Evaluating Patterns and Drivers of Leaf Water Use Efficiency with Ontogeny in Eastern Deciduous Forests of New York State

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Motivation: *What is the current state of model representation of seasonality?*

Research paper

Seasonal trends in photosynthesis and leaf traits in scarlet oak

Angela C. Burnett[1,2,3], Shawn P. Serbin[1], Julien Lamour[1], Jeremiah Anderson[1], Kenneth J. Davidson[1], Dedi Yang[1] and Alistair Rogers[1]

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Effects of seasonal variation of photosynthetic capacity on the carbon fluxes of a temperate deciduous forest

David Medvigy,[1] Su-Jong Jeong,[1] Kenneth L. Clark,[2] Nicholas S. Skowronski,[3] and Karina V. R. Schäfer[4]

Received 17 June 2013; revised 14 November 2013; accepted 16 November 2013.

RESEARCH ARTICLE

Photoperiodic regulation of the seasonal pattern of photosynthetic capacity and the implications for carbon cycling

William L. Bauerle, Ram Oren, Danielle A. Way, Song S. Qian, Paul C. Stoy, Peter E. Thornton,...
+ See all authors and affiliations

PNAS May 29, 2012 109 (22) 8612-8617; https://doi.org/10.1073/pnas.1119131109

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Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

ELSEVIER

Original Articles

Water use efficiency in response to interannual variations in flux-based photosynthetic onset in temperate deciduous broadleaf forests

Jiaxin Jin[a], Wenfeng Zhan[a], Ying Wang[b], Baojing Gu[c], Weifeng Wang[d], Hong Jiang[a,*], Xuehe Lu[a], Xiuying Zhang[a]

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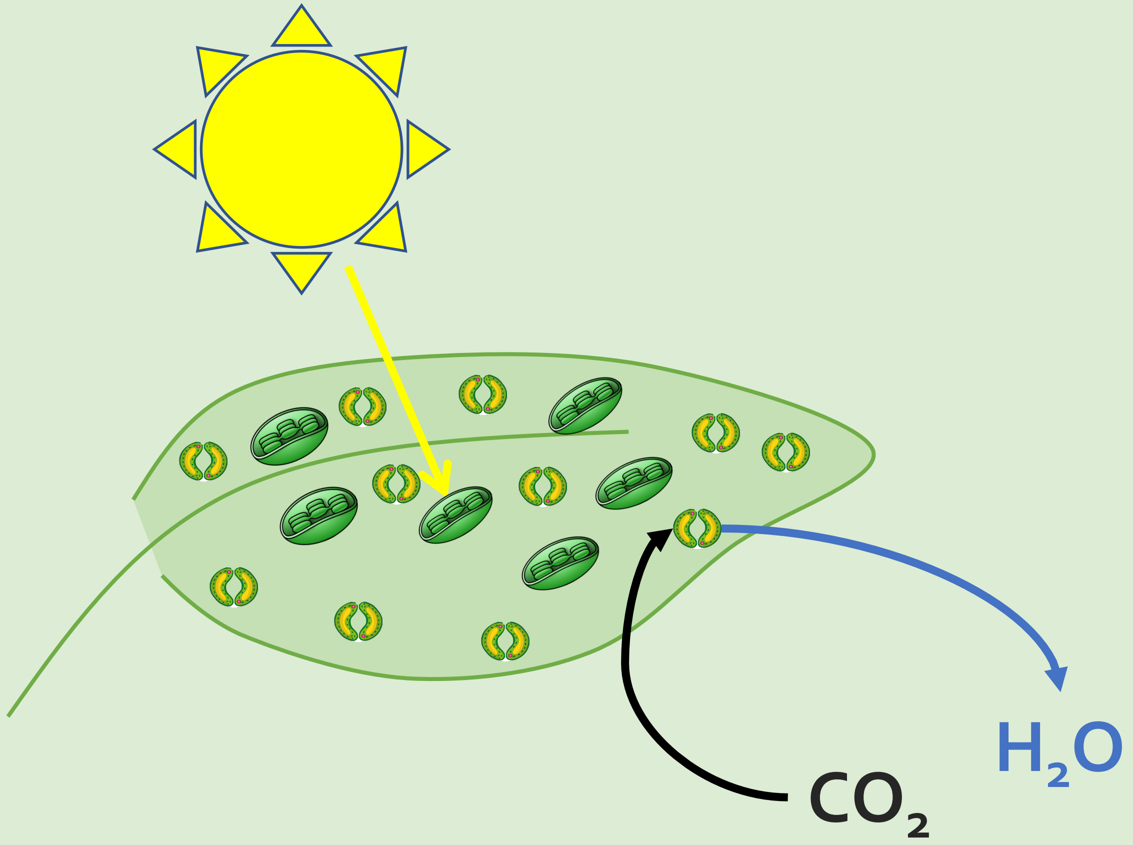
[b] Nanjing Institute of Geography & Limnology, Chinese Academy of Sciences, Nanjing, Jiangsu, China
[c] Department of Land Management, Zhejiang University, Hangzhou, Zhejiang, China
[d] College of Biology and the Environment, Nanjing Forestry University, Nanjing, Jiangsu, China

Background: *Leaf level models*



- **Photosynthesis model (FvCB)**

$$A_n = min(A_c, A_j) - R_{dark}$$

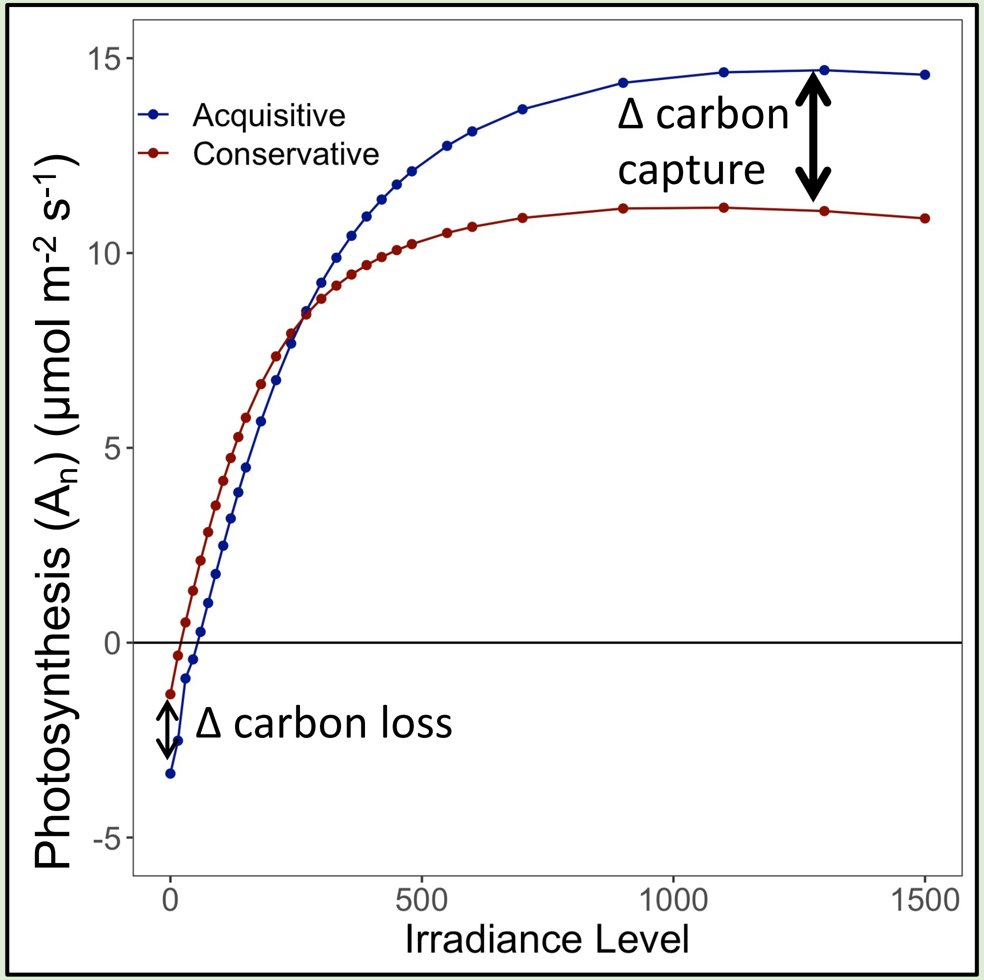
V_{cmax} → A_c, J_{max} → A_j

- **Conductance model (USO)**

$$g_s = g_0 + 1.6 \left(1 + \frac{g_1}{\sqrt{D}}\right)\frac{A_n}{C_a}$$

Background: *Photosynthetic capacity*

- $A_n = min(A_c, A_j) - R_{dark}$
- $min(A_c, A_j)$: dictates carbon capture
  - V_{cmax} → A_c; J_{max} → A_j
- R_{dark}: dictates respiration loss of carbon

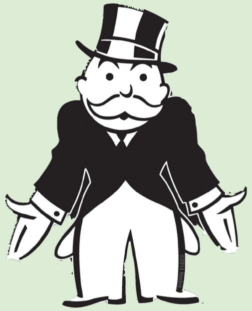


Background: *Stomatal optimality*

- Optimality theory predicts that…
  - Plants maximize carbon gain with respect to water loss (WUE)
  - Carbon has a cost in terms of water

Profligate VS **Conservative**

(Low WUE) (High WUE)



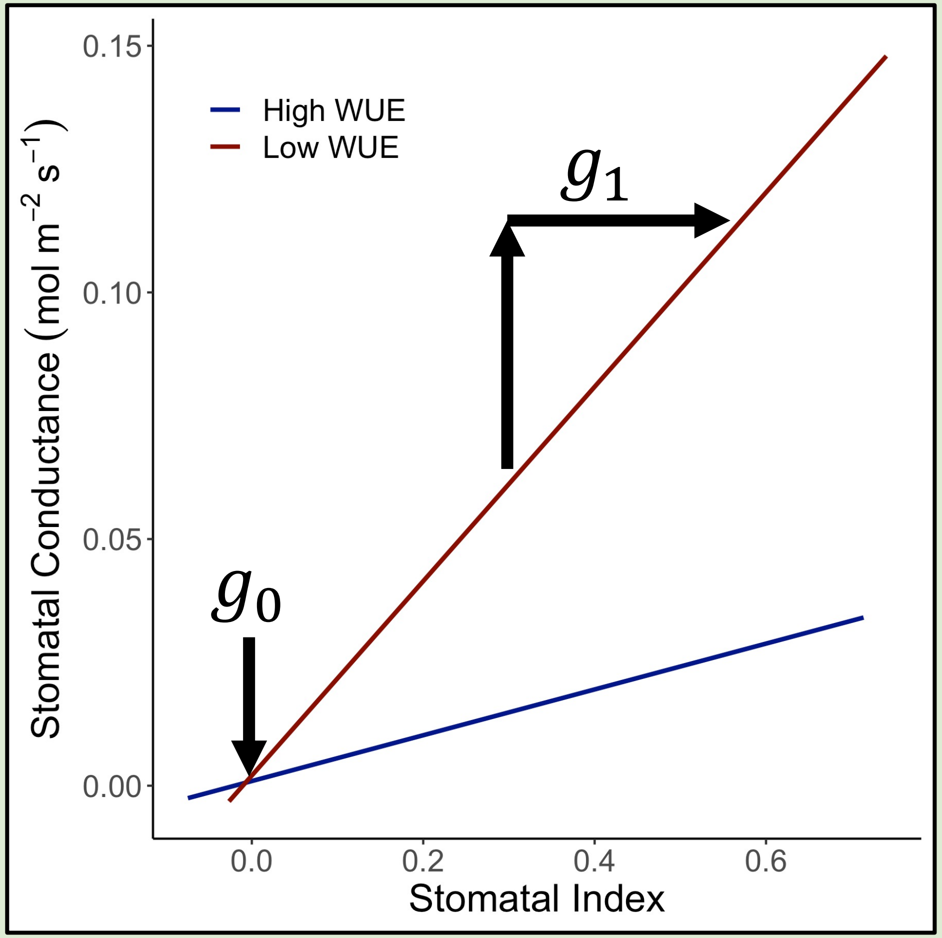
Background: *Stomatal optimality*

g_1

- Slope of relationship between the stomatal index and g_s
- Inversely proportional to WUE

g_0

- g_s when A_n is 0
- Minimum g_s in the light



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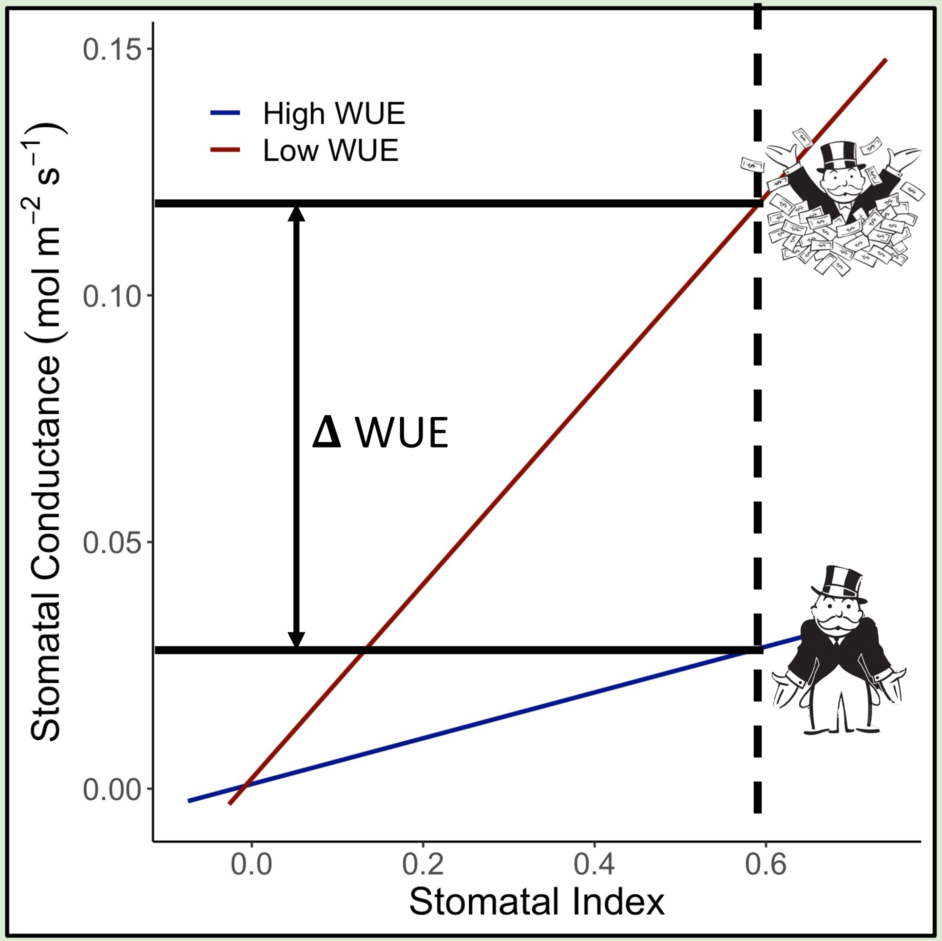

Motivation: *Why does this matter?*

New Phytologist

Viewpoints | Free Access

A roadmap for improving the representation of photosynthesis in Earth system models

Alistair Rogers, Belinda E. Medlyn, Jeffrey S. Dukes, Gordon Bonan, Susanne von Caemmerer, Michael C. Dietze, Jens Kattge, Andrew D. B. Leakey, Lina M. Mercado, Ülo Niinemets, I. Colin Prentice, Shawn P. Serbin, Stephen Sitch, Danielle A. Way, Sönke Zaehle ... See fewer authors

First published: 28 November 2016 | https://doi.org/10.1111/nph.14283 | Citations: 158

"We need to elucidate the mechanism underlying the use of photoperiod scalars to modify photosynthetic parameterization."
-Rogers *et al.* (2017)

JGR Biogeosciences

Research Article | Free Access

A quantitative assessment of a terrestrial biosphere model's data needs across North American biomes

Michael C. Dietze, Shawn P. Serbin, Carl Davidson, Ankur R. Desai, Xiaohui Feng, Ryan Kelly, Rob Kooper, David LeBauer, Joshua Mantooth, Kenton McHenry, Dan Wang

First published: 05 February 2014 | https://doi.org/10.1002/2013JG002392 | Citations: 60

"…uncertainties surrounding water relations are more important for understanding and predicting carbon fluxes than the uncertainties surrounding most of the carbon fluxes themselves."
-Dietze *et al*. (2014)

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Water use efficiency in response to interannual variations in flux-based photosynthetic onset in temperate deciduous broadleaf forests

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[b] *Nanjing Institute of Geography & Limnology, Chinese Academy of Sciences, Nanjing, Jiangsu, China*
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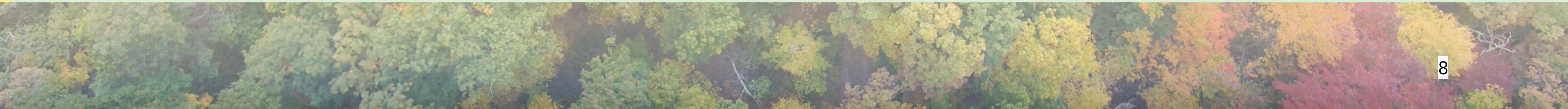
"Here, we argue that phenology, which exerts critical biotic control over most ecological processes, plays a larger role than expected in the regulation of the seasonal WUE and cannot be ignored in earth system models."
–Jin *et al.* (2017)

<u>Our models are only as good as our weakest assumptions</u>

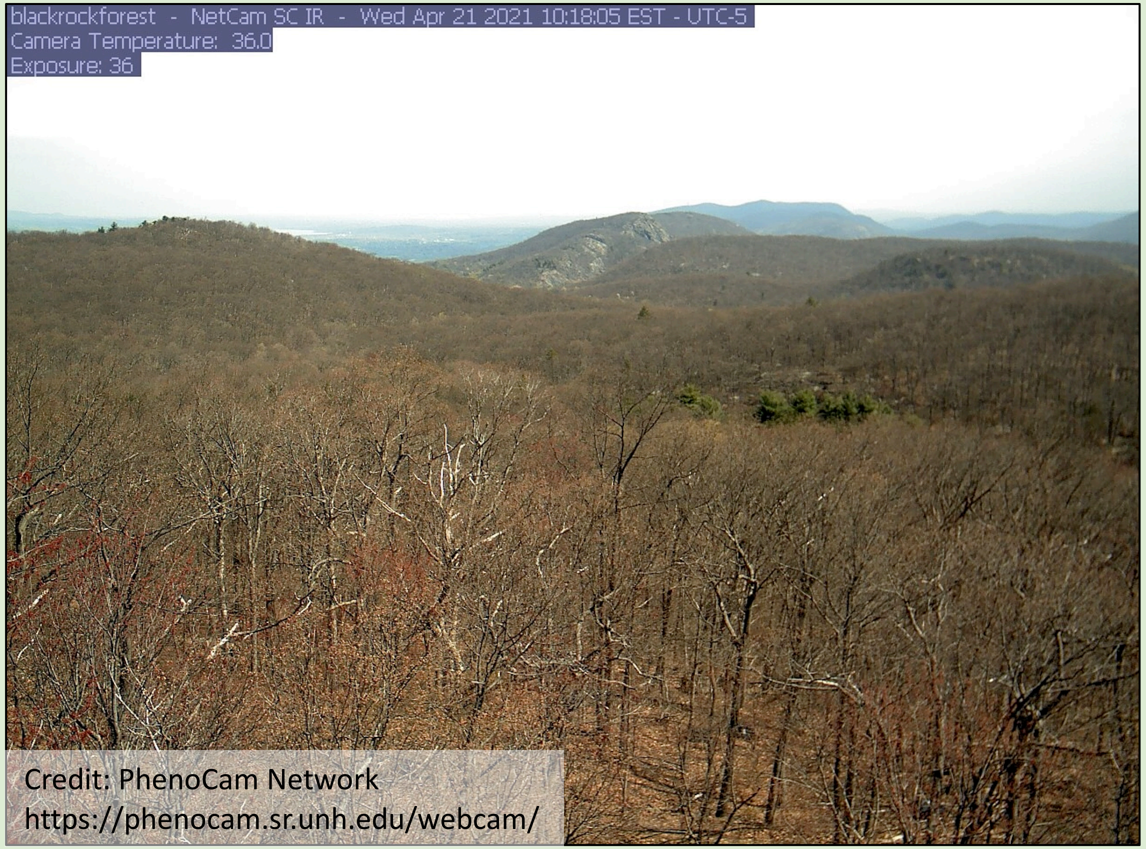


Research Questions:

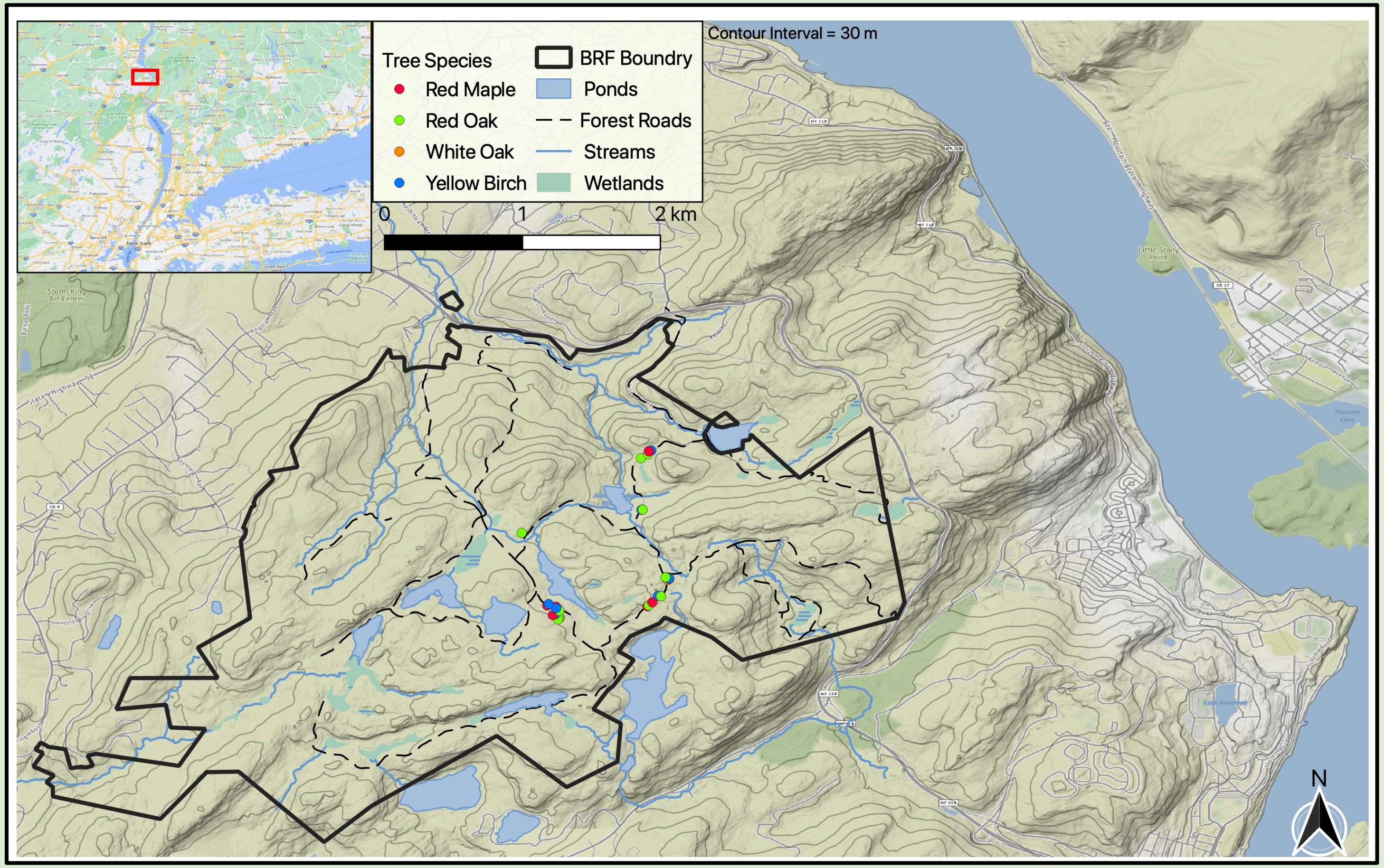
- What are the seasonal patterns of WUE and photosynthetic capacity?

- What are the biotic mediators of these patterns?

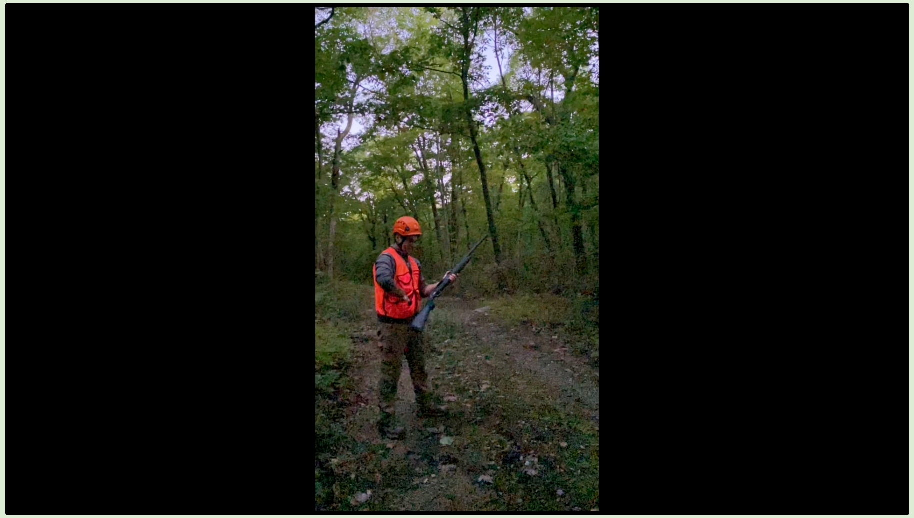
- How does a seasonal parameterization of leaf WUE and photosynthetic capacity impact the modeling of *E* and NPP?



Methods: *Study site*



Methods: *Canopy access*



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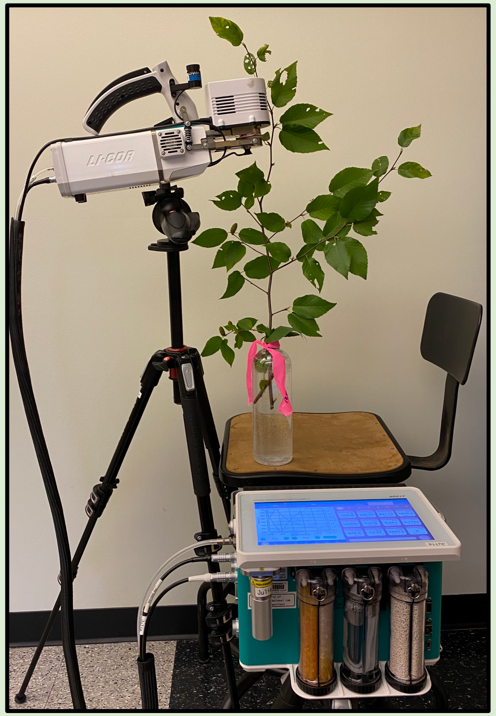
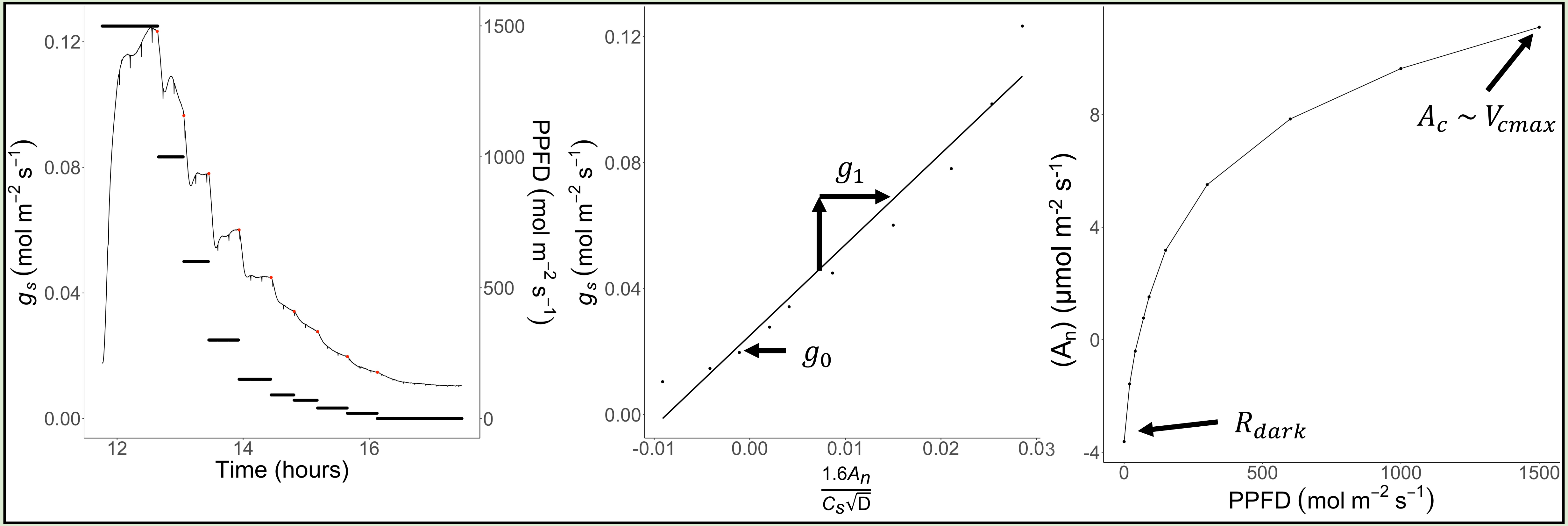
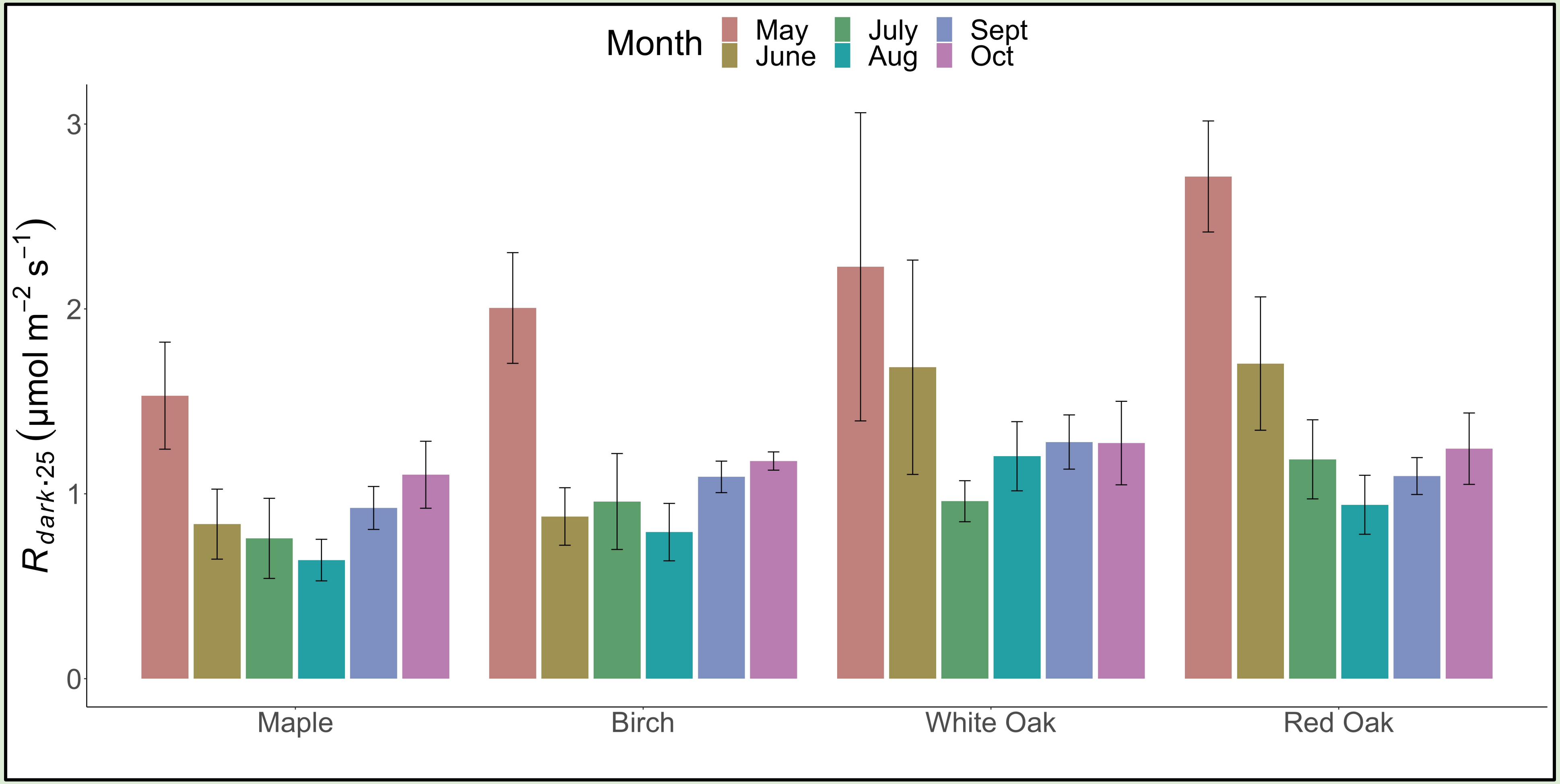


Methods: *Gas exchange*



Results: *Dynamics of Photosynthesis*



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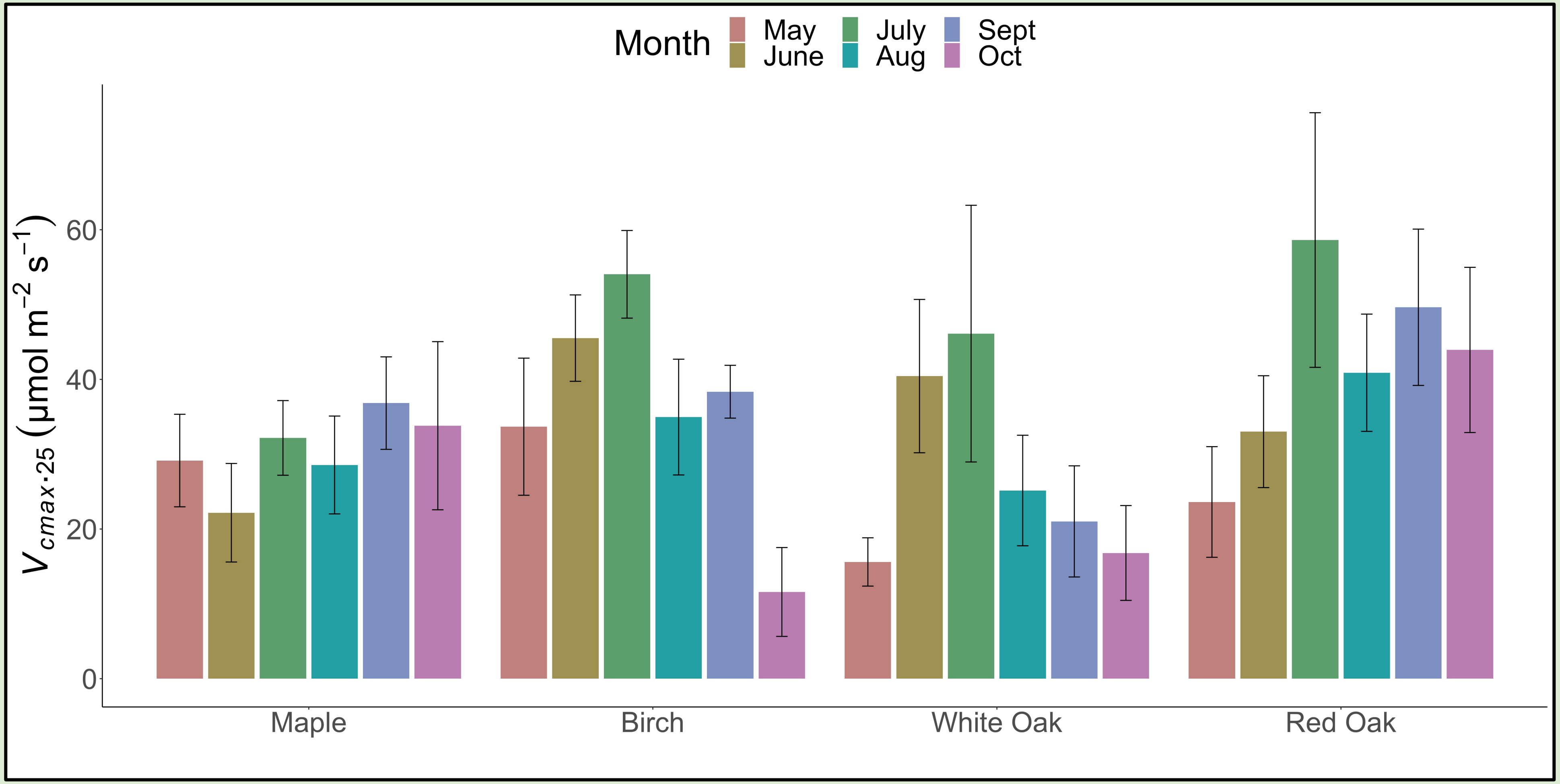
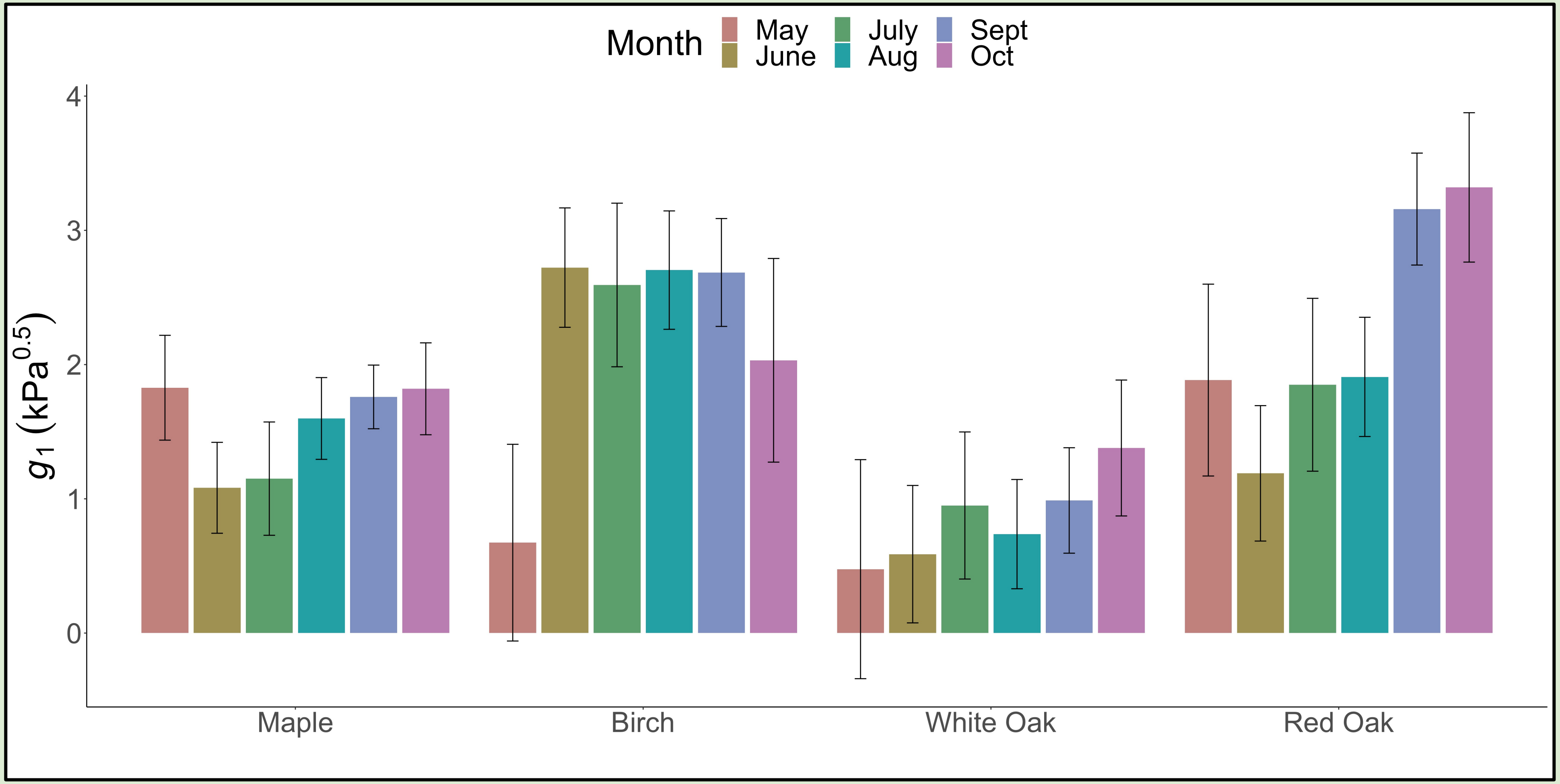
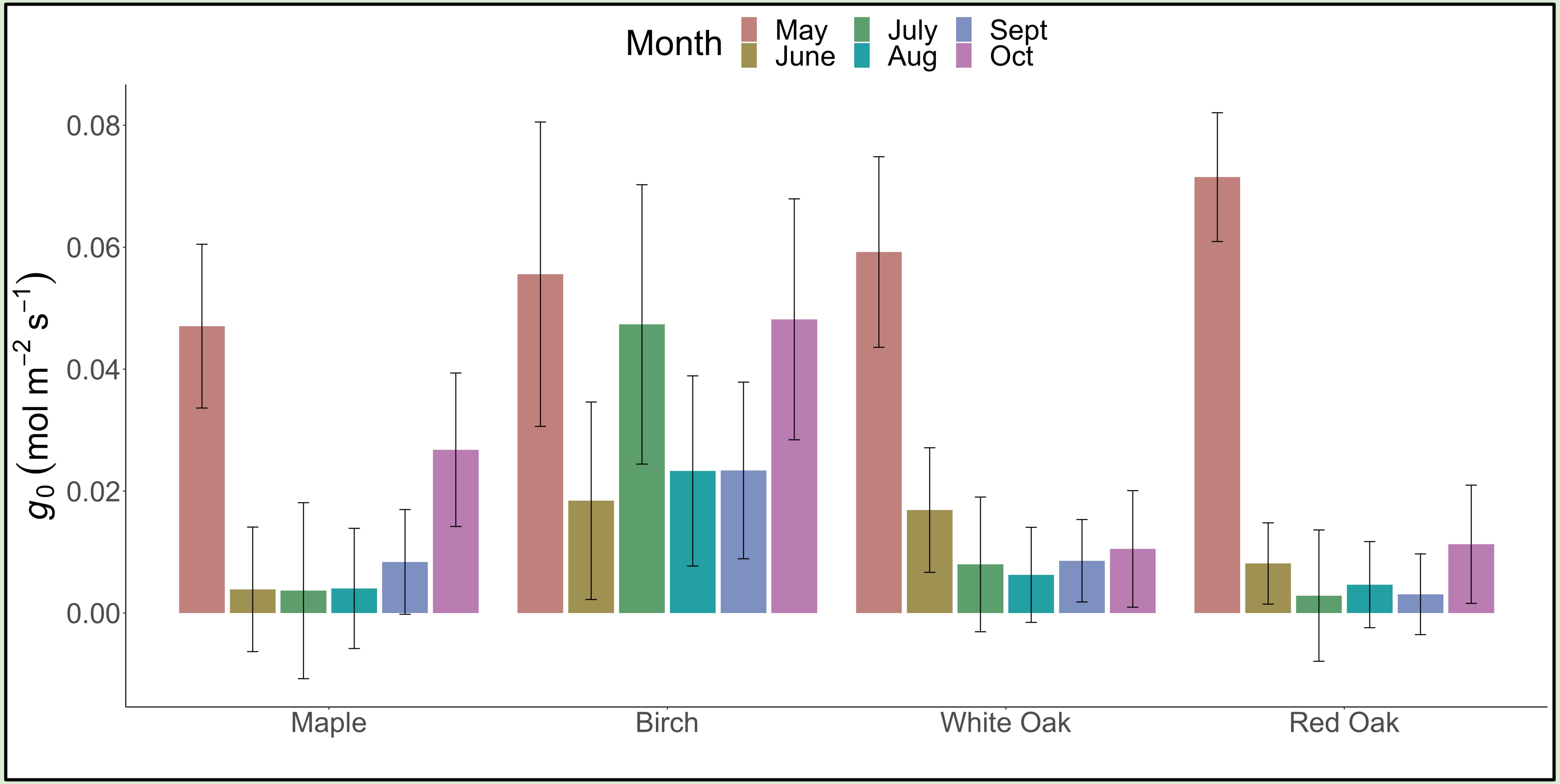


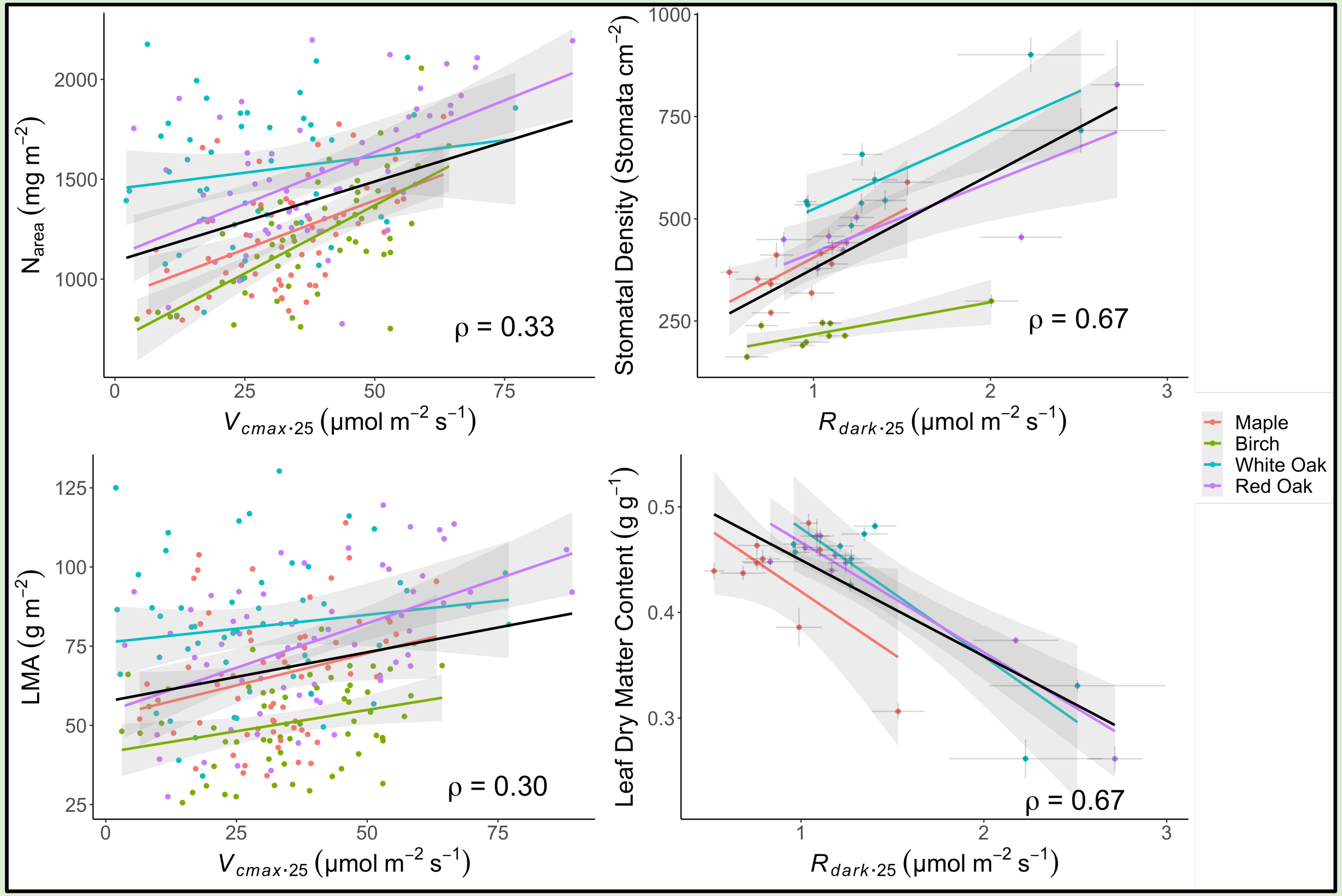
Results: *Dynamics of WUE*



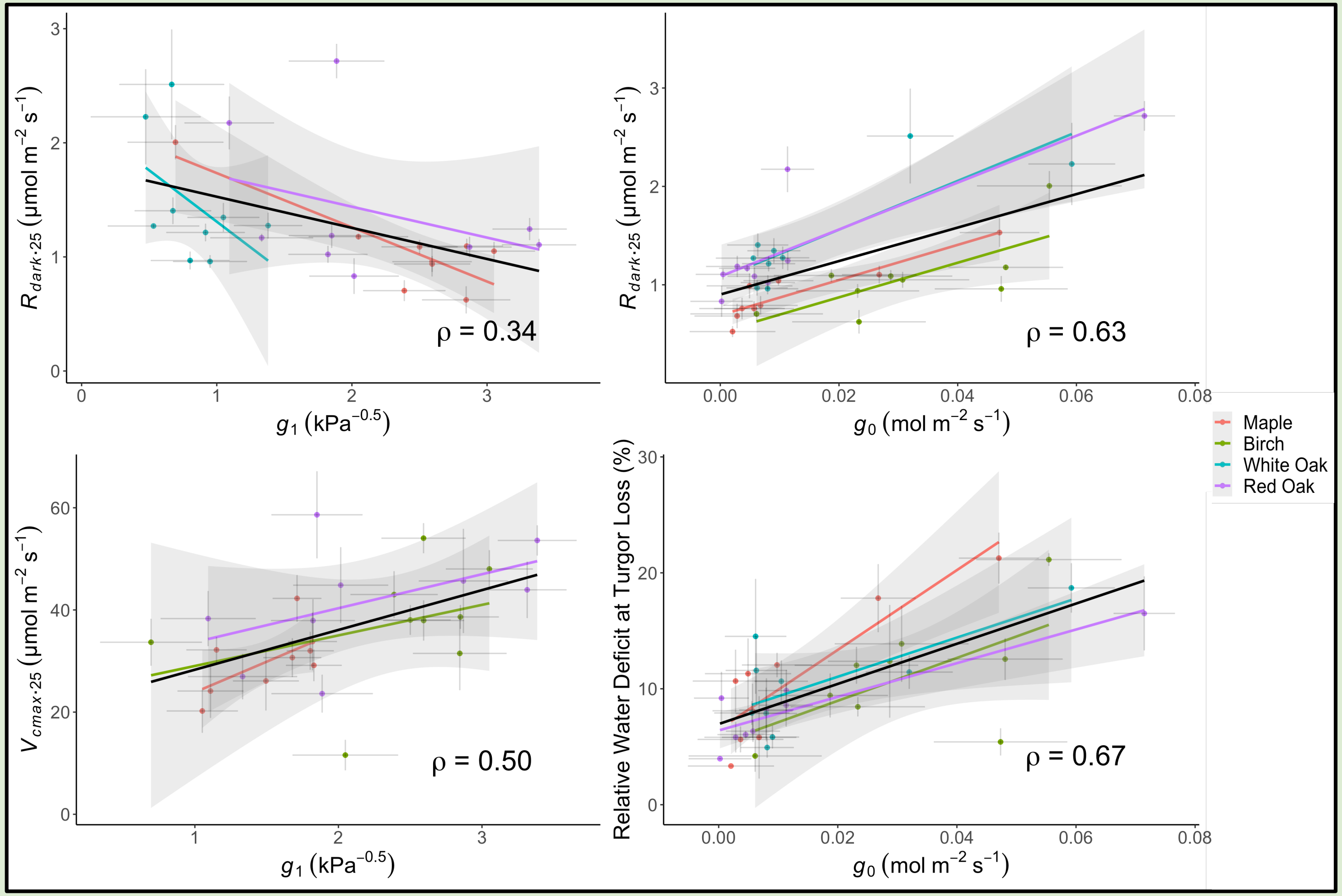
Results: *Dynamics of WUE*



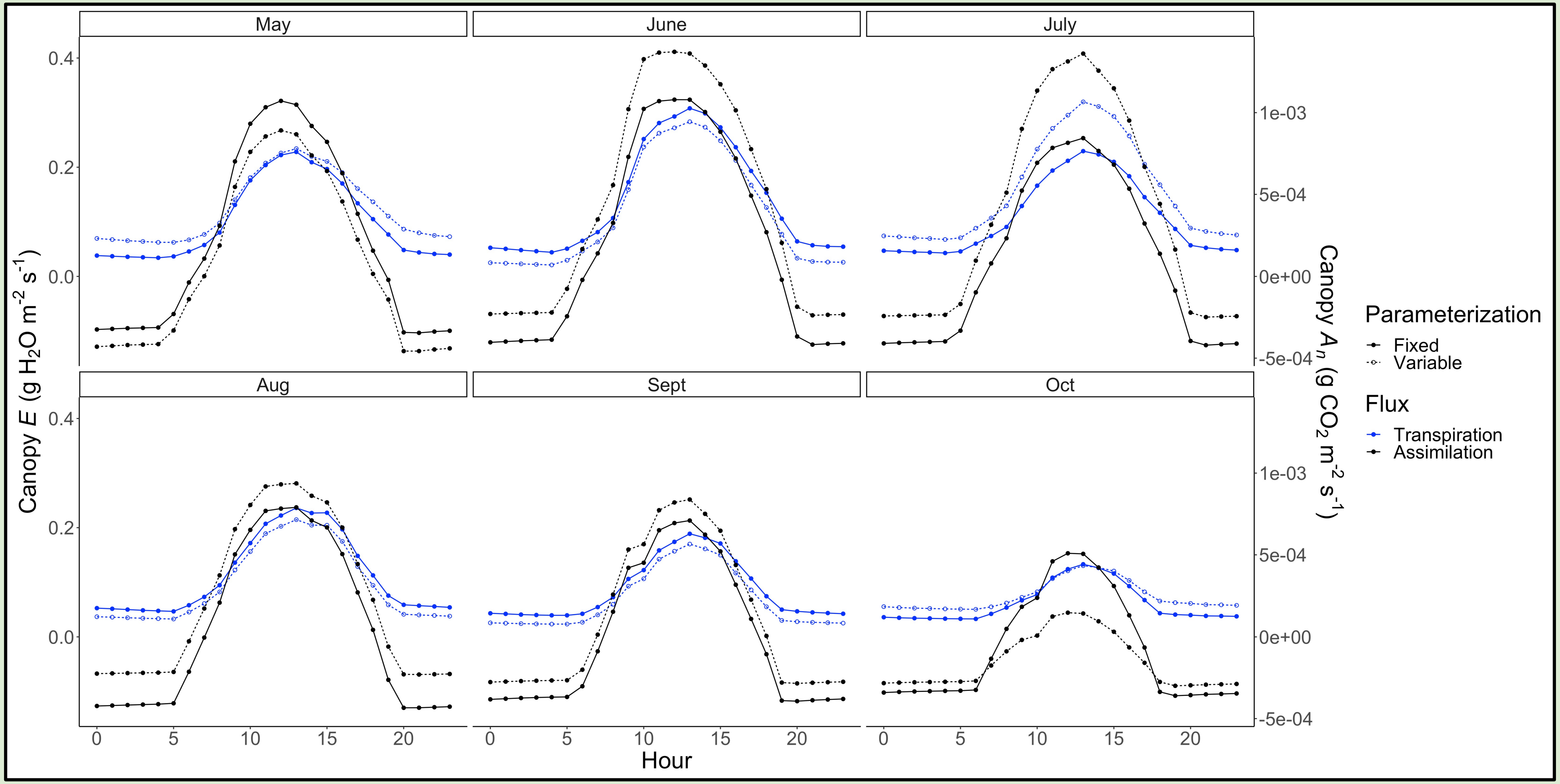
Results: *Biotic mediators of photosynthesis*



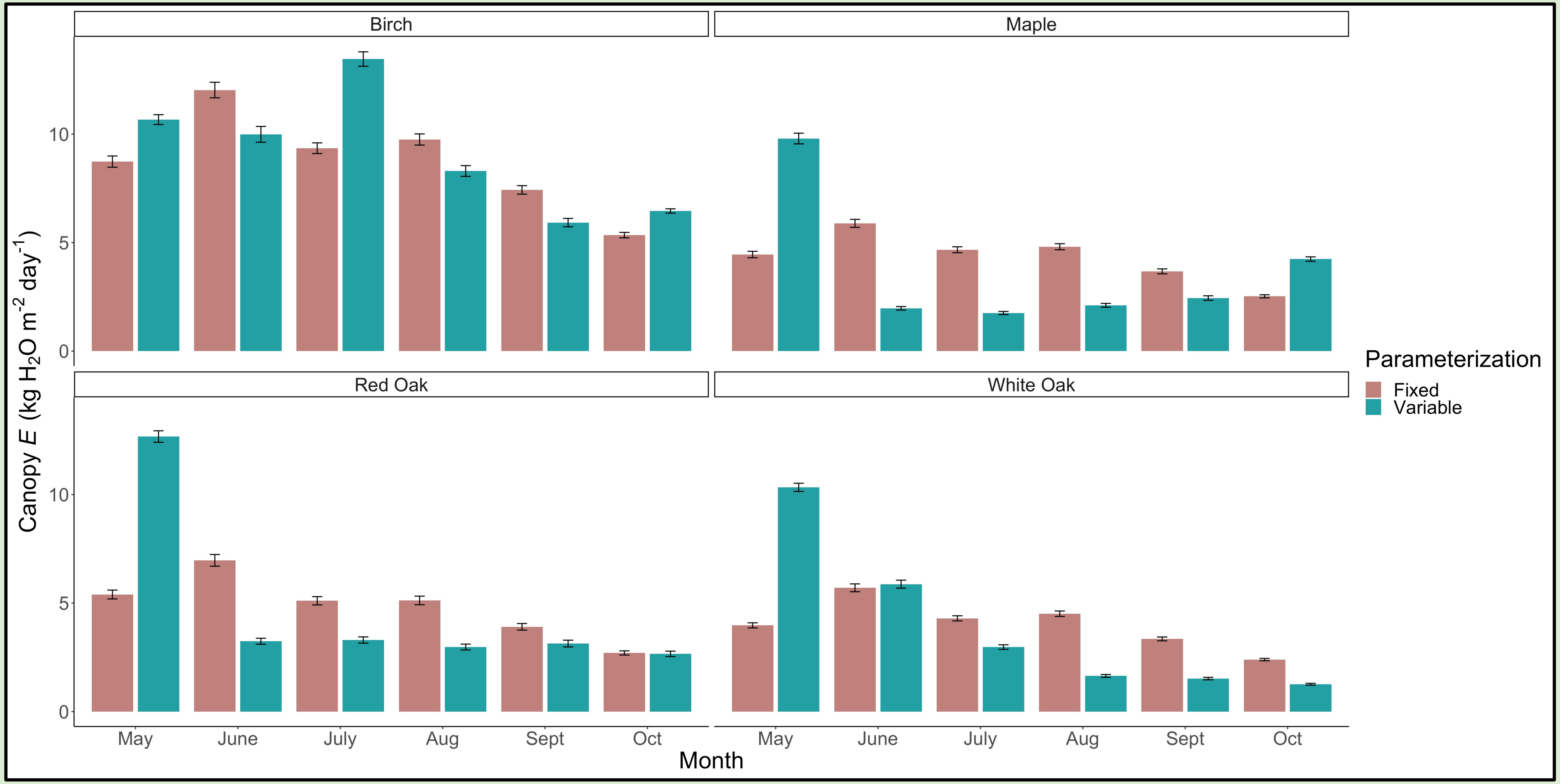
Results: *Biotic mediators of WUE*



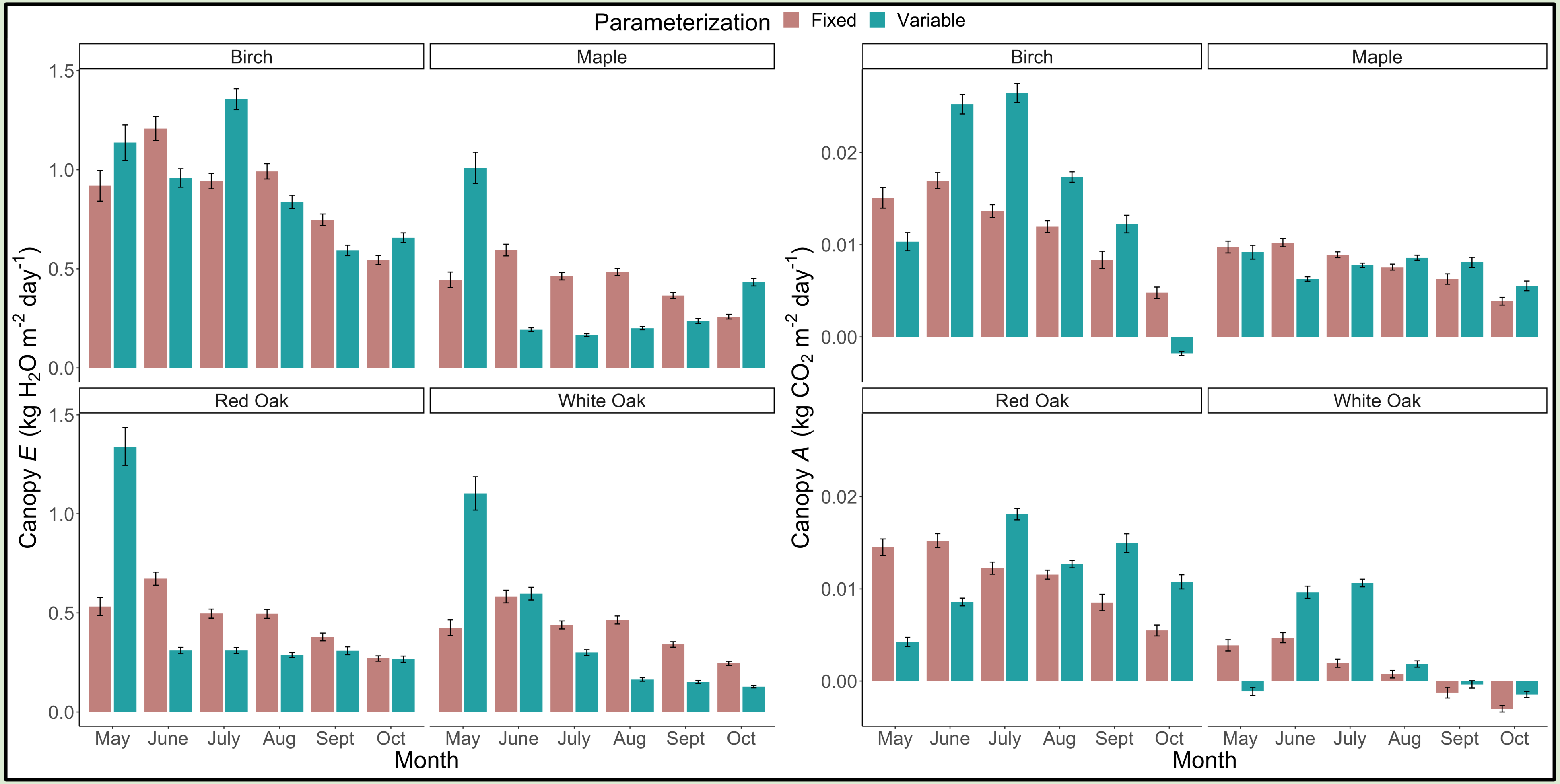
Results: *Diurnal patterns*



Results: *Seasonal patterns*



Results: *Seasonal patterns*



Using fixed values…

- 3% lower estimate of assimilation
- 16% lower estimate of transpiration

Implications: *Why does this matter?*

New Phytologist

Viewpoints | Free Access

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First published: 28 November 2016 | https://doi.org/10.1111/nph.14283 | Citations: 158

JGR Biogeosciences

Research Article | Free Access

A quantitative assessment of a terrestrial biosphere model's data needs across North American biomes

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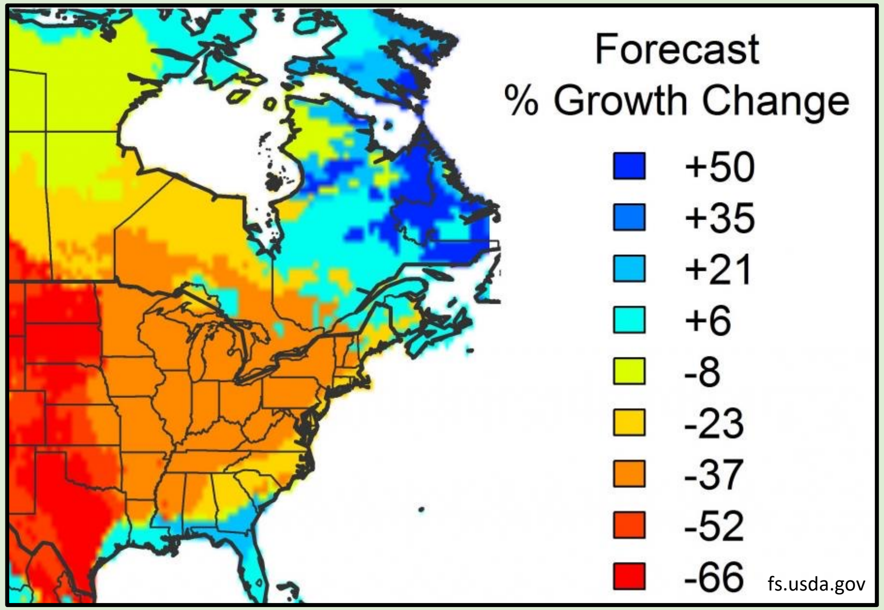

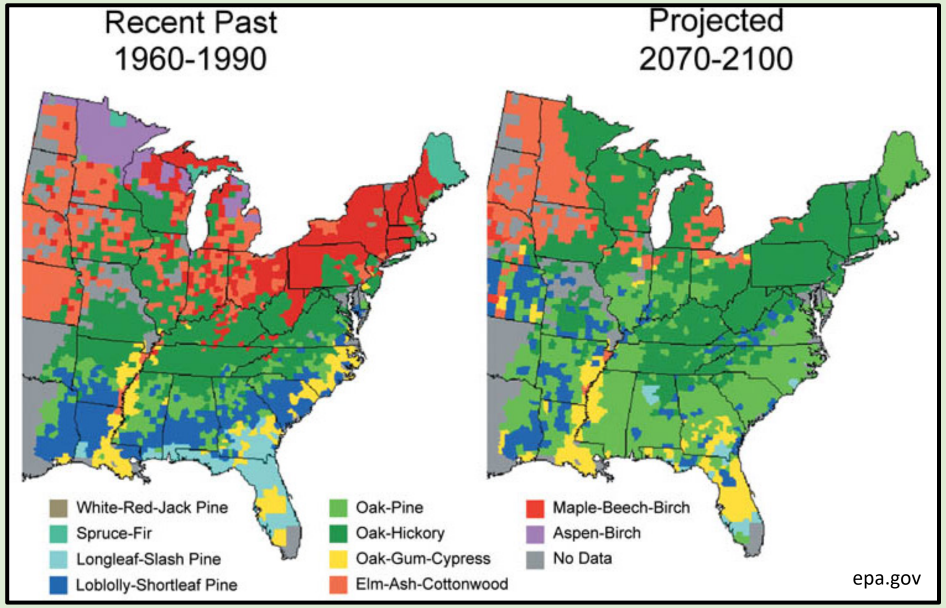

"In New York, habitat for red maple (*Acer rubrum*) and sugar maple (*Acer saccharum*) would decline substantially but not disappear, while most of the habitat is projected to disappear for yellow birch (*Betula alleghaniensis*).... Species with a high possibility of dramatic increases include several oak species" –USFS Climate Change Atlas

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Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY
Office of Science

Next-Generation Ecosystem Experiments-Tropics

Stony Brook University

Questions?

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