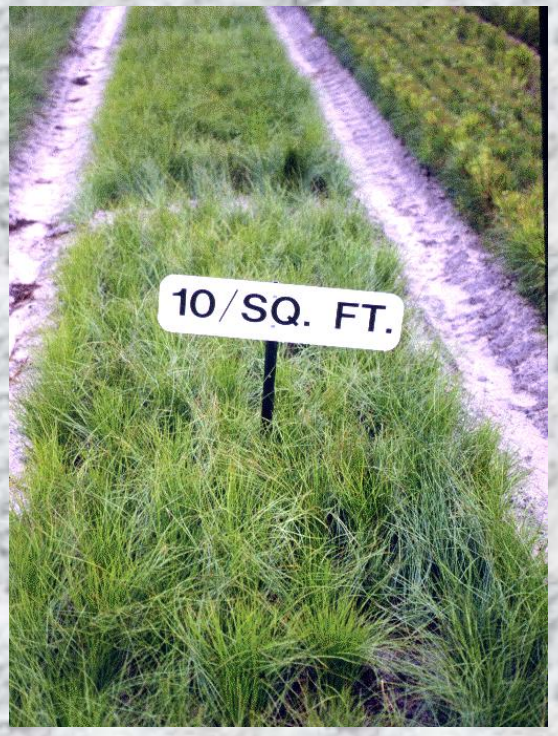
Economics of seedbed density.



David South

Emeritus Professor

School of Forestry and Wildlife Sciences - Auburn University

In the old days, high seedbed densities were recommended

One nurseryman in SC produces unusually good longleaf pine seedlings at a density of approximately 40 per square foot. (Wakeley 1935)

Civilian Conservation Corps

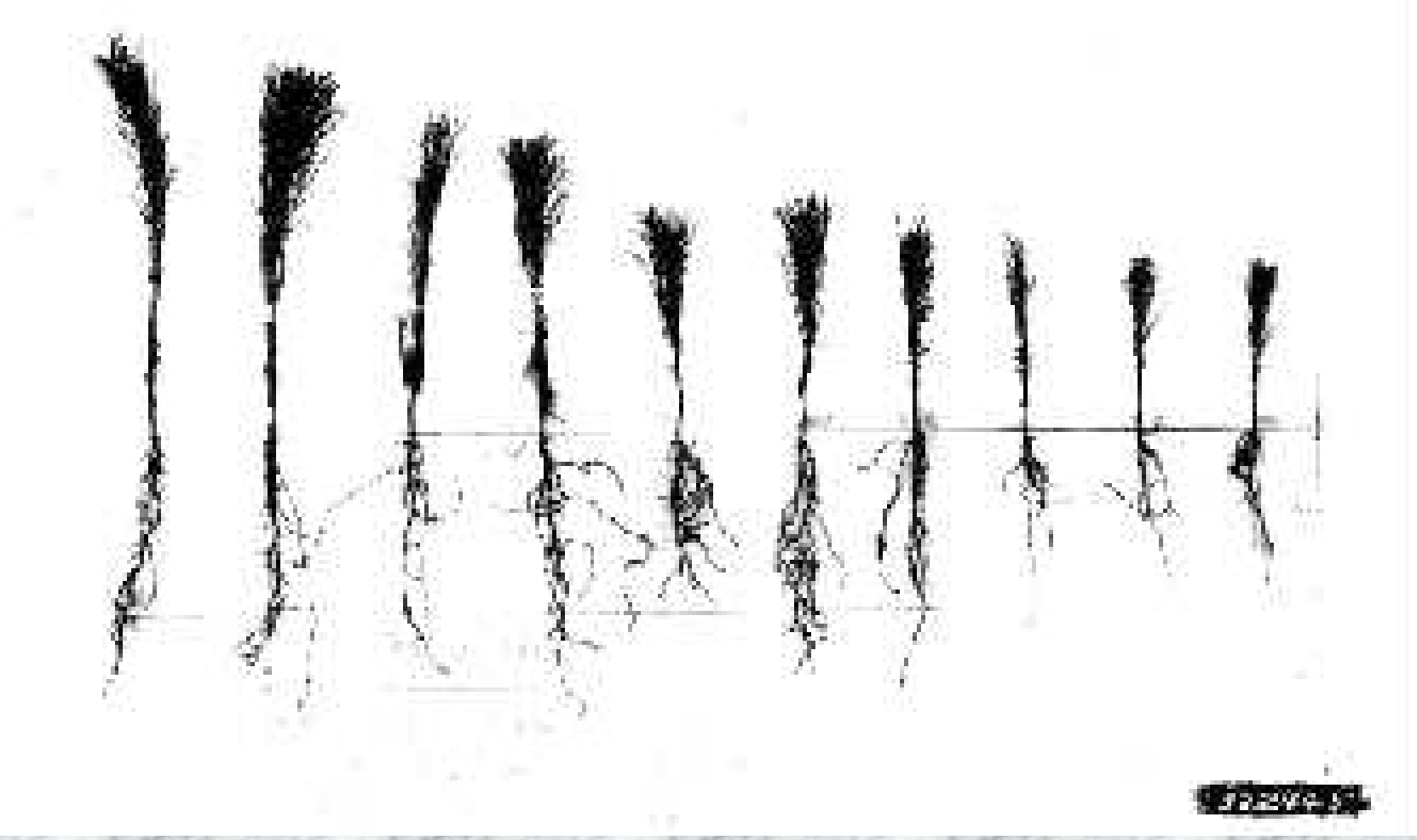
At the left, different stages of seedbed preparation may be seen. In the Center men are hand sowing longleaf seeds. On the right, men are laying down burlap bags as a mulch. Kisatchie National Forests, Louisiana. Photo taken by J.D. Nellis 1934. Credit Line: U.S. Forest Service. (photo #287379)

In the old days, high seedbed densities were recommended

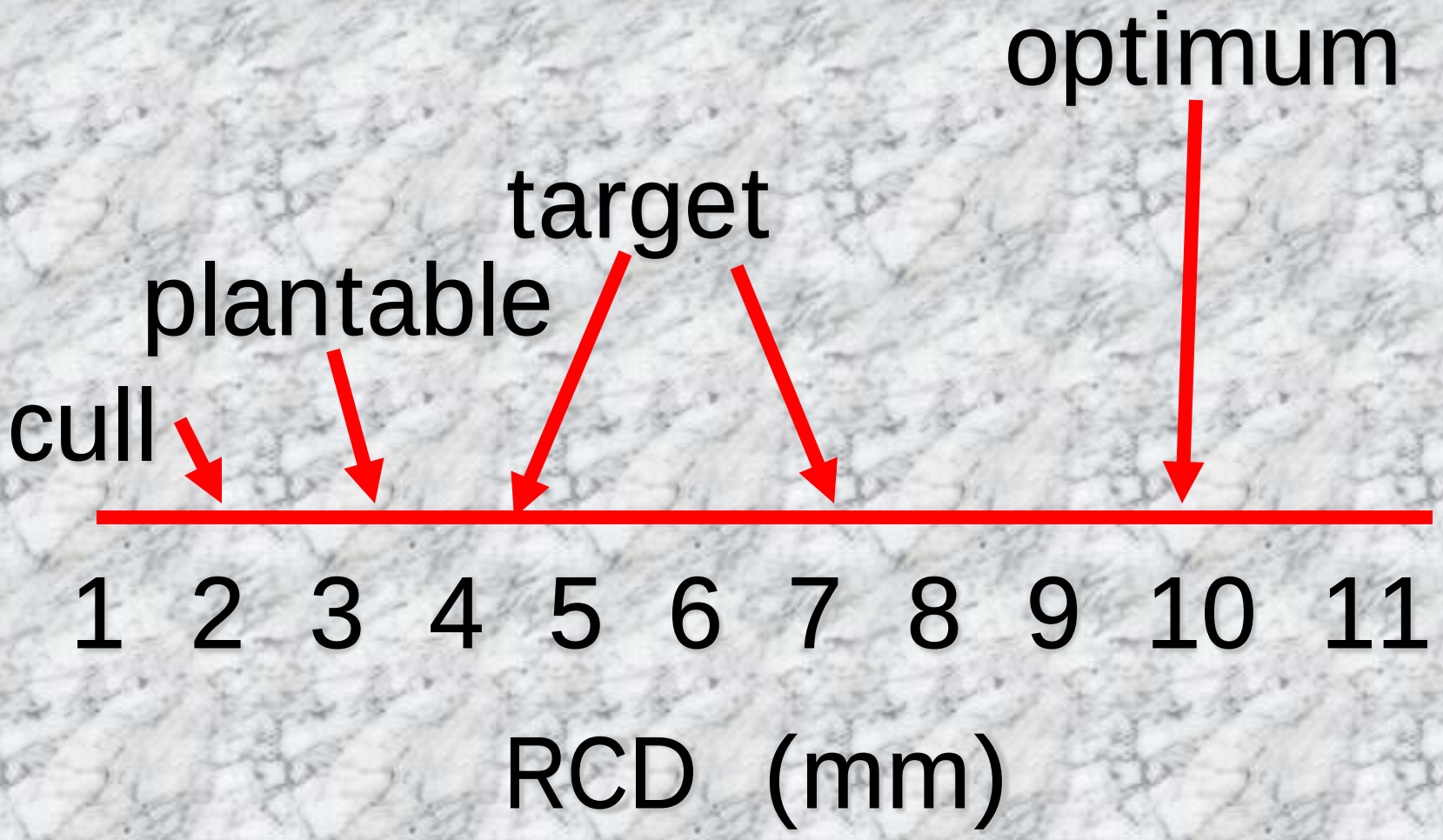
Species	Final density/square foot	
	1935	**2015**
Longleaf	**25- 35**	**13**
Slash	**35-45**	**24**
Loblolly	**40-50**	**24**
Shortleaf	**55-70**	**24**

Why is seedbed density lower now?

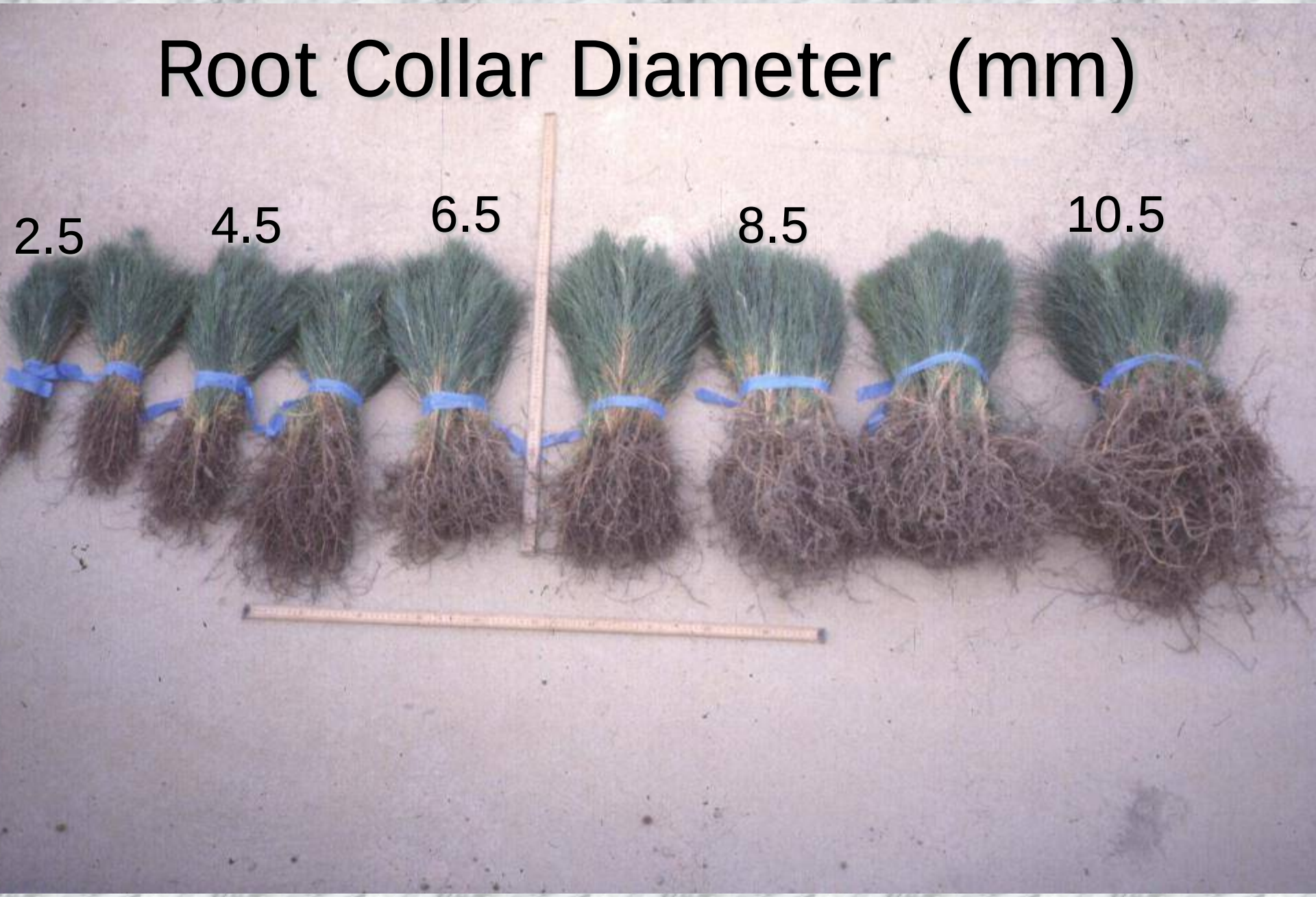
Seedling quality (i.e. target seedling) has increased
genetic improvement has increased
and seed cost has increased

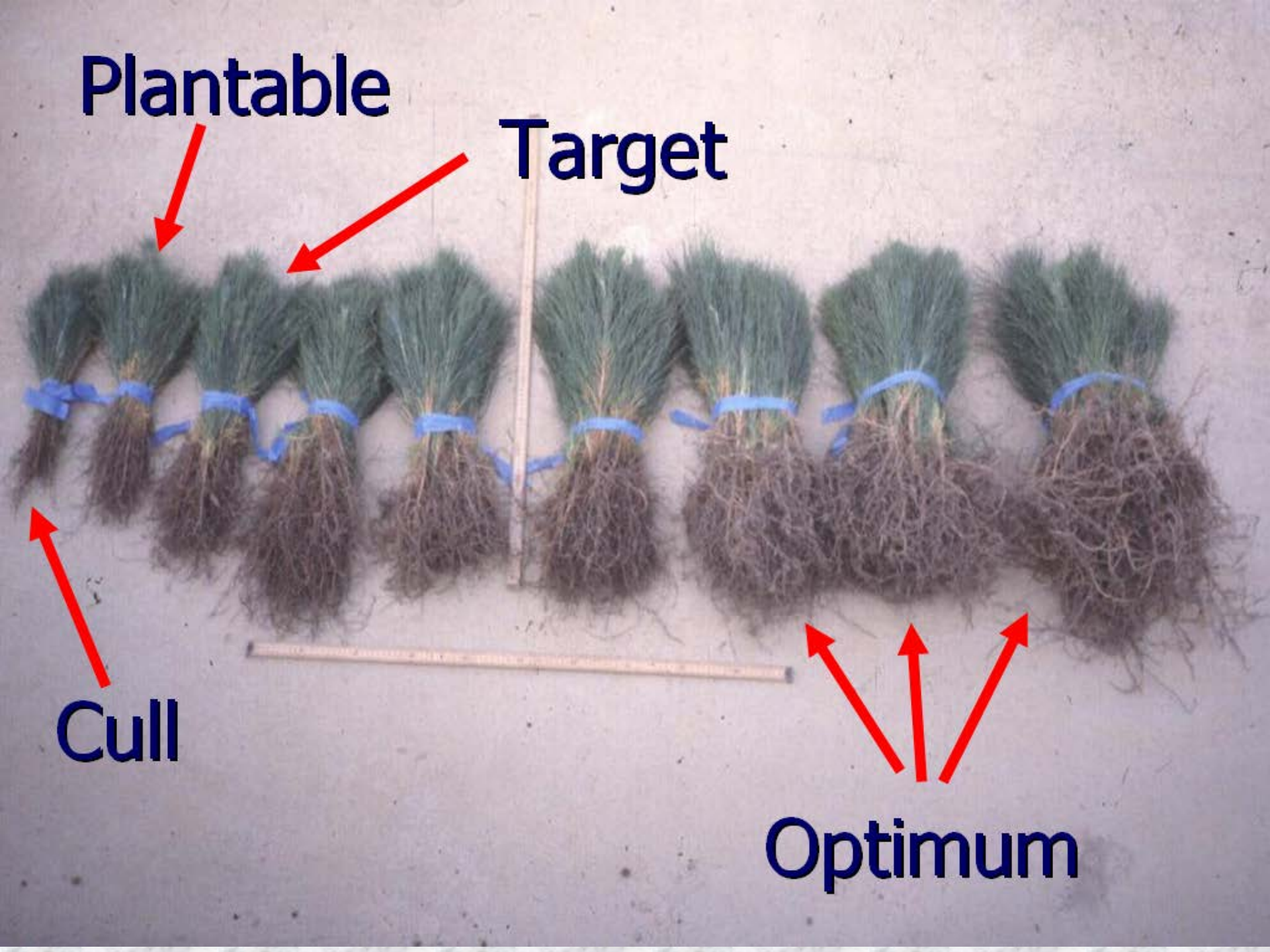


Seedling terms



Root Collar Diameter (mm)




Plantable
Target
Cull
Optimum

“Optimum” Seedling

- The “optimum” seedling is defined as

  the ideotype that will minimize overall reforestation costs while achieving established goals for initial survival and growth.

Rayonier (Dean McGraw 2000)

- About 90% of our seedlings are planted by machine. We would prefer to plant all of our sites with machines but some sites are too rough or too wet. We prefer seedlings with large roots and our target seeding has a RCD of 6 to 7 mm. Some of our lots have averaged 10 mm RCD when measured in February. We are pleased with the rapid early growth of our “morphologically improved” seedlings.

Basic nursery biology

High densities produce more culls

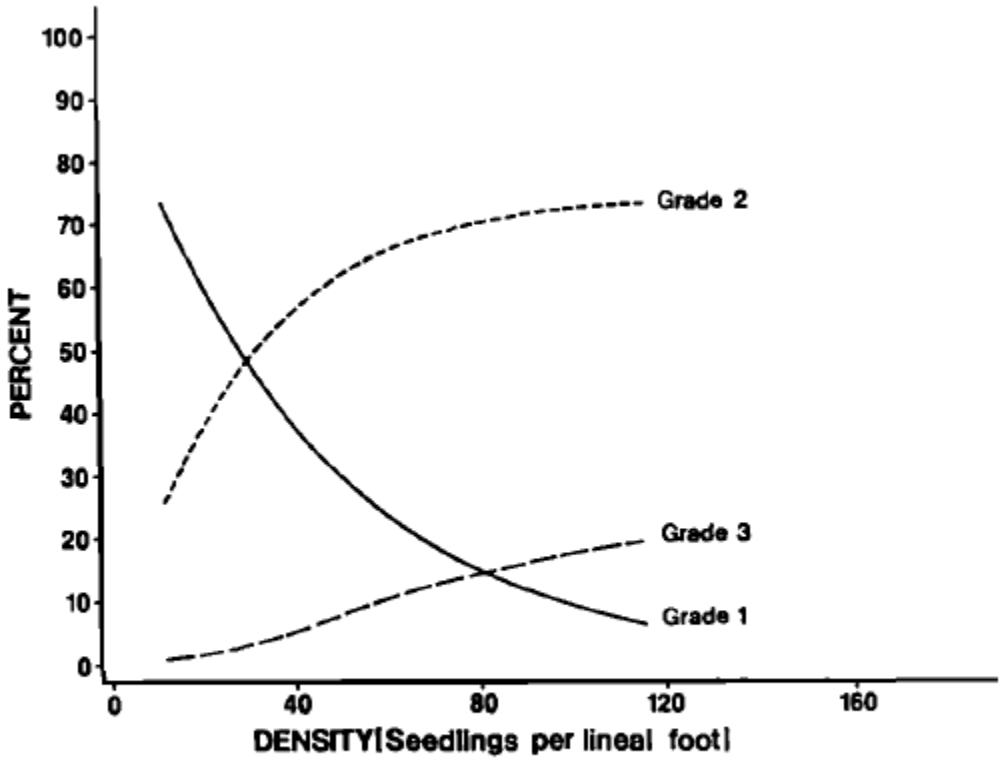
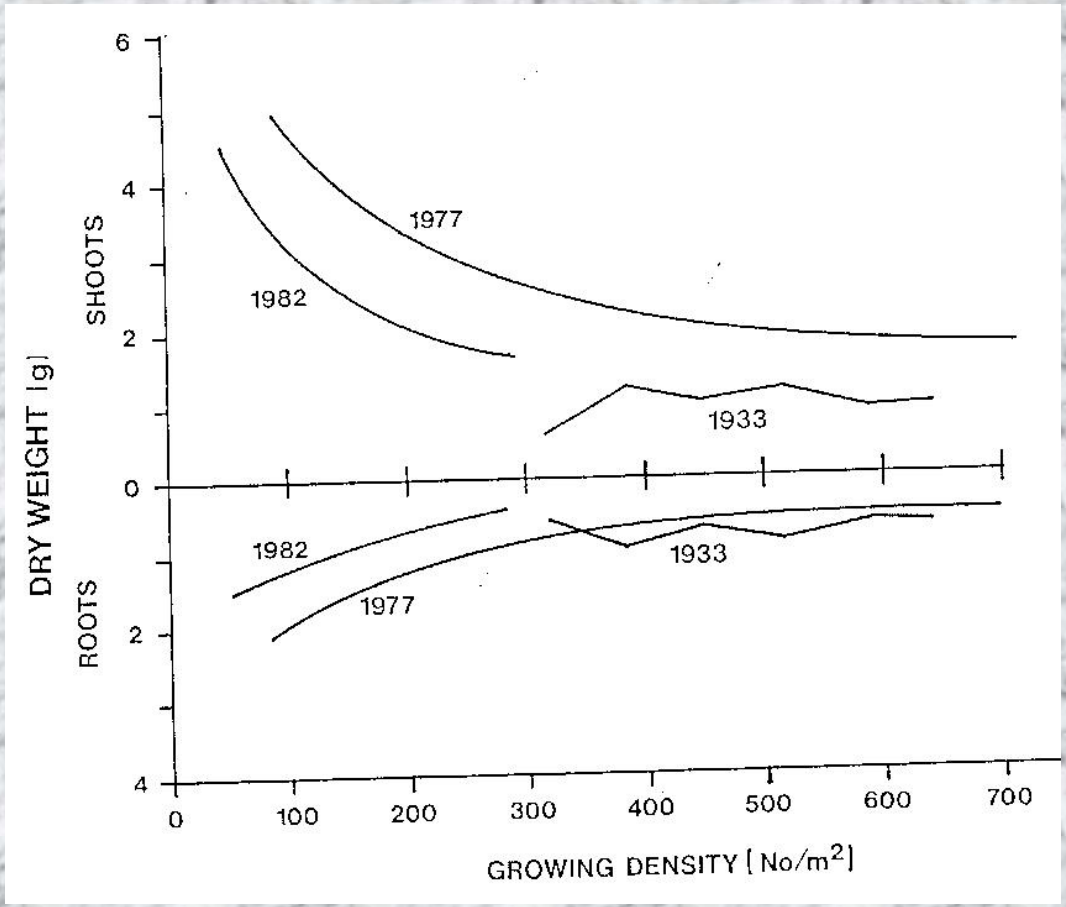


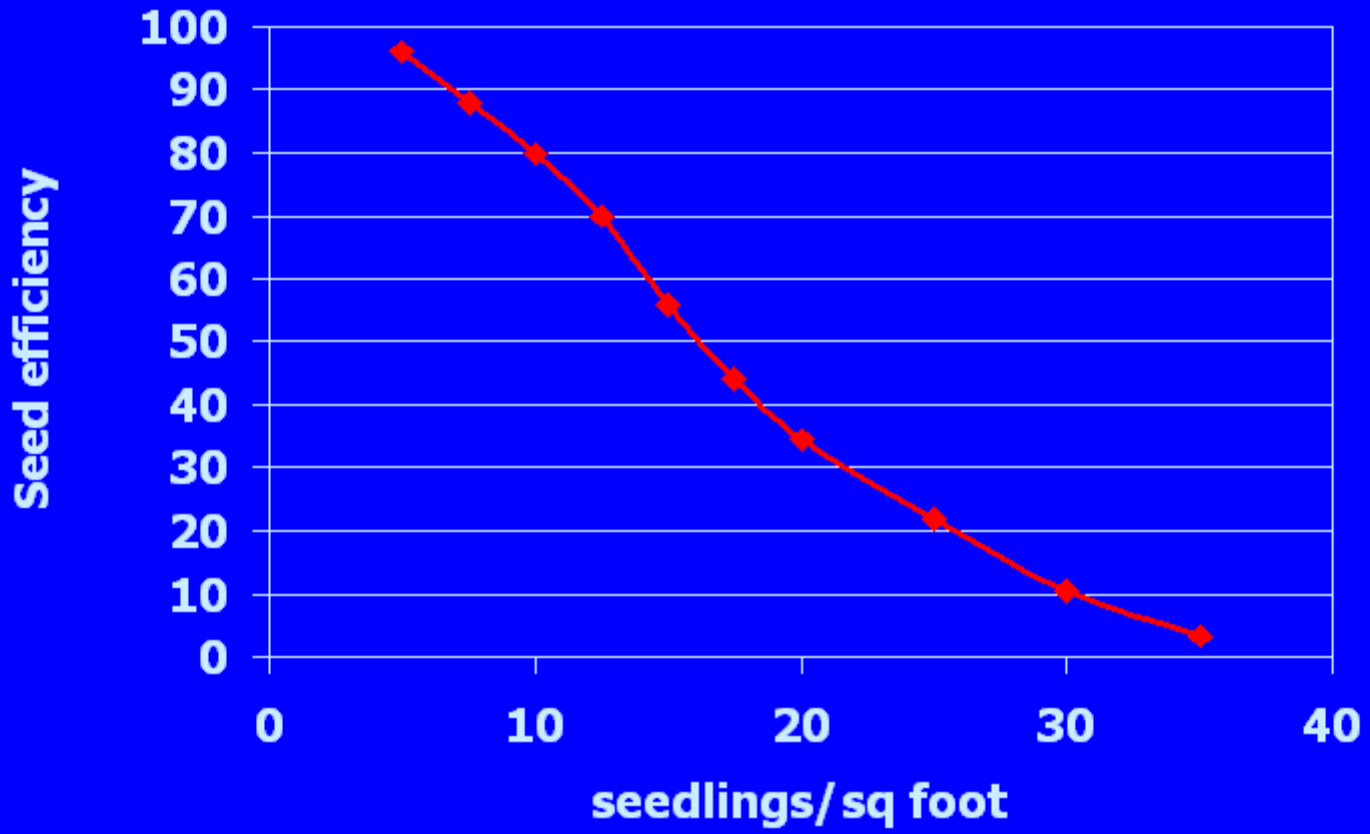
Figure 2. The percentage of loblolly pine seedlings produced in each grade is a function of nursery sowing density (Hammermill Corp., Unpubl. study).

Basic nursery biology

High densities produce smaller roots



High seedbed densities = low seed efficiency



Stoeckeler 1967 USFS Res. Note NC-25

Basic nursery biology

High densities waste seed

21 seed/sq ft vs 31 seed/sq ft

74% vs 68% seed efficiency

(sow dates before April 15)

9% more plantable seedlings per pound of seed New Forests 2:231-246

Nursery Seedbed Density Is Determined by Short-Term or Long-Term Objectives[1]

Jon P. Caulfield, David B. South, *and* **James N. Boyer,**
School of Forestry and Alabama Agricultural Experiment Station, Auburn University, Auburn, AL 36849.

(Paper in folder)

Short-term objectives → typical seedbed density
Long-term objectives → lower seedbed density

Four types of "density"

Seed density = seeds per area

PLS density = Pure live seeds per area

Growing density = plants per area

Target density = plantable seedlings per area

Growing density > target density

(10% culls) 22 = 20

Cost of seedling production

Seed cost
Growing cost
Lifting + Packing cost
Administrative cost

Cost of bareroot seedling production

Hypothetical example

Seed cost	$10
Growing cost	$12
Lifting + Packing cost	$ 8
Administrative cost	$15
Profit	$10
Price per thousand	$55

Price of bareroot seedlings

Real examples

	price per thousand
Lot A	$ 55
Lot B	$ 75
Lot C	$205

Why such a large difference?

Price of bareroot seedlings

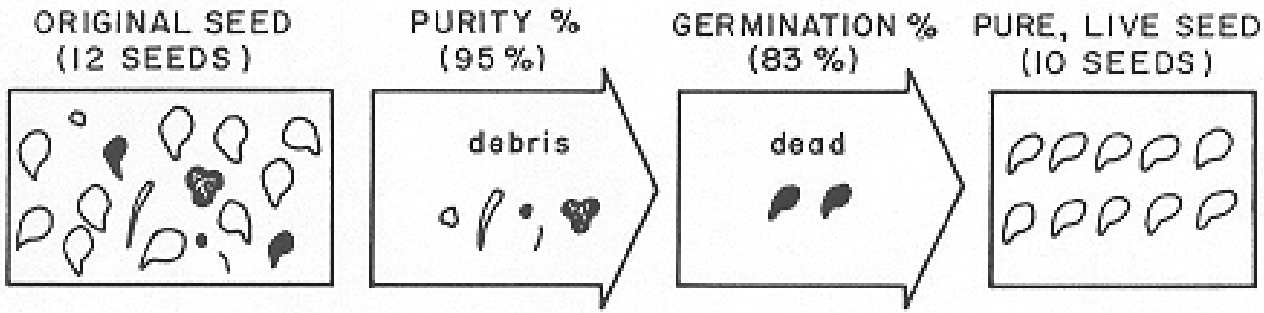
Real example

	price per thousand	Seed cost*
Lot A	$ 55	18%
Lot B	$ 75	40%
Lot C	$205	78%

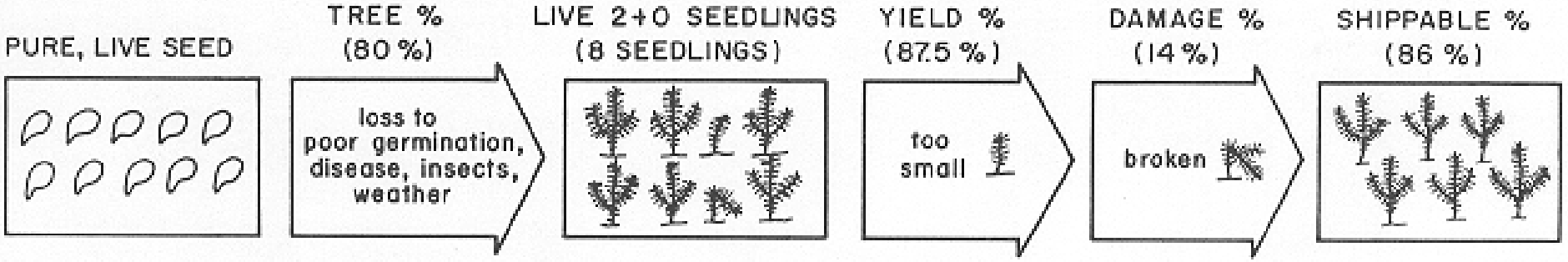
*Assumes seedling price is not a function of demand

High seed efficiency is now important when setting seedbed density

$$\frac{\#\ \text{plantable seedlings}}{\#\ \text{pure live seed}}$$



Plantable seedlings/Pure live seed = SEED EFFICIENCY



6/10 = 60% SEED EFFICIENCY

SEED EFFICIENCY FROM SMALL PLOTS AT SEVEN NURSERIES IN 1984

Nursery	Date sown	Pure live seed sown/ sq. ft.	Total density/ sq. ft.	Plantable seedlings/ sq. ft.	Cull percent	Total mortality	Seed efficiency
		No.	*No.*	*No.*	*Pct.*	*Pct.*	*Pct.*
A	4/25	30.2	29.2	27.8	5	3	92
B	4/23	30.2	27.9	21.7	22	8	72
C	4/23	30.2	27.9	21.0	25	8	69
D	4/19	30.2	24.9	20.6	17	18	68
E	4/19	30.2	23.6	19.0	20	22	62
F	4/20	30.2	21.8	18.2	16	28	60
G	5/17	30.2	17.6	12.6	28	42	41

Factors other than seedbed density will greatly affect seed efficiecy

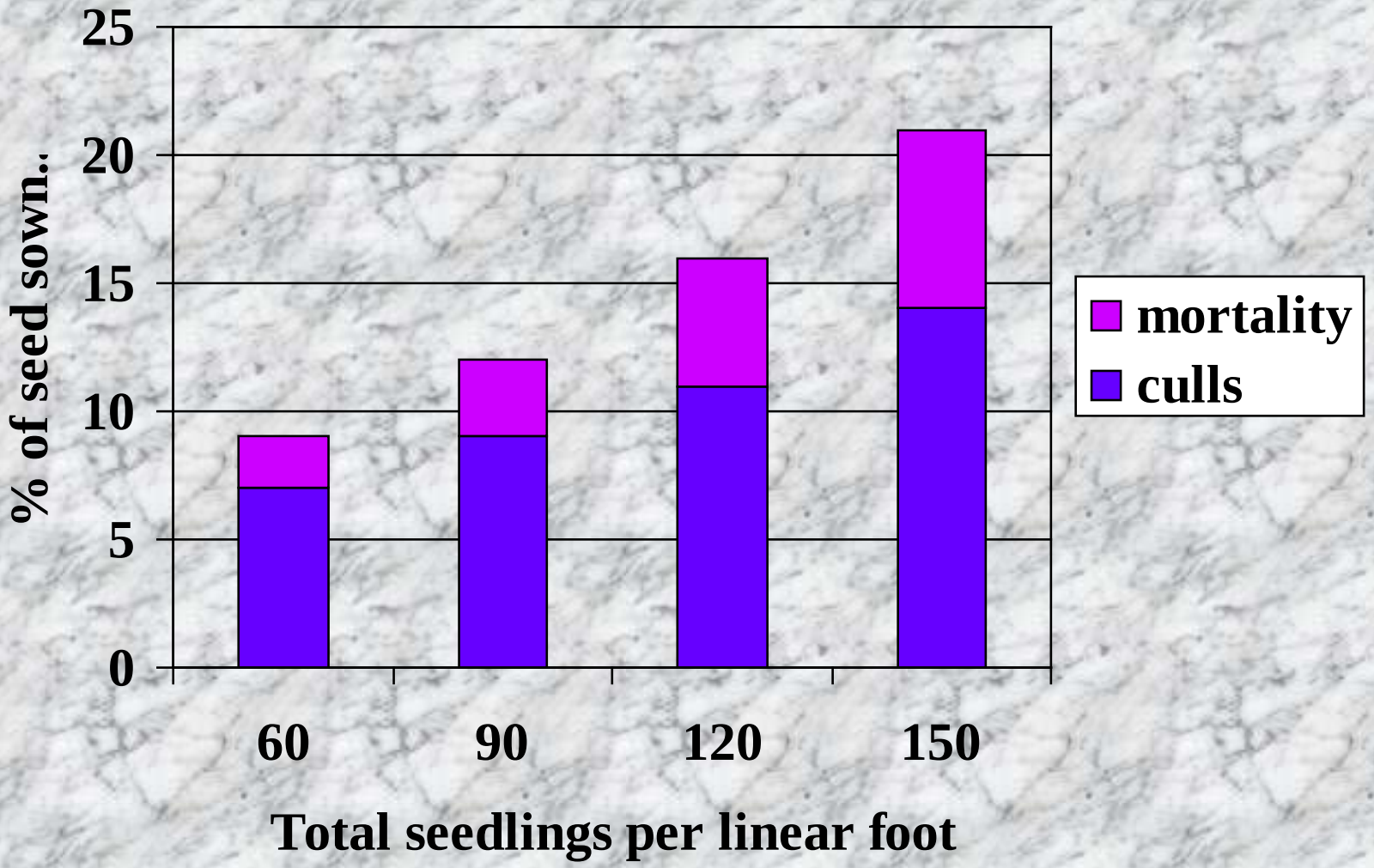
Many factors affect seed efficiency

- Sowing date; sowing depth; **sowing density;** stratification length;
- Fumigation; proper use of herbicides; fungicides; insecticides
- Seed age; bird repellent; soil-stabilizer, pine bark mulch
- Irrigation; fertilization; top-pruning

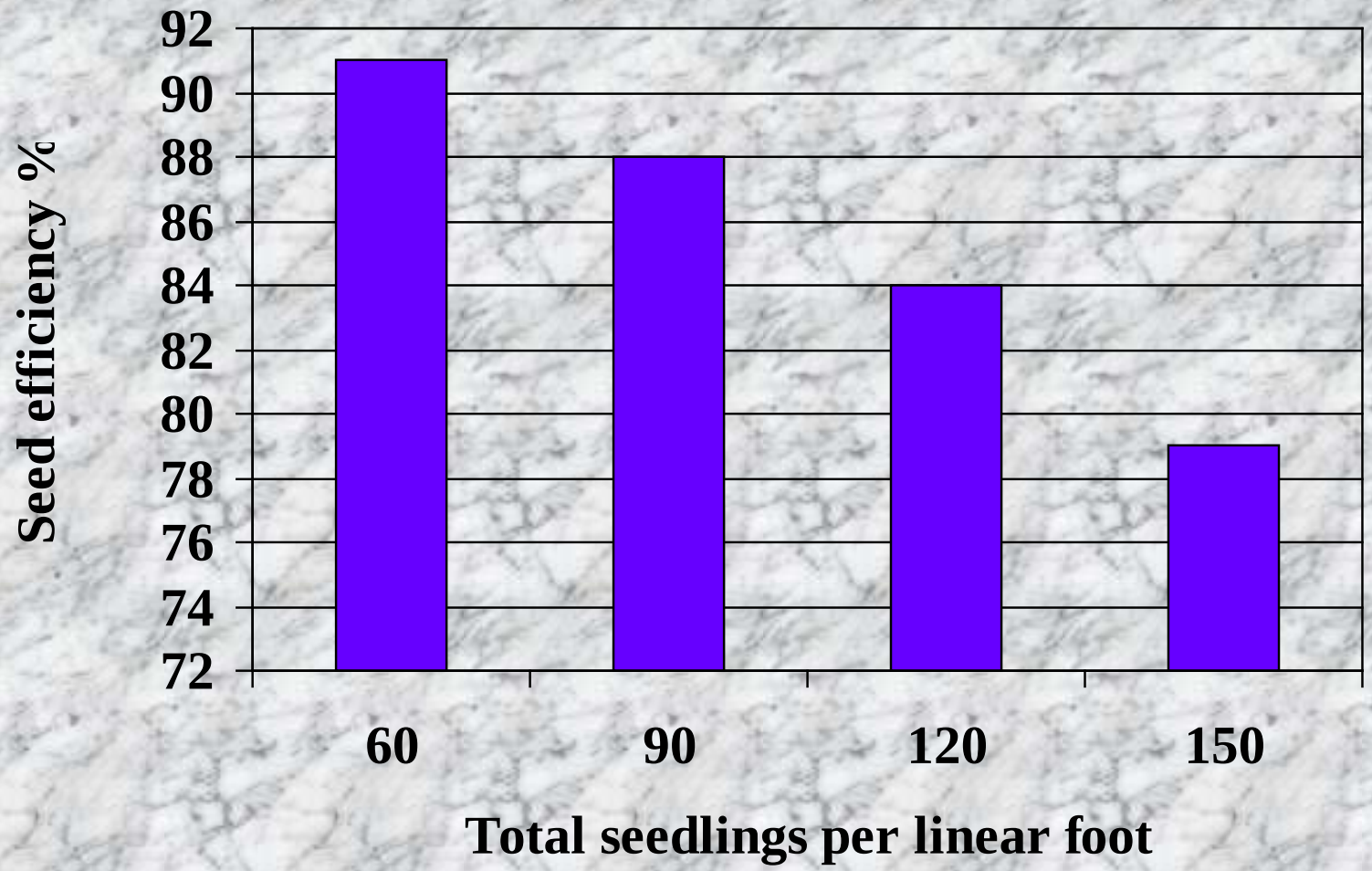
Seedbed density affects culls and seed efficiency

Total Seedlings/ lineal foot	Slash pine grade[b]					
	1		2		3	
	%	No.	%	No.	%	No.
60	61.3	37	31.7	19	7.0	4
90	43.5	39	47.7	43	8.8	8
120[c]	30.9	37	58.0	70	11.1	13
150	22.0	33	64.0	96	14.0	21

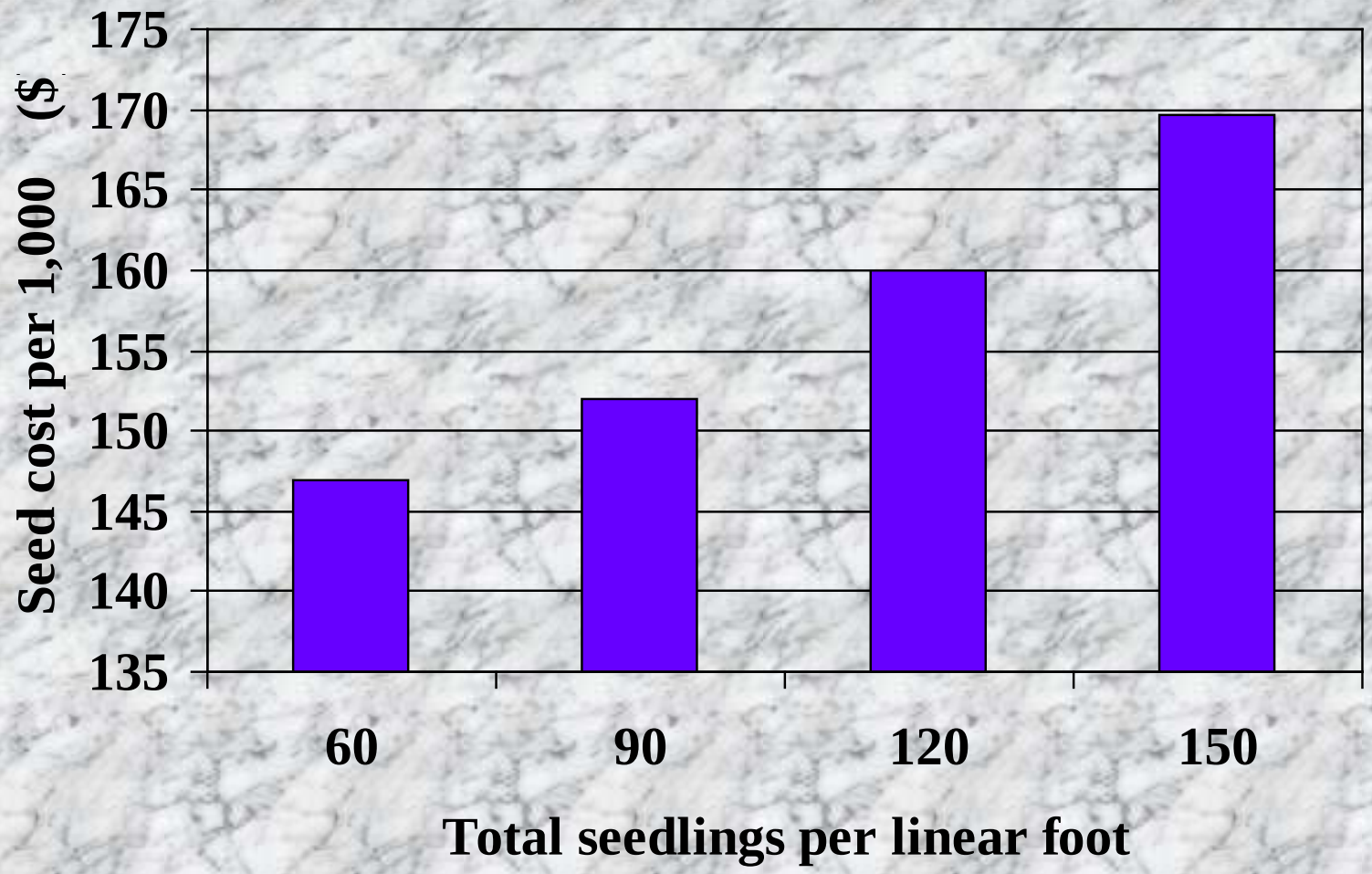
Fewer culls and less mortality at low seedbed density



Seedbed density affects culls and seed efficiency

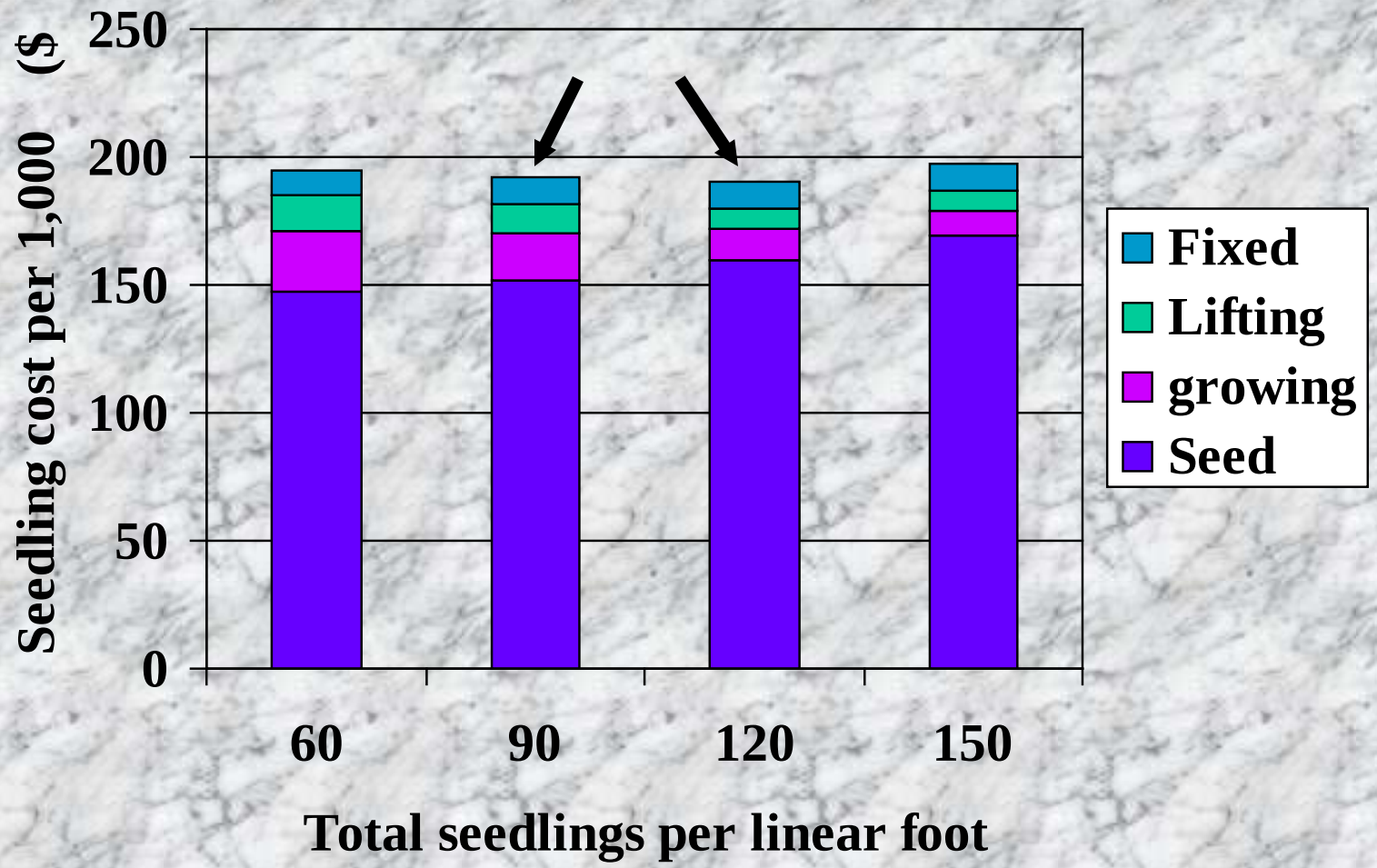


Seedbed density affects culls and seed efficiency



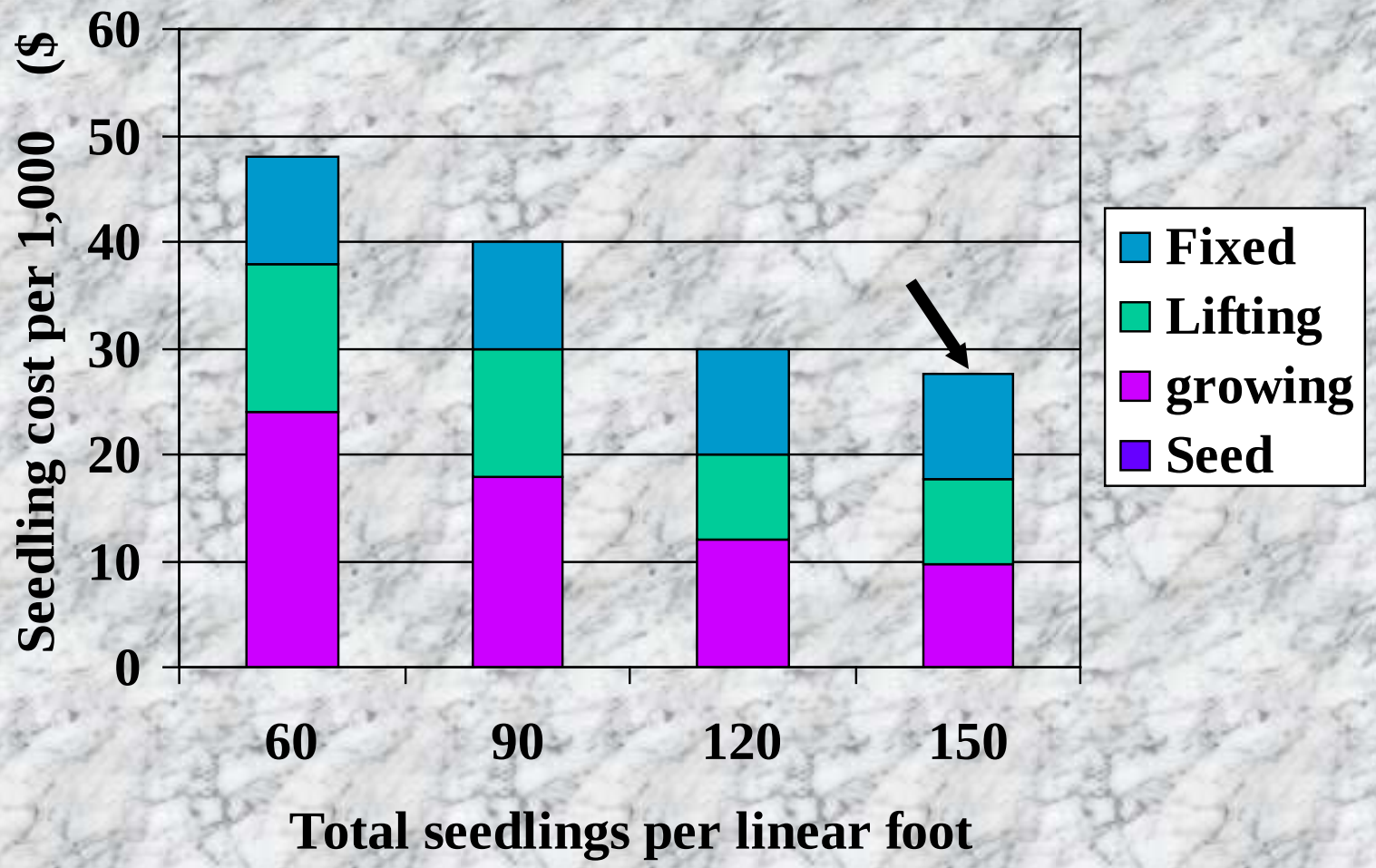
13.4 cents per pure live seed

Seedbed density affects seedling cost



13.4 cents per pure live seed

Seedbed density affects seedling cost



Free seed and no limit to seed supply

(20 years ago)

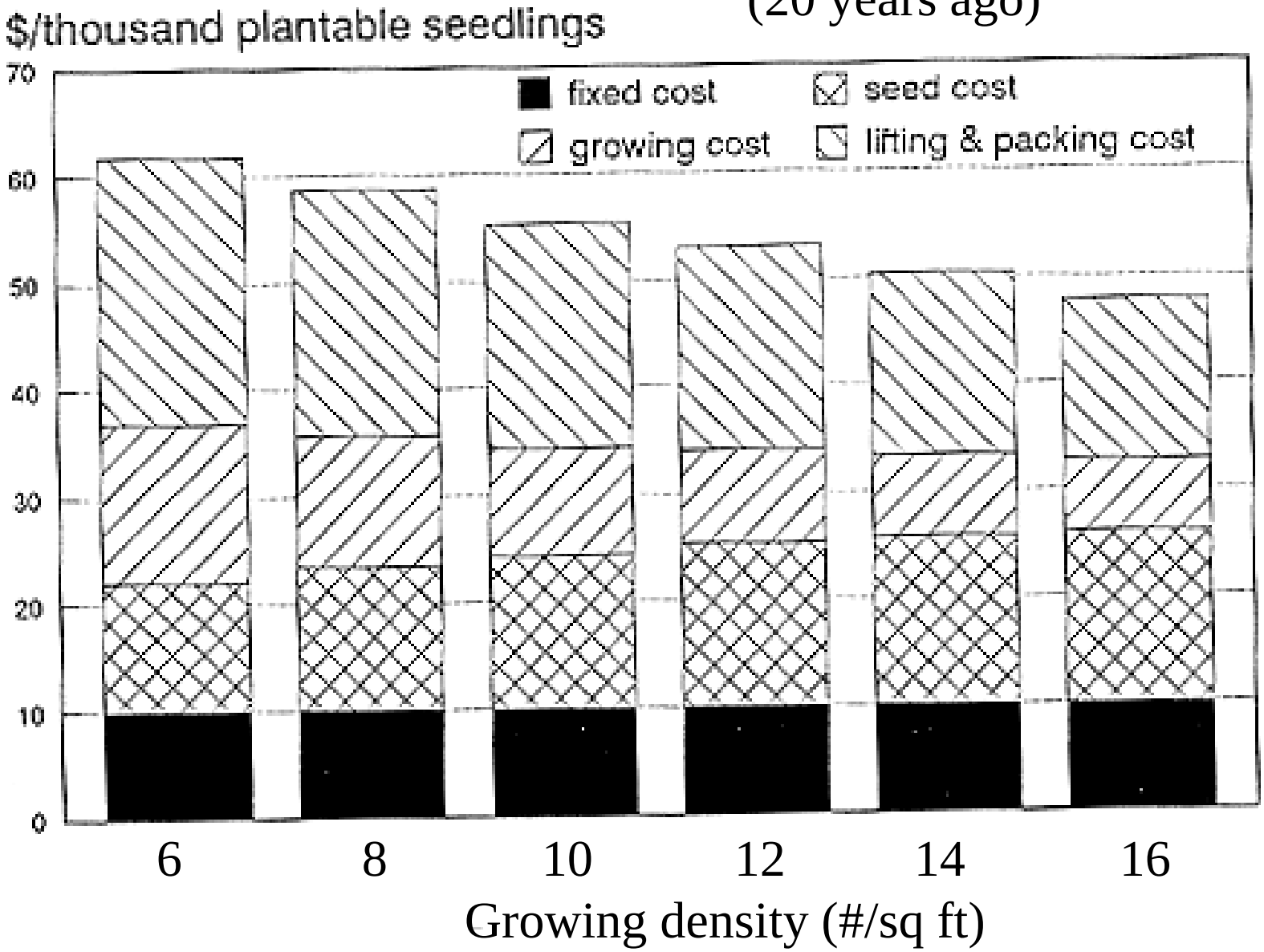


Fig. 9. An example of the effect of growing density (plantable seedlings plus culls) on cost of producing 1000 plantable *P. palustris* seedlings.

REMEMBER!!!

- Free seed favors higher seedbed densities

- Expensive seed favors lower seedbed densities

- Limited seed favors lower seedbed densities

Now let's look at long-term objectives

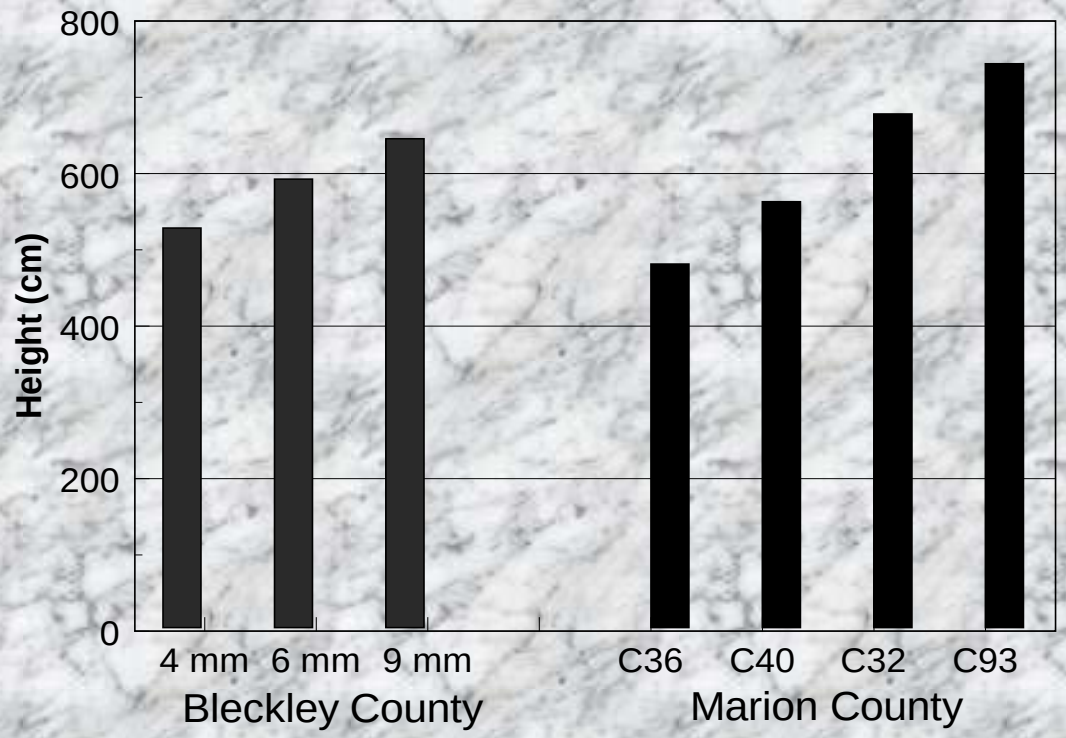
Nursery Seedbed Density Is Determined by Short-Term or Long-Term Objectives[1]

Jon P. Caulfield, David B. South, *and* **James N. Boyer,**
School of Forestry and Alabama Agricultural Experiment Station, Auburn University, Auburn, AL 36849.

(Paper in folder)

Long-term objectives → lower seedbed density

A comparison of height gains (age 5 years) from planting larger *Pinus taeda* transplants (Blackley County, Georgia; clone L-3576) with planting four clones of *Pinus taeda* (Marion County, Georgia). The absolute gain from planting transplants that were 2 mm larger in diameter (ie. 6 mm vs. 4 mm) was approximately the same as that achieved from planting clone C40 vs. clone C36 (Dougherty et al. 2012).



Union Springs, AL

Target density

60 plantable seedlings per linear foot

15 plantable seedlings per sq foot

>90% grade 1 seedlings

Nursery Seedbed Density Is Determined by Short-Term or Long-Term Objectives[1]

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(Paper in folder)

Long-term objectives = more wood at harvest
Large diameter stock = more wood at harvest
Greater genetic gain = more wood at harvest
More wood at harvest = lower seedbed density

Increase in Survival

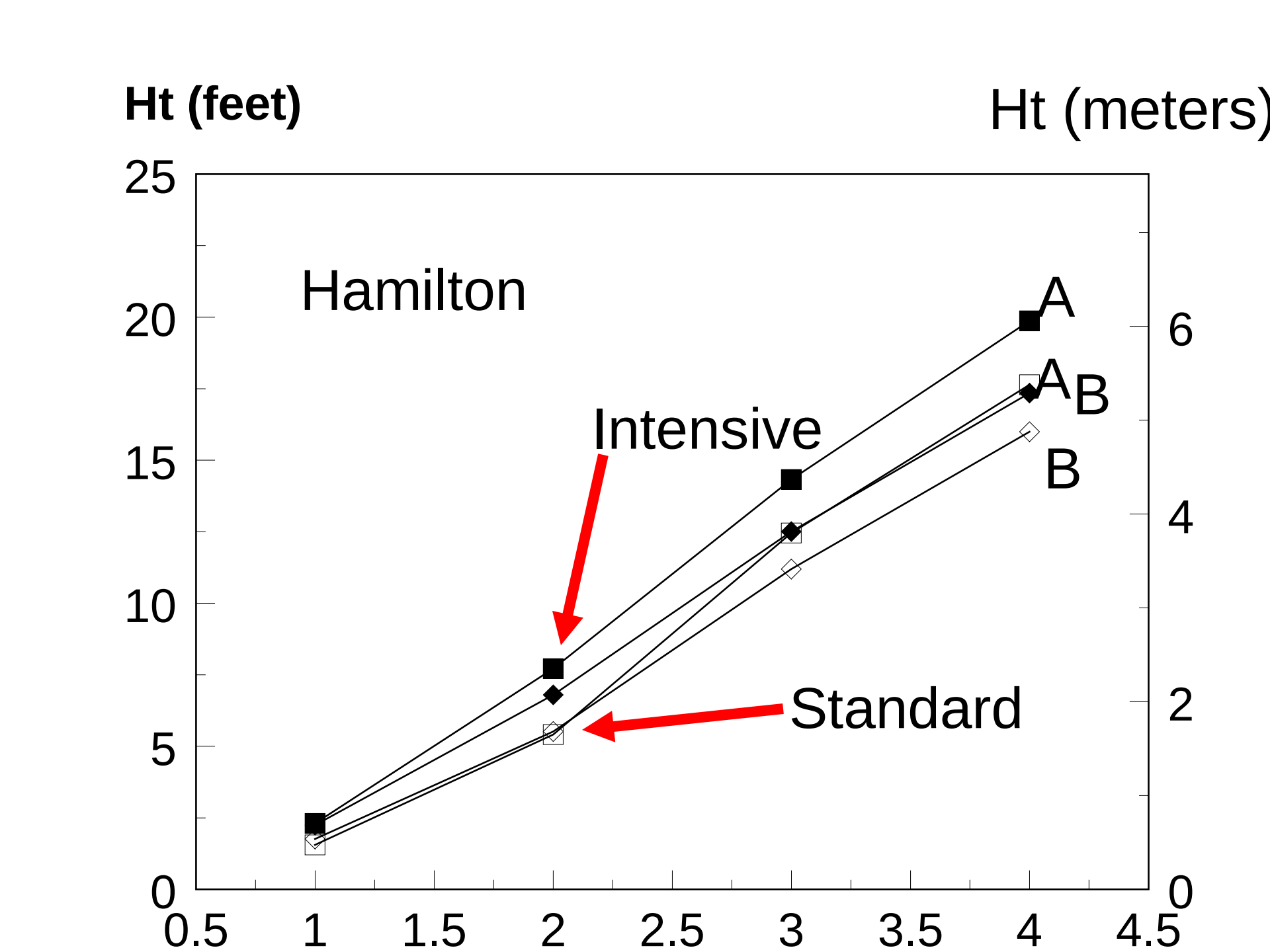
Study	Low density	High	% gain
Rowan	15	30	14
Shoulders	14	38	12
Shoulders	10	30	9
Rowan	15	30	8
Leach	20	30	4
Shoulders	13	31	3
Rowan	15	30	2
Shoulders	12	31	1
Shipman	20	40	1
Carneiro	15	26	-3

- Standard silviculture
- typical seedlings

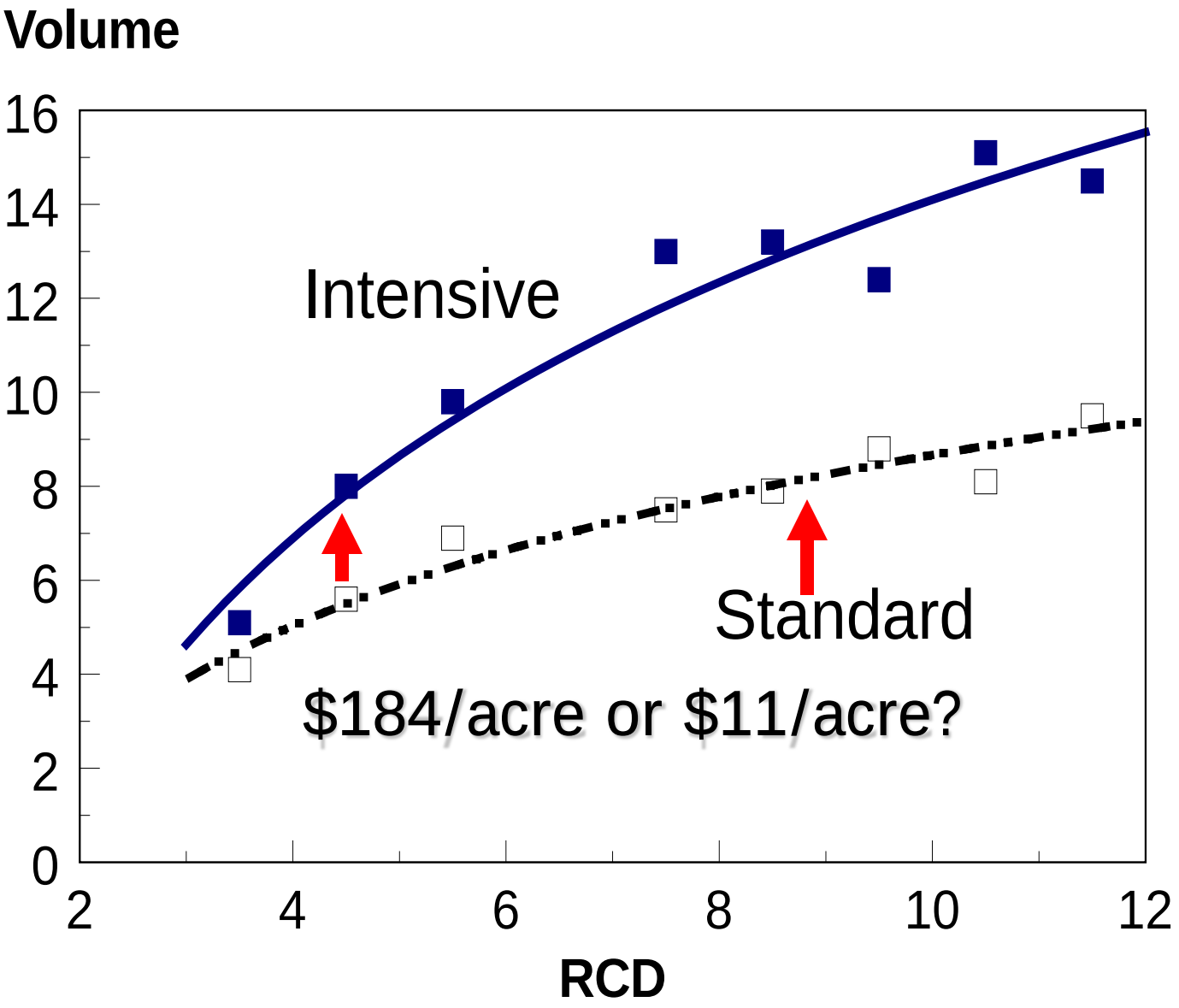
large seedlings

- Intensive silviculture
- typical seedlings

large seedlings


Ht (feet)
Ht (meters)
25
20
15
10
5
0
6
4
2
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Hamilton
Intensive
Standard
A
A
B
B

Hamilton Ridge



Survival was high 93.5% for both seedling sizes.

For the Hamilton site in South Carolina, the “optimum” seedling had a RCD of about 8.5 mm.

When comparing alternative methods of establishment, planting low-density seedlings (in some cases) can achieve the same response as investing $184/acre in intensive management.

Estimated costs and value of loblolly pine seed from different stages of tree improvement program.

	Rogued second generation
	------cents/pure live seed----------
cost of harvest and extraction	0.2
cost of harvest, extraction and tree improvement	0.5
Market value	0.55
present net value of additional wood production*	5.5

* as compared to woods run seed

Conclusions

- Gains in survival and growth can be achieved by planting low-density seedlings (machine planting recommended)
- Per seedling costs are often higher for low-density seedlings than for regular seedlings but the benefit/cost ratio can be substantial

Seedbed density is a function of the most limiting factor

Is land the limiting factor?

Is the cover-crop rotation the limiting factor?

Is seed supply the limiting factor?

Is seedling demand the limiting factor?

Is irrigation pipe the limiting factor?

Is customer satisfaction the limiting factor?

Seedbed density is a function of the most limiting factor

21 seed per square foot or 31 seed per square foot.
Assume 11% more plantable seedlings per pound of seed
Sow 1000 pounds of seed (@15,000 pure live seed per pound)

16 acres of seedbed…. or 11 acres of seedbed….

Which density do you choose?

(a) 18/sq ft ?
(b) 24/sq ft ?

Seedbed density is a function of the most limiting factor

21 seed per square foot or 31 seed per square foot.
Assume 11% more plantable seedlings per pound of seed
Sow 1000 pounds of seed (@15,000 pure live seed per pound)

16 acres of seedbed…. or 11 acres of seedbed….

Which density do you choose?

(a) 18/sq ft ?
(b) 24/sq ft ?

* Assume only 1000 pounds of MCP seed

Seedbed density is a function of the most limiting factor

21 seed per square foot or 31 seed per square foot.
Assume low density produces 11% more plantable seedlings per pound of seed

Sow 1000 pounds of seed (@15,000 pure live seed per pound)

Which density do you choose?

(a) 18/sq ft ? 16 acres of seedbed
(b) 24/sq ft ? 11 acres of seedbed

Seedbed density is a function of the most limiting factor

21 seed per square foot or 31 seed per square foot.
Assume 11% more plantable seedlings per pound of seed
Sow 1000 pounds of seed (@15,000 pure live seed per pound)

Which density do you choose?

(a) 18/sq ft ? 16 acres of seedbed
(b) 24/sq ft ? 11 acres of seedbed

* Assume only 11 acres of seedbed available; high demand for MCP seedlings

Seedbed density is a function of the most limiting factor

21 seed per square foot or 31 seed per square foot.
Assume 11% more plantable seedlings per pound of seed
Sow 1000 pounds of seed (@15,000 pure live seed per pound)

Which density do you choose?

(a) 18/sq ft ? 16 acres of seedbed
(b) 24/sq ft ? 11 acres of seedbed

* Assume plenty of seedbed available; high demand for MCP seedlings; and only 1,000 pounds of MCP seed

Seedbed density is a function of the most limiting factor

21 seed per square foot or 31 seed per square foot.
Assume 11% more plantable seedlings per pound of seed
Sow 1000 pounds of seed (@15,000 pure live seed per pound)

Which density do you choose?

(a) 18/sq ft ? 16 acres of seedbed
(b) 24/sq ft ? 11 acres of seedbed

* Assume plenty of seedbed available; high demand for MCP seedlings; and only 1,000 pounds of MCP seed

Seedbed density is a function of the most limiting factor

21 seed per square foot or 31 seed per square foot.
Assume 11% more plantable seedlings per pound of seed
Sow 1000 pounds of seed (@15,000 pure live seed per pound)

16 acres of seedbed…. or 11 acres of seedbed….

Which density do you choose? (MCP @ $205 per thousand)

(a) 18/sq ft ? 5 more acres = $214,000 more (gross)*
(b) 24/sq ft ?

* Assumes no economic advantage for larger stock

pine

pine

cover crop

cover crop

2:2 rotation @ 26/sq ft

pine

pine

cover crop

2:1 rotation at 20/sq ft

Nursery seedbed density is determined by the target seedling size