Seedling Genetics – Know what you are planting

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NCSU Cooperative Tree Improvement Program
09/16/2020

TREE IMPROVEMENT PROGRAM NC STATE UNIVERSITY

Outline

- Genetics matters
- NCSU Cooperative Tree Improvement Program
- Breeding process
- Deployment of genetics
- NCSU Performance Rating System *PRS*™

Selecting the right seedlings for your land is a ~25 year investment

When visiting a nursery all seedlings look alike

Seedlots are different, Genetics matters!

Four year old field test

Know what you are planting....both Age 11

NCSU Cooperative Tree Improvement Program

Tree Improvement Program Staff

We have a proud history

- 64 Years of **partnership** with forest companies, state agencies, and forest land owners in the southern US

1960

1985

2018

Our mission

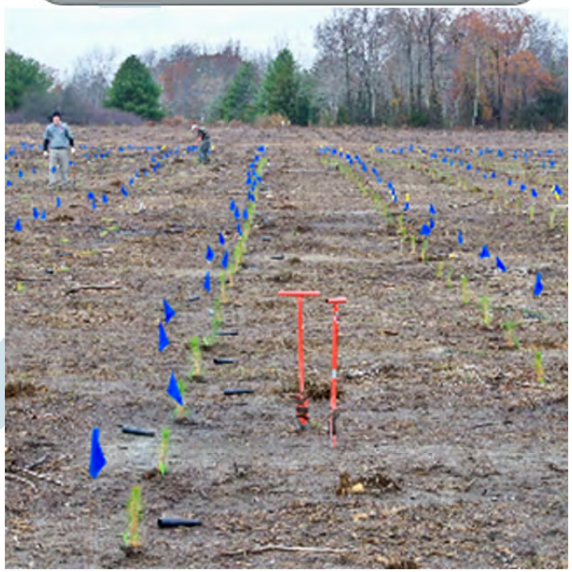
- To Increase value to landowners and citizens through continuous genetic improvement of forest trees

Our Process

Breeding in orchards

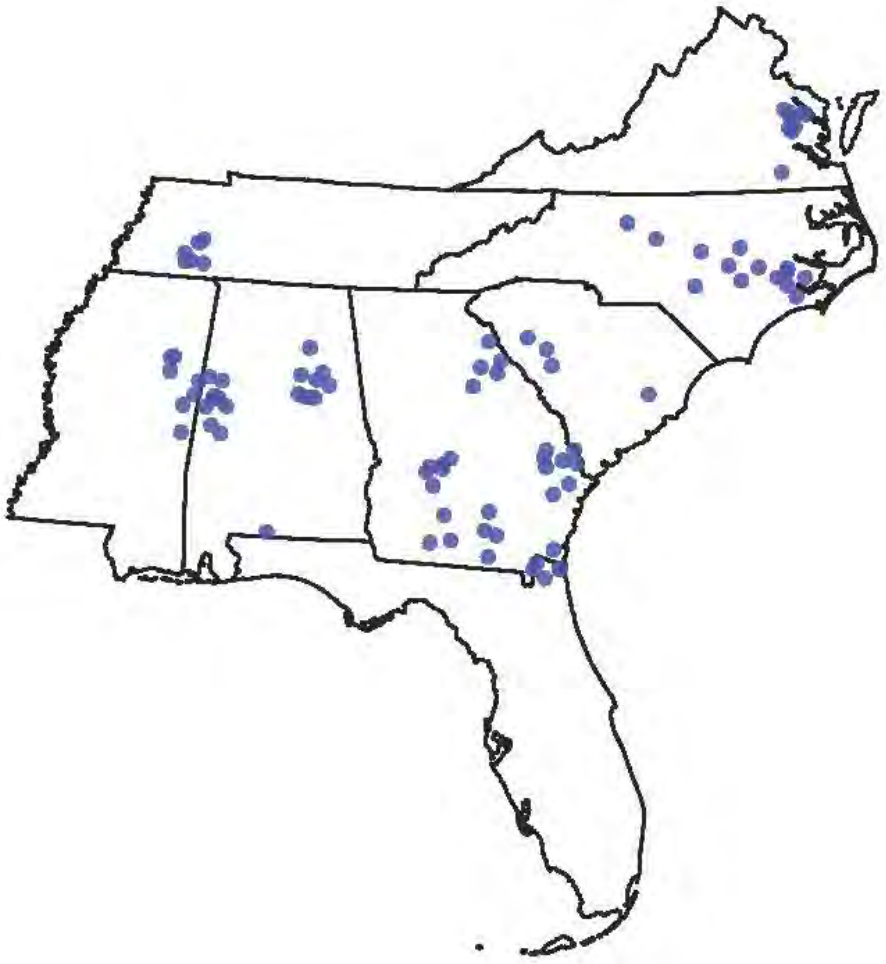
Selection

Field Testing



Progeny testing

4th-Cycle tests established



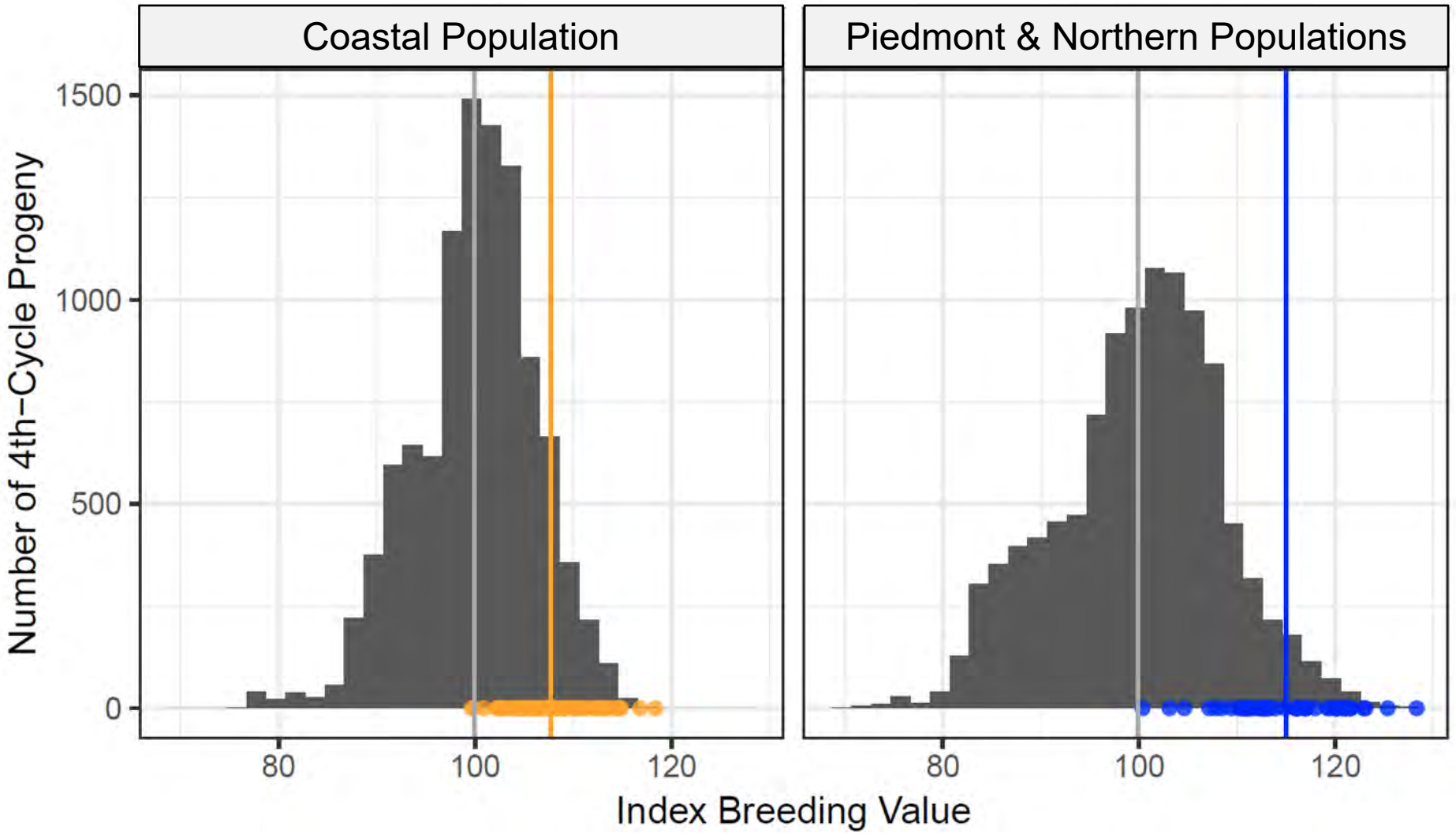
What traits do we select for?

- Depends on economic value and level of genetic control

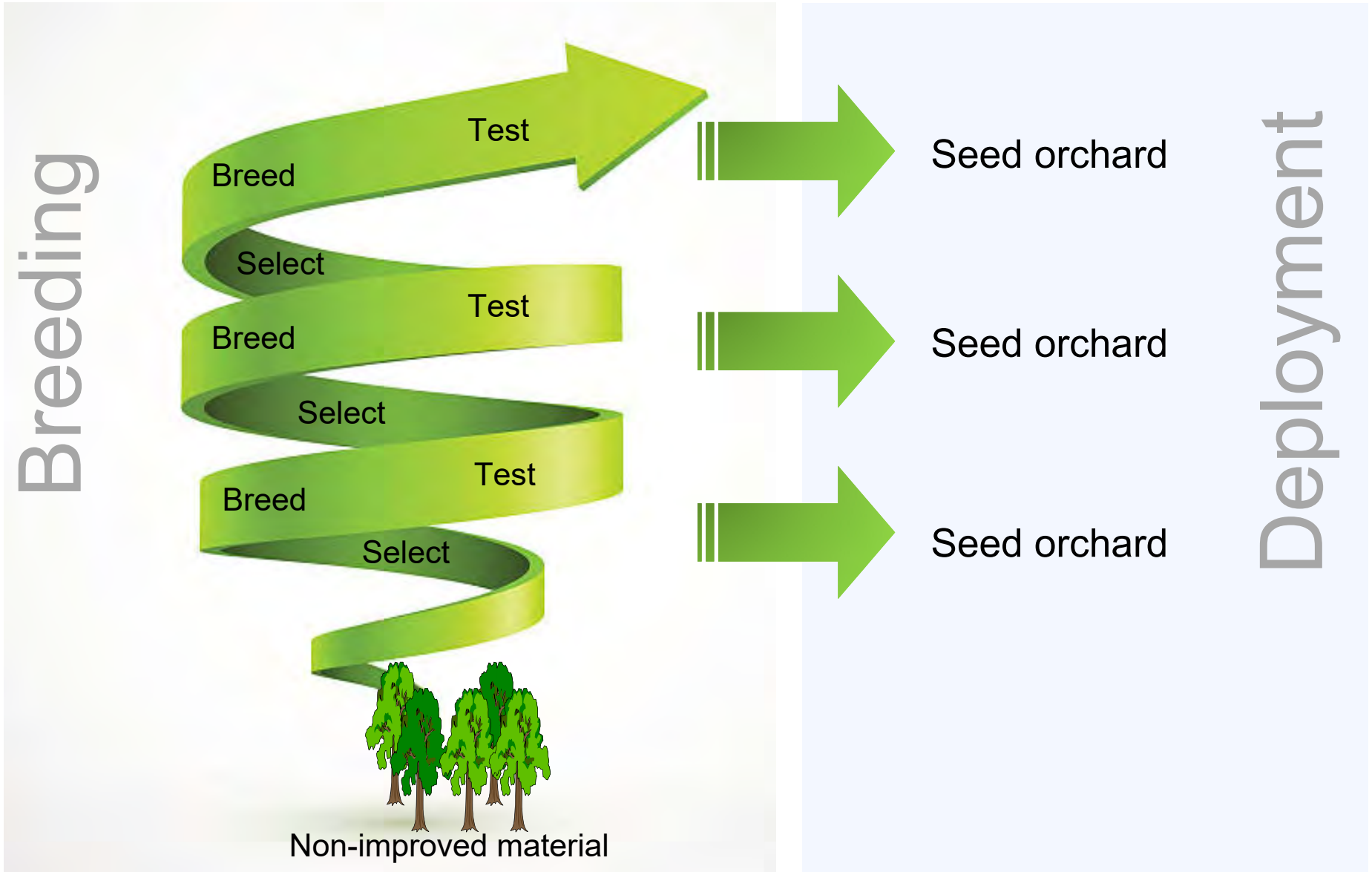
- Stem volume
- Stem straightness
- Fusiform rust resistance

Multi-trait index breeding values

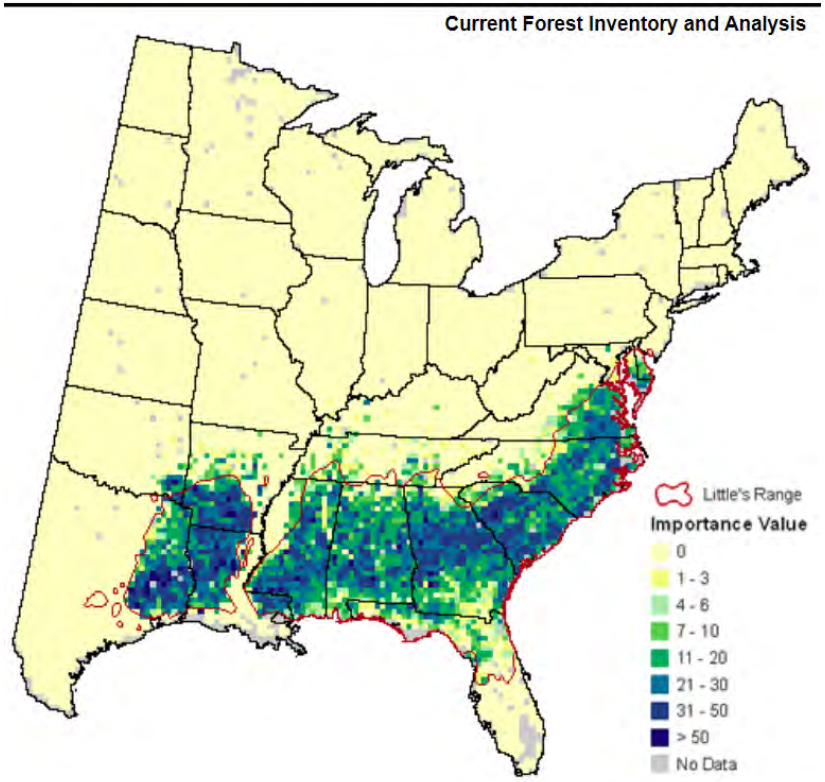
(60% volume, 20% straightness, 20% rust resistance)



Arrowhead Breeding Center, GA

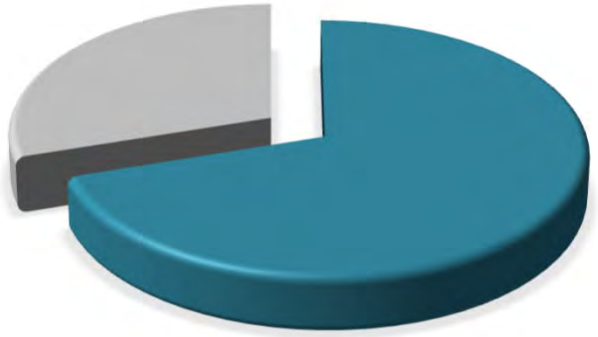

Breeding
Test
Breed
Select
Test
Breed
Select
Test
Breed
Select
Non-improved material
Seed orchard
Seed orchard
Seed orchard
Deployment

Current Distribution Maps for loblolly pine



USDA Forest Service

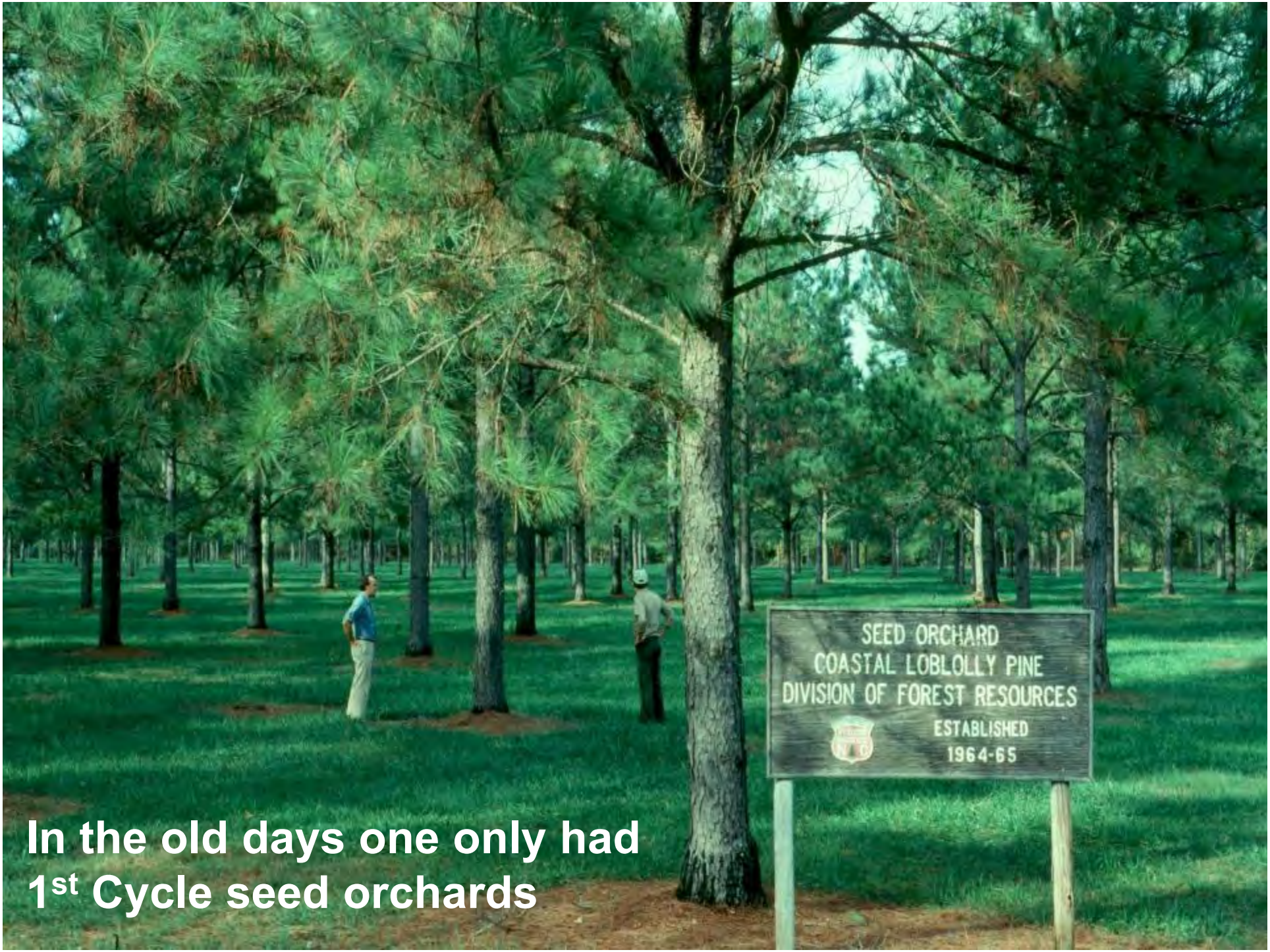
~31 mil ac. Loblolly plantations



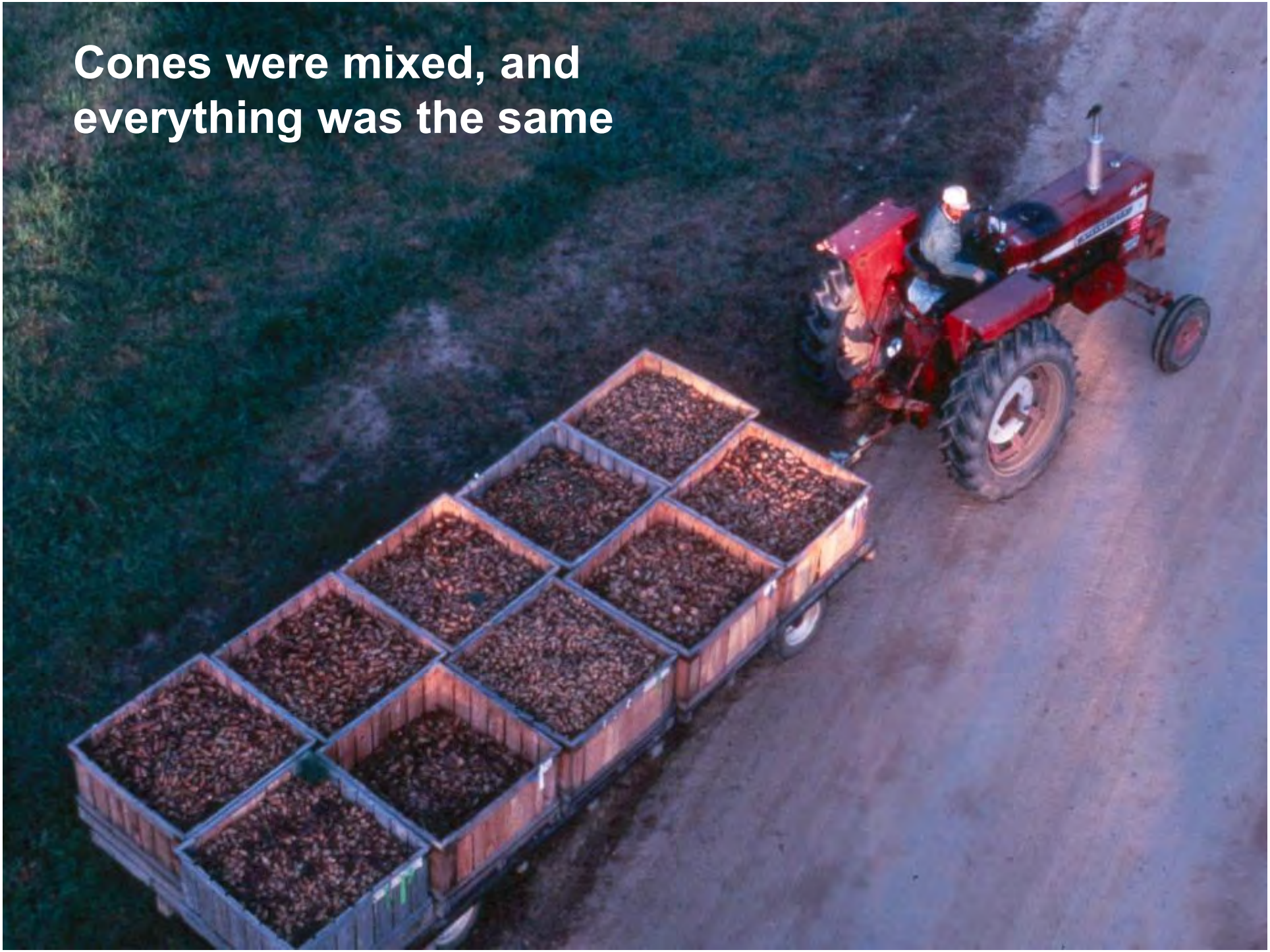
~22 mil ac. derived from the NCSU Cooperative Tree Improvement Program

About 800,000,000 loblolly pine seedlings are grown annually in the South

- From average to excellent genetic quality



In the old days one only had 1st Cycle seed orchards

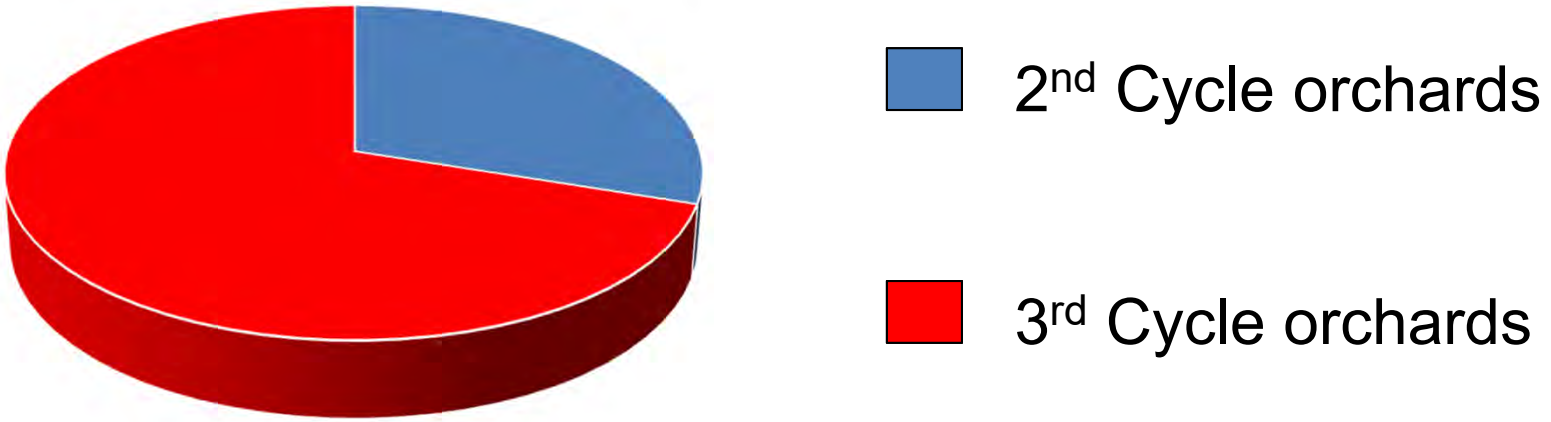

Cones were mixed, and
everything was the same


2nd Cycle Seed Orchards, family deployment
Still active but today there are many more options


3rd Cycle orchards are in full production

Orchard seed contribution

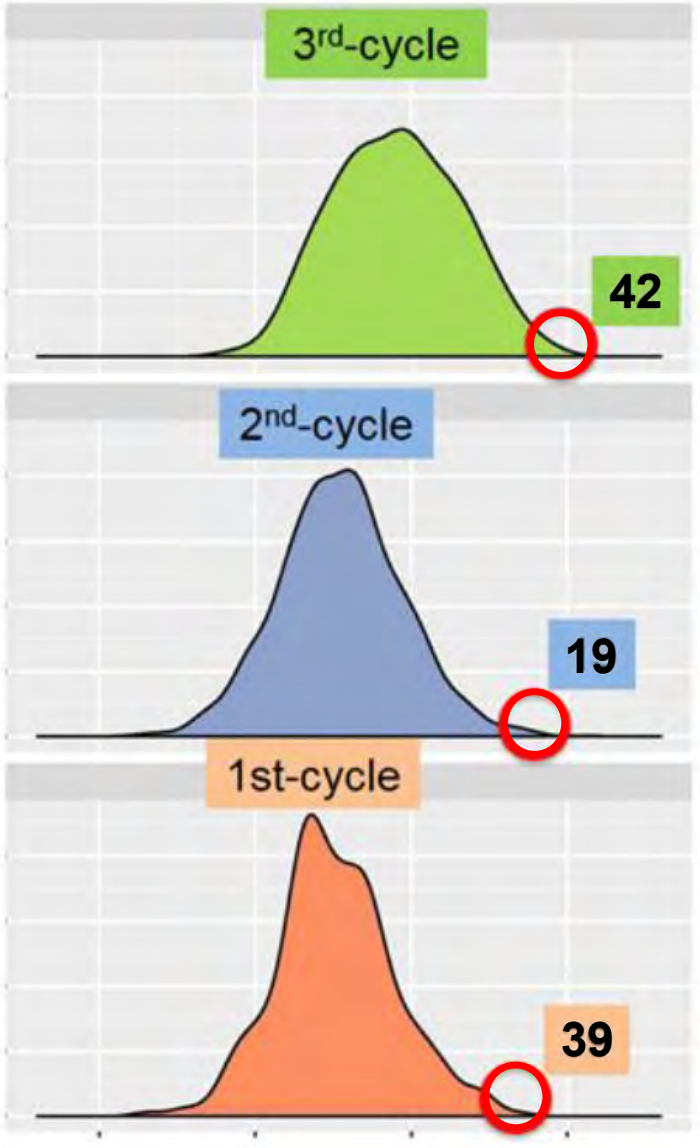
- ~70% seedlings available in the 2018-2019 planting season came 3rd Cycle orchards



- For the 2008-2009 planting season, only 12% of seed came from 3rd Cycle orchards

Top selections from each cycle

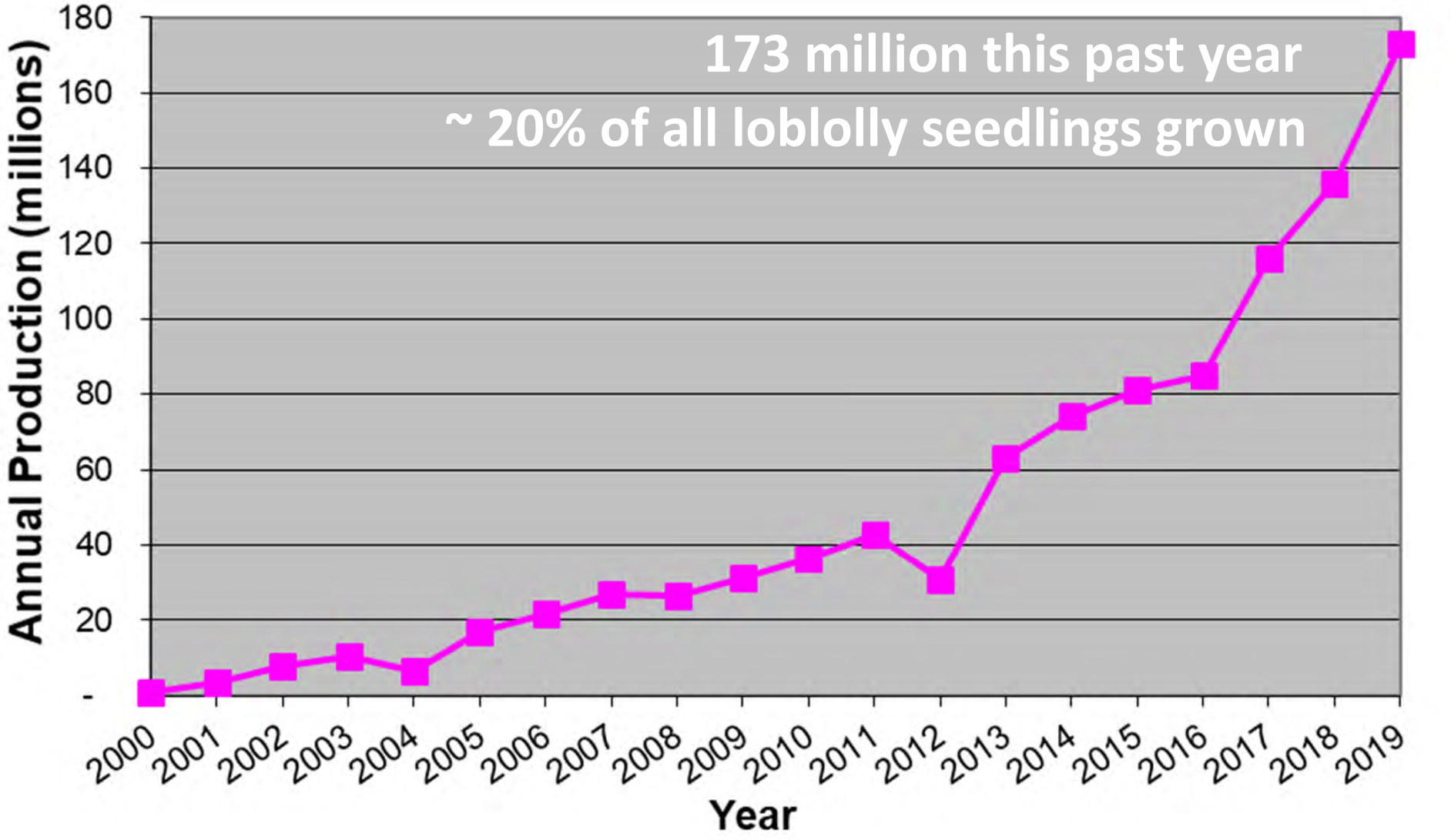
- Frequency distribution of productivity scores for selections in the Coastal Plain breeding population.
- Note the large overlap from one cycle of breeding to the next.
- The number of selections in the top 100 for volume are shown for each breeding cycle.



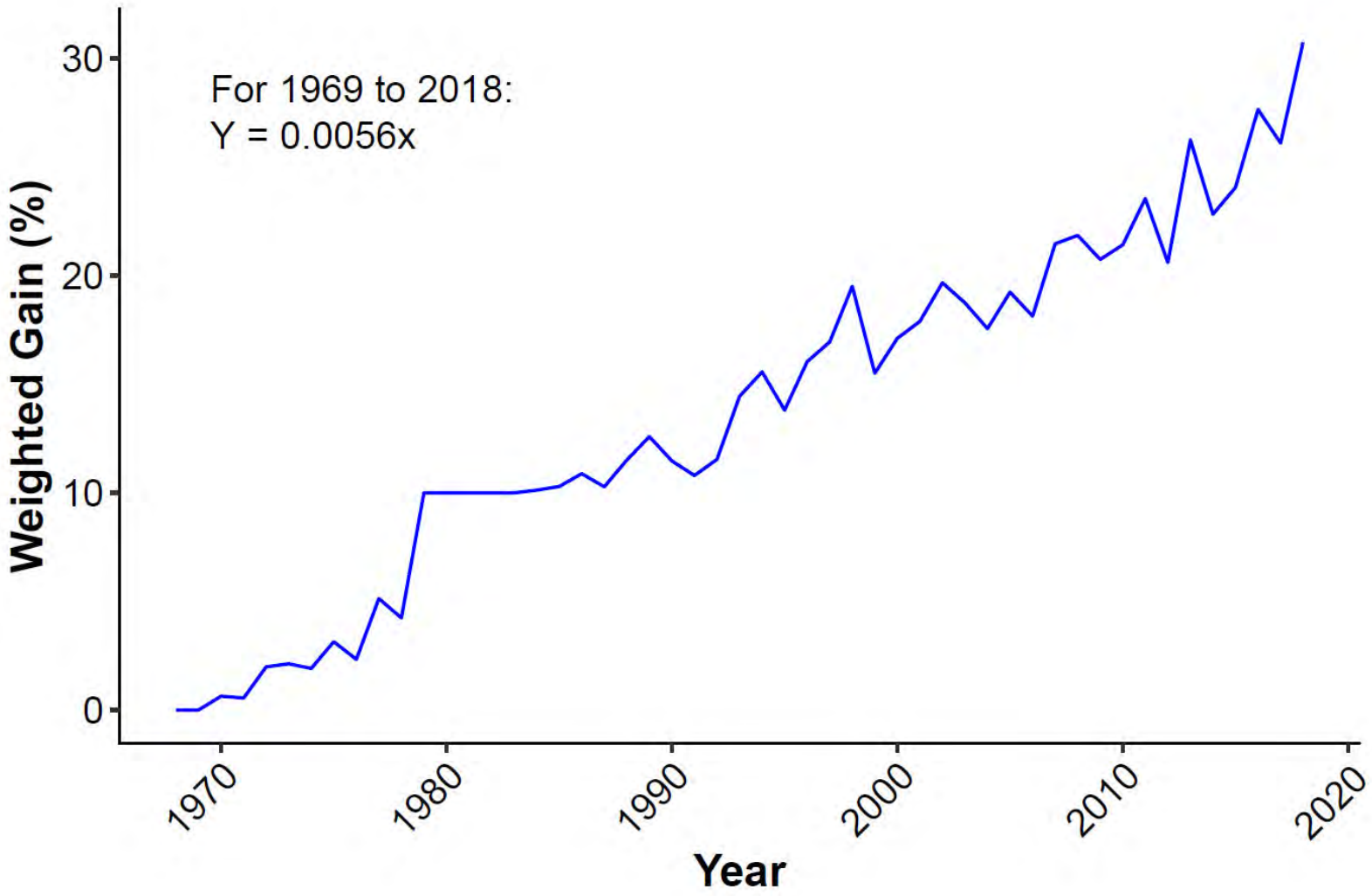
Mass production of control-pollinated seed

Annual use of pollination bags in the Southeast

Annual Mass Production of Specific Crosses of Loblolly Pine Seedlings



Genetic gain deployed in loblolly plantations established with germplasm derived from the NCSUCTIP



Genetic gain is weighted by:

- the number of first-, second-, and third-cycle seedlings and full-sib seedlings that were available for planting, and
- the acres established each year.

Group	1st Cycle	1.5 Cycle	2nd Cycle	3rd Cycle	Full-sib
Gain*	10.0%	15.0%	15.0%	30.0%	40.0%

*Average gain per generation/cycle. The planting of specific families provides the opportunity to increase the gain substantially for volume and quality traits.

Example - Families for the Coastal plain

- Top OP families provide ~70% gain in stem volume over a non-improved checklot at 6 years

- Leading full-sib families provide >80% gain in stem volume over a non-improved checklot at 6 years
  - Elite full-sib families also have superior quality traits including stem straightness and rust resistance

Landowners have never had so many options to plant outstanding genetic quality

Knowledge is Power

Loblolly Pine
Performance Rating System
PRS™

PRS™ expresses the **genetic potential** of a family

NCSU Cooperative Tree Improvement Program

Loblolly Pine *PRS*™

Performance Rating System

Family Code: GOOD TREE

PRS™ Ratings — Predicted Family Performance

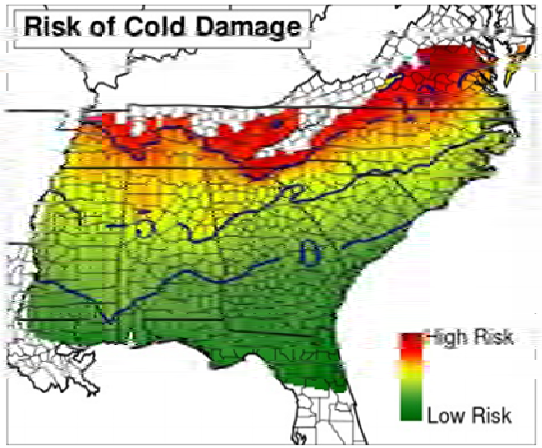
Productivity Rating	**68**
Rust Resistance Grade	**B**
Stem Form Grade	**A**

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

- ***P*** = **68** → Approximately 68% greater stem volume at age 6 compared to the combined average of local non-improved loblolly pine checklots across the **Atlantic and Lower Gulf Coastal Plains**.
- ***R*** = **B** → **Above average** for resistance to fusiform rust disease
- ***S*** = **A** → **Excellent** for stem straightness

The minimum winter temperature "origin" of Family **GOOD TREE** is 15.44°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. 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 **GOOD TREE** has been tested by members of the *NC State University Cooperative Tree Improvement Program*.



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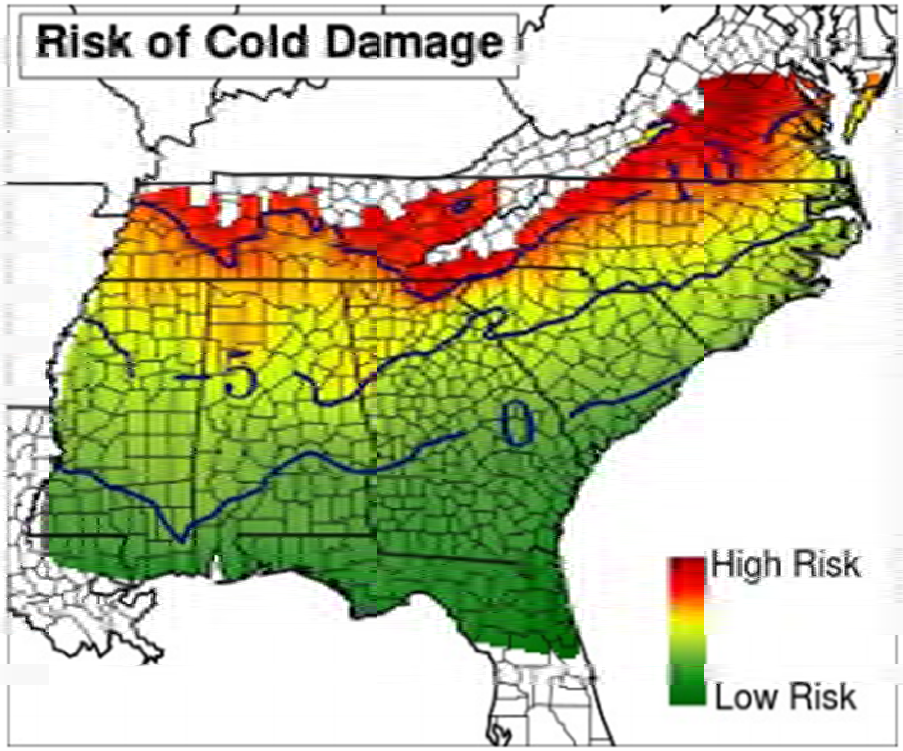


Loblolly Pine *PRS*™ - description

Coastal 2017 V5

Progeny test results of measurements at age 6 years are listed in the box to the right.

Volume Rating and **Height Rating** are predicted progeny performance of open-pollinated (OP) families[2] expressed as percentage deviations from the combined average of local non-improved loblolly pine checklots across the **Atlantic and Lower Gulf Coastal Plains** (e.g. CCC). Family **GOOD TREE** is predicted to be **23%** taller and have **68%** more stem volume at age 6 years compared to non-improved check trees.

R-50 % of **21** indicates that this family is expected to have **21%** of the trees infected with fusiform rust galls at a site where non-improved loblolly pine would have 50% rust infection.

6-Year Progeny Test *PRS*™ Data

Family[2]: **GOOD TREE over CCC**

Volume Rating	68
Height Rating	23
R-50%	21
Straight %	43
Forking (F-50%)	53

Straight % score of **43** indicates that this family is expected to have **43%** straighter stems compared to the non-improved check trees.

Forking (F-50 %) of **53** indicates that this family is expected to have **53%** of the trees with forked stems or major ramicorn branches at a site where non-improved loblolly pine would have 50% forked stems or ramicorn branches.

NCSU Tree Improvement Program Database

Starting Points

Members
TIP Calendar
+PRS Spec Sheet
+PRS & BV Data
PRS Values
Deployment by County
Deployment by Selection
PRS data for Selection
PRS Versions
Breeding Values
Genetic Values
Mid-Parent Values
PRS Test Locations
+Pedigree Information
+Measurement Data

PRS Values

Parent1	Min Temp	Wide Cross	Checklot	Orchard	Productivity	Height	Rust	Rust Grade	Strt	Strt Grade	Fork	Fork Grade
[illegible]	21.4		CCC	CP	77.8	21.6	27.9	C	33.8	C	44.0	C
[illegible]	16.0		CCC	CP	73.4	20.1	9.8	A	29.1	C	45.7	C
[illegible]	15.9		CCC	CP	71.1	24.0	25.7	C	35.3	B	44.1	C
[illegible]	17.2		CCC	CP	70.7	21.3	7.9	A	38.9	B	46.1	C
[illegible]	21.4		CCC	CP	69.9	20.9	38.0	D	27.6	C	50.8	D
[illegible]	15.9		CCC	CP	69.5	21.2	34.2	C	36.3	B	57.3	E
[illegible]	16.3		CCC	CP	69.0	19.5	23.4	C	39.1	B	37.0	A
[illegible]	21.4		CCC	CP	68.8	20.1	27.2	C	36.3	B	51.7	E
[illegible]	15.8		CCC	CP	68.4	20.2	17.8	B	32.7	C	41.5	B
[illegible]	21.4		CCC	CP	68.3	19.5	13.6	A	37.7	B	51.0	D
[illegible]	15.4		CCC	CP	68.0	23.1	20.6	B	43.2	A	52.7	E
[illegible]	17.3		CCC	CP	68.0	17.7	20.1	B	18.8	E	47.7	D
[illegible]	15.2		CCC	CP	67.3	22.1	41.7	E	27.8	C	49.9	D
[illegible]	16.1		CCC	CP	66.5	21.8	6.2	A	37.8	B	44.8	C
[illegible]	16.8		CCC	CP	66.4	21.8	17.6	B	17.9	E	40.8	B
[illegible]	15.6		CCC	CP	66.2	20.8	12.6	A	40.0	A	48.9	D

Calibration study

Improved full-sib family
$p = 66$

Non-improved checklot
$p = 0$

(2006) Journal of Forestry 104 :352-358

What Are the Best Loblolly Pine Genotypes Worth to Landowners?

Steven E. McKeand, Robert C. Abt, H. Lee Allen, Bailian Li, and Glenn P. Catts

ABSTRACT

Forest landowners in the South can realize large financial benefits from planting the best loblolly pine (*Pinus taeda* L.) genotypes. Most of the productivity increases from genetics can be considered as increases in site index. We estimate that landowners can realize net present values of $50 to over $300/ac across a range of productivity and silvicultural management regimes simply by planting the best genotypes that are currently available from commercial and state forest nurseries. Landowners could pay more for the best genotypes, and the best seedlings would be well worth the additional costs.

Keywords: genetic gain, growth and yield, *Pinus taeda* L., tree improvement

Tree improvement has been a standard silvicultural tool in southern pine regeneration programs in the South for almost 50 years. Virtually all of the almost 1 billion loblolly pine seedlings tial genetic gains of full-sib (FS) families from the best second-cycle parents can produce volume gains over 50% (Jansson and Li 2004). If the improvements in stem form and disease resistance are added, stand value our survey, there were no plantation failures reported because of planting a particular family on a particular site (McKeand et al. 2003).

Individual OP families, FS families, and selected clones of loblolly pine display remarkable stability and predictability of growth performance across sites in the southern United States. As long as genotypes are planted in climatic zones to which they are adapted (e.g., Schmidtling [2001]), there is little important genotype by environment interaction (rank change) for most traits (McKeand et al. 2006). This stability of performance is important when trying to predict genetic gains in growth across different

(2006) Journal of Forestry 104 :352-358

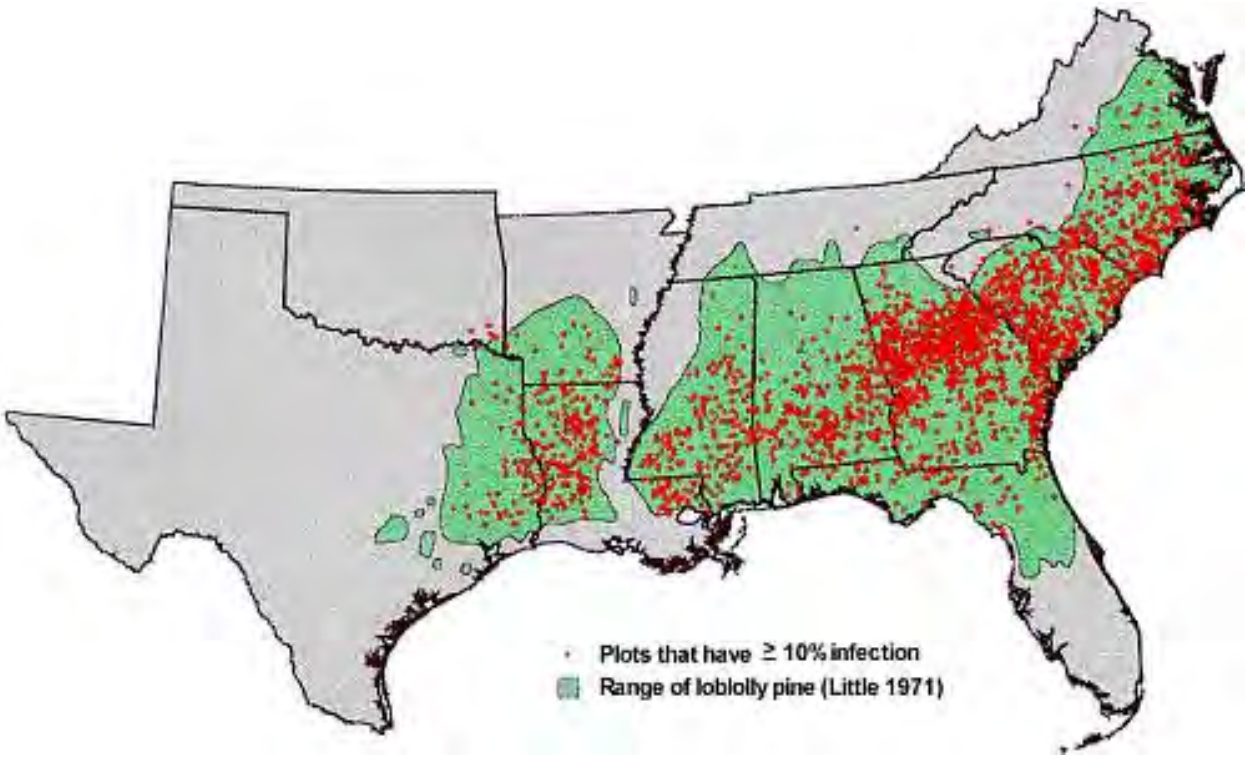
silviculture

What Are the Best Loblolly Pine Genotypes Worth to Landowners?

We estimate that landowners can realize **net present values of $50 to over $300/ac** across a range of productivity and silvicultural management regimes **simply by planting the best genotypes that are currently available** from commercial and state forest nurseries.

What are your management objectives?

Are you in a high fusiform rust hazard zone?

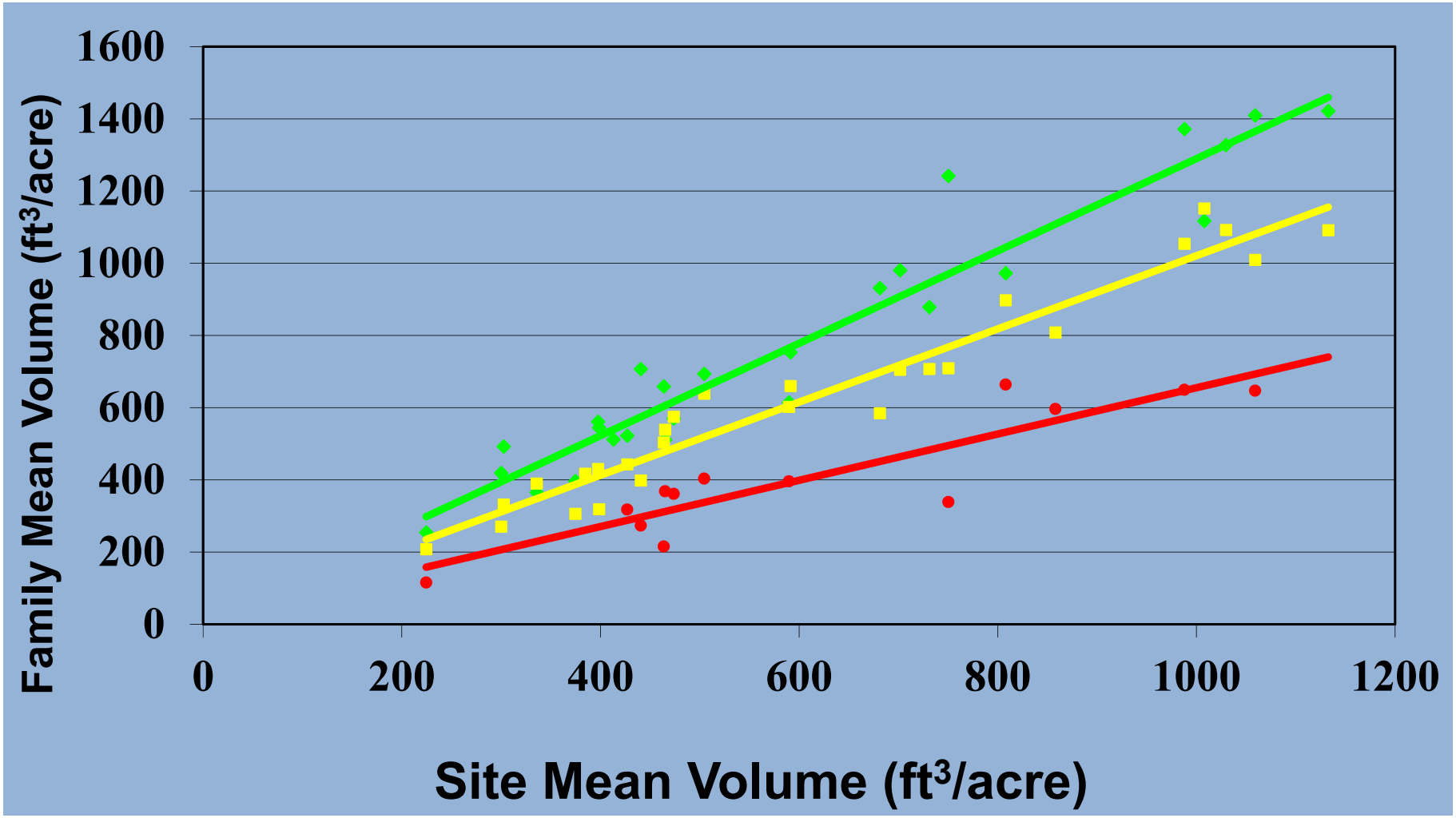


Starkey et al. 1997 USDA Forest Service, Protect. Rep. R8-PR30

Are you managing your stand for a pole market?

Do you have a range in site quality?

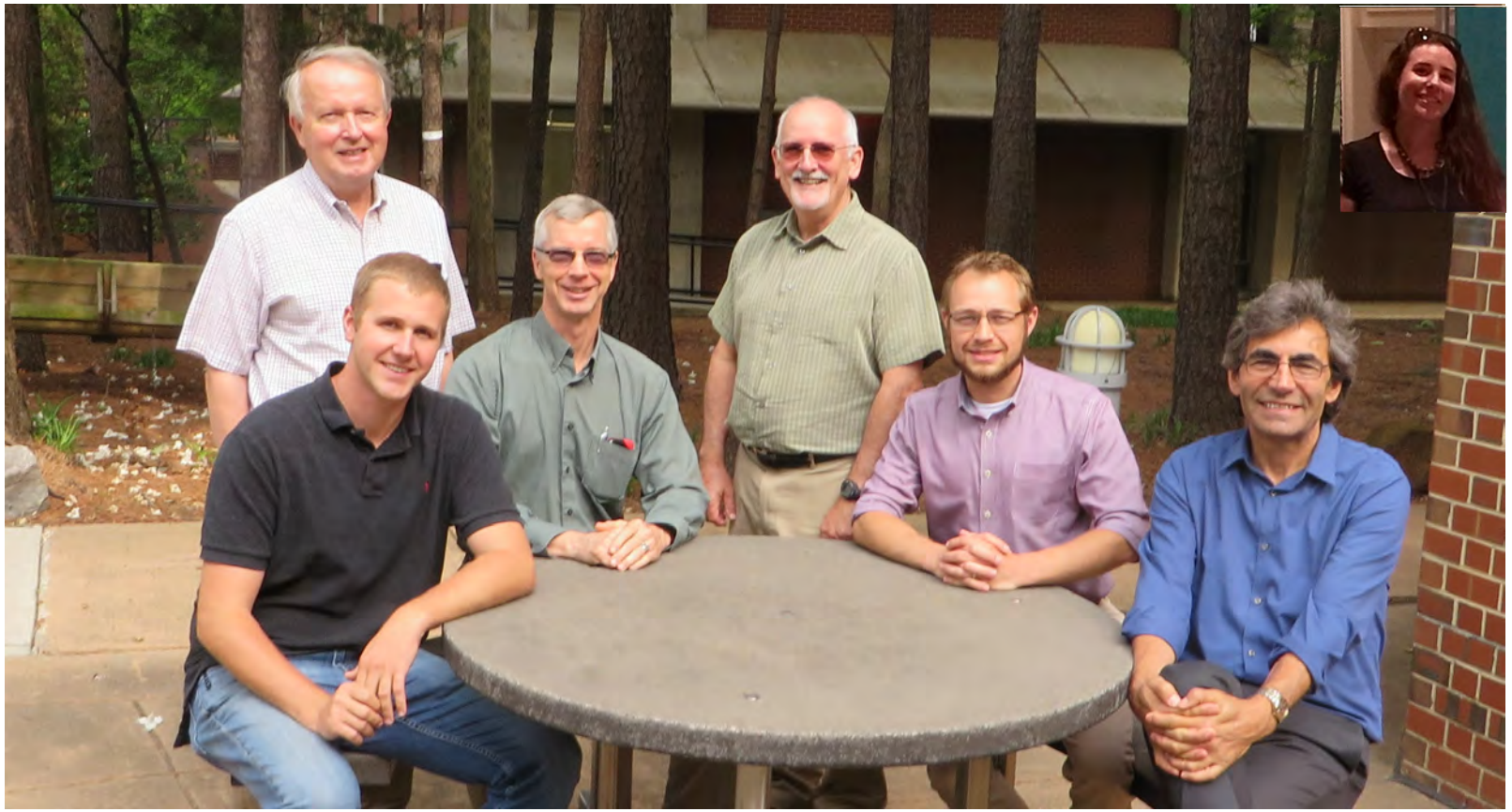
Response of three OP families to environmental differences (age 8)



From: McKeand, Crook, and Allen (1997)

Know what you are planting

Acknowledge Dr. Steve McKeand, former Director of the Cooperative, and fellow staff members for a number of slides provided in this presentation.



Our website: treeimprovement.org