

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



West Haven, CT, August 2011

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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



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Wind abrasion and scorch



Salt Spray

West Haven



Salt Spray



West Haven



1938 Hurricane (Sept. 21)

Effect on Trees of Wind-driven Salt Water. 1940.
A. E. Moss (UConn). *Journal of Forestry*, v.38: 421-455.

- 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



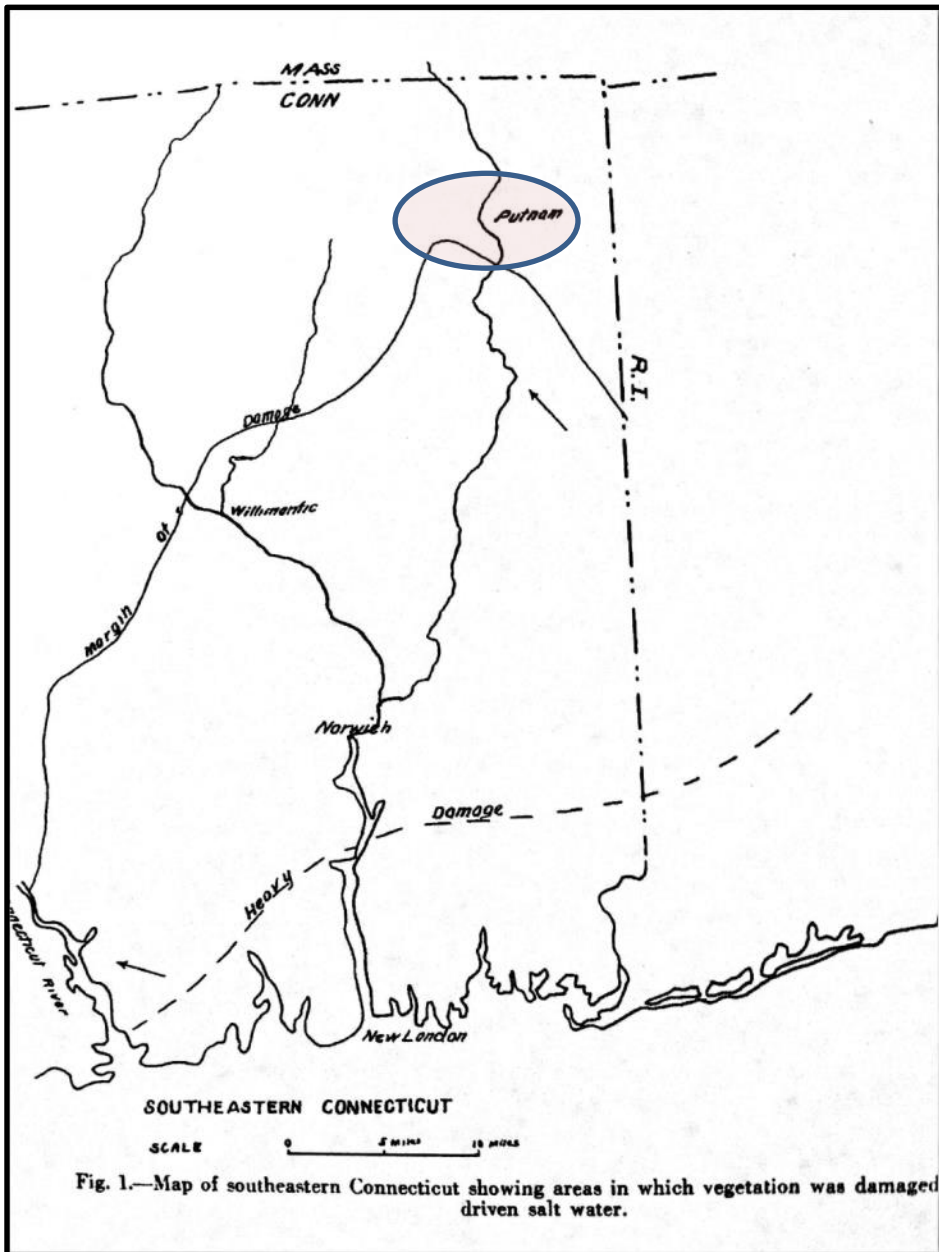
1938: Inland Extent of Salt Spray Injury



- 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



West Haven, CT

Flooding



West Haven, CT

Flooding

Impacts on soil:

- O₂ depletion
- Anaerobic decomposition
 - loss of mycorrhizal fungi
- CO₂ 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 H₂O, O₂
- Raises pH
 - Reduces solubility of minerals (e.g., iron)
- Blocks uptake of Mg⁺⁺ and 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



Tropical Cyclones and Tree Diseases

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

Wind	Salt Spray	Soil Salt		Wind	Salt Spray	Soil Salt	
●			Dogwood	●			White Ash
●			American Holly	●	●		Green Ash
●	●	●	Bald cypress	●	●	●	Sweet Gum
	●		Silver Maple	●			Sweetbay Magnolia
●			Sugar Maple	●	●		Tupelo
●	●		Black Maple	●			Hophornbeam
●			Japanese Maple	●			Red Oak
●	●		River Birch	●		●	Tuliptree
●			Ironwood	●	●		Sycamore
●	●	●	Hickories	●	●		Redcedar
●			Redbud	●	●	●	Black Pines



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, 2nd 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

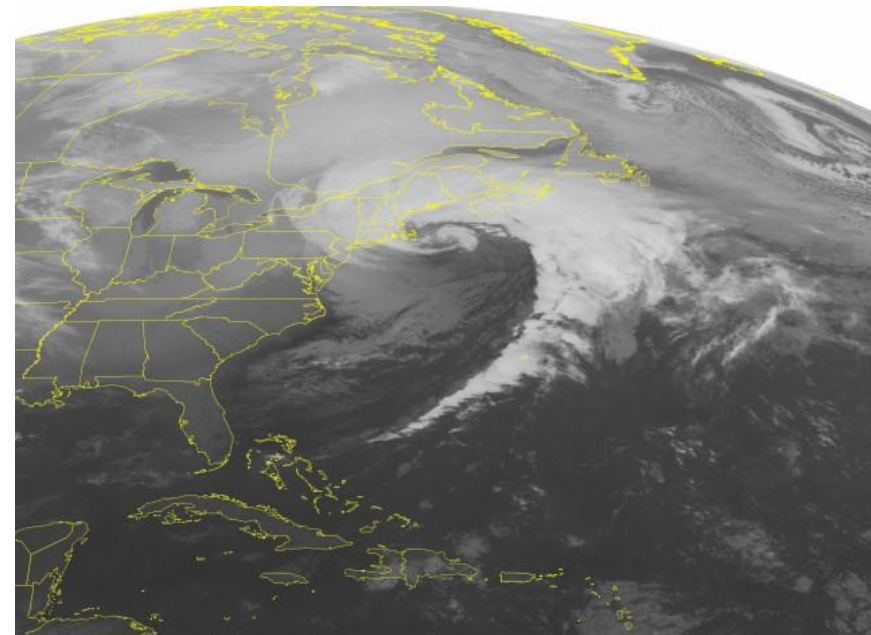
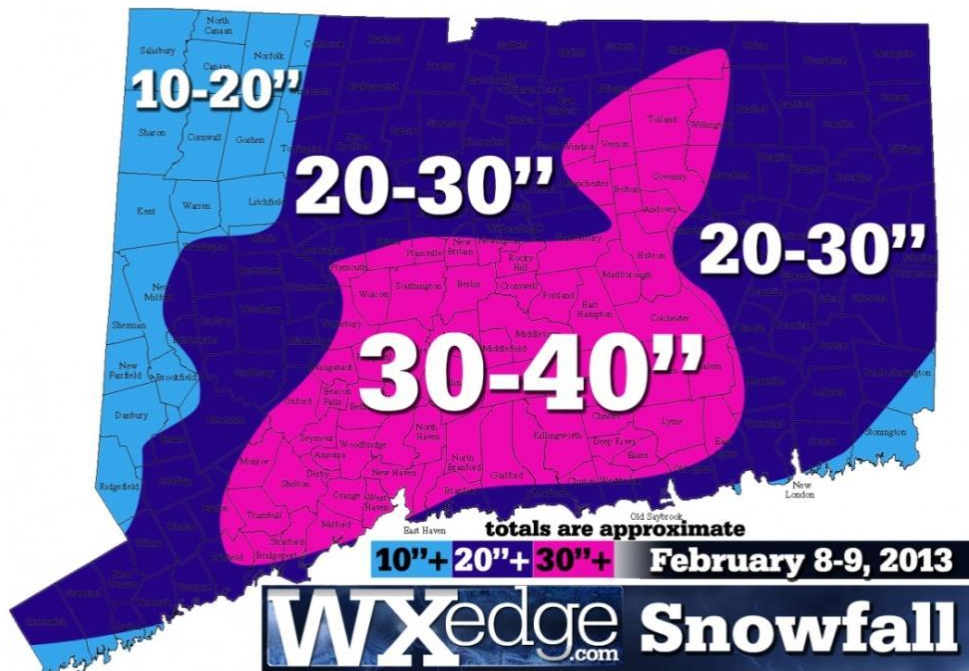
October 2012:

Hurricane Sandy



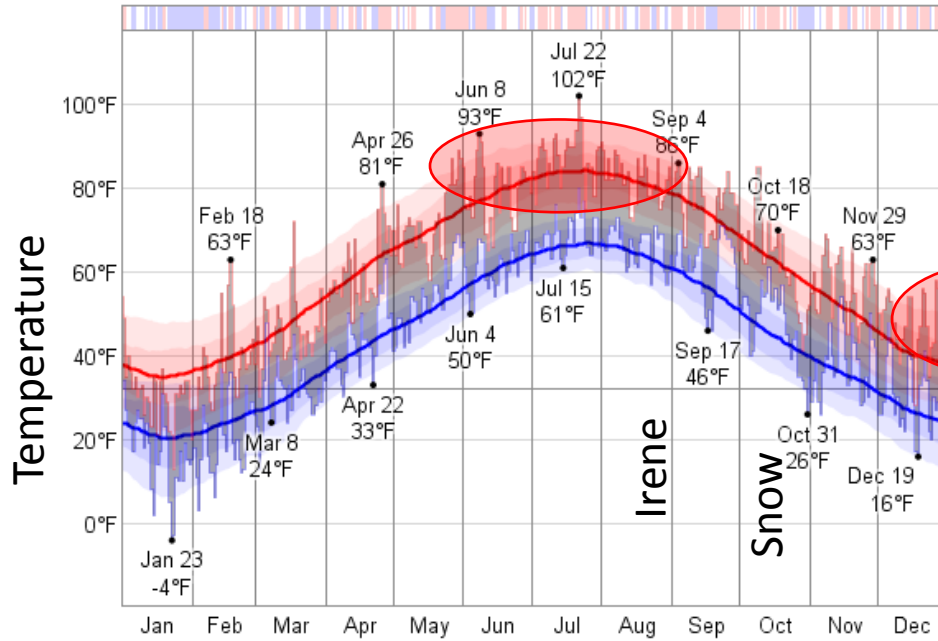
Recent notable weather patterns, cont'd

February 2013 Nor'easter: Winter Storm Nemo Blizzard of 2013

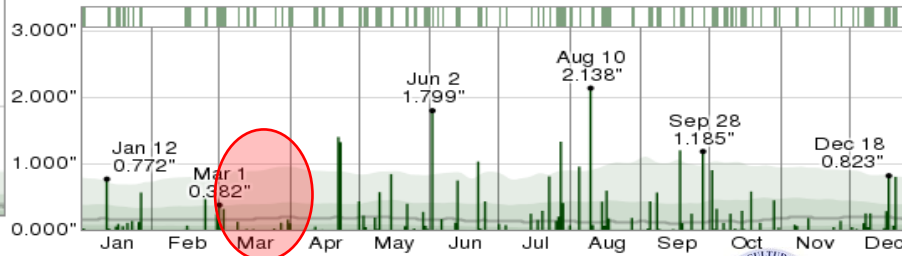
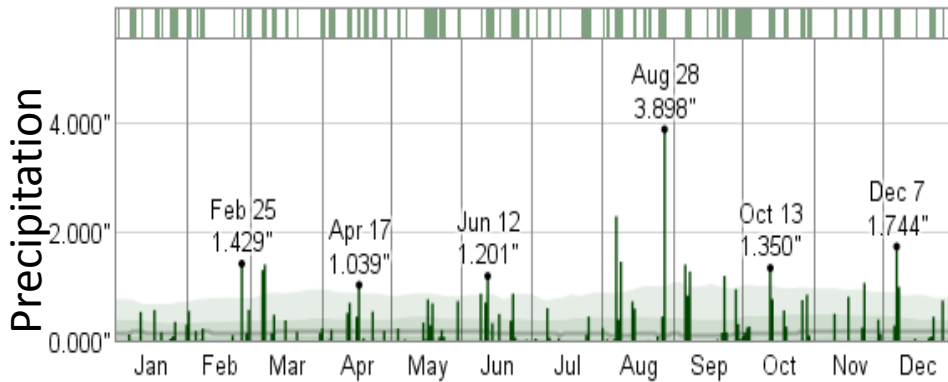
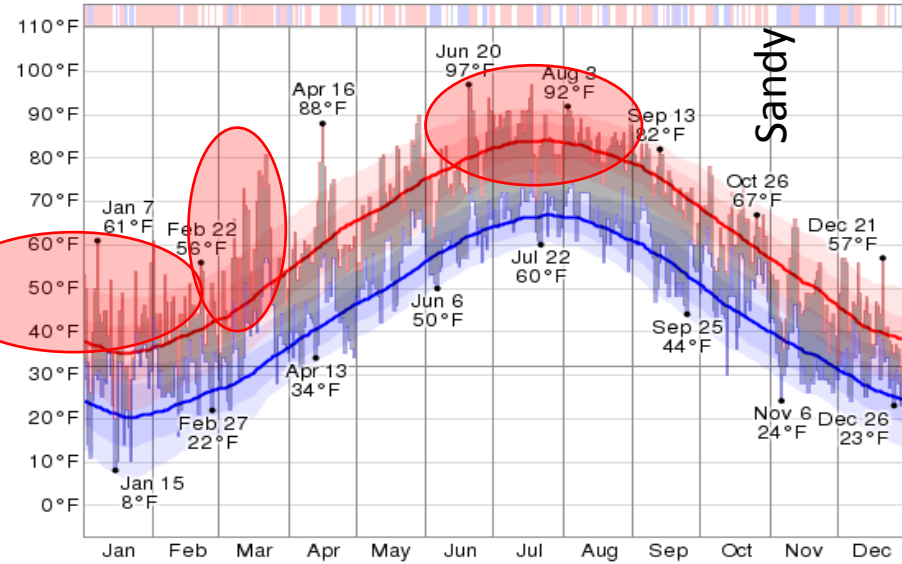


Recent notable weather patterns...a trend?

2011



2012



Hartford, CT



Our Changing Climate

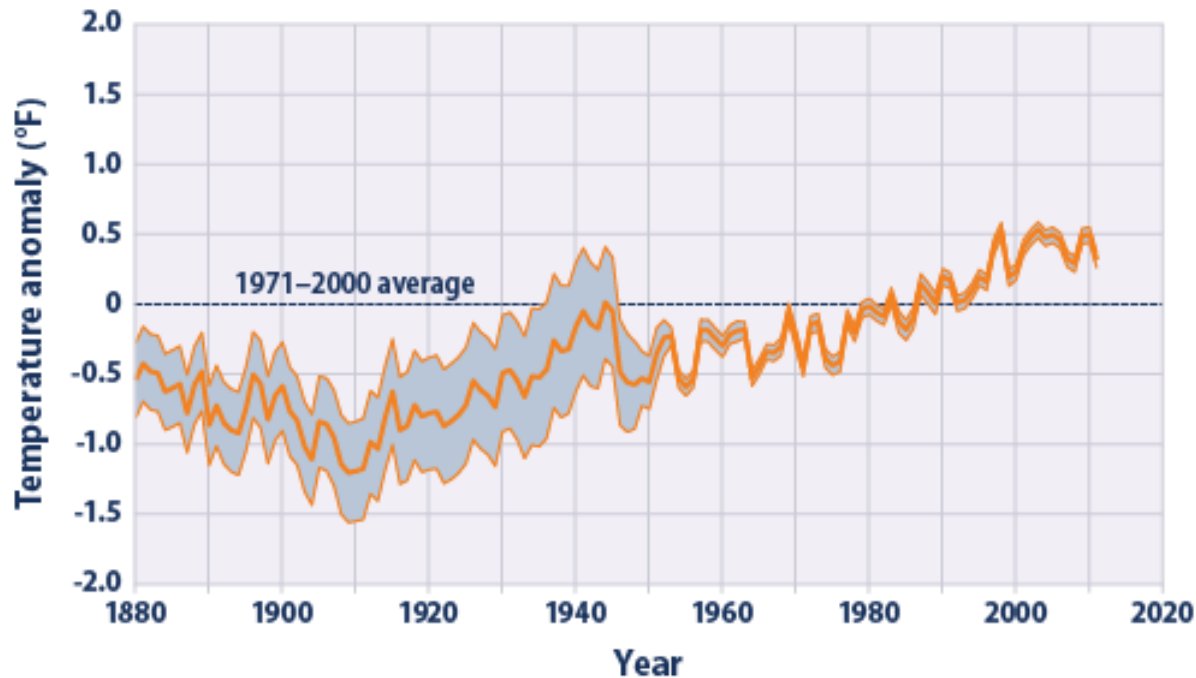
- The Northeast has been warming at a rate of 0.5°F per decade since 1970
 - Winter temperatures: 1.3°F per decade
- More winter precipitation
 - More falling as rain, less as snow
- Winter ice on lakes and rivers
 - Later to freeze, earlier to thaw
- **Rising sea-surface temperatures**
- **Rising sea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



Our Changing Climate

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

Figure 1. Average Global Sea Surface Temperature, 1880–2011

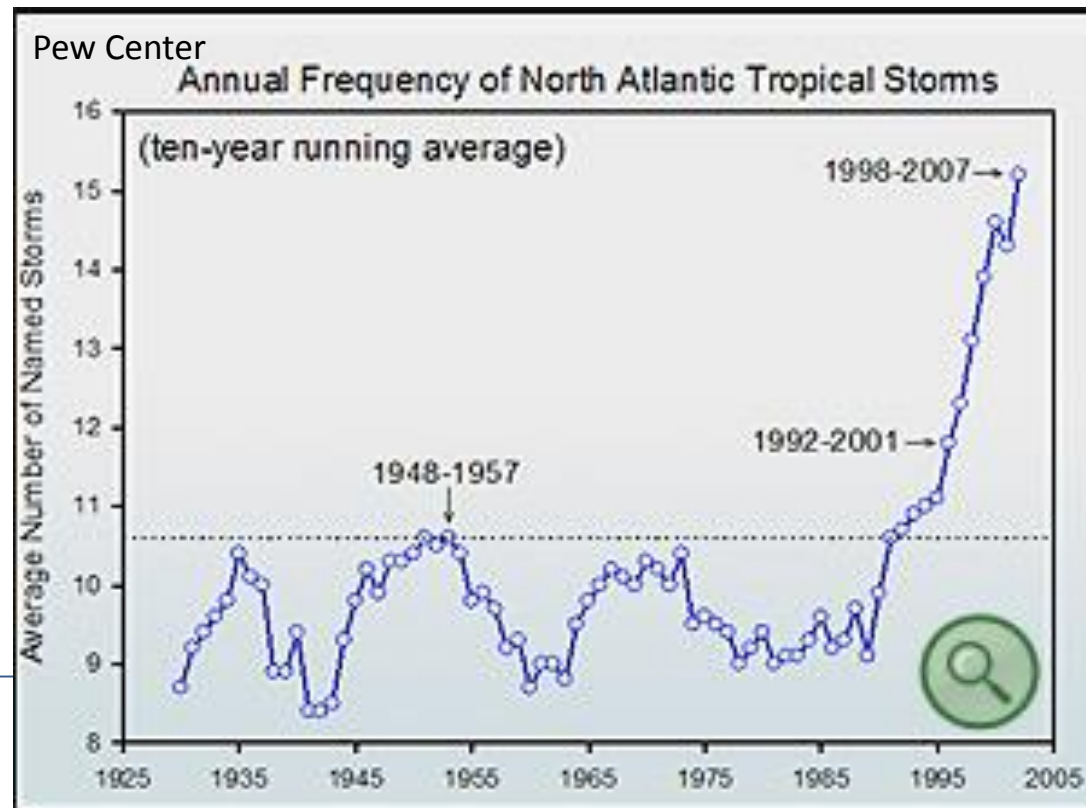


US-EPA



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**



AP, Posted 7/30/2013

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

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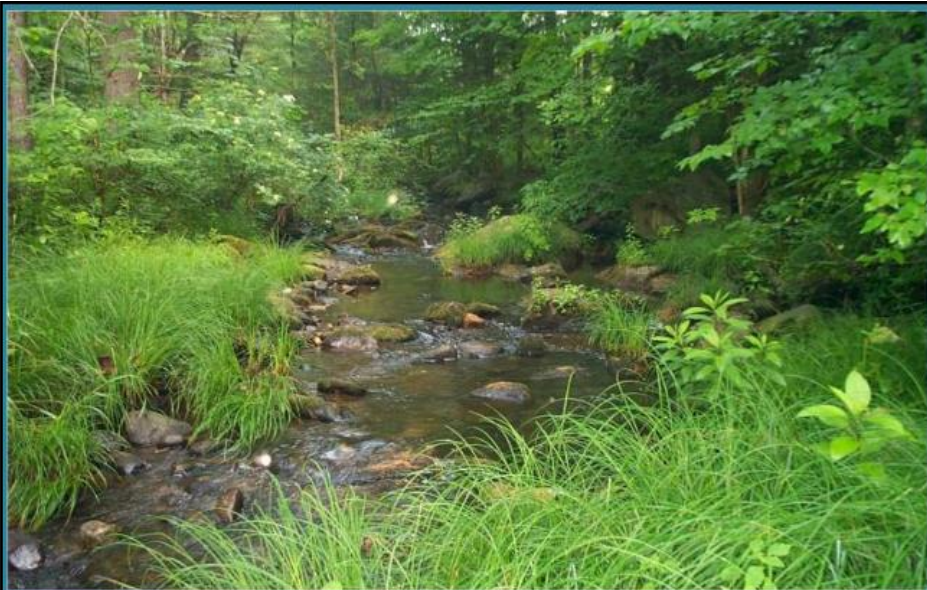
HARTFORD, Conn. (AP) — Connecticut environmental officials are warning of dire consequences from climate change that will affect agriculture, dams and levees, waterfront habitats and public health.

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 Strategies for Agriculture, Infrastructure, Natural Resources and Public Health Climate Change Vulnerabilities

*A Report by the Governor's Steering Committee on Climate Change (GSC)
Adaptation Subcommittee
2011*



Connecticut Climate Preparedness Plan 2011

Adaptation Subcommittee of
the **Governor's Steering
Committee on Climate
Change**

[www.ct.gov/deep/lib/
climatechange](http://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






2013 Long Island Sound Citizens Summit

When

Friday April 26, 2013 from 9:00 AM to 3:15 PM EDT

 [Add to Calendar](#)

Where

Iona College
Ryan Library
715 North Avenue
New Rochelle, NY 10801



[Driving Directions](#)

AGENDA

8:30 **Breakfast**

9:00 Welcome Noam Bramson, Mayor, New Rochelle NY

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,



CLIMATE CHANGE

EVIDENCE,



IMPACTS,



AND CHOICES



answers to common questions about the science
of climate change

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

National Academy
of Sciences, 2012

Available for
download at:

[www.nap.edu/catalog.
php?record_id=14673](http://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



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227
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West Haven, CT
September 2011

CAES- Plant Science Day 2013

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