Integrating the Effects of Climate Change and Invasive Species on Wetland Ecohydrology to Evaluate Management Options

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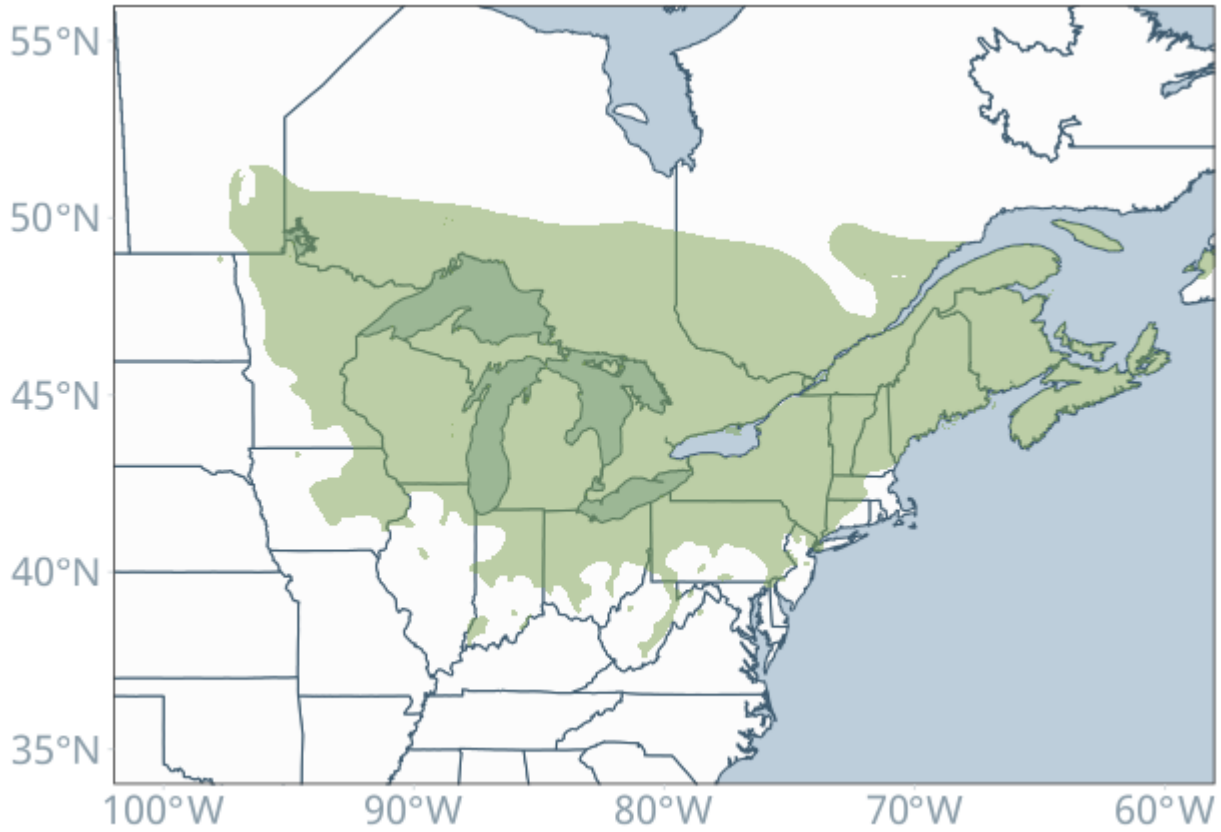
Thank You

Feel free to e-mail (jpshanno@mtu.edu) with questions if you can't make it to the discussion

Black Ash

- Northern deciduous hardwood adapted to flooded conditions
- Dominant hardwood in northern forested wetlands
- Important ecologic, hydrologic, and cultural resource

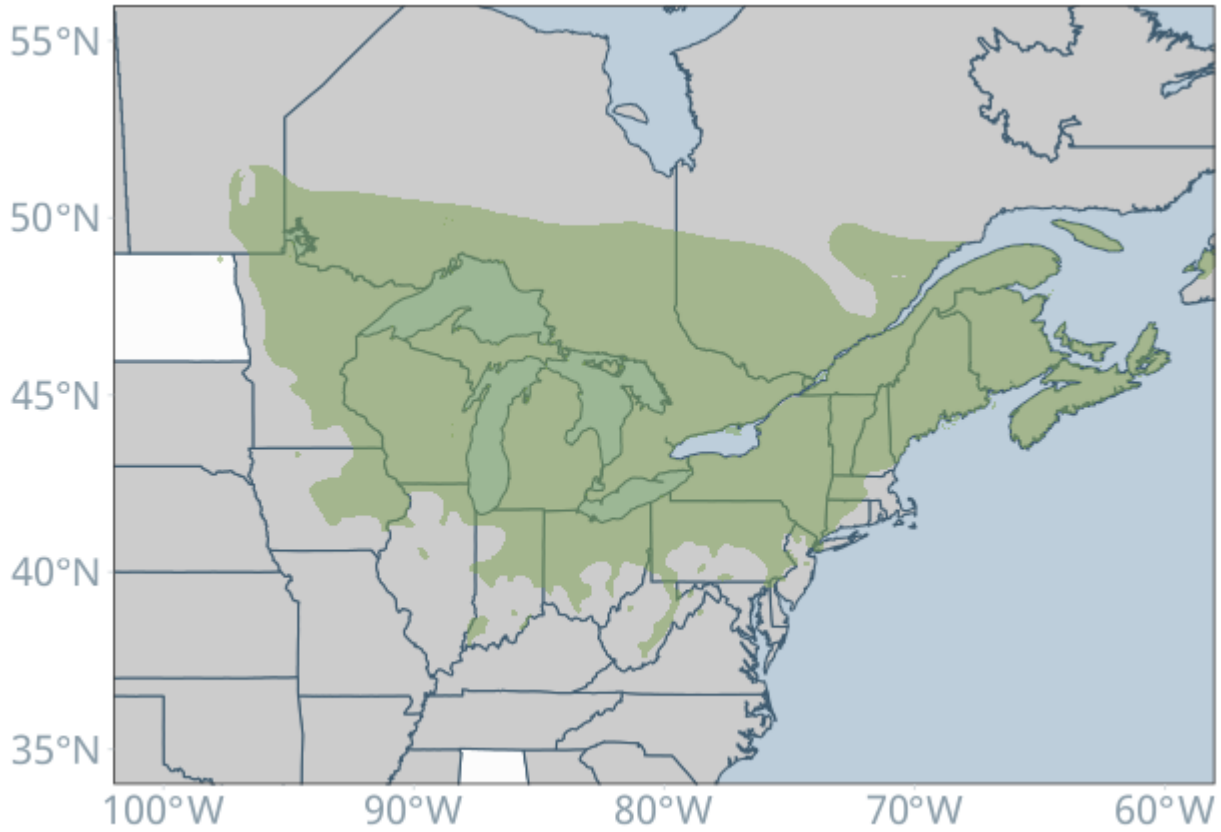


Species range of black ash (Fraxinus nigra) shown in green

Black Ash

& EAB

- Emerald Ash Borer (EAB), an invasive wood-borer
- First detected in southeast Michigan, USA in 2002
- Impacts all North American ash. Now in 40 states & provinces

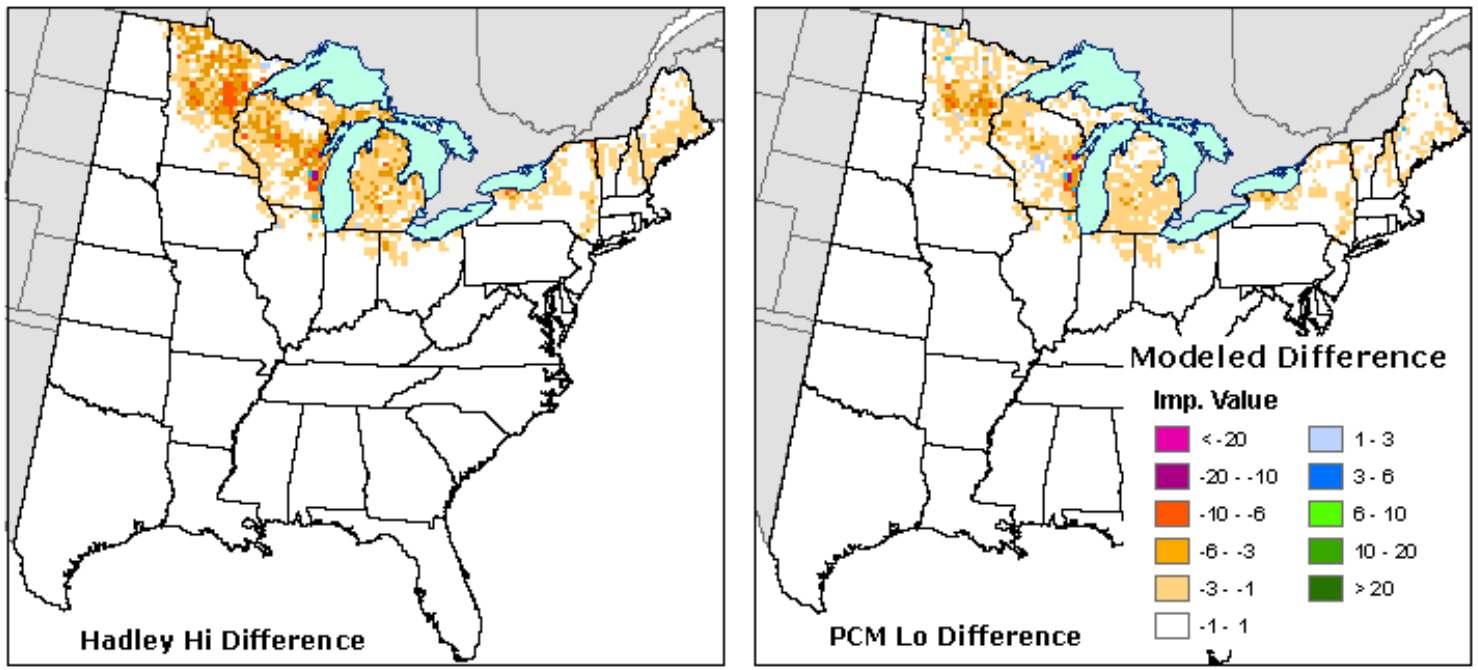


States & provinces where EAB has been detected (gray)

Black Ash & EAB & Climate

Great Lakes Regional Changes

- 3.5-8^{o}C increase in annual temperatures & 0-25% increase in annual precipitation
- Temperature increases more dramatic in winter
- Precipitation increasing in winter & spring, decreasing in the summer
- Changes will impact black ash habitat suitability

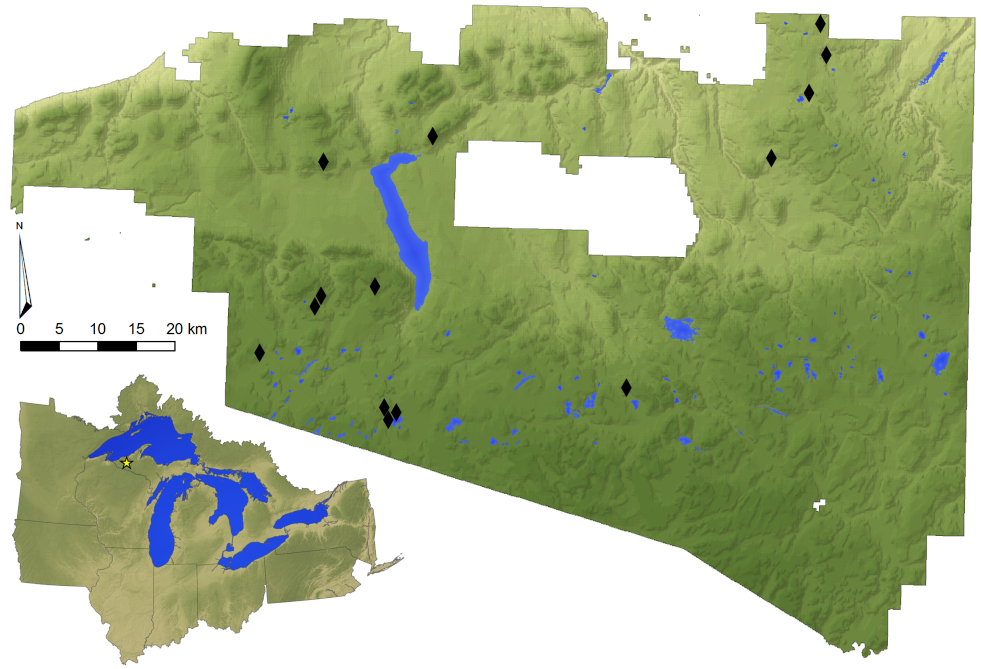


Modeled difference in black ash importance value under high and low sensitivity projections

Map adapted from Prasad, AM; Iverson, LR; Peters, MP; Matthews, SN. 2014. Climate change tree atlas. Northern Research Station, U.S. Forest Service, Delaware, OH. http://www.nrs.fs.fed.us/atlas.

Field Data Collection

- 14 black ash wetlands in Western Upper Peninsula of Michigan
- Monitored from 2012: wetland water levels, outflow (@ 2 sites), vegetation, soil gas efflux, nitrogen availability
- Simulated EAB infestation in winter 2013-2014: Girdle and Ash Cut



Black ash wetland study sites on the Ottawa National Forest (above) and a Ash-Cut treatment 7 years post-treatment (left)

Field Data Results

- Treatment decreased water level drawdown & increased late season levels
- Strong local groundwater signal through the growing season

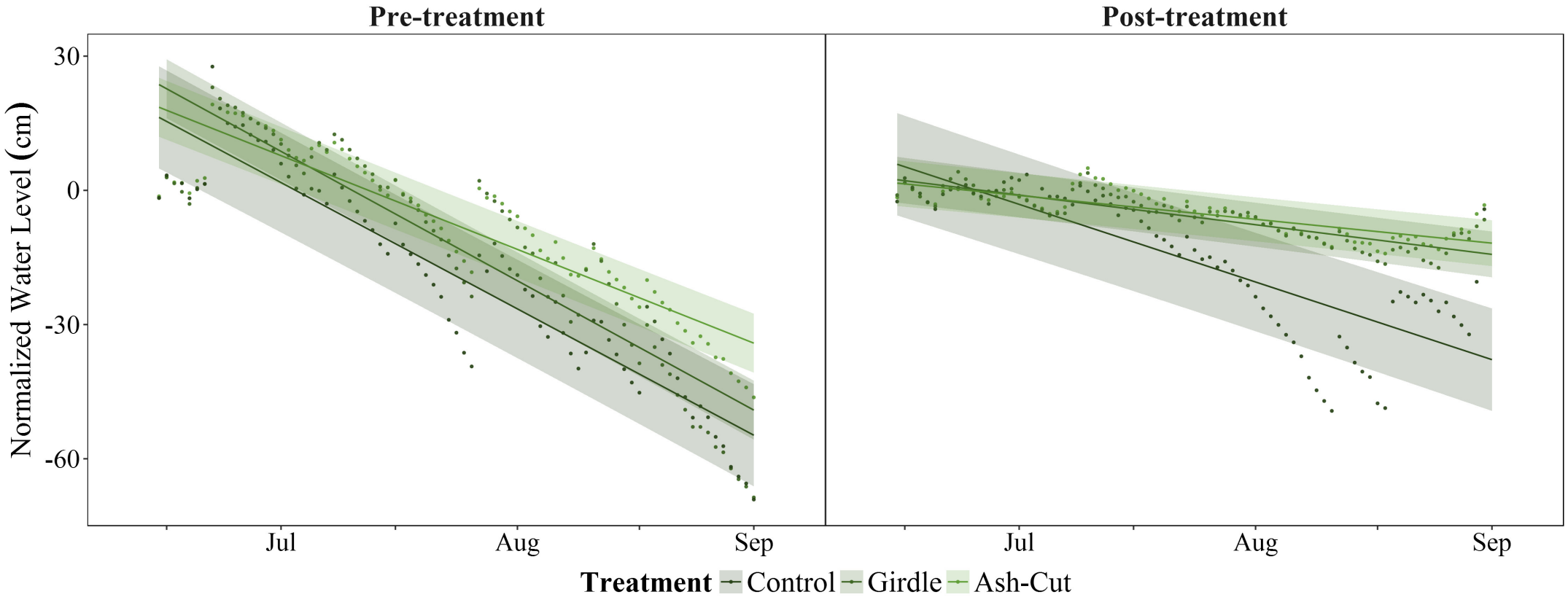


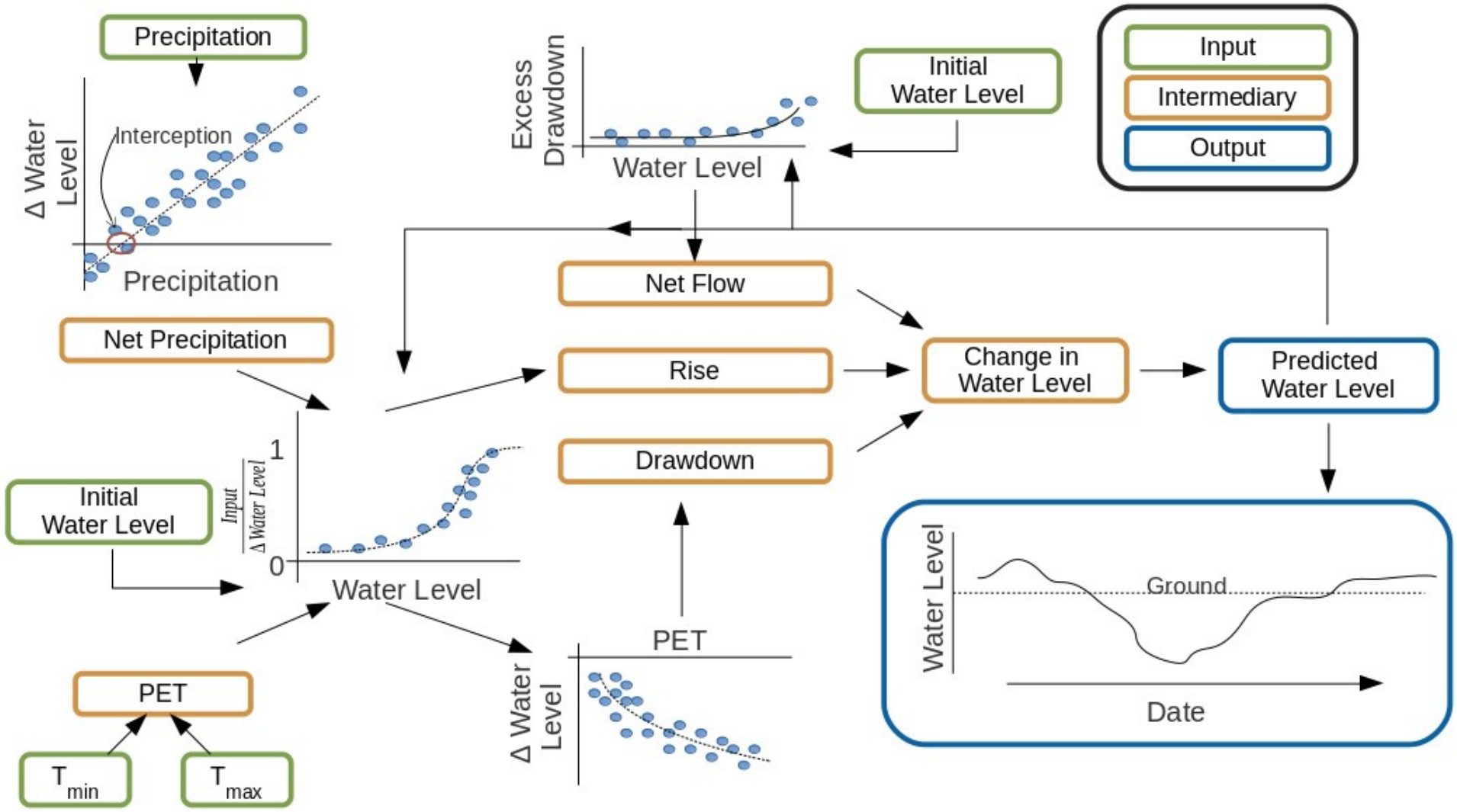
Figure adapted from Van Grinsven, *et al* (2017)

Wetland Water Level Model

- Statistical model to predicting daily water level change
- Linear mixed models for each treatment status with site as the random effect

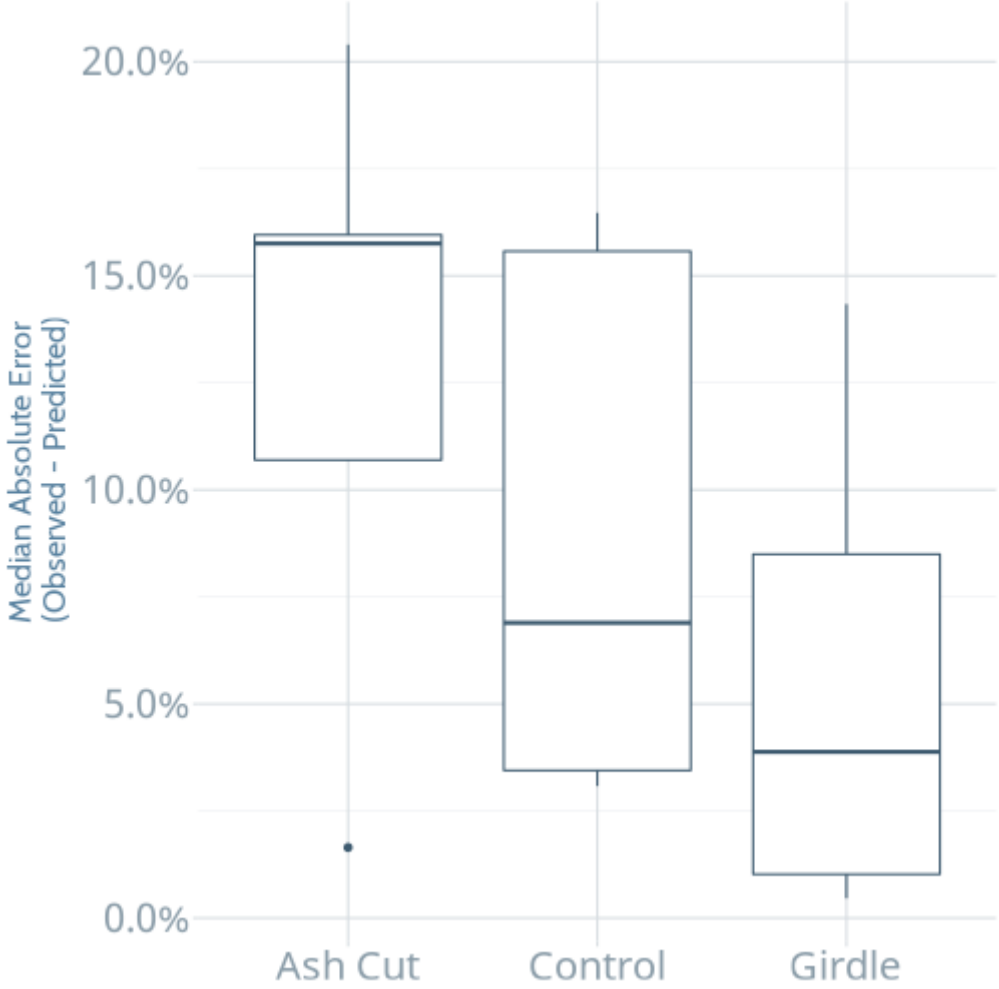
Modeled Parameter	Driver	Purpose
Ecosystem Specific Yield (ESy)	Ratio of rainfall to Δ water level	Scale inputs to ground water response
Interception	Gross Precipitation	Reduce gross precipitation based on canopy status
Precipitation Rise	Net Precipitation	Water level response to precipitation inputs
Potential Evapotranspiration	PET & Cumulative degree days	Water level response to PET pressure
Net flow	Water level & residual Δ water level	Groundwater in/outflows and streamflow

Water Level Model



Wetland Model Validation

- Ash cut showed highest percent errors
  - Partially an artefact of lower water level fluctuations within a growing season
- Inspection indicate a more sensitive drawdown model component is necessary (Predicted:Observed < 1)



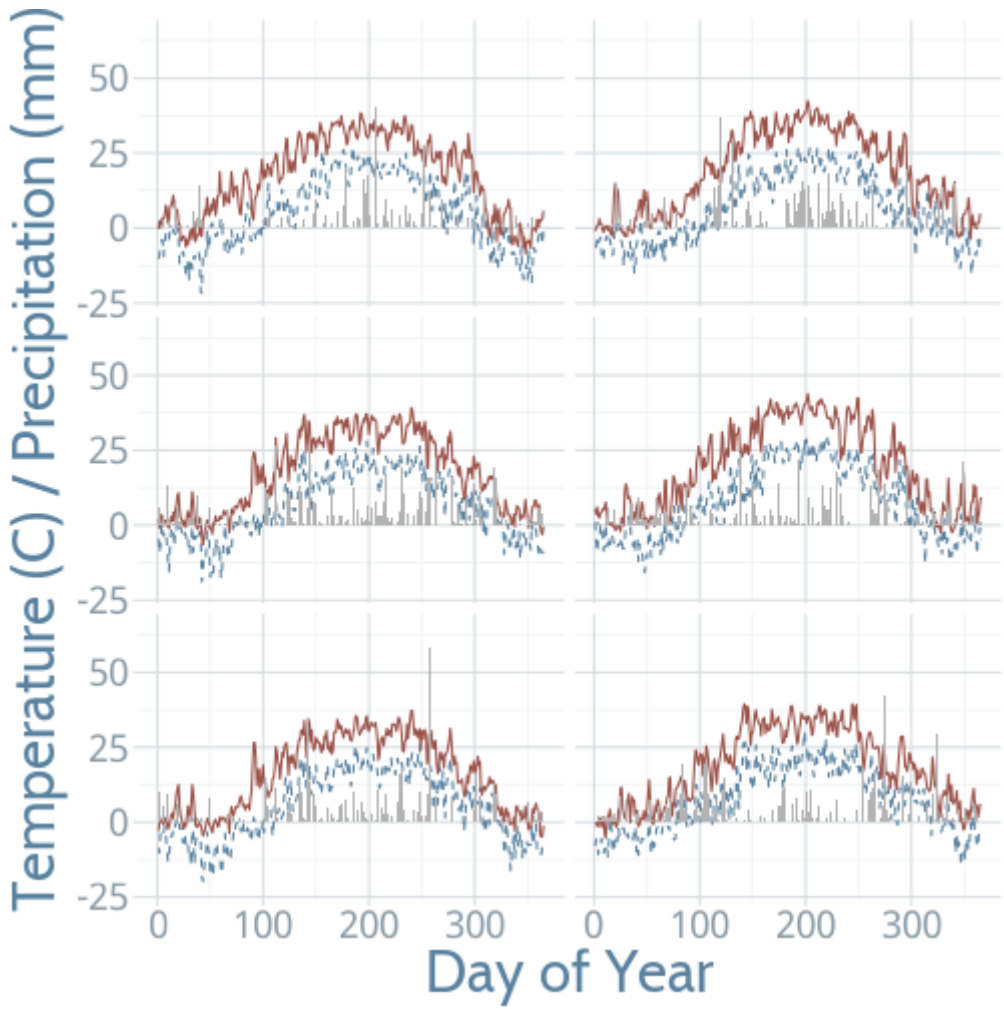
Median absolute error of the predicted daily change in water level as a percent of observed water level

Future Climate Weather Series

GCM	Scenario	Period
GFDL-CM3	RCP 8.5	2070-2099

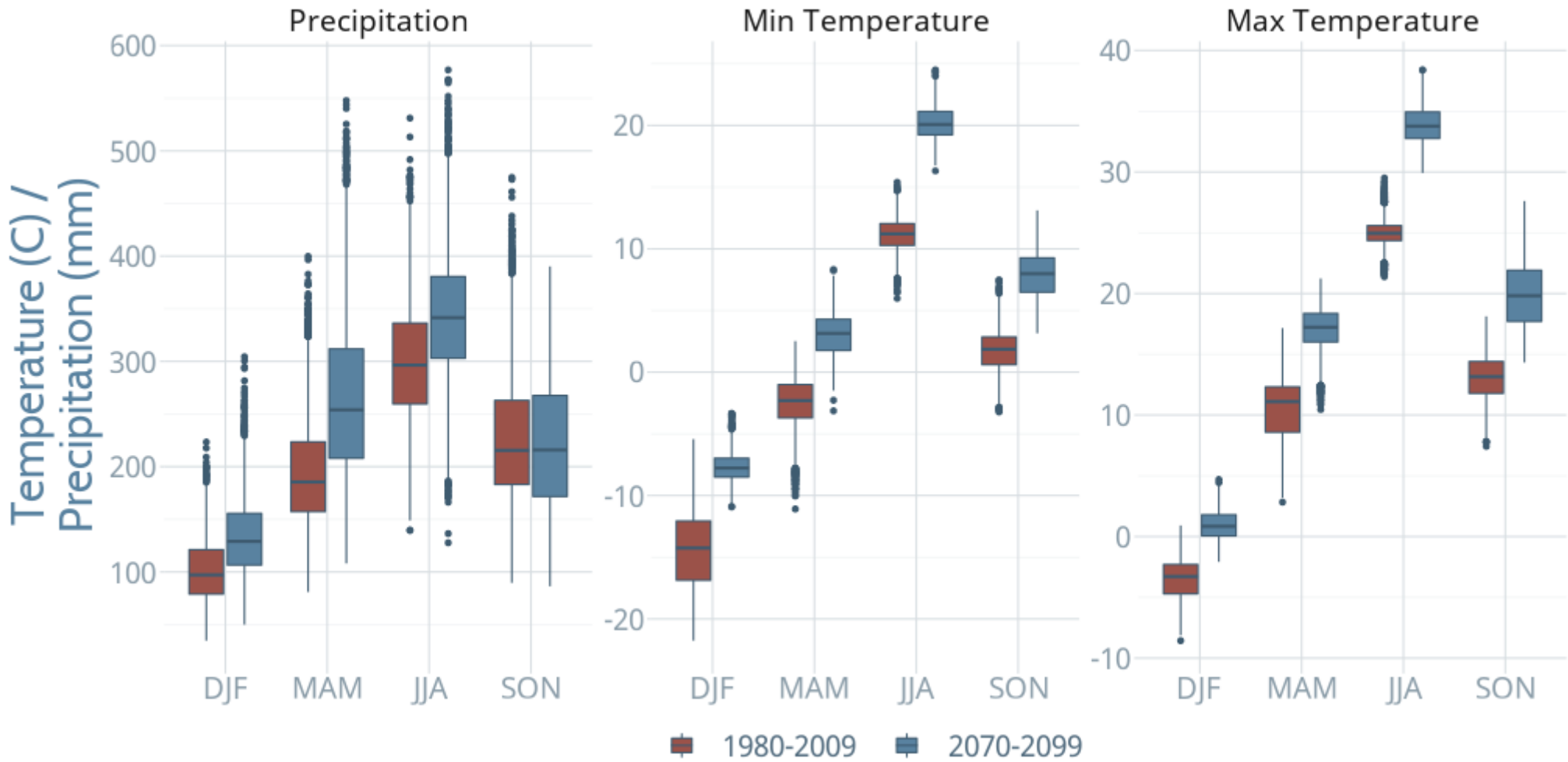
LOCA Downscaling

- Localized Constructed Analogs
- Daily projections over $\frac{1}{16}^{\circ}$ grid
- Precipitation and min/max temperature
- 3000 annual weather sequences (30 years, 100 sampled grid cells)



Sample climate weather sequences showing T_{min} (solid), T_{max} (dashed), and precipitation (columns)

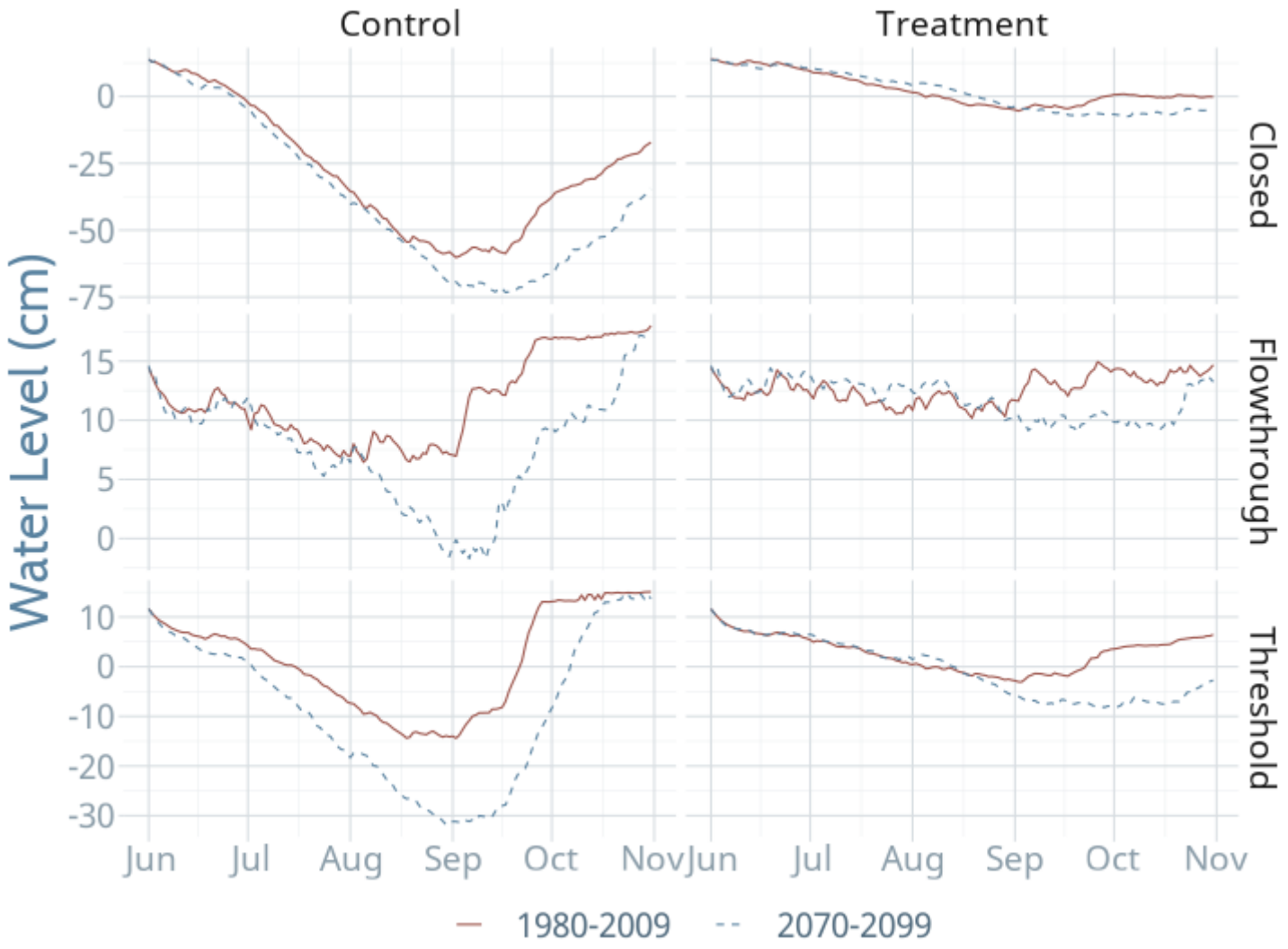
Future Climate Weather Series



Seasonal summary of 3000 annual weather projections extracted from the LOCA-derived estimates.

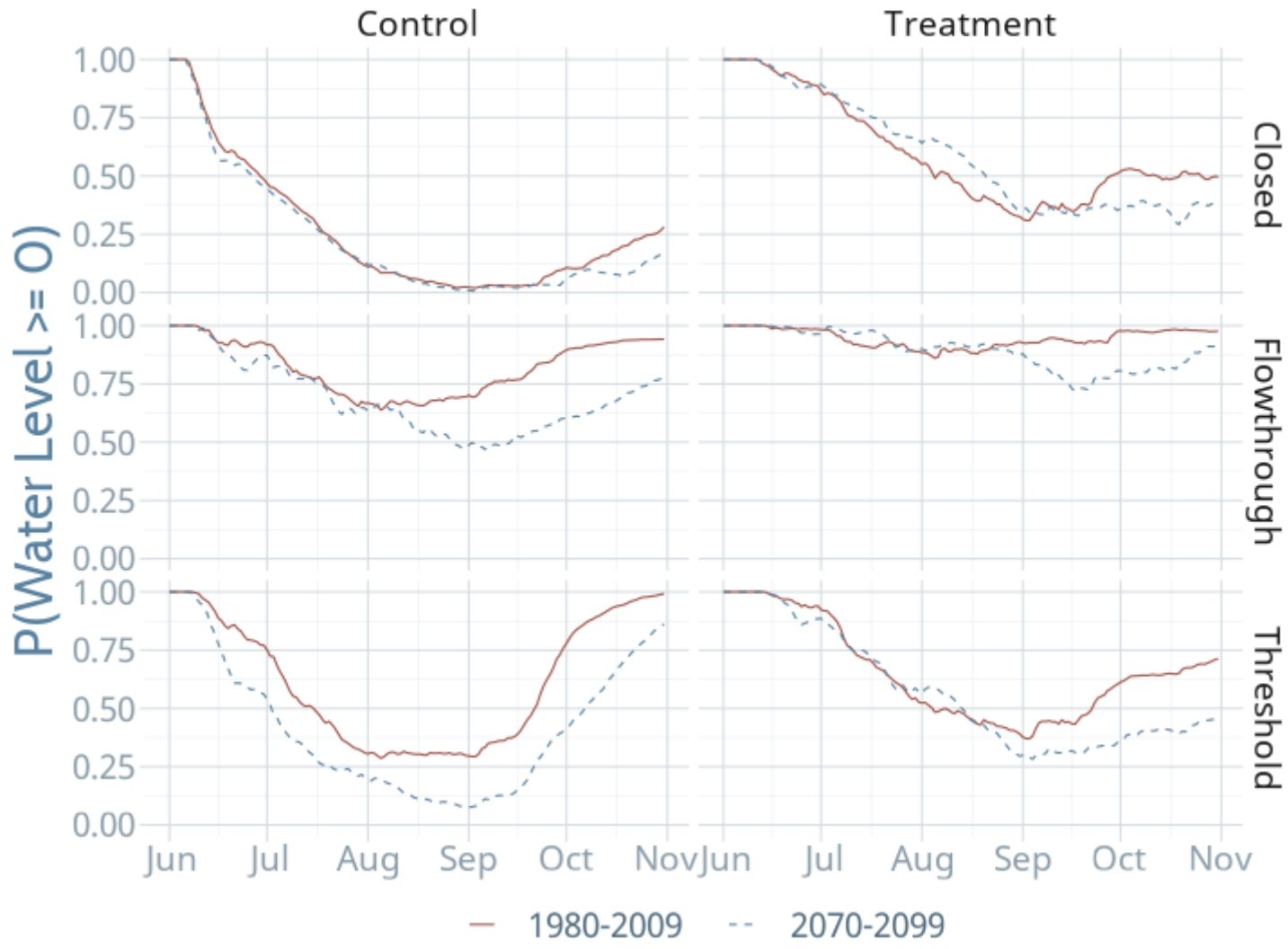
Drawdown Patterns

Median daily water level for 3000 simulations for representative sites of three common black ash wetland morphologies



Occurence of Surface Water

Probability of flooded conditions on a given day of the growing season



Conclusions & Future Work

Conclusions

- Forested sites are expected to be drier relative to current climate conditions
- Non-forested sites will remain wet, with the potential for increased drawdown later in the growing season
- Water level difference will increase through the growing season until fall water level rebound
- Likely to see reduced inundation in forested and unforested sites under future climate scenarios

Additional Model Components

- Test the impact of snow accumulation and melt timing
- Explicitly incorporate groundwater inputs via diurnal water level analysis

Expanded Weather Series

- Simulate future conditions with a low-sensitivity model to provide bookend scenarios
- Transition from LOCA-projected daily values to spatially-explicit stochastic weather generator with climate forcing