

# Predicting the Effects of Climate Change on Loblolly Pine Plantations across the Southeastern US using the 3-PG Model



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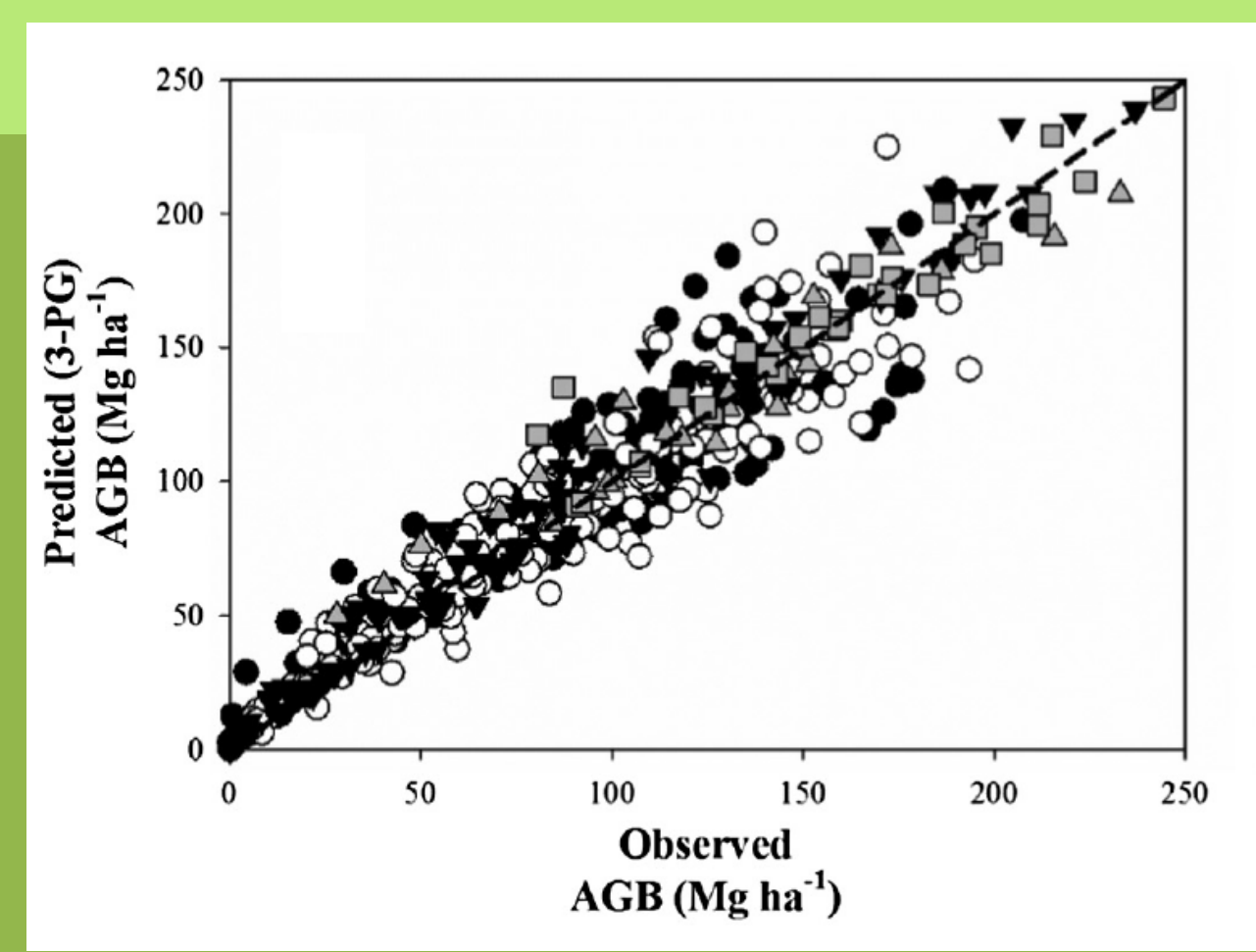
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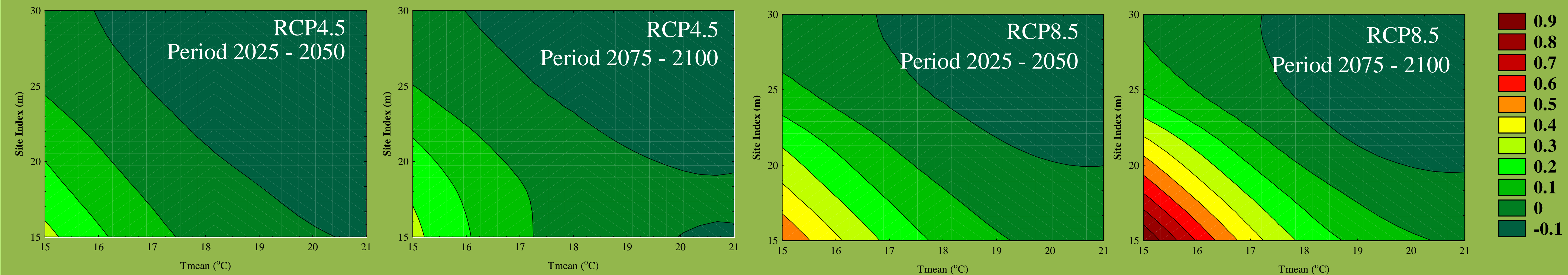
## Introduction

The 3-PG model was used to predict growth under future climate scenarios. Twenty Multivariate Adaptive Constructed Analogs (MACA) from 20 global climate models provided localized baseline and predicted climate data to run the 3-PG model for 36 loblolly pine plantations distributed across the range of the species. It was previously demonstrated that model predicted growth well under the current climate, which is illustrated by the figure below that shows observed (measured) and predicted (using 3-PG) aboveground net primary productivity (AGB) for these sites (Gonzalez-Benecke et al. 2016, *Forest Ecology and Management* 361:237-256).



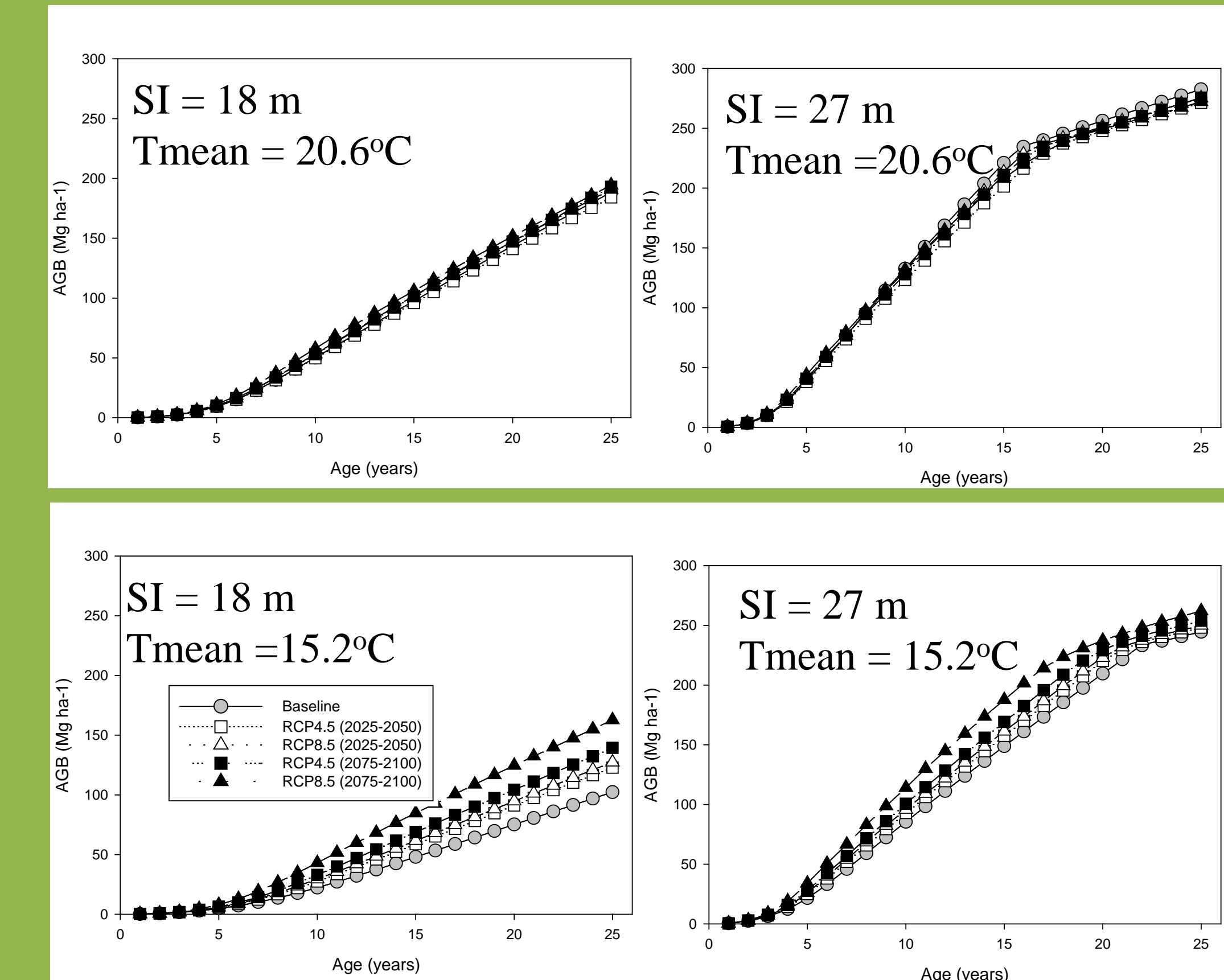
## Results:

### Relative Change in Aboveground Biomass



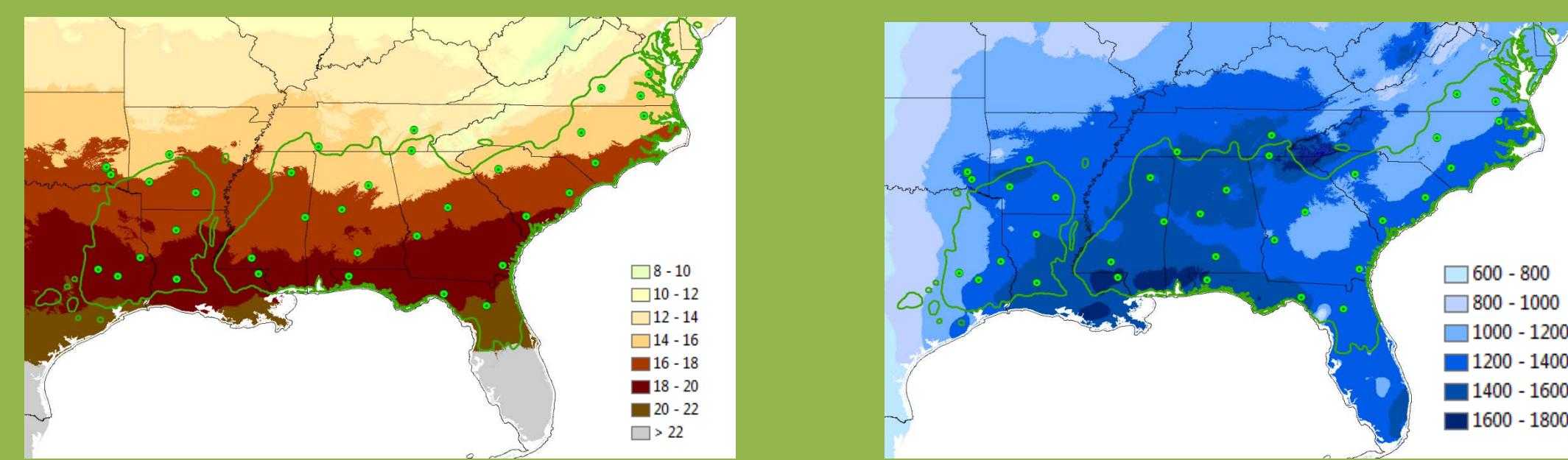
- In all of the contour plots, the y axis is Site Index from 15m to 30m and the x axis is annual mean air temperature (Tmean) from 15 to 21°C.
- The figures above show the relative difference in aboveground biomass (Mg/ha) at the end of 25 year rotations between the Baseline run (ending in year 2005) and RCP4.5 (left two) and RCP 8.5 (right two) climate predictions using the means of the 20 simulation runs made at each of the 36 site locations. Tmean is mean air temperature. The range in Tmean represents the range across the 36 sites. Positive values represent an increase in biomass under the future climate scenario.
- The figures below show the predicted relative change leaf area index and evapotranspiration for the same 3-PG model runs. Note that the relative increase in aboveground biomass and LAI is greater in cooler areas and at sites with a lower site index. All simulations were run under the estimated mean CO<sub>2</sub> concentration for the time period.

## Results:



These graphs show predicted stand aboveground biomass growth (AGB, Mg ha<sup>-1</sup>) over the rotation for actual low and high SI sites in cool and warm areas.

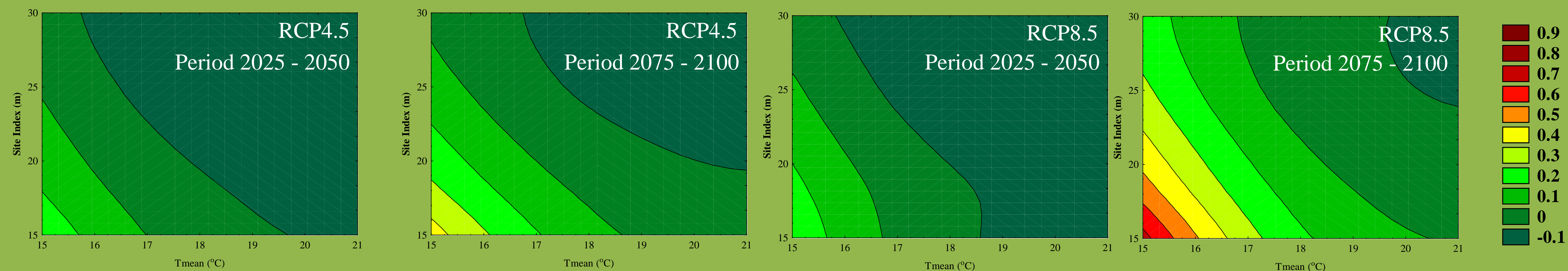
## Materials and Methods



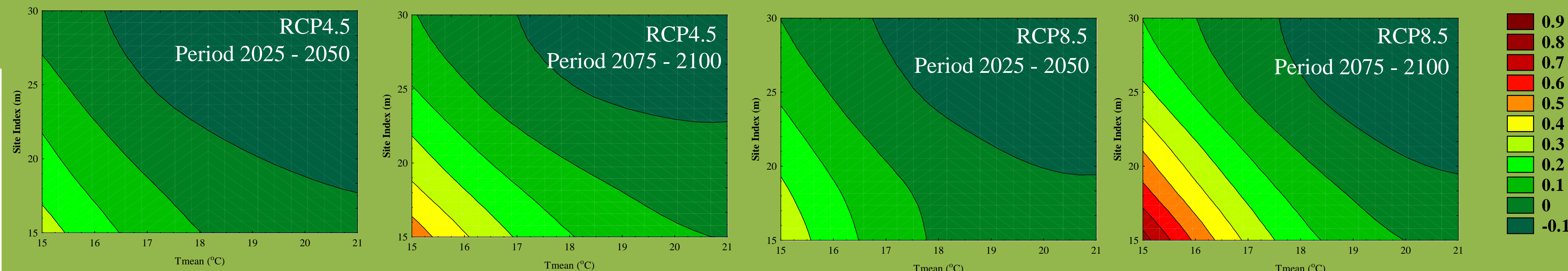
Mean Annual Temp (°C) Annual Rainfall (mm)

Current mean temperature and rainfall at the 36 sites used in this study (green dots) shown above. Mean annual temperature at the sites ranged from <15 to >21°C. The 20 MACA datasets were run separately for each site and for two Representative Concentration Pathways (RCP) 4.5 and 8.5. In addition, at each site 3-PG runs were made for 6 site indexes ranging from 50 to 100 m at age 25. These data were used to create the contour plots shown in Results.

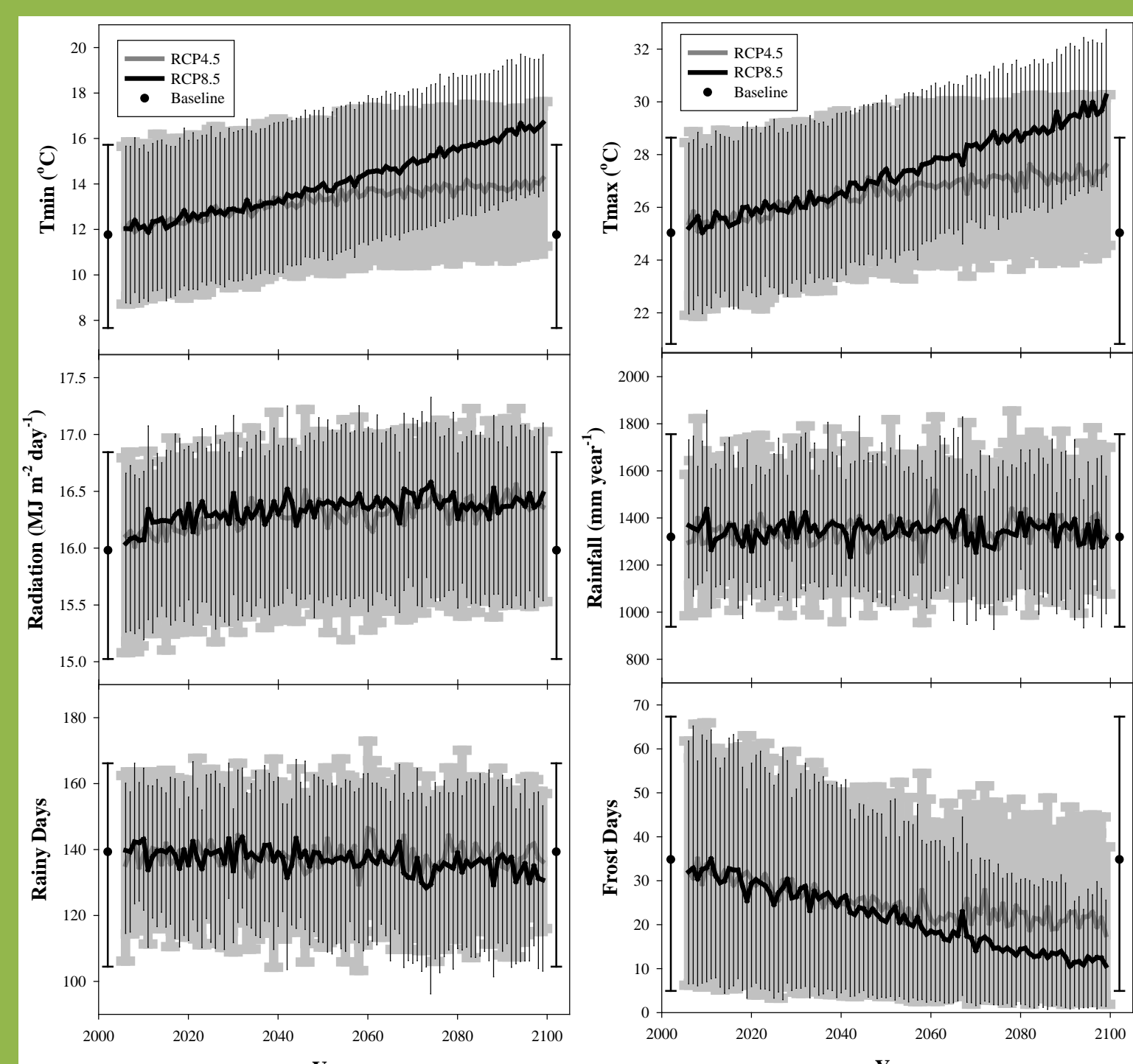
### Relative Change in Leaf Area Index



### Relative Change in Evapotranspiration



The graphs to the left show the average climate predictions for years 2005 to 2100 for RCP 4.5 and 8.5. The bars indicate the variation in estimates across the 20 MACA datasets. Baseline is the mean of MACA climate estimates for years 1975 to 2005.



## Discussion and Conclusions

We found that productivity generally increased under both RCP 4.5 and 8.5 scenarios for rotations in the near future (years 2025 to 2050) and at the end of the century (years 2075 to 2100). However, the relative increase in aboveground biomass was much greater at cooler sites (current mean temperatures between 15 and 18°C) than at warmer sites in the region, such as the lower Coastal Plain. In addition, the response to predicted future climates varied with site quality. Plantations with a high Site Index (SI>25m at age 25) showed very little change in productivity relative to the current baseline climate, and in some cases (warmest sites) exhibited a slight decrease in productivity. This pattern was more pronounced in the RCP 4.5 simulations than those for RCP 8.5, probably due to the compensating effect on growth from the large predicted increase in the atmospheric CO<sub>2</sub> concentration in the RCP 8.5 scenario. Net primary productivity, LAI and evapotranspiration followed very similar patterns to that of aboveground biomass in the simulations. It is important to remember that this analysis is based on the relative change in biomass, LAI and ET, not the absolute values. In all cases, high SI sites and warmer sites had the highest absolute values, but these sites were predicted to have much less change in biomass, LAI and ET under the RCP 4.5 and 8.5 scenarios compared to cooler and lower SI sites.

## Acknowledgments

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