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

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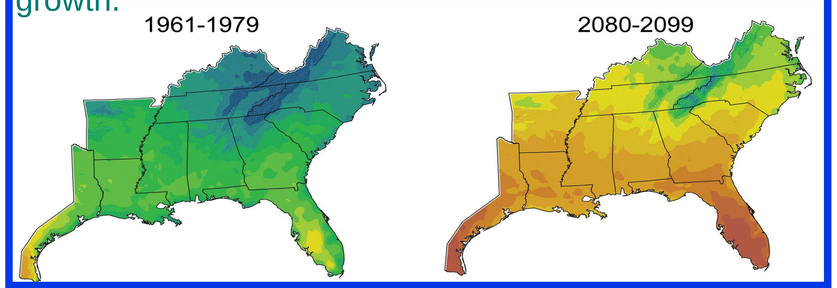
Introduction

Loblolly pine is adapted to grow across wide environmental gradients of soil and climate. The degree of genetic differentiation selected by climate is understudied. Current knowledge suggests, like annual crops, that mean monthly minimum winter temperature, is a key variable for seed movement. Important questions remain about the risks associated with moving local germplasm sources to different climatic zones, and whether additional climatic variables (i.e. rainfall, radiation, etc.) will become more important. Here we used different statistical methods (stepwise regression, LASSO, etc.) to identify climate variables that affect growth.



Hypotheses

Genetic Effects + Climate Change ⟷ Response Function → Forest Growth

Objectives

Create a more robust set of seed deployment guidelines by creating universal response functions with different variable selection methods, and generate maps for matching optimum genetic materials with appropriate planting sites.

Acknowledgement

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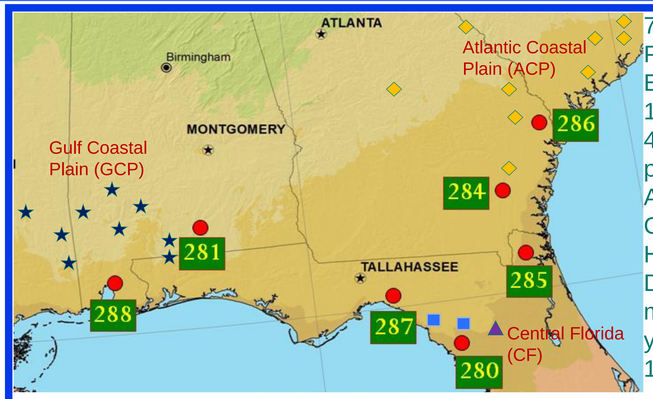
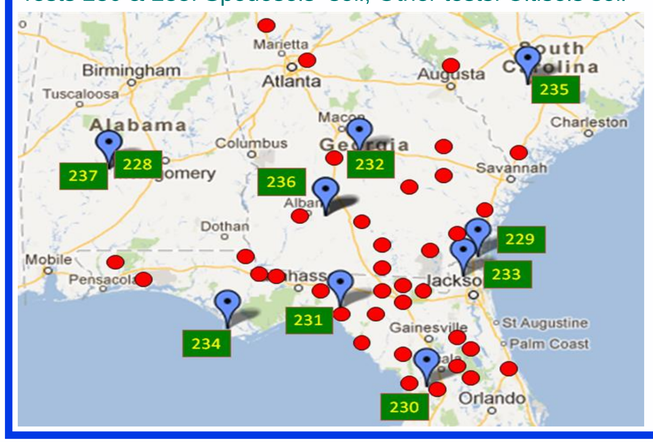
Data



7 Provenance-Progeny Tests Established in 1982-1983 with 4 loblolly pine provenances: ACP, CF & GCP (58 fams). Height, dbh & Disease measured at years 5, 10, &15, 10 trees row plot.

Tests 280 & 285: Spodosols soil; Other tests: Ultisols soil



10 Florida Wild-Seed Tests Established in 2001-2002 with 211 loblolly pine families : single tree plot tests. Height, dbh & Disease measured at years 6, 30600 trees in total.

Conclusions

- Climate variables explain 57% of the performance of loblolly for both test sets except DBH at Provenance-Progeny Tests.
- Results confirm Schmidtling's (USFS) finding that minimum coldest month temperature of the provenance as an important seed deployment guideline.
- Results demonstrate significant longitude effects for provenance.
- Trees grow better with higher radiation in sites and provenance.
- Test site Frost-free Period was negatively correlated with growth, which is difficult to explain but may be due to confounding effects.
- Further analysis needed to validate the model between these two data sets.

References

1. Sierra-Lucero, V., et al., Performance differences and genetic parameters for four coastal provenances of loblolly pine in the southeastern United States. *Forest science*, 2002. **48**(4): p. 732-742.
2. Wang, T., G.A. O'Neill, and S.N. Aitken, Integrating environmental and genetic effects to predict responses of tree populations to climate. *Ecol. Applications*, 2010.**20**(1):p.153-163.

Results: LASSO with Idaho Data

	Resp	Variable	Est.	Partial R^2	Seqn R^2	VIF
Prov-Prog Tests	HT (ft)	Intercept	33.53	——	——	0
		S_FFP	-6.61	0.374	0.374	3.26
		S_MAR	1.874	0.055	0.563	2.17
		S_Hum	3.645	0.134	0.508	2.36
		P_MCMT	0.713	0.03	0.593	1.19
		P_longi	-0.658	0.012	**0.605**	1.18
	DBH (in)	Intercept	5.402	——	——	0
		S_FFP	-0.63	0.091	0.091	3.26
		P_MCMT	0.141	0.093	0.184	1.28
		S_Hum	0.398	0.052	0.237	2.36
		S_MAR	0.353	0.134	0.371	2.17
		P_longi	-0.109	0.01	0.381	1.57
		P_MAP	0.075	0.01	**0.391**	1.33
	Volume (ft3/ac)	Intercept	70.70	——	——	
		S_FFP	-26.62	0.275	0.275	1.53
		S_Hum	18.79	0.278	0.553	1.53
		P_longi	-3.735	0.027	0.580	1.18
		P_MCMT	2.835	0.008	**0.588**	1.18
Florida Wild-Seed Tests	HT (ft)	Intercept	24.17	——	——	0
		S_LSHM	-2.971	0.119	0.119	7.57
		S_MAP	-4.246	0.106	0.225	4.62
		S_MCMT	-3.520	0.135	0.360	4.81
		S_MW99	-3.916	0.224	0.584	6.41
		P_longi	-0.430	0.021	0.605	1.04
		S_Hum	0.715	0.014	0.619	3.55
		P_MAR	0.192	0.003	**0.623**	1.04
	DBH (in)	Intercept	4.549	——	——	0
		S_MAP	-0.878	0.031	0.031	4.62
		S_MW99	-0.903	0.201	0.232	6.41
		S_MCMT	-0.794	0.140	0.372	4.81
		S_LSHM	-0.759	0.146	0.518	7.57
		S_Hum	-0.213	0.028	0.546	3.55
		P_longi	-0.099	0.024	0.569	1.04
		P_MAR	0.023	0.001	**0.570**	1.04
	Volume (ft3/ac)	Intercept	1.363	——	——	0
		S_LSHM	-0.541	0.045	0.045	7.57
		S_MCMT	-0.547	0.104	0.149	4.81
		S_MAP	-0.631	0.107	0.256	4.62
		S_MW99	-0.655	0.324	0.580	6.41
		P_longi	-0.068	0.024	0.604	1.04
		S_Hum	-0.126	0.021	0.625	3.55
		P_MAR	0.019	0.002	**0.626**	1.04