

Adaptation to climate change: Identification of climatically resilient hybrid poplars



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Talk Outline

- Introduction
- Historical Growth-Climate Relationships
- Growth Forecasts Under Future Climate Change
- Future Research Directions

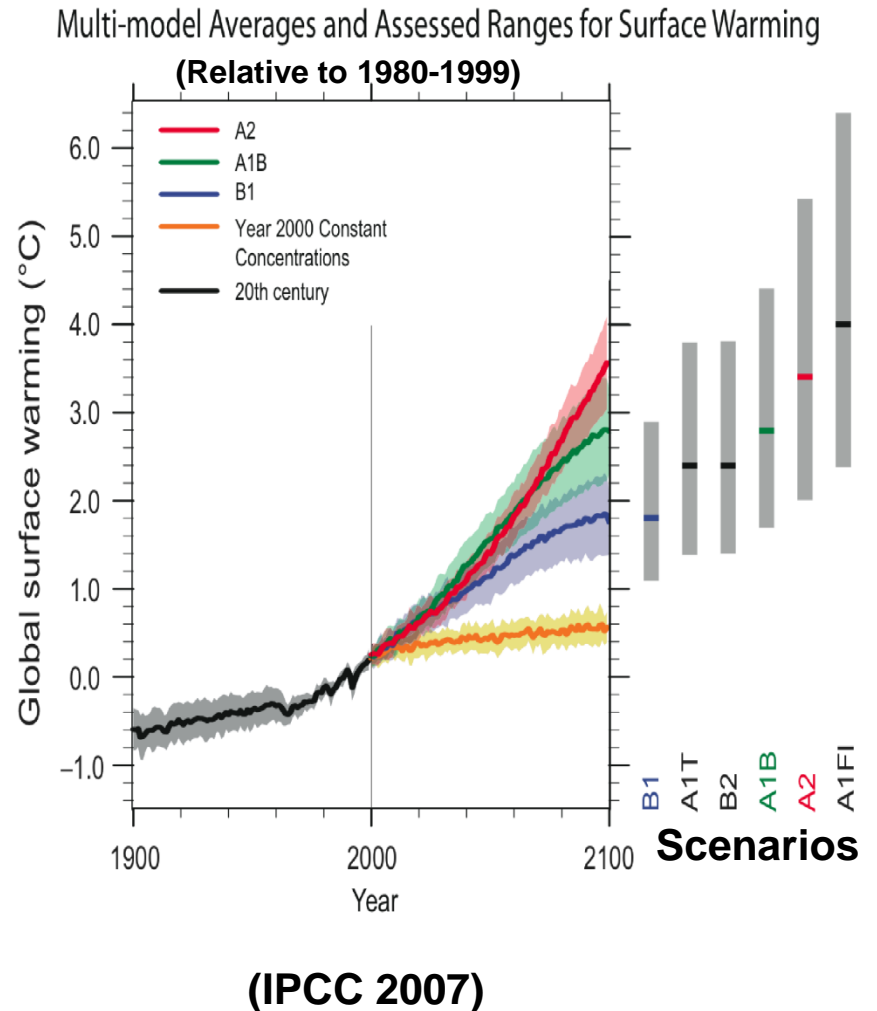
Introduction

■ Global Warming

- 1906-2005: 0.74°C increase
- ↑ CO₂: 1.1°C - 6.4°C increase by 2090-2099

■ Precipitation Trends

- More uncertainty but generally will increase
- Could be negated by increases in evapotranspiration



Introduction

■ Climate Change

- Great Lakes Region
- Michigan



PROJECTED CLIMATE CHANGES IN MICHIGAN

(from Union of Concerned Scientists Web site)

WARMER
TEMPERATURES



A 5 to 10 degree F rise in winter and a 7 to 13 degree F rise in summer temperatures by the end of the century are projected.

PRECIPITATION
CHANGE



Although average annual precipitation may not change much, an overall drier climate is expected because rainfall cannot compensate for the increase in evaporation resulting from greater temperatures. Michigan may see drier soils and more droughts. Seasonally, winter precipitation is expected to increase by 5 to 25 percent while summer precipitation is expected to remain the same.

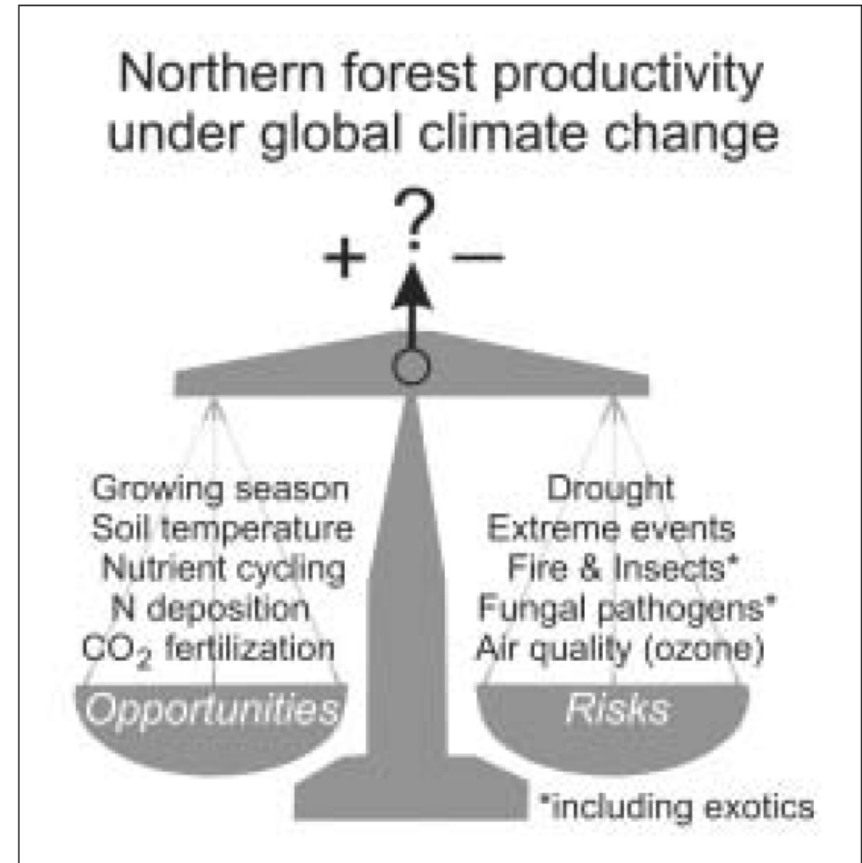
Introduction

■ Impact of Climate on Forests

- Northern regions
- Biomes vs. species

■ Ecosystem resilience

- Capacity of an ecosystem to absorb disturbance and undergo some degree of change but still maintain its essential functions and structure



(Hogg & Bernier 2005)

Adaptation to Climate Change

■ Adaptation framework

- Overall goal: Minimize the negative impacts of climate change and realize potential benefits
- Examples:
 - Human assisted migration of trees
 - Reforestation with drought tolerant provenances
- Challenge: Costs and GCM uncertainties
- Framework should start with monitoring and early detection of forest vulnerabilities to climatic stress

Tree-Ring Analysis

■ Vegetation-Climate Relationships: Methodological Approaches

- 1) Pollen analysis: coarse temporal resolution
- 2) Eddy covariance flux towers: prohibitive costs
- 3) Remote sensing: need ground truthing
- 4) Dendrochronology: tree ring analysis
 - Interannual
 - Tree age
 - Ring width



Tree-Ring Analysis

- **Supplement to permanent sample plots (PSPs)**
 - **Monitoring forest growth and stand development**
 - **PSPs generally measured at 5- to 10-year intervals: coarse temporal resolution**
 - **Dendrochronology based stand reconstructions: annual resolution**



Rationale & Objectives: Poplar

■ Rationale

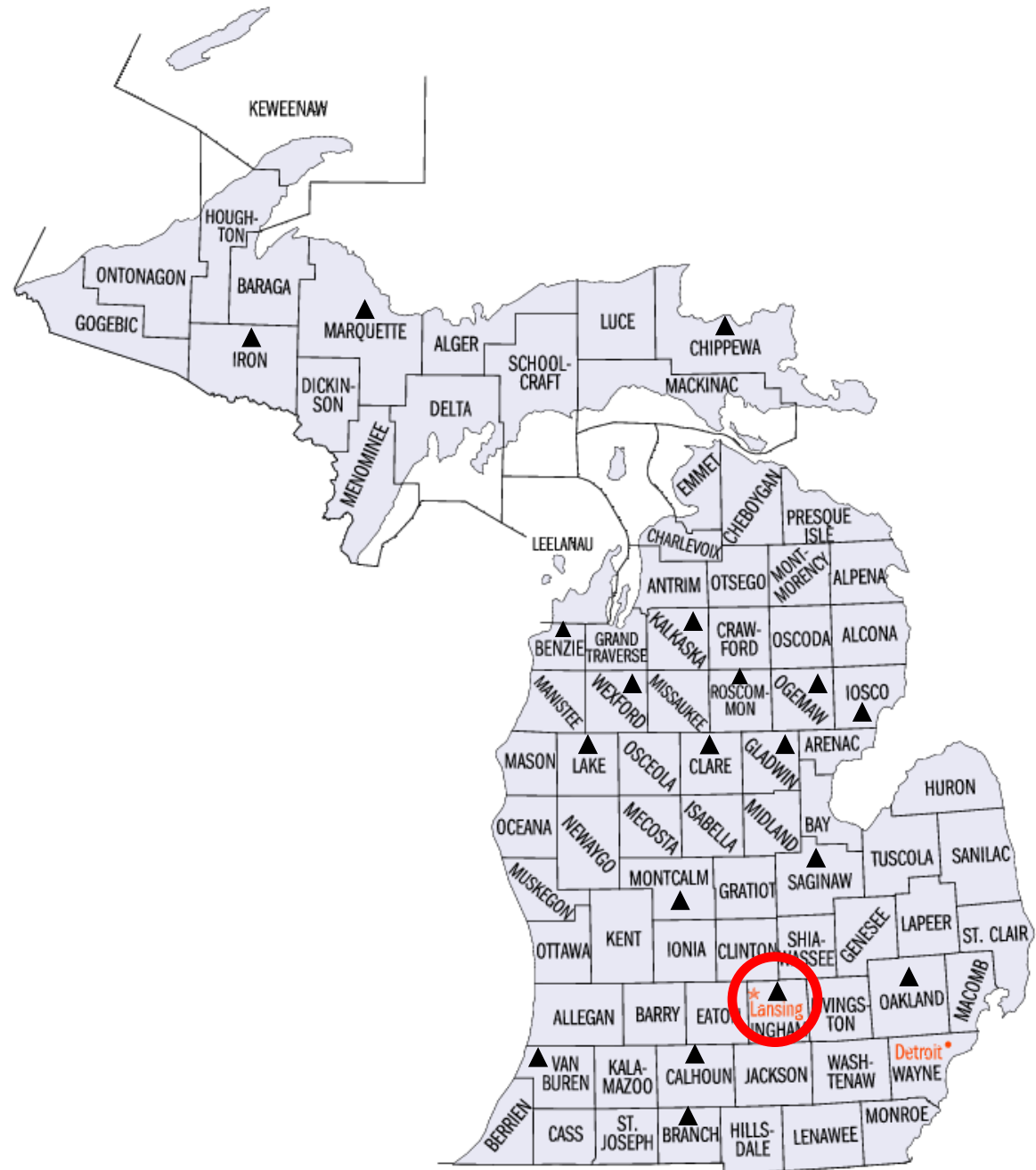
- Bioeconomy: biofuels & bioenergy
- Hybrid poplars

■ Objectives

- 18 full-sib families of *P. x smithii* Boivin (Big-tooth aspen x Trembling aspen)
- Which hybrid poplar families will likely be more resilient to climate change?

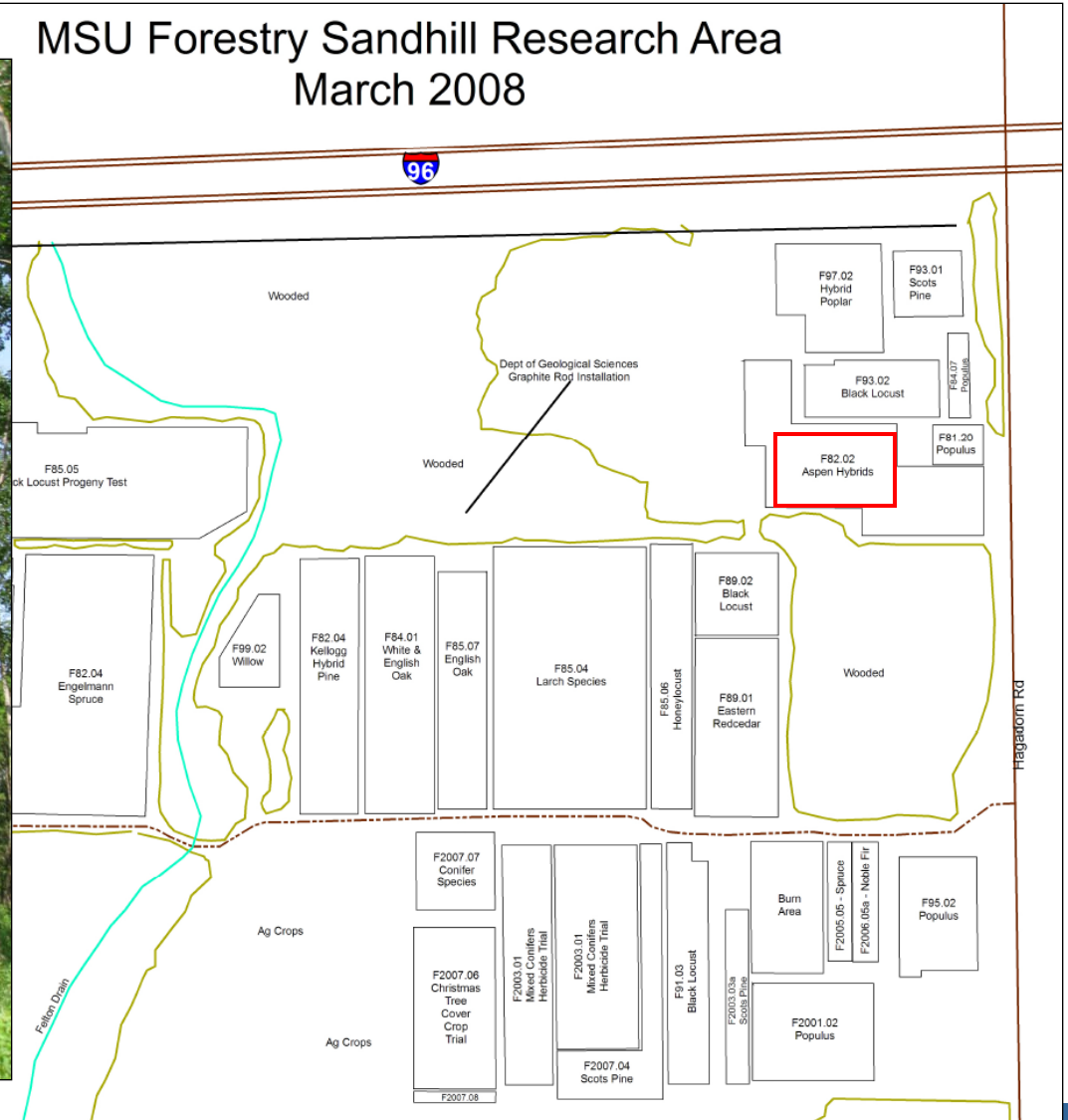


Methods: Parental Sources



Field Methods

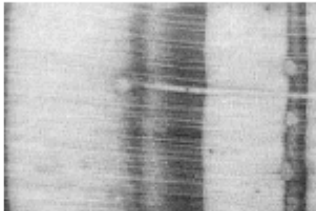
MSU Forestry Sandhill Research Area March 2008



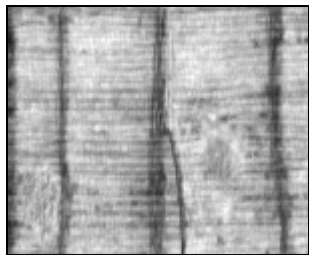
Lab. Methods

- Sanding
- Crossdating
 - False rings
 - Missing rings

Full Ring

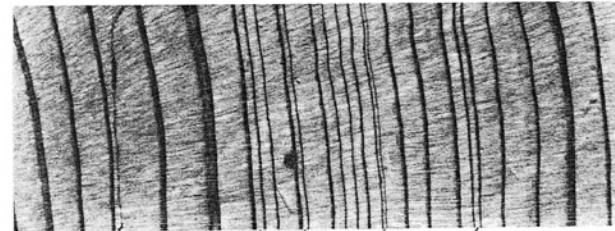


False Band



Locally Absent

(<http://www.ltrr.arizona.edu/>)



(Stokes & Smiley 1996)

Methods



Annual Ring Width



Area of Circle



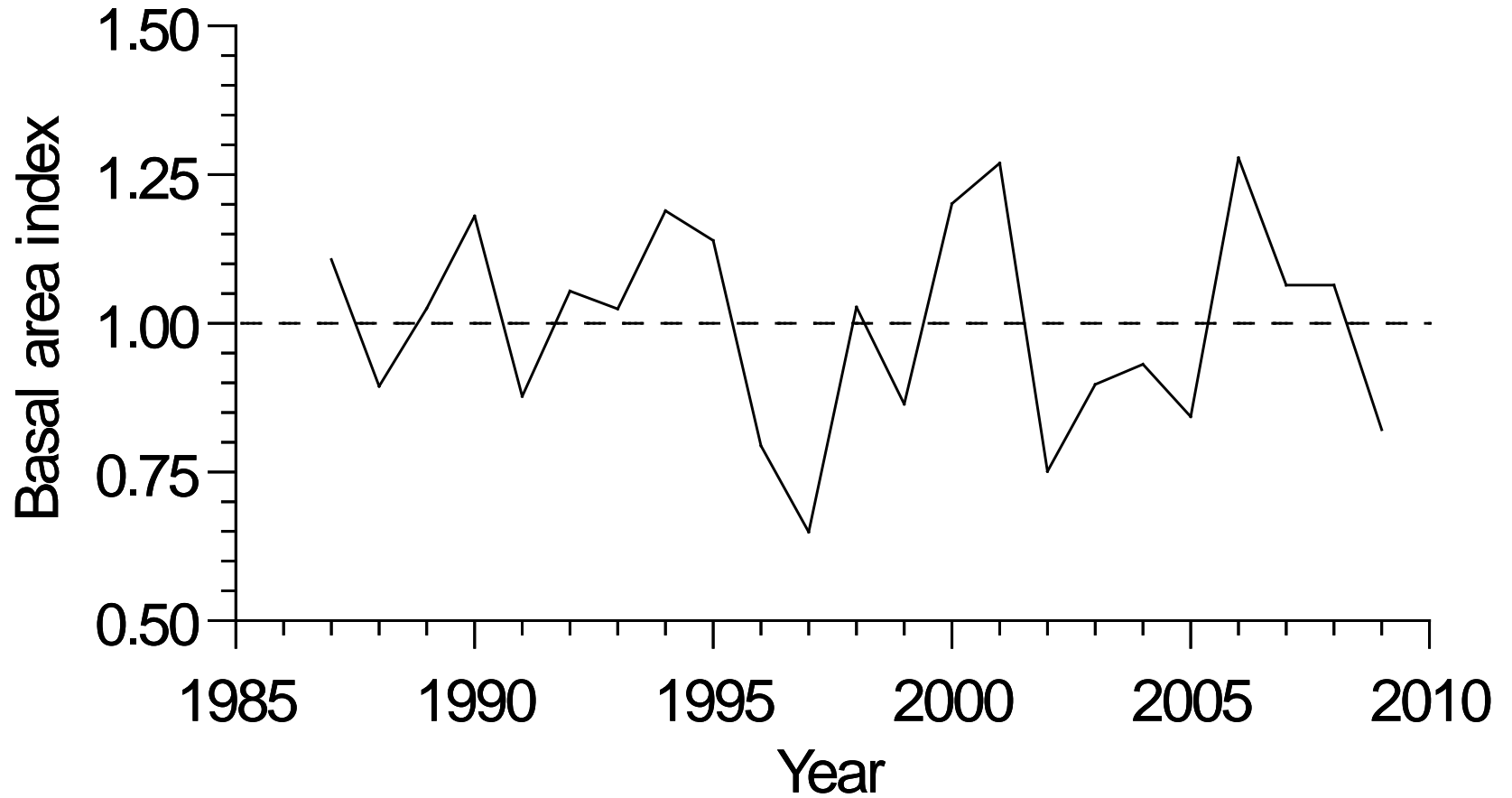
Annual Basal Area

■ Ring Measurement

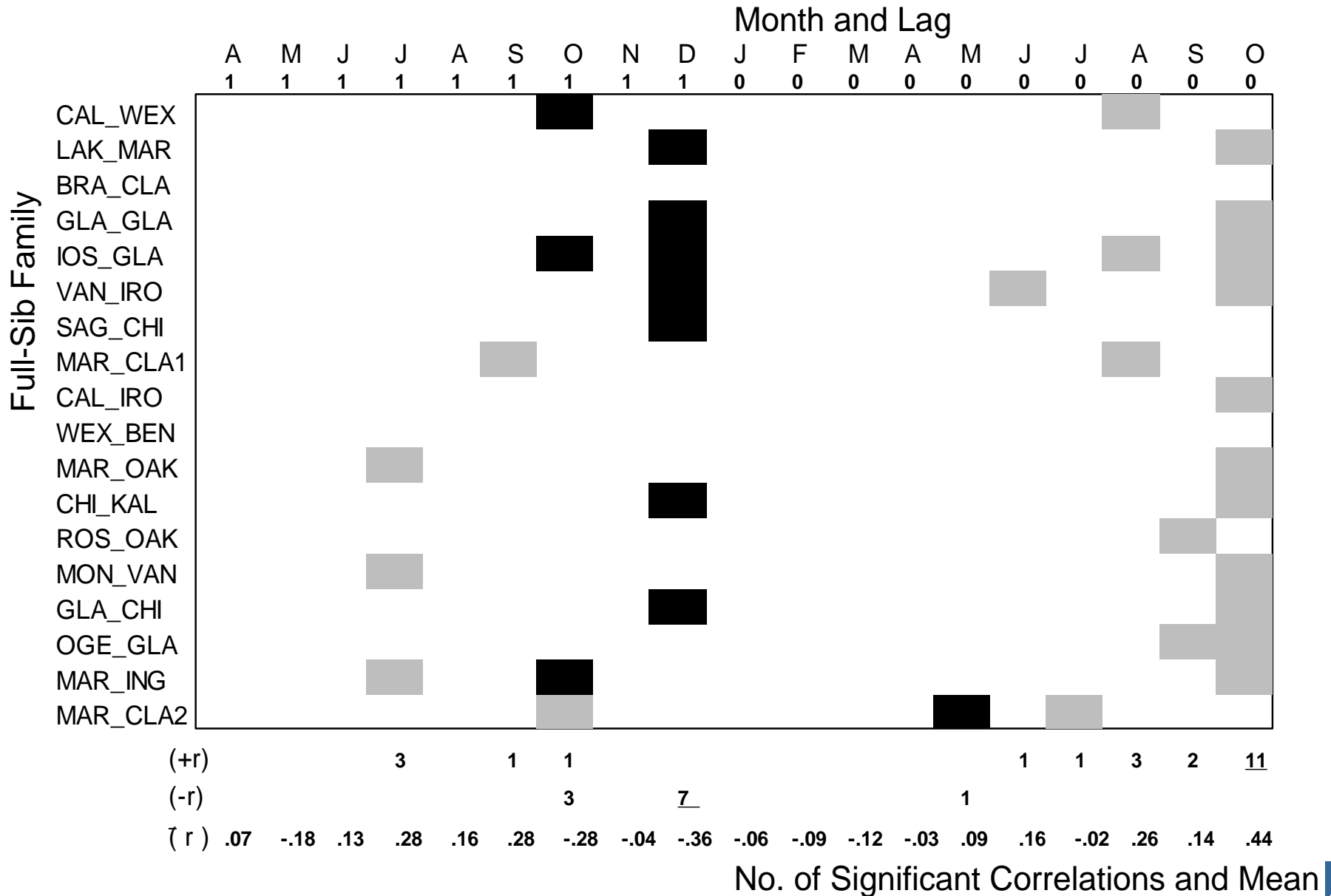
- Image analysis
- Stage micrometer



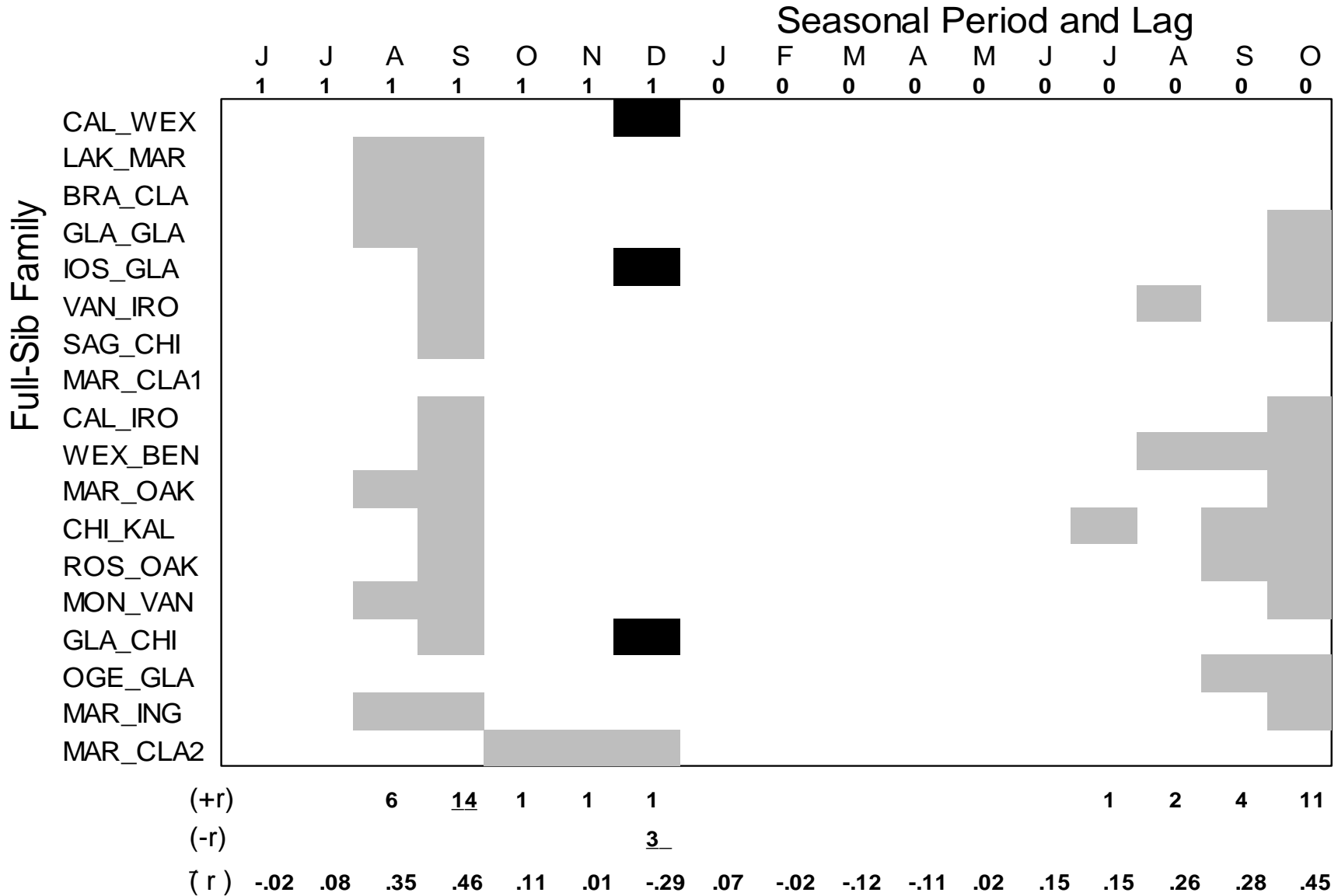
Growth



Growth vs. Climate: Monthly Precipitation



Growth vs. Climate: Seasonal Precipitation



No. of Significant Correlations and Me

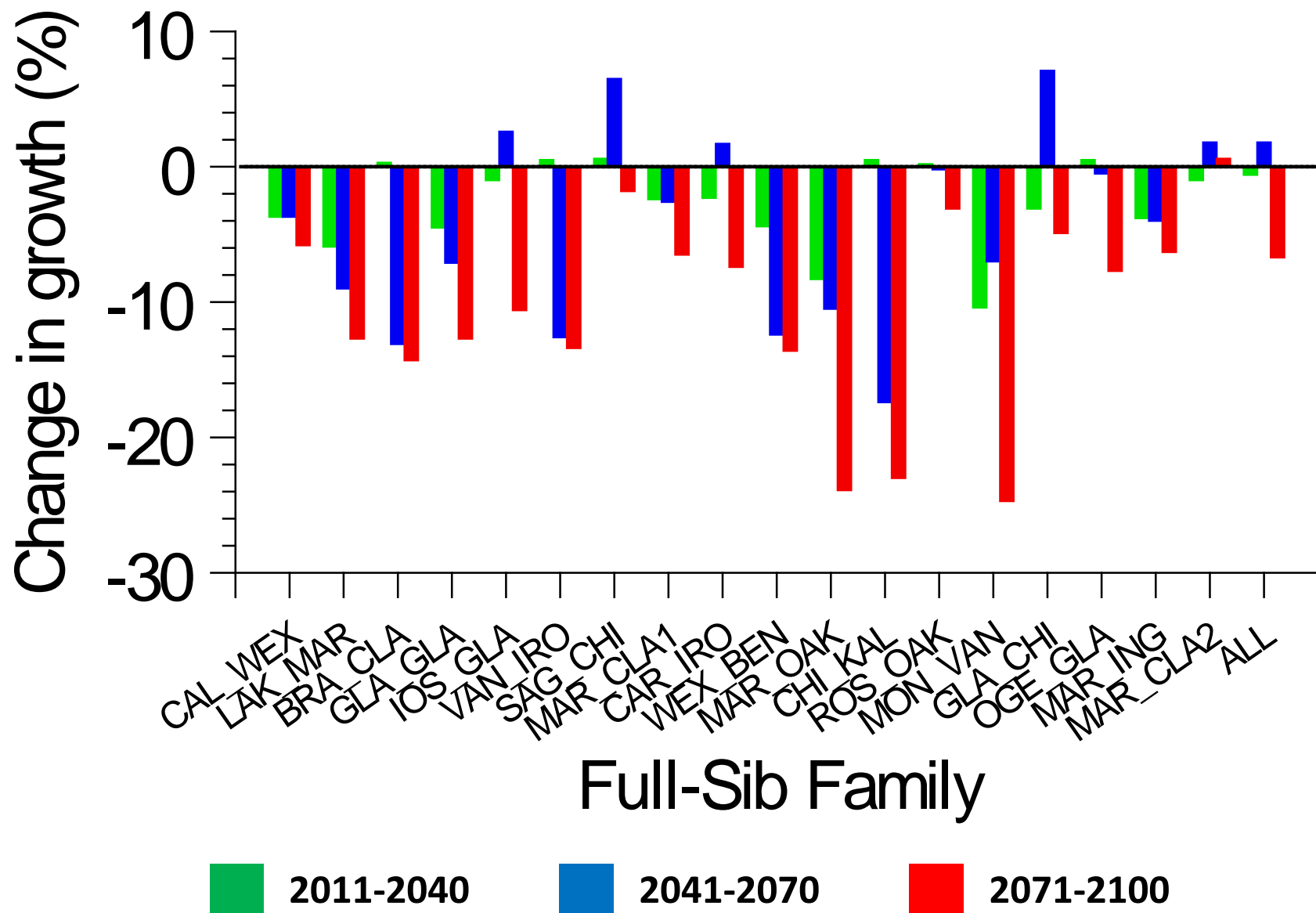
Climate Change: Characteristics

■ Climate Change Scenarios

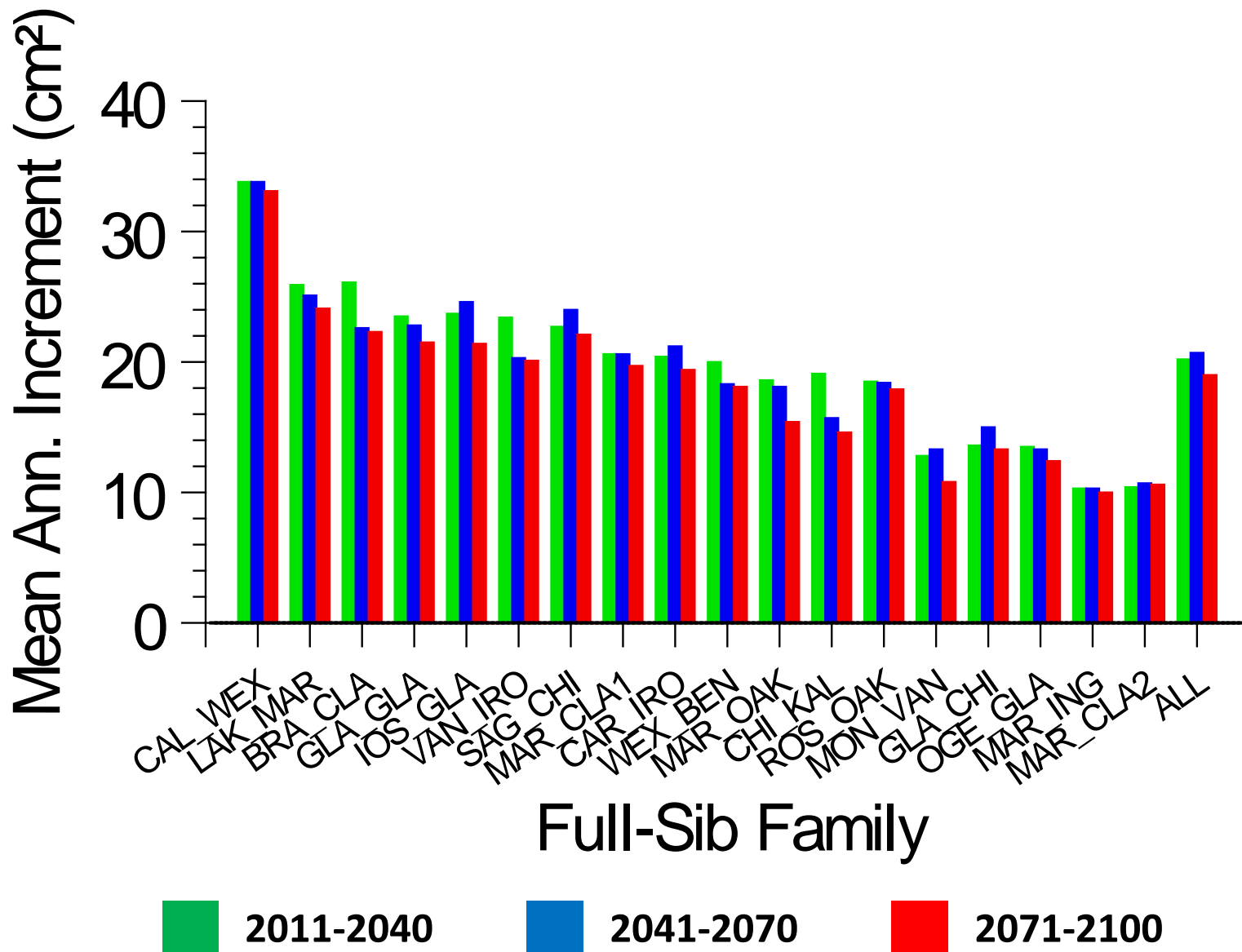
- A1B: convergent world, balanced energy use
- B1: convergent world, environmental sustainability
- A2: heterogeneous world, high population growth

Climate	Summer			Winter			Annual		
	GCM Forecast Periods								
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temp. (°C)	1.1	2.8	3.8	1.8	3.6	4.4	1.6	3.2	4.1
Precip. (mm)	34	-7	25	49	45	77	99	88	143
P-PET (cm)	0.4	-9.9	-10.1	2.9	0.2	2.1	2.7	-9.3	-9.8

Climate Change: Growth Forecasts



Climate Change: Growth Forecasts



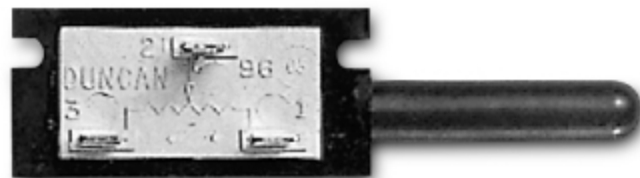
Summary & Conclusions

- **Climatic sensitivity in hybrid poplar**
 - **Late summer and early fall moisture stress**
 - **Current growth season**
 - **Lag effect**
 - **The degree of winter harshness**

Future Work

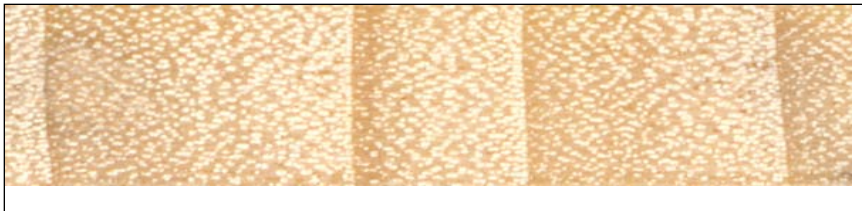
■ Stem Dendrometers

- Radial growth: automatic band dendrometer
- Microclimate variables
 - Soil moisture
 - Light intensity
 - Air temperature
 - Relative humidity
 - Soil temperature

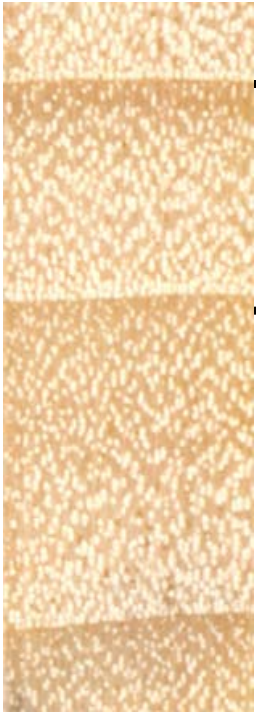


Future Work: Tree-Ring Anatomy

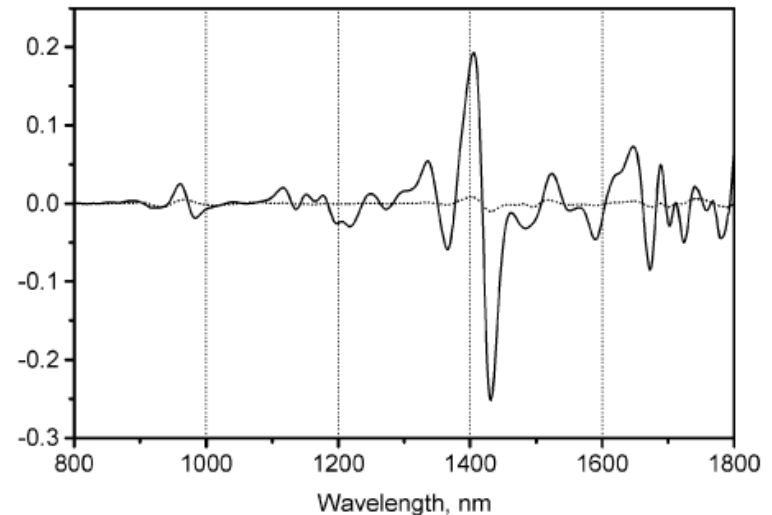
- Implications for wood hydraulic properties



Future Work: Near-Infrared Spectroscopy



- **Physical properties**
 - Wood density
 - Method: X-ray densitometer
- **Chemical properties**
 - Cellulose
 - Lignin
 - Method: Wet-chemical lab
- **Near-infrared spectroscopy**
 - Calibration
 - Validation



(Yeh et al. 2005)

Acknowledgements

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