PINEMAP

Refined Seedling Deployment Tools

Steve McKeand

NC State University Cooperative Tree Improvement Program

Pine Plantation Research and Decision Support Tool Rollout

May 16-17, 2017 Athens, GA

USDA United States Department of Agriculture National Institute of Food and Agriculture

PINEMAP

Refined Seedling Deployment Tools

Special thanks to Ross Whetten, Fikret Isik, and Alfredo Farjat

And all members of the

NC State University Cooperative Tree Improvement Program

They did all the work!

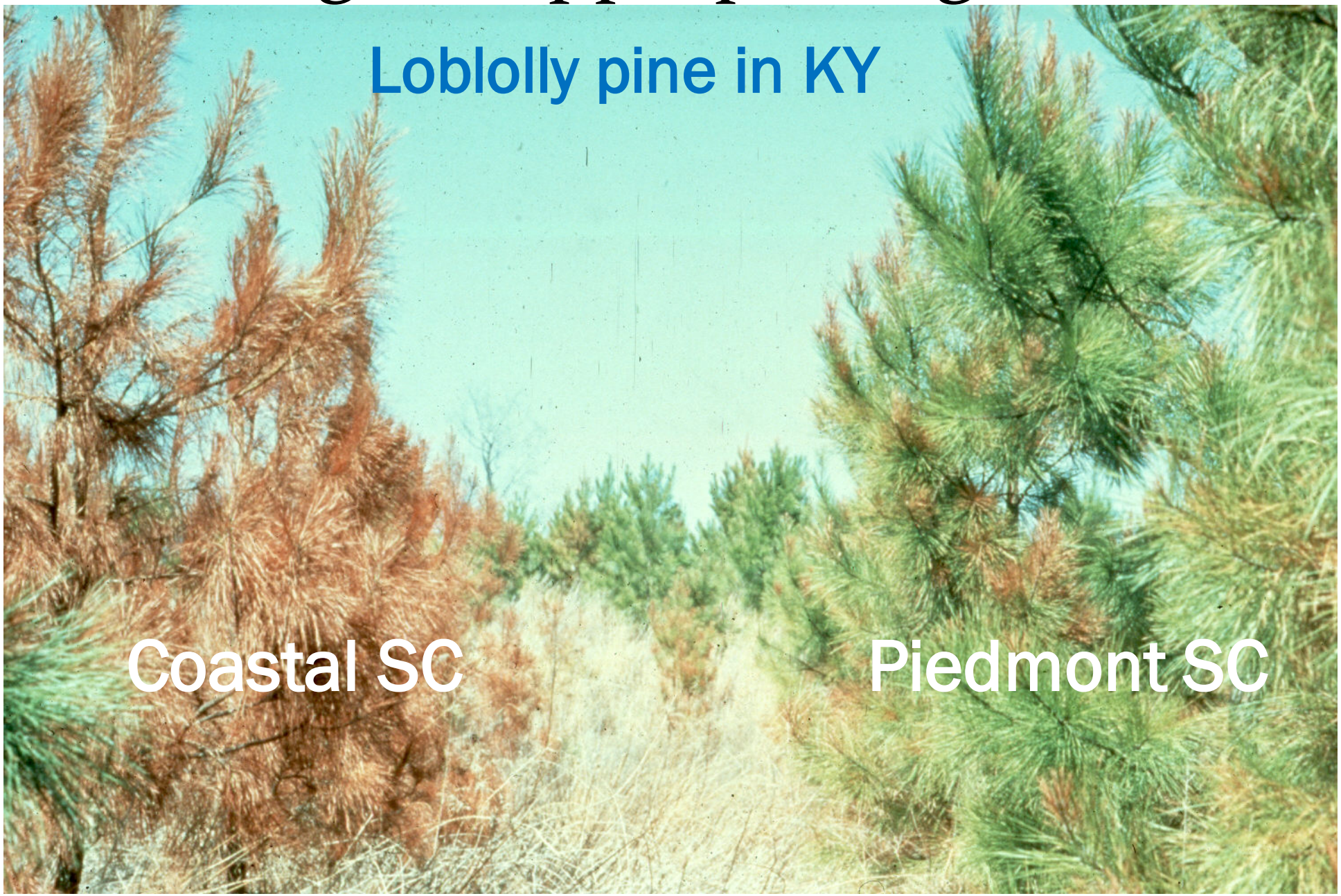
USDA United States Department of Agriculture National Institute of Food and Agriculture

Seedling Deployment

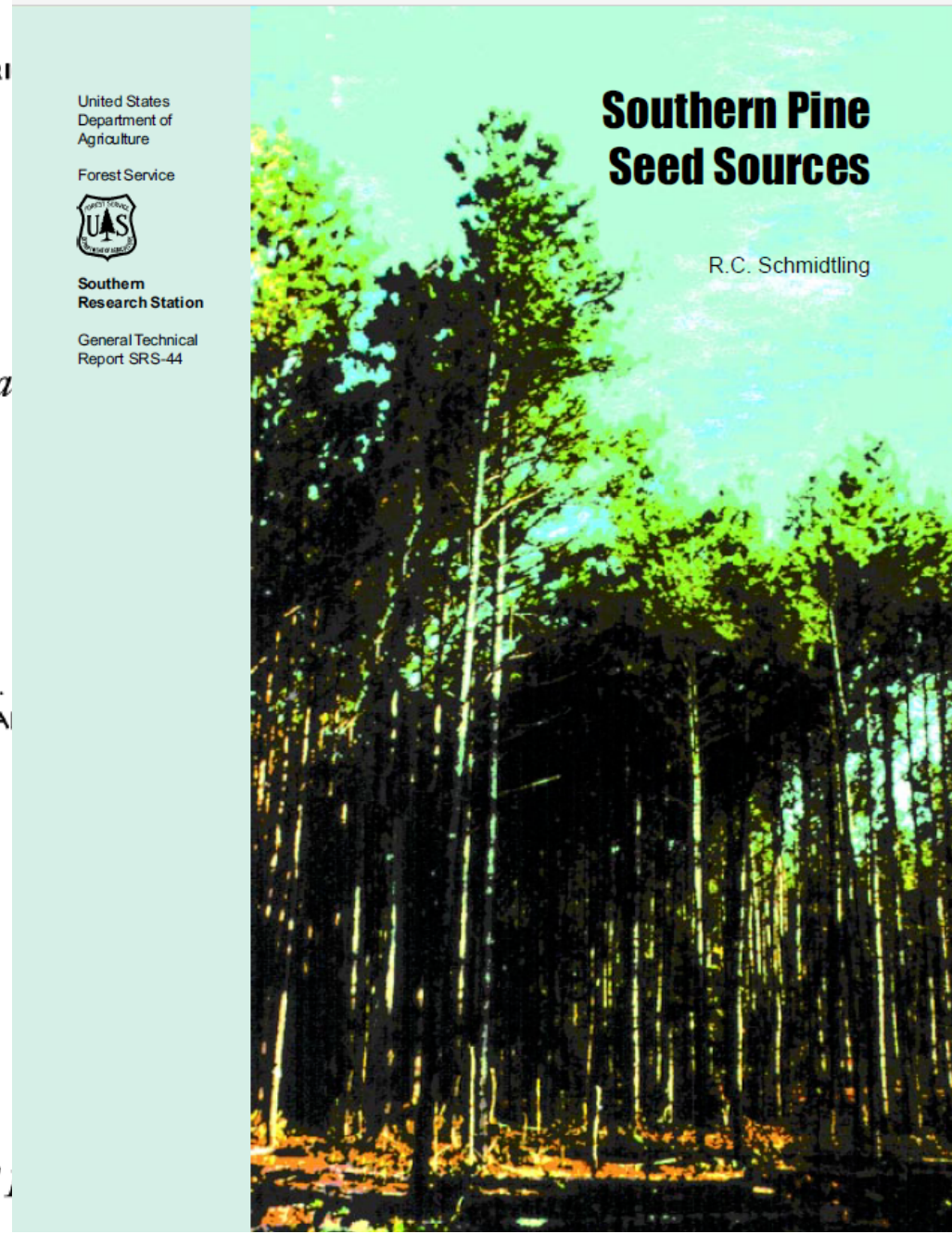
- What seedlings to plant to meet your objectives
  … FOR 101
- Typical objectives:
  - Growth, rust resistance, quality, …
  - Plant adapted trees, grow and survive
  - And make you $$$

This may be your objective

But selecting the appropriate genetics …



We know a lot about seed sources of loblolly pine



We know a lot about seed sources of loblolly pine

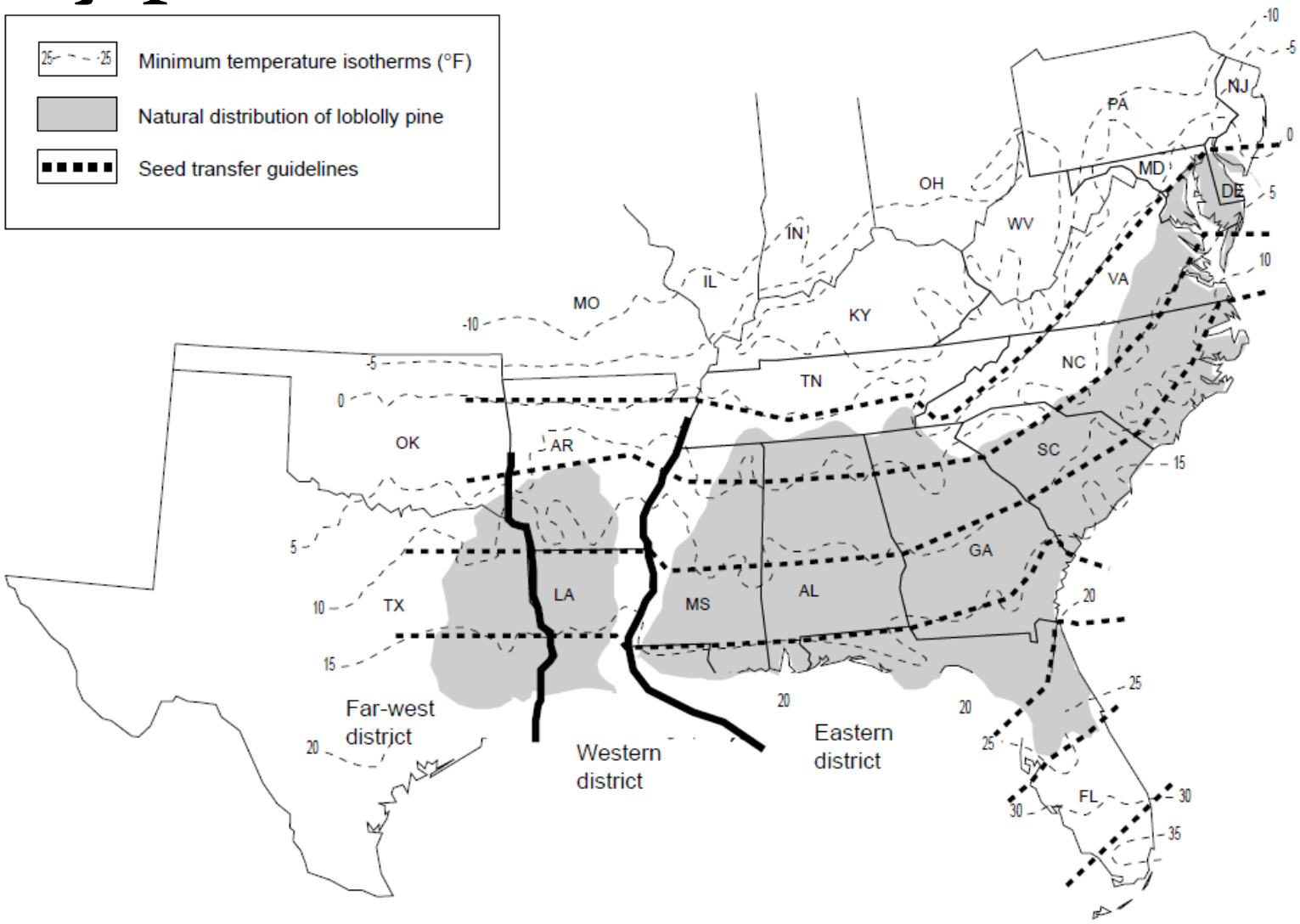
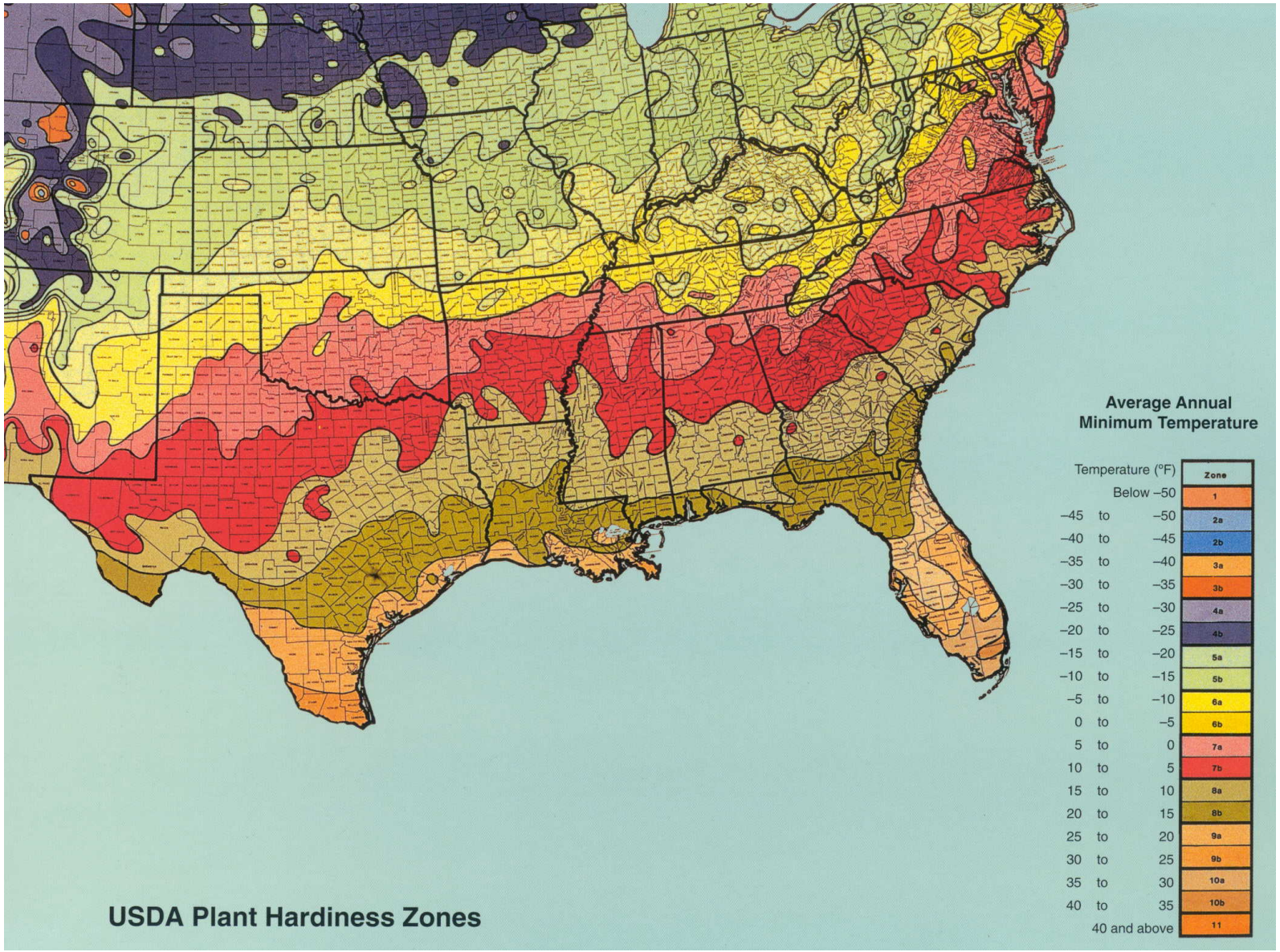
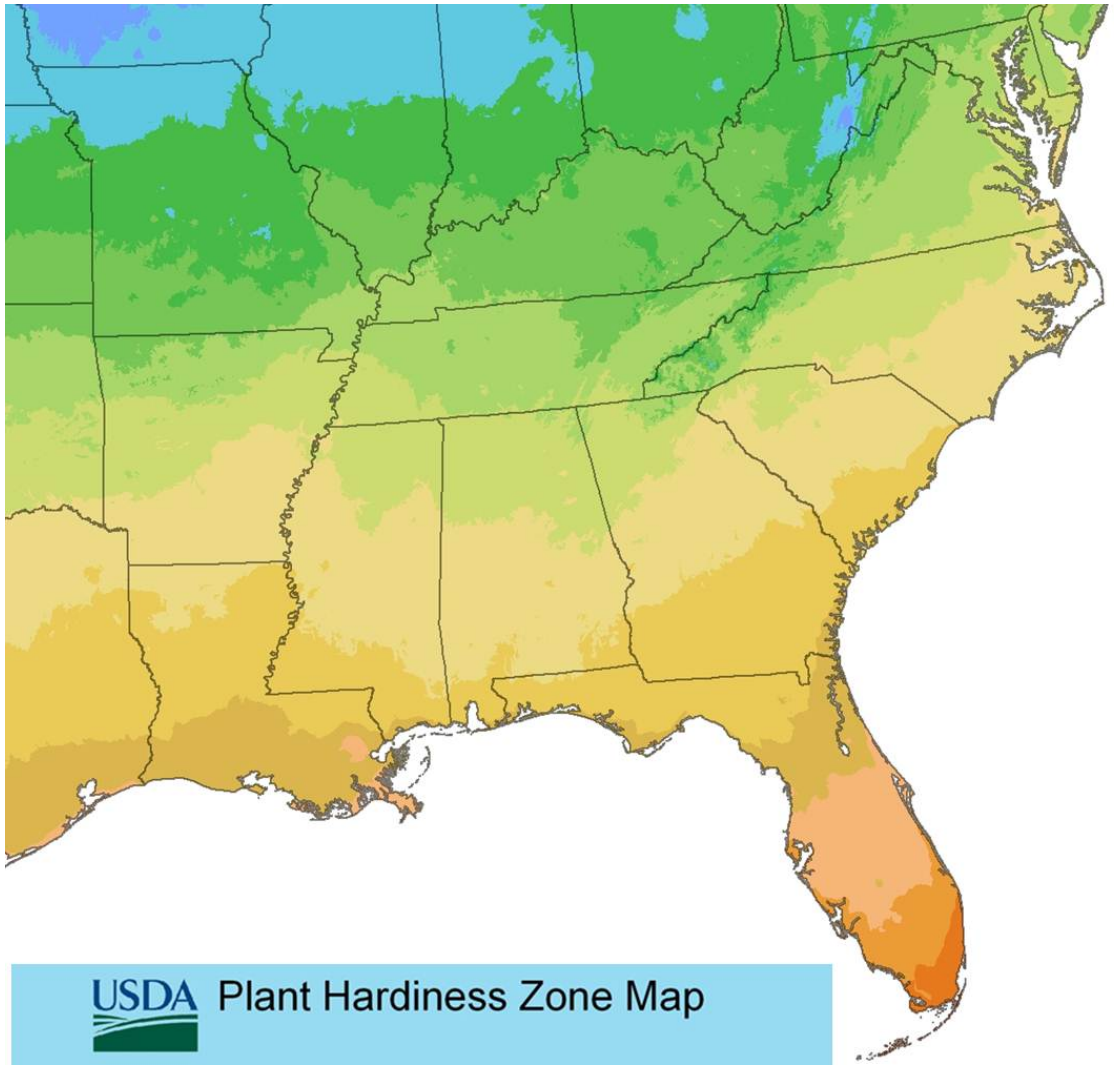


Figure 2—Loblolly pine distribution with seed transfer guidelines. Natural distributions of species adapted from Critchfield and Little (1966); minimum temperature isotherms from USDA (1990).

We know a lot about seed sources of loblolly pine



We know a lot about seed sources of loblolly pine



USDA Plant Hardiness Zone Map

Southeastern U.S.

Average Annual Extreme Minimum Temperature 1976-2005

Temp (F)	Zone	Temp (C)
-60 to -55	1a	-51.1 to -48.3
-55 to -50	1b	-48.3 to -45.6
-50 to -45	2a	-45.6 to -42.8
-45 to -40	2b	-42.8 to -40
-40 to -35	3a	-40 to -37.2
-35 to -30	3b	-37.2 to -34.4
-30 to -25	4a	-34.4 to -31.7
-25 to -20	4b	-31.7 to -28.9
-20 to -15	5a	-28.9 to -26.1
-15 to -10	5b	-26.1 to -23.3
-10 to -5	6a	-23.3 to -20.6
-5 to 0	6b	-20.6 to -17.8
0 to 5	7a	-17.8 to -15
5 to 10	7b	-15 to -12.2
10 to 15	8a	-12.2 to -9.4
15 to 20	8b	-9.4 to -6.7
20 to 25	9a	-6.7 to -3.9
25 to 30	9b	-3.9 to -1.1
30 to 35	10a	-1.1 to 1.7
35 to 40	10b	1.7 to 4.4

Funding from PINEMAP

Enhance our knowledge about seed sources and adaptability

- And from our leader:

> "We spent $20MM to find out that Schmidtling was right" Martin (2015)

- Minimum winter temperature is very important

FUNDAMENTAL RESEARCH

For. Sci. 63(1):39–48
http://dx.doi.org/10.5849/forsci.15-107

PINEMAP

genetics & tree improvement

Variation among Loblolly Pine Seed Sources across Diverse Environments in the Southeastern United States

Alfredo E. Farjat, Aaron K. Chamblee, Fikret Isik, Ross W. Whetten, and Steven E. McKeand

Seven seed sources of first-generation plantation selections of loblolly pine (*Pinus taeda* L.) were evaluated for six traits in test sites across most of its native range east of the Mississippi River in the southeastern United States. The traits evaluated were survival, height, volume, straightness, stem forking, and incidence of fusiform rust disease (caused by *Cronartium quercuum* [Berk.] Miyabe ex Shirai f. sp. *fusiforme*). At age 8 years, survival was high, with most seed sources having survival greater than 75% at all but two test sites. South Carolina Coastal and Georgia-Florida Coastal seed sources exhibited the fastest growth and most resistance to fusiform rust, whereas the Virginia seed source exhibited the slowest growth but had the best stem form. Test sites and seed source were significantly different for all traits. Seed source × site interactions (genotype × environment [G × E]) were also significant for all traits except stem forking. Low type B genetic correlation values (r_B <0.67) for height, volume, and straightness suggest the presence of G × E interactions. The South Carolina Coastal and Virginia seed sources contributed disproportionally the most to G × E interactions for growth traits, but environmental contributions to G × E interactions were distributed relatively uniformly across most test sites. The results indicate that when seed sources are moved outside of their adaptive range, important G × E interactions should be expected and the difference among seed sources originating from a wide range of climates are expected to be more pronounced in older ages.

Keywords: *Pinus taeda*, seed source, provenance test, genotype × environment interaction, multienvironmental trial analysis

For. Sci. 61(●):000–000
http://dx.doi.org/10.5849/forsci.14-075

PINEMAP

genetics & tree improvement

Modeling Climate Change Effects on the Height Growth of Loblolly Pine

Alfredo E. Farjat, Fikret Isik, Brian J. Reich, Ross W. Whetten, and Steven E. McKeand

We present a statistical model to predict the effects of climate change on the height growth of loblolly pine (*Pinus taeda* L.) families in the southeastern United States. Provenance-progeny trials were used for assessing the response of loblolly pine seed sources to environmental change. Ordinary least squares, ridge regression, and LASSO regression were used to develop height growth prediction models. The approach integrates both genetic and environmental effects and is meant to overcome the critical limitations of population response function and transfer function methods by making full use of data from provenance trials. Prediction models were tested using a hypothetical future climate scenario with 5% decrease in precipitation and 0.5° C increase in maximum and minimum temperatures, relative to historical average values. Under this scenario, local families from the coastal plains of Georgia, Florida, and South Carolina showed the highest performance relative to the current climate in their native environments. As these seed sources were moved to colder northern and inland regions from their origin, we observed declines in their height growth. Similarly, the climatic change scenario suggested that performance of northern seed sources declined significantly when they were moved to more southern warmer regions. The statistical model can be used as a quantitative tool to model the effect of climatic variables on the performance of loblolly pine seed sources and may help to develop sound breeding deployment strategies.

Keywords: *Pinus taeda*, provenance test, statistical model, universal response function, climate change

We know a lot about seed sources of loblolly pine

- BUT… we need to know more about seed sources **and** specific families of loblolly pine
- General guidelines are great, but how do specific families perform?
- Critical information given the current deployment strategies
- PINEMAP funded a survey of Cooperative members to see what is being planted

2013 Deployment Survey

What did we find?

- 843,466,000 seedlings planted / year

Loblolly:	734,553,536	87.1%
Slash:	51,138,215	6.1%
Longleaf:	48,483,299	5.7%
Other:	9,291,092	1.1%

Pine Integrated Network: Education, Mitigation, and Adaptation project (PINEMAP) is a Coordinated Agricultural Project funded by the USDA National Institute of Food and Agriculture, Award #2011-68002-30185

2013 Deployment Survey

Loblolly Deployment

- 95% deployed as OP, FS, clones
- OP families – still the current standard, 84%

Pine Integrated Network: Education, Mitigation, and Adaptation project (PINEMAP) is a Coordinated Agricultural Project funded by the USDA National Institute of Food and Agriculture, Award #2011-68002-30185

PINEMAP

2nd-Generation OP (open-pollinated) Seed Orchard

2013 Deployment Survey

Loblolly Deployment

- 95% deployed as OP, FS, clones
- OP families – still the current standard, 84%
- FS families – becoming more popular, ~8% of loblolly pine regeneration

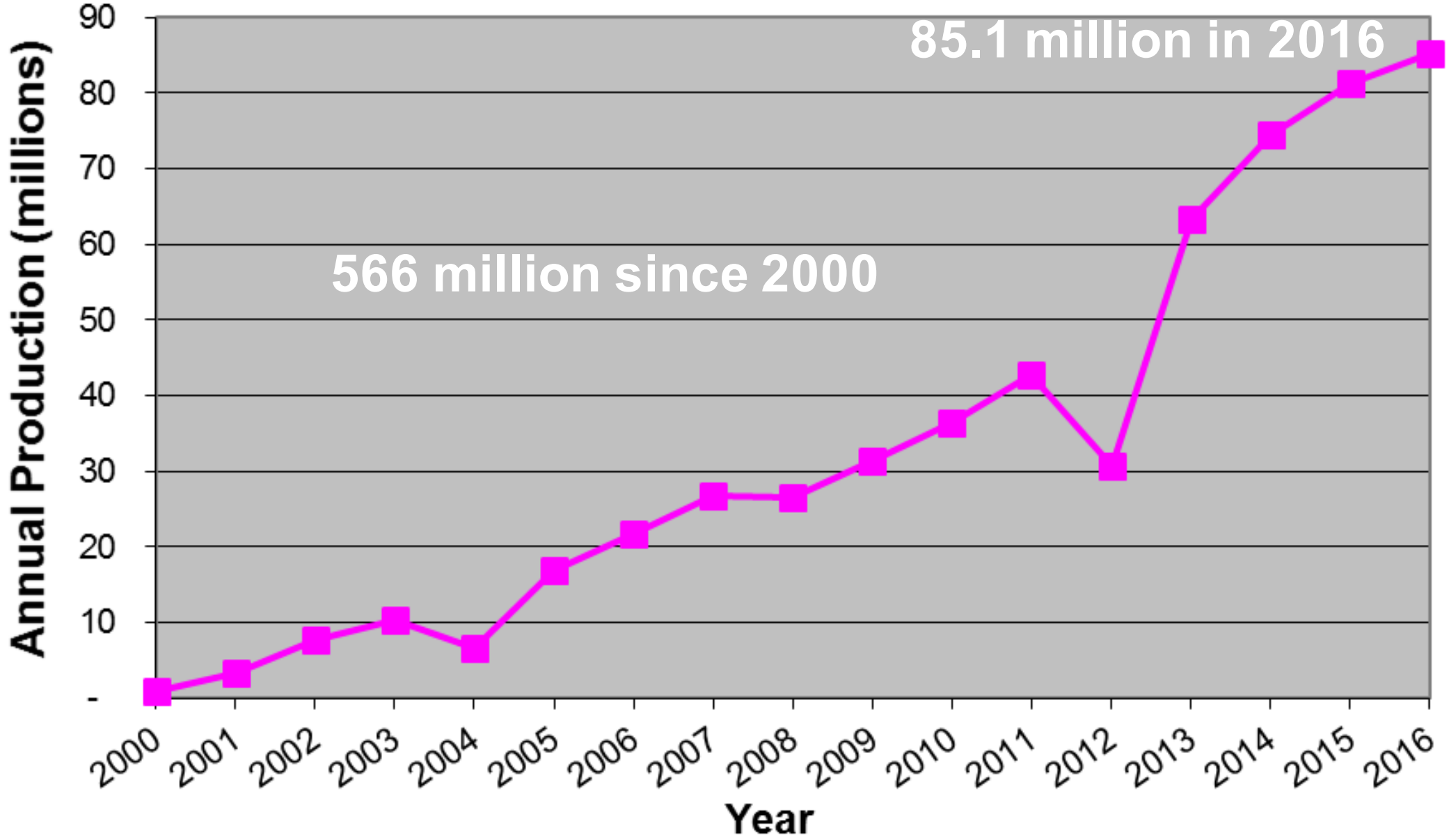
Pine Integrated Network: Education, Mitigation, and Adaptation project (PINEMAP) is a Coordinated Agricultural Project funded by the USDA National Institute of Food and Agriculture, Award #2011-68002-30185

PINEMAP

Mass Production of Control Crosses

PINEMAP

Annual Mass Production of Specific Crosses of Loblolly Pine Seedlings



2013 Deployment Survey

Loblolly Deployment

- 95% deployed as OP, FS, clones
- OP families – still the current standard, 84%
- FS families – becoming more popular, ~8% of loblolly pine regeneration
- Clonal (sometimes called varieties) – about 2% of loblolly pine regeneration
- Seed orchard mix – almost none, ~ 5%

Pine Integrated Network: Education, Mitigation, and Adaptation project (PINEMAP) is a Coordinated Agricultural Project funded by the USDA National Institute of Food and Agriculture, Award #2011-68002-30185

2013 Deployment Survey

Loblolly Deployment

- **95% deployed as OP, FS, clones**
- So we better understand how specific families perform

Pine Integrated Network: Education, Mitigation, and Adaptation project (PINEMAP) is a Coordinated Agricultural Project funded by the USDA National Institute of Food and Agriculture, Award #2011-68002-30185

http://climate.ncsu.edu/pinemap/

climate.ncsu.edu/pinemap/index.php

PINEMAP DECISION SUPPORT SYSTEM | About | Environment | Establishment | Management | Production

DSS Introduction

The guide below describes the features of the PINEMAP Decision Support System. Once you're ready to begin using the DSS, select a tool using the menu above.

1. Background
2. Climate Data
3. Emissions Scenarios
4. Three-Map Layout
5. Time Series

- You can use tools in the PINEMAP DSS to explore **climate-based risks and opportunities** for loblolly pine growth
- Pine trees influence their local climate yet are also themselves **sensitive to climate factors** including temperature and precipitation
- The Pine Integrated Network: Education, Mitigation, and Adaptation Project (**PINEMAP**) studies planted loblolly pine forests in the Southeast US
- DSS tools work best with the current version of major browsers in full-screen mode

Related Resources:

- *What is PINEMAP?*
- *More background on the PINEMAP DSS*

USDA United States Department of Agriculture National Institute of Food and Agriculture

The Pine Integrated Network: Education, Mitigation, and Adaptation project (PINEMAP) is a Coordinated Agricultural Project funded by the USDA National Institute of Food and Agriculture, Award #2011-68002-30185.

If you have any questions, suggestions, or bugs to report with the PINEMAP DSS, please email us at **pinemap@climate.ncsu.edu**.

PINEMAP

NCSU Tree Improvement Program Database

Home

Starting Points

Login

Login
NCSU Login

Introduction

These pages provide access to the NCSU Tree Improvement database.

TREE IMPROVEMENT PROGRAM NC STATE UNIVERSITY

Questions or comments

We know a lot about seed sources of loblolly pine

- BUT… we need to know more about seed sources and specific families of loblolly pine
- General guidelines are great, but how do specific families perform?

- All families from a given region are predicted to have same adaptability
- Not the same growth, rust, or form

Family Code: Athens Family

PRS™ Ratings — Predicted Family Performance

Productivity Rating	38
Rust Resistance Grade	C
Stem Form Grade	C

The **PRS™** ratings indicate that the progeny of family is projected to be:

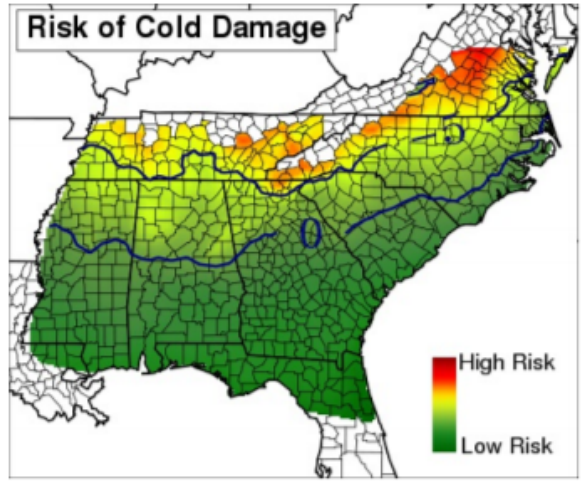
P = 38 → Approximately 38% greater stem volume at age 6 compared to a non-improved loblolly pine checklot for the **Average 2nd-Cycle Parents from Piedmont Region**.

R = C → **Average** for resistance to fusiform rust disease

S = C → **Average** for stem straightness

The minimum winter temperature "origin" of Family **Athens Family** is 11.6°F (0° line). Planting in the green shaded areas on the map up to 5°F colder (south of -5° line) has minimal risk of cold damage[1]. Planting in areas that are 5-10°F colder than the origin (between -5° and -10° lines) will increase the risk of cold damage. Areas that are more than 10°F colder than the origin are too cold and planting is not advised (north of -10° line).

Family **Athens Family** has been tested by members of the *NC State University Cooperative Tree Improvement Program.*



[1]These adaptability guidelines were developed by the USDA Forest Service (Schmidtling 2001), Southern Pine Seed Sources, available at: http://www.srs.fs.usda.gov/pubs/gtr/gtr_srs044.pdf

PINEMAP

FUNDAMENTAL RESEARCH

For. Sci. 61(●):000–000
http://dx.doi.org/10.5849/forsci.14-075

genetics & tree improvement

The models given in Table 2 explained about 22% of the total variation in height growth. The estimated coefficients associated with the climate variables were highly significant. It is interesting to note that only one climate variable associated to the pine family was selected as the predictor of future growth, i.e., yearly average minimum temperature (TMINf).

coastal plains of Georgia, Florida, and South Carolina showed the highest performance relative to the current climate in their native environments. As these seed sources were moved to colder northern and inland regions from their origin, we observed declines in their height growth. Similarly, the climatic change scenario suggested that performance of northern seed sources declined significantly when they were moved to more southern warmer regions. The statistical model can be used as a quantitative tool to model the effect of climatic variables on the performance of loblolly pine seed sources and may help to develop sound breeding deployment strategies.

Keywords: *Pinus taeda*, provenance test, statistical model, universal response function, climate change

PINEMAP

FUNDAMENTAL RESEARCH

For. Sci. 61(●):000–000
http://dx.doi.org/10.5849/forsci.14-075

genetics & tree improvement

The models given in Table 2 explained about 22% of the total variation in height growth. The estimated coefficients associated with the climate variables were highly significant. It is interesting to note that only one climate variable associated to the pine family was selected as the predictor of future growth, i.e., yearly average minimum temperature (TMINf).

coastal plains of Georgia, Florida, and South Carolina showed the highest performance relative to the current climate in their native environments. As these seed sources were moved to colder northern and inland regions from their origin, we observed declines in their height growth. Similarly, the climatic change scenario suggested that performance of northern seed sources declined significantly when they were moved to more southern warmer regions. The statistical model can be used as a quantitative tool to model the effect of climatic variables on the performance of loblolly pine seed sources and may help to develop sound breeding deployment strategies.

Keywords: *Pinus taeda*, provenance test, statistical model, universal response function, climate change

We know a lot about seed sources of loblolly pine

- BUT… we need to know more about seed sources and specific families of loblolly pine
- General guidelines are great, but how do specific families perform?
- To explain more variation in adaptability (not just 8-year height), we would need to establish long-term trials of many families across many sites
  - Not gonna happen!
  - Alternative genetic approaches…