and in the 2012 versus 2013 years (Table 2).

	2008-2013	2012 (Dry)	2013 (Wet)
TP39	1. VPD (-) 2. downPAR (+) 3. Year 2011 (-)	**1. SM Deep (+)**	1. VPD (-) 2. downPAR (+) 3. Month of May (-)
TP74	1. VPD (-) **2. SM Shallow (+)** 3. downPAR (+) 4. Ta (+)	**1. SM Deep (+)** 2. VPD (-)	1. VPD (-) **2. SM Deep (+)** 3. downPAR (+)

Table 2: The ranking of model components, using stepwise modeling, all with a p value of <0.05. The sign of the relationship coefficient is in brackets.

Conclusions & Future Work

- Compared to TP39, more of the younger TP74 forest's functional roots are in a shallower depth that is subject to drying via evaporation. This may lead to the **increased drought sensitivity**.
- **Age related factors** (i.e. root depth and foliage biomass) appear to contribute to a stronger transpiration decrease in response to drought in the younger white pine plantation.
- Given the forecast of more variability in precipitation, this study shows that the age of biological carbon sinks play a role in their drought tolerance.
- **Future work** will focus on the interactions between tree temperature, sapflow and root-flow, and also examine the current root distributions

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