Predicting Growth in Michigan Tree Species Using Climatic and Physiological Data

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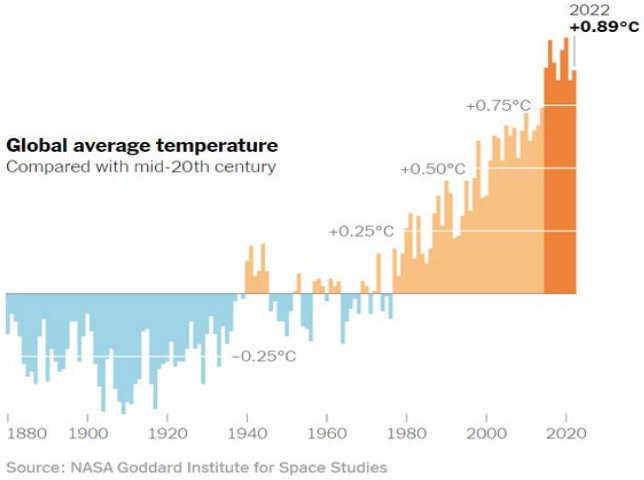
Intro and Relevance

- Predicting tree growth is valuable
  - Resilient forests
  - Silviculture
  - Changes in range
  - Species composition and tolerance
- Climate change



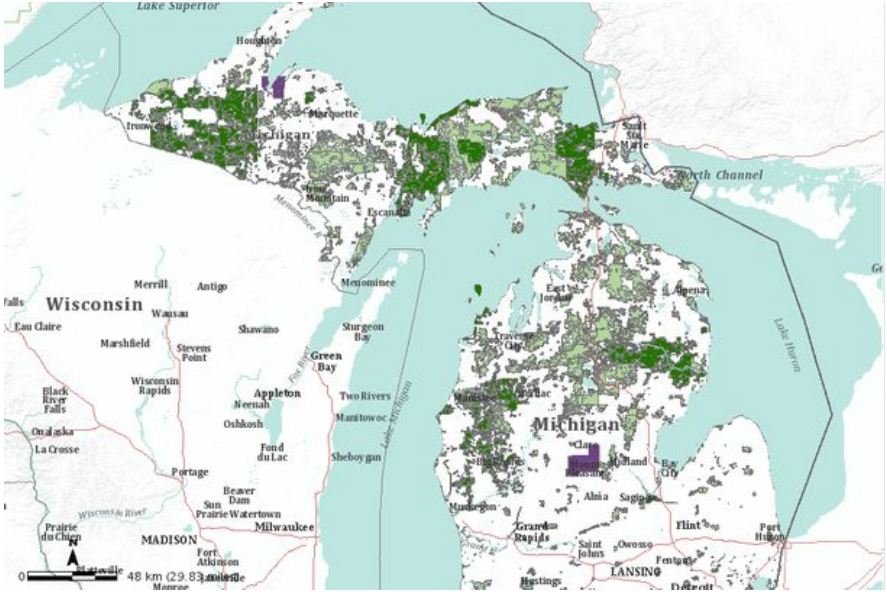
New York Times

Detroit Free Press

Current Research and Knowledge Gap

- Modeling species specific growth
- Explore species suitability and successionary directions

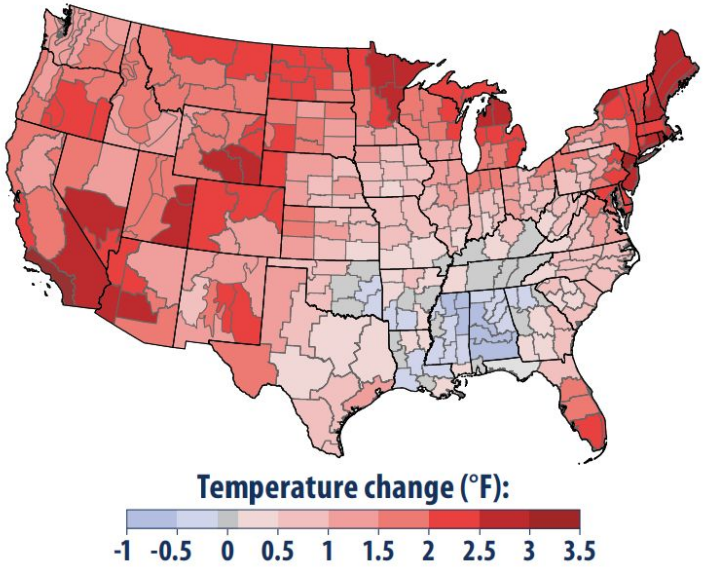
https://nature-mentor.com/



https://databasin.org/

Driving Question

How do increasing temperatures due to climate change affect growth in different tree species in Lower Michigan?



epa.gov

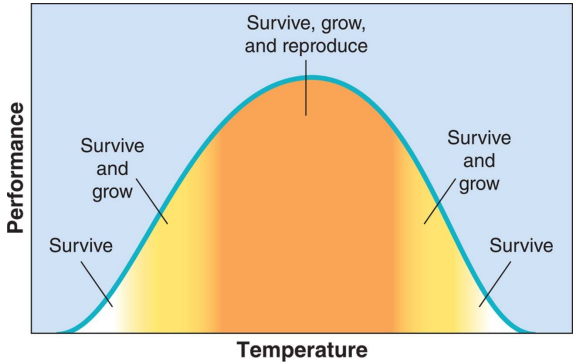


Figure 17.1
Friedland, *Environmental Science for AP®*, 2e, © 2015 W.H. Freeman and Company

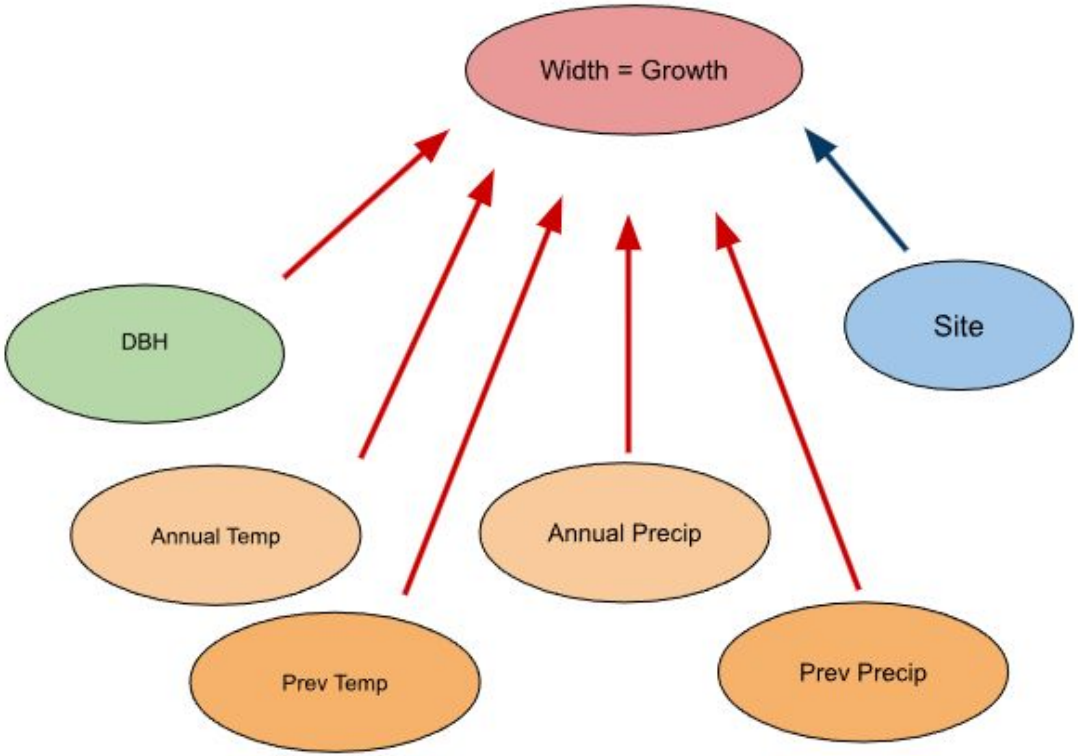
Data and Methods

- Tree cores
- 1980-2017 width measured over the years
  - DBH is used to normalize tree growth across levels of maturity/age
- Multiple Sites
  - Radrick Forest
  - Stinchfield Forest
- Multiple species
- Climate data from NOAA
  - July precipitation
  - Average summer temperatures

Wang, X.; Ibáñez, I. The Contrasting Effects of Local Environmental Conditions on Tree Growth between Populations at Different Latitudes. *Forests* **2022**, *13*, 429. https://doi.org/10.3390/f13030429

https://amazon.com

https://serc.carleton.edu/



- β_0,site(i) is the intercept for the site where tree i is located.
- β_DBH is the new coefficient that quantifies the effect of DBH on growth.
- $T_{(□-1)}$ and T□ are the temperatures for the previous and current years, respectively.
- $P_{(□-1)}$ and P□ are the precipitation values for the previous and current years.
- The weights (w_T1, w_T2) and (w_P1, w_P2), allow for flexible contributions from the two times.

Likelihood

For each species and each tree i at time t (located at site j), the observed tree ring width (growth) is modeled as:

$$Growth_{i,t} \sim N(\mu_{i,t}, \sigma^2_{i,t})$$

$$\ln(\sigma^2_{i,t}) = a + b \times DBH_{i,t}$$

Process Model

$$\mu_{i,t} = \beta 0_{site(i)} + \beta_{DBH} \ln(DBH_{i,t}) + \beta_T(\omega_{T1} T_{t-1} + \omega_{T2} T_t) + \beta_P (\omega_{P1} P_{t-1} + \omega_{P2} P_t)$$

Priors

$\beta 0_{site} \sim Normal(\beta\beta 0, \sigma^2_{\beta 0})$ # one intercept at each site

$\beta\beta 0 \sim Normal(0, 1000)$ # overall intercept

$1/\sigma^2_{\beta 0} \sim Gamma(0.0001, 0.0001)$ # variance of intercepts across sites

$\beta DBH \sim Normal(0, 1000)$# effect of DBH on growth for each species

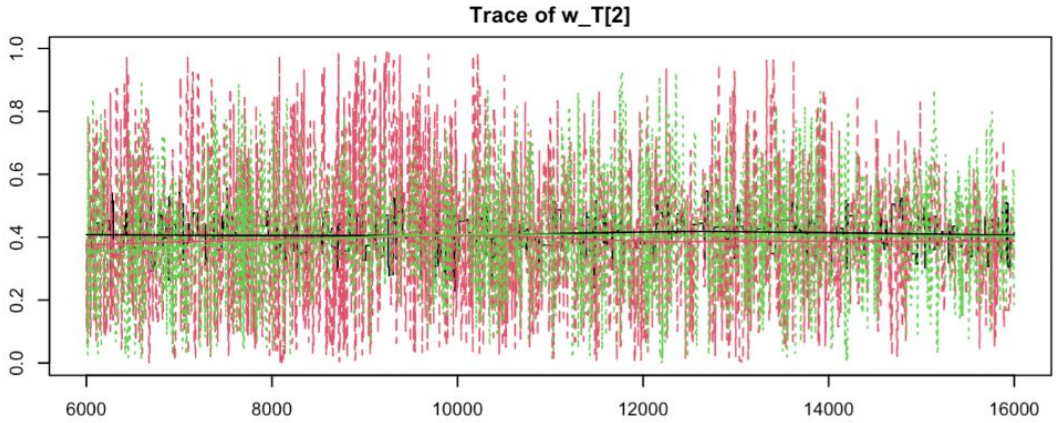
$\beta T \sim Normal(0, 1000)$#effect of Temp on growth for each species

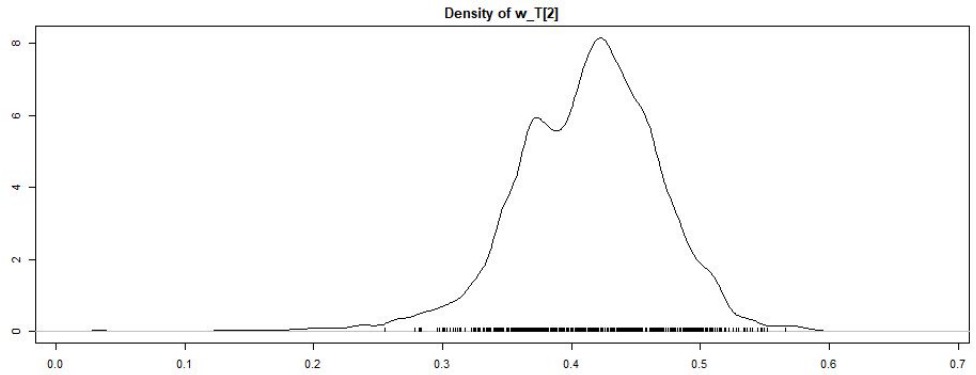
$\beta P_s \sim Normal(0, 1000)$# effect of Precip on growth for each species

$\omega\ * \sim Dirichlet(1)$# weights for each year of temp and precipitation included

Results

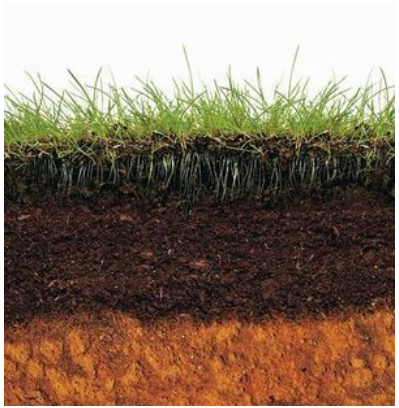
	All	Acer rubrum	Quercus alba	Quercus velutina
b				
beta0				
betaDBH	No significance		No significance	No significance
betaP	No significance		No significance	No significance
betaT				
wp1				
wp2				
wt1				
wt2				



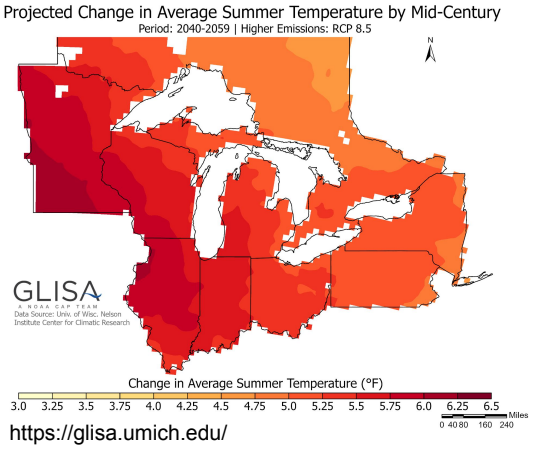


Discussion

- No significance from DBH or precipitation
  - Suggests need for reworking of the model
  - Add soil as a predictor
- Temperature most significant predictor



https://soil.evs.buffalo.edu/



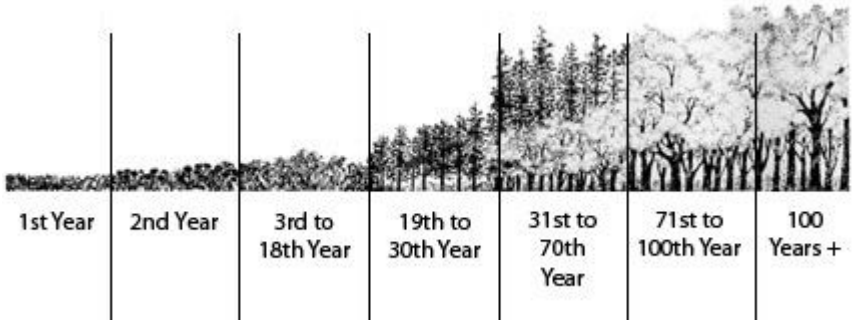
https://glisa.umich.edu/

Climate and **soil** are among the most important growth factors and thus drivers of tree species distributions. Important climatic factors are temperature and water, and important edaphic factors are water, nutrients, and probably soil aeration.

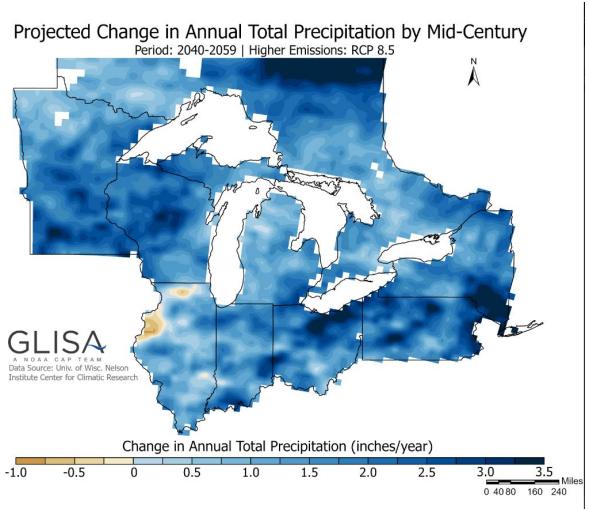
Walthert L, Meier ES. Tree species distribution in temperate forests is more influenced by soil than by climate. *Ecol Evol*. 2017; 7: 9473–9484. https://doi.org/10.1002/ece3.3436

Further Exploration and Significance

- As always, more research and data collection
- Continue looking at predictors of growth
- What does a warmer and wetter Michigan mean for trees?



https://dukeforest.duke.edu/



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