Blow-Down with Hurricane Ivan

by
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1. INTRODUCTION

Strong northeasterly winds aloft associated with the remnants of hurricane Ivan produced areas of blow-down across areas of central Pennsylvania. Some areas experienced sporadic blow-down while other areas experienced large swaths of blow-down.

The term blow-down refers to trees which were simply blown over by straight line winds. In most instances, the trees fell with root balls intact. The blow down is believed to be the result from the combined effects of wet soils, wet leaves which add weight to the tree, and the winds. The winds cause the trees to move and push down on the wet grounds. In clay soils this can cause phenomena known as solifluction. The action of the wet ground and moving tree can act to loosen the soil, making the tree more susceptible to falling with moderate to strong winds.

The most pronounced areas of blow-down were observed on the exposed eastern slopes of the ridges in central Pennsylvania and in valley locations near the foot of these ridges. In many instances, there were concentrated areas of blow-down. This suggests similar slope or soil types made the trees in these areas extremely vulnerable to the wind stress. In the areas examined, where hundreds of trees were felled only a few trees showed any signs of being snapped above the ground, and nearly 50 percent of these had been damaged by falling trees.

This phenomenon was likely observed in Pennsylvania with the passage of Hurricane Floyd in 1999. There were reports of fallen trees with wind speeds of 40 to 45 mph in some areas during Floyd.

An observations[1] from Cape Cod associated with hurricane Bob from 1991 described a similar effect. All of the trees fell with "root balls" popping out of the ground. There were vivid jolts as the as the bigger trees uprooted. The trees were pushed downward by the steadiness of the wind. The imbedded wind gust induced a swaying motion which was not strong enough to snap most trees. But these winds incrementally loosened the soil around the root systems until the tap roots snap and the trees sort of lazily falls over. At least that's what I observed in Bob.

Most of the sustained wind damage in Pennsylvania was weak in nature (F0 and weak F1). This made distinguishing between tornadic and straight-line wind a difficult challenge. Normally, with a tornado, the damage pattern is enhanced in the direction of the large-scale winds. This is normally in the same direction as the tornadoes movement. Therefore, any tornadoes during the evening of 17 September should have been moving from south-southeast to north-northwest. In this case, there were strong low-level northeasterly winds (Fig. 1) which became more southerly and southwesterly aloft. Steering winds were from the south while a low-level vortex would have had strong northeasterly momentum to bring to the surface.

Therefore, the dominant damage from tornadoes would have been strong northeasterly winds to blow down large objects and the southeast to northwest momentum to carry lighter objects to the

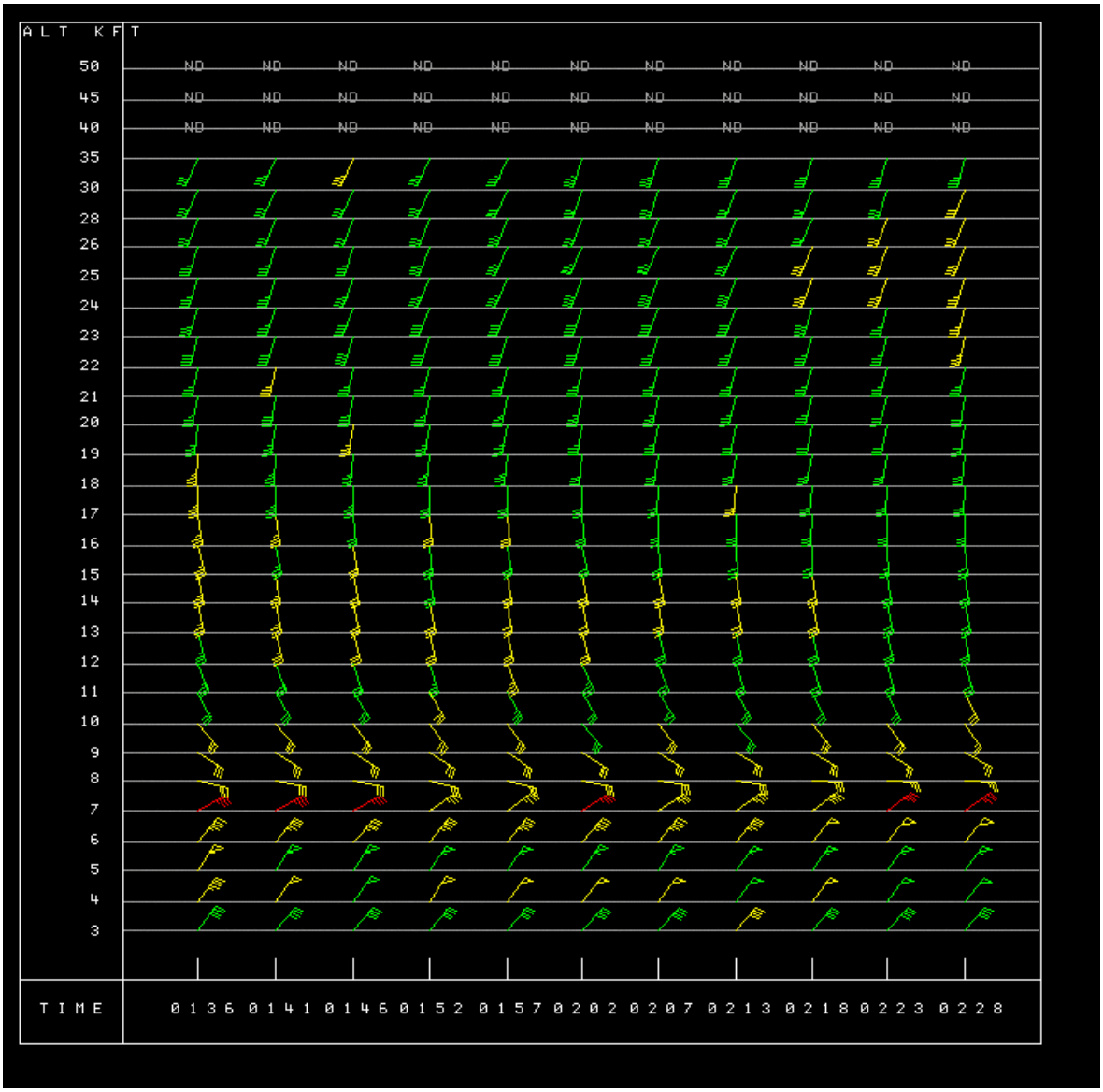

Figure 1. KCCX vertical wind profile valid 0136 through 0229 UTC 18 September 2004. This profile shows the strong low-level northeasterly winds with more southerly winds above 9000 feet.

north-northwest. In areas with massive damage aligned generally from northeast (040) to southwest, the damage was attributed to blow down. Some of the hatched or crossed pattern of the fallen trees, was most likely due to the combined effects of terrain slope (forcing trees to lean in a down-hill direction) and varying wind directions due to the terrain and timing when individual trees fell. The wet soils and water laden leaves also were likely contributors to the tendency for tropical storm force winds to topple trees.

This document will address the issue of blow-down in central Pennsylvania in association with the passage of the remnants of hurricane Ivan. The public information statement released in association with this phenomenon is attached in appendix A.

2. METHODS

Radar, surface observations and storm surveys were used to

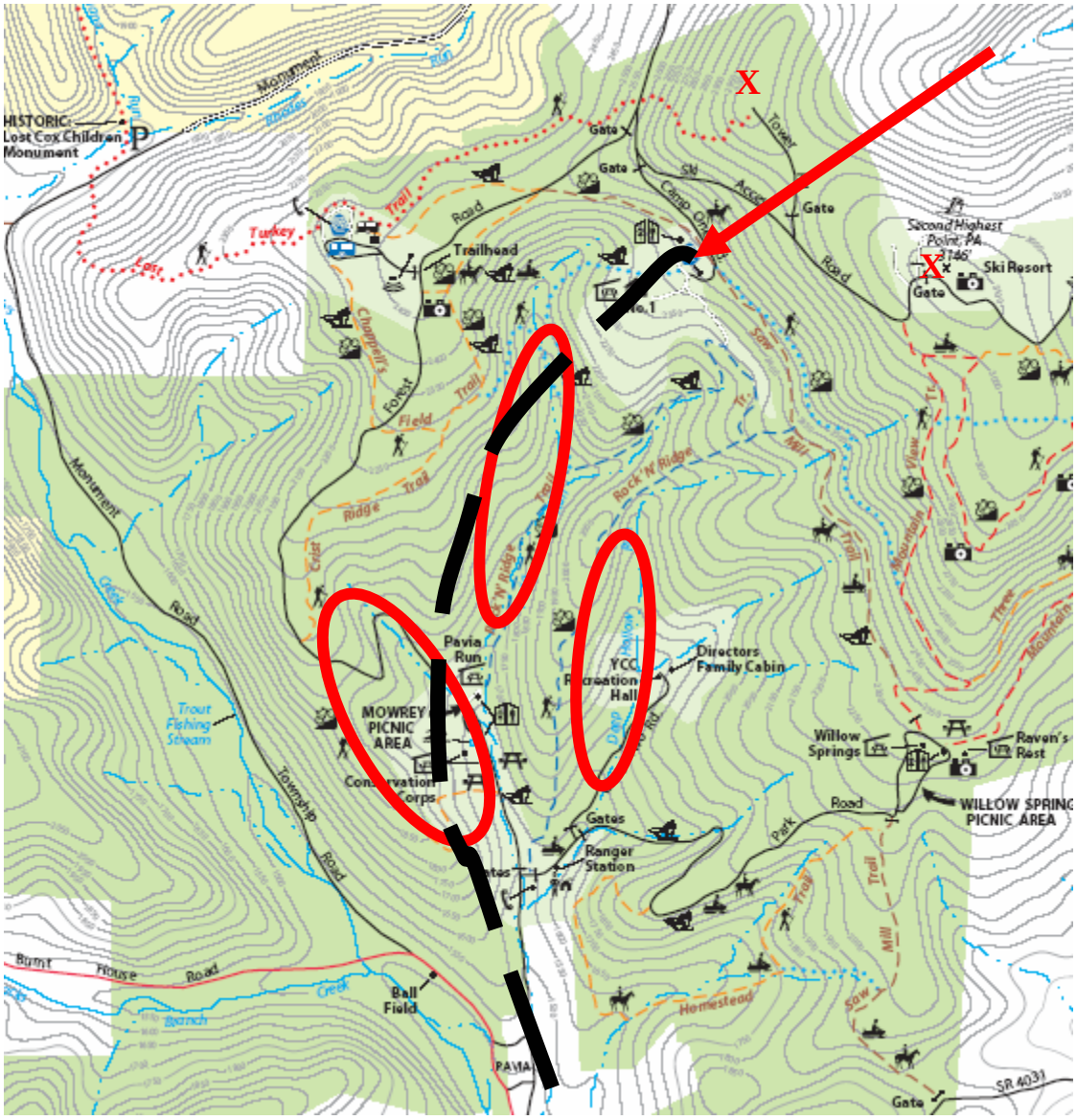

Figure 2 Pennsylvania Department of Conservation and Natural resources (DCNR) map of Blue Knob State Park. Red ovals outline ridge slopes with blow-down. The red arrow shows the wind direction through the saddle between the two peaks (red X's). The black line show the swath of trees that fell. Sporadically along this line, trees were downed all the way into Pavia and to the south. The red ovals denote areas of extensive blow-down where hundreds of trees were uprooted.

determine the areas and causes of blow down. We hope in the future to see if LANDSAT imagery may reveal larger swaths of damage.

3. RESULTS

At Blue Knob, the gap between the two peaks created a gap from 020 to about 060 (Fig. 2) which may have funneled the low-level northeasterly winds shown in Figure 1 between the two peaks (red X's in Figure 2) thus damaging the trees on the eastern slopes of these two ridges west of the gap. The red ovals in Figure 2 show areas along the eastern

Figure 3 Blow down (upper) Blue Knob State Park looking toward about 040 degrees along a ridge and (lower) Roth Rock State Park looking from approximately 020 degrees down a 3-5 miles swath of downed trees.

slopes were greater than 50% of all trees were uprooted. Following the ridge near the Mowery picnic area, trees fell from the northeast from about 040 degrees. Figure 3a shows downed trees along the ridge close to the location of the picnic area. Figure 4 shows a large downed Cherry tree about ½ mile down the ridge line. Farther south, near the ranger station, the trees fell from a more northerly direction, with some trees falling from 330 degrees. This suggests there was a channeling of the winds down the terrain causing the more north-northwesterly fall patterns. The black lines show the general path of sustained damage. There were sporadic areas of uprooted trees and south of Pavia. Leaving the park to the north there was sporadic tree damage along the road mainly on the eastern slopes and valleys adjacent to these slopes. The wind damage in this area affected northern Bedford County and portions of southern Blair County.

The radar image shows that Blue Knob was an area of convergence in the 0.5 degree slice. The winds at Altoona, to the northeast, were blowing gusting to 36KTS. Most of the trees in these two areas fell from about 040 (pointing upslope). These ridges extended to the southeast and east and there was a turning of the downed trees from 040 to

Figure 4 Blown down cherry tree in Blue Knob State Park. Photo taken on 20 September 2004.

330 moving southeastward down the two ridges and in the valley near the village of Pavia.

The radar image in Figure 5 shows the KCCX base velocity at 0.5 and 1.5 degrees valid around 0100 UTC 18 September (8 PM 17 September 2004). The black arrow denotes the approximate location of Blue Knob. Note that the temperature at Altoona is 59F with a northeast wind gusting to 36KTS. This supports the idea the the blow-down was be confined to areas that remained in the low-level cool air. These areas were not directly impacted by the warm humid tropical air and the bands that fed in on the eastern side of the surface cyclone.

In Figure 5, it is apparent that Blue Knob acted to block the flow. Note the area of

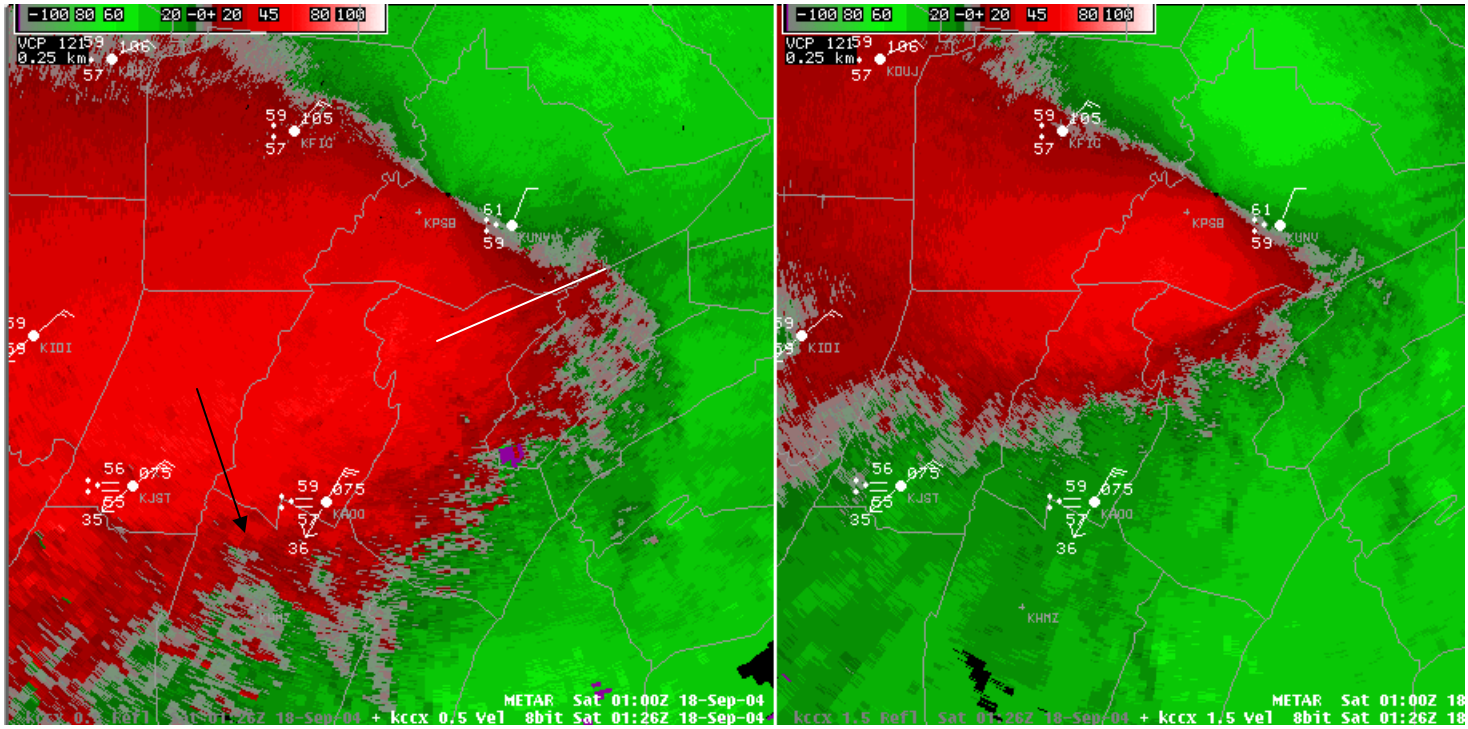

Figure 5 KCCX 0.5 and 1.5 degree velocity data valid at 0100 UTC 18 September 2004. The black arrow denotes Blue Knob and the white line the approximate blow down region in Roth Rock State Forest.

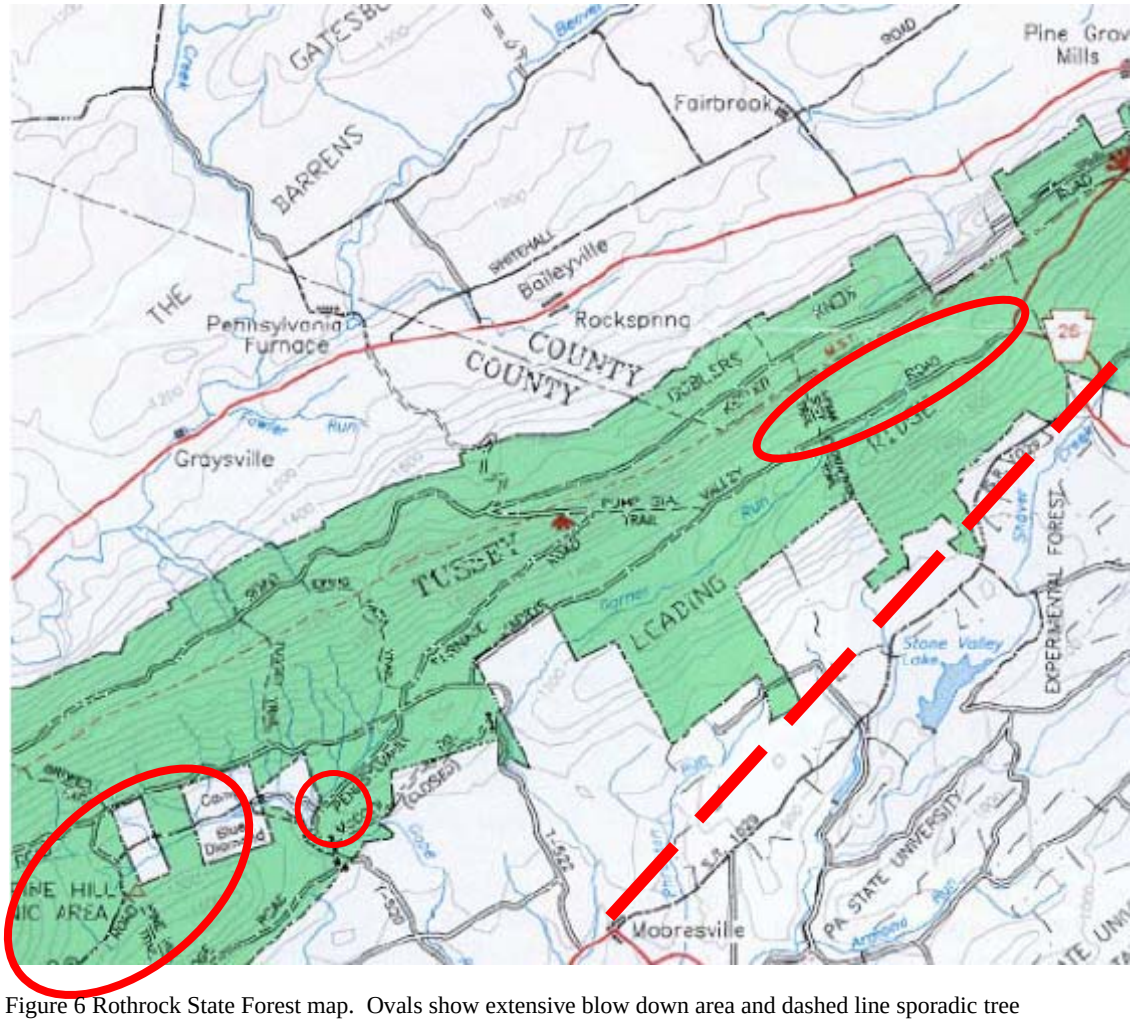

Figure 6 Rothrock State Forest map. Ovals show extensive blow down area and dashed line sporadic tree blowdown damage. The map does not allow the oval along Diamond valley road to extend as far south as the damage path. This area had the most extensive blow-down.

inbounds just south and west of the peak. This showed up as a persistent and weak rotation center in the storm relative velocity product. This implies that the combination of the stable conditions at low-levels and the obstacle of the peaks created shear that impacted the winds. This may have contributed to motions favoring loosening roots making the trees susceptible to toppling.

There were other areas of blow-down in Bedford County southeast of Blue Knob. All of these areas had eastern exposures and the trees fell from the north-northeast with rootballs intact. This area was hard to survey because wind damage was reported at 2 distinct times. The first time coincided with a mesocyclone that moved southeast to northeast between 2330 and 2345 UTC and then strong wind hit the area about 3 hours later, as the larger scale surface cyclone moved eastward.

The Rothrock State Forest damage swath is indicated by the white line in Figure 5. A map of surveyed damage is shown in Figure 6. A close examination of the 0.5 degree velocity at this time reveals a subtle wind maximum near the line. This feature may have been the enhanced jet that downed the trees along the eastern slopes of the ridges. The county line in the Figure closely

follows the ridge tops. Thus this enhanced outbound area is just to the east of the ridge line.

The appendix contains a series of velocity images from 2345 UTC 17 September through 0641 UTC 18 September 2004. These data show that the enhanced jet east of Tussey Mountain persisted for several hours. Between 0600 and 0800 UTC this feature accelerated toward the south as a frontal system moved in from the west. This may explain the late times of wind damage from strong winds in Bedford, Fulton, and Juniata Counties.

This enhanced jet may explain the larger and pronounced 3-5 mile swath in a valley location near the foot of Tussey Mountain. This area was south of Blue Diamond Camp, along Diamond valley road. The park map does not extend far enough southwest to show the entire damage swath. Blow down to the north is not shown but reports indicated similar swaths east of the ridge line near Penn Roosevelt State Park.

The downed trees along and mainly on the west side of Diamond Valley road were in very wet area and the many of holes created by the up rooted trees contained standing water when surveyed on 22 September 2004. This was not the case at Blue Knob, where the trees were on steeper slopes. The trees fell in a criss-crossed pattern initially suggesting a tornado (Fig. 3 lower panel). However, all trees had root balls intact and fell generally from a north-northeast direction.

There were reports of other areas of blow-down near terrain features. Not all were examined but most suggest wind damage from the north and northeast. A few areas experienced damage later, after 0400 UTC, these areas were farther east and the damage showed more north to south fall pattern.

4. CONCLUSIONS

Strong winds a few thousand feet above the surface combined with wet soils to blow-down trees in Pennsylvania. These winds were associated with the remnants of hurricane Ivan. Surface reports suggest winds were on the order of 35 to 40 KTS. However, radar data suggests that winds in the 50 to 60KTS range could have been mixed down to the surface in favorable topographical areas. This made the eastern slopes susceptible to the high winds.

Contributing factors to these terrain locked wind events appeared to include the heavy rains, gusty winds, and stability. The heavy rains made the soil soft and the water made the trees and leaves heavier. The winds and wind gusts likely caused motions that loosened the root structures. The persistent winds finally toppled the trees. The stability likely helped funnel and channel the winds down the terrain features. The slope may have increased the wind speeds making some valley locations at the foot of the ridges susceptible such as was observed in Rothrock State Forest.

An examination of the trees at both Blue Knob State Park and Rothrock State Park might initially suggest a tornado passed over the region. However, the character of the damage the vivid descriptions, especially at Blue Knob, suggests this was not the case. The park superintendent at Blue Knob described strong winds buffeted the park around 0030 UTC (730 PM) and limbs fell blocking a road. This required sending a crew t open the road. By 0030 UTC (830 PM) the winds strengthened and it was difficult to get to the vehicle.

More reports of trees blocking roads came in. Between 0130 and 0100 UTC at the Park Headquarters the staff could hear the sounds of crashing trees. This clearly established a prolonged period of wind damage and a single damaging tornado. In areas were there was a large amount of blow-down, such as Blue Knob and Roth Rock State forest, nearly all the trees fell from 040 (See Figure 2a). A tornado, with the shear profile would have been moving to the north-northwest. There was no evidence at any of these locations of damage moving from south to north. In fact the damage swaths would have suggest tornado paths moving from northeast to southwest, further evidence of blow-down and not of a tornado. The majority of the trees fell from 330 to 080.

Apendix A:
National Weather Service Public Information Statement 23 September 2003:

STORM SURVEYS OF SEVERAL AREAS OF DOWNED TREES IN BLAIR...BEDFORD...FULTON...SOUTHERN CENTRE AND HUNTINGDON COUNTIES HAVE REVEALED LARGE AREAS OF BLOW-DOWN. IN THE SURVEYED AREAS...THE COMBINATION OF WET LEAVES...WET SOILS AND STRONG WINDS CAUSED TREES TO TOPPLE. IN MOST CASES THE TREES CAME DOWN WITH ROOT BALLS INTACT. THE BLOW DOWN WAS MAINLY CONFINED TO EASTERN SLOPES AND VALLEY LOCATIONS AT THE FOOT OF THESE SLOPES.

BLUE KNOB STATE PARK EXPERIENCED LARGE AREAS OF BLOW DOWN ALONG THE EAST FACING RIDGES. BASED ON REPORTS FROM THE PARK...MOST OF THE TREES FELL FROM 8 PM THROUGH 9 PM FRIDAY NIGHT SEPTEMBER 17TH. SOME EARLIER DAMAGE WAS OBSERVED AT 730 PM. INITIAL ESTIMATES SUGGEST AROUND 800 ACRES OF FOREST EXPERIENCED BLOW DOWN. POCKETS OF BLOW-DOWN WERE OBSERVED ON BOTH SIDES OF BLUE KNOB STATE PARK AND IN PAVIA. EAST FACING RIDGES ALONG BLUE KNOB ROAD FROM PAVIA INTO THE PARK EXPERIENCED EXTENSIVE BLOW-DOWN. MOST OF THE TREES FELL FROM THE NORTHEAST.

ANOTHER LARGE AREA OF BLOW-DOWN WAS FOUND IN ROTHROCK STATE FOREST ON THE EASTERN SLOPES AND VALLEY AT THE FOOT OF TUSSEY MOUNTAIN. ONE AREA OF BLOW-DOWN WAS ALONG THE CENTRE HUNTINGDON COUNTY BORDER ALONG HARRYS VALLEY ROAD. EXTENSIVE AREAS OF BLOW DOWN WERE FOUND ON THE WEST SIDE OF DIAMOND VALLEY ROAD. A TREE DESTROYED A CAMPER AT CAMP BLUE DIAMOND AND ANOTHER TREE DAMAGED A HUNTING COTTAGE ABOUT 3 MILES SOUTH OF BLUE DIAMOND CAMP. SIMILAR DAMAGE WAS REPORTED FARTHER NORTH NEAR PENN ROOSEVELT STATE PARK ALONG STONE CREEK ROAD. MOST OF THE TREES FELL FROM THE NORTHEAST. MOST OF THE DAMAGE WAS CONFINED TO HUNTINGDON COUNTY.

ANOTHER AREA OF SPORADIC BLOW DOWN WAS FOUND ALONG BLACK BEAR ROAD IN FULTON COUNTY. MOST OF THE TREES FELL FROM THE NORTHEAST ON THE EASTERN SLOPES OF SIDELING HILL.

THERE WERE POCKETS OF BLOW DOWN IN BLAIR COUNTY. THERE WERE SEVERAL TREES UPROOTED IN ALTOONA AND NEAR THE COUNTY LINE NEAR BLUE KNOB AND ON BRUSH MOUNTAIN.

THESE AREAS OF DAMAGE WERE DETERMINED NOT TO HAVE BEEN ASSOCIATED WITH TORNADOES. THE DAMAGE PATTERN AND THE LACK OF ANY SOUTH TO NORTH FALLING OF TREES SUGGESTS STRAIGHT LINE WIND DAMAGE. EYE WITNESS ACCOUNTS OF PROLONGED PERIODS OF FALLING TREES ALSO SUGGEST SUSTAINED PERIODS OF STRONG STRAIGHT LINE WIND DAMAGE.

GRUMM/LACORTE

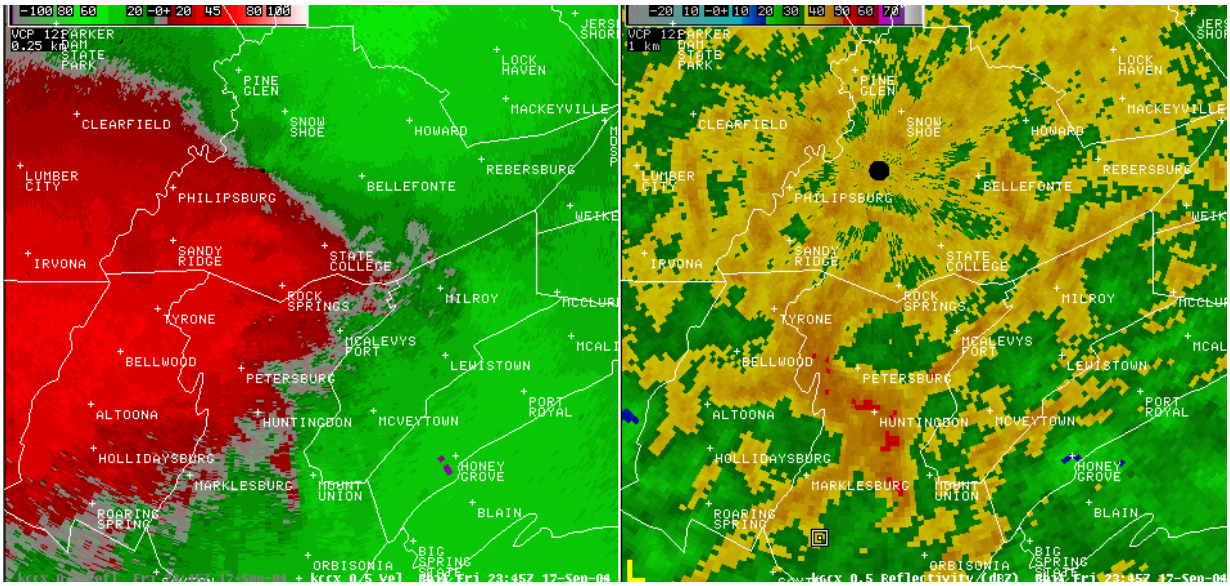

Figure A1 0.5 degree velocity and reflectivity valid at 2345 UTC 17 September 2004.

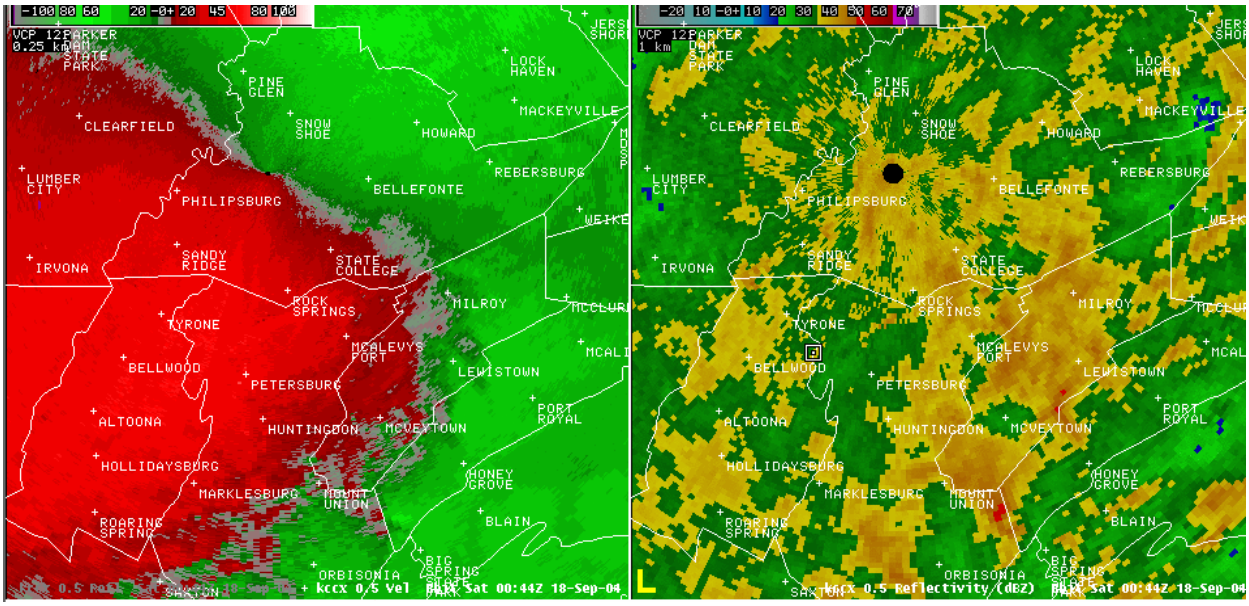

Figure A2 0.5 degree velocity and reflectivity valid at 0044 UTC 18 September 2004.

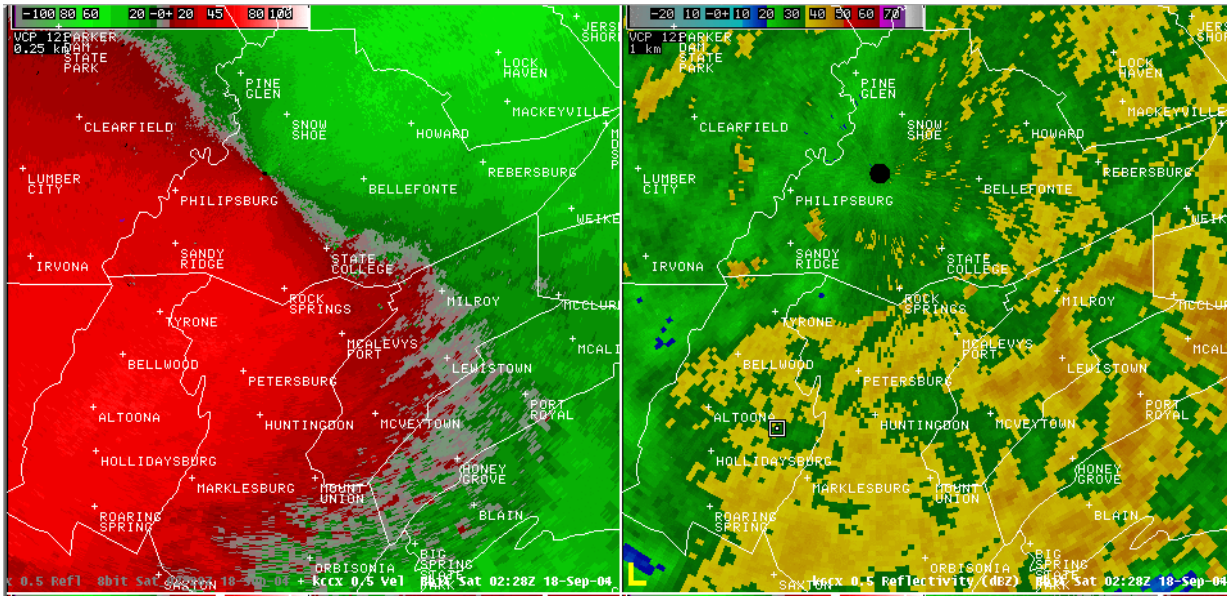

Figure A3 As in Figure A1 excpet valid at 0228 UTC 18 September 2004.

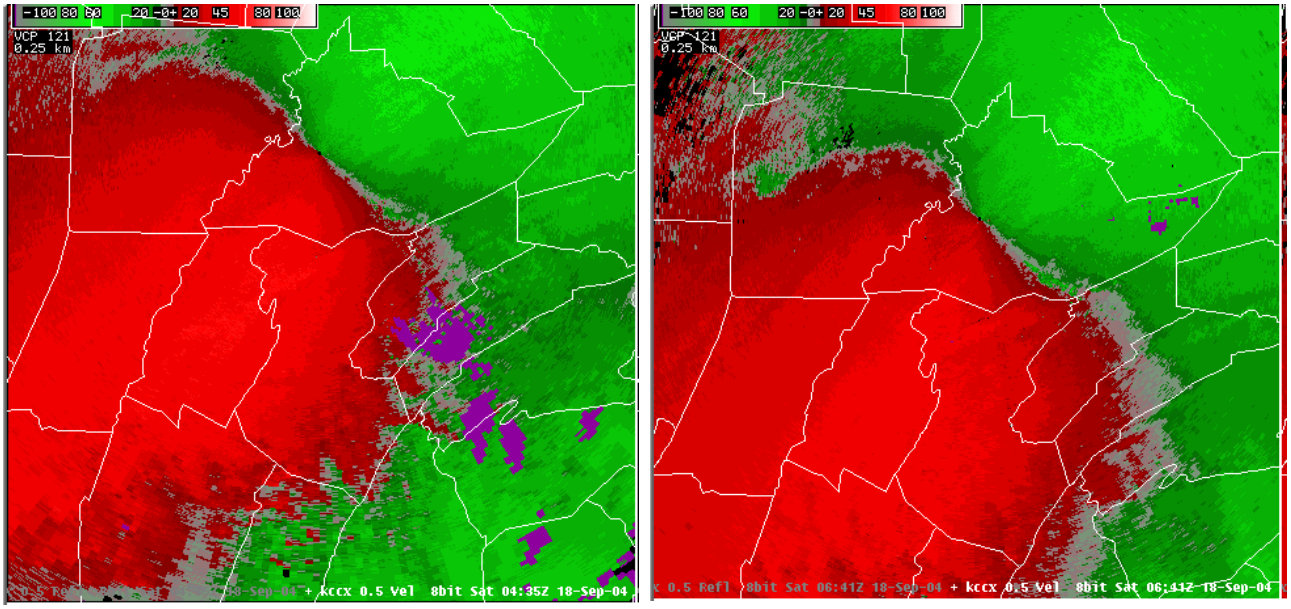

Figure A4 0.5 degree velocity data valid at (left) 0435 and (right) 0641 UTC 18 September 2004.