

# EFFECTS OF HURRICANE ISABEL ON EASTERN FORESTS: PRELIMINARY FINDINGS

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## Abstract

Hurricane Isabel made landfall in North Carolina on September 18, 2003, as a Category 2 storm. By the time the storm reached our primary research plot 410 km away in the Maryland Piedmont, Isabel had been downgraded to a tropical storm. At the study site, where a hectare had been established in 1998 in 80- to 100-year-old secondary forest to examine forest growth and regeneration, there were sustained winds of 37 mph and gusts up to 50 mph. Only 5 cm of precipitation was associated with the storm. Despite the relatively weak character of the storm, Isabel did a great deal of damage in the previously established hectare (West Woods - permanent plot), and on six other sites in the Piedmont and the Blue Ridge in Maryland, West Virginia and Virginia.

Following Isabel's passage, we established a 0.4 hectare plot adjacent to the permanent plot, comparable to it in soil type, slope, aspect, forest age and tree species composition. This plot (Less Damaged Plot) sustained much less damage than did the permanent plot. In both plots, we identified downed trees to species, measured tree diameters and heights, and measured the volume and biomass of downed woody debris by the line transect method (Van Wagner 1968, Harmon et al. 1986). In the other six damage sites, we identified to species and measured diameters of downed trees in paired 20 x 100 m damaged and adjacent control transects. In both the permanent and the less damaged plots, we conducted an exotic invasive plant survey in fall 2003 after the storm, identifying 12 species of herbaceous and woody invasive plants, and estimating their percentage cover in 5 x 5m quadrats. Because these species had flowered and fruited earlier in the year, Isabel had not affected their distribution and density; we therefore used this census as an estimate of the invasives present prior to the storm.

We conducted the same census in 2004, scheduled so that quadrats were censused during the same week as in the preceding year. We took simultaneous light readings (photosynthetically active radiation in  $\mu\text{g}/\text{m}^2/\text{sec}$  with a LICOR 250) at the southwest corner of each 10 x 10 m quadrat in the Permanent and Less Damaged Plots and in an adjacent field, to measure percentage of full sunlight in the plots. We mapped areas of higher and lower light levels in the permanent plot (gaps and non-gaps). We identified and counted woody seedlings in a subset of quadrats in the permanent plot.

At the West Woods site, 71 of 425 trees greater than 10 cm DBH were uprooted; 21.5% of the total basal area of 36.3  $\text{m}^2/\text{ha}$  was damaged; treefall was overwhelmingly to the west (225-315°); and canopy height was reduced to less than 5 m at 21.5% of the 10 x 10 m gridpoints in the hectare, whereas previously it had been that low at 1.7% of those points. Trees with larger DBH were more likely to be uprooted. Logistic regression of the binary variable "Uprooted vs. Not Uprooted" showed highly significant effects of DBH ( $B = 0.042$ ,  $P < .001$ ). *Prunus serotina* Erhr., black cherry, was uprooted much more frequently than would be expected. Black cherries comprised 15% of the trees in the permanent plot, but accounted for almost 33% of the downed trees. After correcting for DBH, cherry was the only species that showed a significantly higher than expected probability of uprooting ( $P < .004$ ). Isabel produced literally tons of coarse woody debris in the permanent plot (78.1  $\text{Mg}/\text{ha}$ ), four times the amount present before the hurricane.

We found the same pattern of larger trees blown down at the other six sites. Mean DBH of uprooted trees in 0.2 ha transects was consistently larger than undamaged trees in adjacent control plots ( $t = 5.89$ ,  $P$  (two-tailed) = .002).

Of the 12 exotic invasive species found in the West Woods site in Fall 2003, the most frequent were *Lonicera japonica* Thunb. (88% of quadrats), *Alliaria petiolata* (M. Bieb.) Cavara and Grande (80% of quadrats) and *Rosa multiflora* Thunb. (56% of quadrats). These species were widely distributed, but not especially dense. In most cases, they covered less than 5% of each quadrat. In the 2004 census, we found two species that had been present close to, but not in the plot previously: *Polygonum perfoliatum* L., mile-a-minute, and *Microstegium vimineum* (Trin.) Camus, Japanese stiltgrass. We also found *Polygonum caespitosum* Blume, long-bristled smartweed, an exotic invasive that had not been present anywhere near the plot in 2003.

We compared the change in percentage cover of all invasive plants from 2003 to 2004 in a subset of 45 quadrats from the less damaged plot, and the lower and higher light areas of the permanent plot. The mean change in percentage cover was significantly higher in the high-light areas of the permanent plot than in the low-light areas or the Less Damaged Plot (47.8%, 4.8%, and 4.2%, respectively, Kruskal-Wallis,  $P < .001$ ). We expect to see the same pattern when the data from all quadrats are analyzed. Most of this difference can be attributed to the change in percentage cover of four species, mile-a-minute, Japanese honeysuckle, long-bristled smartweed and garlic mustard. The percentage cover of the first three increased significantly (Kruskal-Wallis,  $P < .001$ , .005 and .002, respectively), and of the last, decreased significantly ( $P < .001$ ). It is unclear whether the reduction in garlic mustard occurred from shading competition or simply reflects the second year cohort of this biennial species.

The seedlings most frequently found in the permanent plot were:

- *Acer negundo* L., Boxelder (1785/ha),
- *Fraxinus americana* L., White ash (1169/ha)
- *Carya cordiformis* (Wang.) K. Koch, Bitternut hickory (1097/ha)
- *Toxicodendron radicans* (L.) Ktze. (738/ha)
- *Prunus serotina* Ehrh., Black cherry (338/ha)

Although *Liriodendron tulipifera* L., yellow-poplar, is the most common adult tree in the plot, (32.5% of 425 stems), we found very few yellow-poplar seedlings. With more light available in the forest, seedlings of this shade-intolerant species may increase in the future.

Work in 2005 will include a spring recensus of native and exotic herbs, a recensus of woody invasives, a fall recensus of exotic invasive plants, measurement of the modification of tree pits and mounds over time and correlation of soil disturbance with invasion, and a complete species census of 36 deer exclosures established in November 2004 in canopy gaps, intact canopy and in an adjacent abandoned agricultural field. The deer exclosure data should help illuminate the impact of browse on post-hurricane succession of natives, invasives and woody seedlings. We expect to expand these censuses to our five additional sites in Maryland.

We predict that as eastern hardwood forests mature and trees increase in size, they are going to become increasingly susceptible to even low-level storm damage, and that the resulting canopy gaps are going to be patchy and larger, rather than limited primarily to single-tree gaps. Further, we expect that forests will become increasingly vulnerable to invasion by exotic species able to take advantage of large disturbances to establish themselves. Yellow-poplar and similar intolerant tree species, which require large gaps for successful recruitment, will become more dominant. Large amounts of coarse woody debris produced by even mild storms may create variations in carbon sequestration rates, as carbon is released from storm-damaged forests and taken up in increased regeneration.

## References

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