

Estimating transpiration and growth efficiency in loblolly pine (*Pinus taeda*) plantations using the 3-PG model



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Introduction

- Loblolly pine is the principal timber species planted in the US, and is an important contributor to carbon sequestration and the Southeast's economy.
- Forest plantation growth and yield are currently predicted by empirical models, which lack flexibility and the ability to predict growth under different climatic conditions.
- Hybrid models are an alternative tool, and can be useful for understanding the production ecology of loblolly pine in different environmental conditions (Landsberg *et al*, 1997; Bryars *et al*, 2012).
- Climate change will likely have a important impact on carbon sequestration of southern pine plantations and the water cycle (Karl *et al*, 2009).
- Higher temperatures and rates of evapotranspiration are expected; and the pattern of precipitation may be altered (as well as the occurrence of drought events).
- The aim of this work is parametrize the 3-PG model, in order to predict biomass and water use accurately across the climate gradients of the southeastern US.

Objectives

- Determine the accuracy of the 3-PG model for predicting water use by loblolly pine plantations.
- Determine the growth efficiency (GE) and water use efficiency (WUE) by 3-PG in different location of loblolly pine range.

Methods

- Parameterization of the 3-PG model was performed using inventory and sap flow data from GA Tier III site. The Tier III sites in VA, FL and OK were used to validate the model's output.
- Each site has four replicated treatments imposed: control; throughfall reduction (a 30% reduction versus ambient); fertilization (one time fertilization with 224 kg N ha⁻¹, 27 kg P ha⁻¹ and 52 kg K ha⁻¹) and throughfall reduction + fertilization.
- GE - Growth Efficiency (increment of biomass of stemwood + bark + branches/Peak LAI);
- WUE - Water use efficiency (increment of biomass of stemwood + bark + branches/water use in the period);

Further Information

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Results – Biomass & Transpiration

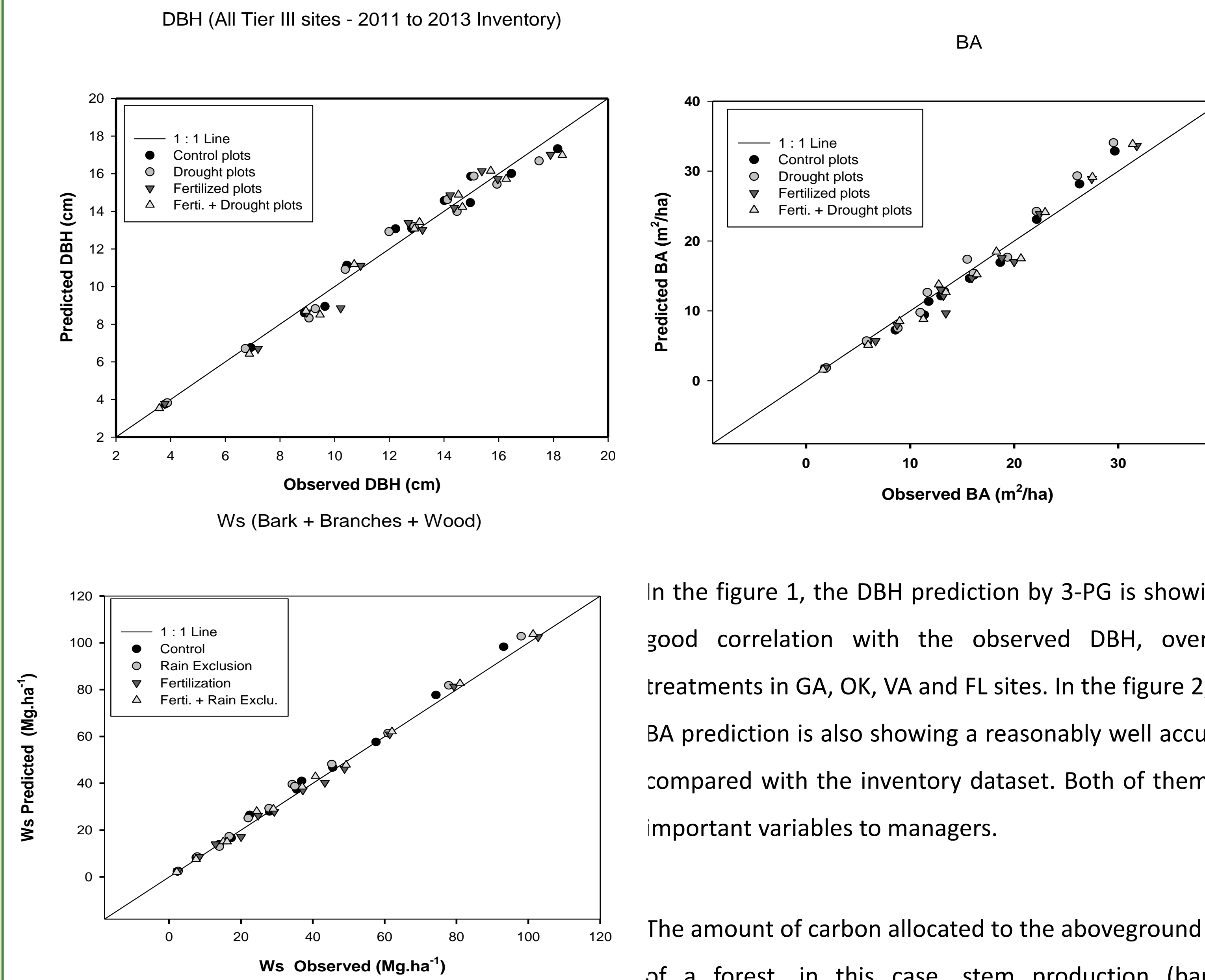
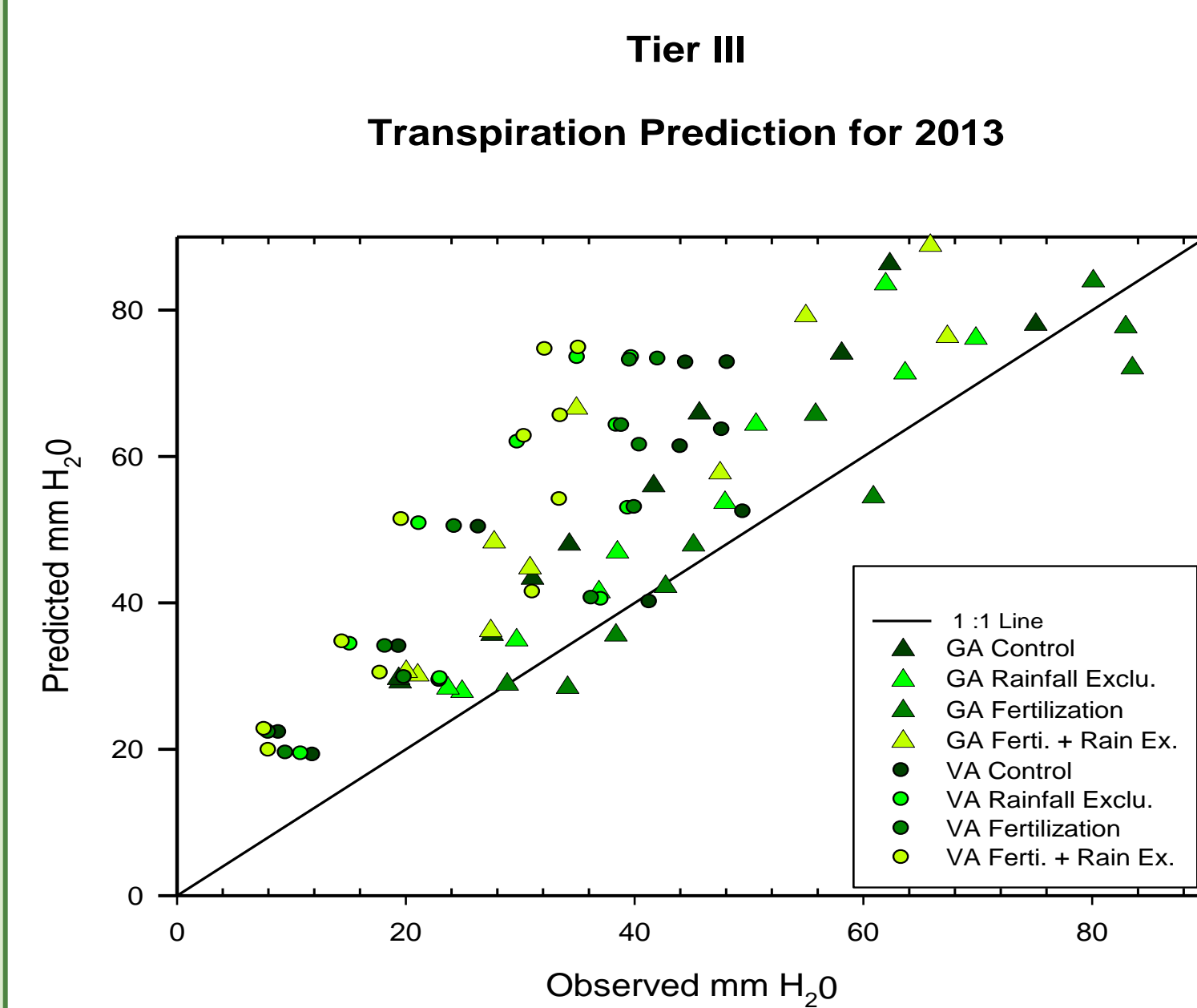


Fig. 2-5 – DBH, BA, WS Inventory and transpiration predictions of all tier III sites.



In the figure 1, the DBH prediction by 3-PG is showing a good correlation with the observed DBH, over all treatments in GA, OK, VA and FL sites. In the figure 2, the BA prediction is also showing a reasonably well accuracy compared with the inventory dataset. Both of them are important variables to managers.

The amount of carbon allocated to the aboveground part of a forest, in this case, stem production (bark + branches + bole) is an indicator of how productivity a forest stand is compared to another stand.

The 3-PG predictions of water use for GA site are showing an overall good accuracy even for the range of the different treatments imposed on GA site. Nonetheless for a colder site, the model is over-predicting the values along all treatments. Further investigation of sap flow data from other validation sites (FL and OK) are necessary to demonstrate the ability of the model in predicting transpiration along a range of locations.

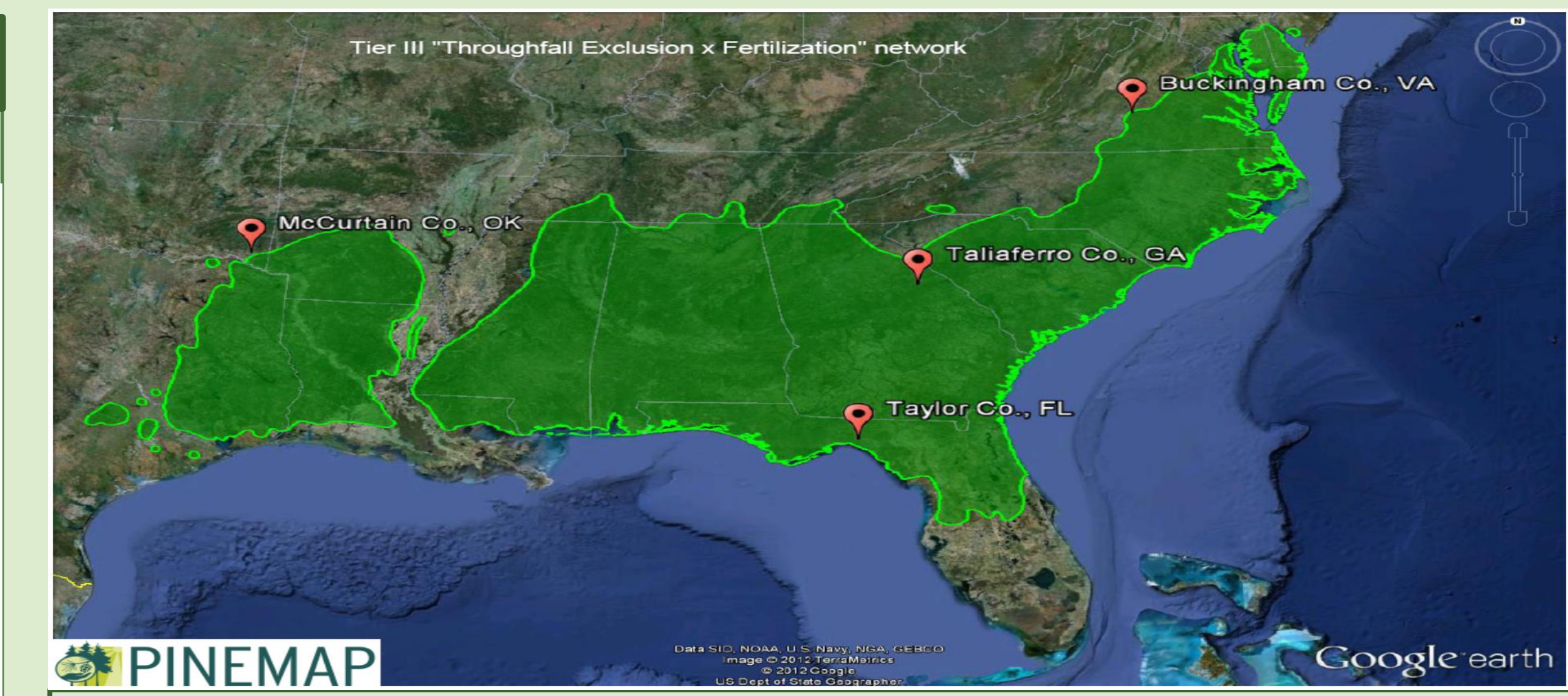
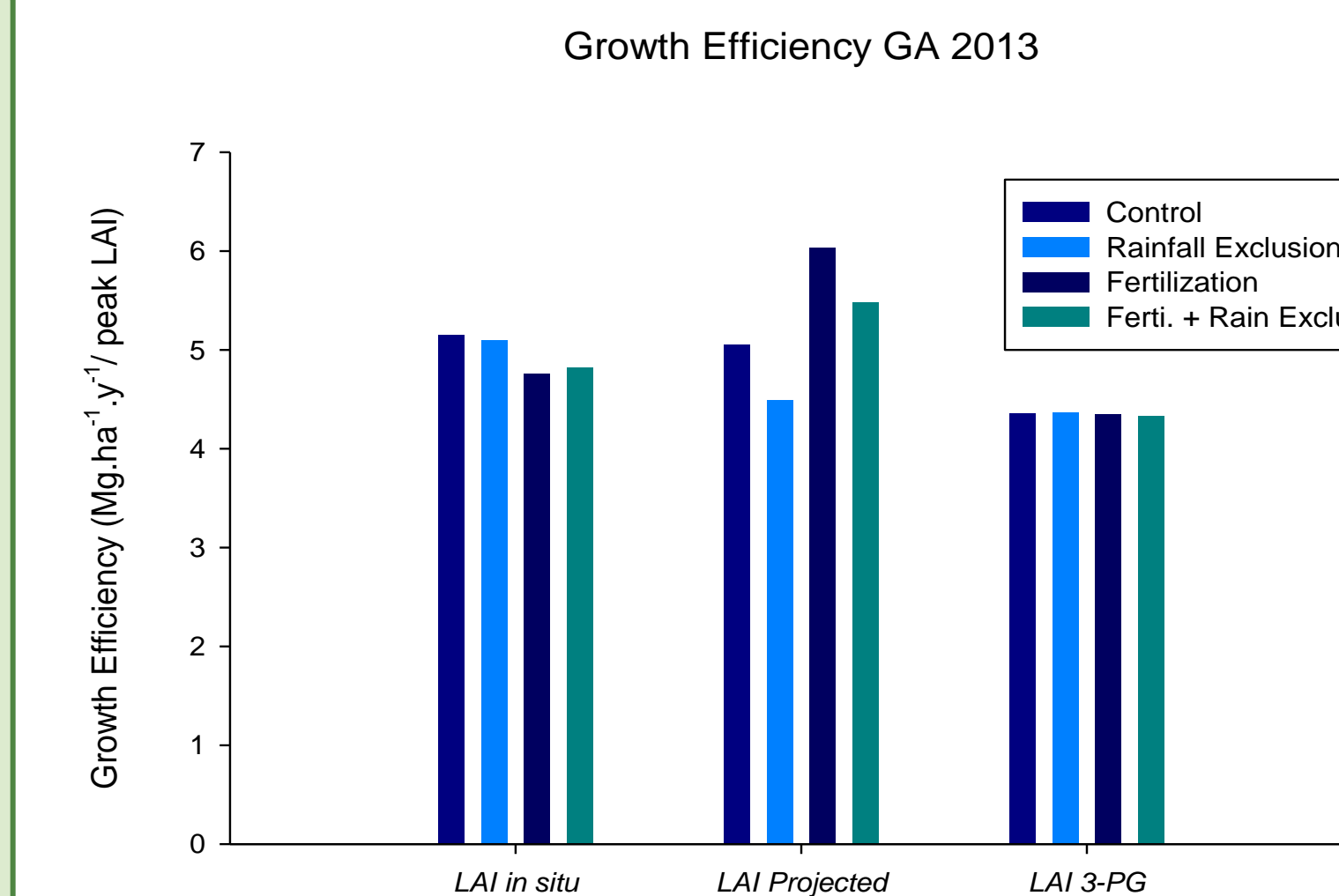
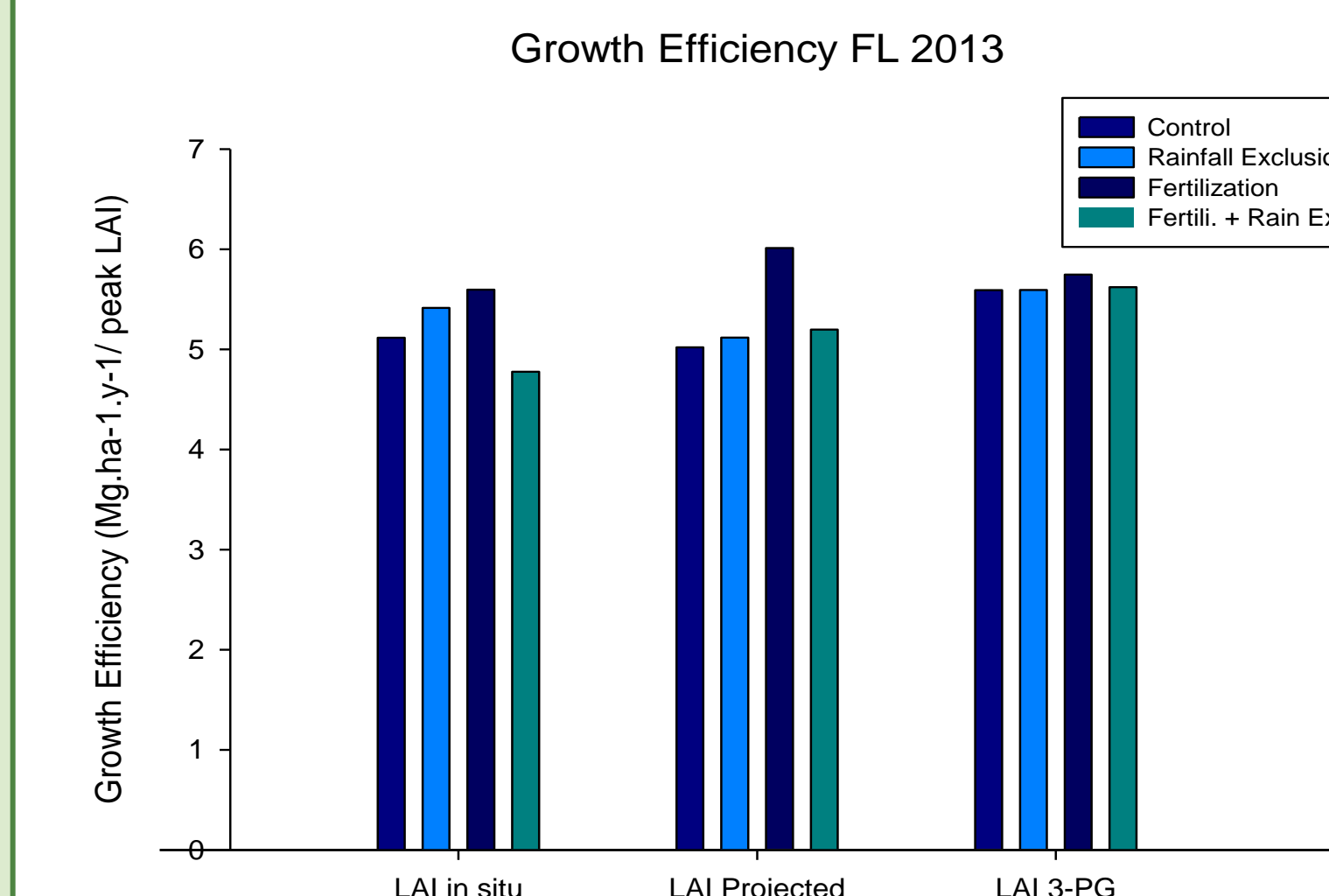


Fig. 1 – Pinemap Tier III site location and loblolly pine native range

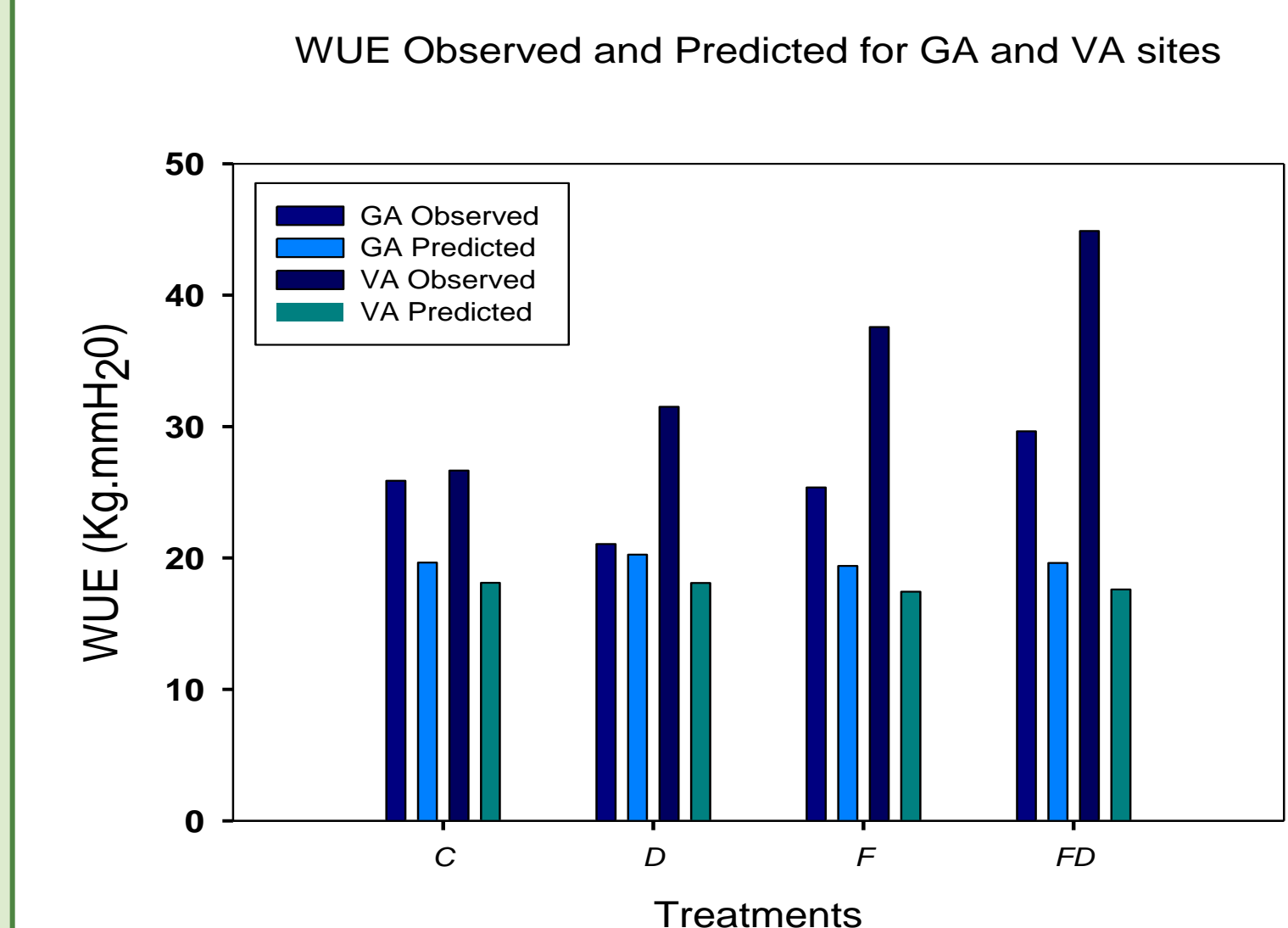
GE and WUE



The GE estimations of the model, are showing no distinction between treatments of each site.



For the FL site, the same problem can be visualized, although the model is predicting the GE within the range of the observed values.



The WUE estimations of the model are showing no distinction of treatments, and for VA site, the model is showing a poor accuracy.

Conclusions

- The 3-PG model is showing a reasonable well accuracy for biomass components and over-predicting transpiration values.
- Since the model is showing good accuracy in estimating the aboveground biomass and its components, it will be used to investigate the allocation pattern along the native range of loblolly pine.

- Although the model is showing a good accuracy for biomass, it seems the ability of the model in not capturing the seasonal pattern of LAI, might be related to its indifference in predicting the GE for the 4 treatments imposed at the both Tier III (FL and GA).
- The estimations of WUE might be biases (VA) due to the over prediction of transpiration for a colder site (Fig 5).