Inter-annual Differences in the Transpiration of Sugar Maple in Response to Experimental Warming and Irrigation

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Introduction

• Mean annual temperature is expected to increase 3-5°C in the Upper Midwestern USA by 2100 (Kunkel et al., 2013).
• Sugar maple (Acer saccharum), an economically important timber and syrup species, is not expected to do well under current climate projections (Prasad et al., 2007).
• Crown dieback, likely related to decreased water availability, is increasing in the region and could be exacerbated further by warming (Horsley et al., 2002).

Objective and Hypotheses

• Objective: Investigate the effects of experimental infrared soil warming and irrigation on the transpiration of sugar maple.
• H1- Transpiration will decrease with heating-only due to increased soil evaporation
• H2- Transpiration will increase with water-only due to increased soil moisture
• H3- Transpiration will not change with heat+water due to the balance of heating induced evaporation and watering

Methods

• Transpiration was measured in summer 2011 - 2013 at the Ford Forest in Alberta, Michigan.
• Heat dissipation sap flow sensors (Fig.2) were used in 33 trees at variable sapwood depths in eight 100 m² plots (2-6 trees/plot) with two reps in each of four treatments:
  1. Heat-only (+ 4-5 °C ambient soil temperature; Fig. 1)
  2. Water-only (+ 30% ambient precipitation)
  3. Heat + water
  4. Control (No infrastructure)

Results – Tree Level

- 2011: H1-H3 supported
  • Significant heat, water, and heat+water interaction effects (Figs. 3a & 4).
- 2012: H1 only supported
  • Significant heat effect
  • Both the heat-only and heat+water treatments had similar decreased levels of water use when compared to the control (Figs. 3b & 4).
- 2013: H1 and H3 supported
  • Significant heat and water interaction effect
  • All treatments with heat had decreased sap flow rates relative to control.
  • Overall, water addition caused significant increased sap flux rates over treatments with heat (Figs. 3c & 4).

Results – Stand Level

- 2011: When upscaled to stand level H1-H3 supported; significant heat, water, and heat+water interaction effects (Fig. 5).
- 2012: H1 only supported; significant heat effect, both heat-only and heat+water treatments had decreased levels of water use when compared to control (Fig. 5).
- 2013:H1 and H3 supported; significant heat and heat + water interaction effect, all treatments with heat had decreased sap flux rates relative to control. Overall, water addition caused significant increased sap flux rates over treatments with heat (Fig. 5).

Conclusions

• Interannual variation in effect size likely due to variation in growing season precipitation; 2012 was dry and 2013 was wet.
• Increased temperature alone (heat+water treatment) had minimal effects on transpiration rates of sugar maple when precipitation was normal.
• Increased temperature alone had decreased transpiration when precipitation was low likely due to decreased soil moisture.
• Warming-induced drought effects could exacerbate sugar maple sensitivity to climate change and potentially decrease sugar maple productivity and health on drier sites within its current range.

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References