An Ice Storm Manipulation Experiment in a Northern Hardwood Forest

Lindsey Rustad and John Campbell (US Forest Service, Northern Research Station)

Ice Storms

- Ice storms are important natural disturbances within forest ecosystems of northeastern North America.
- These storms form under unique climatological conditions when moisture rich warmer air overrides a layer of subfreezing air at ground level. Precipitation falling from the warmer upper air layer reaches the cold layer as rain, and then supercools, forming a freezing layer of ice as it lands on cold objects such as tree branches or power lines.
- In the US, ice storms are particularly prevalent in the broad “ice belt” that extends from east Texas to New England, with the greatest risk for damage in the northeastern states (Fig. 1).
- In forested ecosystems, ice storm damage is primarily characterized by branch and crown loss, with consequent reductions in the photosynthetic area of trees, and decreased carbohydrate production needed for growth, wound closure and the production of plant protection compounds necessary to control the spread of pathogens (Fig. 2).
- Current models suggest that the frequency and severity of ice storms may increase in the coming decades in response to changes in climate.

Fig. 1 Days of Freezing Rain (after Changnon, 2003)

Fig. 2 Ice Storm of 1998

Experimental Approach

- Study Site: The experiment was conducted in a mixed northern hardwood forest at the Hubbard Brook Experimental Forest in the White Mountains of New Hampshire, USA (Fig. 3).
- Ice Storm Simulation: An ice storm was simulated on the treatment plots by spraying water from Hubbard Brook up and over the forest canopy during sub-freezing conditions on February 9, 2011
- Experimental Design:
  - 4 plots (15 X 15 m; Fig. 4)
  - 2 treatment and 2 reference
  - 9 subplots (5 X 5 m)
- Measurements:
  - Ice thickness
  - Throughfall
  - Fine litter
  - Coarse litter
  - Hemispherical photographs
  - Crown damage assessment

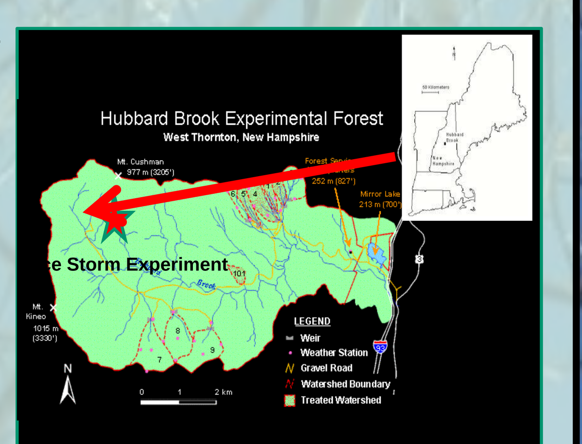


Fig. 3. Site Location.

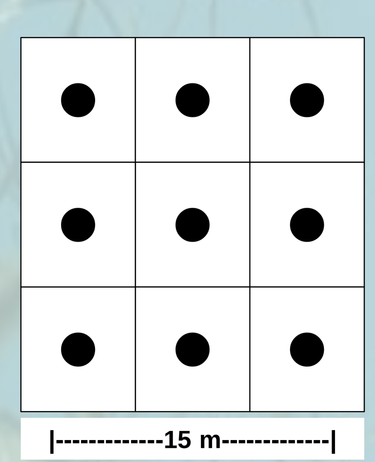


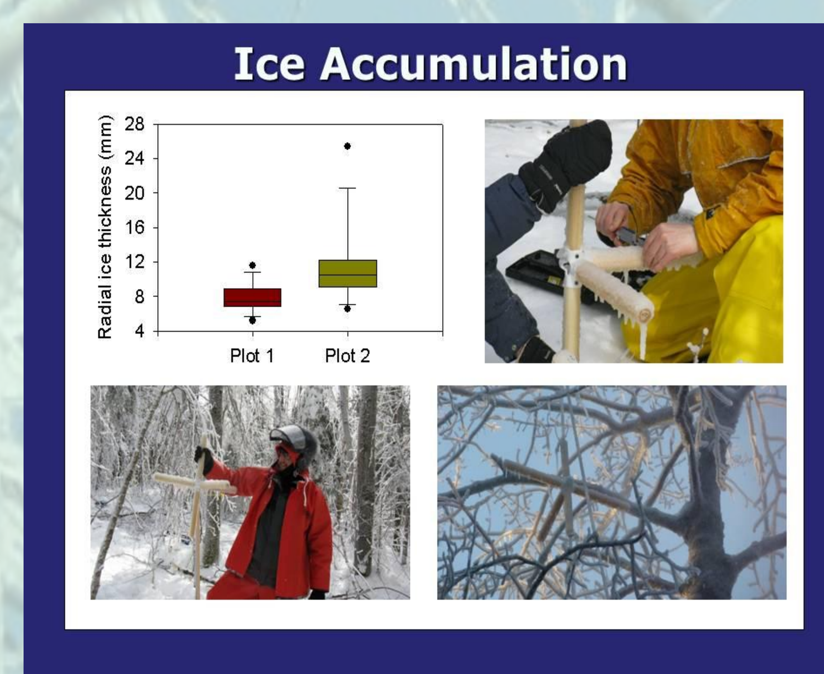
Fig. 4. Plot Layout.

Ice Storm Experiment

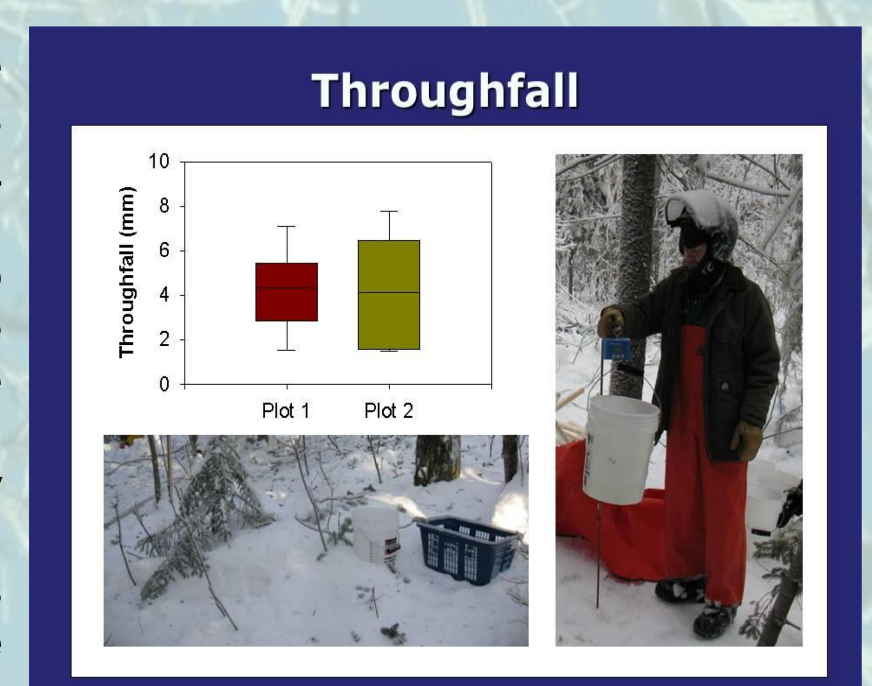
Here we demonstrate a unique approach to an experimental ice storm manipulation experiment, evaluate ecosystem metrics of response, and suggest directions for future research.

Results

- The Manipulation: Water was sprayed for a total of 78 mm depth in Plot 1 and 86 mm in Plot 2 over an ~ 2 hour period. This compares to 83 mm recorded during the 1998 ice storm event at the site.



- Ice Accumulation: Average radial ice thickness was 7.8 mm (±0.4 SE, n=19) in Plot 1 and 11.6 mm (±1.3 SE, n=14) in Plot 2. This compares to 5.9 to 14.4 mm during the 1998 ice storm event at the site.
- Throughfall: Average throughfall depth was 42 mm (±6 SE) in Plot 1 and 40 mm (±8 SE) in Plot 2, with no significant difference between plots. These results suggest that, in this experiment, roughly half the water sprayed onto the plot was retained as ice in the canopy.



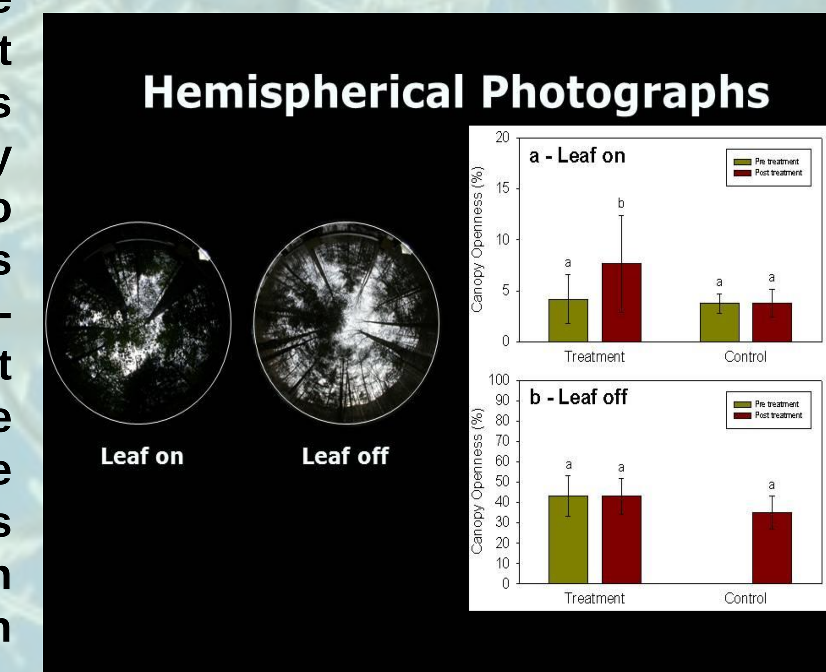
	Ice Storm Experiment	1998 Ice Storm	Annual Long Term Mean
Fine Litter	142 +/- 29	-----	171
Coarse Litter	217 +/- 107	434	20

Table 1. Fine and Coarse Litter (g C m^{-2})

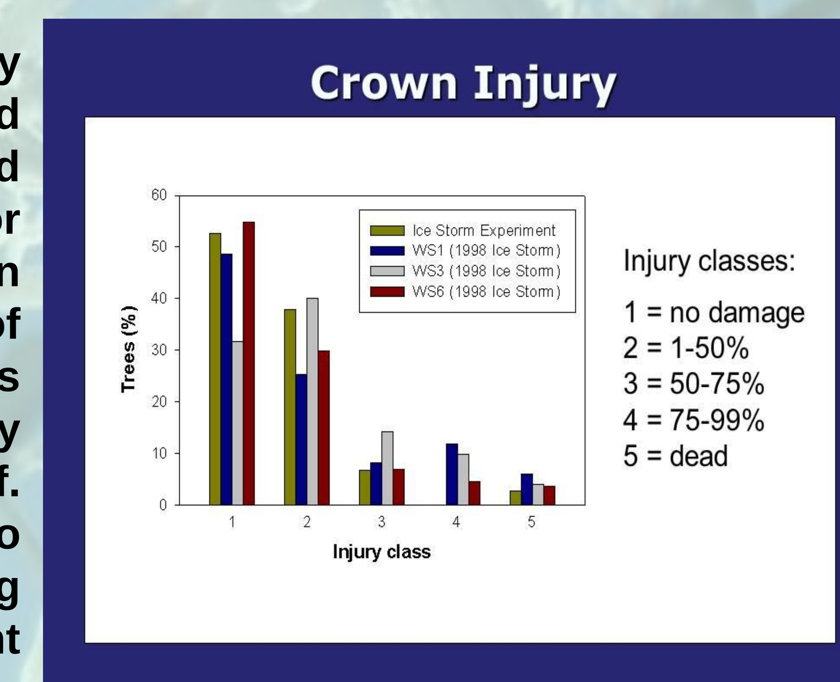
- Litter: Fine litter amounted to 171 (±33 SE) and 113 (±23 SE) g C m^{-2} in Plots 1 and 2. Coarse litter was more variable, at 325 (±138 SE) and 110 (±67 SE) g C m^{-2} in Plots 1 and 2, respectively. Fine litter was similar to the long term average at the site. Coarse litter was an 10x higher, although similar to the 1998 ice storm.

Results (cont)

- Hemispherical Photography: During the leaf-on period, percent canopy openness increased significantly after the treatment. No significant difference was observed between pre- and post-treatment canopy openness in the control plots. During the leaf-off period, there was no significant difference in canopy openness between the pre- and post-treatment periods.



- Crown Injury: ~Fifty percent of the trees had no visible damage and 38% had only minor damage (i.e. <50% crown injury). ~Ten percent of the trees had crowns that were severely injured or snapped off. Results were similar to those observed during the 1998 ice storm event at the site.



Conclusions

Although our understanding and ability to predict the occurrence of extreme events such as ice storms is still limited, the scientific consensus remains that the frequency and intensity of these types of events are likely to increase. It is thus imperative to improve our understanding of the direct and indirect, and short and longer-term impacts of extreme events on natural and managed ecosystems.

This study demonstrates the feasibility of a relatively simple approach to simulating an ice storm in a northern hardwood forest. Future research can utilize this experimental technique to simulate ice storms of different intensity and frequency and in different forest types to better understand the impacts of these extreme winter weather events on the structure and function of northern hardwood forest ecosystems.

Rustad, L.E. and J.L. Campbell. An ice storm manipulation experiment in a northern hardwood forest. Can. J. For. Res. October 2012.