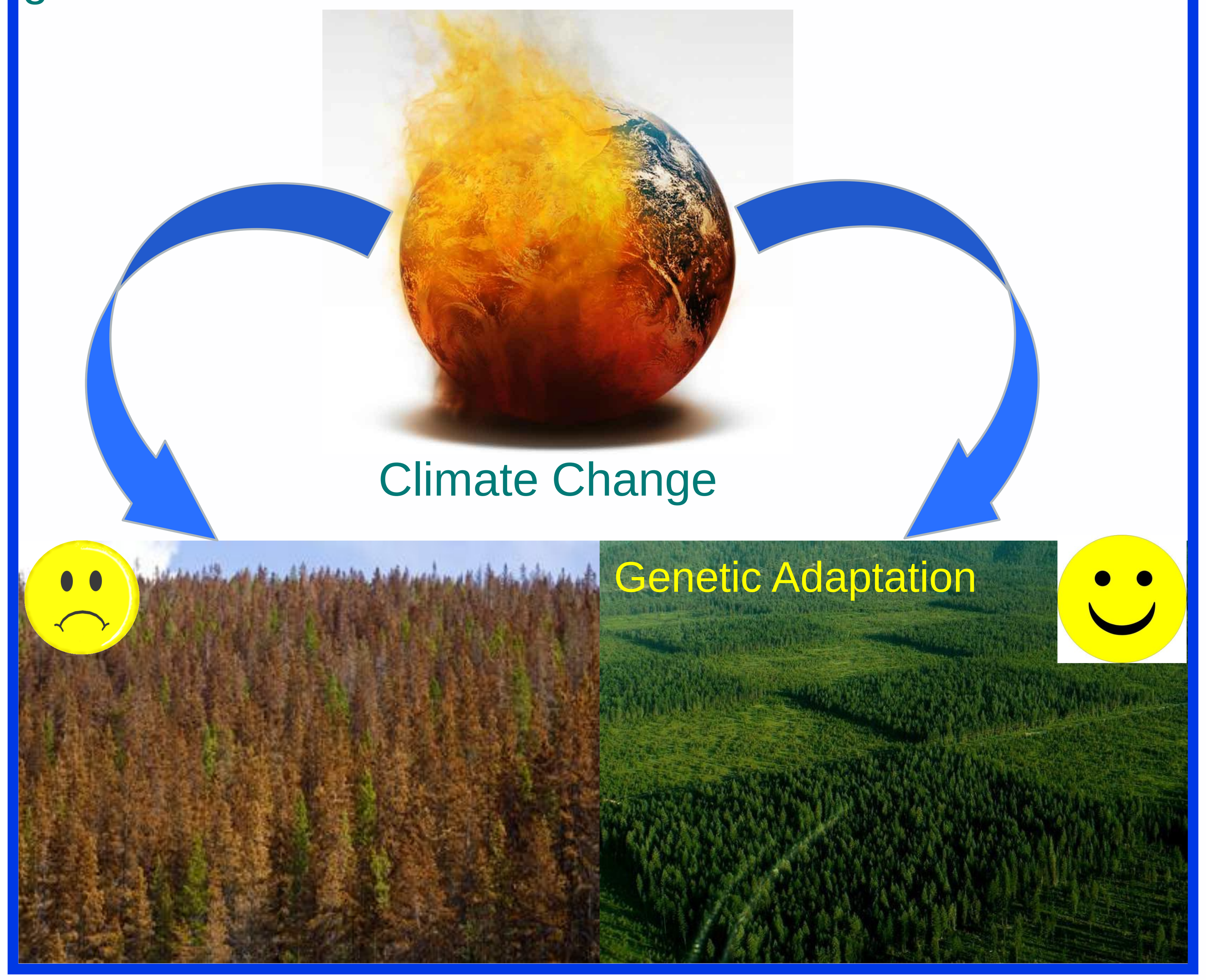
Integrating Climate and Genetic Effects of Southeastern Loblolly Pine by Universal Response Functions

Jianxing Zhang[1, 2], Salvador A. Gezan[1], Gary F. Peter[1,3]

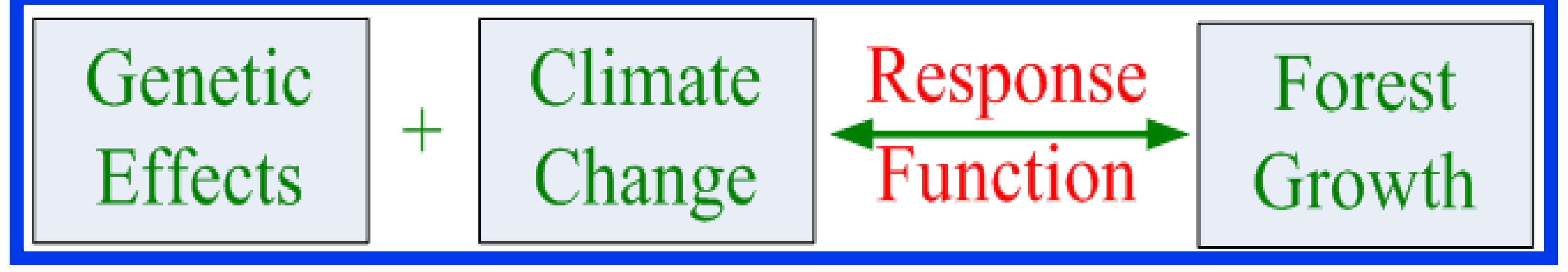
[1] School of Forest Resources & Conservation, [2]Statistics, [3]Plant Molecular and Cellular Biology Program, University of Florida, Gainesville, FL 32611

Introduction

Genetic improvements in forestry dramatically increase the productivity of planted pine in the southeast US. Climate is a key environmental factor affecting the phenotypes and genotypes of trees. How can forestry adapt to changes in climate and climate variability? How can forest growth connect with climate and genetic effects?



Hypotheses

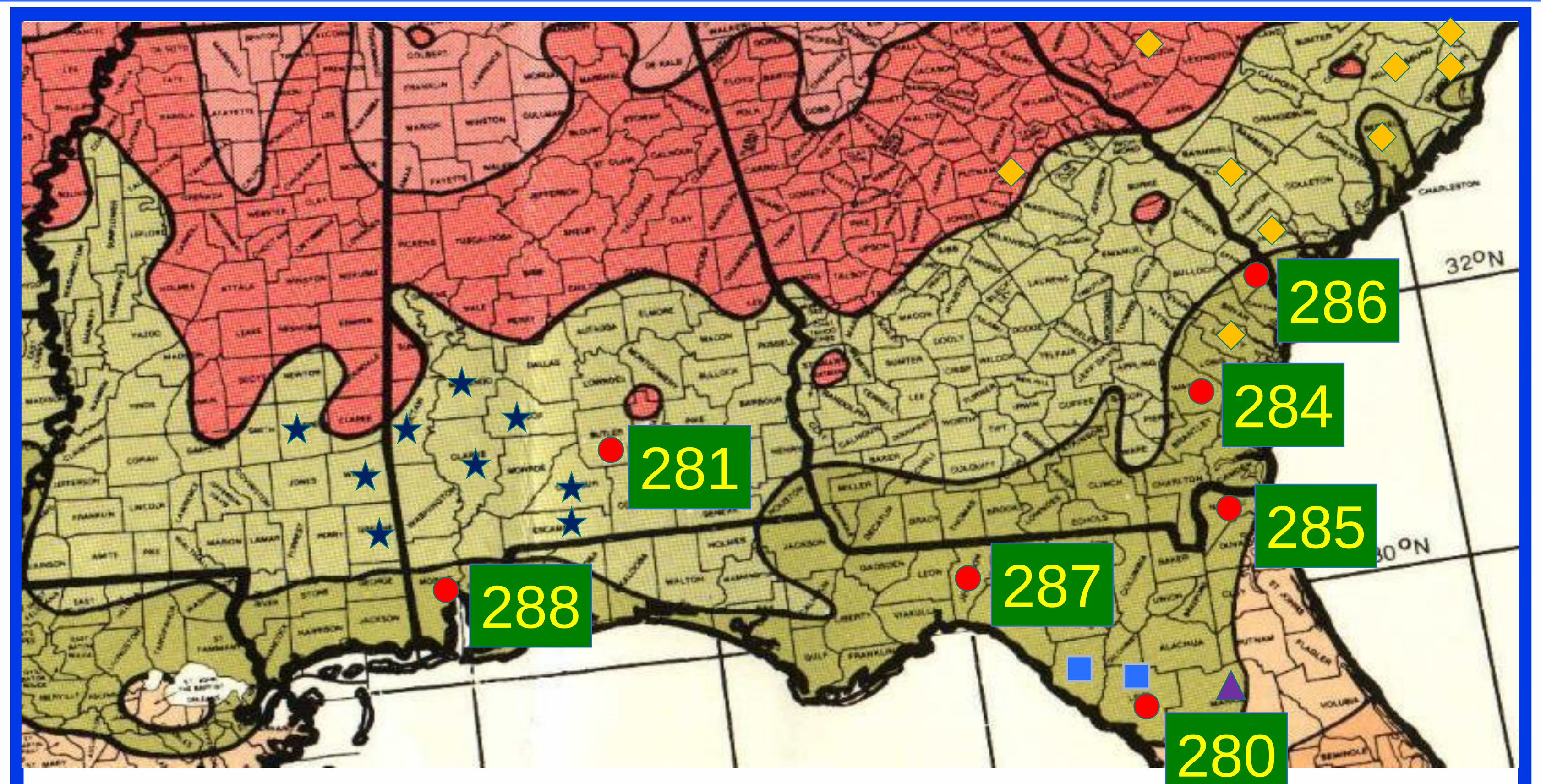


Objectives

1.Based on loblolly provenance-progeny tests, develop universal response functions to understand the climate and genetic effects influencing growth and adaptation.

2. Deliver deployment guidelines for genotypes suited for varied climatic conditions to maximize resiliency and reduce adverse impacts of climate change on productivity.

Data



In 1982-1983, seven provenance-progeny tests were established in Alabama, Florida, Georgia and Mississippi. (Test Locations ●) with 4 loblolly pine provenances from South Carolina and Georgia (Atlantic Coastal Plain, ACP ◆), Central Florida (CF ▲), Marion County Florida (MCF ■), and Alabama and Mississippi (Gulf Coastal Plain, GCP ★). At each field location, 38-58 families were planted in a randomized complete block design in a split-plot experiment with 3-5 complete blocks. Spacing varied at the different locations from about 2 m×3 m to 3 m×3 m. Provenances were arranged as whole plots and families within a whole plot were planted in 10-tree row subplots. In total, the 7 sites included approximately 14,500 individual trees at time of planting. Height, stem diameter, volume and disease traits were measured at years 5, 10, & 15.

Method

Individual Response Function

$$Y_i = b_0 + b_1 X_{1i} + b_2 X_{1i}^2 + e_i$$

Individual Transfer Function

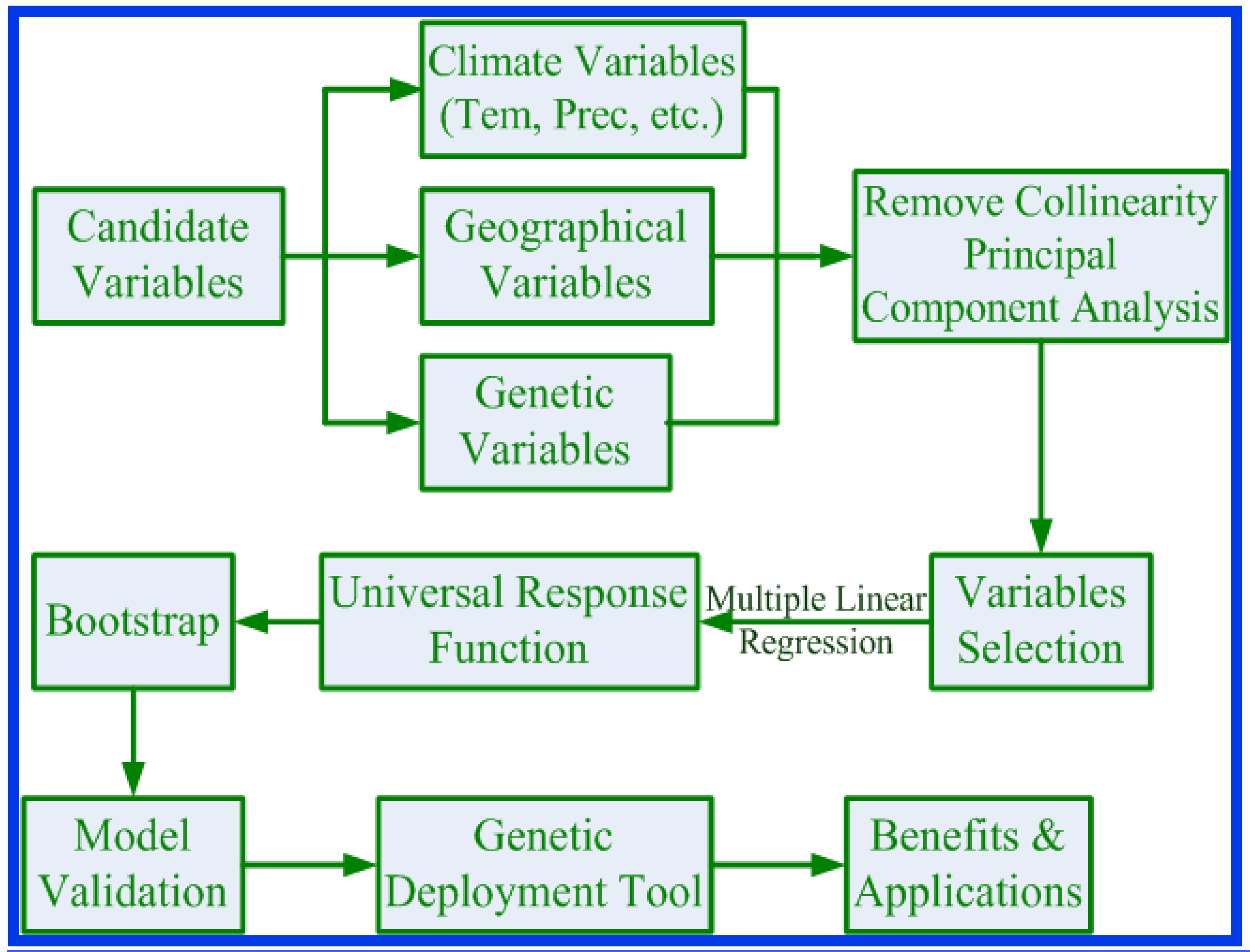
$$Y_j = b_0 + b_1 X_{2j} + b_2 X_{2j}^2 + e_j$$

Universal Response Function

$$Y_{ij} = b_0 + b_1 X_{1i} + b_2 X_{1i}^2 + b_3 X_{2j} + b_4 X_{2j}^2 + b_5 X_{1i} X_{2j} + e_{ij}$$

A combination of the individual response function and the individual transfer function could be viewed as a universal response function. Y_i is the observation of a population at the test site i, X_{1i} is one or more climate variables for test site i, X_{2j} is one or more climate variables for provenance j, Y_{ij} is the observation of population j at the test site i. b's and e's are regression coefficients and residuals, respectively.

Plans



Benefits

1. Genetic deployment tool and uniform response functions could help forest managers target appropriate/selected seedlots and families to specific planting sites based on climate information.
2. This modeling tool could be used to plan current, or future situations based on climate change, and it also helps us assess risk, and increase productivity and resilience in the future.

Acknowledgement

This research is supported by the project of Pine Integrated Network: Education, Mitigation, and Adaptation project (PINEMAP), USDA National Institute of Food and Agriculture (NIFA).

References

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2. Wang, T., G.A. O'Neill, and S.N. Aitken, Integrating environmental and genetic effects to predict responses of tree populations to climate. Ecological Applications, 2010. 20(1): p. 153-163.