DSI
Dead Seedling Investigation

David South

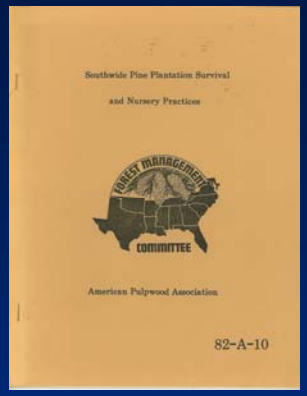
1982

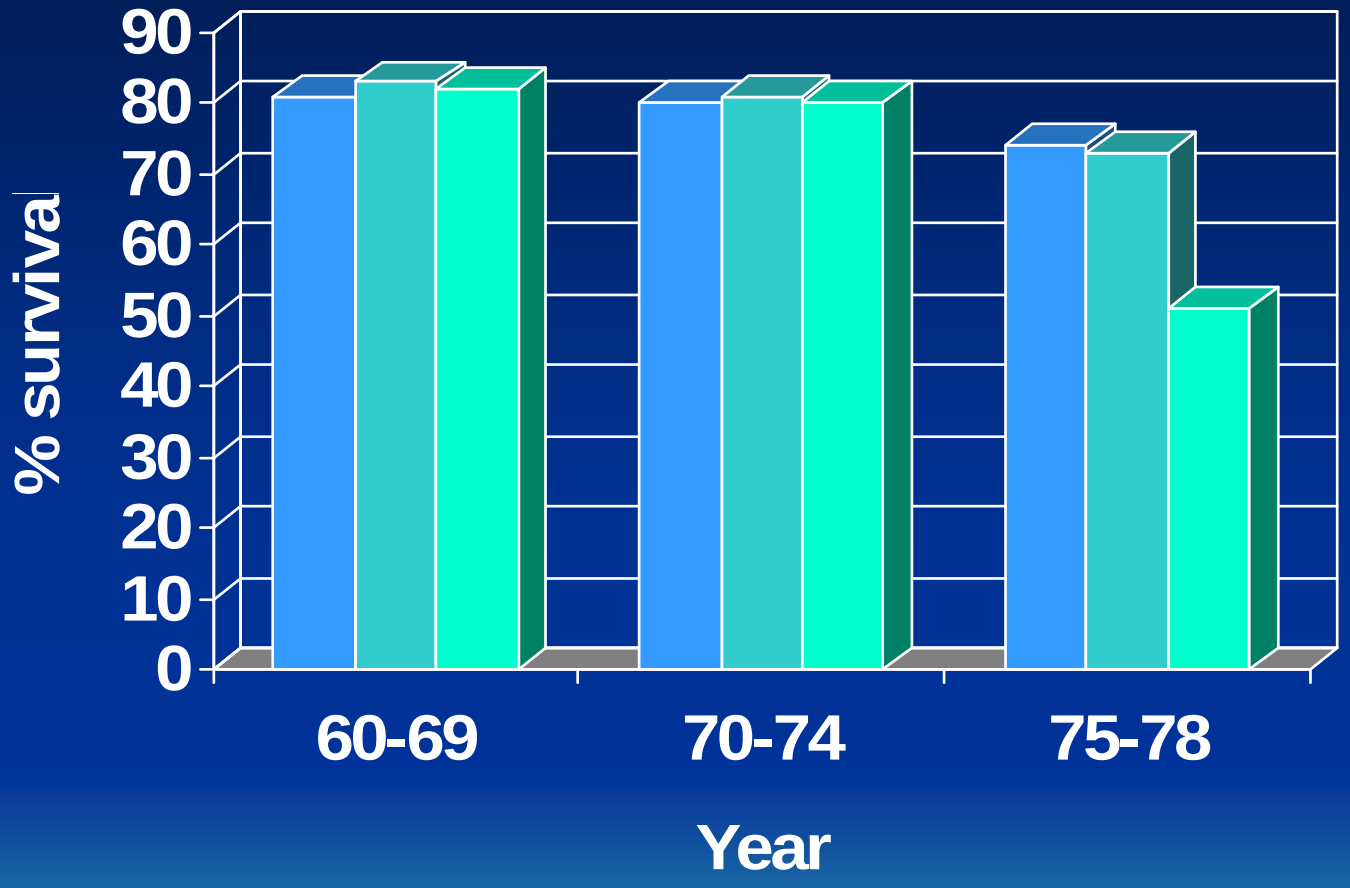
Southwide Pine Plantation Survival

and Nursery Practices

American Pulpwood Association

82-A-10


Southwide Pine Plantation Survival
and Nursery Practices
FOREST MANAGEMENT
COMMITTEE
American Pulpwood Association
82-A-10


% survival
90
80
70
60
50
40
30
20
10
0
60-69
70-74
75-78
Year
Coastal Plain
Piedmont
Highlands

Southwide Pine Plantation Survival

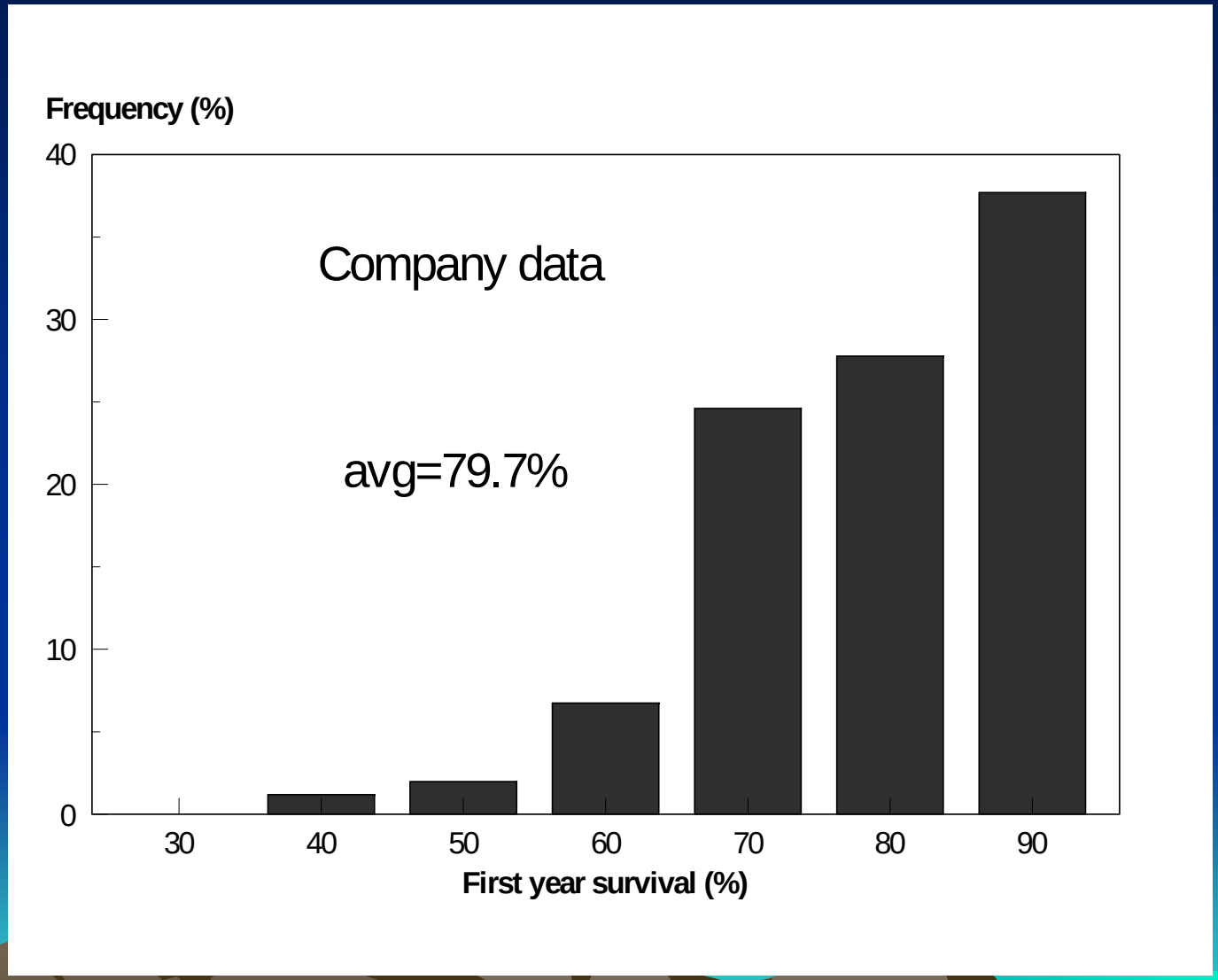
and Nursery Practices

EXECUTIVE SUMMARY

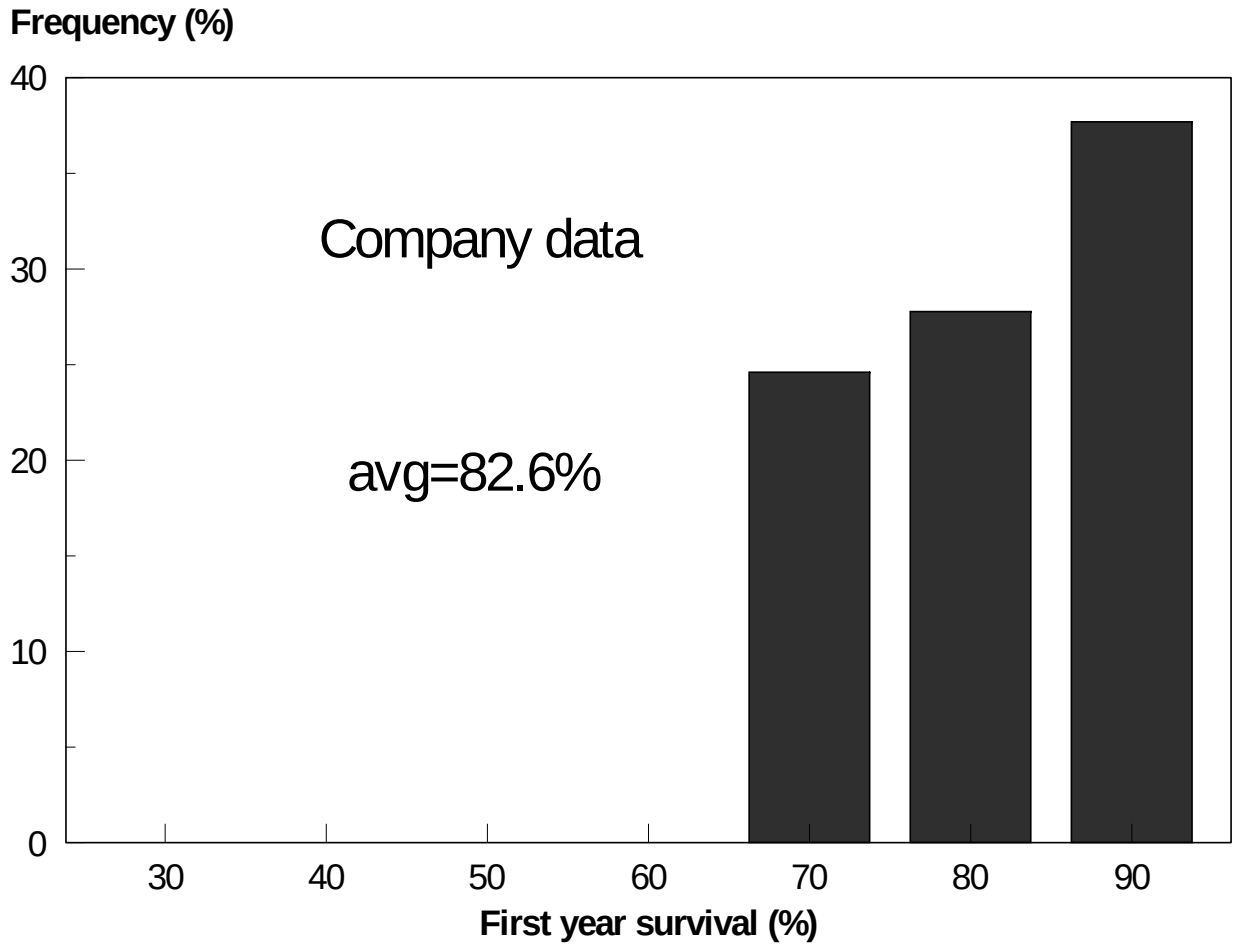
In 1978, members of the Forest Management Committees of APA's two southern technical divisions expressed concern about pine plantation survival, particularly in the first year following planting. The southern technical divisions' Policy Committees established a Southwide Pine Plantation Survival Committee to survey the forest industry and state forestry agencies and determine the scope of the perceived survival decline. The Policy Committees charged the committee with conducting a survey to determine if there was a pine plantation survival problem in the South. The committee tried to determine broad rather than specific problem areas of survival decline. Working with the Forest Management Committees, Policy Committees, and the Southern Industrial Forestry Research Council, the committee conducted a detailed survey of industry planting practices and industry and state nursery practices in late 1979. Data were analyzed by scientists at Mississippi State University's Department of Forestry.

Plantation survival problems have been documented well into the rotation age (Williston, 1980). Our survey definitely suggests early survival problems in pine plantations across the South. These problems have intensified as regeneration operation aspects have changed over time. We feel plantation survival is now more related to management problems than to biological problems. Planting and nursery practices which appear to have an influence on plantation survival are highlighted and examined.

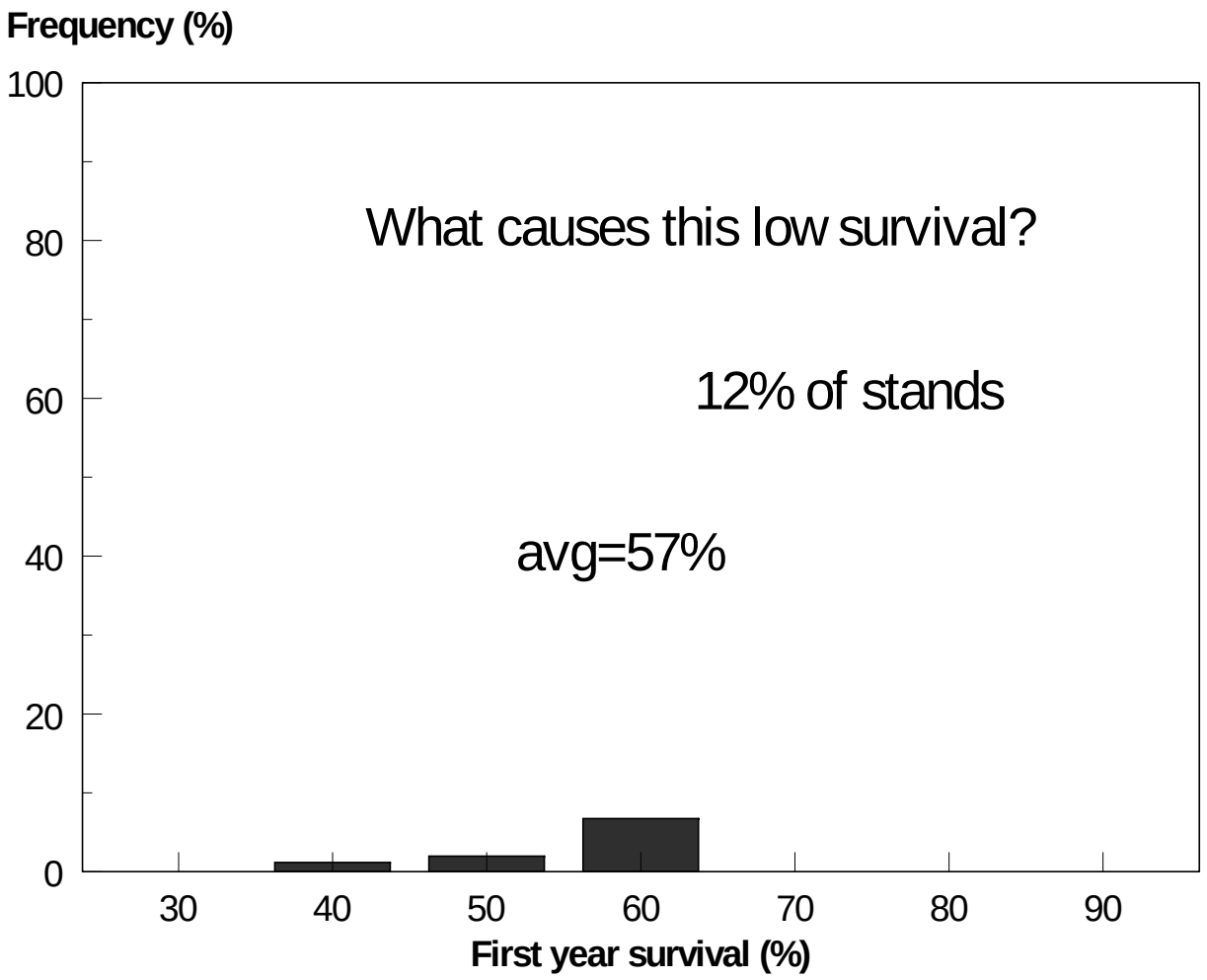
2004


Frequency (%)
40
30
20
10
0
Company data
avg=79.7%
30
40
50
60
70
80
90
First year survival (%)

2004


Frequency (%)
40
30
20
10
0
Company data
avg=82.6%
30
40
50
60
70
80
90
First year survival (%)

2004


Frequency (%)
100
80
60
40
20
0
What causes this low survival?
12% of stands
avg=57%
30
40
50
60
70
80
90
First year survival (%)

What causes unexpected mortality?

- Freeze injury?
- Hand planting practices (poor supervision)?
- Planting anaerobic roots?
- Not planting roots deep?
- Planting tall seedlings?
- Machine lifting
- Cool storage?
- Planting half-sib families ?

Sources of failure

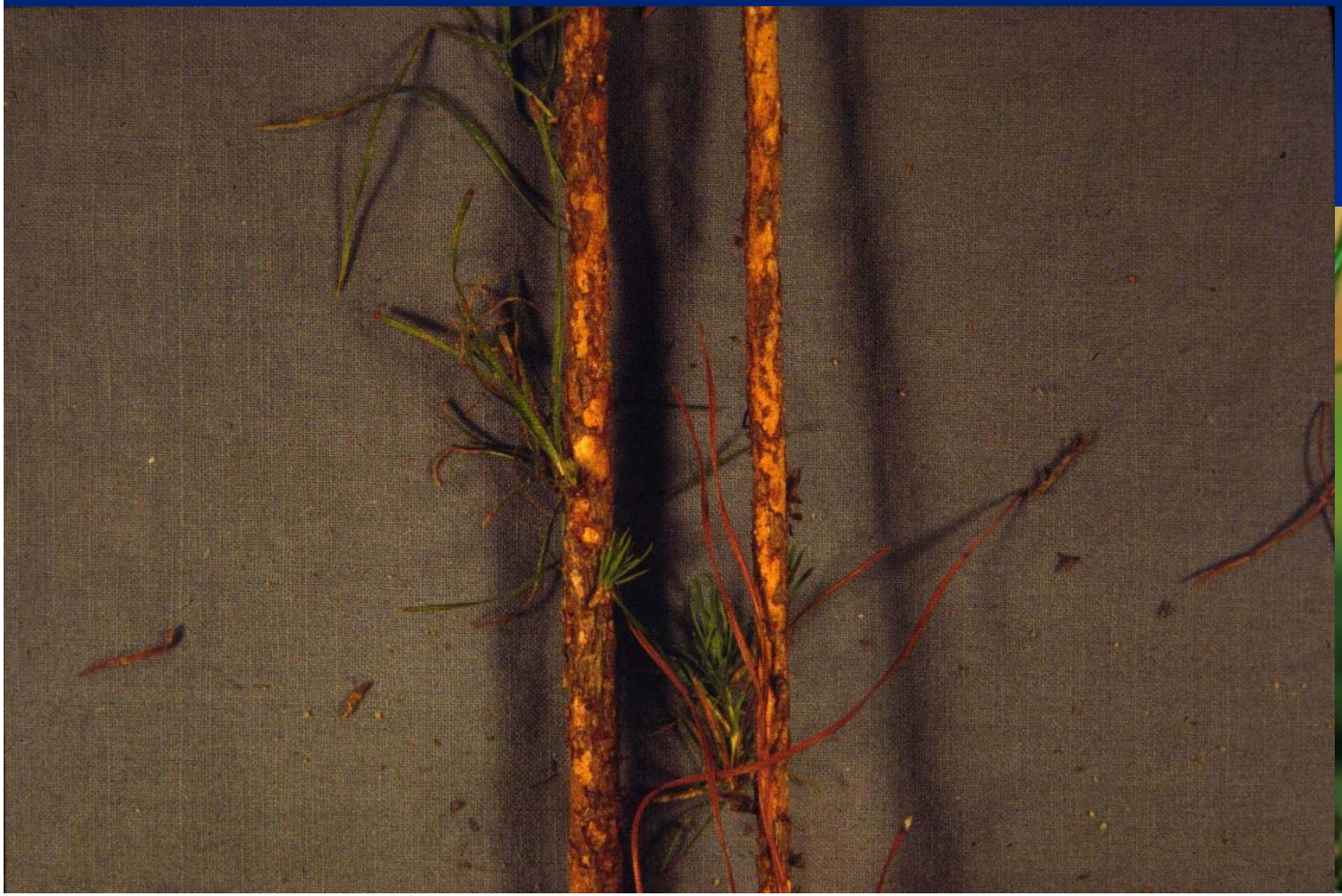
- Nursery
- Genetics
- Planting crew
- Storage
- Weather
- Post-planting treatments
- Animals
- Fire

Planting failures can be classified into two groups:

(1) obvious clues do not require an expert

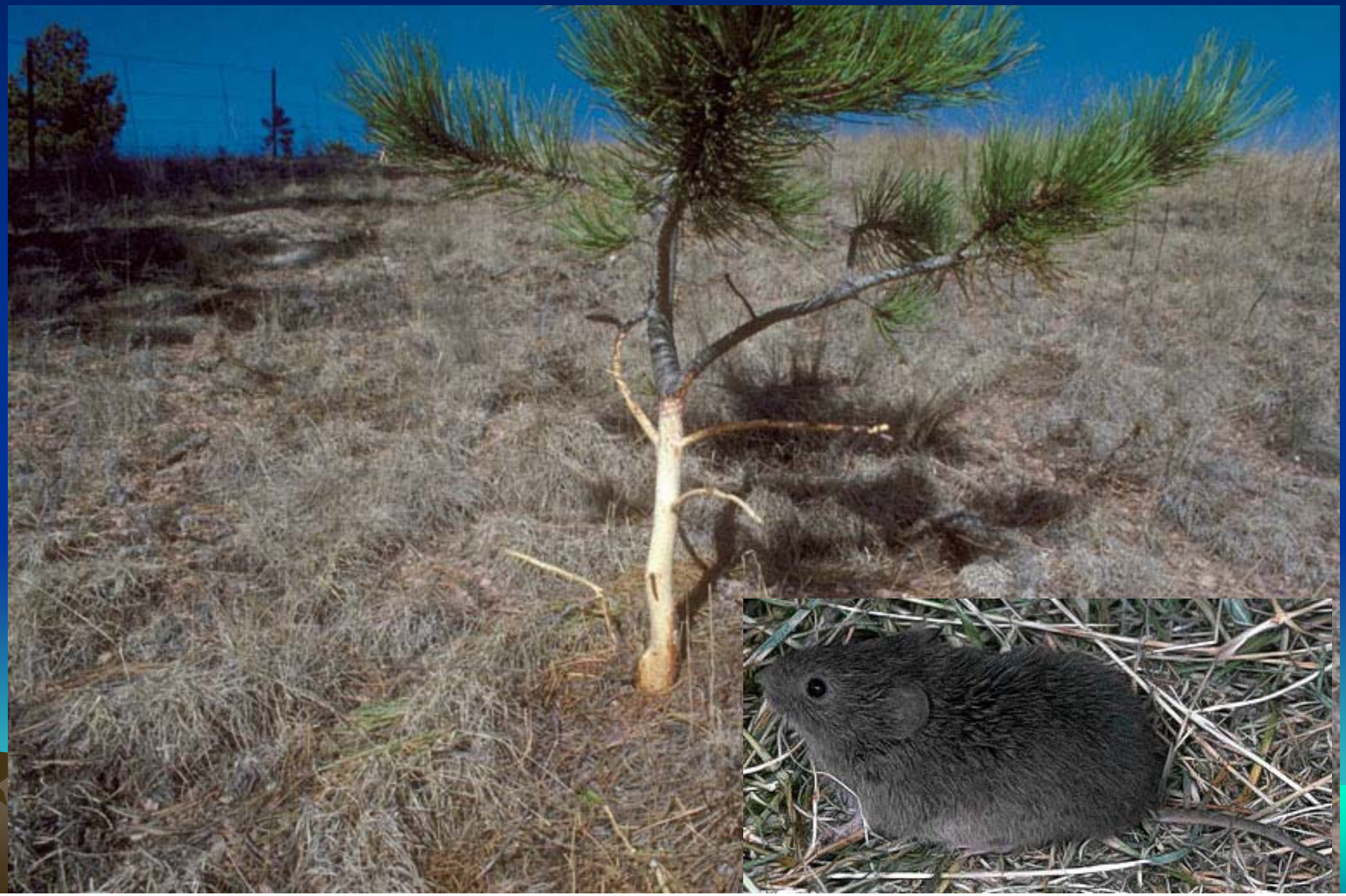
Easy clue

Easy clue



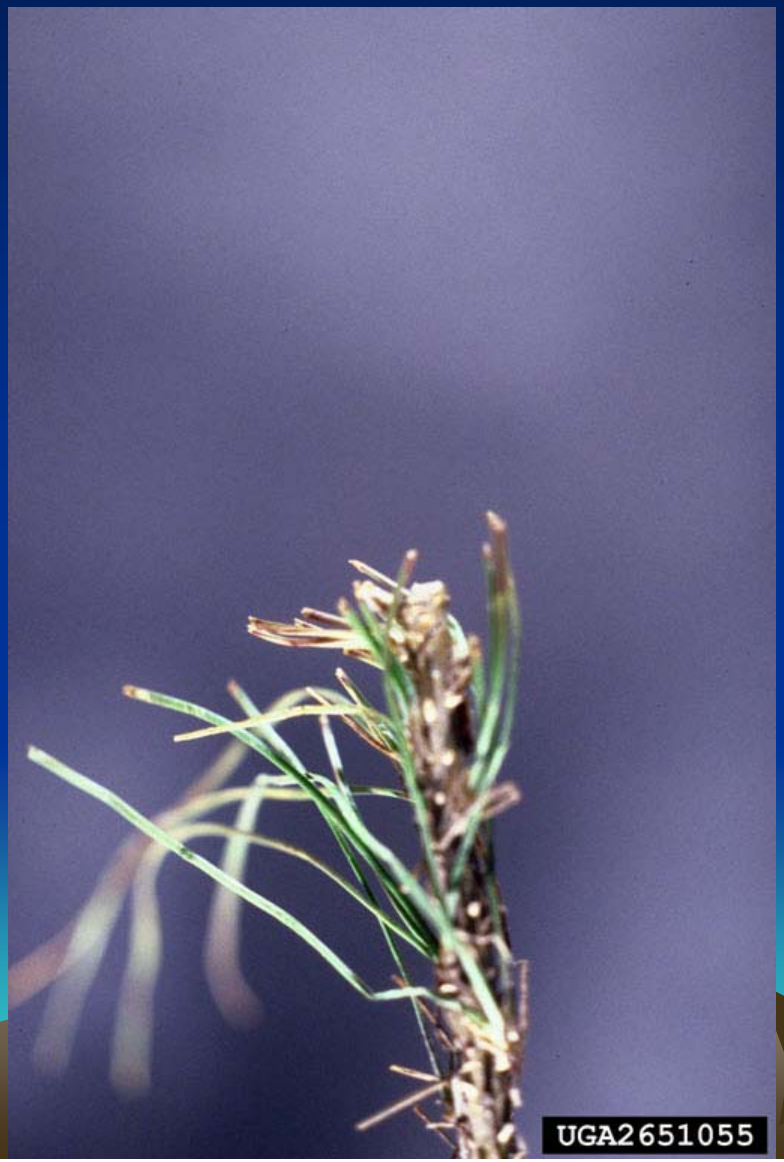
Easy clue

Easy clue



Easy clue

Easy clue

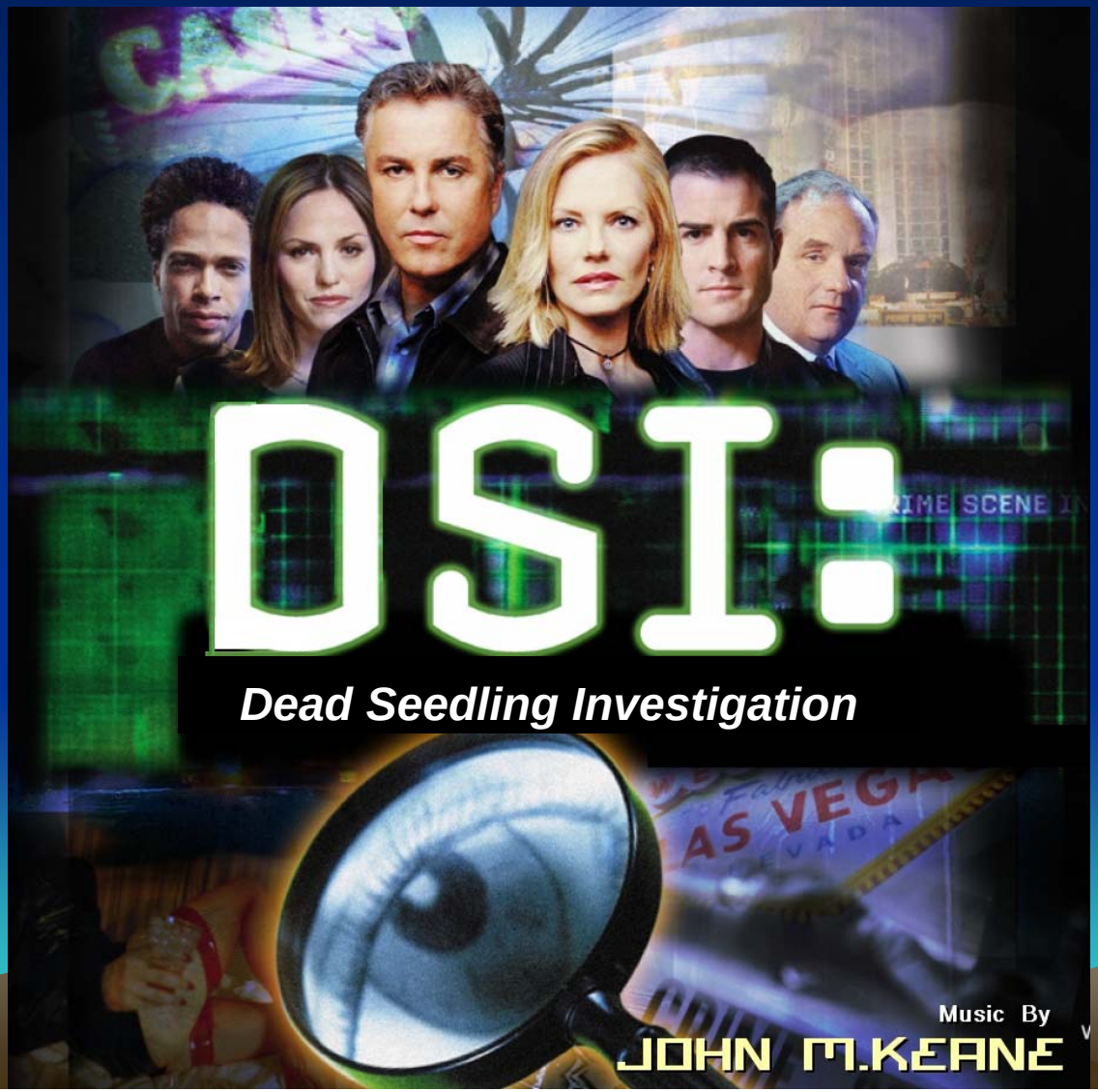


Easy clues

- Fire killed seedling
- Vole killed seedling
- Weevil killed seedling
- Rabbit killed seedling
- Cattle killed seedling
- Deer killed seedling
- Tree planter killed seedling

(2) Not so obvious clues require a DSI team

(2) Some failures require a Dead Seedling Investigation

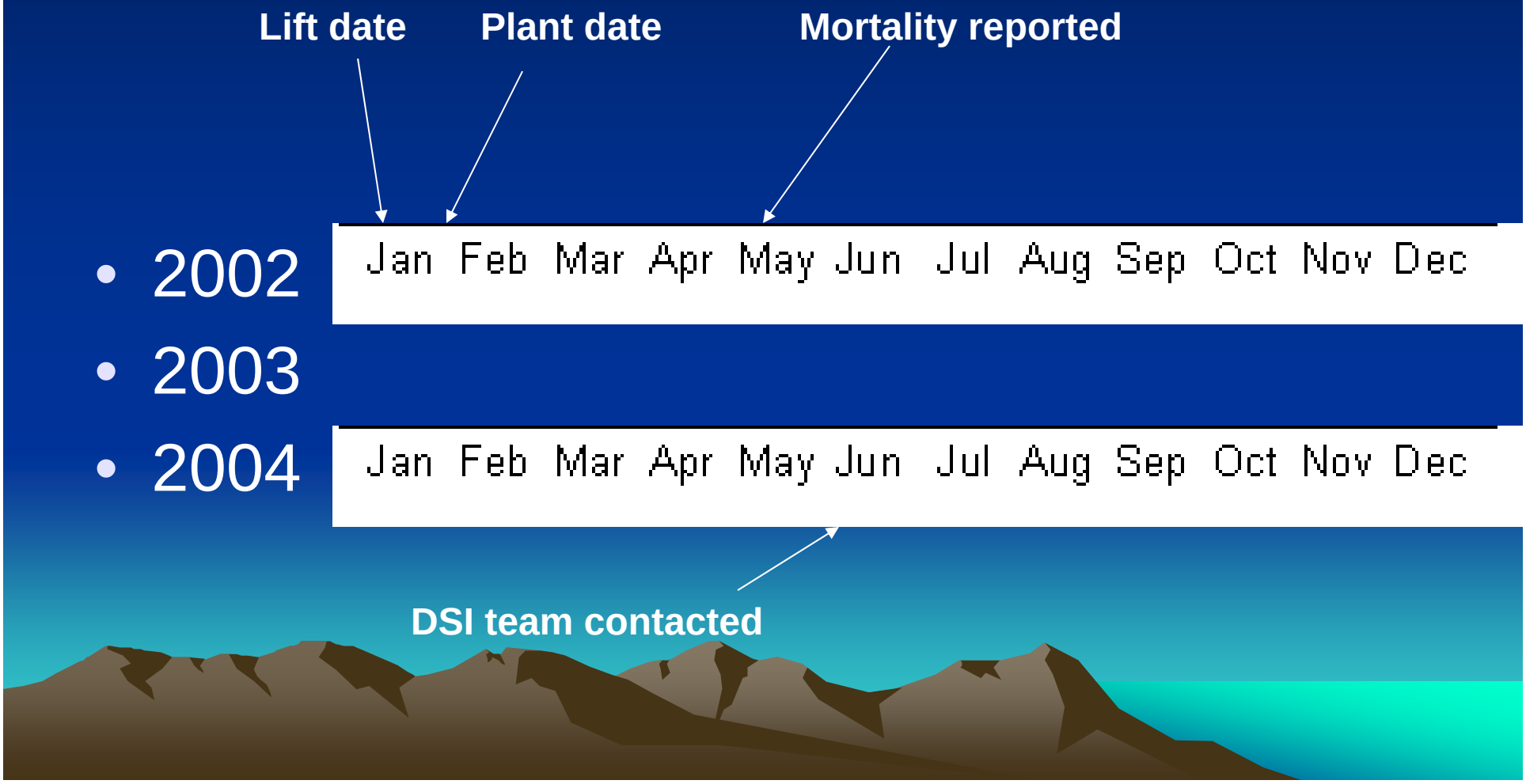


When clues to seedling death are not obvious… do not waste time and get the DSI team to the scene quickly!!!

Forensic evidence fades rapidly

Witnesses memory fades rapidly

Case # 2583


Lift date
Plant date
Mortality reported
2002
2003
2004
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
DSI team contacted

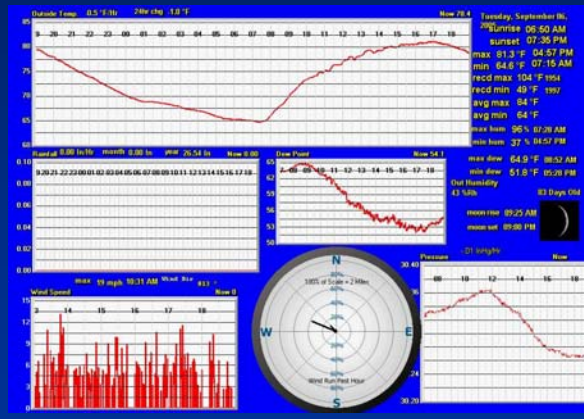
In addition to on-site evidence, the DSI team needs good records to adequately diagnose plantation failure

- Weather records
- Nursery records
- Storage records
- Planting records

The goal of the DSI team is to find enough clues to determine what factor(s) caused the “death”

Nursery

Storage



Transportation

Tree Planter

Contractor

Develop a timeline

- **Dec. 9:** Jill is the nursery manager. Sometime between 8:45 and 8:55 a.m. the seedlings in question were lifted with an 8-row belt lifter. Seedlings were packed in boxes and stored overnight in a cooler (2 degrees C).
- **Dec. 10:** Joe came with an open pick-up and loaded 10 boxes in the open bed. Seedlings were transported to the planting site and unloaded about noon.
- **Dec. 11:** Hand planters arrived about 8 AM and began sorting and pruning roots. Each planter planted about 3,000 trees per day. A portion of the field was machine planted.
- **May. 12:** The landowner visited the site and found many dead seedlings. He called the consultant and wanted to know why the trees died.
- **May. 19:** The consultant phoned the nursery to complain about selling dead seedlings. After much finger pointing, it was decided to call in the DSI team.

Interview witnesses

- **Nursery Manager:** The manager supplied weather records, cooler temperature records, and the seed lot number. She indicated the half-sib family was from the Coastal Plain but she did not know either the GPS location or the hardiness zone. She supplied landowner names who picked up seedlings the same day.
- **Joe** was interviewed but could not remember much about what he did on Dec. 10. He said he does have a temp indicator in his pick-up but made no record during transportation. He did remember stopping in town for lunch before delivering the trees.
- **Crew Boss:** When asked about planting conditions on Dec. 11, he could not remember but he did say the trees looked a little off-color (they had bronze-purple needle tips). When asked about pruning, he said "We prune the roots in order to fit the planting hole." He said they prune roots to avoid having J-roots. When asked about depth of planting he said it varies but to avoid j-roots, they plant the root-collar at groundline. When asked for planting records, he said we know the number of bags each planter planted that day.
- **Landowner:** The landowner visited the site on May 12 and was upset with the number of dead trees. He immediately called the consultant and asked why the trees died. He called the consultant and wanted to know why the trees died.
- **Consultant:** The consultant did not conduct a planting quality survey. He said he met with the landowner in May and visited the site.

Visit site

- **May 29:** The DSI team visited the site and surveyed the mortality. The “sorting deck” was located and many pruned roots were found in piles on the ground. The DSI team found that survival of hand planted trees was about 48% while that of machine planted seedlings was 95%. The Team asked the consultant to supply data from the “planting quality survey” but this data did not exist. The DSI team measured the RCD and planting depth of alive and dead seedlings. A number of dying seedlings were sent to the lab for microbial analysis. Roots were excavated and examined for freeze injury, root mass and white root tips.

Obtain weather records

- **Daily low temperatures**
- **Daily high temperatures**
- **Rainfall records (starting from Oct 1).**
- **Wind speed**

Obtain nursery records

- **Seed lot number (family lot or mixed lot)**
- **Provenance**
- **Sowing density**
- **Fertilization records**
- **Irrigation pH**
- **Herbicide-fungicide-insecticide records**
- **Top-pruning dates**
- **Lifting date**
- **Machine lifting speed/2-row lifter?**
- **Root washing treatment?**
- **Time between lifting and packing**
- **Cooler temperature records**
- **Gas powered fork-lift?**
- **Pathology reports**
- **Shipping date**
- **Seedling morphology data (RCD… height… etc.)**
- **Weekly Seedling quality checks (outplanting)**

Obtain transportation records

- **Date and time seedlings left nursery**
- **Trailer type (refer, flatbed)**
- **Packing condition**
- **Temperature records during transportation**
- **Date and time seedlings arrived at planting site**

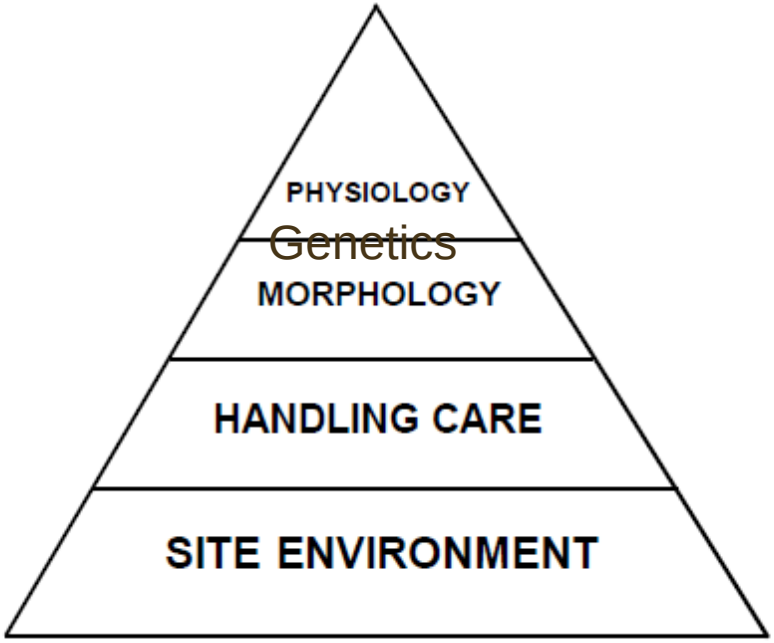
Obtain planting records

- **Date and time seedling arrived on site**
- **Seedling storage on site**
- **Seedling counts made on site?**
- **Seedling roots pruned on site?**
- **Roots stripped before planting?**
- **Planting depth**
- **Loose soil packing**
- **Beds firmed?**
- **Planting tool**
- **Machine planting**
- **Planter speed**
- **Soil moisture levels**

Obtain establishment records

- **Dates and method of site preparation**
- **Level of weed competition**
- **Herbicide rates and dates**
- **Fertilization rates and method of application**

Figure 2. A generalized model illustrating the relative importance of four factors affecting survival of transplanted pine seedlings. Any one factor can be the major cause of failure in a particular event.

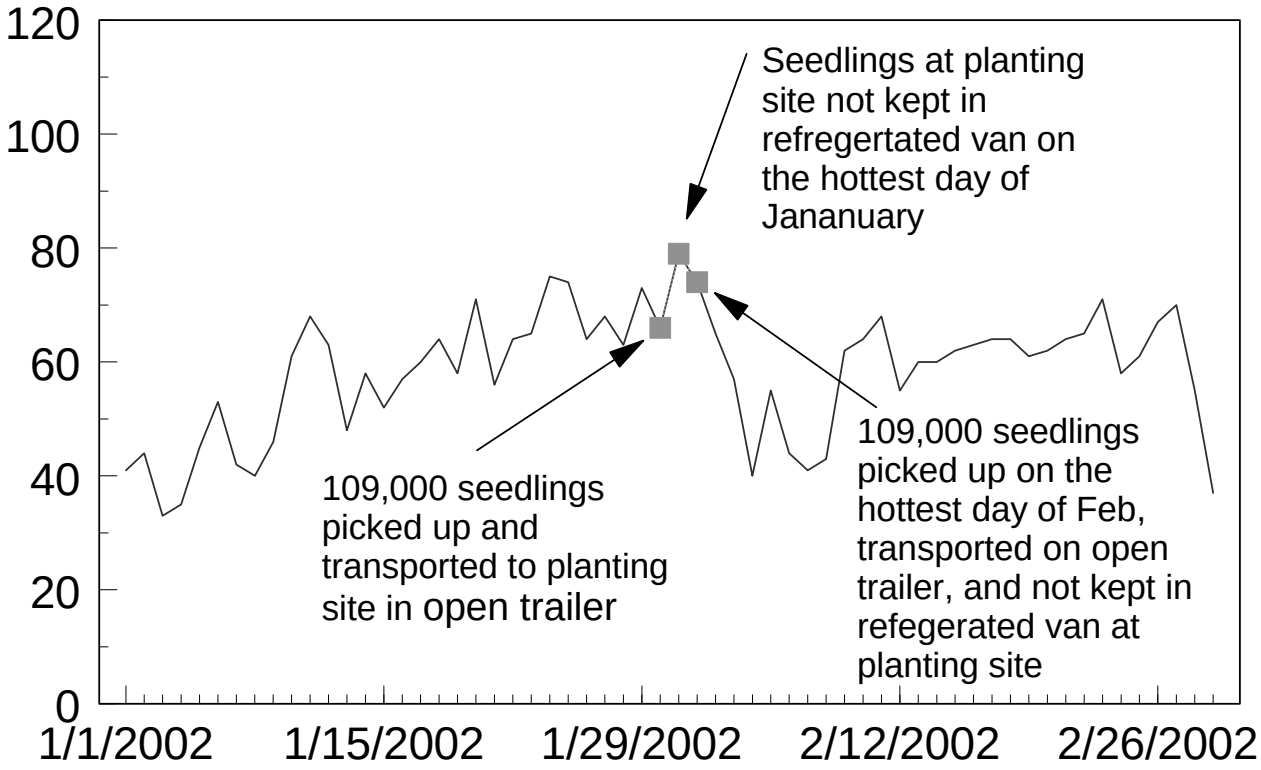


Synthesize data and prepare the report

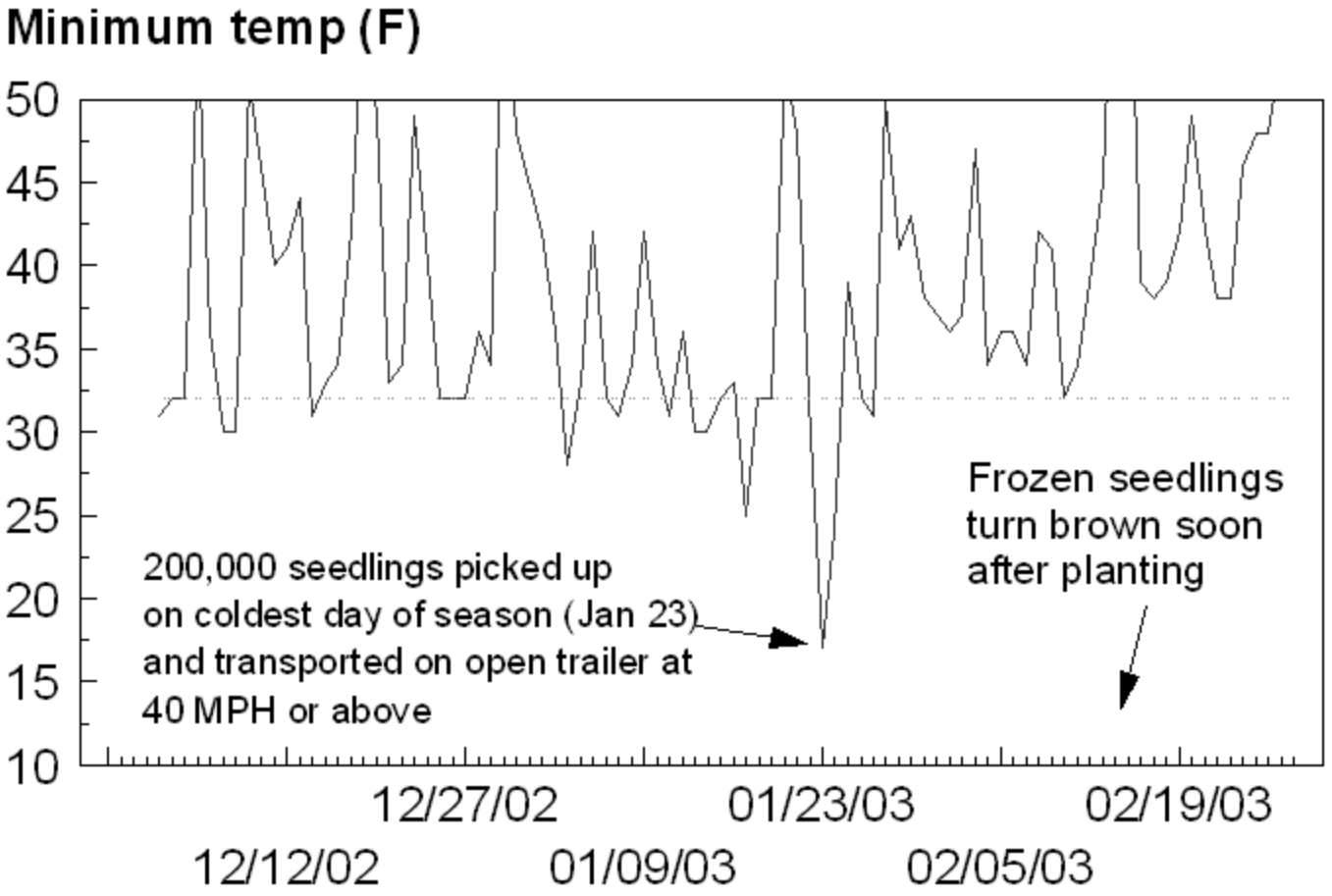
Why did this container-grown seedling die?

Transporting and storing seedings in 2002

Maximum temp (F) - Fairhope



Transporting seedings in 2003



SE Georgia - Homerville

Site location – SE GA

- Slash pine

  Machine planted October 1991

  Single bedded

  Imazapyr applied in late March, 1992

  Planting depth (RC 5” below ground)

  Survival 54%

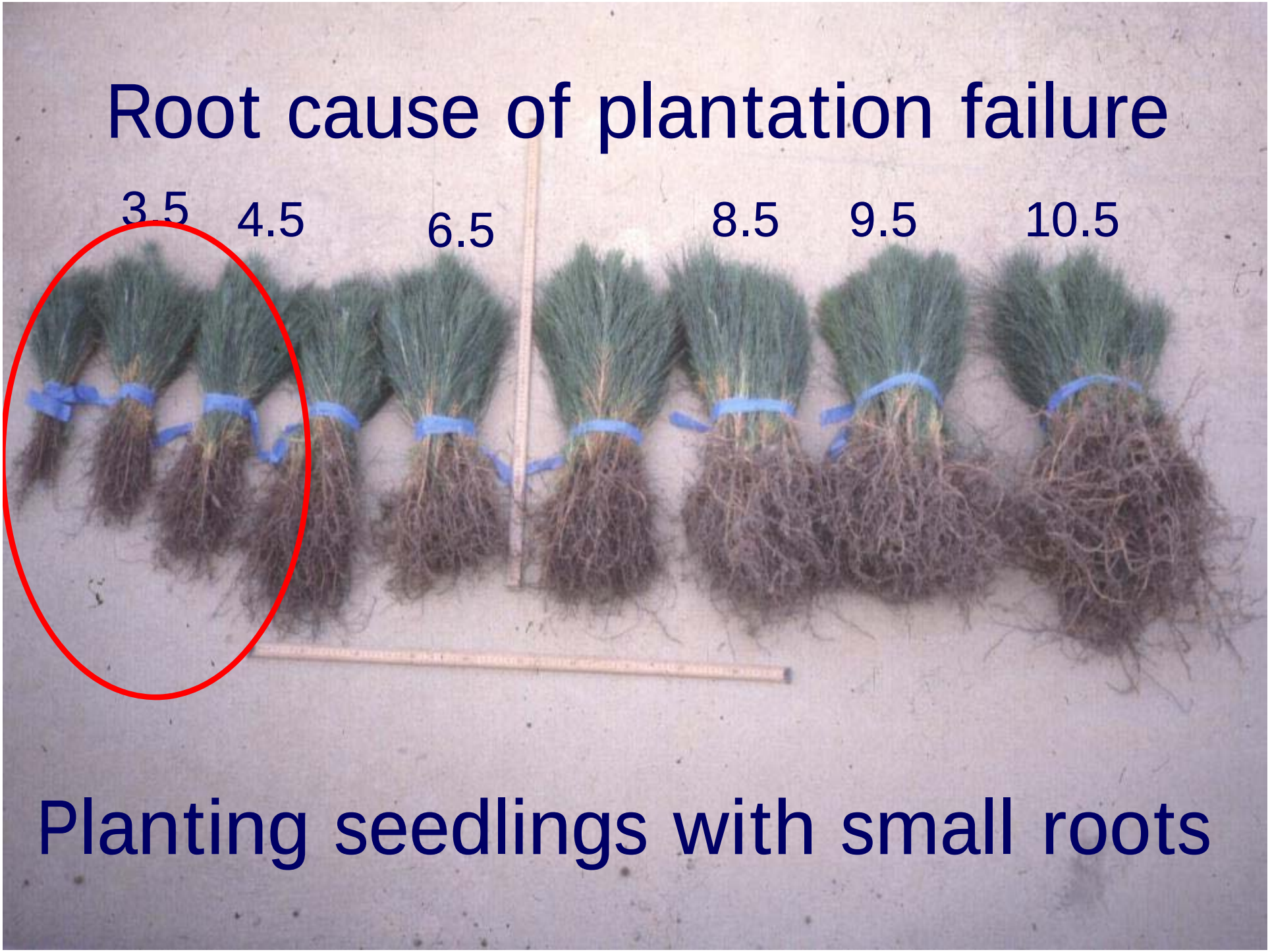
Site location – SE GA

- Slash pine
- Machine planted October 1991
  Single bedded
  Imazypyr applied in late March, 1992
  Planting depth (RC 5” below ground)

  Survival 54% = 3.5 mm seedlings
  94% = 9.5 mm seedlings


Root Collar Diameter
3.5
4.5
6.5
8.5
9.5
10.5

Root cause of plantation failure



Planting seedlings with small roots

Site location – S AL

- Longleaf pine (bareroot)

  Hand planted March 1997

  Metsulfuron (1 oz/acre) applied May 20

  Survival 27%

Site location – S AL

- Longleaf pine (bareroot)

  Hand planted March 1997

  Metsulfuron (1 oz/acre) applied May 20

  Survival 27%

  Survival 83% - no herbicide

Freeze injury to southern pine seedlings

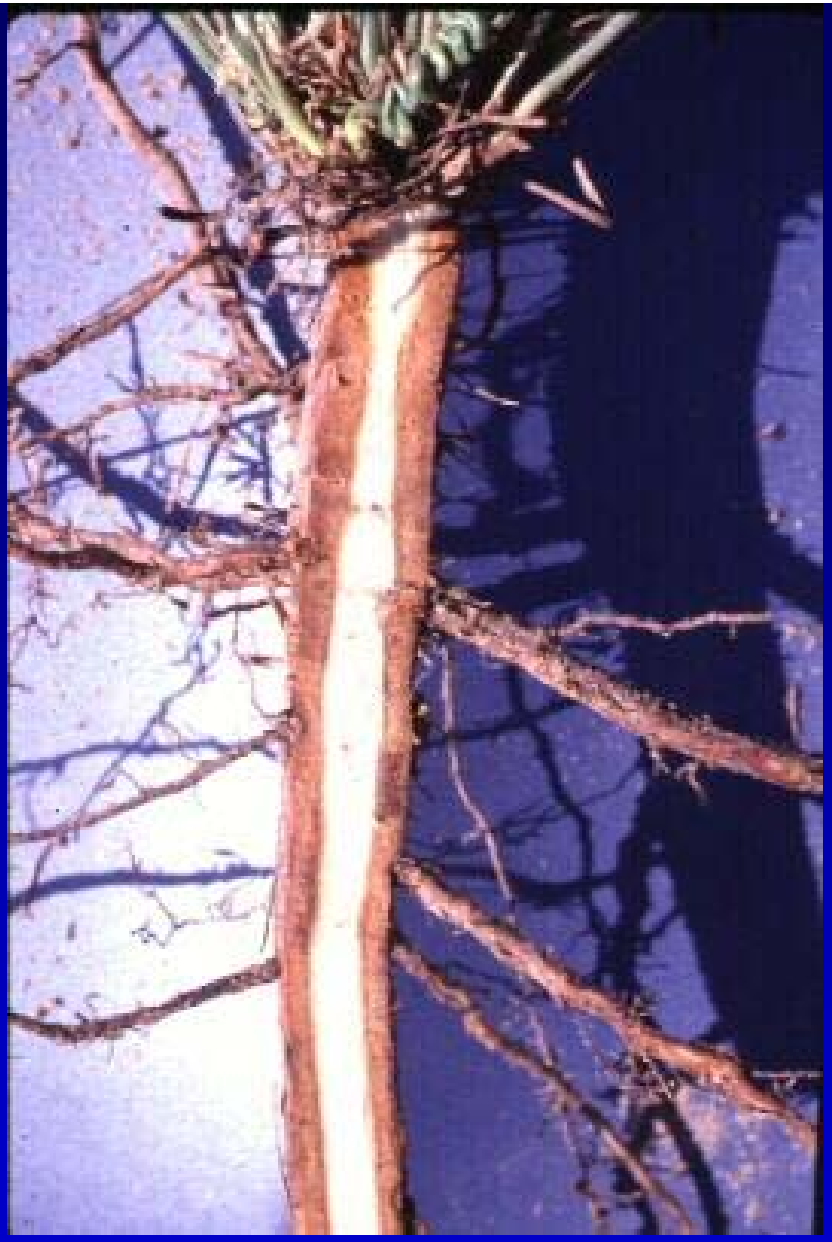
David B. South

Auburn University

AU Southern Forest Nursery Management Cooperative

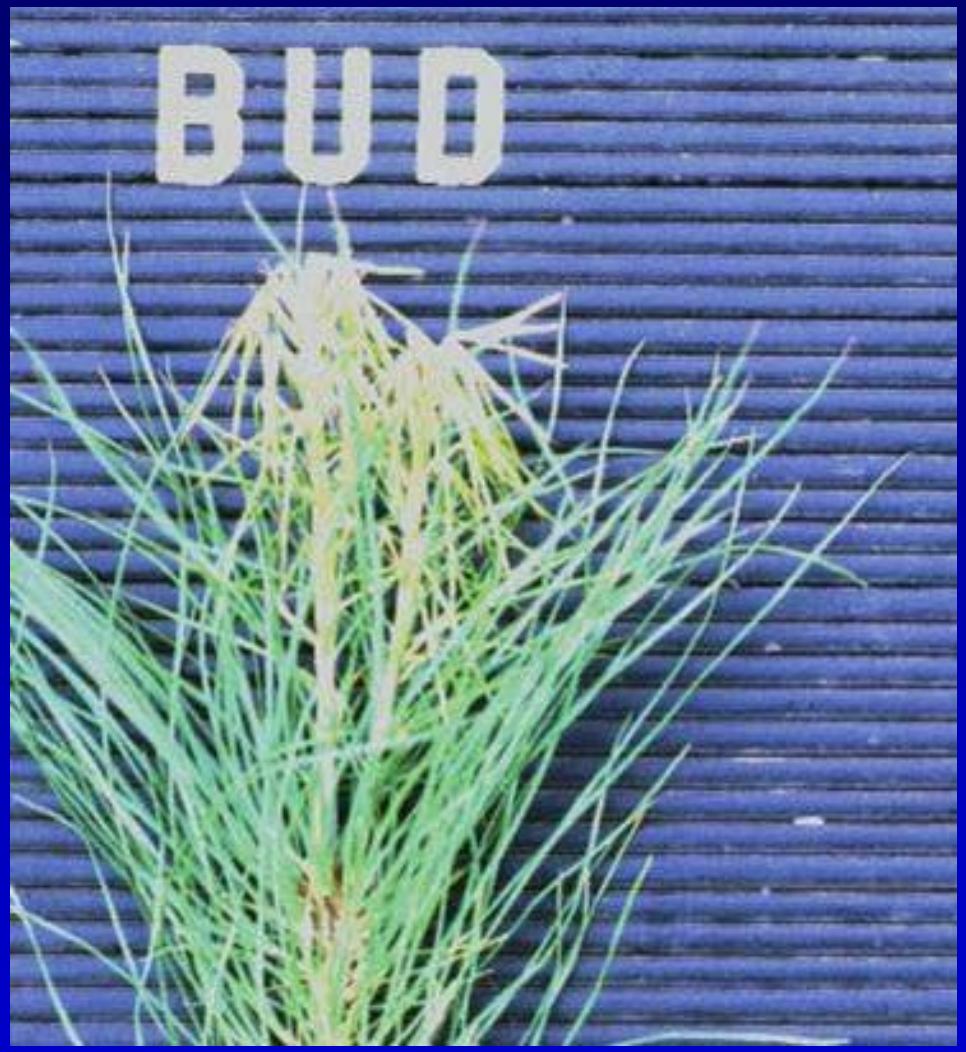
Four types of freeze injury

- Injury to root systems
  (roots more sensitive to freeze than shoots)
- Injury to succulent foliage
- Frost heaving
- Winter desiccation



Injury to roots

19 F – November 5, 1991



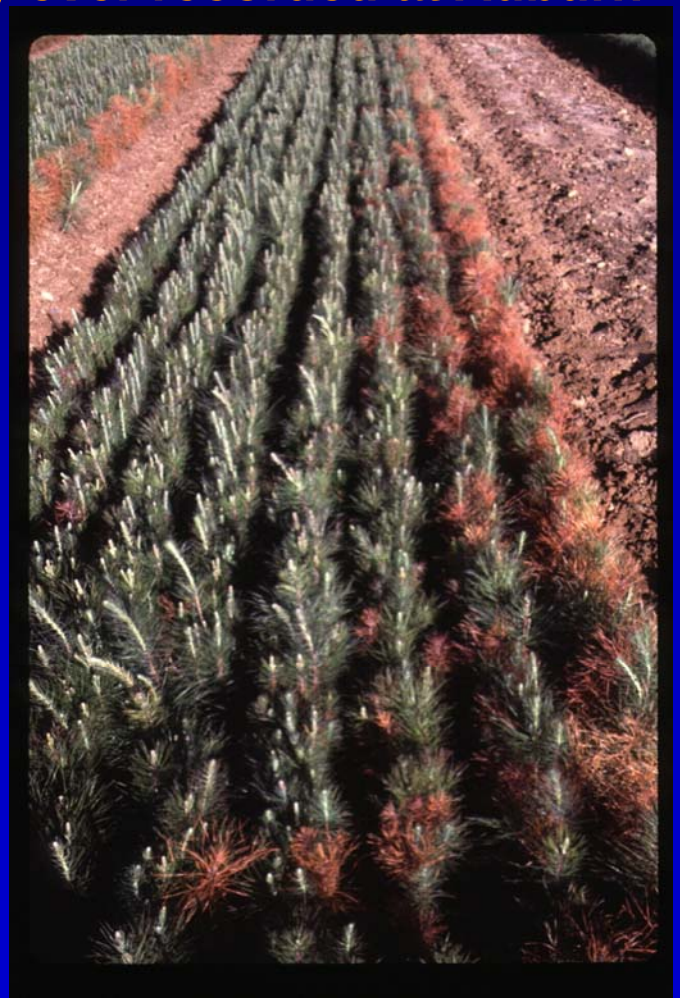
Injury to succulent foliage

Winter desiccation

Frost damage in Christmas 1983 devastated pine seedling crops in Alabama and Georgia.

Records we set for the coldest December day ever recorded at Auburn Alabama.

(5°F. on December 25th beat the old record)



Frost damage in 2004 affected pine seedling roots throughout the South.

Record warm temperatures were set for the first week of January.

In some places, it was 73°F. on January 5th and then dropped to

21 F on January 7th.)

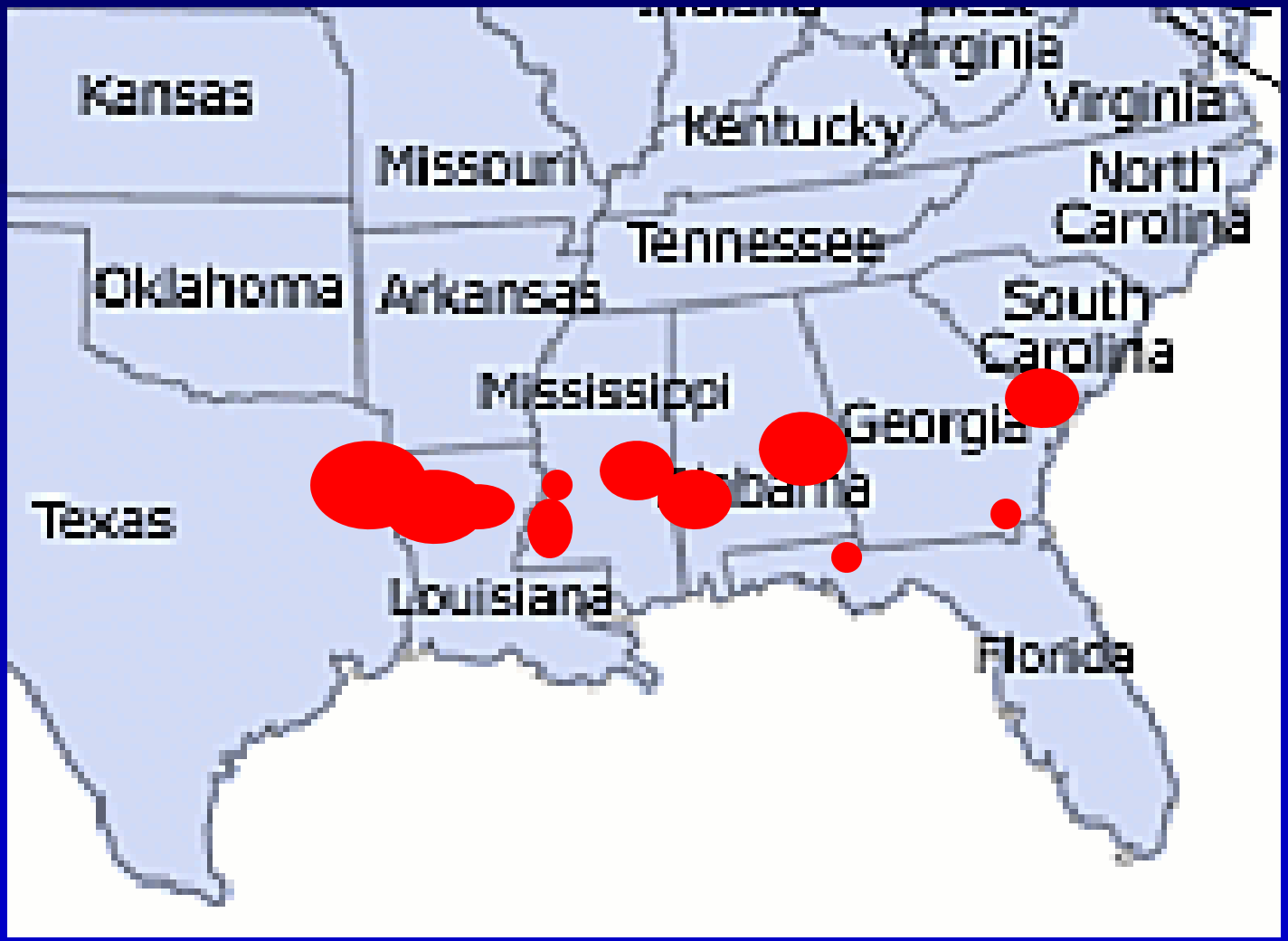
Date	Temperature (°F)		
	high	avg	low
January			
4	73	66	59
5	68	58	44
6	44	40	33
7	41	31	21
8	37	30	24
9	42	38	35
10	37	35	33

Many newly planted seedlings were “mysteriously” dead or brown by April 2004.

The 2003-04 freeze

Location	Date	F (5 ft)
Auburn, AL	Jan 7, 2004	18 º
Shreveport, LA	Jan 7, 2004	21 º
Meridian, MS	Jan 7, 2004	21 º
Ft. Valley, GA	Jan 7, 2004	21 º
Florence, SC	Jan 11, 2004	17 º

Temperatures in frost pockets may be 10 º F lower than above.



Injury occurred from TX to SC

16 F – January 7, 2004

Injury to roots

Symptoms of root injury

- Lack of new root growth
- Lack of shoot growth
- “Thumb nail test”
  Injured tissue in roots range in color from red, orange, purple and brown.

Note: root injury is often overlooked in the field

Reasons for the mortality in 2004

- Deacclimation of roots due to very warm temperatures in early January
- Rapid freeze event (40º F drop in 48 h)
- Winds (above 10 mph)
- Planting freeze sensitive families (i.e. South-Gulf Coastal sources)

Note: temperature at ground can be 2-3 º F lower than temperature at 5 feet.

Reasons for the mortality in 2004

- Roots do not go “dormant” in the winter
- “Acclimation” is not translocated to roots
- Root growth is regulated by soil temperature
- *Minimum* air temperatures before the freeze were above 60 º F – Maximum air temperatures were above 70 º F !!!

GENOTYPES

Sensitive to freeze injury

- Longleaf pine
- Slash pine
- Loblolly pine

Coastal plain sources (e.g. 7-56)

Freeze injury in 2007

Excessive Rain in the Fall Can Affect Physiology of Pine Seedlings

David South and Bill Carey
School of Forestry
Auburn University

Occurrences in US

- Wakeley (1954)
- Mississippi (Oak 1983)
- Georgia 1994 - Carey
- Alabama 1994 - Carey
- Alabama 1997 - Carey
- Alabama 1998 – Carey
- Louisiana 2006 - South

HISTORY

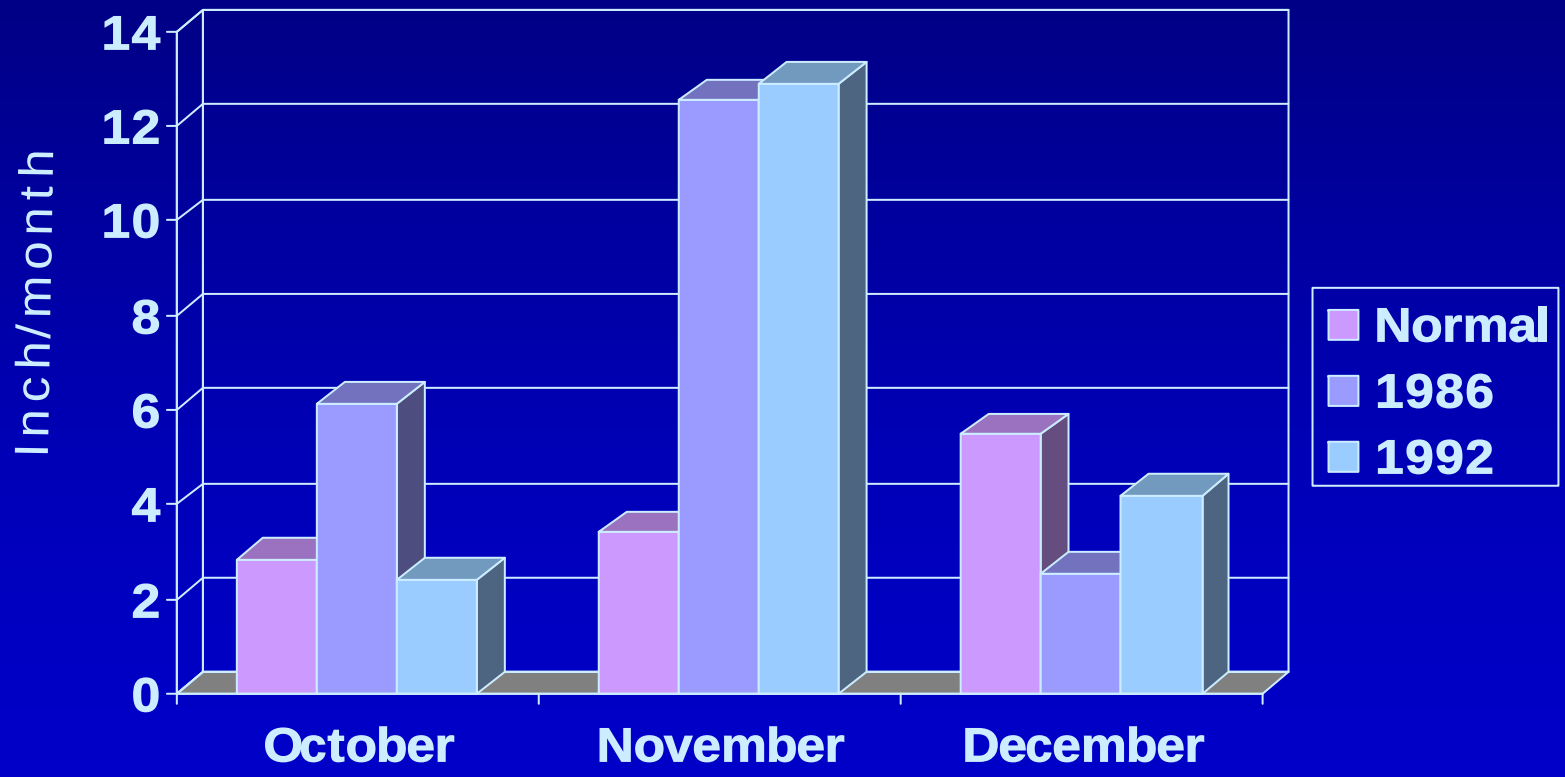
- In a year of extraordinary weather conditions, severe late fall or early winter drought might reduce survival; or *excessive fall rain* might reduce it by lowering the physiological quality of the nursery stock.

  Wakeley 1954

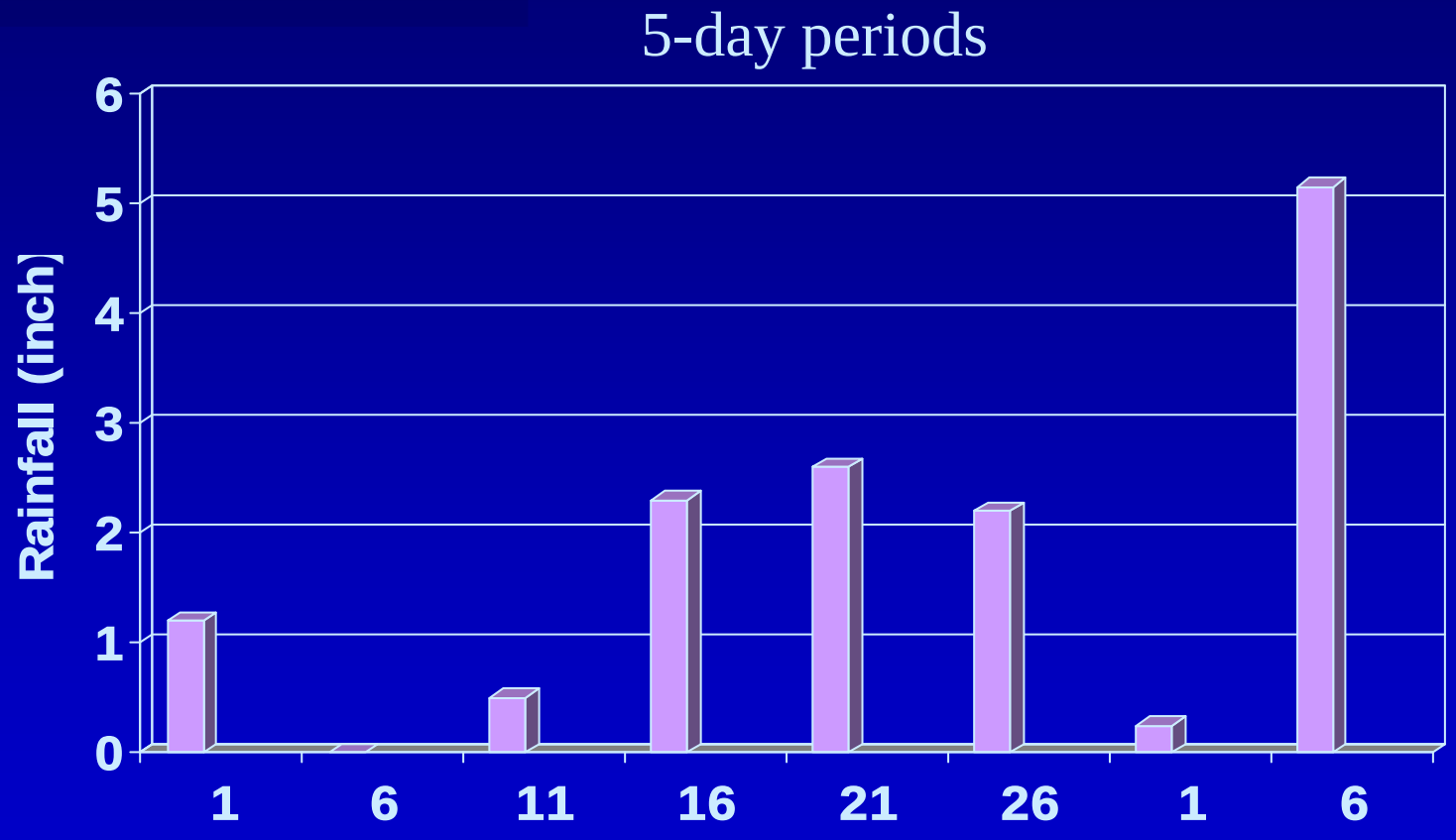
Pinus radiata

- Waterlogging in the nursery reduced mycorrhizal fungi of pine (Gadgil 1972)
- Waterlogging for 1 week cause no change
- 2 weeks purplish black root tips
- 4 weeks black root tips, brown mycorrhiza, and roots dark brown

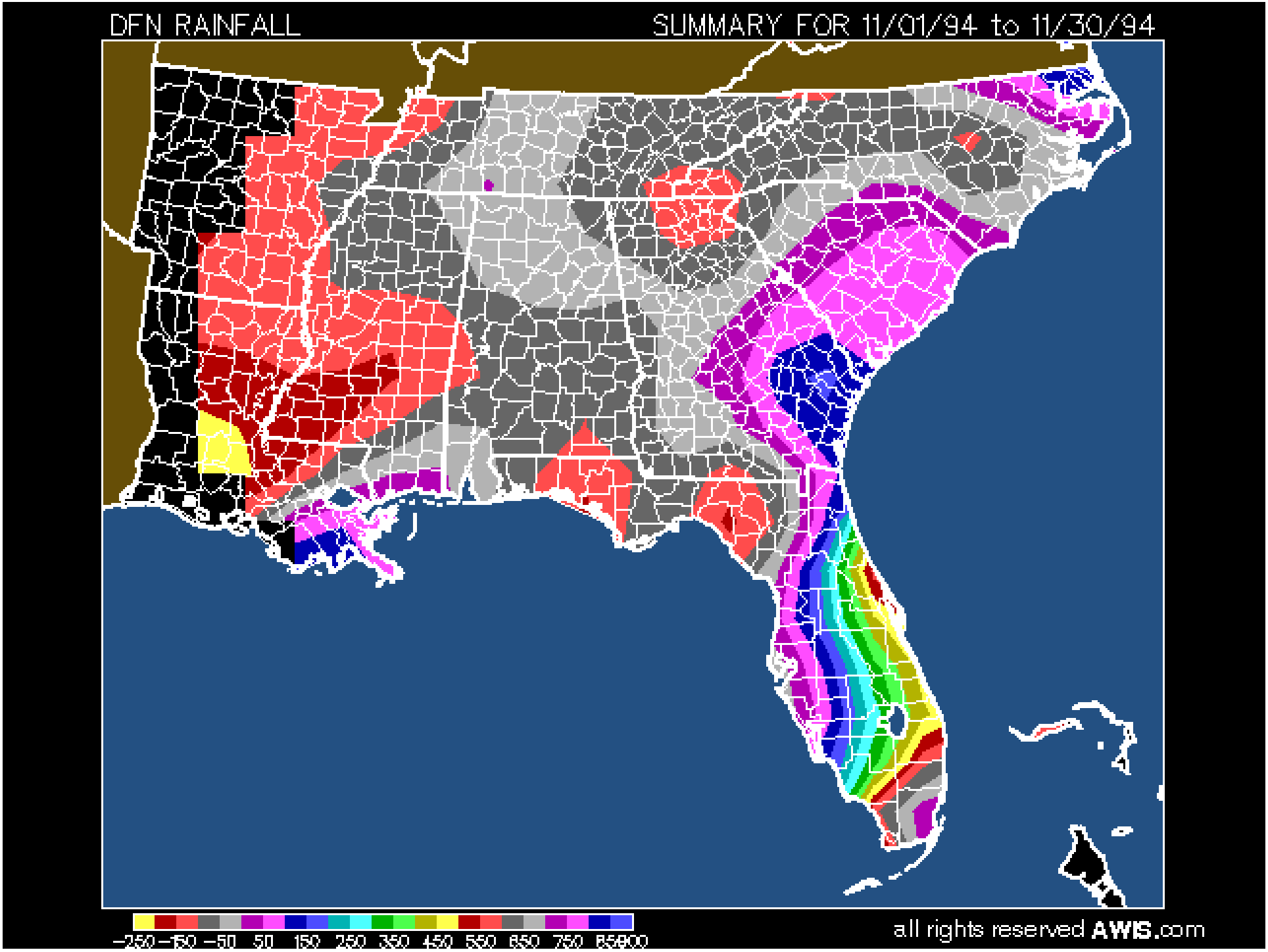
Monthly Precipitation

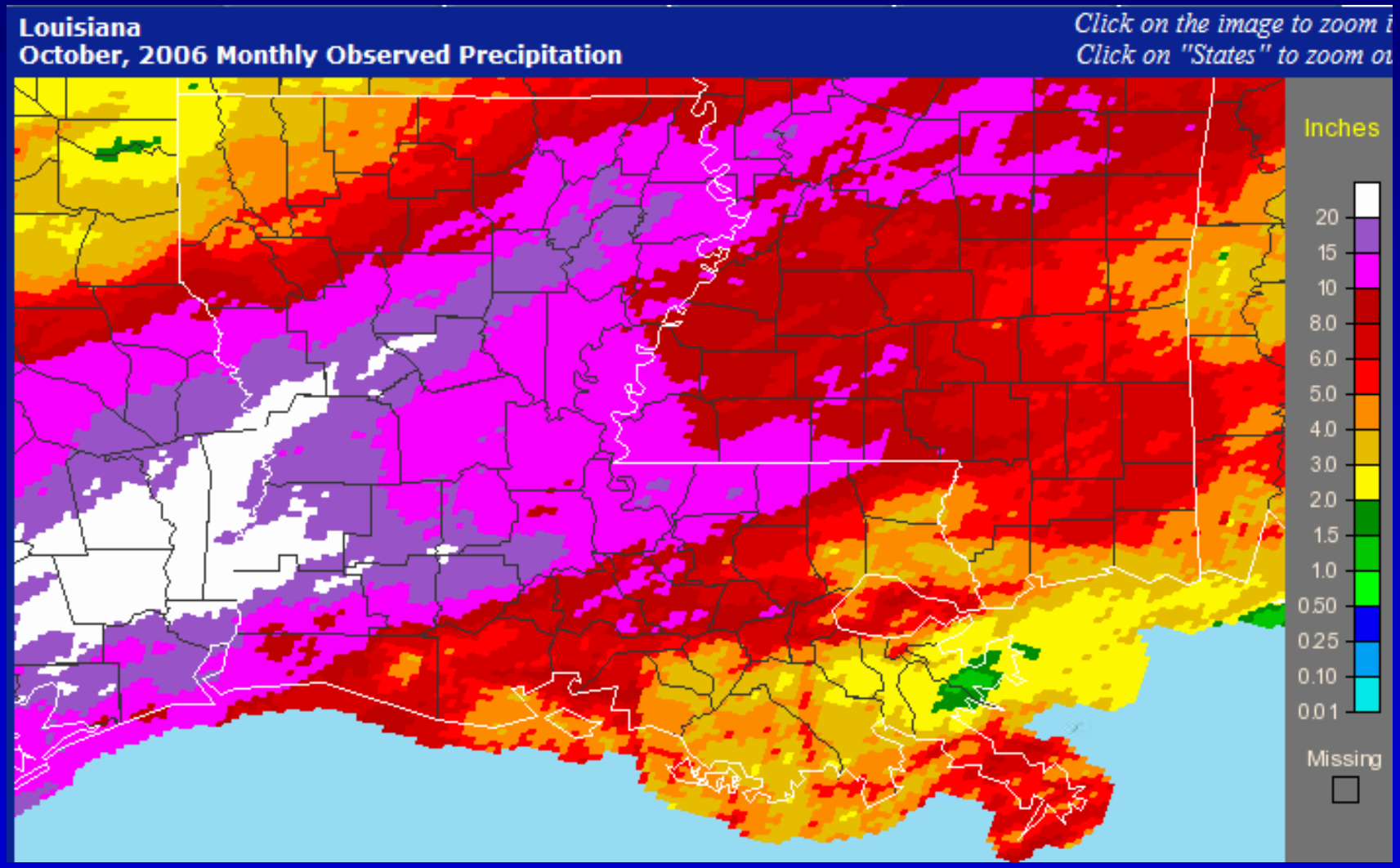


Precipitation - 1982



Lifting began on Dec. 9th


DFN RAINFALL
SUMMARY FOR 11/01/94 to 11/30/94
-250 -150 -50 50 150 250 350 450 550 650 750 850+
all rights reserved AWIS.com


Louisiana
October, 2006 Monthly Observed Precipitation
Click on the image to zoom i
Click on "States" to zoom ou
Inches
20
15
10
8.0
6.0
5.0
4.0
3.0
2.0
1.5
1.0
0.50
0.25
0.10
0.01
Missing

- Excessive rainfall in the fall can affect seedling physiology and mycorrhiza if soil oxygen levels are reduced for an extended period of time.
- Lifting seedlings just after a period of low soil oxygen could reduced survival.

Questions?

Site location – FL

- Loblolly pine
  Hand planted February 1979
  chop-burned bedded
  well drained soil
  Planting depth (??)

  Survival 51%

Site location – FL

- Loblolly pine
  Hand planted February 1979
  chop-burned bedded
  well drained soil
  Planting depth (??)

  Survival 51% 2-row machine lifter
  85% Hand lifted

Site location – Marion Co. AL

- Loblolly pine
  Hand planted April 1979
  inject and burn
  seedling size 5.3 mm (GLD)
  Velpar applied in June (1 lb. ai/ac)
  Planting depth (??)

  Survival 50%

Site location – Marion Co. AL

- Loblolly pine
  Hand planted April 1979
  inject and burn
  seedling size 5.3 mm (GLD)
  Velpar applied in June (1 lb. ai/ac)
  Planting depth (??)

  Survival 50% treated with Velpar June
  83% not treated with Velpar

Site location – Aiken, SC

- Loblolly pine

  Hand planted January 1981

  burned-shear-rake and windrowed

  Planting depth (??)

  Survival 47%

Site location – Aiken, SC

- Loblolly pine
  Hand planted January 1981
  burned-shear-rake and windrowed
  Planting depth (??)

  Survival 47% roots stripped by tree planter
  68% not root stripped

Site location – Athens, GA

- Loblolly pine

  Hand planted Dec 9, 1993

  roller-drum chopper

  Seedling size 4 mm @ root-collar

  Planting depth (??)

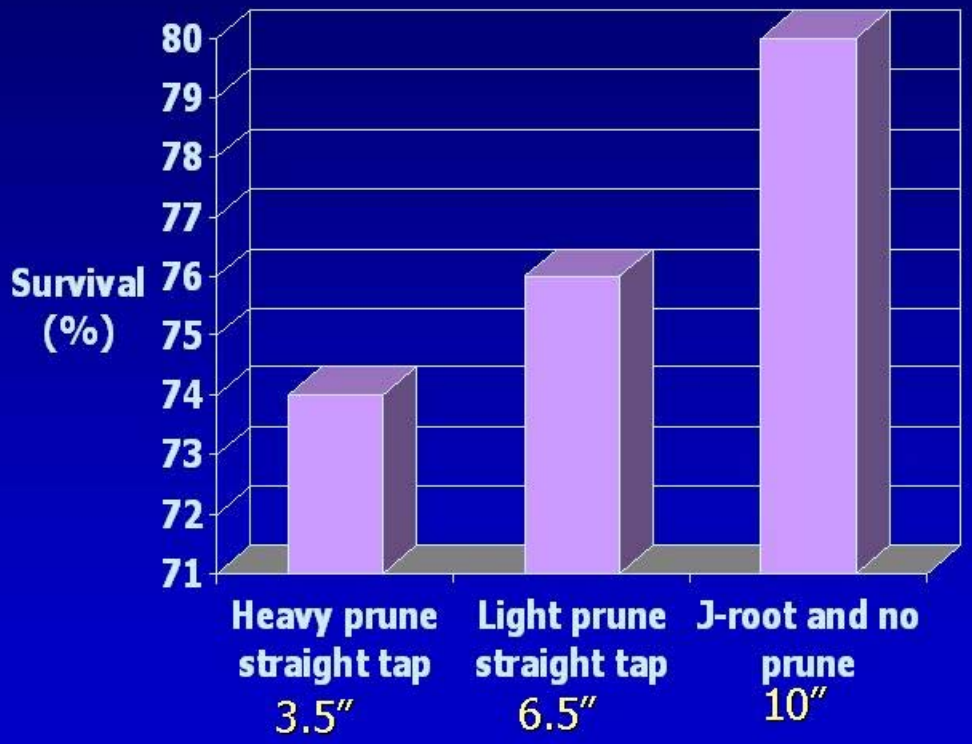
  Survival 74%

Site location – Athens, GA

- Loblolly pine
  Hand planted Dec 9, 1993
  roller-drum chopper
  Seedling size 4 mm @ root-collar
  Planting depth (??)

  Survival 74% roots pruned by tree planter
  87% no pruning (planted with shovel)

Hand planters like to prune roots in order to speed up the planting rate



435 TPA

	Heavy prune straight tap 3.5″	Light prune straight tap 6.5″	J-root and no prune 10″
Planting cost/acre	$17.80	$21.04	$22.82

Harrington and Howell (1998)

Note: most hand planters not paid by hour

Site location – VA

- Loblolly pine
  Hand planted Dec 13, 1984

  Planting depth (??)

  Survival 53%

Site location – VA

- Loblolly pine
  Hand planted Dec 13, 1984

  Planting depth (??)

  Survival 53% seedlings not top-pruned
  76% seedlings top-pruned

Site location – central, LA

- Loblolly pine
  Hand planted January 1977?

  Planting depth (??)

  Survival 38%

Site location – central, LA

- Loblolly pine
  Hand planted January 1977?

Planting depth (??)

Survival 38% Franklin Co. MS source
68% N. MS or NE Texas source

Site location – central, NC

- Loblolly pine
  Hand planted 1964

  Planting depth (??)

  Survival 58%

Site location – central, NC

- Loblolly pine
  Hand planted 1964

  Planting depth (??)

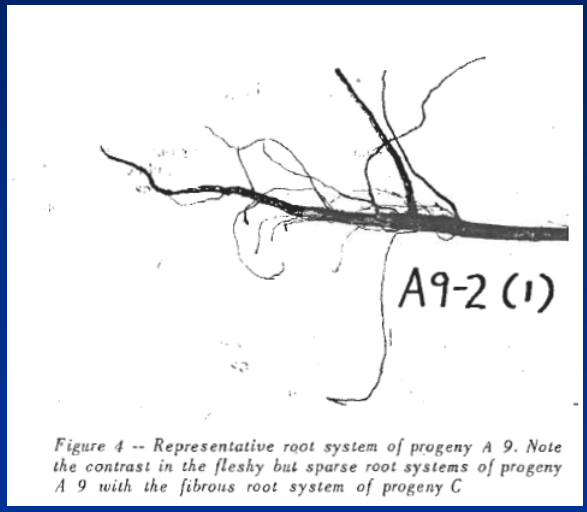


Figure 4 -- Representative root system of progeny A 9. Note the contrast in the fleshy but sparse root systems of progeny A 9 with the fibrous root system of progeny C

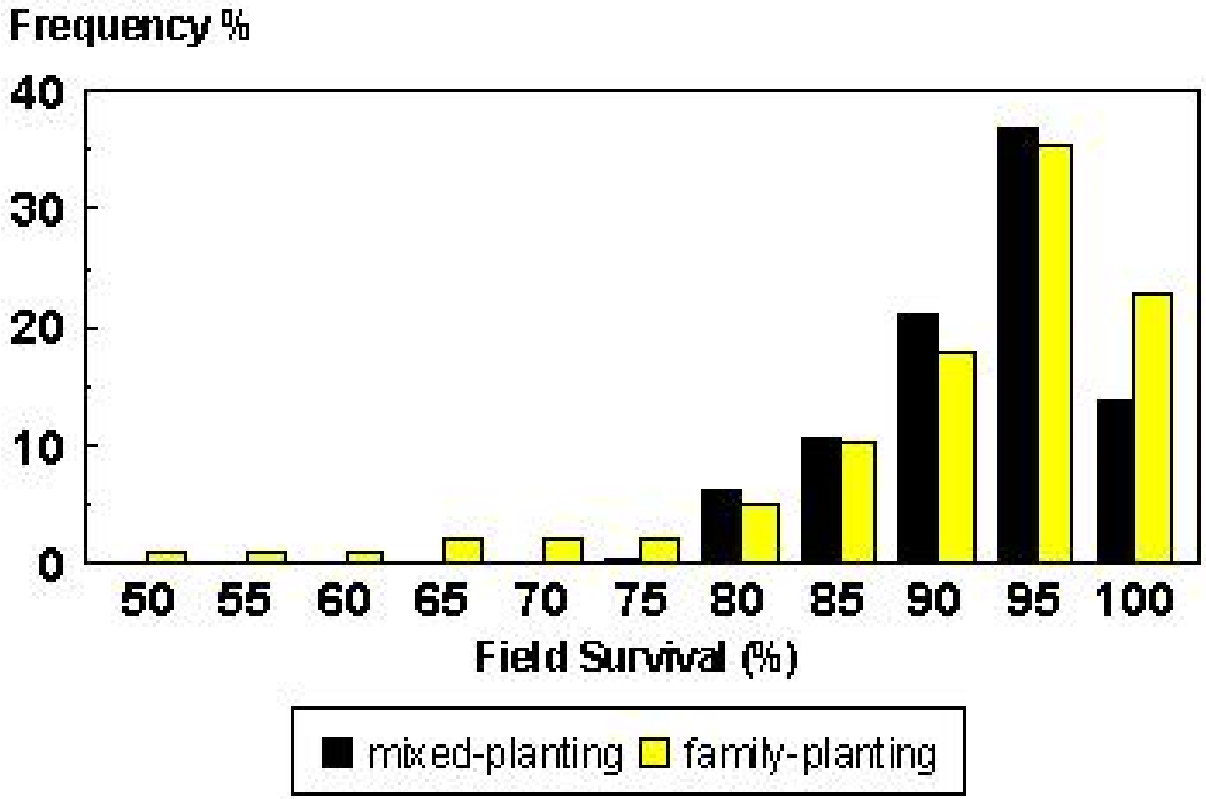
Survival 58% family with carrot root system
68% average site survival

Planting half-sib families

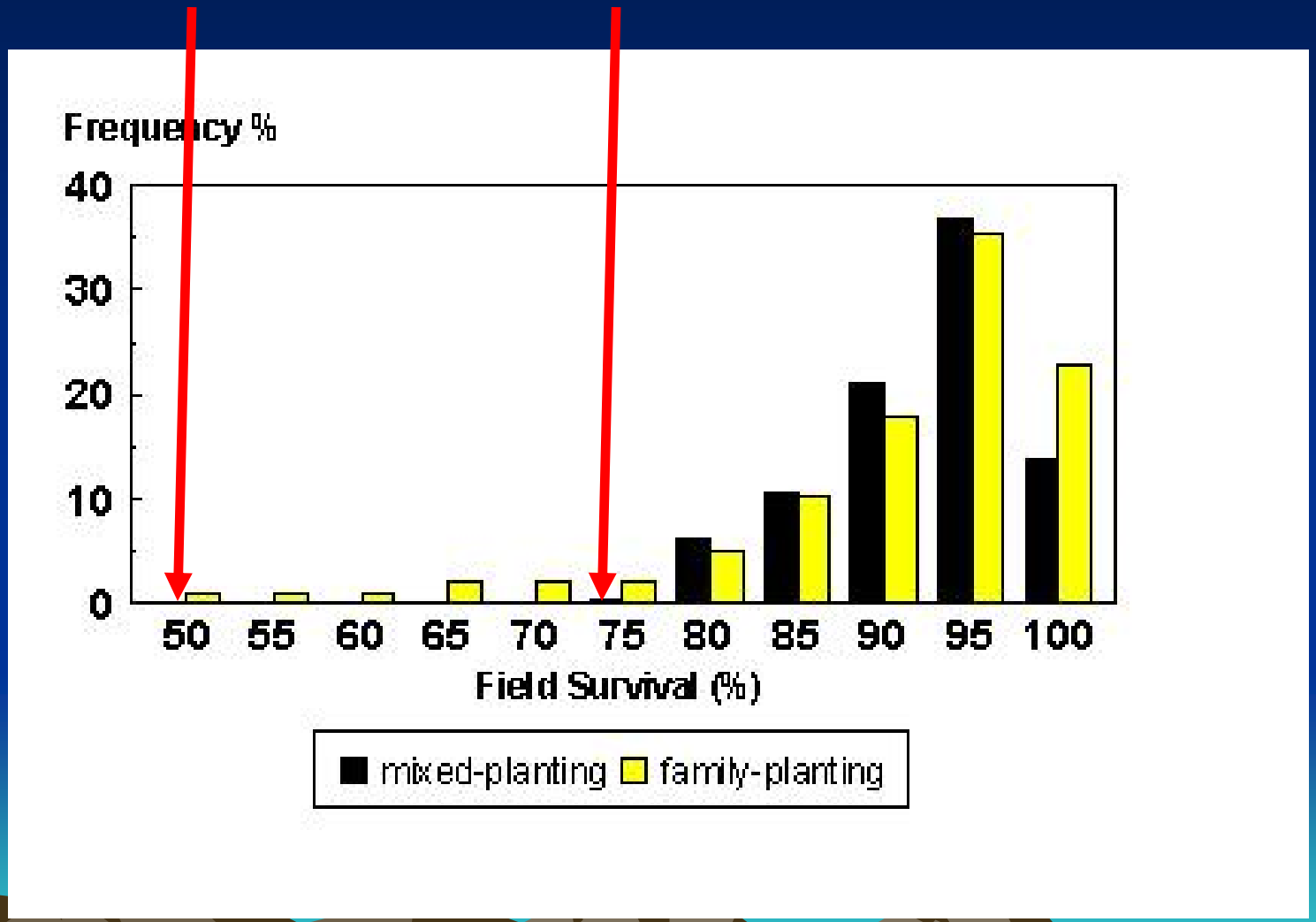
- “Planting half-sib families instead of a mixed-seed orchard lot will increase the range in observed survivals. Even when there is no “genetic drift” (for survival) over time, family planting will (for a limited number of sites), result in lower survival.”

South 2005

Range in survival is greater with family planting.



Range in survival is greater with family planting.



Genetic factors affecting survival

- Differences in RGP
- Differences in nursery height
- Differences in root fibrosity
- Differences in root-weight ratios
- Differences in freeze resistance

Site location – Central, AL

- Coastal Plain Loblolly pine
- lifted December 27/28, 2004.
- Shipped January 17, 2005.
- Hand planted January 22, 2005.
- Storage and handling conditions unknown.
- None of the dead/dying seedlings examined and returned to Auburn had symptoms of excessive flooding. This would include lenticles on the stems and black root systems.

- Survival: 35%

A warm December followed by a 15 degree freeze likely injured Coastal Plain seedlings in the nursery without causing injury to Piedmont sources. Seedlings from Piedmont sources are know to be more resistant to freezing temperatures.

Site location – Warren, GA

- Loblolly pine
  planted early 1981?
  machine planted
  Planting depth (??)

  Survival 27%

Site location – Warren, GA

- Loblolly pine
  planted early 1981?
  machine planted
  Planting depth (??)

  Survival 27% landowner planted
  97% hand planted by Dr. Jim Rowan

Site location – Okaloosa Co., FL

- Slash pine
  planted Jan 1989
  machine planted
  Planting depth (??)
  CRP plantation
  Survival 47%

Site location – Okaloosa Co., FL

- Slash pine
  planted Jan 1989
  machine planted
  Planting depth (??)
  CRP plantation
  Survival 47% not scalped
  88% scalped

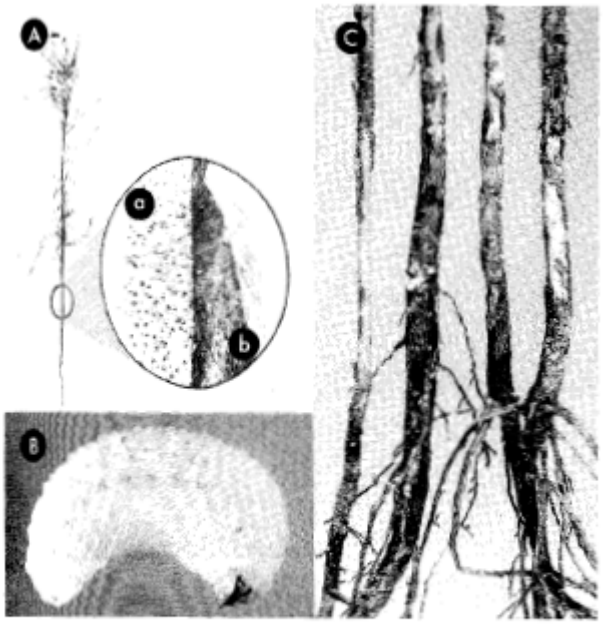


Figure 1. (A) Microsclerotia of *Macrophomina Phaseolina* as seen with a hand lens beneath the bark at the root collar of a dead slash pine (a—on xylem surface; b—underside of bark). (B) Larva of whitefringed beetle (mature size = ca. 12 mm). (C) Feeding damage (i.e., decortication) caused by whitefringed beetle larvae.

Conclusions

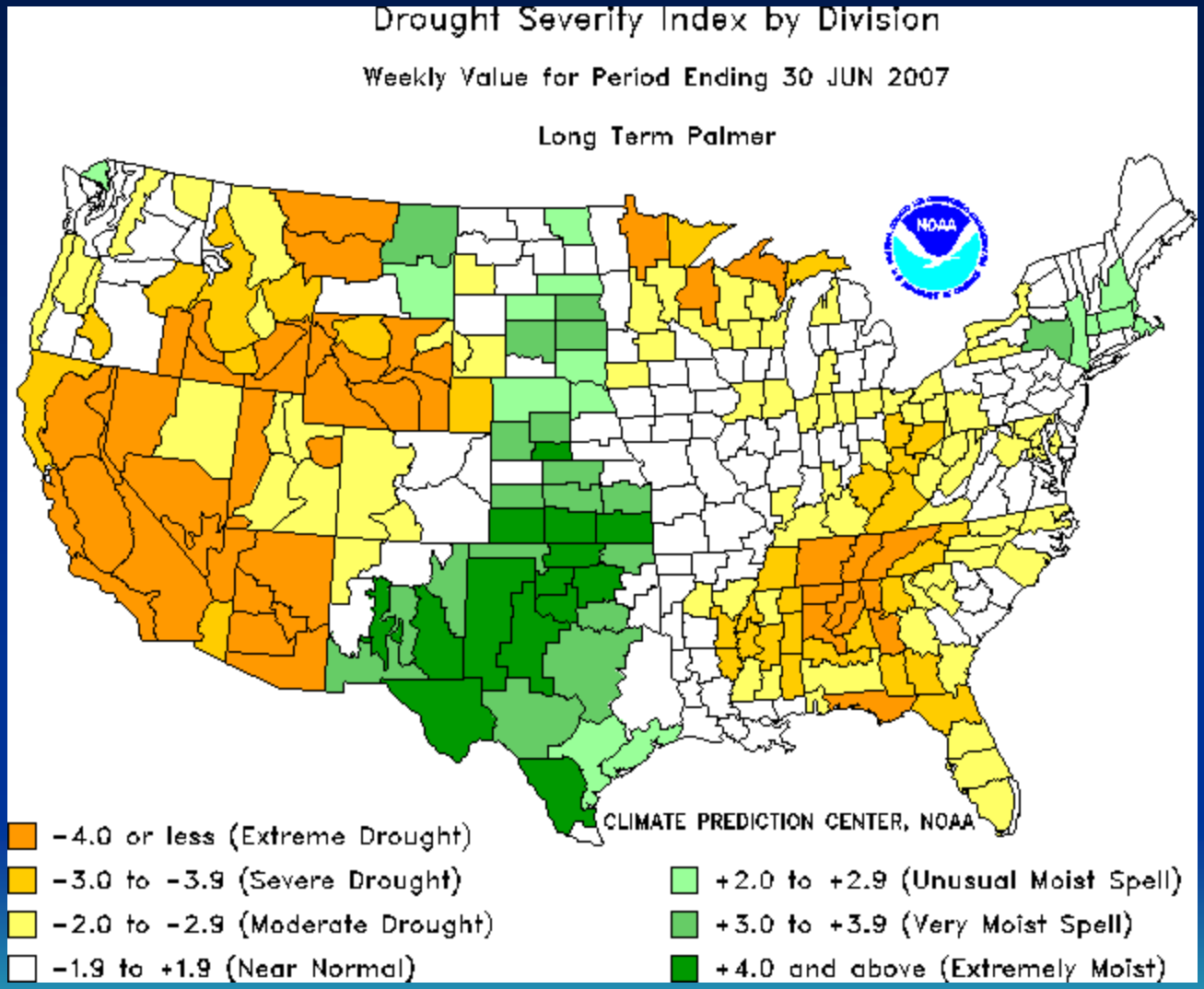
- Some planting failures are easy to explain
- Some failures need a DSI team to find the cause of poor survival (but good records are required)
- When important records are missing, the cause of seedling failure may never be determined.

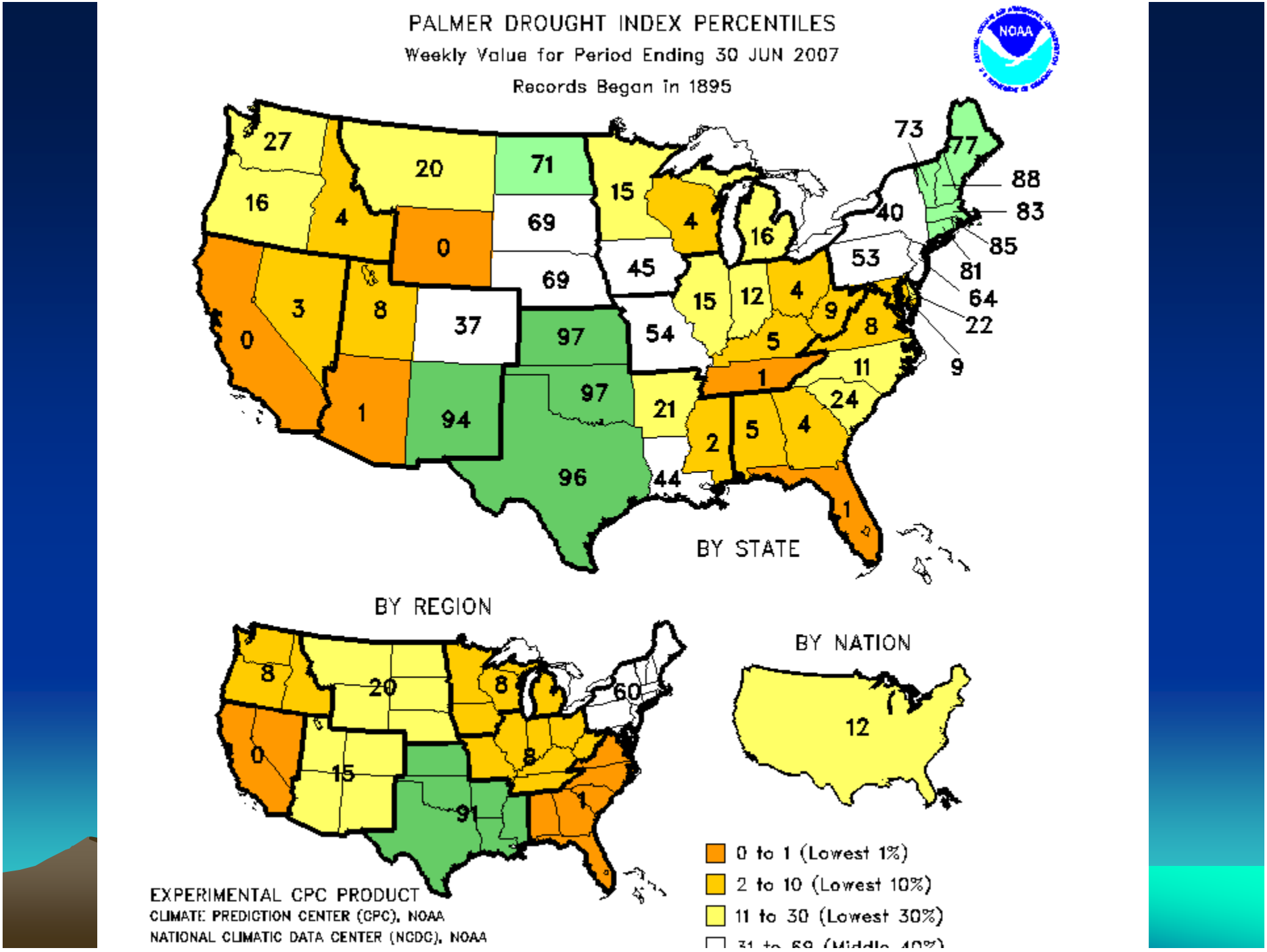
- Since 1980, many planting failures in hardiness zone 8 have been due to freeze injury
- Some failures have been caused by excessive rainfall at the nursery
- Many failures are due to poor planting/supervision
- Planting small diameter seedlings (i.e. small roots) with the root-collar at the groundline will often result in lower survival when moisture is limited.

Recommendation

- Every two weeks during the lifting season, plant some seedlings at the nursery
- (no irrigation).


QUESTIONS?


Drought Severity Index by Division
Weekly Value for Period Ending 30 JUN 2007
Long Term Palmer
NOAA
CLIMATE PREDICTION CENTER, NOAA
-4.0 or less (Extreme Drought)
-3.0 to -3.9 (Severe Drought)
-2.0 to -2.9 (Moderate Drought)
-1.9 to +1.9 (Near Normal)
+2.0 to +2.9 (Unusual Moist Spell)
+3.0 to +3.9 (Very Moist Spell)
+4.0 and above (Extremely Moist)


PALMER DROUGHT INDEX PERCENTILES
Weekly Value for Period Ending 30 JUN 2007
Records Began in 1895
NOAA
27
16
20
4
0
71
69
69
15
4
45
16
73
77
88
83
40
53
85
81
64
22
9
15
12
4
9
8
5
1
11
24
4
5
2
3
0
8
37
97
54
1
94
97
21
96
44
1
BY STATE
BY REGION
8
20
8
60
0
15
8
91
1
BY NATION
12
0 to 1 (Lowest 1%)
2 to 10 (Lowest 10%)
11 to 30 (Lowest 30%)
EXPERIMENTAL CPC PRODUCT
CLIMATE PREDICTION CENTER (CPC), NOAA
NATIONAL CLIMATIC DATA CENTER (NCDC), NOAA