Tropical Storms, Hurricanes, Superstorms: Impact and Influence on Tree Diseases

Dr. Robert E. Marra
Department of Plant Pathology & Ecology
The Connecticut Agricultural Experiment Station

West Haven, CT, August 2011
Overview

- Storm forces
- Storm damage
- Salt injury
- Climate
Tropical Cyclones

- Tropical depressions, tropical storms, hurricanes – and “superstorms”

- all are “Tropical Cyclones”
Tropical Cyclone Forces

- Wind
- Salt spray
- Lightning
- Rain
- Storm surge
Tropical Cyclone Damage

- Blowdowns
- Crown twists
- Branch and stem failures
- Wind abrasion
- Salt injury
Blowdowns

West Haven
Branch and stem failures
Wind abrasion and scorch

DNR-Wisc

CAES- Plant Science Day 2013
Salt Spray

West Haven
Salt Spray
1938 Hurricane (Sept. 21)


- 10 inches of rain
- 120 mph sustained SE winds
  - Gusts estimated at >180 mph
Salt spray (wind-driven salt water)

1938 Hurricane
- Entire stands of hardwoods wind-thrown or broken
- Complete defoliation of deciduous trees
  - “early fall to full winter in two hours”
- East sides of white houses stained yellow-green
- Extensive evidence of salt injury
  - White pines most sensitive
1938: Inland Extent of Salt Spray Injury

- White pines used as indicators of salt spray extent
1938: Inland Extent of Salt Spray Injury

- White pines used as indicators of salt spray extent
- Salt injury as far inland (45 miles) as Pomfret/Putnam area
- Extent and severity of injury increased towards coast line
Salt spray: Foliar Symptoms

- Crown thinning
- Twig die-back
- Conifer needles turn brown
  - Beginning at tips, progressing towards base
- Broadleaf trees
  - Marginal chlorosis of leaves
  - Delayed or failed budbreak or flowering
  - witch’s broom
Flooding
Flooding

West Haven, CT

CAES- Plant Science Day 2013
Flooding

Impacts on soil:

- $O_2$ depletion
- Anaerobic decomposition
  - loss of mycorrhizal fungi
- $CO_2$ accumulation
- Mineral depletion
- Soil compaction
Flooding

Impacts on trees:

- Yellowing, browning, curling, wilting foliage
- New leaves smaller
- Early fall color
- Branch die-back
- Gradual decline and death over 1-3 year period
Flooding

Tree responses:

- Reduced root growth
  - decrease in drought tolerance
- Reduced uptake of macronutrients
- Reduced nutrient content in leaves
- Increased susceptibility to pathogens and pests
Salt

HOW does it injure plants?
Salt Water

- Principle salt in sea water is sodium chloride (NaCl)
- NaCl
  - Table salt
  - Rock salt

- NaCl is the principle salt in the human body
Mechanisms of Salt Injury

- Salt is *hygroscopic*
  - absorbs water from leaf tissue, roots
  - creates drought-like environment, despite presence of water

- Sodium (Na\(^+\)) and chloride (Cl\(^-\)) have very different modes of action in plants
Salt in Soil

**Sodium, Na⁺**
- Prevents aggregation of soil particles
  - Compaction
    - Reduces availability of $\text{H}_2\text{O}$, $\text{O}_2$
- Raises pH
  - Reduces solubility of minerals (e.g., iron)
- Blocks uptake of $\text{Mg}^{++}$ and $\text{K}^+$
  - Essential to chlorophyll synthesis
- Slowly translocates to buds/leaves
  - Builds to toxic concentrations
    - Dehydration
Salt in Soil

**Chloride, Cl⁻**

- Taken up by roots more rapidly than Na⁺
  - Symptoms of Cl⁻ damage usually appear first
- Translocates through xylem to shoot tips and leaf margins
  - Accumulates to toxic concentrations
  - Delays or prevents bud opening
  - Marginal scorch in leaves
Physical damage caused by wind, water and salt

Stress and reduced tree vigor

Increased susceptibility to diseases

- may take years to manifest
## Cyclone-“resistant” Trees

<table>
<thead>
<tr>
<th>Wind</th>
<th>Salt Spray</th>
<th>Soil Salt</th>
<th>Wind</th>
<th>Salt Spray</th>
<th>Soil Salt</th>
</tr>
</thead>
<tbody>
<tr>
<td>●</td>
<td></td>
<td></td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>●</td>
<td>Dogwood</td>
<td></td>
<td>●</td>
<td>White Ash</td>
<td></td>
</tr>
<tr>
<td>●</td>
<td>American Holly</td>
<td></td>
<td>●</td>
<td>Green Ash</td>
<td></td>
</tr>
<tr>
<td>● ●</td>
<td>Bald cypress</td>
<td></td>
<td>● ●</td>
<td>Sweet Gum</td>
<td></td>
</tr>
<tr>
<td>●</td>
<td>Silver Maple</td>
<td></td>
<td>●</td>
<td>Sweetbay Magnolia</td>
<td></td>
</tr>
<tr>
<td>●</td>
<td>Sugar Maple</td>
<td></td>
<td>● ●</td>
<td>Tupelo</td>
<td></td>
</tr>
<tr>
<td>● ●</td>
<td>Black Maple</td>
<td></td>
<td>●</td>
<td>Hophornbeam</td>
<td></td>
</tr>
<tr>
<td>●</td>
<td>Japanese Maple</td>
<td></td>
<td>●</td>
<td>Red Oak</td>
<td></td>
</tr>
<tr>
<td>● ●</td>
<td>River Birch</td>
<td></td>
<td>● ●</td>
<td>Tuliptree</td>
<td></td>
</tr>
<tr>
<td>●</td>
<td>Ironwood</td>
<td></td>
<td>● ●</td>
<td>Sycamore</td>
<td></td>
</tr>
<tr>
<td>● ●</td>
<td>Hickories</td>
<td></td>
<td>● ●</td>
<td>Redcedar</td>
<td></td>
</tr>
<tr>
<td>●</td>
<td>Redbud</td>
<td></td>
<td>● ● ●</td>
<td>Black Pines</td>
<td></td>
</tr>
</tbody>
</table>
Putting Storm Damage Into Context: Recent notable weather patterns

August 2011:

Tropical Storm Irene
Putting Storm Damage Into Context: Recent notable weather patterns

October 2011:
Snowmageddon

Winter 2011-2012:
Mild, 2\textsuperscript{nd} warmest on record in Hartford

March 2012:
North American Heat Wave
CT: hottest, driest March on record
Recent notable weather patterns, cont’d

Summer 2012:
3rd hottest summer on record

October 2012:
Hurricane Sandy
Recent notable weather patterns, cont’d

February 2013 Nor’easter:
Winter Storm Nemo
Blizzard of 2013
Recent notable weather patterns...a trend?

Hartford, CT
Our Changing Climate

- The Northeast has been warming at a rate of 0.5°F per decade since 1970
  - Winter temperatures: 1.3°F per decade
- More winter precipitation
  - More falling as rain, less as snow
- Winter ice on lakes and rivers
  - Later to freeze, earlier to thaw
- Rising sea-surface temperatures
- Rising sea levels
Our Changing Climate

- Rising sea-surface temperatures
  - 1901-2011: approx 0.13°F per decade
Our Changing Climate

- Rising sea-surface temperatures
  - 1901-2011: approx 0.13°F per decade
  - Increased frequency and intensity of tropical cyclones
Our Changing Climate

- Rising sea level
  - As water warms, it expands
  - Melting polar ice caps
  - Long Island Sound
    - 1” per decade for past 200 years
  - More powerful storm surges
Connecticut Officials Warn Of Dire Climate Change Consequences

AP | By STEPHEN SINGER
Posted: 07/30/2013 3:02 pm EDT | Updated: 07/30/2013 6:02 pm EDT

HARTFORD, Conn. (AP) — Connecticut environmental officials are warning of dire consequences from climate change that will affect agriculture, dams and levees, waterfront habitats and public health.

For example, sea level rise will leave Hammonasset Beach State Park, among Connecticut's most popular state parks, mostly inundated by sea water by the end of the century, according to a new report by the Department of Energy and Environmental Protection.

Most agriculture in Connecticut is likely to be "highly impacted" by climate change "and most of these potential impacts are negative," Monday's report said.

Maple syrup, dairy, warm weather produce, shellfish and apple and pear production will be affected by changes in temperature and the abundance of rain or lack of it.
Connecticut Climate Change Preparedness Plan

Adaptation Subcommittee of the Governor’s Steering Committee on Climate Change

www.ct.gov/deep/lib/climatechange
Senate Bill No. 1013

Special Act No. 13-9

AN ACT CONCERNING CLIMATE CHANGE ADAPTATION AND DATA COLLECTION.

Approved June 6, 2013
Superstorm Sandy and the "New Normal:"
Rebuilding for Resiliency and Adapting to Climate Change

This year's conference is dedicated to the memory of Art Glowka

The aftermath of Superstorm Sandy has left many wondering how to successfully address the changing climate and impacts on our infrastructure,
National Academy of Sciences, 2012

Available for download at:

www.nap.edu/catalog.php?record_id=14673
Summary

- Tropical Cyclones present unique challenges to trees
  - wind, salt spray, and flooding
- Salt injures trees through foliage and soil
- Salt and flood tolerance vary among tree species
- Diseases resulting from wind, salt, and flood damage may take years to manifest
- Proximal and distal weather patterns have synergistic effects on overall tree health
- A changing climate must inform decisions on trees
  - What to plant, where to plant…whether to plant
Dr. Robert E. Marra  
Department of Plant Pathology & Ecology  
123 Huntington Street  
P. O. Box 1106  
New Haven, CT 06504  
Phone: 203.974.8508  
Email: Robert.Marra@ct.gov  
Website: www.ct.gov/caes