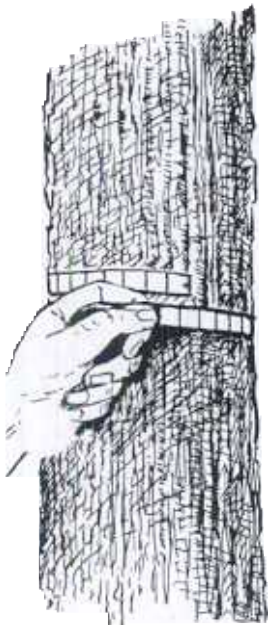
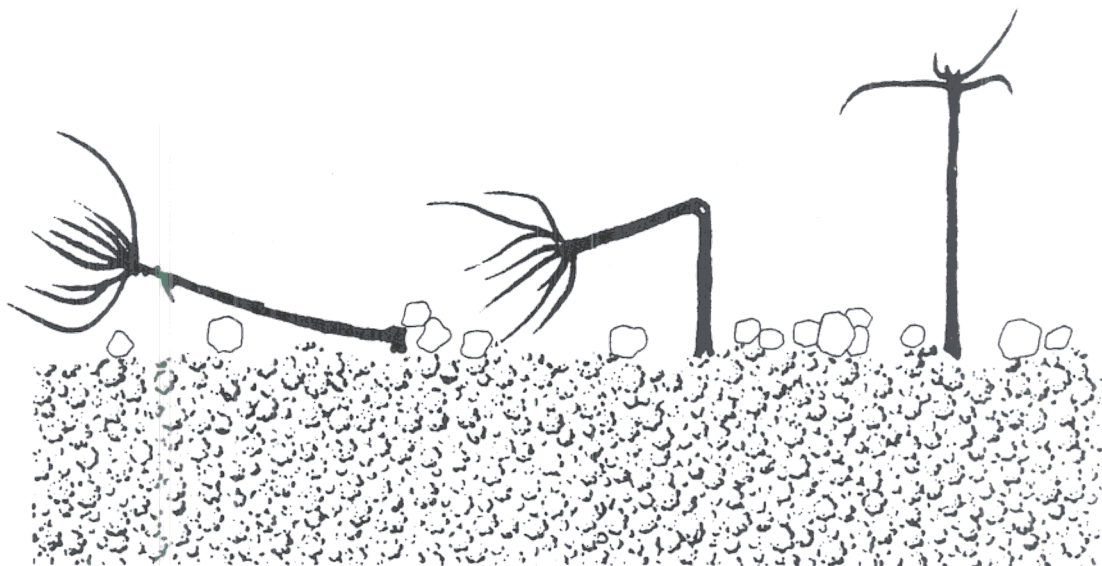
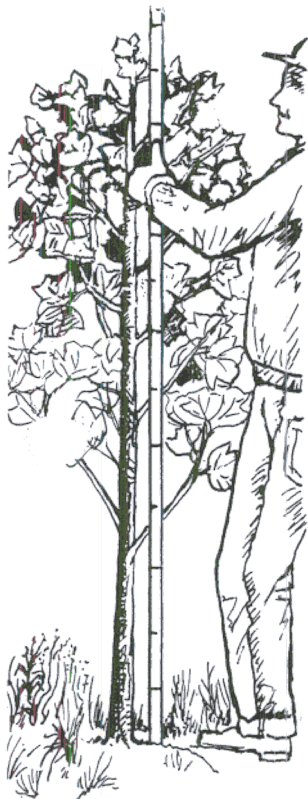




# Survival and Growth of Loblolly Pine Seedlings Damaged by an Early Hail Storm



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Damaged by an Early Hail Storm

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Abstract. In May of 1983, just 29 days after completion of seeding, a severe hail storm struck the New Kent Nursery. Immediate mortality of loblolly pine seedlings was about 16 percent. Surviving seedlings with three different kinds of damage were marked and observed through the season. Seedlings with stems broken at the groundline (and thus supported) survived best (62 percent), and survivors had the best growth. Seedlings with stems broken above the groundline (and thus not supported) survived worst (24 percent), and survivors were intermediate in growth. Seedlings with unbroken stems, but which lost most of their cotyledons, were intermediate in survival (46 percent), and survivors had the slowest growth. Seedlings that "escaped" the hail by germinating late, after the storm, had a survival of only 50 percent and made less growth than seedlings with stems broken at the groundline.

INTRODUCTION

On May 26, 1983, 29 days after seeding was completed, a serious hail storm struck the New Kent Nursery in late afternoon. Hail stones up to the size of large marbles fell intermittently for about 45 minutes. Seedlings were less than three weeks old when the storm occurred, and those in the cotyledon stage were extremely vulnerable. Some seed was still germinating. Along with the hail, about three inches of rain caused additional mortality by washing out and/or burying some seedlings. However, in low areas where the rain accumulated, it protected seedlings somewhat from the impact of hail stones.

The day after the storm we tried to assess seedling damage on 54 permanent sample plots that were evenly distributed over the Nursery. These plots were six inches wide and extended across the seedbed. We tallied seedlings as "living" (which included many seriously damaged seedlings, because the majority of seedlings sustained at least some hail damage) or "dead" (top completely broken off, broken so badly that there was no chance of recovery, or all cotyledons gone). The average for these 54 plots was 77 "living" and 15 "dead", for an immediate mortality of 16 percent. We wondered about the many seriously damaged seedlings that we tallied as "living", how many would survive and how well they would grow, and so we installed the following study. From here on, seedling mortality will refer to seriously damaged seedlings that were tallied as "living" when the initial assessment was made.

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## PROCEDURE

On June 7, 12 days after the storm, we selected 168 seriously damaged seedlings, in ten small plots scattered over the Nursery, for observation throughout the growing season. A one-inch diameter steel ring was placed over each damaged seedling, so that other seedlings were excluded, with a colored toothpick inside the ring to indicate the following three kinds of damage (Figure 1):

1. Seedling stem broken at groundline, lying horizontally and supported by the ground (red toothpick)

2. Stem broken above the ground, and not supported by the ground (green toothpick)

3. Stem not broken, but only one or two cotyledons intact (blue toothpick)

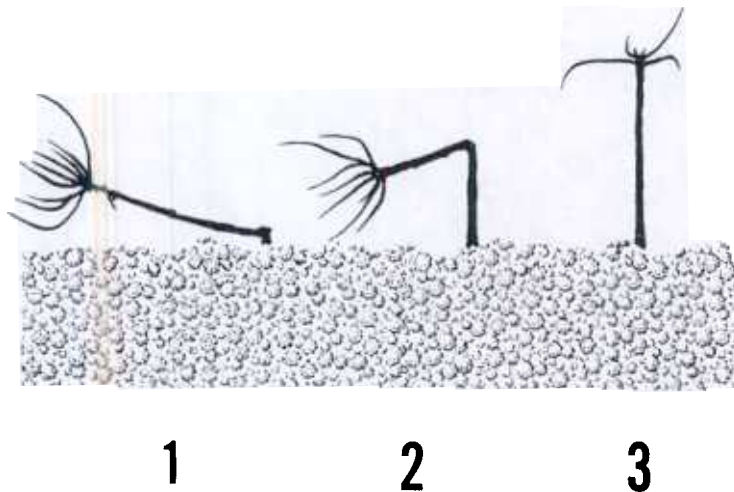


FIGURE 1. Illustration of three kinds of damage:

1. Stem broken at groundline (supported)
2. Stem broken above groundline (not supported)
3. Stem not broken, but most cotyledons broken off

We also marked seedlings that had emerged after the hail storm, with steel rings and yellow toothpicks. The ten plots varied in length, and each contained from 15 to 26 damaged seedlings and 0 to 5 late germinants.

## RESULTS

A steady loss of damaged seedlings occurred throughout the growing season; when a final evaluation was made on November 7, only 43 percent of the seedlings that had been marked were still alive (Table 1). Survival of seedlings with stems broken at the groundline was best; it was next best for seedlings with all but one or two cotyledons broken off, and worst for seedlings with stems broken above the groundline. Only half of the late germinants survived.

Table 1. Number of seedlings marked on June 7 and still alive on November 7

Plot Location	Damage Class						Totals		Late Germinants		
	1		2		3		6/7	11/7	6/7	11/7	
	6/7	11/7	6/7	11/7	6/7	11/7					
W1	Z-3	5	4	5	4	5	5	15	13	5	5
	FF-5	5	3	5	1	5	2	15	6	5	3
W2	V-6	5	3	5	1	5	4	15	8	0	-
	X-6	10	6	11	1	5	3	26	10	0	-
	II-8	5	1	5	1	5	2	15	4	3	1
W3	CC-2	5	2	5	1	5	2	15	5	5	2
	II-5	10	8	10	1	2	0	22	9	2	1
	QQ-5	5	4	6	2	4	0	15	6	5	3
FW1	K-7	5	4	5	2	5	2	15	8	0	
FW3	D-7	<u>5</u>	<u>2</u>	<u>5</u>	<u>1</u>	<u>5</u>	<u>1</u>	<u>15</u>	<u>4</u>	<u>5</u>	<u>0</u>
Totals		60	37	62	15	46	21	168	73	30	15
% Survival		62		24		46		43		50	

Growth of surviving seedlings varied considerably according to type of damage (Table 2 and Figure 2). Seedlings with stems broken at the groundline grew most, seedlings with stems broken above the groundline were intermediate in growth, and seedlings with only one or two cotyledons grew least. Late germinants grew slightly better than seedlings with stems broken above the groundline. The average root collar diameter for the Nursery as a whole was 4.9/32 inch, based on seedlings lifted and measured from the 54 permanent plots in November.

Seedlings with broken stems grew surprisingly well. Compression wood straightened the stem where it had broken, and by the end of the season only a slight angular offset and/or a small swelling remained of the injury. On many seedlings the break was hardly noticeable (Figure 2). Seedlings that lost most of their cotyledons grew poorly, and some were stunted so badly that they were no larger in November than they were in early June. It was possible in November to find living seedlings with only the one or two cotyledons that survived the hail storm. Late germinants never caught up with undamaged or lightly damaged seedlings that germinated earlier.

Table 2. Average root collar diameter (32<sup>nd</sup> of inch) and top length (inches) on November 7

Damage Class	Root Collar Diameter		Average Top Length <sup>1/</sup>	
	Mean	Range	Mean	Range
1	4.7	2 to 8	6.1	2 to 9
2	3.7	2 to 6	5.0	1 to 7
3	3.0	2 to 5	4.0	1 to 7
Late Germinants	3.9	2 to 6	5.7	4 to 7

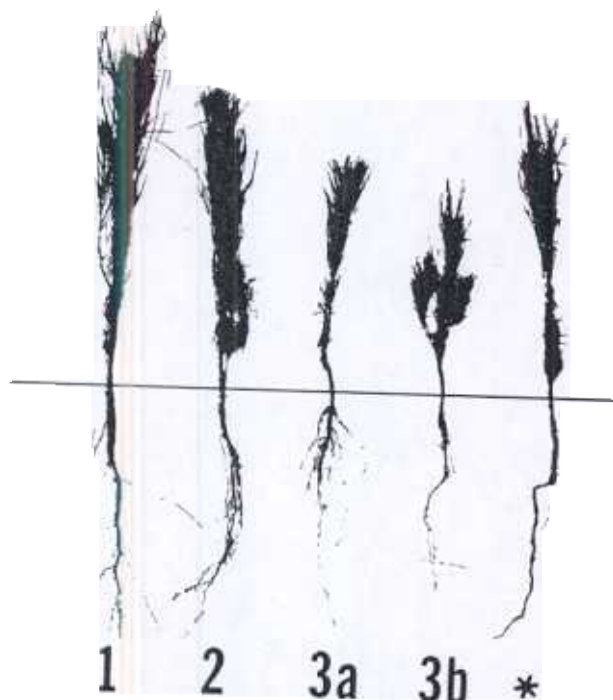


FIGURE 2. Typical seedlings, of average root collar diameter and top length, from each damage class:

1. Stem broken at groundline
2. Stem broken above groundline
3. Stem not broken, but most cotyledons broken off
  - a. Average size
  - b. Shrubby seedling that frequently resulted from this kind of damage

\* Typical late germinant

<sup>1/</sup> The seedling crop was top-clipped three different times: during the second week of August and the first and fourth weeks of September. Clipping heights were approximately 6 to 7 inches for the first clipping and 7 to 8 inches for the second and third clippings. Approximately 50 percent of the seedlings were clipped at least once, and seedlings cut at the first clipping were generally cut again at the third clipping.

Many severely damaged seedlings developed multiple leaders, and in many cases none of the leaders assumed dominance. Many of these "shrubby" seedlings never grew tall enough to plant (Figure 2, 3b). The ranges in top length in Table 2 also illustrate this: some severely damaged seedlings were only one or two inches tall on November 7, while late germinants (which, of course, were not damaged) were all at least four inches tall.

The losses from the hail storm forced us to reduce our minimum root-collar diameter for a plantable seedling to 2.5/32 inch. By this standard, the percentages of surviving seedlings that were plantable were 86, 60 and 33 percent for damage categories 1, 2, and 3 respectively, and 73 percent for late germinants. For the Nursery as a whole, the estimate was 93 percent, based on the 54 permanent sample plots. Percentages of plantable seedlings based on the numbers initially marked on June 7 are 53, 15, 15, and 37 percent for damage classes 1, 2, 3 and late germinants respectively. For the crop as a whole, 81 percent were plantable, based on the initial counts made on the 54 permanent plots on May 27. This 81 percent is considerably lower than what is attained in a normal year with no hail storms. In 1981 and 1982, 94 and 97 percent of the seedlings present on June 1 had a root collar diameter of 2.5/32 inch or larger by November.