WSRC-RP-89-1288

OCTOBER 1, 1989 TORNADO AT THE SAVANNAH RIVER SITE (U)

JANUARY 1990

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

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by

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ABSTRACT

A tornado with wind speeds in the 113 to 157 mph (F2) range struck the southern portion of the Savannah River Site near Aiken, SC at around 7:30 pm on October 1, 1989. The tornado was spawned from a severe thunderstorm with a height of 57,000 ft in a warm and humid air mass. Two million dollars in timber damage occurred over 2,500 acres along a ten-mile swath, but no onsite structural damage or personal injury occurred. Tree-fall patterns indicated that some of this damage was the result of thunderstorm downbursts which accompanied the tornado. Ground-based and aerial photography showed both snapped and mowed over trees which indicate that the tornado was elevated at times.

CONTENTS

INTRODUCTION 1

TORNADO DAMAGE 1

SYNOPTIC CONDITIONS 2

TORNADO CHARACTERISTICS 3

REFERENCES 5

LIST OF FIGURES

1 Swath of damage (hashed area) of the October 1, 1989 tornado at the SRS 6
2 Aerial view showing multiple tree-fall directions 7
3 Tree-falls approximately 70 degrees apart 8
4 Tree-falls approximately 70 degrees apart 9
5 Stand of hardwoods with considerable damage 10
6 Extensive area of downed pine forest 11
7 Broken and snapped pines near Road A-18 near Williams Cemetery 12
8 An approximately 15-ft-high root ball resultant from the fall of four pine trees just south of Gate 23 on Road 9. The tree diameters were (1) 24 in., (2) 18 in., and (1) 8 in.. (The height of the ruler and person are 15 in. and 6 ft, respectively.) 13
9 A severely damaged pine forest just south of Gate 23 on Road 9 showing breaks at different levels 14
10 Close up of broken pine over 15 in. (ruler length) in diameter just south of Gate 23 on Road 9 15
11 Two projectiles just south of Gate 23 on Road 9. The splinter (lower left adjacent to 15-in. ruler) and branch (lower right) were impacted 8 and 15 in. deep, respectively 16
12 Large snapped and split pine tree with a 6-ft person near Gate 23 17
13 A toppled hardwood on a felled pine (about 30-in. diameter) near Gate 23 18
14 Uprooted and broken pine forest about 1 mile southeast of Gate 23 off Road A-18 (Tennessee Road). Note how few trees are standing in the distance. This damage path width was estimated to be 0.5 mile 19
15 Broken hardwood near Road A-18 about 1.5 miles east of Gate 23 on Road A-18. 20
16 Surface analysis for 8 p.m. 01 Oct 1989 21
17 Radar summary for 7:35 p.m. 01 Oct 1989 21
18 500 mb heights (dekameters) for 8 p.m. 01 Oct 1989 22
19 850 mb heights (dekameters) for 8 p.m. 01 Oct 1989 22
20 SRS tower data for the 15-minute period ending at 7:30 p.m. 23
21 SRS tower data for the 15-minute period ending at 7:45 p.m. 24
22 SRS tower data for the 15-minute period ending at 8:00 p.m. 25
23 SRS tower data for the 15-minute period ending at 8:15 p.m. 26
24 Tree-fall directions for the area south of Tennessee Road 27
25 Downed pines showing a divergent tree-fall pattern 28

LIST OF TABLES

A. Rainfall Amounts for the 24-hr period ending October 2, 1989 3
B. Tornado Strength Scale 4

OCTOBER 1, 1989 TORNADO AT THE SAVANNAH RIVER SITE (U)

INTRODUCTION

On the evening of October 1, 1989 a severe thunderstorm accompanied by a tornado and downbursts occurred at the Savannah River Site. The tornado struck the site around 7:30 p.m. and cut a path of damage 1/2 to 1 mile wide and 10 miles long across the southern part of the site. Because the tornado was confined to uninhabited areas, no injuries were reported. Property damage was limited to an offsite house and trailer near Snelling, SC. However, two million dollars of timber damage covering over 2,500 acres resulted.

The first hint of the possibility of severe weather came with the 5:15 p.m. forecast from the National Weather Service (NWS) which predicted an 80% chance of rain with possible thunderstorms. By 7:24 p.m., the NWS issued a severe thunderstorm warning for western Aiken County until 8:15 p.m.. Another severe thunderstorm warning was issued at 8:04 p.m. until 8:30 p.m. for southern Barnwell County for the same thunderstorm which had continued to track to the northeast. A tornado watch was issued at 8:25 p.m. until 3:00 a.m. by the Severe Storms Forecast Center in Kansas City, MO. Based on this information, the tornado most likely occurred around 7:30 p.m.. (Newspaper reports in the *Augusta Herald* indicated that damage was observed at 9:00 p.m. near Snelling in Barnwell County.)

Wackenhut inspectors D.E. Buck and G.C. O'Neal stationed at Barricade 5 (at the intersection of Road 9 and SC 125) reported very heavy rain, vivid lightning, and strong winds at the time of the storm passage. The wind was strong enough to "push" Mr. O'Neal back into the doorway as he attempted to leave the gate shelter. Barricade 5 was subsequently closed for about 5 hours due to downed trees in the nearby area. Inspector G.W. Jenkins, who was stationed at Barricade 4 (at the intersection of Road G and Road B (SC 64)) during the storm, also reported very heavy rain, frequent lightning with numerous nearby strikes, and strong winds, and that a power generator became necessary when the power was knocked out by the storm.

The October 1 tornado is the first documented tornado at the SRS since April 23, 1983 (Garrett, 1983).

Tornado Damage

The tornado path extended across the south of the SRS from the WSW to the ENE and generally followed Road A-18 (Tennessee Road) (see Figure 1). Tree damage occurred in the Savannah River swamp near Stave Island and reports of damage were received from areas in Georgia west of the Savannah River. The furthest east of any reported property damage was offsite near Snelling, SC on the east side of the SRS. It is possible that the tornado touched down in rural areas outside the SRS, but this was not reported.

The width of the tornado track was variable but, according to aerial photos obtained by the U. S. Forest Service-Savannah River Station, varied between 1/4 and 1 mile wide. The track of major damage was observed to be 1/3 to 1/2 mile wide and was bordered by areas with isolated tree damage.

Aerial photos of several tree damaged areas are shown in Figures 2, 3, 4, 5, and 6. Figure 2 shows pine trees scattered in several directions. Closer inspection reveals a preferential orientation of trunks in two directions approximately 90 degrees apart. Figures 3 and 4 show areas of uprooted and broken off pine trees with trunks lying about 70 degrees apart. Figure 5 shows a stand of mainly hardwoods mowed over by the storm. Figure 6 shows an extensive area of downed pine trees. As in Figures 3 and 4, the trees have fallen mainly in two directions separated by about 70 degrees.

A better appreciation of the extent of damage can be gained from ground-based photographs. Figure 7 shows a pine forest near Williams Cemetery on Road A-18 with mowed down and snapped trees. The largest trees in this area are approximately 1 ft in diameter.

Figures 8, 9, 10, 11, 12 and 13 were taken in the mature forest 1/4 mile south of Gate 23 on Road 9. This area is significant because no evidence of surface high winds was found. Rather, only the taller, mature trees were felled or broken. This pattern implies that the tornado was above the ground in this area. Figure 9 shows the large number of trees broken off 15 to 25 ft above the ground in this area. The branches on the ground in the picture's foreground are from upper sections of tree trunks.

Figures 10, 12 and 13 show some of the largest pine trees destroyed by the tornado. Figures 10 and 12 show 18-inch-diameter pines broken off 6 ft and 18 ft above ground, respectively. Figure 13 is a 13-inch pine tree felled by the tornado.

Figure 11 shows two projectiles stuck in the ground in this area. The 3-inch-diameter branch was buried in the ground to a depth of 8 inches. Overall, however, projectile damage was rarely observed.

The photographs in Figures 14 and 15 were taken about 1 mile southeast of Gate 23 off of Road A-18. Few trees were left standing in this area, and even small trees showed the effects of high winds.

Figure 15 shows one of the largest hardwoods snapped by the tornado. The tree is 18 inches in diameter at the base and was broken off 15 feet above the ground.

Synoptic Conditions

Figure 16 shows the 8 p.m. surface analysis for the southeastern U. S. A cold front extended from the Gulf of Mexico across Florida to northwestern Georgia where it intersected with a stationary front which passed through South Carolina. A trough of low pressure reached from this intersection into central Tennessee. The radar summary from 7:35 p.m. on October 1, 1989 is shown in Figure 17. The bulk of the precipitation is shown to the east of this system with the heaviest activity in the warm, moist unstable air to the south of the stationary front and to the east of the cold front. Individual thunderstorm heights of up to 57,000 ft are shown in the SRS vicinity. It should be noted that heights of 50,000 ft plus are infrequent over the Southeast. A severe thunderstorm warning had been issued for western Aiken County at this time.

The upper levels of the atmosphere showed that a high pressure ridge was situated off the southeast coast (Figure 18) with a trough suggested over the Tennessee area (Figures 18 and 19) This pattern was conducive to a large moisture influx from the Gulf of Mexico to the southeast throughout the lower half of the atmosphere.

The mesoscale wind pattern for the thunderstorm is shown by the 15-minute averages of wind speed and direction from the eight 60-meter instrumented towers located at the SRS. This array of towers is designed for emergency response to effluent releases and is not capable of detecting a tornado unless a direct strike of one of the towers occurs. Since the nearest tower was several miles from the tornado, these towers did not detect the tornado directly but did detect some characteristic tornado features. These features include local cyclonic flow patterns and strong wind gusts.

The first indication of a thunderstorm occurred after 7:30 p.m. (Figure 20) when a cyclonic flow pattern was observed over the southern part of the SRS. This flow pattern existed through 8:15 p.m. (Figures 21-23), and gusts up to 34 mph were observed during this period. Spatial wind direction variation suggested that a thunderstorm passed over the southern portions of the SRS. Higher wind speeds would be expected in a thunderstorm which produced a tornado, but none of the area towers appeared to be in the path of the thunderstorm cell. The tower observations are consistent with the timing of two severe thunderstorm warnings issued for western Aiken and southern Barnwell Counties by the National Weather Service. However, no indication of the existence of a tornado was shown.

Rainfall amounts over the SRS were very heavy on October 1, 1989. Amounts ranged from 1.90 inches at A-Area to 3.68 inches in D-Area, and Table A. lists all of the reported rainfall amounts.

Table A. Rainfall Amounts for the 24-hr period ending October 2, 1989

Location	Amount (inches)
Barricade 2	2.00
Barricade 3	2.25
Barricade 5	3.00
773A	1.95
700A	1.90
100C	2.25
400D	3.68
200F	2.88
200H	2.50
100K	3.25
100L	3.00
Bush Field (AGS)	1.52

Tornado Characteristics

When inspecting damage from severe weather, it is often difficult to distinguish between tornadic and downburst (thunderstorm downdraft) destruction. Many times the two phenomena occur together. Dr. T. Theodore Fujita of the University of Chicago has spent his career making such reports and has written two guide books [Fujita (1978 &1985)] that are extremely useful tools for assessing such damage. Distinguishing between the two can be done with aerial and ground based inspections of damaged areas.

According to Fujita, tornado damage is distinguishable from downbursts by circular tree-fall patterns when viewed from above. Figure 24 shows tree fall directions in the damage swath to the east of Road 9. Arrows indicate the direction of felled trees in this area. These

directions strongly suggest that the small scale and highly cyclonic wind circulation of a tornado passed over the area. On a slightly smaller scale, Figure 2 shows many directions of felled trees indicative of tornado damage.

While most of the damage to the SRS was caused by the tornado some areas show evidence of downbursts. Downburst damage is characterized by divergent rather than circular tree fall patterns when viewed from above. Such a divergent pattern is shown in Figure 25.

The accepted method of rating relative tornado intensities is the F scale developed by Fujita (1971). Table B lists the various F scales, winds, and associated damage.

Table B. Tornado Strength Scale

F 0	Light	40-72 mph	TV antennae bent; breaks twigs off trees; mobile homes pushed over
F 1	Moderate	73-112 mph	Mobile homes overturned; weak trees uprooted; outbuildings blown down
F 2	Considerable	113-157 mph	Roofs off houses; light-object missiles generated; weak structures smashed
F 3	Severe	158-206 mph	Walls torn off houses; trees in forest flattened; large missiles generated
F 4	Devastating	207-260 mph	Well-constructed houses flattened; large missiles generated; some trees debarked
F 5	Incredible	261-310 mph	Strong structures blown off; trees debarked by wind; high-speed missiles generated

The highest wind speeds were estimated to be in the F2 category (113 to 157 mph). The maximum wind speed associated with this storm was estimated based on the observed damage to hardwood and pine trees. Most trees were either uprooted or sheared off at elevated levels, but little evidence of projectile damage or debarked trees was noted. The heights of the sheared breaks varied widely which seems to suggest that the base of the tornado was elevated at times. This elevation was especially evident in one particular stand of mixed pine and hardwood forest where the only trees that were damaged were pines (3 ft base diameter) that were taller than the surrounding forest. Other forest areas which were 80% flattened are indicative of direct contact between the funnel cloud and the ground. A rating of F2 was corroborated by Robert Storey of the Augusta office of the National Weather Service after inspecting the SRS tornado damage.

References

Fujita, T. 1971. *Proposed Characterization of Tornadoes and Hurricanes by Area and Intensity.* SMRP Research Paper No. 91. University of Chicago. 42 pp.

_____. 1978. *Workbook of Tornadoes and High Winds for Engineering Applications.* SMRP Research Paper No. 165. University of Chicago. 142 pp.

_____. 1985. The Downburst: Microburst and Macroburst. The University of Chicago. 82 pp.

Garrett, A. J. 1983. *April 23, 1983 Tornado at the Savannah River Plant.* E. I. du Pont de Nemours & Co., Savannah River Laboratory Aiken, SC. DP-1667. 23 pp.

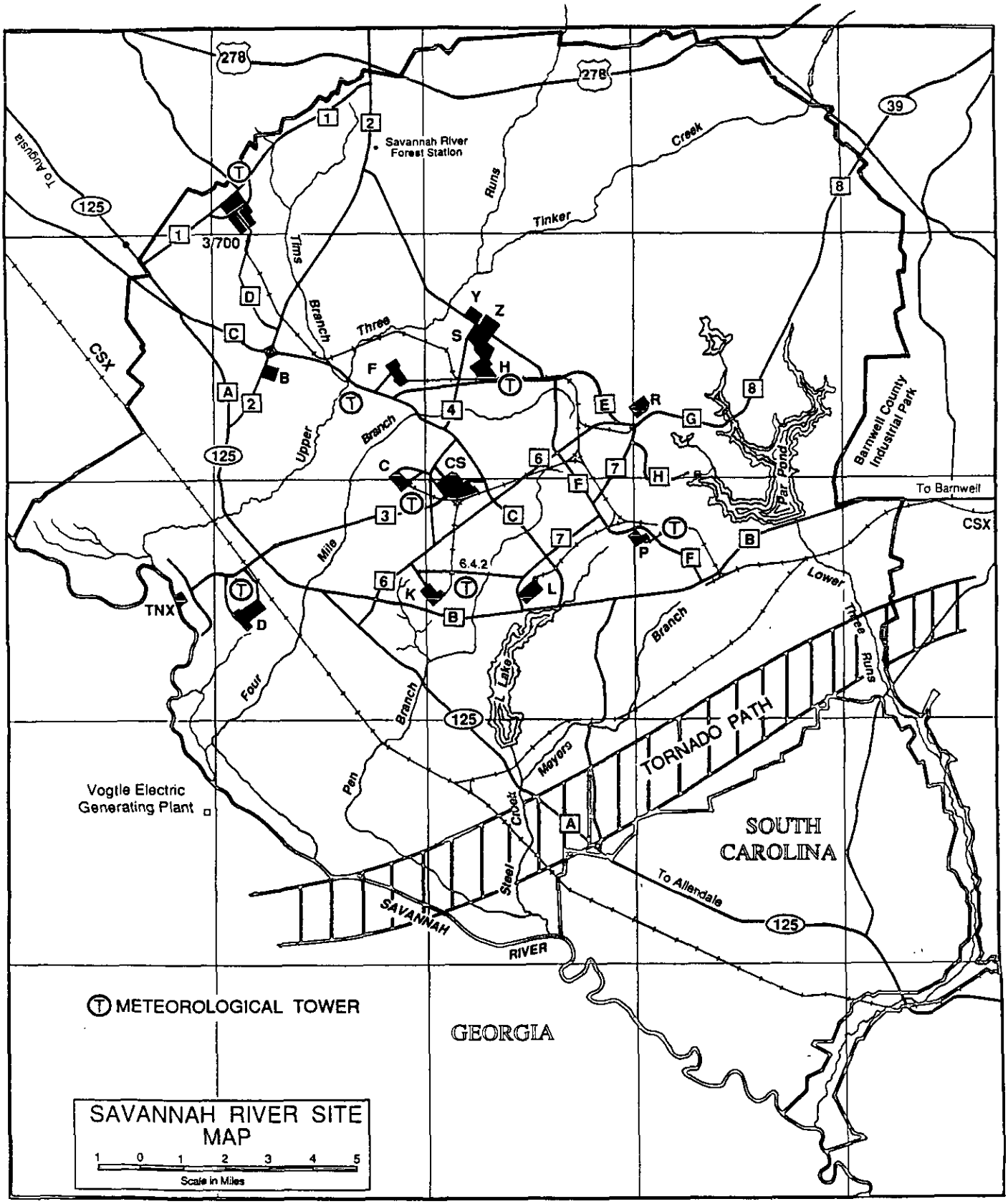


Figure 1. **Swath of damage (hashed area) of the October 1, 1989 tornado at the SRS.**

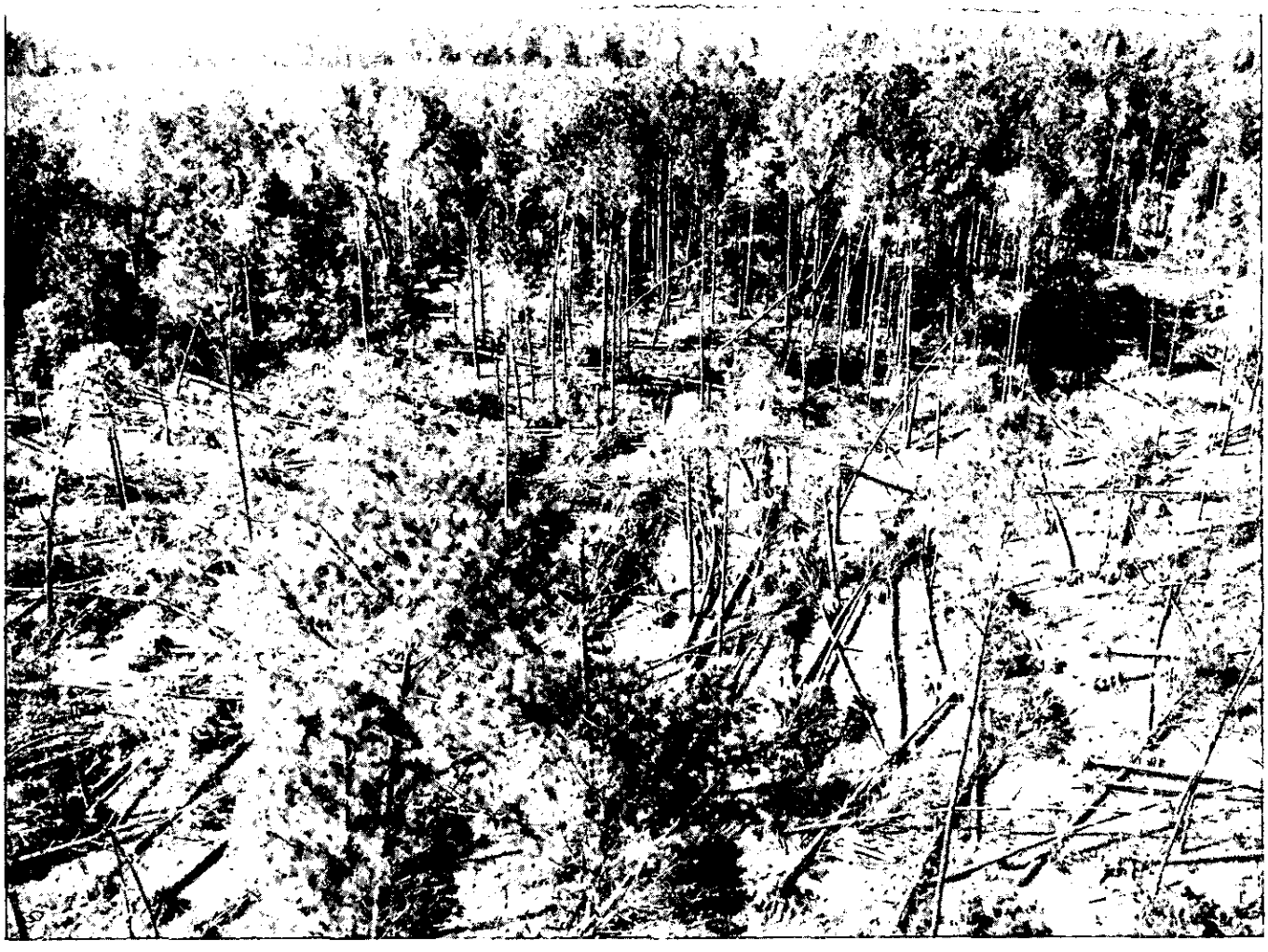


Figure 2. Aerial view showing multiple tree-fall directions.

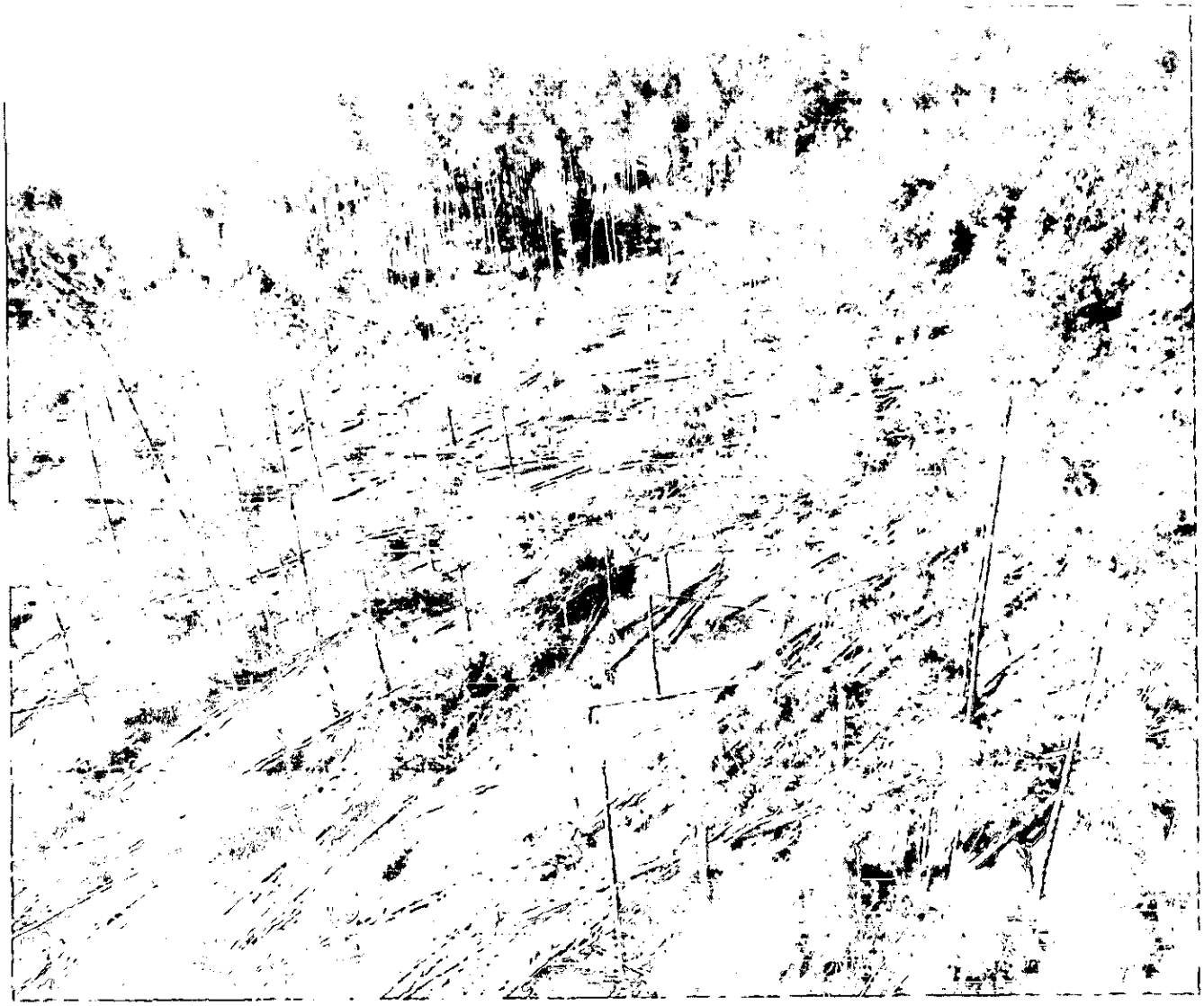


Figure 3. Tree-falls approximately 70 degrees apart.

Figure 4. Tree-falls approximately 70 degrees apart.

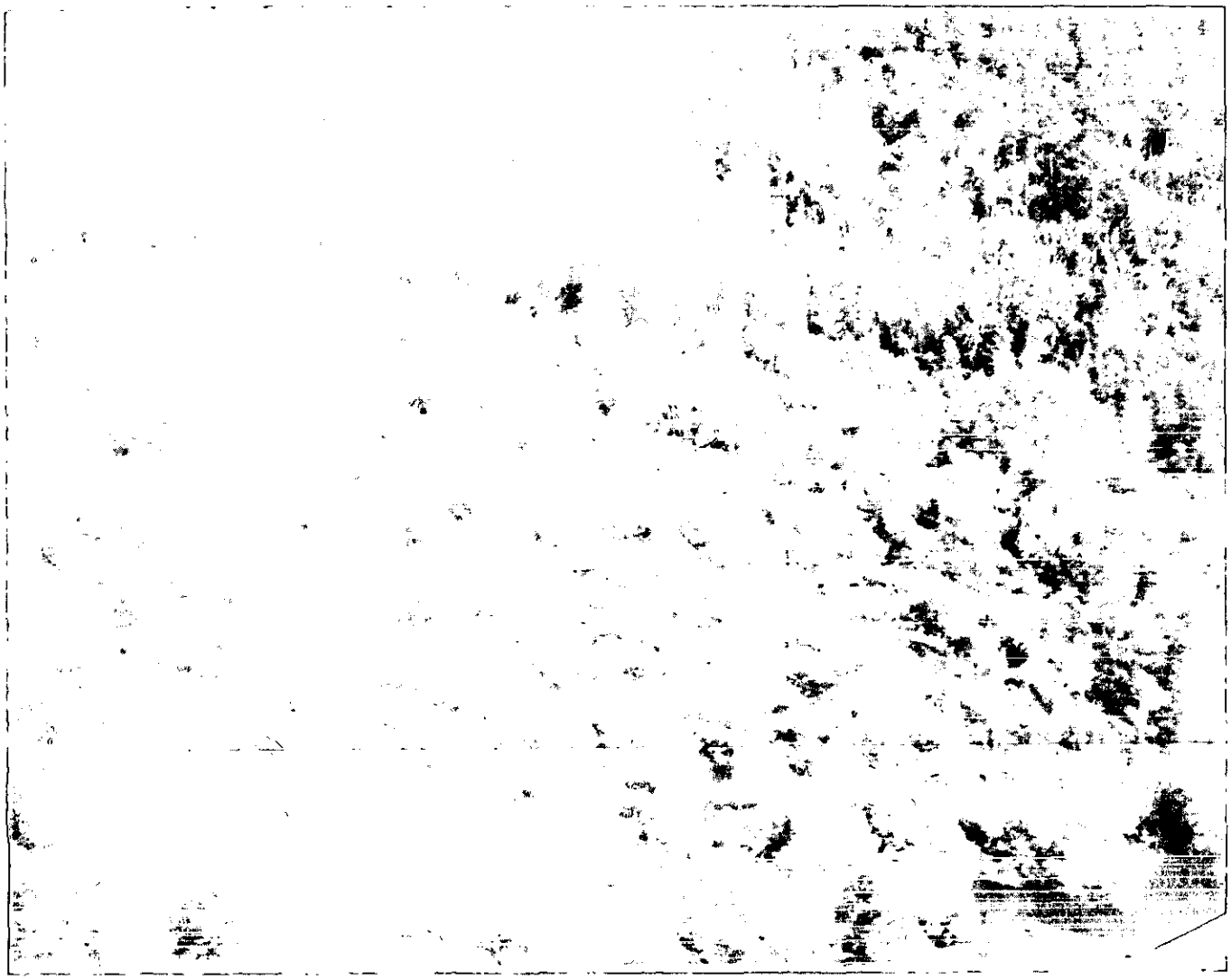


Figure 5. Stand of hardwoods with considerable damage.

Figure 6. Extensive area of downed pine forest.

Figure 7. **Broken and snapped pines near Road A-18 near Williams Cemetery.**

Figure 8. **An approximately 15-ft-high root ball resultant from the fall of four pine trees just south of Gate 23 on Road 9. The tree diameters were (1) 24 in., (2) 18 in., and (1) 8 in.. (The height of the ruler and person are 15 in. and 6 ft, respectively.)**

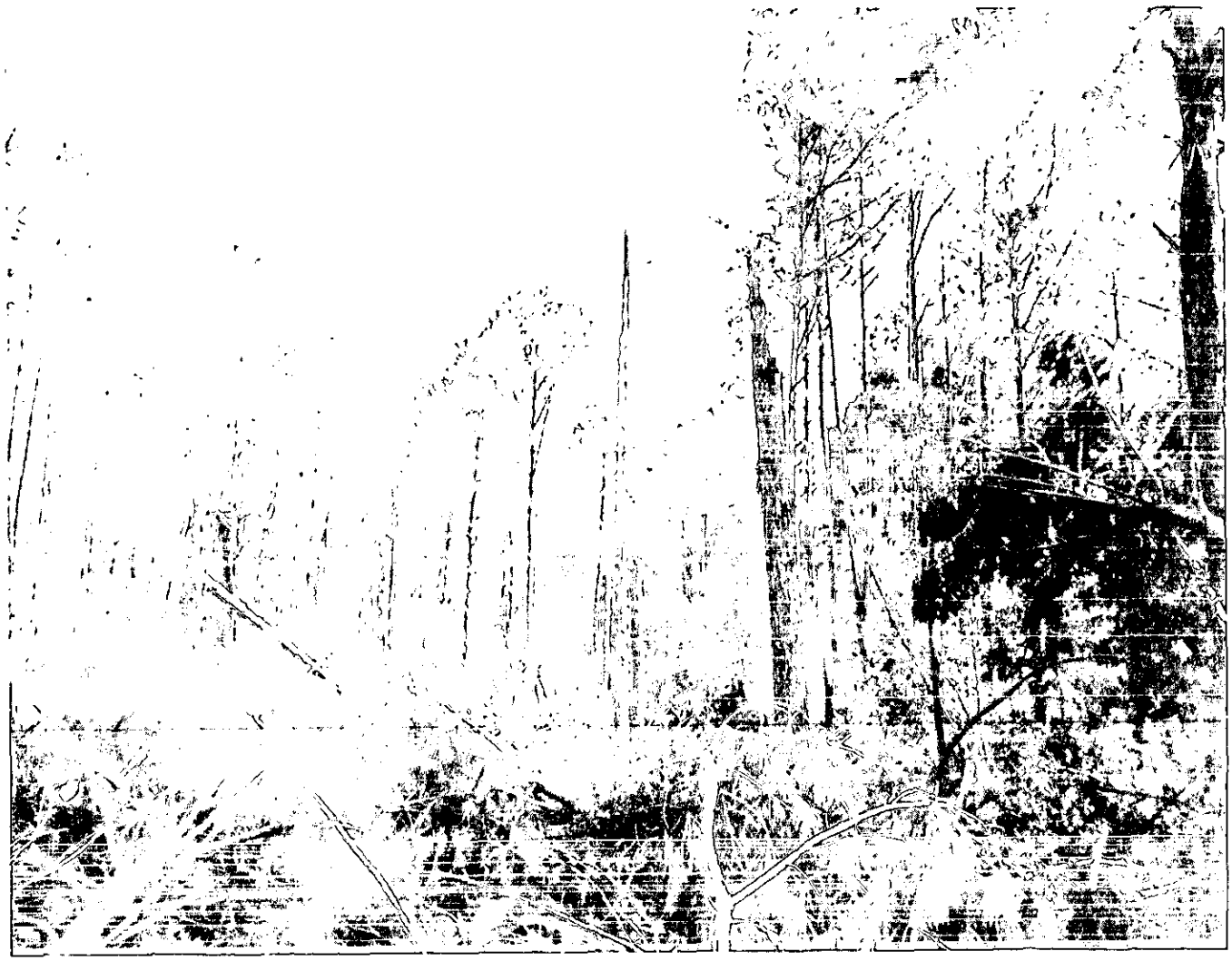


Figure 9. **A severely damaged pine forest just south of Gate 23 on Road 9 showing breaks at different levels.**

Figure 10. Closeup of broken pine over 15 in. (ruler length) in diameter just south of Gate 23 on Road 9.

Figure 11. Two projectiles just south of Gate 23 on Road 9. The splinter (lower left adjacent to 15-in. ruler) and branch (lower right) were impacted 8 and 15 in. deep, respectively.

Figure 12. Large snapped and split pine tree with a 6-ft person near Gate 23.

Figure 13. A toppled hardwood on a felled pine (about 30-in. diameter) near Gate 23.

Figure 14. Uprooted and broken pine forest about 1 mile southeast of Gate 23 off Road A-18 (Tennessee Road). Note how few trees are standing in the distance. This damage path width was estimated to be 0.5 mile.

Figure 15. Broken hardwood near Road A-18 about 1.5 miles east of Gate 23 on Road A-18.

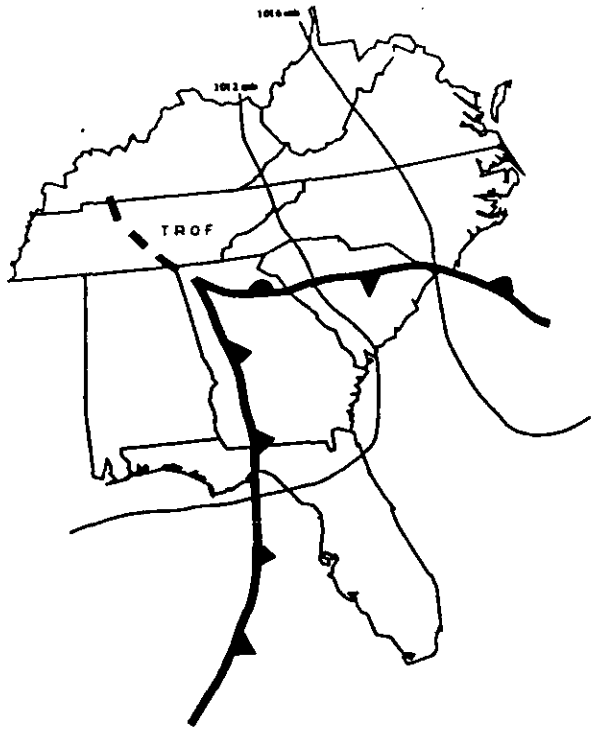


Figure 16. Surface analysis for 8 p.m. 01 Oct 1989.

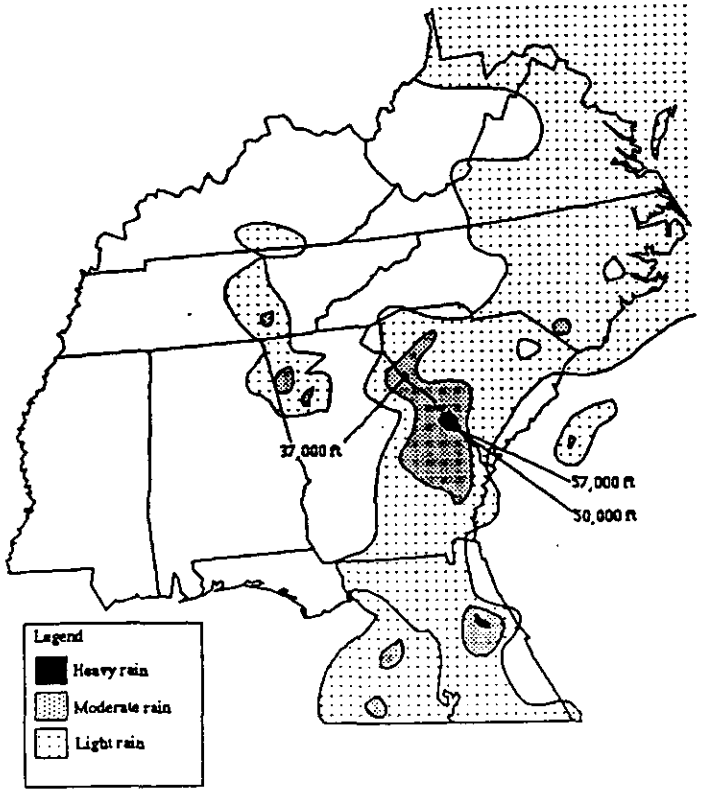


Figure 17. Radar summary for 7:35 p.m. 01 Oct 1989.

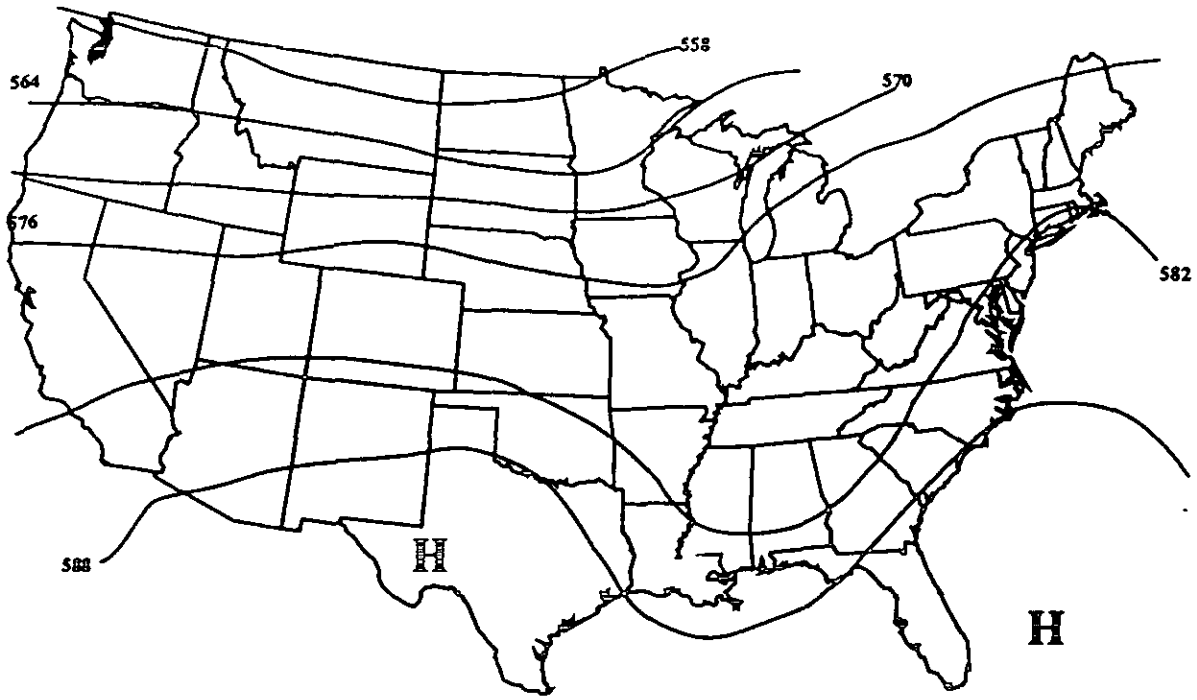


Figure 18. 500 mb heights (dekameters) for 8 p.m. 01 Oct 1989.

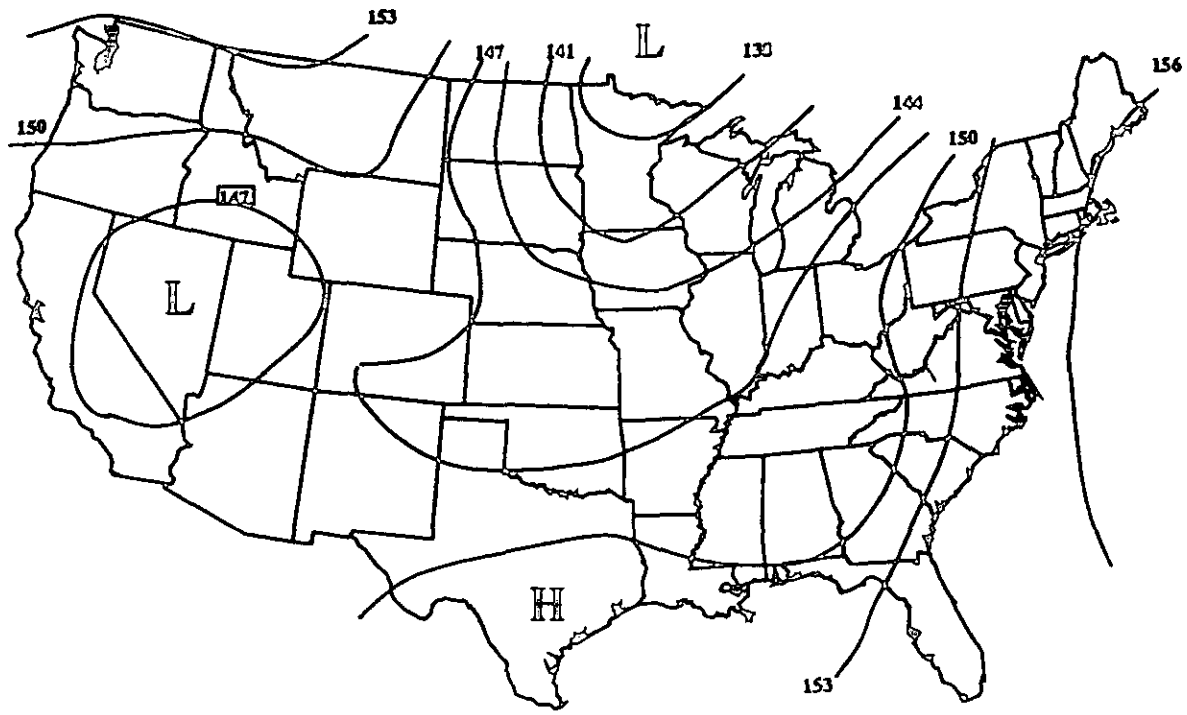
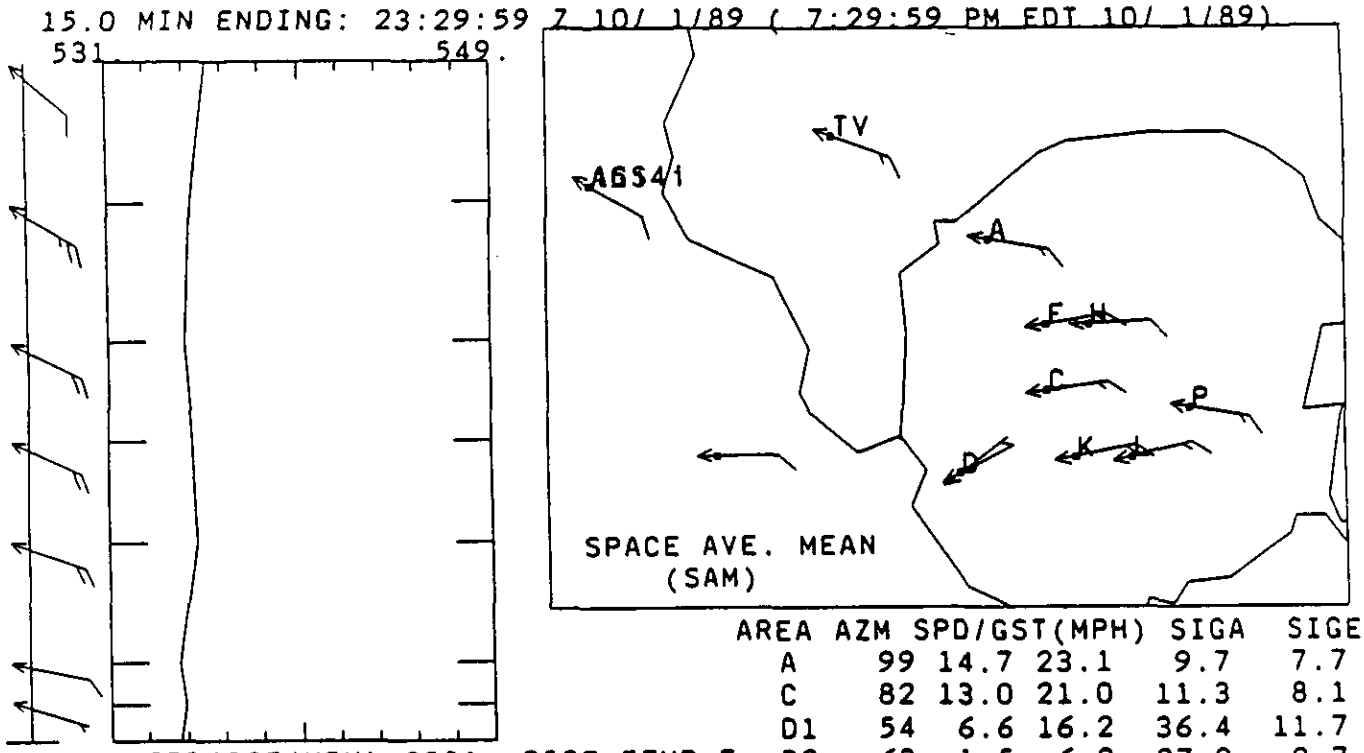


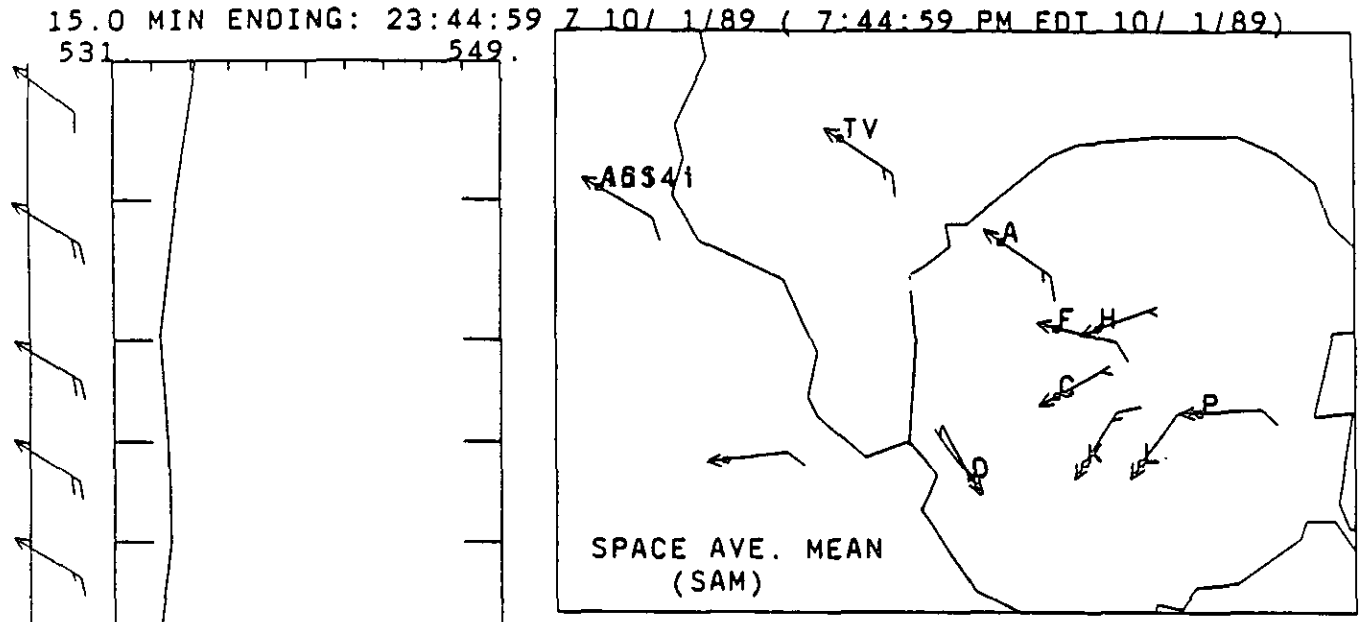
Figure 19. 850 mb heights (dekameters) for 8 p.m. 01 Oct 1989.



HT	AZM	SPD/GST(MPH)		SIGA	SIGE	TEMP F
999F	134.	11.5	20.6	6.6	4.7	70.72
800F	124.	23.6	32.5	5.7	4.3	71.00
600F	120.	22.0	27.8	6.1	4.3	71.73
450F	118.	19.5	26.0	5.8	5.2	72.84
300F	113.	18.3	26.2	6.7	6.7	73.84
120F	104.	10.9	19.4	11.3	11.0	73.95
59F	109.	6.5	15.8	22.0	24.7	74.49
7F						74.57

AREA	AZM	SPD/GST(MPH)		SIGA	SIGE
A	99	14.7	23.1	9.7	7.7
C	82	13.0	21.0	11.3	8.1
D1	54	6.6	16.2	36.4	11.7
D2	63	1.5	6.0	27.0	9.7
F	81	13.9	21.4	9.6	8.2
H	88	10.4	18.1	14.3	10.8
K	78	14.1	21.8	11.1	9.5
P	99	14.3	23.3	11.9	9.2
L	76	14.0	21.5	11.8	8.4
TV	109	14.6	26.2	8.6	8.5
SAM	89	12.3	26.2	12.8	8.9
AGS	120	9.2(-99.0/-99.0			ST:4)

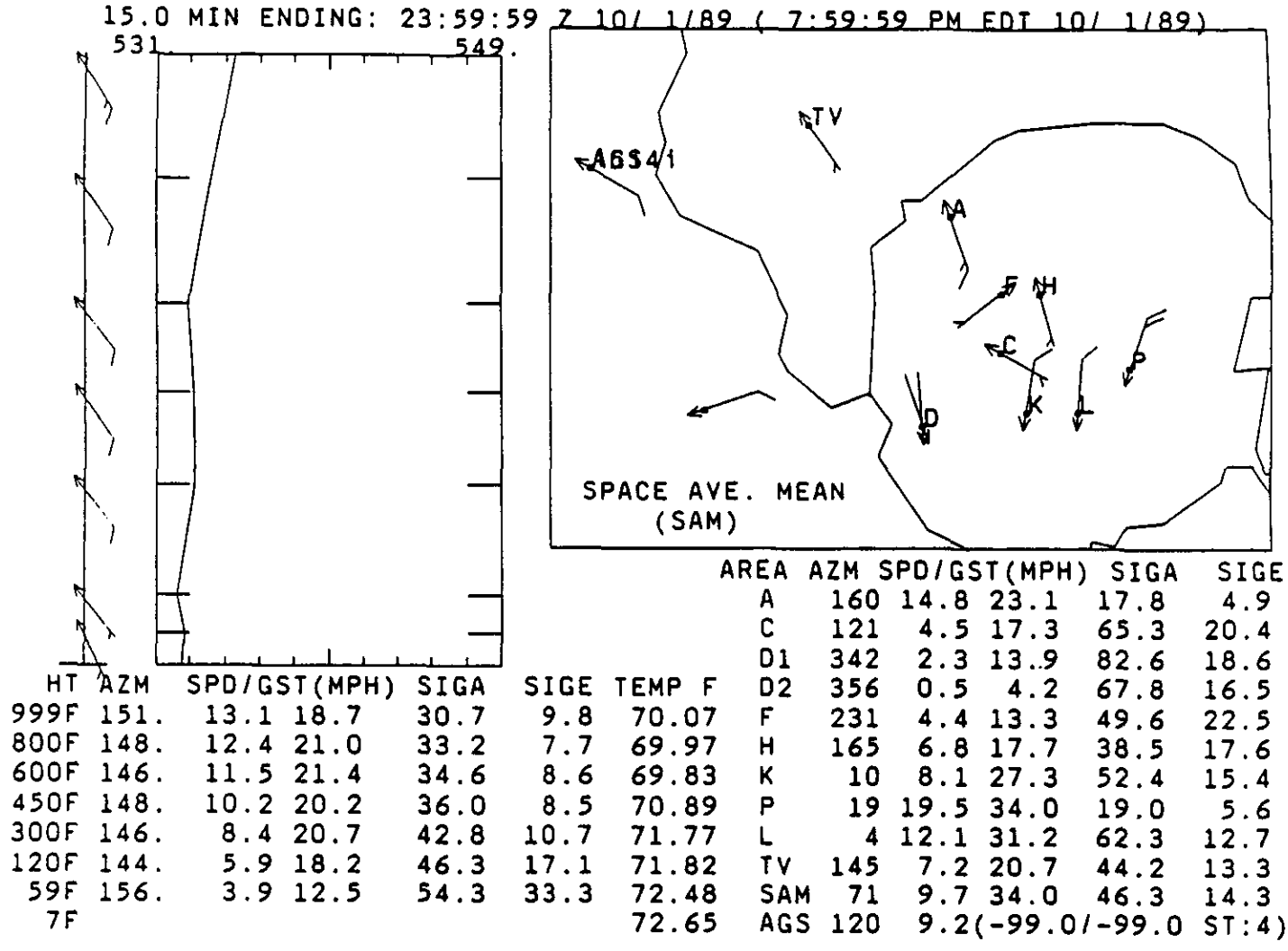
Figure 20. SRS tower data for the 15-minute period ending at 7:30 p.m..



HT	AZM	SPD/GST(MPH)		SIGA	SIGE	TEMP F
999F	133.	12.0	18.7	10.8	6.2	69.82
800F	125.	20.3	28.7	9.8	5.6	69.94
600F	125.	19.7	26.6	10.5	5.5	70.29
450F	128.	17.6	25.5	11.0	6.8	71.40
300F	126.	16.9	27.7	13.5	8.7	72.32
120F	123.	10.2	23.6	18.6	13.6	72.63
59F	132.	6.2	17.7	28.2	24.6	73.47
7F						73.81

AREA	AZM	SPD/GST(MPH)		SIGA	SIGE
A	124	15.2	22.9	14.4	6.6
C	61	7.1	17.1	17.5	10.6
D1	325	5.4	13.2	53.9	12.0
D2	334	1.0	4.3	49.4	11.6
F	103	9.2	16.8	27.4	9.8
H	70	6.6	17.3	20.4	15.2
K	33	12.9	22.4	22.7	8.3
P	87	11.3	19.4	24.3	8.6
L	35	11.4	25.2	28.6	9.0
TV	125	13.6	27.7	15.6	10.8
SAM	83	9.8	27.7	24.5	10.1
AGS	120	9.2(-99.0/-99.0			ST:4)

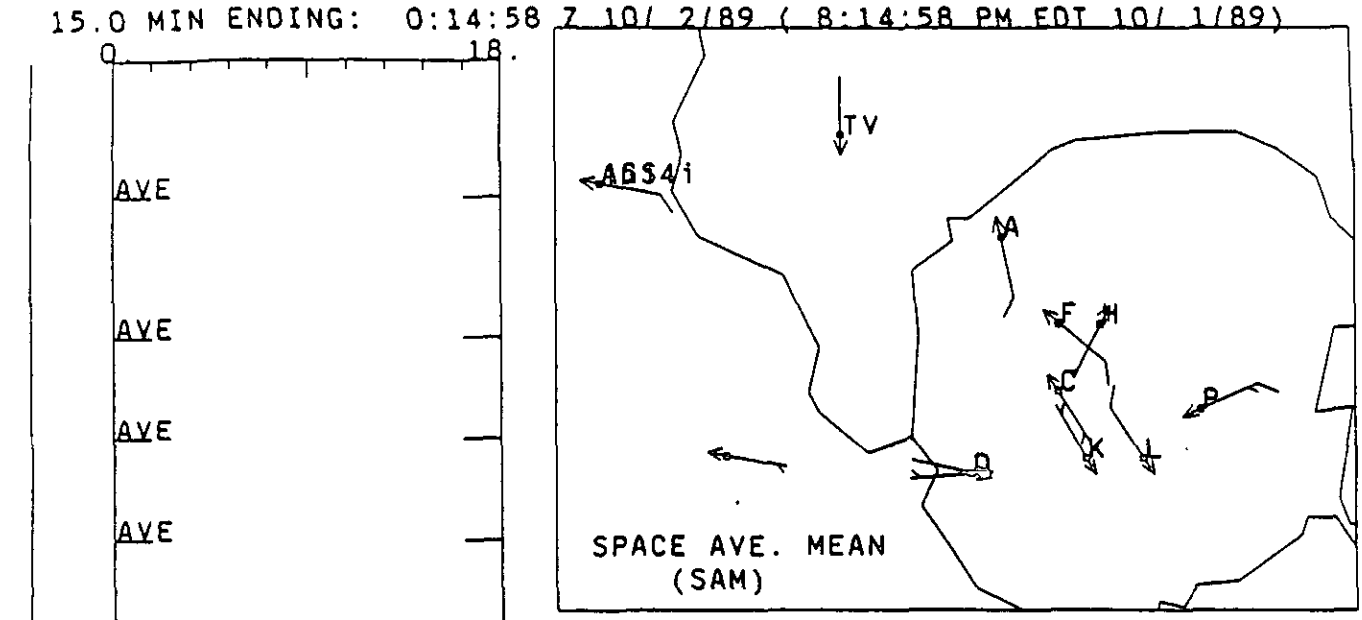
Figure 21. SRS tower data for the 15-minute period ending at 7:45 p.m..



HT	AZM	SPD/GST(MPH)	SIGA	SIGE	TEMP F
999F	151.	13.1 18.7	30.7	9.8	70.07
800F	148.	12.4 21.0	33.2	7.7	69.97
600F	146.	11.5 21.4	34.6	8.6	69.83
450F	148.	10.2 20.2	36.0	8.5	70.89
300F	146.	8.4 20.7	42.8	10.7	71.77
120F	144.	5.9 18.2	46.3	17.1	71.82
59F	156.	3.9 12.5	54.3	33.3	72.48
7F					72.65

AREA	AZM	SPD/GST(MPH)	SIGA	SIGE
A	160	14.8 23.1	17.8	4.9
C	121	4.5 17.3	65.3	20.4
D1	342	2.3 13.9	82.6	18.6
D2	356	0.5 4.2	67.8	16.5
F	231	4.4 13.3	49.6	22.5
H	165	6.8 17.7	38.5	17.6
K	10	8.1 27.3	52.4	15.4
P	19	19.5 34.0	19.0	5.6
L	4	12.1 31.2	62.3	12.7
TV	145	7.2 20.7	44.2	13.3
SAM	71	9.7 34.0	46.3	14.3
AGS	120	9.2(-99.0/-99.0		ST:4)

Figure 22. SRS tower data for the 15-minute period ending at 8:00 p.m..



HT	AZM	SPD/GST(MPH)		SIGA	SIGE	TEMP F
999F	0.?	0.0?	0.0?	0.0?	0.0?	32.00?
800F	0.?	0.0?	0.0?	0.0?	0.0?	32.00?
600F	0.?	0.0?	0.0?	0.0?	0.0?	32.00?
450F	0.?	0.0?	0.0?	0.0?	0.0?	32.00?
300F	0.?	0.0?	0.0?	0.0?	0.0?	32.00?
120F	0.?	0.0?	0.0?	0.0?	0.0?	32.00?
59F	0.?	0.0?	0.0?	0.0?	0.0?	32.00?
7F						32.00?

AREA	AZM	SPD/GST(MPH)		SIGA	SIGE
A	167	9.4	15.7	25.7	6.8
C	148	2.9	16.7	74.7	16.4
D1	265	3.3	13.4	84.7	14.7
D2	283	1.1	3.8	70.6	18.6
F	129	8.8	25.5	26.7	11.4
H	206	4.8	18.3	61.7	14.5
K	331	6.1	11.2	41.4	13.4
P	66	12.5	33.2	13.9	8.3
L	328	10.5	21.7	23.8	11.5
TV	0	0.0	0.0	0.1	0.1
SAM	101	7.0	33.2	37.6	11.2
AGS	100	9.2(	73.4/	73.4	ST:4)

Figure 23. SRS tower data for the 15-minute period ending at 8:15 p.m..

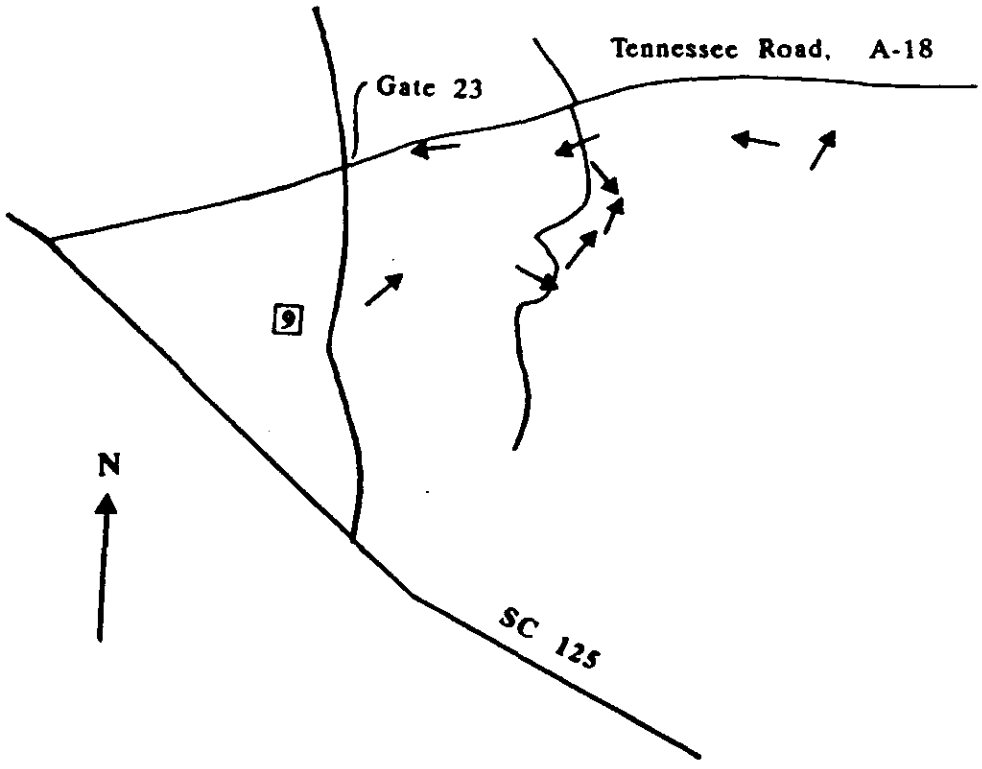


Figure 24. Tree-fall directions for the area south of Tennessee Road.

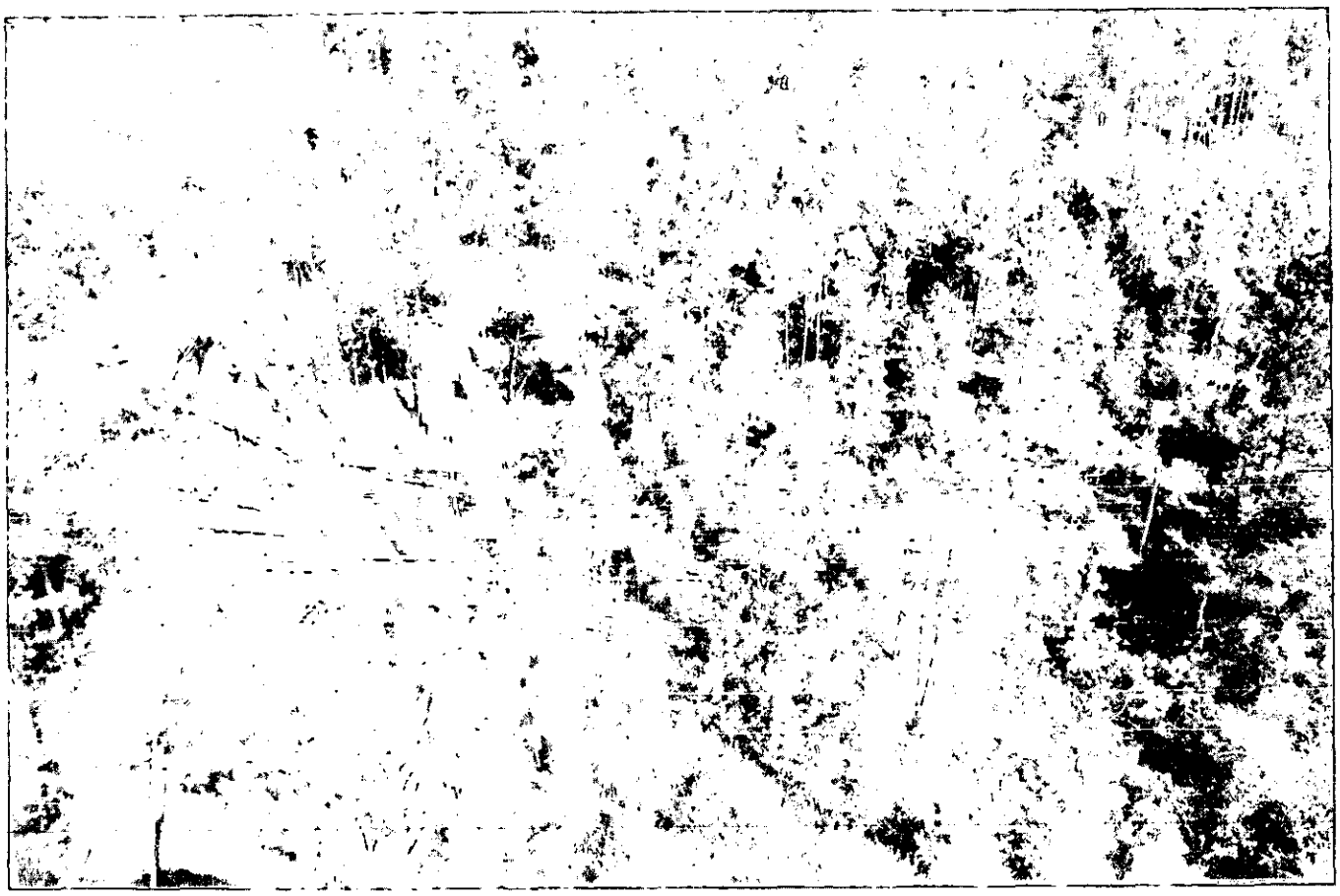


Figure 25. Downed pines showing a divergent tree-fall pattern.

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