Forest Genetics & Seedling Productivity

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AUBURN UNIVERSITY

SOUTHERN FOREST NURSERY MANAGEMENT COOPERATIVE

TREE IMPROVEMENT PROGRAM NC STATE UNIVERSITY

September 9, 2105

Tree Improvement and Nurseries

- If not for nurseries and nursery managers, tree improvement would be a trivial exercise
- Our impact on landowners and forest productivity and value is 100% dependent on you

Thank You!!!

Regeneration Options for Landowners

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

Pine Seedling Selection and Planting

- What options do landowners have?
- Why so many options today? What has changed?
- In "the good old days" (about 10 years ago), not all of the best genetics were available on the open market

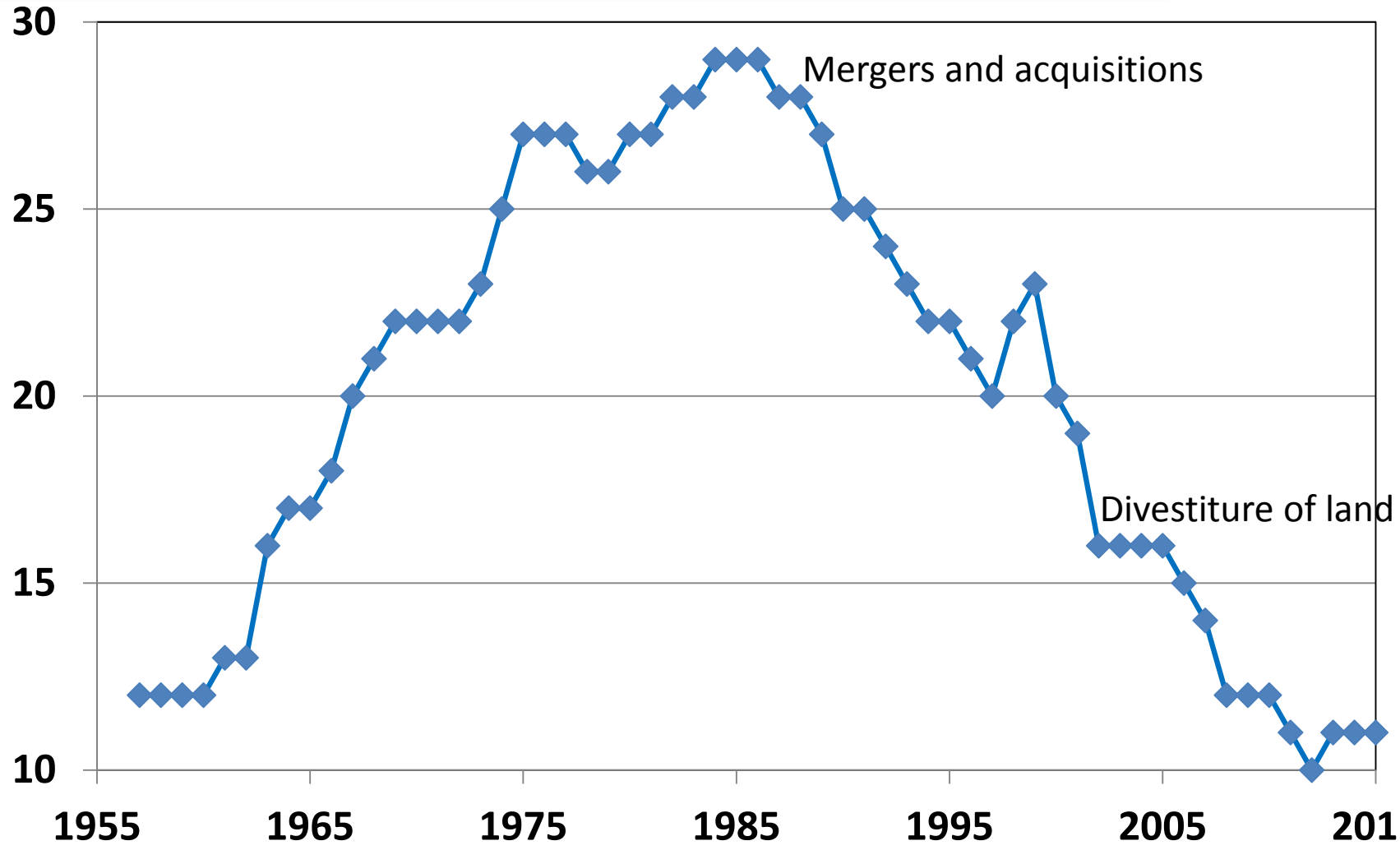
Why?

Pine Seedling Selection and Planting

Why have markets changed so much?

- Fundamental change in the structure of the forest products industry
- Vertically integrated forest products companies sold their land

NCSU CTIP **Full** Members 1956-2015



Pine Seedling Selection and Planting

Why have markets changed so much?

- Fundamental change in the structure of the forest products industry
- Vertically integrated forest products companies sold their land
- In many cases, there was no longer the need to plant company lands
- No longer did the best genetics always go to company lands

Pine Seedling Selection and Planting

A true seedling market has evolved

- Everything is for sale
- No longer did the best genetics always go to company lands

Regeneration Options for Landowners

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Pine Seedling Selection and Planting

A true seedling market has evolved

- Everything is for sale
- No longer did the best genetics always go to company lands
- Landowners need to understand those options
- The attitude that “a seedling is a seedling is a seedling” started to change

Quiz: Which seedlings have best genetic quality?

Pine Seedling Selection and Planting

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- Everything is for sale
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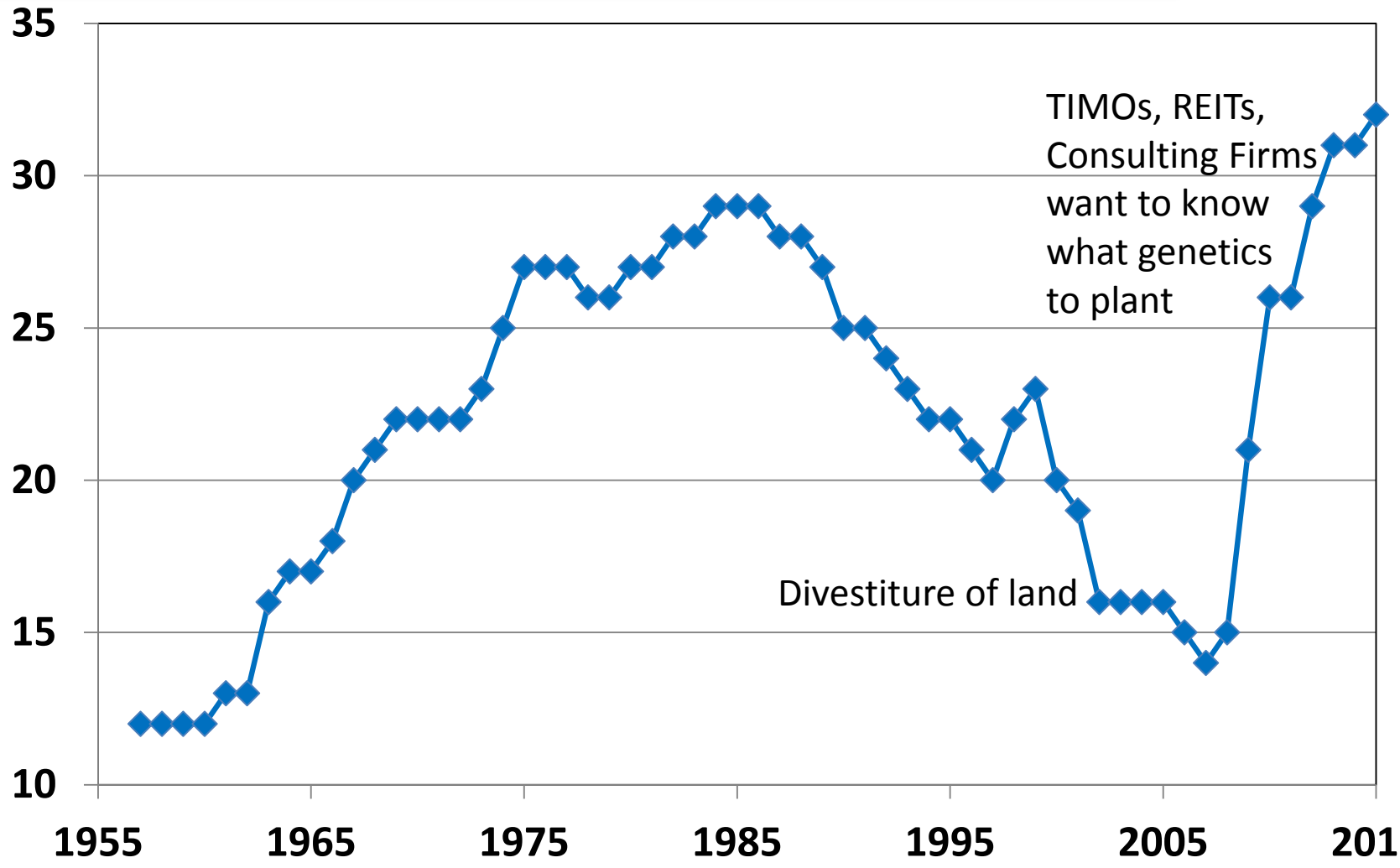
- Landowners need to understand those options
- The attitude that "a seedling is a seedling is a seedling" started to change
- Nurseries started aggressive marketing of seedlings

NCSU CTIP Full, Contributing, and Research Associate Members 1956-2015



Cooperative Tree Improvement Program

11 *Full Members*

ArborGen, Inc.
Georgia Forestry Commission
Hancock Timber Resources Group
International Forest Company
North Carolina Forest Service
Plum Creek Timber Company
Rayonier, Incorporated
TN Division of Forestry
Virginia Department of Forestry
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3 *Research Members*

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17 *Contributing Members*

American Forest Management
Campbell Global
Charles Ingram Lumber Co.
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F&W Forestry Services, Inc.
Jordan Lumber & Supply Company
Meeks Farms & Nursery, Inc.
Milliken Forestry Company
Molpus Timberlands Management, LLC
NC Natural Resource Foundation
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South Carolina Forestry Commission
Timberland Investment Resources
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TREE IMPROVEMENT PROGRAM NC STATE UNIVERSITY

Pine Seedling Selection and Planting

A true seedling market has evolved

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- Landowners need to understand those options
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- Nurseries started aggressive marketing of seedlings

More on this later

Tree Improvement and Forest Productivity in the Southern U.S.

Forest Productivity

Tree Improvement +

Silviculture =

Healthy, Managed Forest

About 31,000,000 acres of southern pine plantations exist, ~80% *Pinus taeda*

But, pine plantations are only about 15% of southern US forests

~ 2/3 of forests are hardwoods (52%) or mixed pine/hardwood (14%)

Some Southern Forestry Facts & Figures

- Only 15 % of commercial forest land (31 MM acres) is in plantations (Sheffield and Dickson 1998)
- But, plantations provide >50% of the timber supply
- 80% of planting is with genetically improved loblolly pine

The South has truly become the “wood basket” for the US

The 12 southern states accounted for about 80% of the nation’s tree planting each year

Plantations help provide:

Reliable,

Ecologically Sustainable,

Economically Affordable

Supply of Wood

Genetic Improvement of Loblolly Pine

So, how does tree improvement work?

Conceptually, tree improvement is straightforward

Look for good trees

Select them

Bring them together to intermate

Test their progeny

Select the winners

Start cycle over

So What Has This Gotten Us?

Regeneration Options for Landowners

- Landowners and foresters need to know when and when not to invest in the best genetics
- Understanding the benefits and costs of specific families allows foresters to optimize land management decisions

Regeneration Options

SOM

OP

MCP / ACMP

SE

Alphabet soup of options is confusing

What is actually being planted?

Trends in Deployment of Loblolly Pine Germplasm in the South

PINEMAP Survey

Steve McKeand, Tom Byram, & Gary Peter

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.

http://pinemap.org/

Seedling Deployment Survey

- Survey to all Nursery Vendors in the 3 Tree Improvement Cooperatives
- Essentially a repeat of the survey we conducted in 2002 and published in the Journal of Forestry 2003

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Deployment of Genetically Improved Loblolly and Slash Pines in the South

Steve McKeand

Journal of Forestry
April/May 2003

Steve McKeand, Tim Mullin, Tom Byram, and Tim White

ABSTRACT

Foresters in the southern United States are responsible for more than 75 percent of the nation's tree planting, and more than 95 percent of the seedlings are genetically improved loblolly and slash pines. Planting the best open-pollinated families on the best sites can dramatically increase productivity. However, such practices reduce genetic diversity in a plantation. Although a survey of state and industrial plantation managers reveals no problems thus far, as more homogeneous plantations are established on more acres, both gains and potential risks must be quantified so that landowners can make informed decisions about deployment options.

Keywords: genetics; industry; plantation forestry; silviculture

Seedling Deployment Survey

- Essentially a repeat of the survey we conducted in 2002 and published in the Journal of Forestry… **but**
  - More deployment information on a regional basis
  - Companies that sell and deploy seedlings across a wide geographic area answered questions for each region.

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Table 1. Results of a survey of 31 state and industry members of tree improvement cooperatives (100% response).

Annual seedling production (average annual number of seedlings the last 3 years)
- Loblolly: 1,137 million
- Slash: 150 million
- Longleaf: 32 million
- Other: 28 million

Number of seedlings deployed on your own lands (average the last 3 years)
- Loblolly: 427 million
- Slash: 73 million
- Longleaf: 6 million
- Other: 3 million

Number of seedlings for market sales and/or contracts (average the last 3 years)
- Loblolly: 697 million
- Slash: 86 million
- Longleaf: 28 million
- Other: 25 million

Number of seedlings deployed as open-pollinated family blocks (average the last 3 years)
- Loblolly: Company lands: 340 million
  Market sales and/or contracts: 332 million
- Slash: Company lands: 37 million
  Market sales and/or contracts: 28 million

Percentage of regeneration with 1st-generation seedlings (including 1½-genera
Percentage of regeneration with 2nd-generation seedlings: 54%
Percentage of regeneration with 3rd-generation seedlings (including 2½-gener

Number of open-pollinated families deployed as family blocks (average the last
- Loblolly: Company lands: 47 (average for each company)
  Market sales and/or contracts: 66
- Slash: Company lands: 11
  Market sales and/or contracts: 5

Average size of family blocks in plantations (on your own lands)
- Loblolly: 77 acres
- Slash: 82 acres

Number of parent clones in the seed orchards that supply your seed:

Loblolly: Rough average: 24	Fewest: 14	Most: 36
Slash: Rough average: 42	Fewest: 25	Most: 55

Note: Some numbers may not sum to expected totals because of some slight double counting and estimation of seedlings being planted.

Overall, 59 percent of the loblolly pine plantations are established as single open-pollinated family blocks.

Deployment Survey 10 years ago

- Over 1.1 billion loblolly pine seedlings were planted annually
- All were genetically improved
  - about 50:50 1st- vs. 2nd-generation
- Deployment of genetically improved seedlings was and is standard silvicultural practice

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Deployment Survey 10 years ago

- Seed orchard mix – was the standard for years
  - Who remembers planting only mixes?
- OP families – became the standard
- FS families – essentially none, but becoming more popular
- Clonal (sometimes called varieties) – was none, but more now

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2013 Deployment Survey

- Sent to all **seedling vendors** who are members of cooperative tree improvement programs in the South (CFGRP, NCSUCTIP, WGFTIP)

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As part of the USDA funded Pinemap research project, the three tree improvement cooperatives in the South are conducting a survey of nurseries and tree improvement programs to determine how genetically improved seedlings are being deployed in the region. Our intention is to utilize these data in a paper where we evaluate the risks of deploying genetically improved trees. Obviously the "risks" have been minimal, and we all have a tremendous success story to tell regarding increases in forest productivity. We also want to document what tree breeders are doing and how they are deploying the genetic gains. We think that this benchmarking of the level of genetic improvement will be valuable for all participants in the survey.

2013 Deployment Survey

- Sent to all **seedling vendors** who are members of cooperative tree improvement programs in the South (CFGRP, NCSUCTIP, WGFTIP)
- 100% response
- And there are a lot of data!

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2013 Deployment Survey

Since the last survey in 2002, some significant changes have occurred:

- A true seedling market has evolved

  More of a revolution than evolution

- Everything is for sale
- In the "old" days (about 7-8 years ago), the seedling market was "inefficient"
- Economist speak for …

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2013 Deployment Survey

- Lack of recognition of the value of a product in the market place
- The vertically integrated forest products companies (VIFPCo) recognized value of genetics
  - What did they do with the best genetics?

    Planted on their own lands
- State agencies sold seed orchard mixes

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2013 Deployment Survey

Since the last survey in 2002, some significant changes have occurred:

- Little opportunity for recognition of the value of genetics in the seedling markets since best genetics were not available
- So what changed the last 10+ years?
- VIFPCo's went away

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2013 Deployment Survey

Since the last survey in 2002, some significant changes have occurred:

- Some TIMOs, REITs, Consultants, and other landowners recognized the value of genetics
- Cooperatives started preaching the value of genetics to new customers
- Nurseries started **really** marketing genetics

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2013 Deployment Survey

What did we find?

- 843,466,000 seedlings planted / year
- 1,347,000,000 in 2002 survey
  - 37% reduction last 10 years

And BTW…

- 31 state and industry members in 2002
- 17 state and industry members in 2013

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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%

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2013 Deployment Survey

What did we find?

- Caveat
- This is NOT as comprehensive as the Auburn Nursery Cooperative survey as far as seedling production numbers
- Primary value is for what genetics is being deployed

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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%

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2013 Deployment Survey

Loblolly Deployment – planted where?

- **2002**
  - 38% planted on own lands
  - 62% market sales
- **2013**
  - 25% planted on own lands
  - 75% market sales

Market sales ↑

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2013 Deployment Survey

Loblolly Deployment - How many different families planted in family blocks?

	OP Families	FS Families
Average # families		
Company lands	11	7
Market Sales	15	7
Range	1-74	1-24
Total # families		
Company lands	158	61
Market Sales	354	86

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2013 Deployment Survey

Loblolly Deployment

Advanced-generation families

1st-gen:	79,716,831	10.9%
2nd-gen:	408,150,988	55.6%
3rd-gen:	242,780,874	33.1%
4th-gen:	3,904,844	0.5%

2002 Survey: 50:50 1st- vs. 2nd-gen

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

2013 Deployment Survey

Loblolly Deployment – diversity

	2002
Average size (acres) of family blocks in plantations (on your own lands):	Avg = 84 Min = 45 Max = 120
Number of parent clones in the seed orchards that supply your seed:	Avg = 45 Min = 5 Max = 138

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2013 Deployment Survey

Loblolly Deployment – diversity

	2002	2013
Average size (acres) of family blocks in plantations (on your own lands):	Avg = 84 Min = 45 Max = 120	Avg = 77
Number of parent clones in the seed orchards that supply your seed:	Avg = 45 Min = 5 Max = 138	Avg = 24 Min = 14 Max = 36

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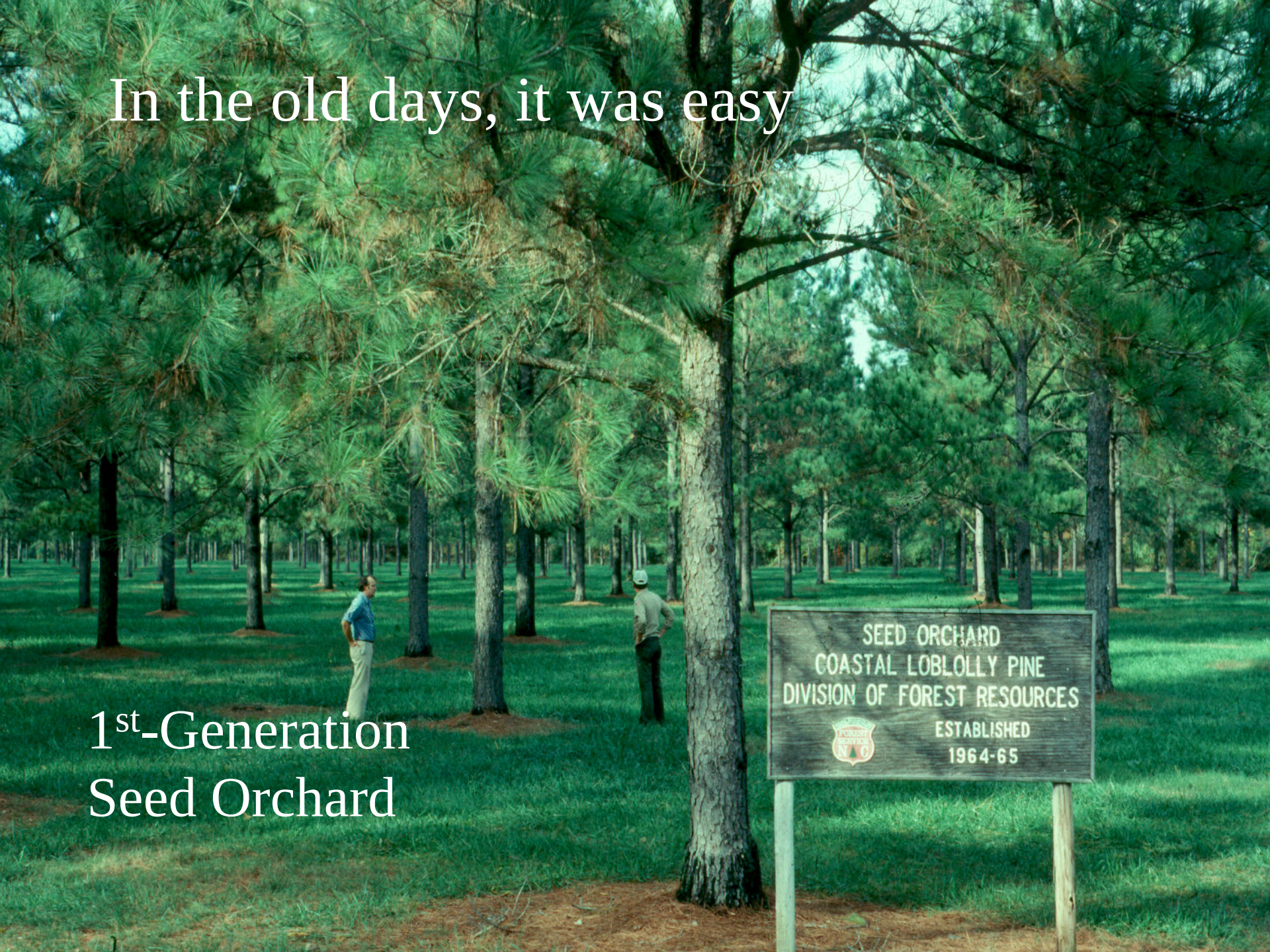

In the old days, it was easy
SEED ORCHARD
COASTAL LOBLOLLY PINE
DIVISION OF FOREST RESOURCES
ESTABLISHED
1964-65
1st-Generation
Seed Orchard

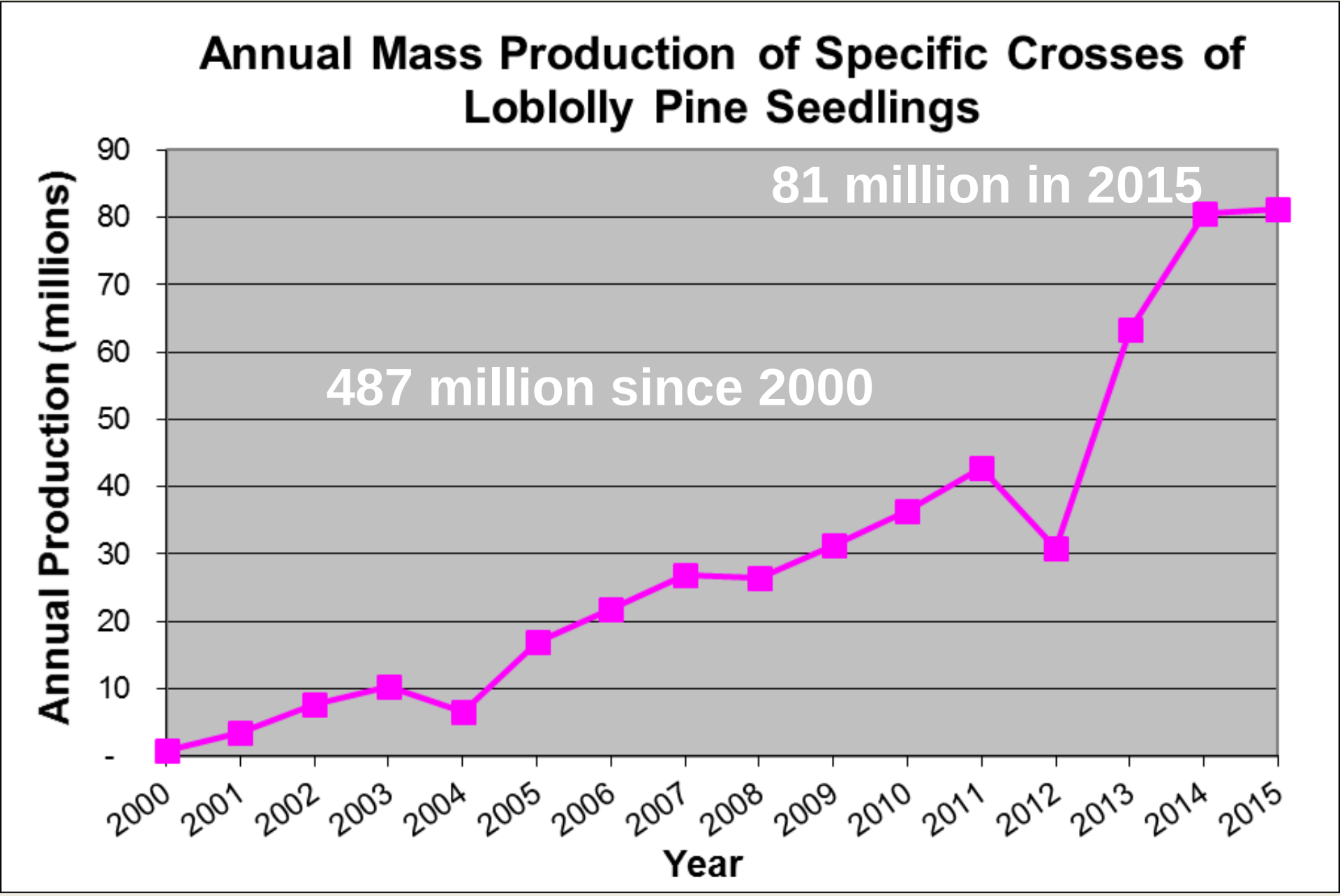

In the old days, it was easy
Cones were mixed, and
everything was the same


2nd-Generation OP
(open-pollinated)
Seed Orchard
Today…
many more options

Over 820,000,000 open-pollinated loblolly pine seedlings are grown annually in the South

- From average to excellent genetic quality


3rd-cycle orchards
Currently ~ 60% of seed harvests

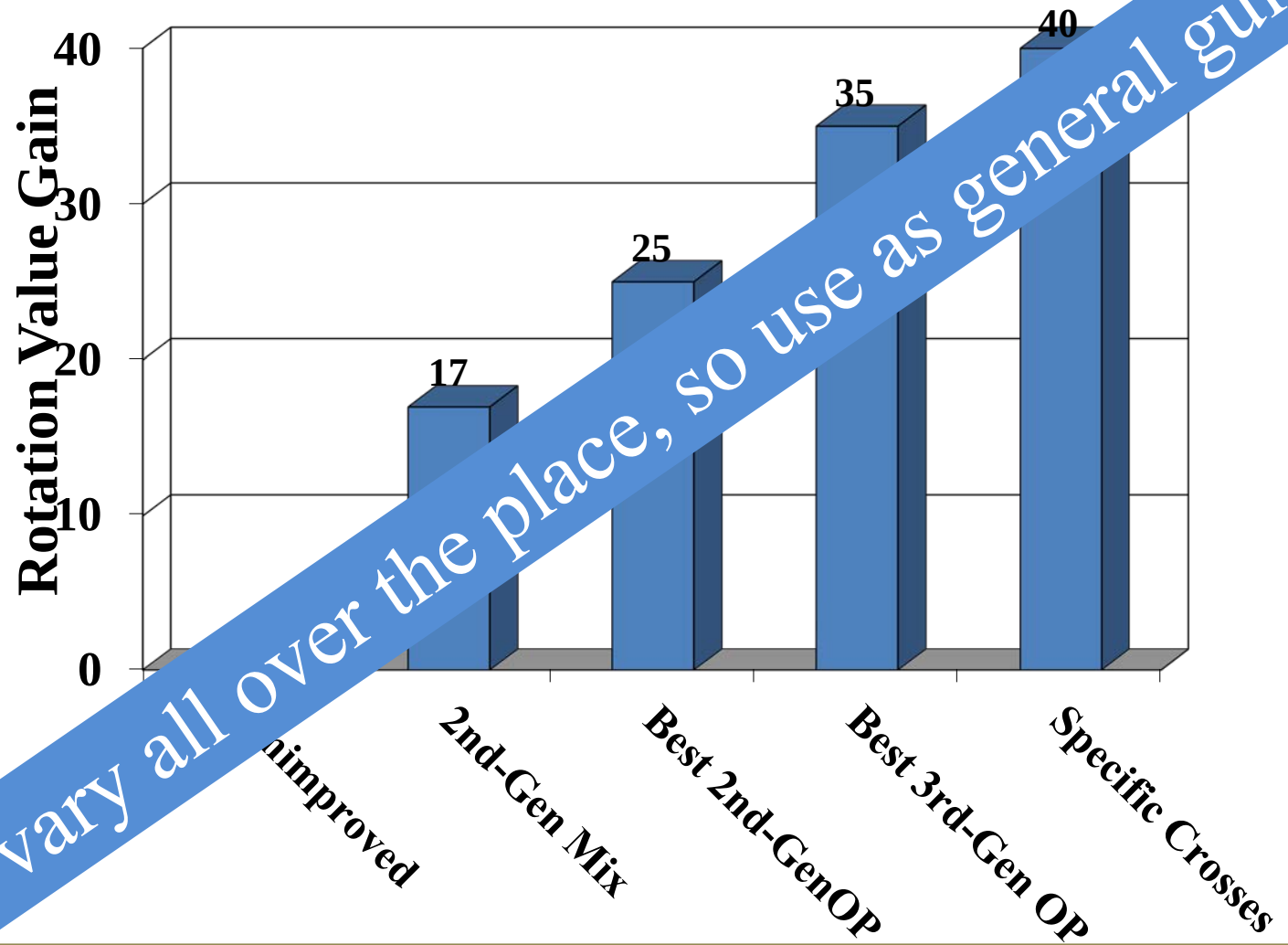

Annual Mass Production of Specific Crosses of Loblolly Pine Seedlings
Annual Production (millions)
90
80
70
60
50
40
30
20
10
-
81 million in 2015
487 million since 2000
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year

Mass Production of Control Crosses

- Has become operational
- 487 million since 2000
- Much greater gains


Clonal varieties are available
~ 5-15 million planted per year

Summary of Genetic Gain Options



These vary all over the place, so use as general guideline.

Regeneration Options

SOM
OP
MCP / CMP
SE

It is confusing!!!

But, it's well worth understanding!

Would you prefer to sell this?


Or this?

So what's all this worth?

Oct/Nov 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

So what's all this worth?

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.

How do we convey this range in value to customers and landowners?

Loblolly Pine
Performance Rating System

PRS™

Marketing Our Product

- Educating foresters and landowners about the value of tree improvement
- Development of Performance Rating System

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PRS™

- The Cooperative the Loblolly Pine Performance Rating System (***PRS***™) as a service to landowners, nursery managers, the tree improvement community, and loblolly pine breeders.
- ***PRS*** also stands for ***P***roductivity, ***R***ust, and ***S***traightness that are the three traits that are evaluated in ***all*** genetics trials

PRS™

- The **PRS** expresses the **genetic potential** of a family for stem volume production, resistance to fusiform rust disease, stem straightness as well as other traits.

PRS™

- Landowners should request seedlings from forest nurseries with the highest **PRS** Rating they can obtain and afford to purchase.
- Most nurseries sell seedlings of specific individual OP families and specific crosses, and these families could range from the very best genotypes to average genotypes.

Loblolly Pine *PRS*™

Performance Rating System

Family Code: **Piedmont 21**

PRS™ Ratings — Predicted Family Performance

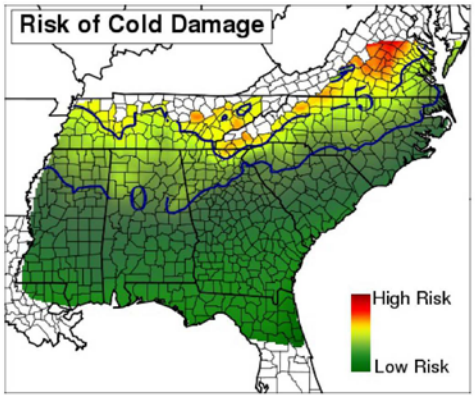
Productivity Rating	**84**
Rust Resistance Grade	**A**
Stem Form Grade	**A**

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

- ***P*** = **84** → Approximately 84% greater stem volume at age 6 compared to the combined average of local non-improved loblolly pine checklots across the **Piedmont regions of Georgia and the Carolinas and the Upper Gulf Coastal Plain**.
- ***R*** = **A** → **Excellent** for resistance to fusiform rust disease
- ***S*** = **A** → **Excellent** for stem straightness

The minimum winter temperature "origin" of Family **Piedmont 21** is 10.12°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).

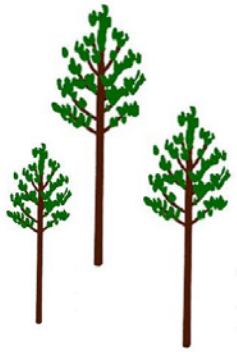
Family **Piedmont 21** has been tested by members of the *NC State University Cooperative Tree Improvement Program.*



[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

Loblolly Pine *PRS*™

Performance Rating System



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The minimum winter temperature "origin" of Family **Piedmont 21** is 10.12°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).

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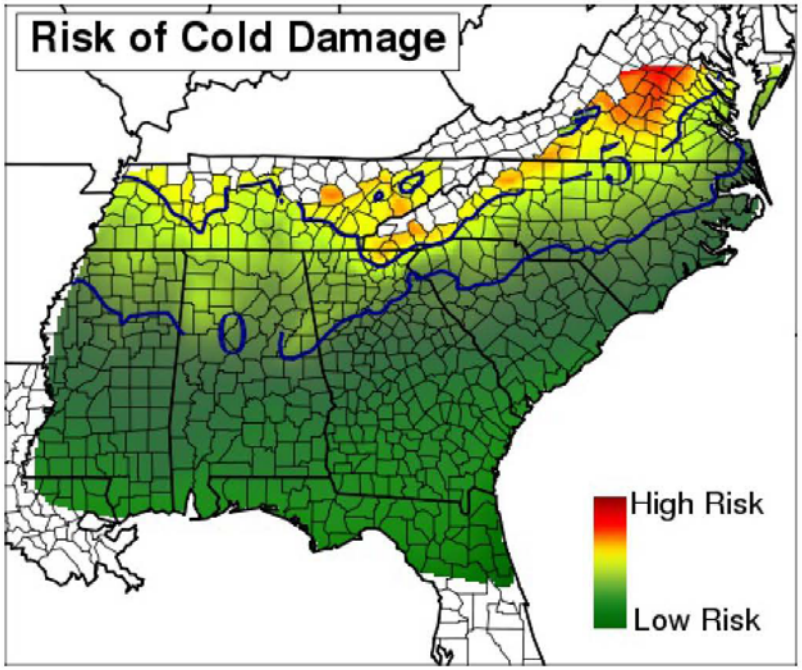
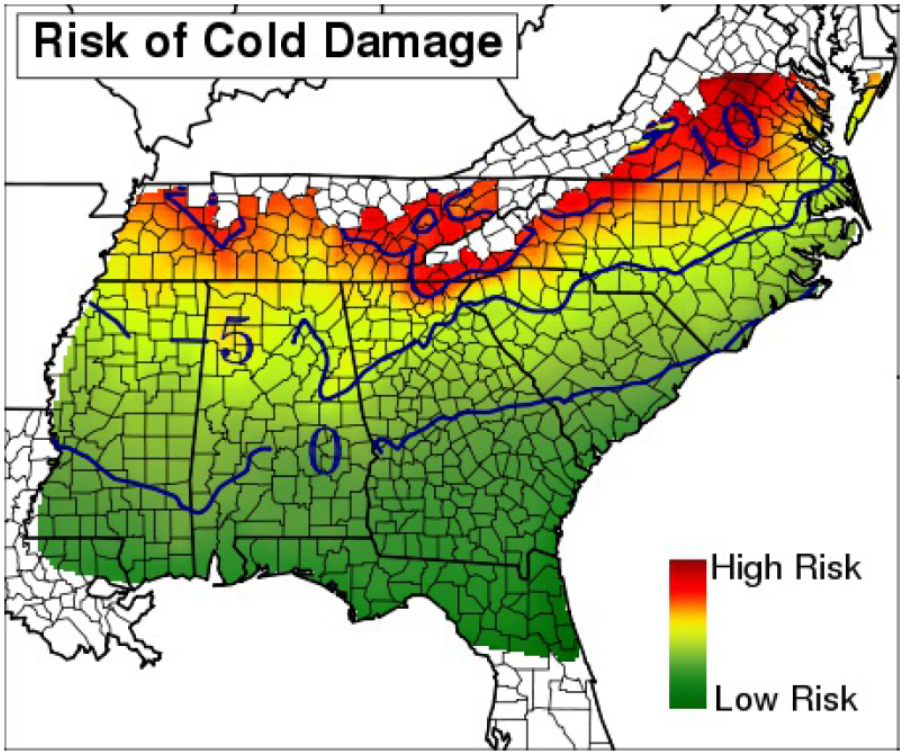


[1]These adaptability guidelines were developed by the USDA Forest Service (Schmidtling 2001), Southern Pine Seed Sources, available at: http://www.srs.fs.usda.gov/pubs/gtr/gtr_srs044.pdf

Adaptability Risk for SC Coastal family

The minimum winter temperature "origin" of Family **MOO11** is 14.54°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 **MOO11** has been tested by members of the *NC State University Cooperative Tree Improvement Program*.

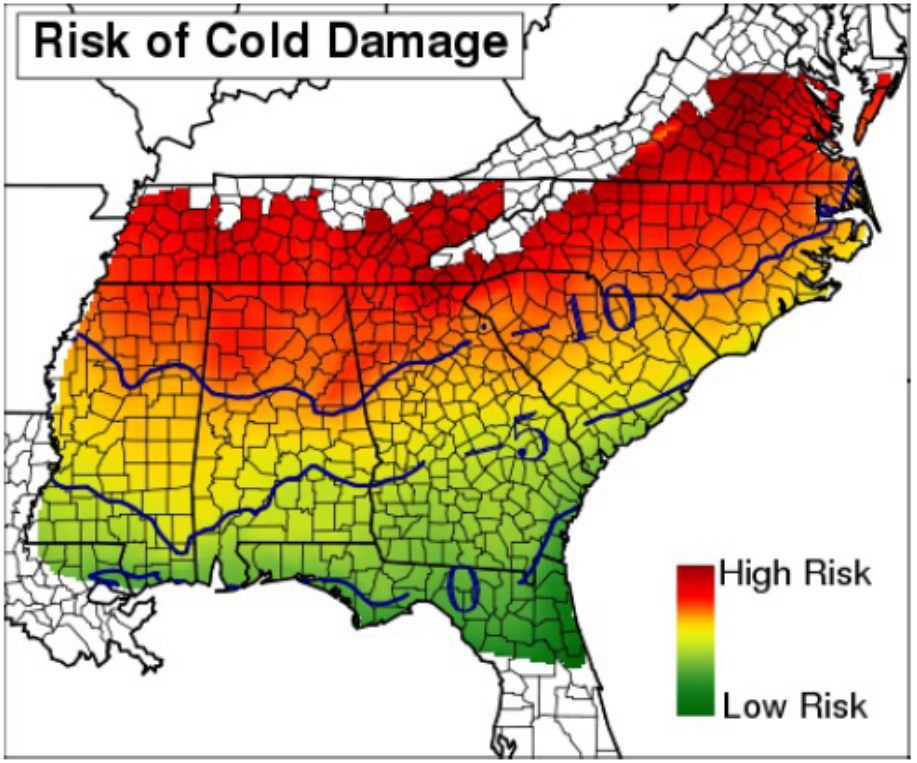


[1]These adaptability guidelines were developed by the USDA Forest Service (Schmidtling 2001), Southern Pine Seed Sources, available at: http://www.srs.fs.usda.gov/pubs/gtr/gtr_srs044.pdf

Adaptability Risk for Florida family

The minimum winter temperature "origin" of Family **FL Loblolly** is 20.87°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 **FL Loblolly** 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

Loblolly Pine *PRS*™

Performance Rating System

Family Code: **SCFC 2nd-Gen**

PRS™ Ratings — Predicted Family Performance

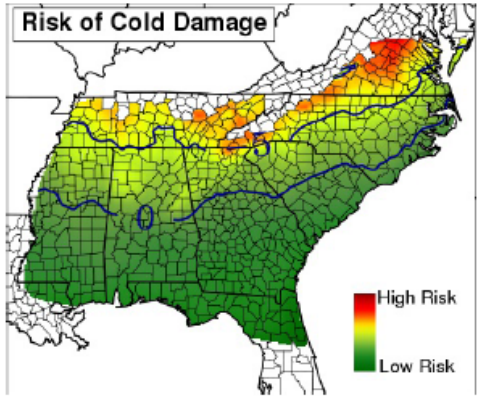
Productivity Rating	**84**
Rust Resistance Grade	**A**
Stem Form Grade	**C**

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

- ***P*** = **84** → Approximately 84% greater stem volume at age 6 compared to the combined average of local non-improved loblolly pine checklots across the **Piedmont regions of Georgia and the Carolinas and the Upper Gulf Coastal Plain**.
- ***R*** = **A** → **Excellent** for resistance to fusiform rust disease
- ***S*** = **C** → **Average** for stem straightness

The minimum winter temperature "origin" of Family **SCFC 2nd-Gen** is 11.87°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 **SCFC 2nd-Gen** 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

Loblolly Pine *PRS*™ - description

Piedmont 2013 V1

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 **Piedmont regions of Georgia and the Carolinas and the Upper Gulf Coastal Plain** (e.g. CCC). Family **Piedmont 21** is predicted to be **23%** taller and have **84%** more stem volume at age 6 years compared to non-improved check trees.

R-50 % of **17** indicates that this family is expected to have **17%** 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]: **Piedmont 21 over CCC**

Volume Rating	84
Height Rating	23
R-50%	17
Straight %	40
Forking (F-50%)	32

Straight % score of **40** indicates that this family is expected to have **40%** straighter stems compared to the non-improved check trees.

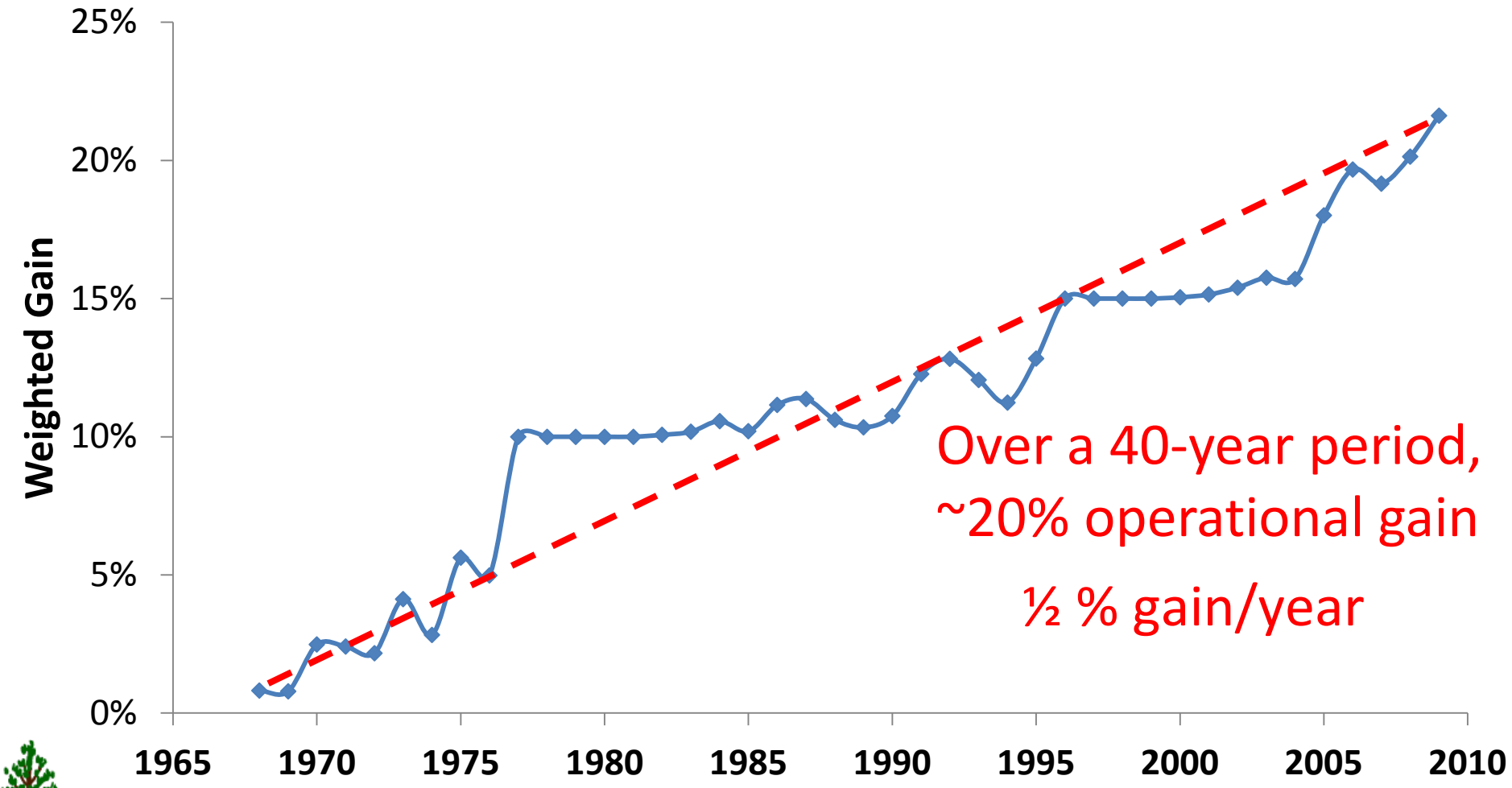
Forking (F-50 %) of **32** indicates that this family is expected to have **32%** of the trees with forked stems or major ramicorn branches at a site where non-improved loblolly pine would have 50% forked stems or ramicorn branches.

Tree Improvement in the South

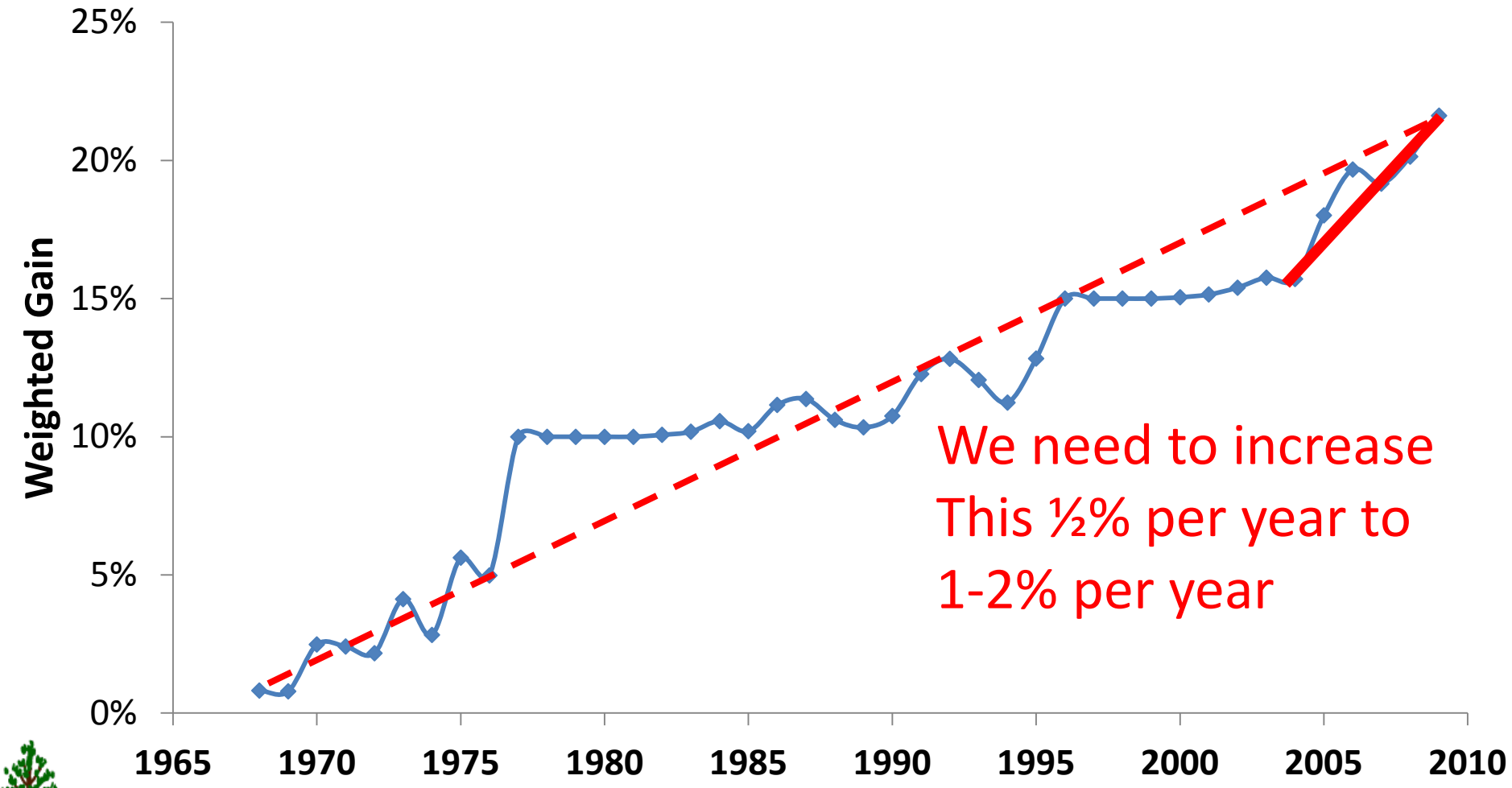
And finally…

Where are we headed?

Estimate of operational genetic gain going to landowners



Estimate of operational genetic gain going to landowners



Incentives to increase value via tree improvement are large

Investing in Genetically-Improved Loblolly Pine

Landowner Benefits Today and for Generations to Come

Steve McKeand, Patrick Cumbie, and Bob Abt
North Carolina State University Cooperative Tree Improvement Program and Department of Forestry and Environmental Resources

Tree breeders are responsible for the genetic resource that is available today and for generations to come. From the previous discussion and the article by Dougherty and others also in this issue (page 19), the economic incentive for breeding, testing, and selecting the best trees possible should be apparent. Through the application of traditional breeding methods used in agronomic and horticulture crops for decades, tree breeders have developed families or varieties of loblolly pine that produce 30 to 50 percent more wood per acre than was available 40 years ago. These families are more resistant to fusiform rust disease (see article on page 37), have better wood quality due to enhancement of straightness and disease resistance, and are widely adapted to a range of site types and forest management regimes.

Forest Landowner 2010

These gains are realized over time

- Operational gains = what landowners actually plant and eventually harvest
- What is the value to the region?
- **The rate of getting genetic gain to landowners is a critical measure of success for our program**

Rate of Genetic Improvement

- Good for all of us in the room
- Get the highest valued plantations established as soon as possible
- Economic development issue for each state, the region, and the country
- If tree improvement slows down,

… we all suffer

Well, just how much do "we" suffer?

Economic consequences of reduced breeding effort in loblolly pine

- PV analysis of what happens if we stop or slow TIP
- Assumptions of the analyses:

  - PV only, no costs – what are the losses?

  - 25-year rotation, vary stumpage values ($2500+/- per acre)

  - Constant rate of genetic improvement (0.5% to 1% per year) being planted

  - Discount PV's for some interest rate(s) – **use 6%**
- Compare the PV's for different scenarios – what are losses?

Spreadsheet

Economic consequences of reduced breeding effort in loblolly pine

- The economic consequences of slowing or stopping tree improvement are staggering
  - Even a few $$$/a loss when spread over hundreds of thousands of acres is a BIG number (**1.2 million acres planted each year**)
  - Reducing effort from 1% gain/yr to 0.9% gain/yr is a loss of **$232/a**

    Opportunity loss of $289 million for southern US
  - **In Alabama alone, the cost (PV) of slowing the rate of improvement on the 219 M acres planted each year is**

    $50,700,000

Economic consequences of reduced breeding effort in loblolly pine

- The economic consequences of slowing or stopping tree improvement are staggering
  - Even a few $$$/a loss when spread over hundreds of thousands of acres is a BIG number
- **Alternatively, the economic incentives to speed up tree breeding and deployment of the best genetics is tremendous**

Spreadsheet

Economic consequences of ~~reduced~~ breeding effort in loblolly pine

- The economic consequences of slowing or stopping tree improvement are staggering
  - Even a few $$$/a loss when spread over hundreds of thousands of acres is a BIG number
- **Alternatively, the economic incentives to speed up tree breeding and deployment of the best genetics is tremendous**

Economic consequences of enhanced breeding effort in loblolly pine

- The economic consequences of slowing or stopping tree improvement are staggering
  - Even a few $$$/a loss when spread over hundreds of thousands of acres is a BIG number
- **Alternatively, the economic incentives to speed up tree breeding and deployment of the best genetics is tremendous**
- **For the southern US where about 1.2 million acres of loblolly pine are planted each year, the increased value to all landowners from this slight increase in genetic improvement would be $300 million.**

In Alabama, it is worth $52+ million

Economic consequences of reduced breeding effort in loblolly pine

- The economic consequences of slowing or stopping tree improvement are staggering
- I have used this with state agencies and companies to emphasize how critical it is that support for tree improvement continues

  When a cooperator leaves the program or slows effort, breeding progress slows
- Consequences of OOPS's in our breeding program

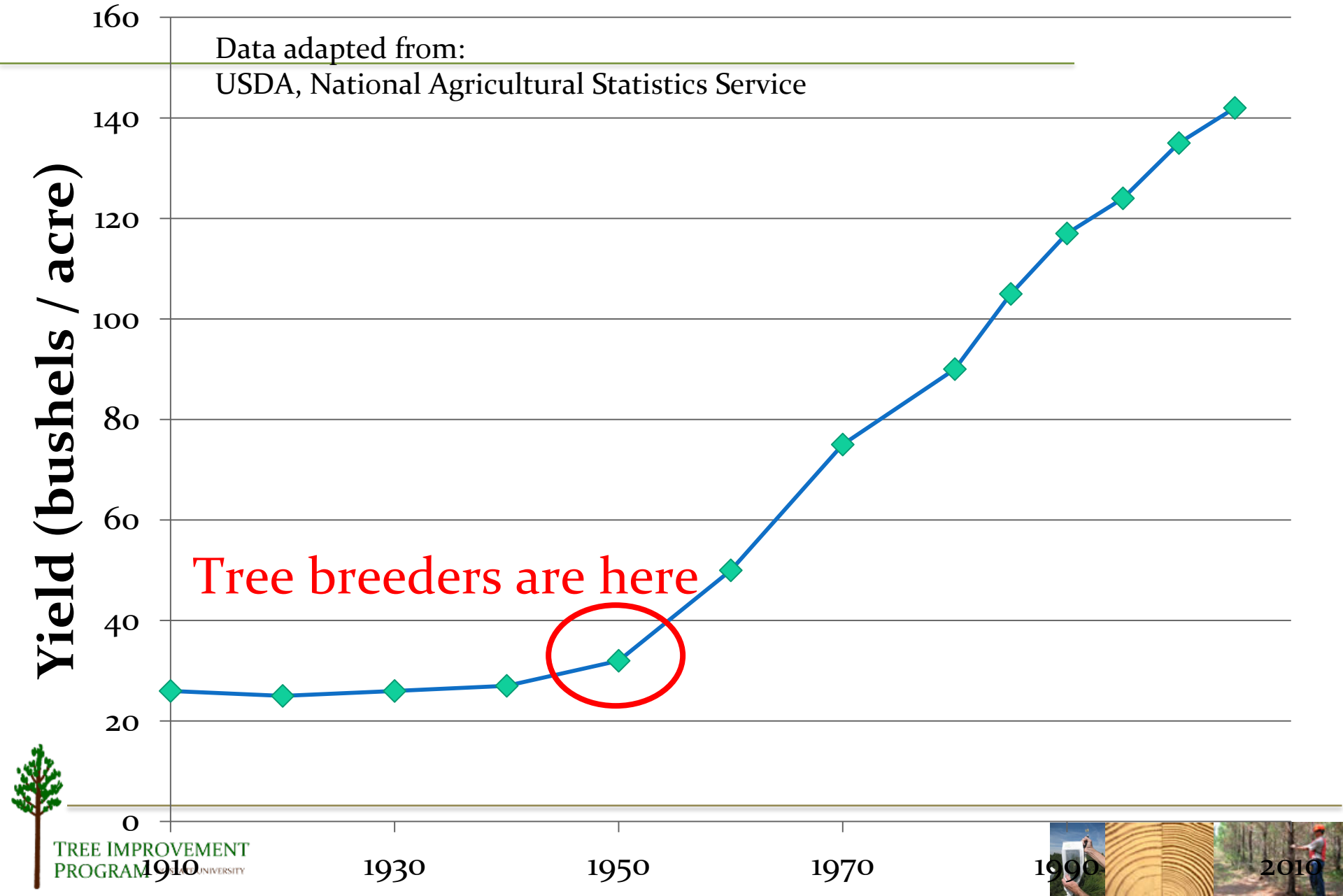
  Every delay in breeding or screwed up test or poor quality test has significant economic impact

Tree improvement is a critical, regional economic development issue

Tree improvement is a critical, regional economic development issue

And we've just begun our quest to reach our potential

US Corn Yields (General Trend)



TREE IMPROVEMENT PROGRAM


Thank You!
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