Freeze injury to southern pine seedlings

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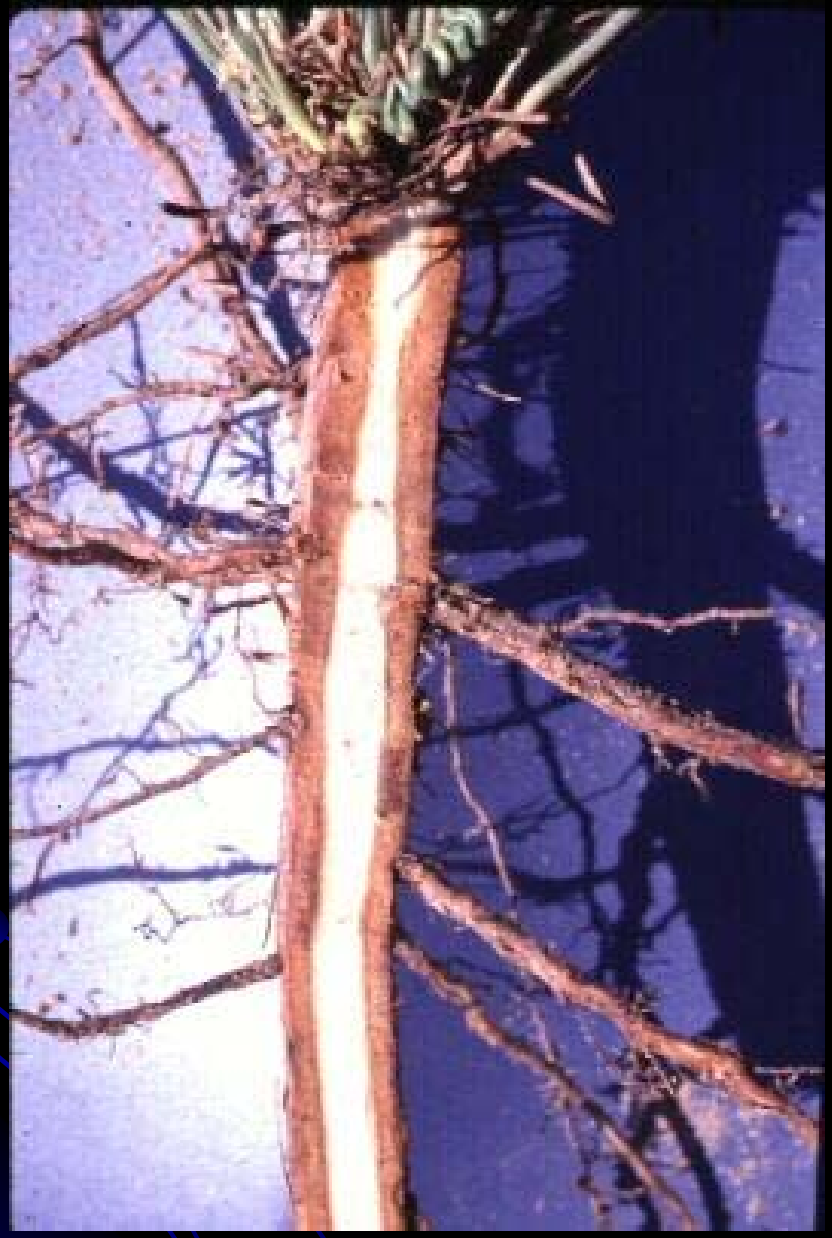
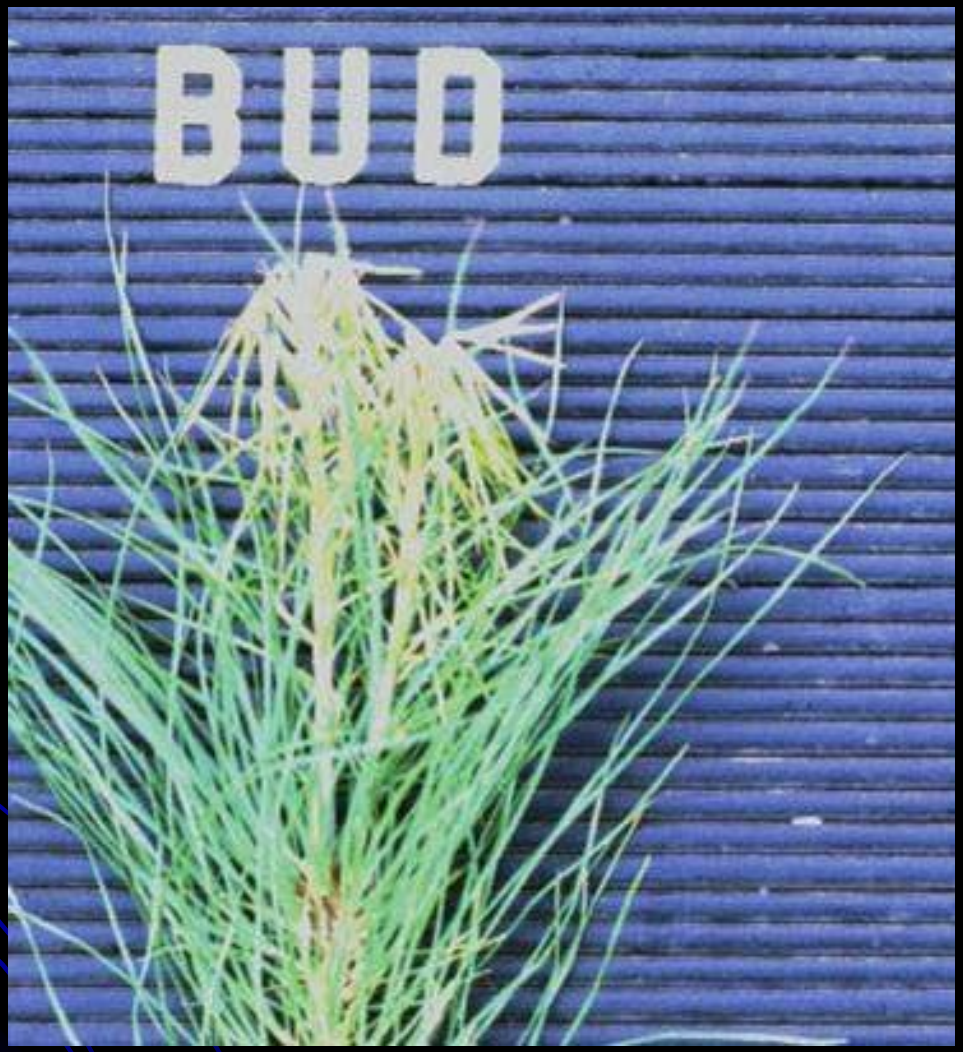
Four types of freeze injury

- 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

Frost heaving

26 F – Dec. 27, 1999

Winter desiccation

Frost damage in 2001 and 2002 devastated Phipps' seedling crop in Oregon. It resulted in a $2.7 million insurance payment…..

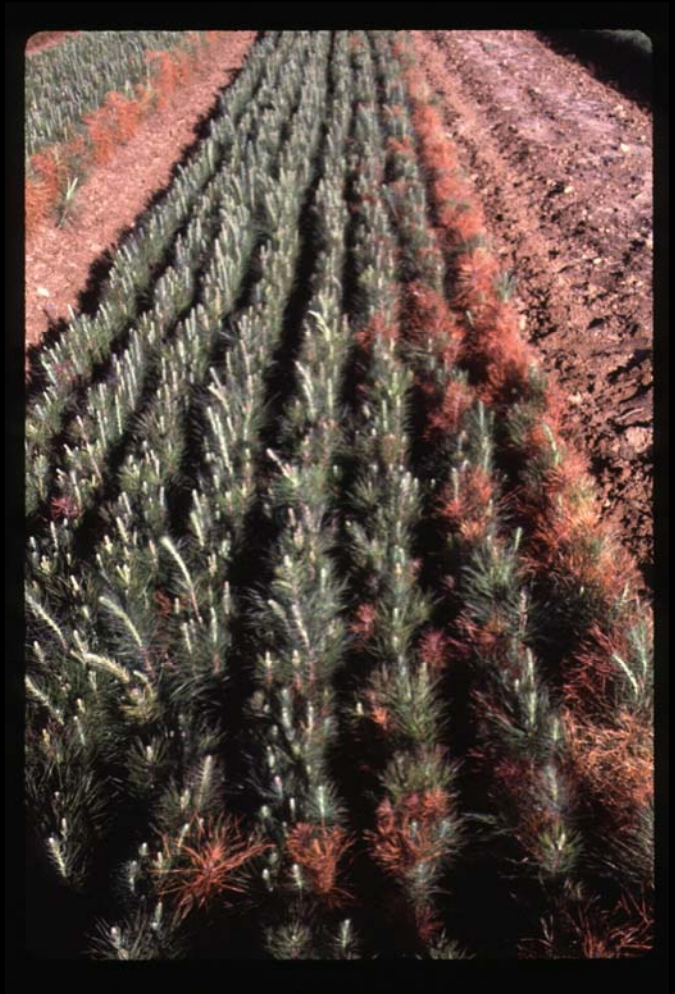
Along with the rest of Oregon and Washington we set records for the coldest October day ever recorded at Elkton.

(16°F. on October 31st 2001 beat the old record of 25° in October 1985)

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.)

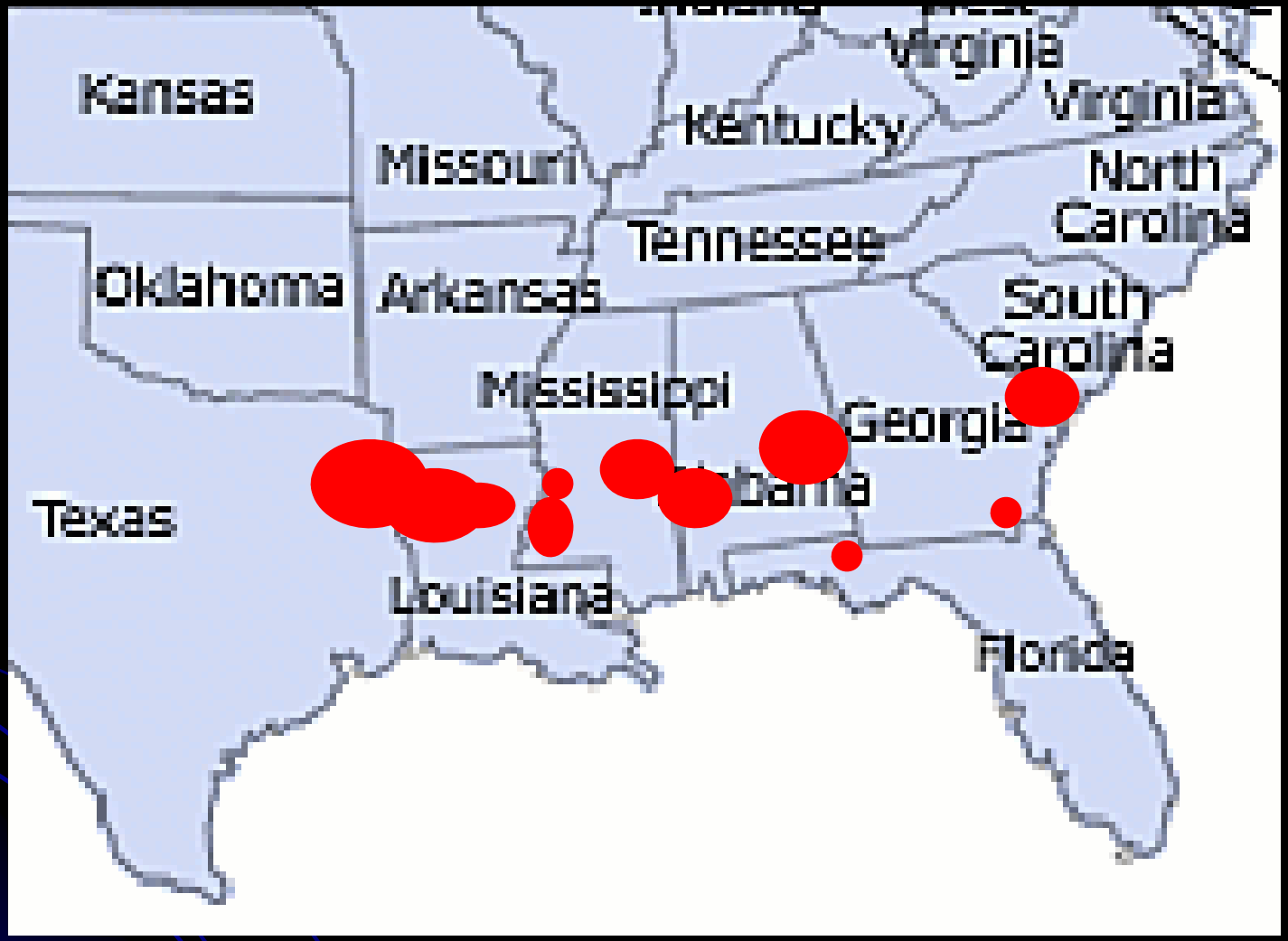
Date	Temperature (°F)		
	high	avg	low
January			
4	73	66	59
5	68	58	44
6	44	40	33
7	41	31	21
8	37	30	24
9	42	38	35
10	37	35	33

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)

Loblolly pine genotypes and freeze

Cold Hardiness in Loblolly Pine:
Artificial Screening and Physiological Mechanisms

by
Gary R. Hodge

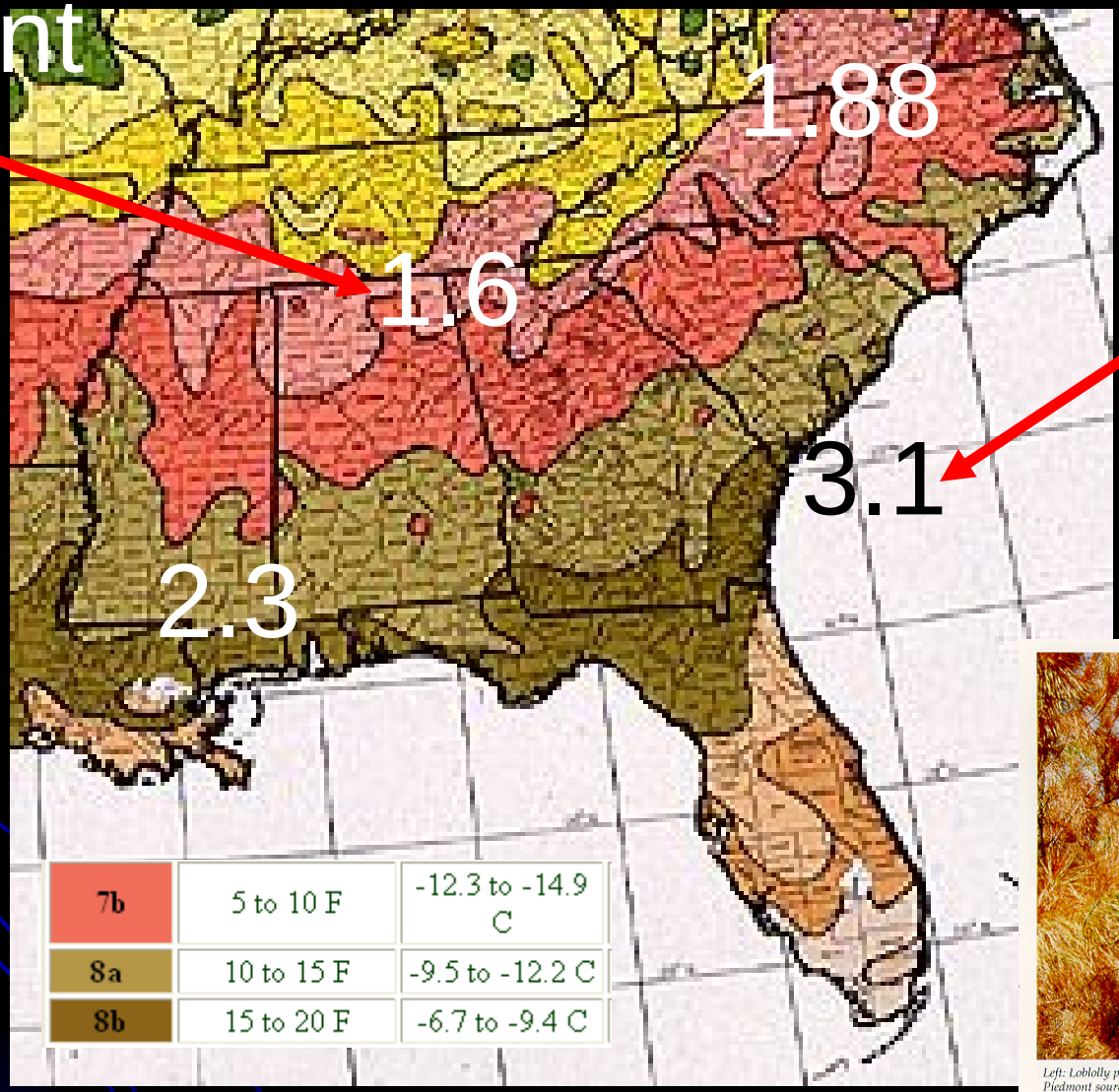
A thesis submitted to the Graduate Faculty of
North Carolina State University
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

Raleigh

1984

Tolerant

Injured



Left: Loblolly pine from a south coastal source; right: loblolly pine from a northern Piedmont source.

1 = no injury; 4 = all foliage brown

Family 7-56 is susceptible to freeze injury

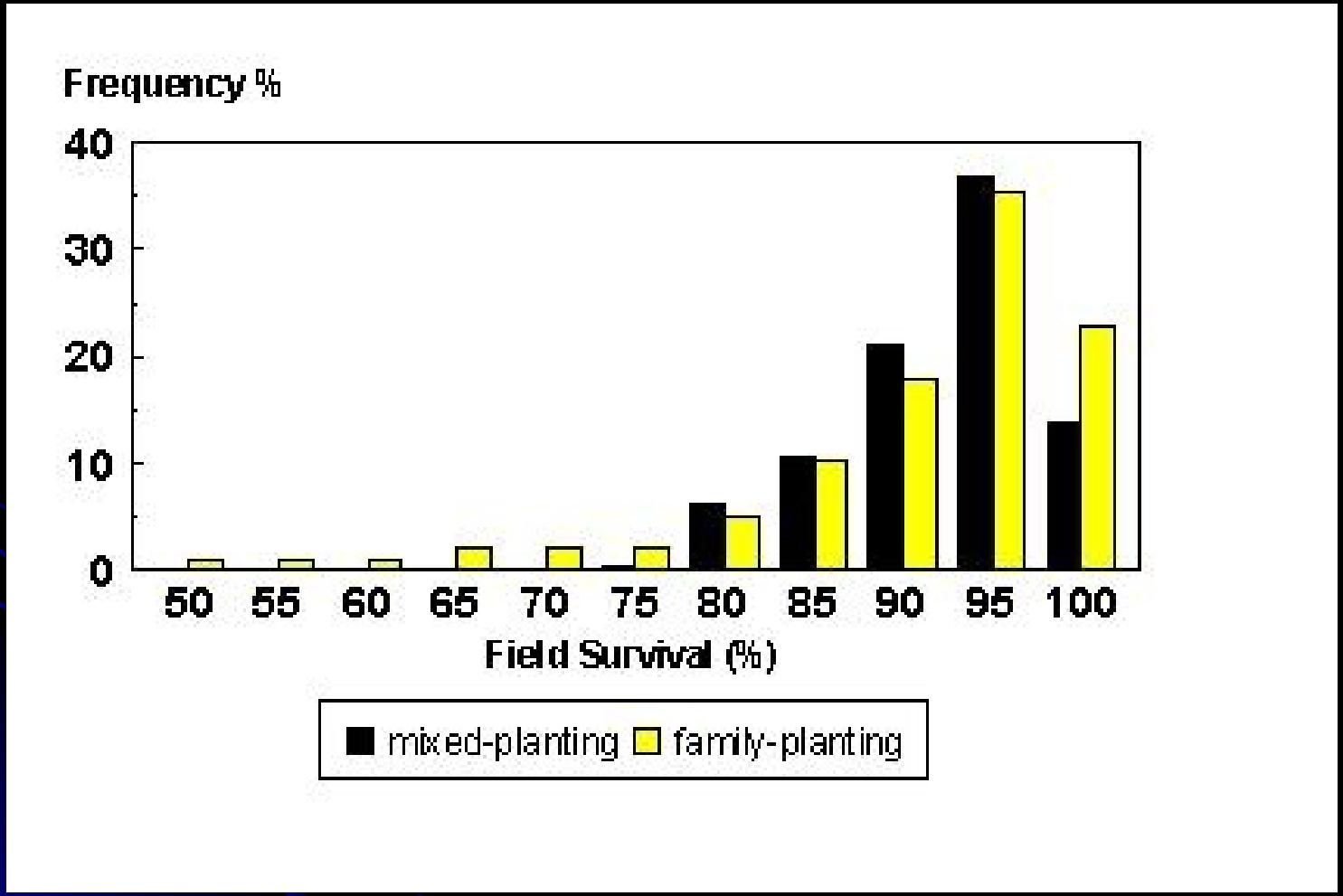
Table 1. Seedbed density (#/sq.ft), mean diameter (mm) and visual freeze damage estimates for 60 seedlings from five seed lots at an Alabama nursery.

Family	Density	Diameter	Damage (O-2) External	Damage (O-2) Internal	% damage
7-56	22	5.2	1.67	1.93	97
12-42	20	5 6	0.25	0.03	27
1-82	22	5.4	0.03	0.27	15
I .5 Mix	20	5.0	0.25	0.20	22
2.0 Mix	21	4 7	0.08	0.18	I3

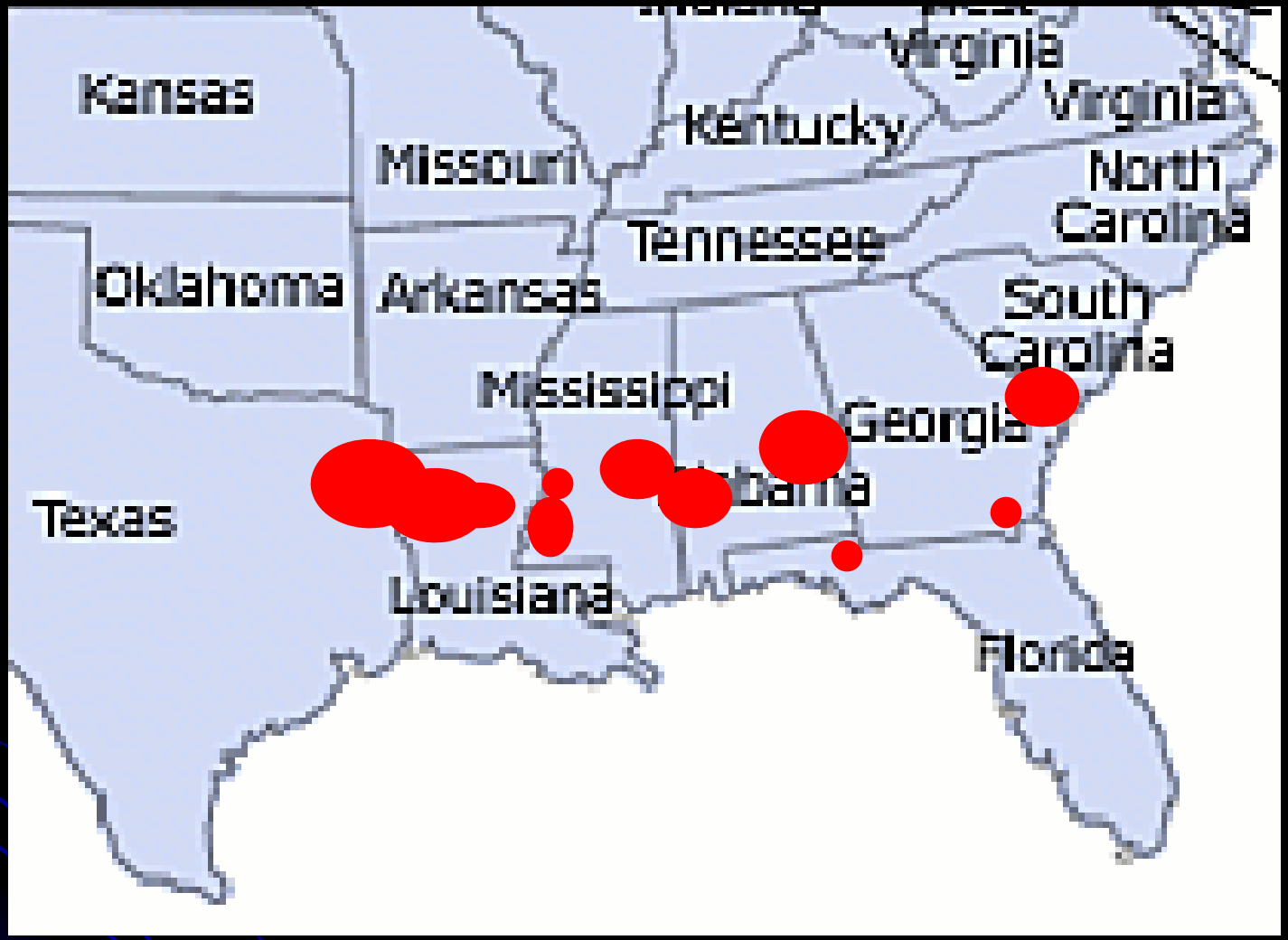
% damage is the percentage of seedlings with either internal or external symptoms

Rapid 16 F freeze on Jan 19th, 1996

Survival range is greater when loblolly pine is outplanted by family



Heritability for survival: 0.49 to 0.89



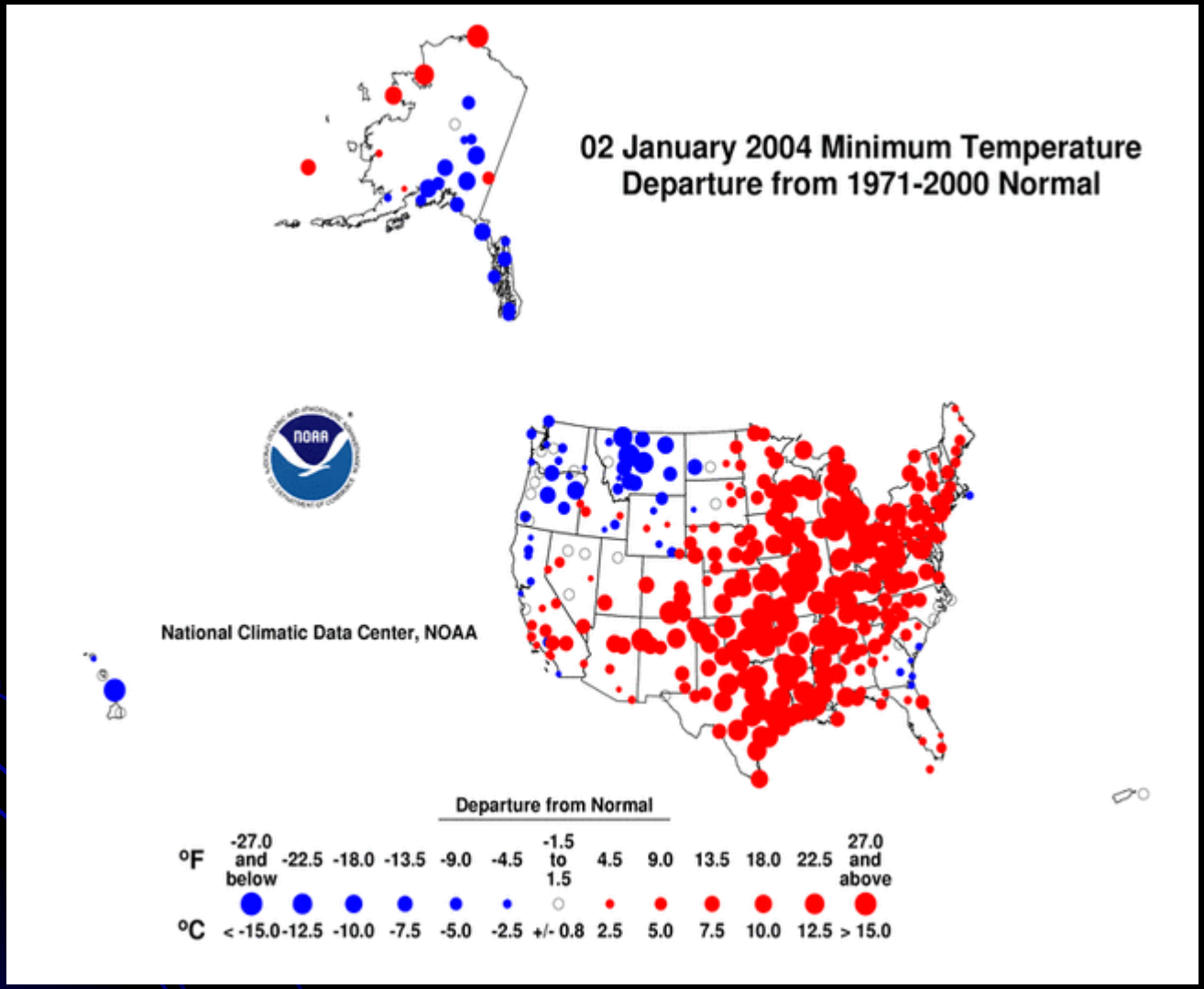
Injury from hardiness zones 8 and 7b
Coastal plain sources planted.

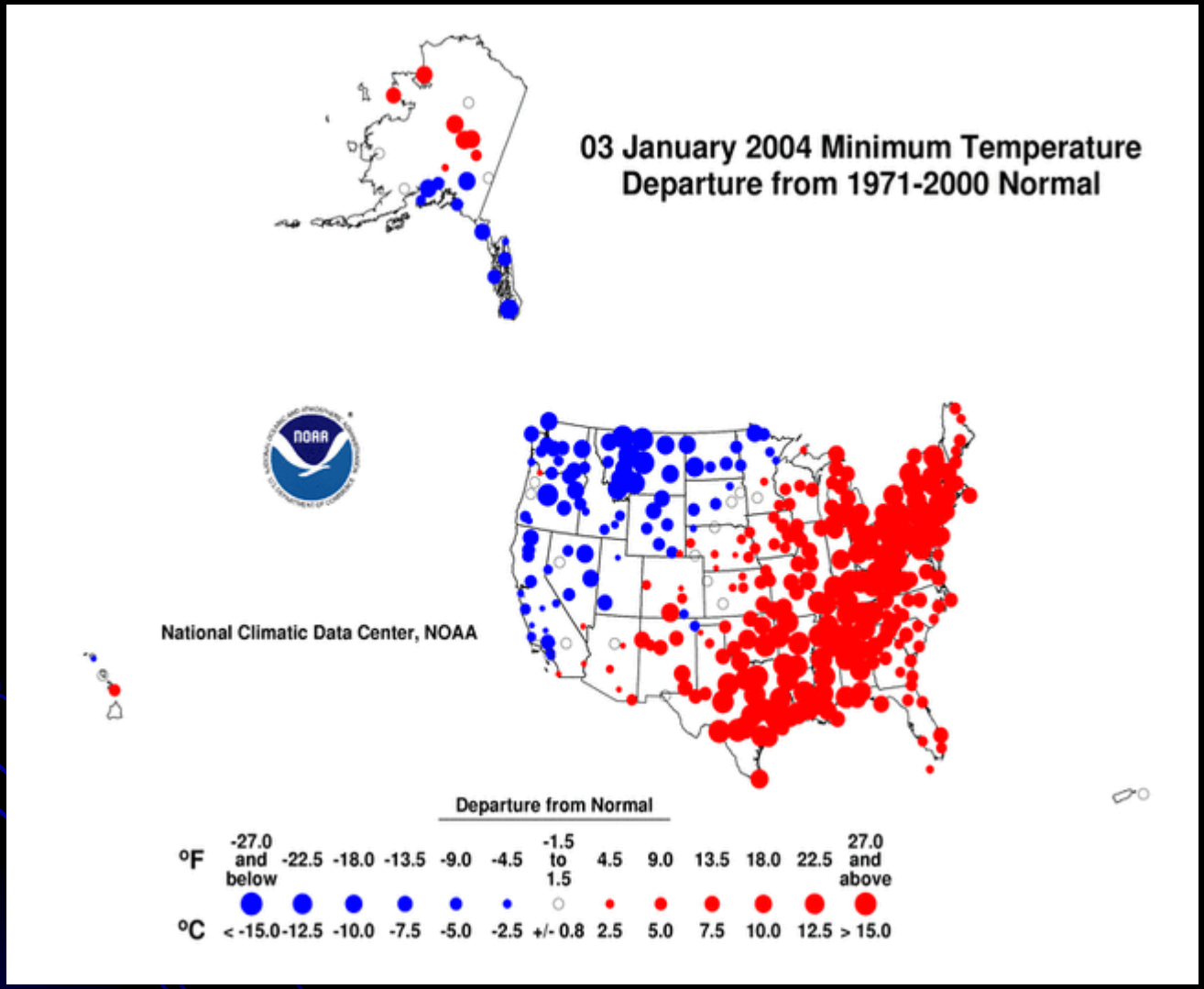
The 2003-04
No injury in zone 7a

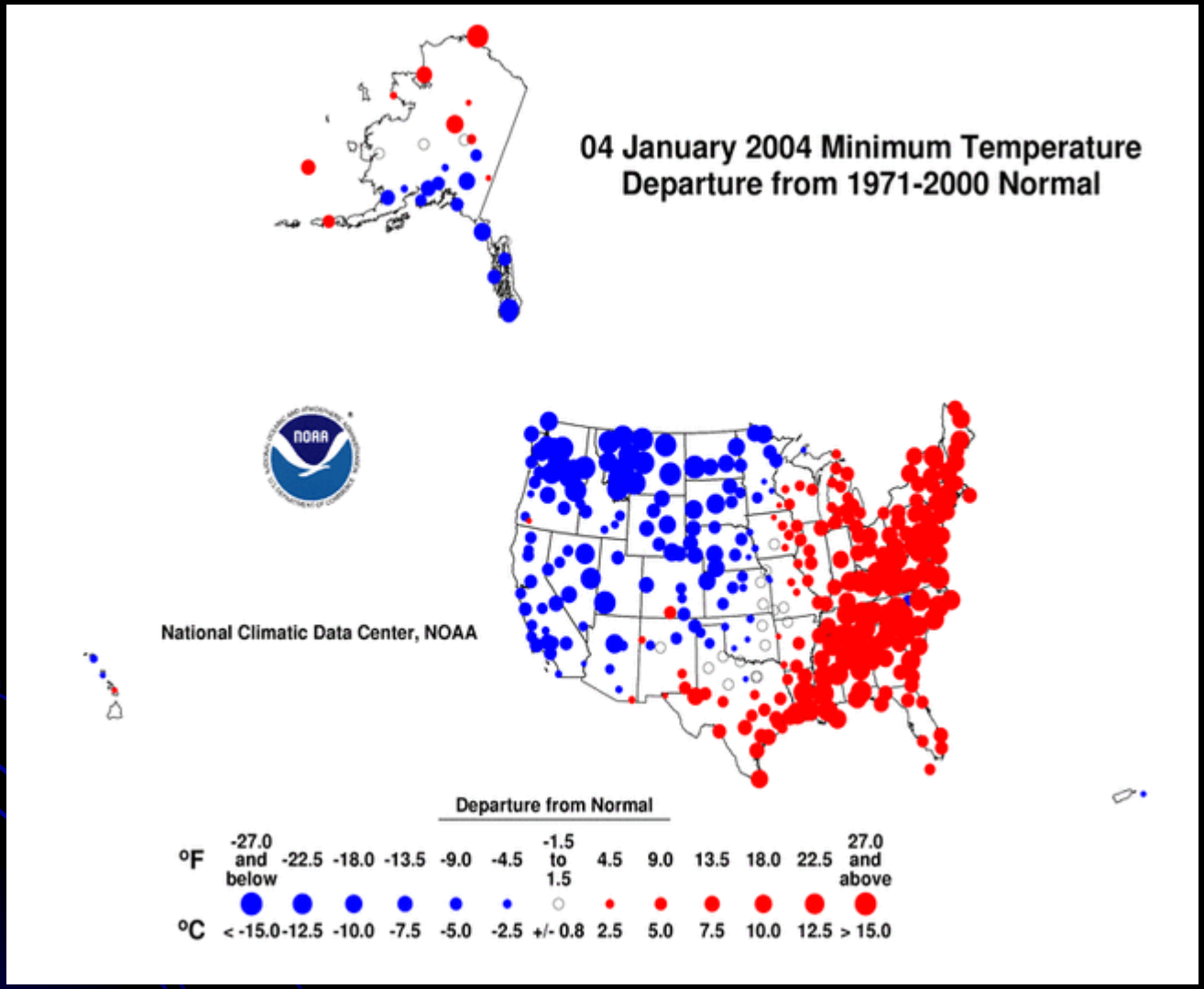
Location	Date	Min. degree F
Cullman, AL	Jan 7, 2004	16
Fayetteville, AR	Jan 7, 2004	12
Jackson, TN	Jan 9, 2004	9
Richmond, VA	Jan 11, 2004	11
Durham, NC	Jan 11, 2004	11

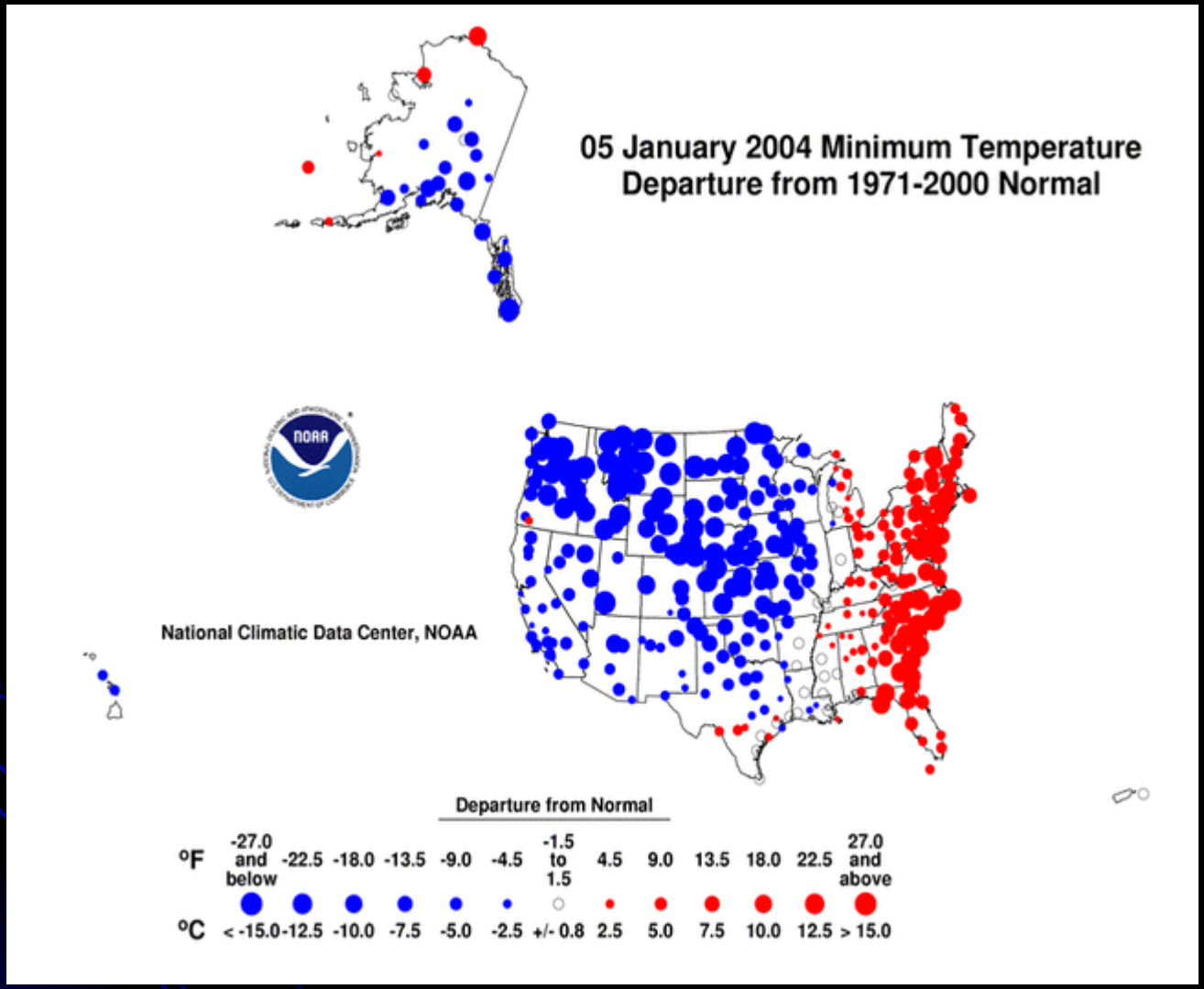
Piedmont sources planted

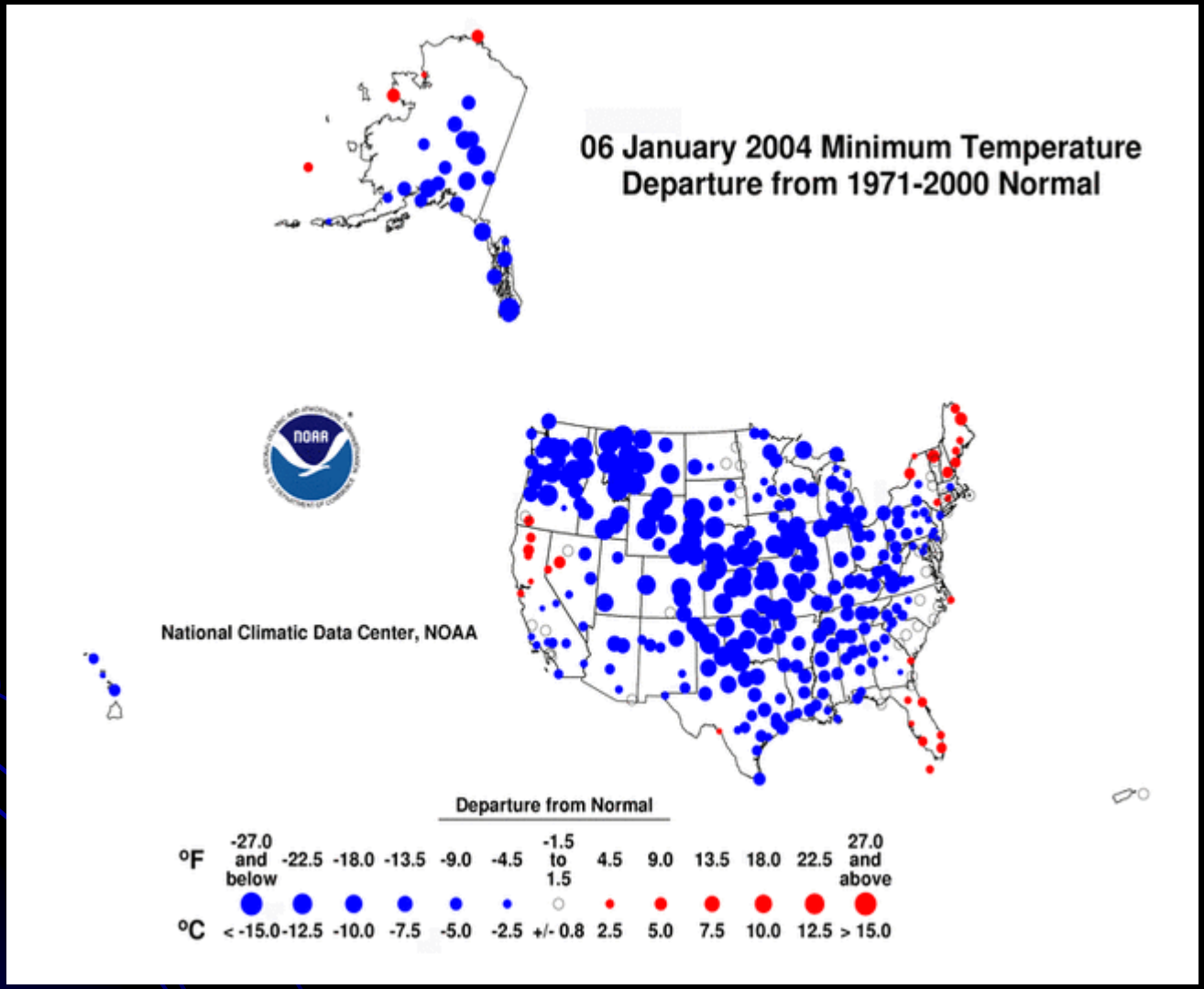
Warm weather caused deacclimation root injury

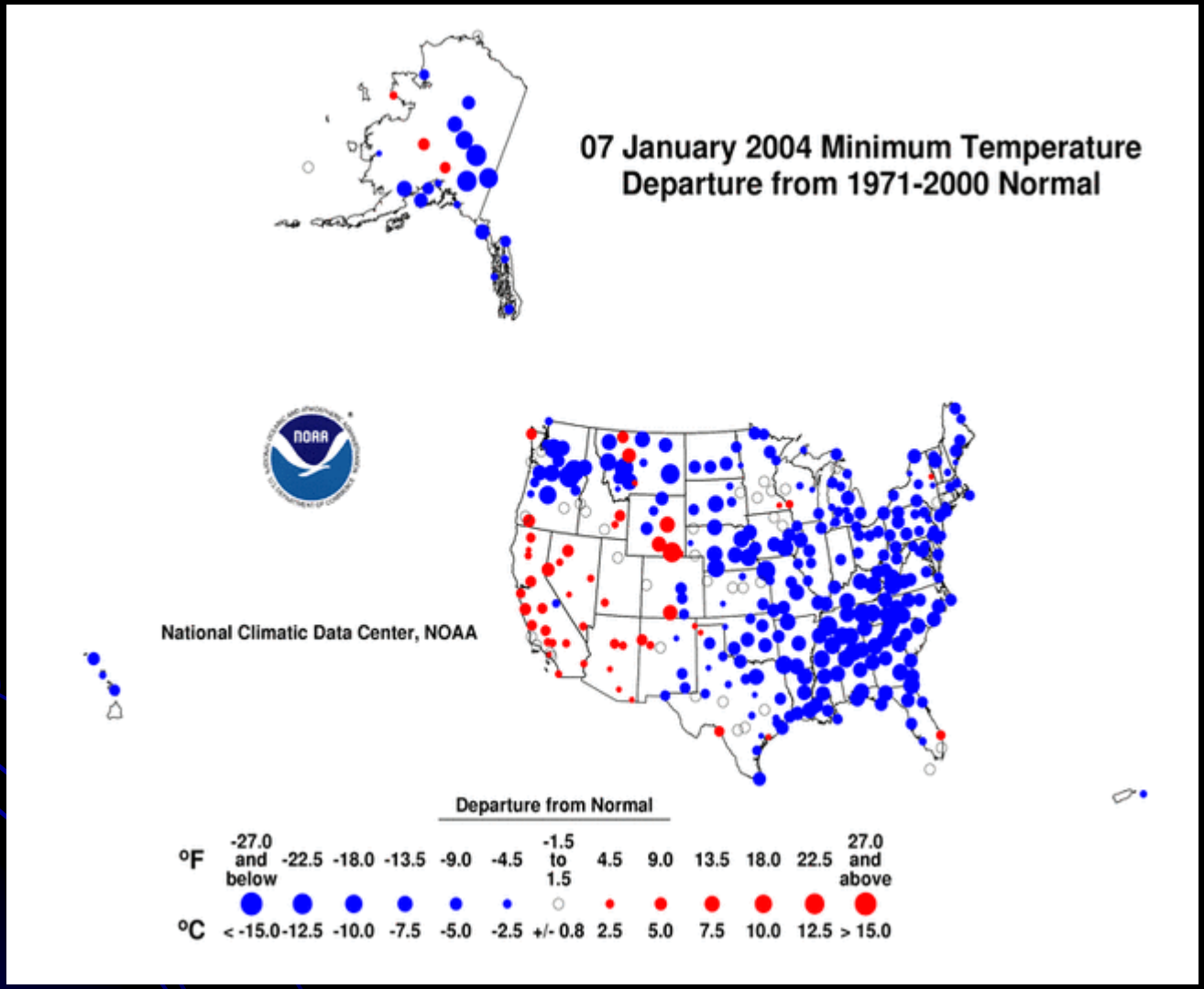

02 January 2004 Minimum Temperature
Departure from 1971-2000 Normal
National Climatic Data Center, NOAA
Departure from Normal
°F -27.0 and below -22.5 -18.0 -13.5 -9.0 -4.5 -1.5 to 1.5 4.5 9.0 13.5 18.0 22.5 27.0 and above
°C < -15.0 -12.5 -10.0 -7.5 -5.0 -2.5 +/- 0.8 2.5 5.0 7.5 10.0 12.5 > 15.0

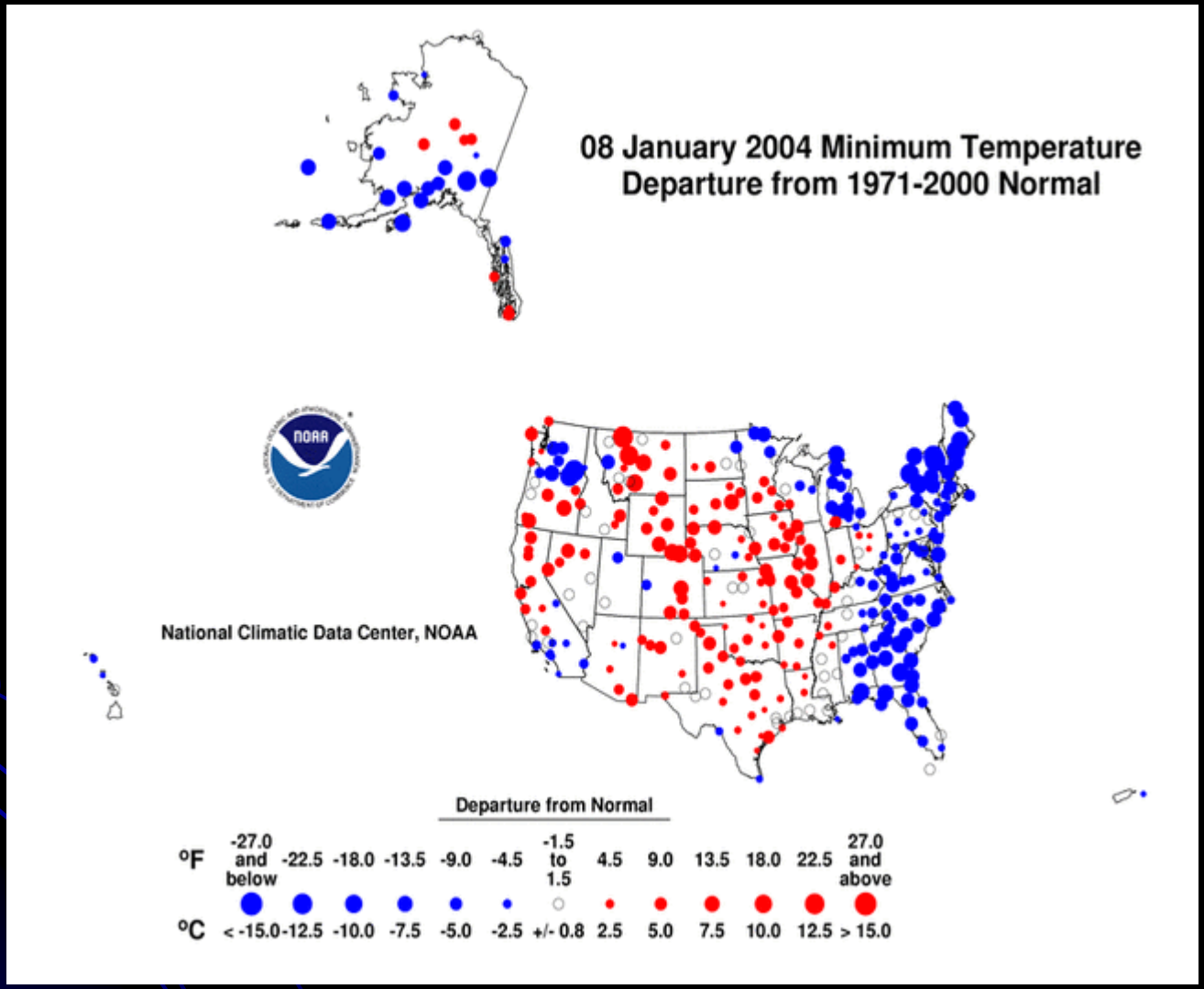

03 January 2004 Minimum Temperature
Departure from 1971-2000 Normal
NOAA
National Climatic Data Center, NOAA
Departure from Normal
°F
-27.0 and below
-22.5
-18.0
-13.5
-9.0
-4.5
-1.5 to 1.5
4.5
9.0
13.5
18.0
22.5
27.0 and above
°C
< -15.0
-12.5
-10.0
-7.5
-5.0
-2.5
+/- 0.8
2.5
5.0
7.5
10.0
12.5
> 15.0


04 January 2004 Minimum Temperature
Departure from 1971-2000 Normal
National Climatic Data Center, NOAA
Departure from Normal
°F
-27.0 and below
-22.5
-18.0
-13.5
-9.0
-4.5
-1.5 to 1.5
4.5
9.0
13.5
18.0
22.5
27.0 and above
°C
< -15.0
-12.5
-10.0
-7.5
-5.0
-2.5
+/- 0.8
2.5
5.0
7.5
10.0
12.5
> 15.0

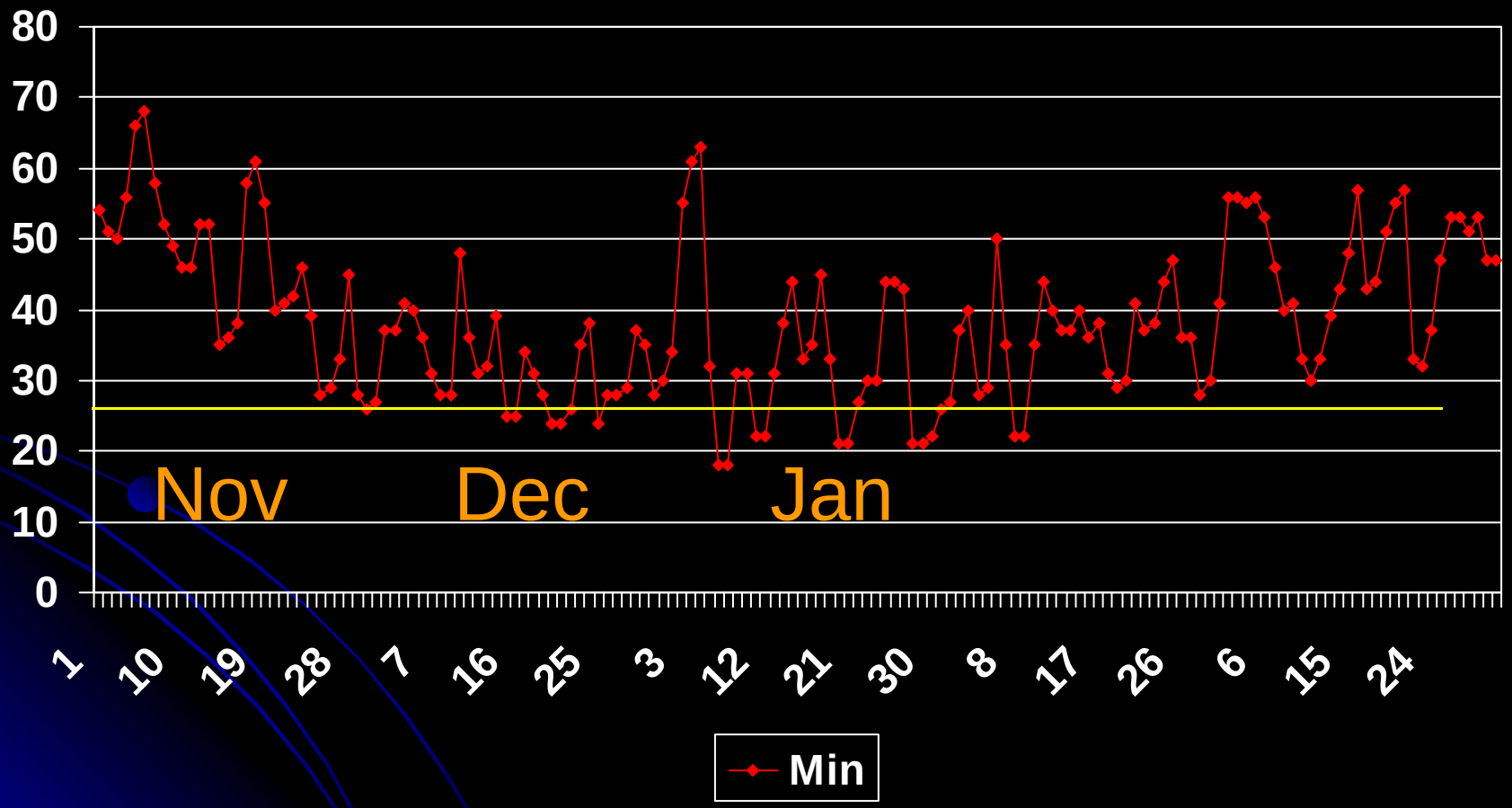

05 January 2004 Minimum Temperature
Departure from 1971-2000 Normal
National Climatic Data Center, NOAA
Departure from Normal
°F
-27.0 and below
-22.5
-18.0
-13.5
-9.0
-4.5
-1.5 to 1.5
4.5
9.0
13.5
18.0
22.5
27.0 and above
°C
< -15.0
-12.5
-10.0
-7.5
-5.0
-2.5
+/- 0.8
2.5
5.0
7.5
10.0
12.5
> 15.0


06 January 2004 Minimum Temperature
Departure from 1971-2000 Normal
National Climatic Data Center, NOAA
Departure from Normal
°F -27.0 and below -22.5 -18.0 -13.5 -9.0 -4.5 -1.5 to 1.5 4.5 9.0 13.5 18.0 22.5 27.0 and above
°C < -15.0 -12.5 -10.0 -7.5 -5.0 -2.5 +/- 0.8 2.5 5.0 7.5 10.0 12.5 > 15.0

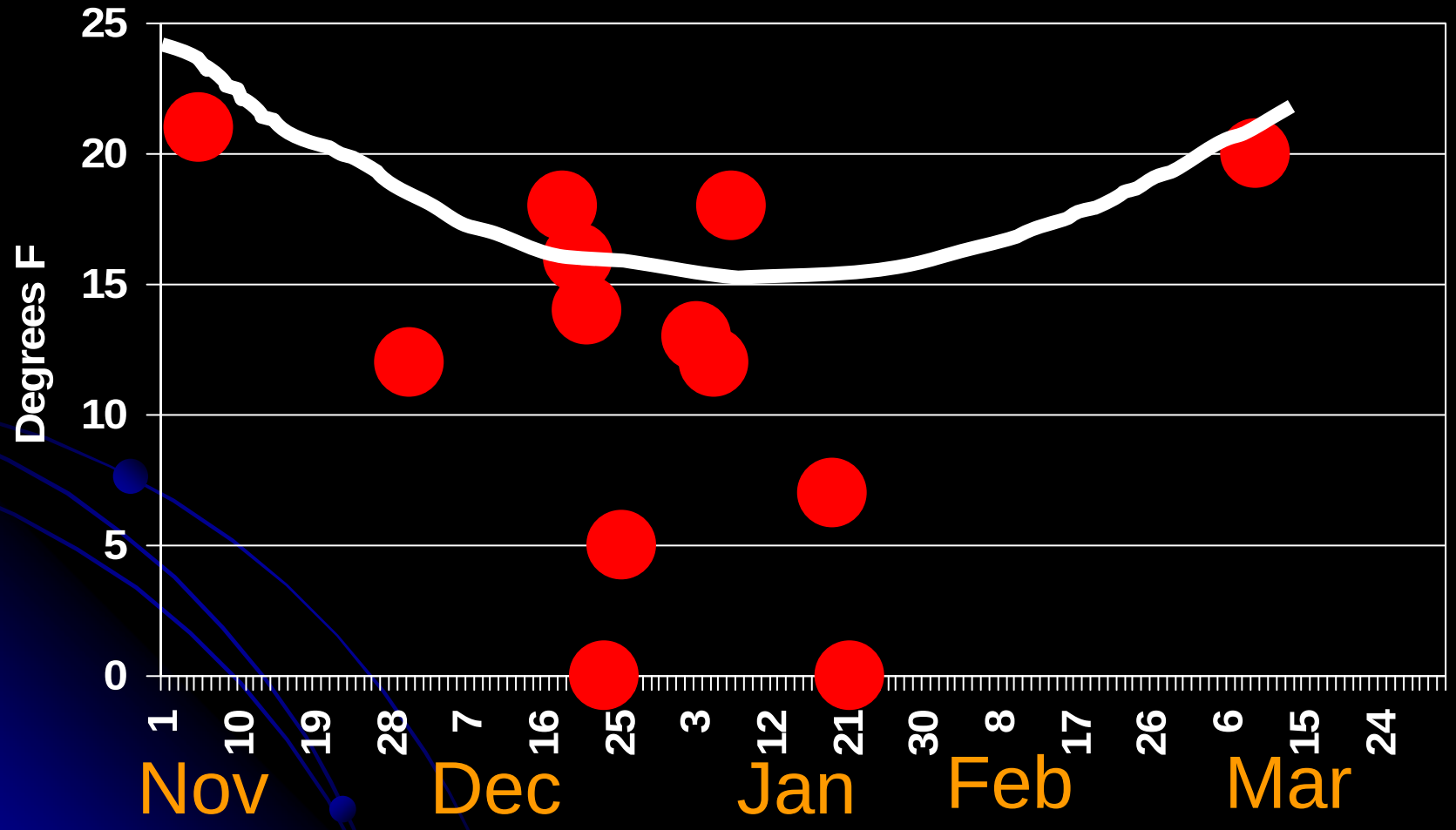

07 January 2004 Minimum Temperature
Departure from 1971-2000 Normal
National Climatic Data Center, NOAA
Departure from Normal
°F
-27.0 and below
-22.5
-18.0
-13.5
-9.0
-4.5
-1.5 to 1.5
4.5
9.0
13.5
18.0
22.5
27.0 and above
°C
< -15.0
-12.5
-10.0
-7.5
-5.0
-2.5
+/- 0.8
2.5
5.0
7.5
10.0
12.5
> 15.0


08 January 2004 Minimum Temperature
Departure from 1971-2000 Normal
National Climatic Data Center, NOAA
Departure from Normal
°F
-27.0 and below
-22.5
-18.0
-13.5
-9.0
-4.5
-1.5 to 1.5
4.5
9.0
13.5
18.0
22.5
27.0 and above
°C
< -15.0
-12.5
-10.0
-7.5
-5.0
-2.5
+/- 0.8
2.5
5.0
7.5
10.0
12.5
> 15.0

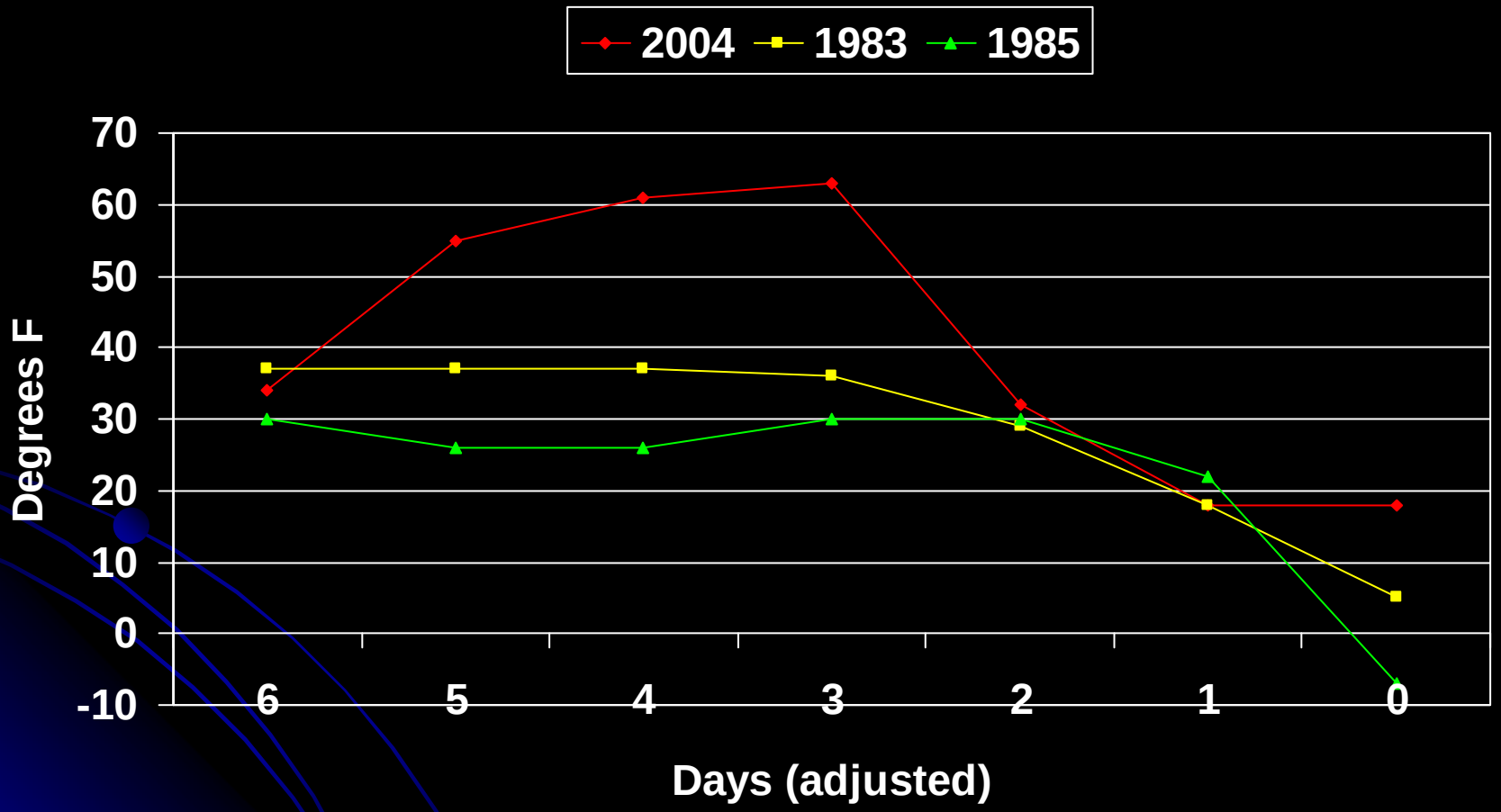
Minimum temp – Alabama



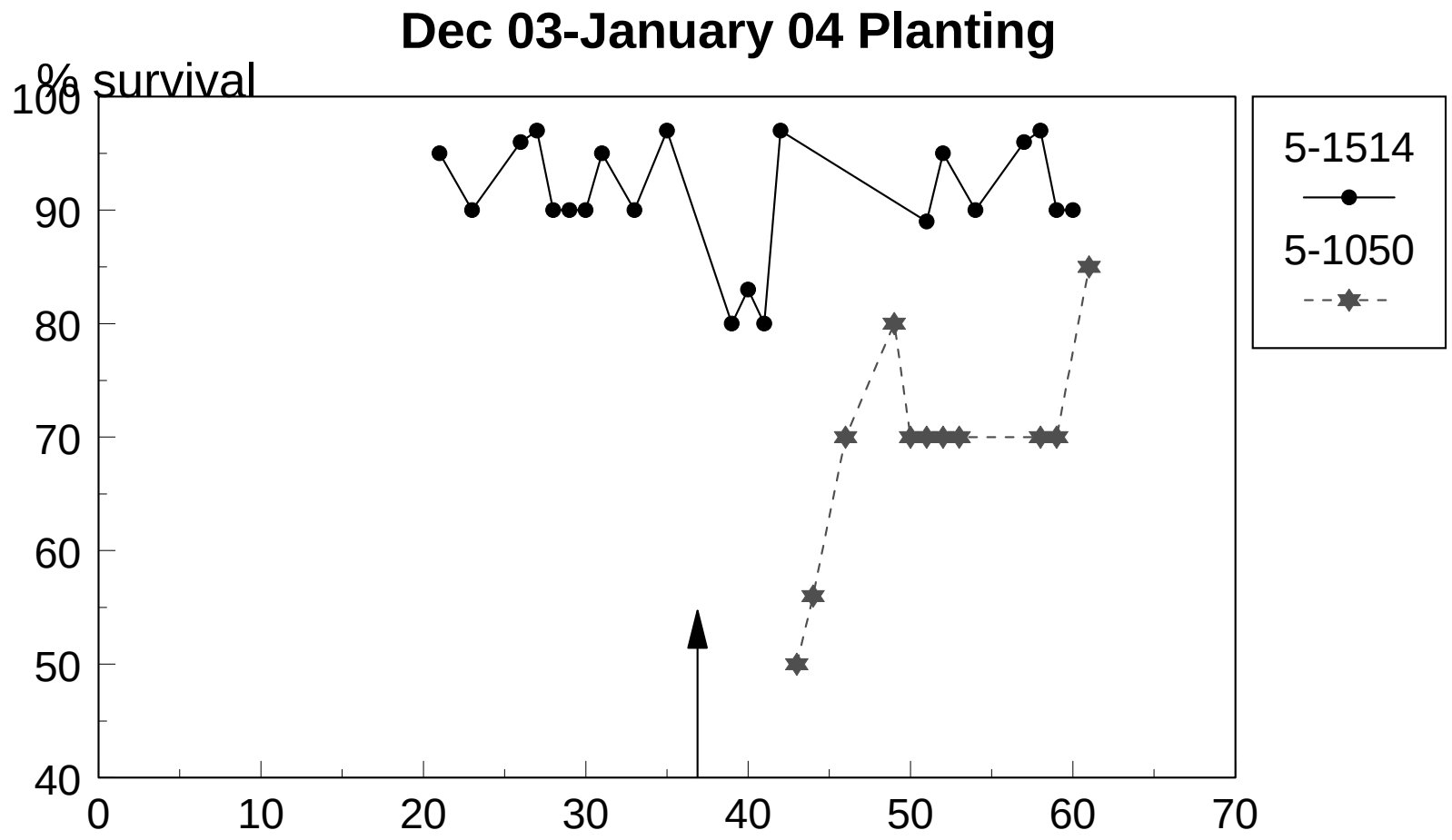
Past freeze injuring events to pines



Minimum temperatures for 3 freeze events – Alabama



3 days above 50º F



Jan 7

Dip in survival after freeze

Summary

- The heritability for seedling survival is high.
- Coastal plain families for loblolly pine are less tolerant of freeze than Piedmont sources.
- Early mortality of seedlings in 2004 was primarily in hardiness zone 8.
- Seedling roots de-hardened when nighttime temperatures were above 50 F for 3 days.
- The January 7 freeze likely injured Coastal Plain families in several nurseries and plantations.

Questions?

Injury to longleaf pine roots

Date (EST)	Air Temp (°F)	
	Min	Max
Jan 03, 2004	56.9	75.1
Jan 04, 2004	54.7	78.3
Jan 05, 2004	51.7	79.1
Jan 06, 2004	36.8	51.0
Jan 07, 2004	27.9	47.7
Jan 08, 2004	26.1	46.7

The 2004 freeze

Microenvironment is important