Tropical Storms, Hurricanes, and "Superstorms": Impacts and Influence on Tree Diseases

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Overview

- Storm forces
- Storm damage
- Salt injury
- Diseases

Storm Forces

- Tropical Storms
- Hurricanes
- ?Superstorms?

What's in a name?

- Hurricanes and Tropical Storms are "Tropical Cyclones"

Tropical Cyclones:

- *Tropical* : geographic origin
  - Form over tropical oceans
- *Cyclone* : cyclical nature
  - Northern Hemisphere:

    counterclockwise

  - Southern Hemisphere:

    clockwise

Tropical Cyclones

- ***Tropical Depression:***
  - winds < 39 mph
- ***Tropical Storm:***
  - winds 39-74 mph
- ***Hurricane (typhoon):***
  - winds > 74 mph
- ***"Superstorm"***
  - Unusually destructive
  - Sandy: merged with a winter storm system from West

Tropical Cyclones

Rainfall amounts depend on:

- size and speed of the system
- Position in the system
- ocean temperature
- vertical wind sheer
- topography (e.g., coastlines, mountains)

- Unrelated to wind speed

Tropical Cyclone Forces

- Wind
- Salt spray
- Lightning
- Rain
- Storm surge

Tropical Cyclone Damage

Above ground:

- Blowdowns
- Crown twists
- Branch and Stem failures
- Wind abrasion
- Salt spray

Tropical Cyclone Damage

Below ground:

- Uprooting
- Root shearing
- Inundation
  - Rainwater
  - Sea water

Tropical Cyclone Damage

Blowdowns

Easton

Tropical Cyclone Damage

Blowdowns

Easton

Tropical Cyclone Damage

Blowdowns

West Haven

Blowdowns

- Some known true facts:
  - The higher the wind speed, the more likely that a tree will fail.
  - Trees in groups are more likely to survive high winds than those grown singly.
  - Trees with healthy roots are less likely to fail.
  - Some tree species do better than others.

Blowdowns

Blowdowns

Trees with Wind Resistance

- Typical characteristics:
  - Wide spreading branches
  - Low center of gravity
  - Strong penetrating root systems
  - Small leaf size

Trees with Wind Resistance

- Dogwood (*Cornus florida*)
- American holly (*Ilex opaca*)
- Baldcypress (*Taxodium distichum*) * §
- Silver maple (*Acer saccharinum*) *
- Sugar maple (*Acer saccharum*)
- Black maple (*Acer nigrum*) *
- Japanese maple (*Acer palmatum*)
- River birch (*Betula nigra*) *
- Ironwood (*Carpinus caroliniana*)
- Hickories (*Carya* spp.) * §
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- Hophornbeam (*Ostrya virginiana*)
- Red oak (*Quercus rubrum*)
- Tulip tree (*Liriodendron tulipifera*) §
- Sycamore (*Platanus occidentalis*) *
- Red Cedar (*Juniperus virginiana*)*
- Black pines (*Pinus thunbergii, P. nigra*)*§

* salt spray tolerant
§ soil salt tolerant

Tropical Cyclone Damage

Branch and stem failures

Easton

Tropical Cyclone Damage

Branch and stem failures

West Haven

Branch and Stem Failures

- Some known true facts:
  - Unhealthy trees are more prone to branch and stem failures.
  - Poor structure or included bark make trees more vulnerable in high wind.
  - Well-pruned trees are more likely to survive in a hurricane.


Univ Missouri Extension

Tropical Cyclone Damage

Wind abrasion and scorch

Wind abrasion and scorch

Mechanical damage:

- abrasion of leaves/needles against each other

Desiccation:

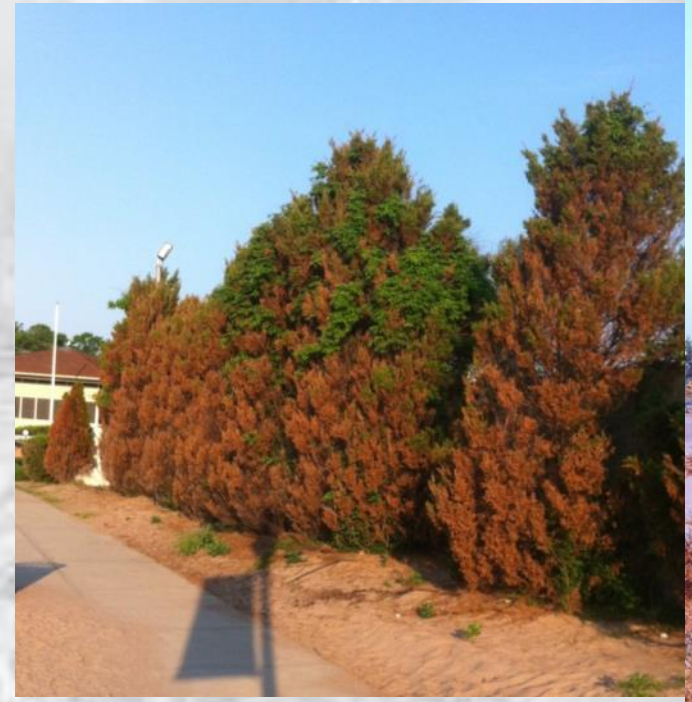
- similar to drought and temperature stress
- air passing over stomates enhances water stress

Impact of wind abrasion/scorch is complex:

- Dependent on other variables (water, temperature)

Tropical Cyclone Damage

Salt spray



Tropical Cyclone Damage

Salt spray

Tropical Cyclone Damage

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
  - "early fall to full winter in two hours"
- East sides of white houses stained yellow-green
- Extensive evidence of salt injury

Salt spray

Salt spray

West Haven

1938: Inland Extent of Salt Spray Injury

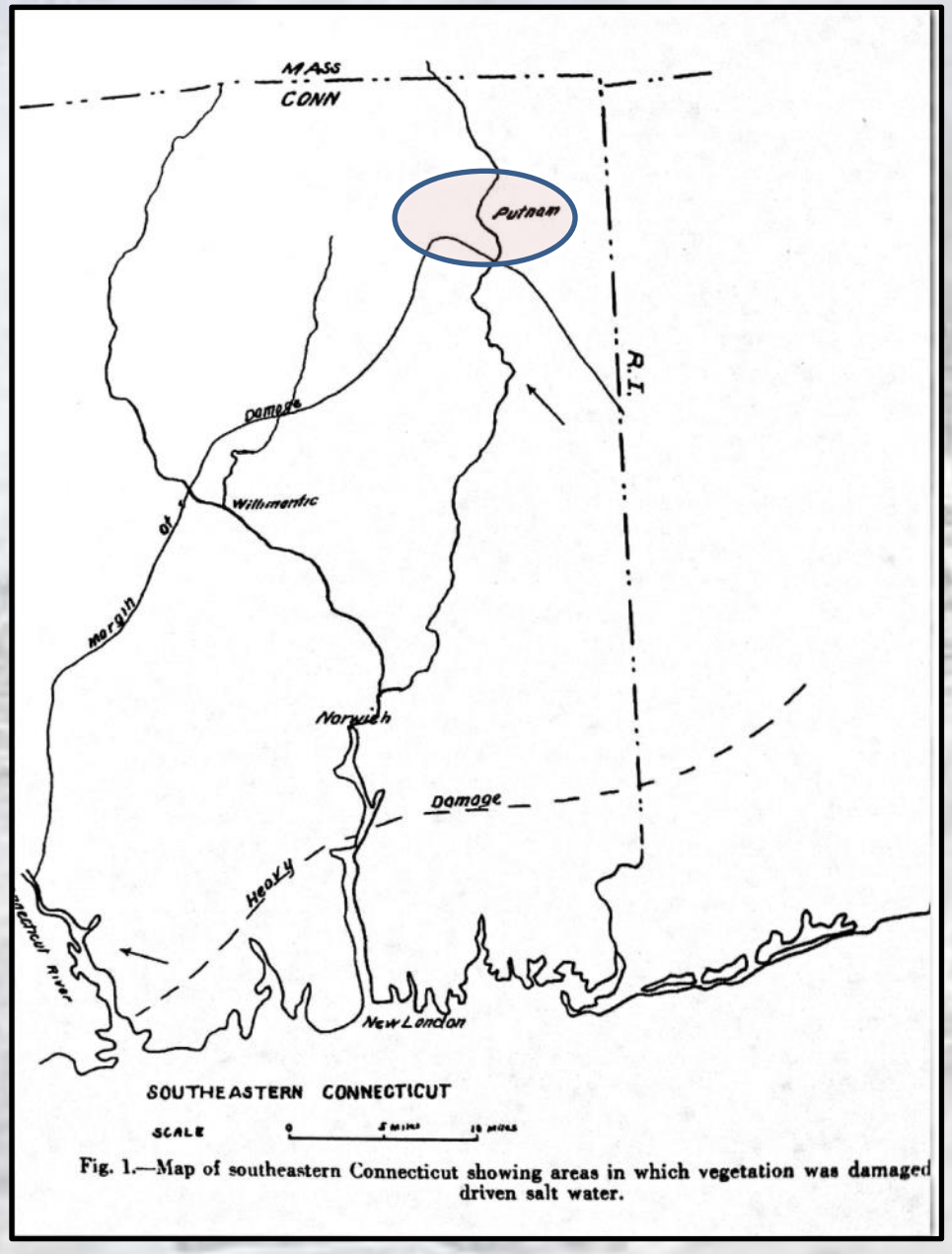


Fig. 1.—Map of southeastern Connecticut showing areas in which vegetation was damaged driven salt water.

- White pine used as indicator 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

1938 Hurricane

- Conifers resistant to salt spray injury:
  - Colorado blue spruce
  - Black, pitch, red pines
- Conifers susceptible to salt spray injury:
  - White pine
  - White cedar
  - Hemlock
  - Arborvitae

West Haven

West Haven

Salt spray

1938 Hurricane :

Spring 1939 Observations

Susceptible hardwoods: Tulip tree, tupelo

- Dieback or loss of terminal twigs on windward sides: no new growth
- Delayed leaf-out

Wind vs. Salt spray

Salt spray: an important factor in coastal ecology. 1937.

B.W. Wells and I.V. Shunk. *Bulletin of the Torrey Botanical Club*, v.65: 485-492.

Salt spray – *not wind* – drives the scorching of foliage on windswept coasts.

Inland Deposition of Sea Salt

Four mechanisms:

1. Aerosolized sea water from "breaking bubbles" on waves.
2. "Spume droplets" formed by wind-shearing of wave crests.

Amount determined less by wind speed and more by frequency and size of waves.

Inland Deposition of Sea Salt

Four mechanisms (cont'd):

3. Wind-blown salt from dried storm surge water.
4. Hurricane rainwater:

   minimal salt

Inland Deposition of Sea Salt

NASA (2003) **:**

Cirrus clouds over Great Plains containing frozen sea salt and ocean plankton.

National Geographic (2010):

Chlorine (Cl) from sea spray detected as far inland as Boulder, CO.

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

Tropical Cyclone Damage

Flooding

Hoboken, NJ

Charles Hack, The Jersey Journal

Tropical Cyclone Damage

Flooding

West Haven, CT

Tropical Cyclone Damage

Flooding

West Haven, CT

Flooding (Inundation)

- Most trees can tolerate 2-3 days of flooding.
- Flood tolerance varies among and within species.
  - "Halophytes" are plants that thrive in saline environments.
    - Saltmarsh grasses, *Spartina* spp.
    - Mangroves
- Established healthy trees do better than stressed, very young and very old trees.
- Dormant trees more tolerant than actively growing trees.

Flooding

Impacts on soil:

- O_2 depletion
- Anaerobic decomposition
- CO_2 accumulation
- Depletion of iron and manganese
- Alteration of soil structure
  - waterlogging
- Inhibition of seed germination

Flooding

Symptoms of water stress in trees :

- Yellowing, browning, curling, and/or wilting leaves
- Reduced size of new leaves
- Defoliation
- 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
- root rot
  - » water molds, e.g., *Phytophthora*, *Pythium* spp.
- loss of mycorrhizal fungi due to anaerobic conditions.

Flooding

Tree responses:

- Reduced uptake of macronutrients (N, P, K, Ca, Mg).
  - » Uptake requires O_2, which is displaced from waterlogging
- Reduced nutrient content in leaves.
- Increased susceptibility to pathogens and pests.

Flooding

Tree responses:

- With regular flooding, some trees adapt:
  - Aerial absorption of O_2
  - Hypertrophied lenticels on submerged stems and roots
    - Exchange of dissolved gases in flood water
  - Adventitious roots

Flooding

Flooding

Some trees recover:

- Salt leaches out much more rapidly in sandy soils than clay soils.
- Healthy trees more likely to recover than those already stressed.

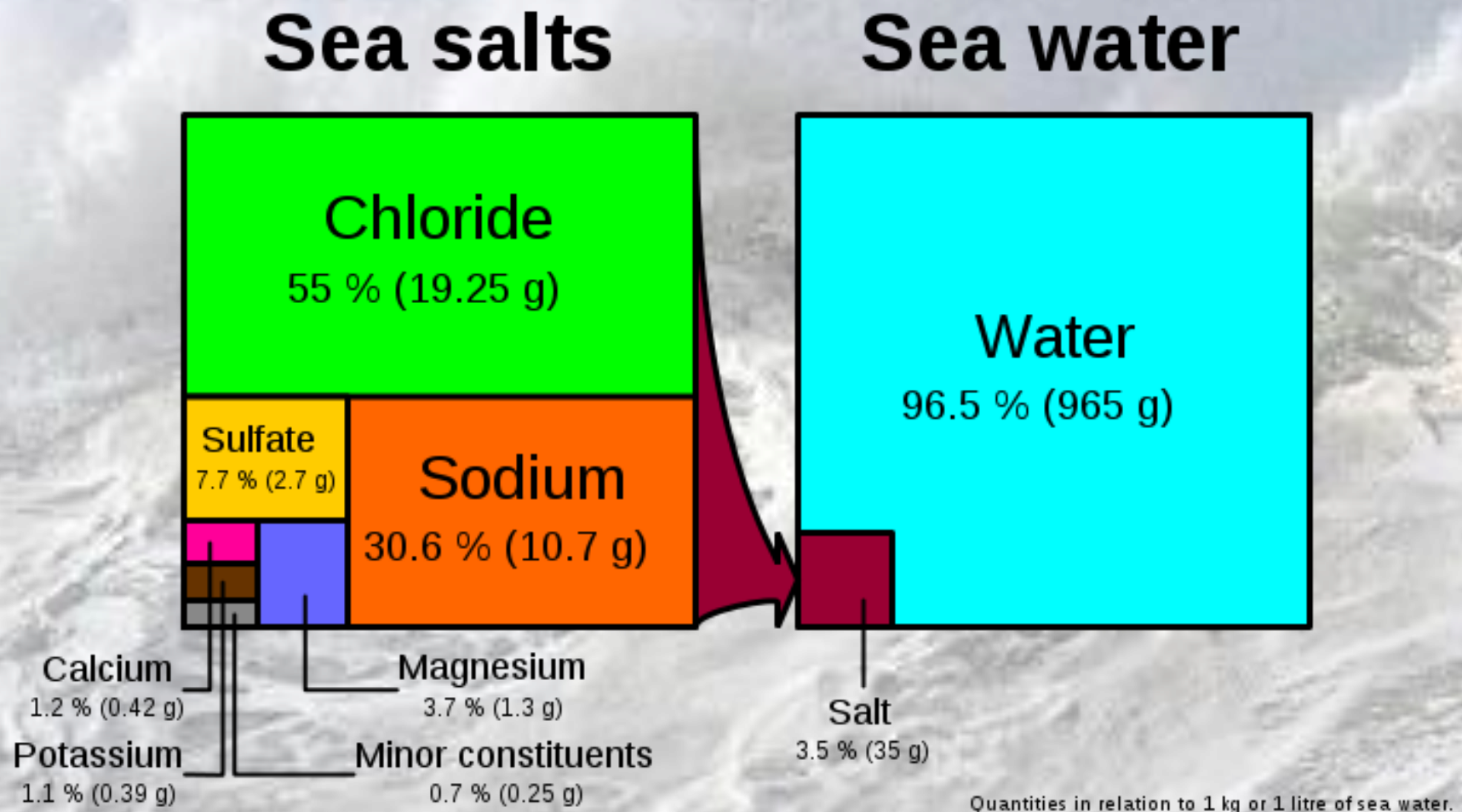
Salt

HOW

does it injure plants?

Sodium Chloride (NaCl)

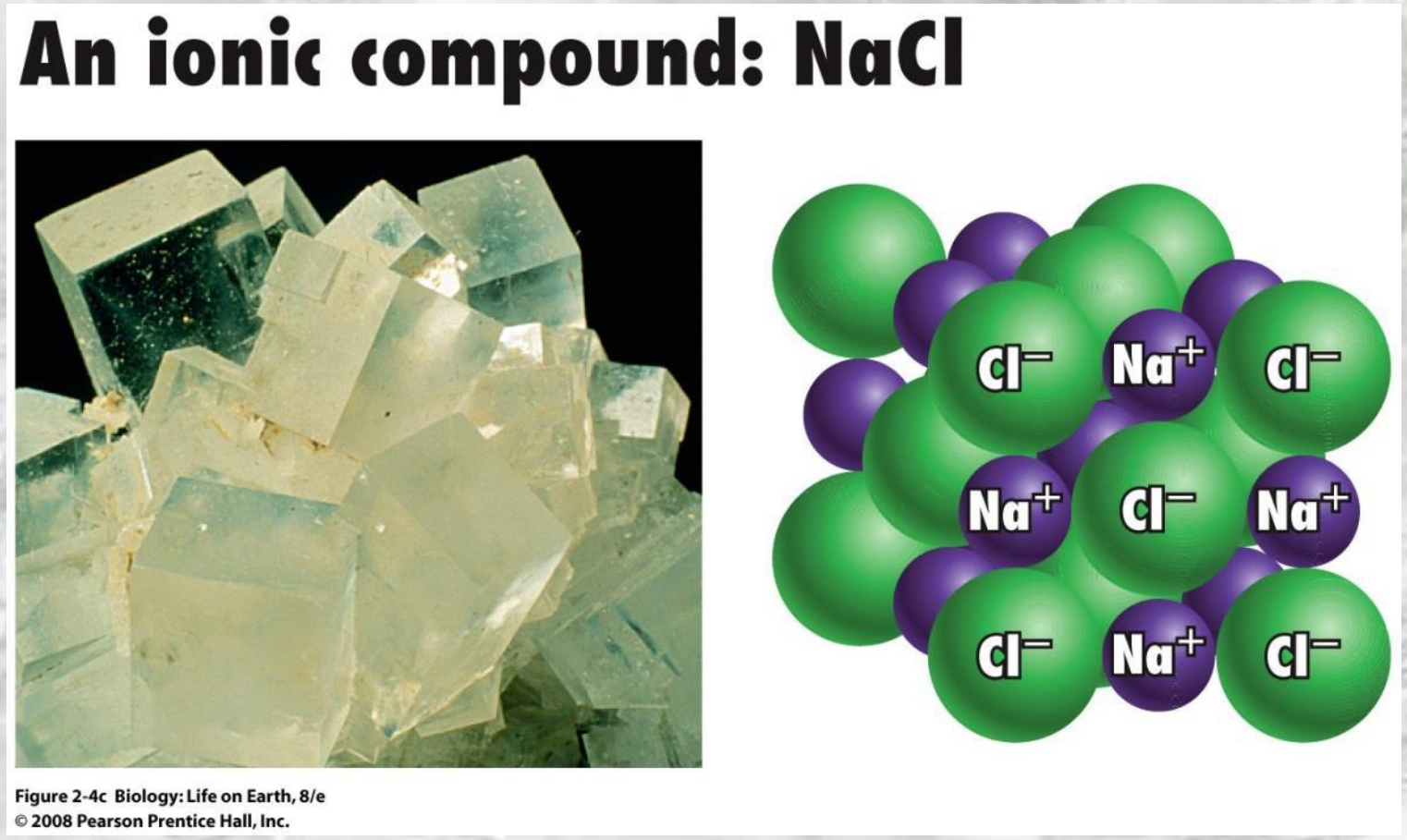
- Table salt
- Road salt
- Primary saline constituent of sea water
  - 3.5% (35g/L) NaCl
    - Human body fluids: 0.9% NaCl



Hannes Grobe/Stefan Majewsky

Salt :

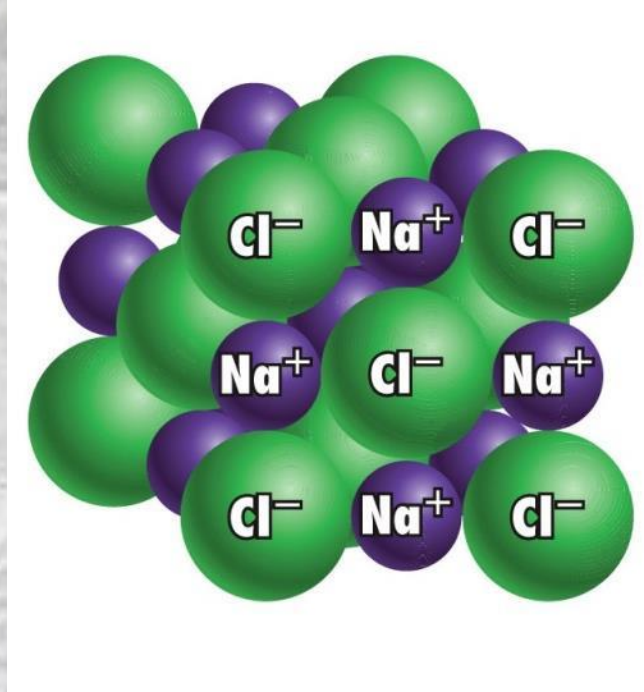
an ionic crystalline compound

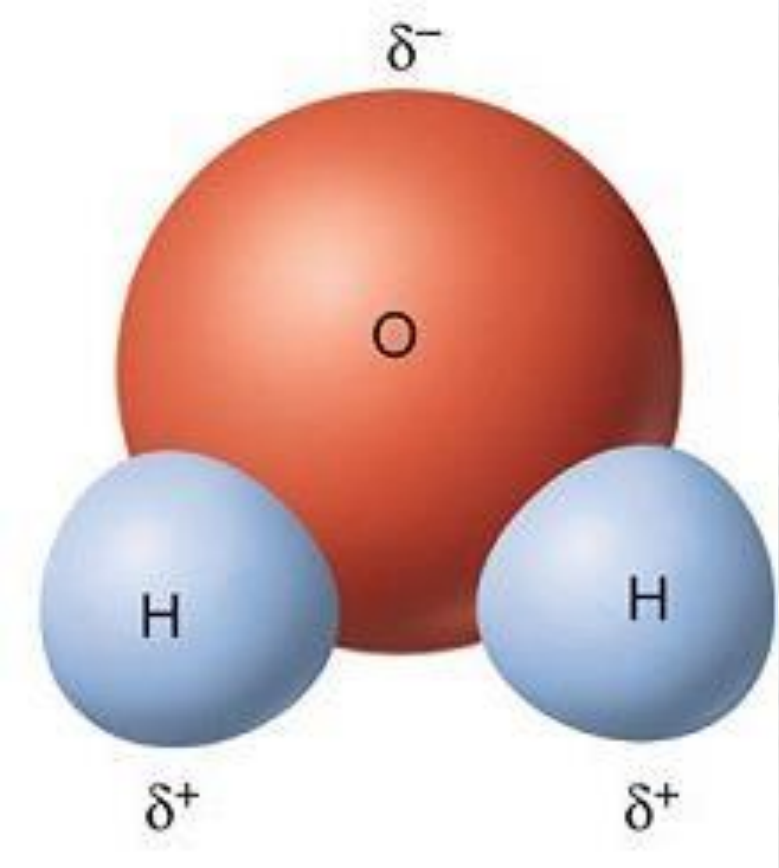


Salt :

an ionic crystalline compound

- **Compound:** made up of two or more atoms
- **Ion:** an atom with a positive or negative electrical charge due to loss or gain of electrons
- **Crystalline:** regularly ordered, repeating 3-D pattern





Water, H_2O

Polar molecule: slightly negative and positive sides.

NaCl in water

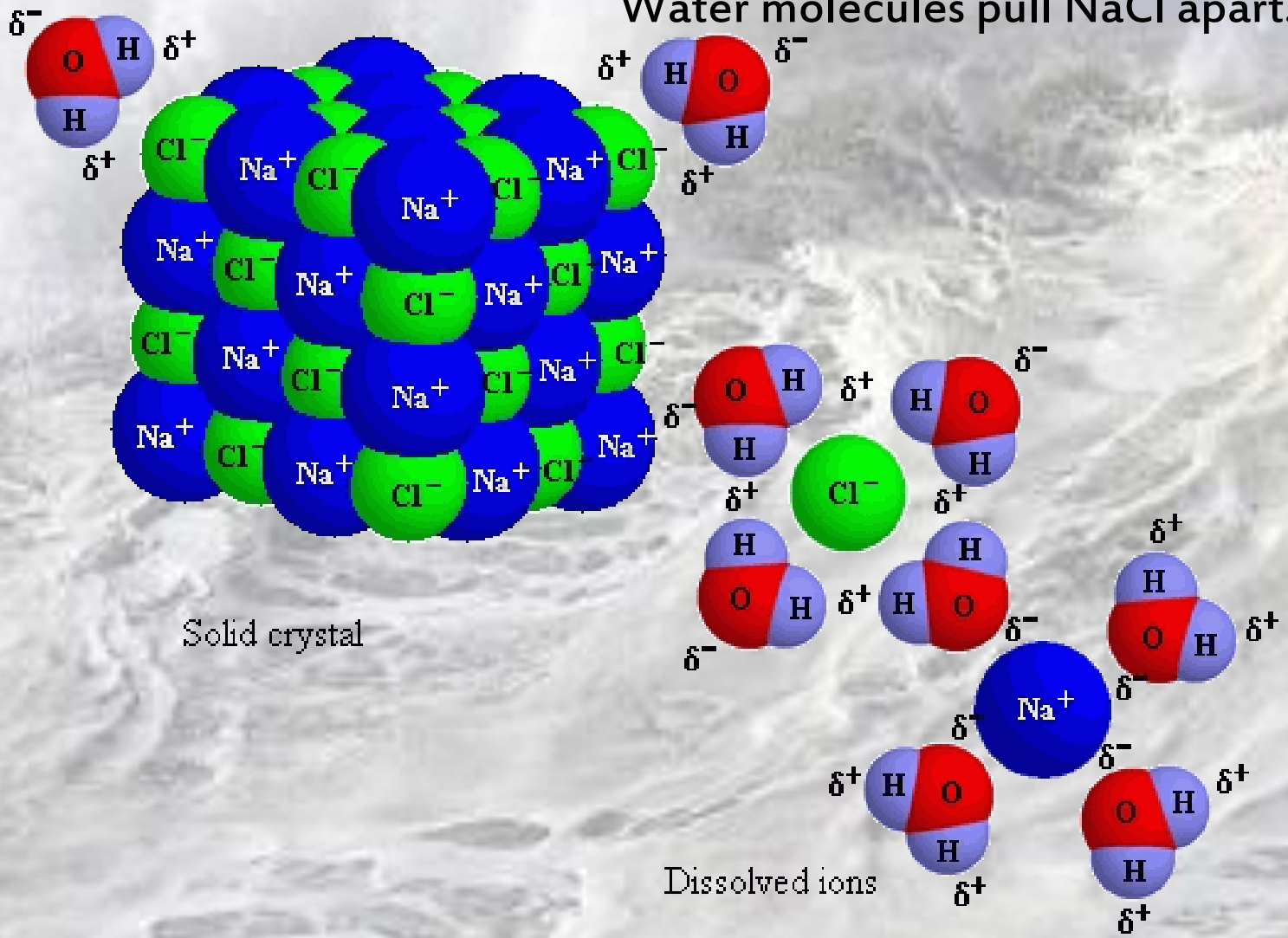
~ sea water

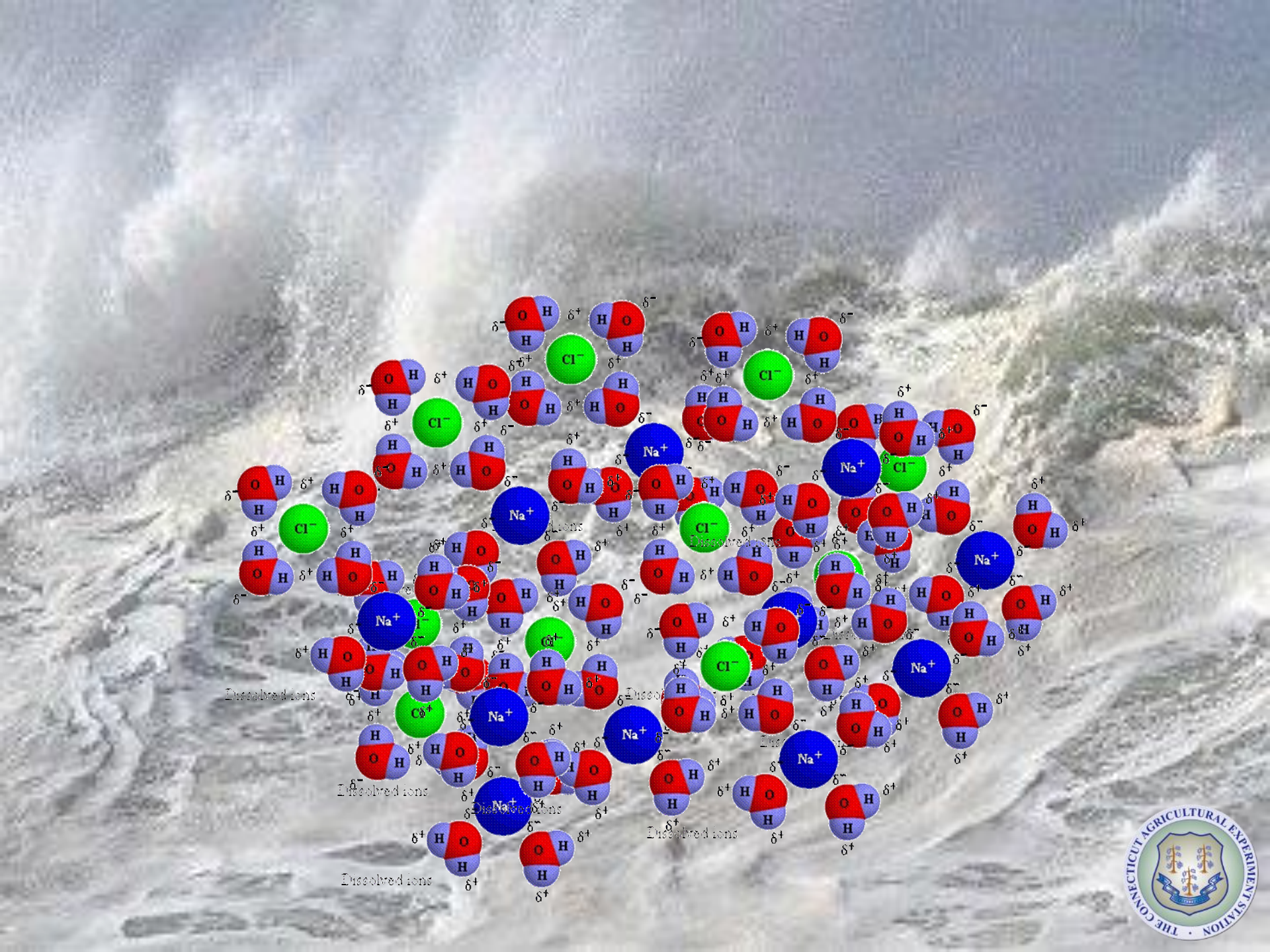
NaCl in water

=sea water

Water (H_2O) is polar: slightly negative and positive sides.

Water molecules pull NaCl apart.




Na+
Cl−
Dissolved ions

Salt

HOW

does it injure plants?

Mechanisms of Salt Injury

- Salt is "hygroscopic": absorbs water
  - out of leaf tissue and around roots
  - creates drought-like environment, despite presence of water
  - as water is taken up by roots or lost to evaporation, salt concentration increases.
- Sodium (Na^+) and chloride (Cl^-) have very different modes of action in plants.

Water, water, every where,
And all the boards did shrink;
Water, water, every where,
Nor any drop to drink.

~From "The Rime of the Ancient Mariner,"
Samuel Taylor Coleridge, 1798

Salt on Foliage

- Once absorbed, translocated to tips of needles or margins of leaves
  - Reach toxic concentrations
- Degree/rate of absorption of Na^+ and Cl^- ions into foliage varies
  - Thickness of cuticle
  - Stomates

Salt in Soil

Sodium, Na^+

- Prevents aggregation of soil particles
  - Compaction
    - reduced availability of H_2O, O_2
- Raises pH
  - Reduces solubility of minerals (e.g., iron)
- Blocks uptake of Mg^{++} and K^+
  - Essential to chlorophyll synthesis
  - Outcompetes for membrane channels that shuttle ions into cells
- Translocated to buds/leaves
  - Slowly 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.
- Translocated through xylem to shoot tips and leaf margins
  - Accumulates to toxic concentrations
  - Delay or prevent bud opening
  - Marginal scorch in leaves

Tropical Storms and Tree Diseases

- Reduced tree vigor leads to increased susceptibility to diseases
- Compounded by physical damage caused by wind
  - Abrasion of foliage
  - Stem/branch breaks
  - Root shearing

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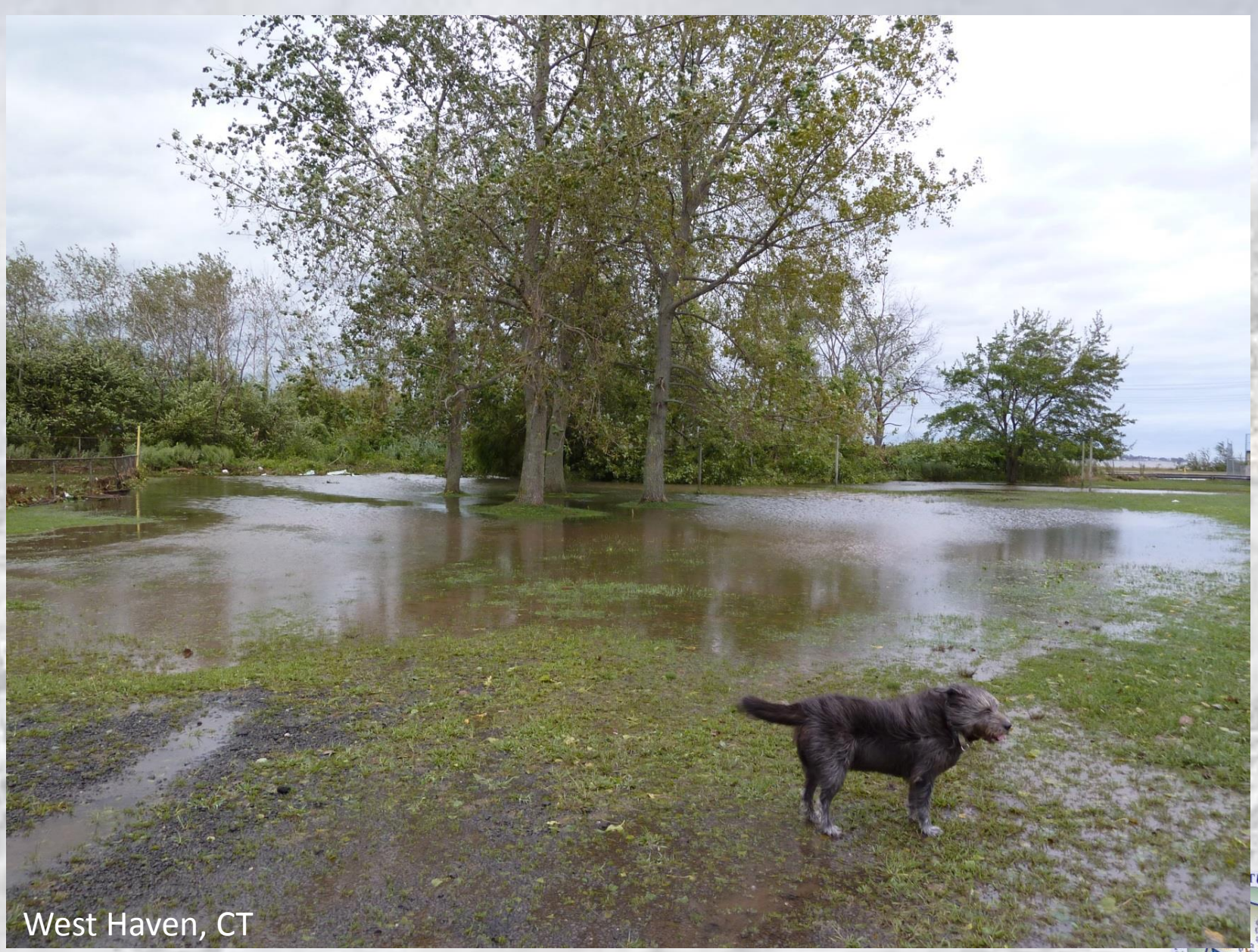
West Haven, CT


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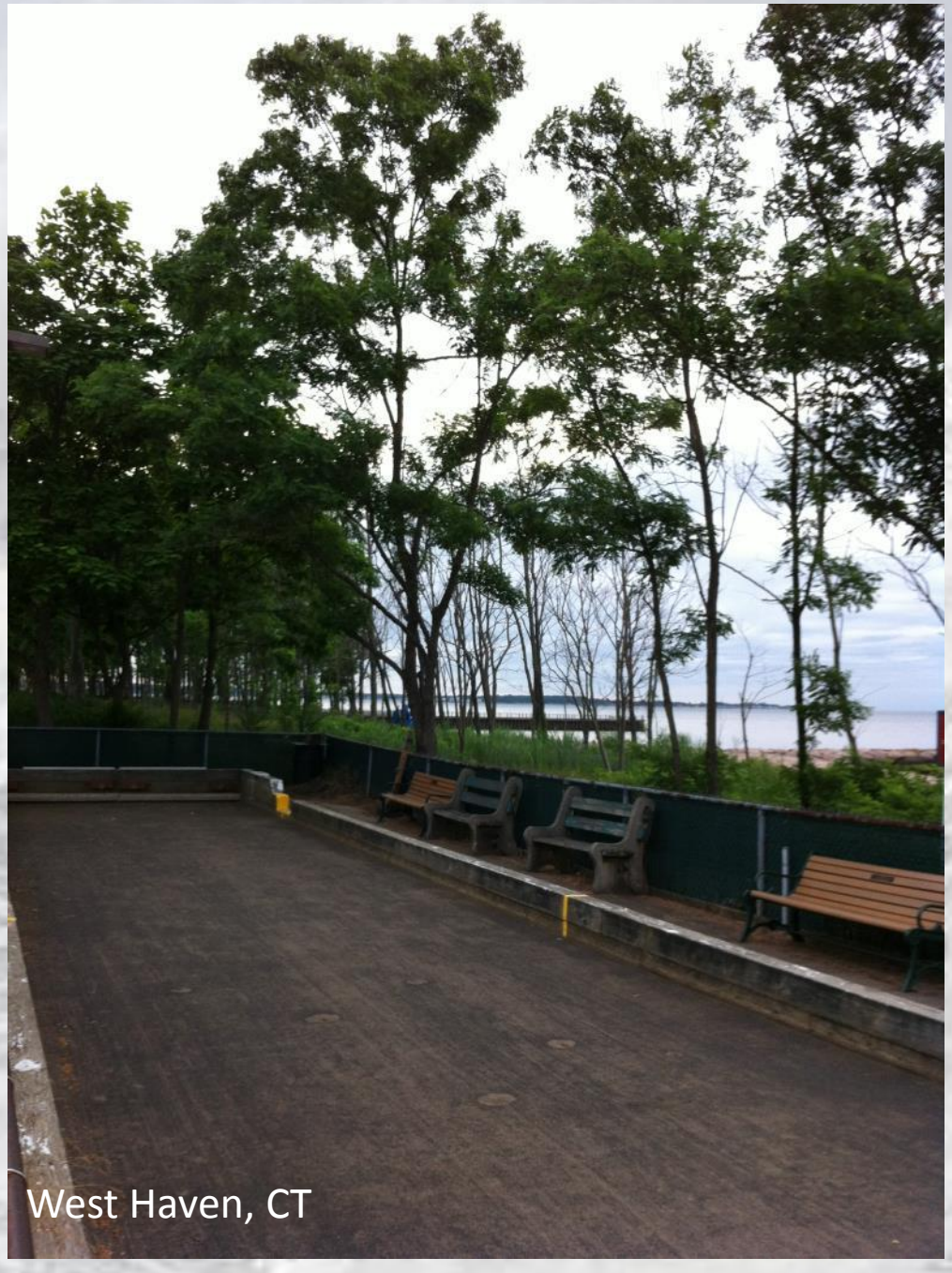


West Haven, CT


West Haven, CT

Tropical Storms and Tree Diseases

- Impaired defenses
- Canker-causing fungi
  - *Valsa sordida*
  - *Fusarium lateritium*
  - *Cytospora*
  - *Botryosphaeria dothidea*
  - *Nectria cinnabrina*
  - Sooty canker
  - *Cerrena*, *Trametes*, *Schizophyllum*
- Diplodia dieback
- Sapwood decay
- Root rot (e.g., *Armillaria*)

Putting Storm Damage Into Context: Recent notable weather patterns

August 2011:

Tropical Storm Irene

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**
- **July the 9th hottest month on record in CT**

October 2012:

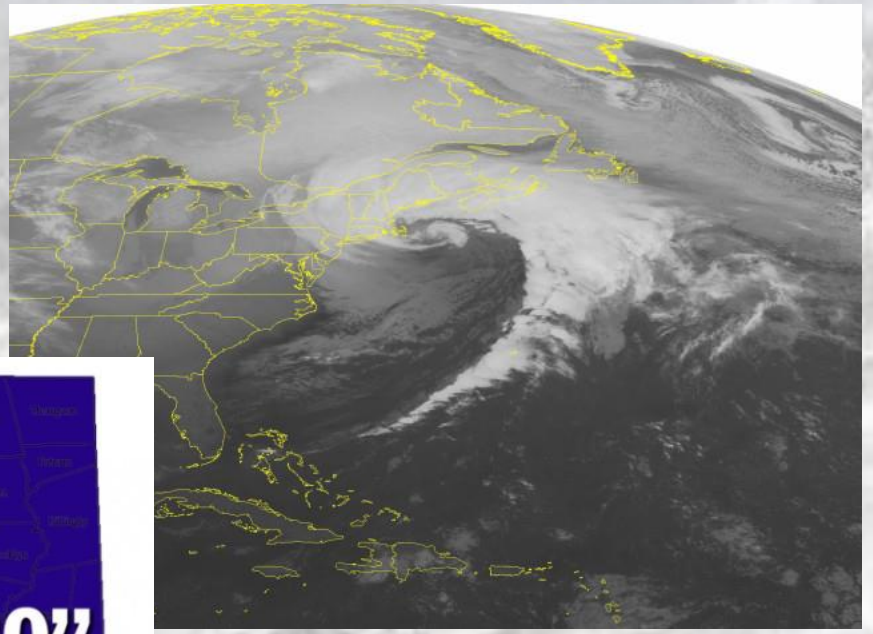
- **Hurricane Sandy**

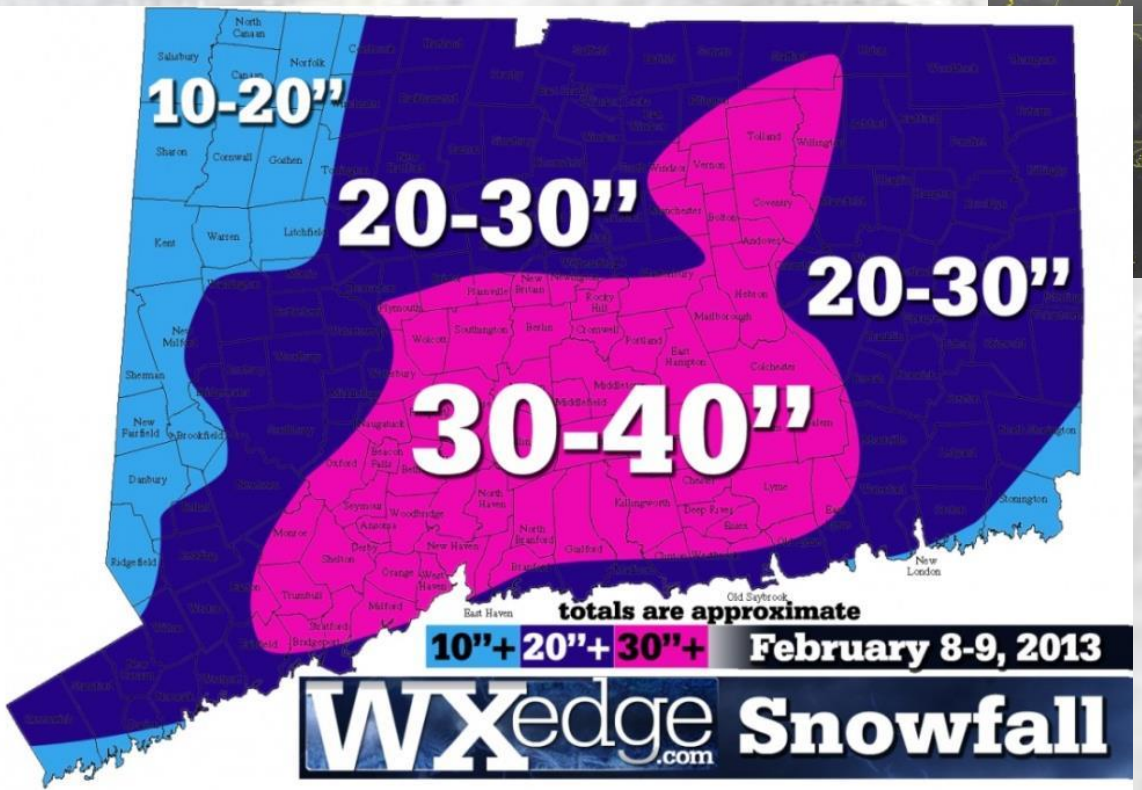
Recent notable weather patterns, cont'd

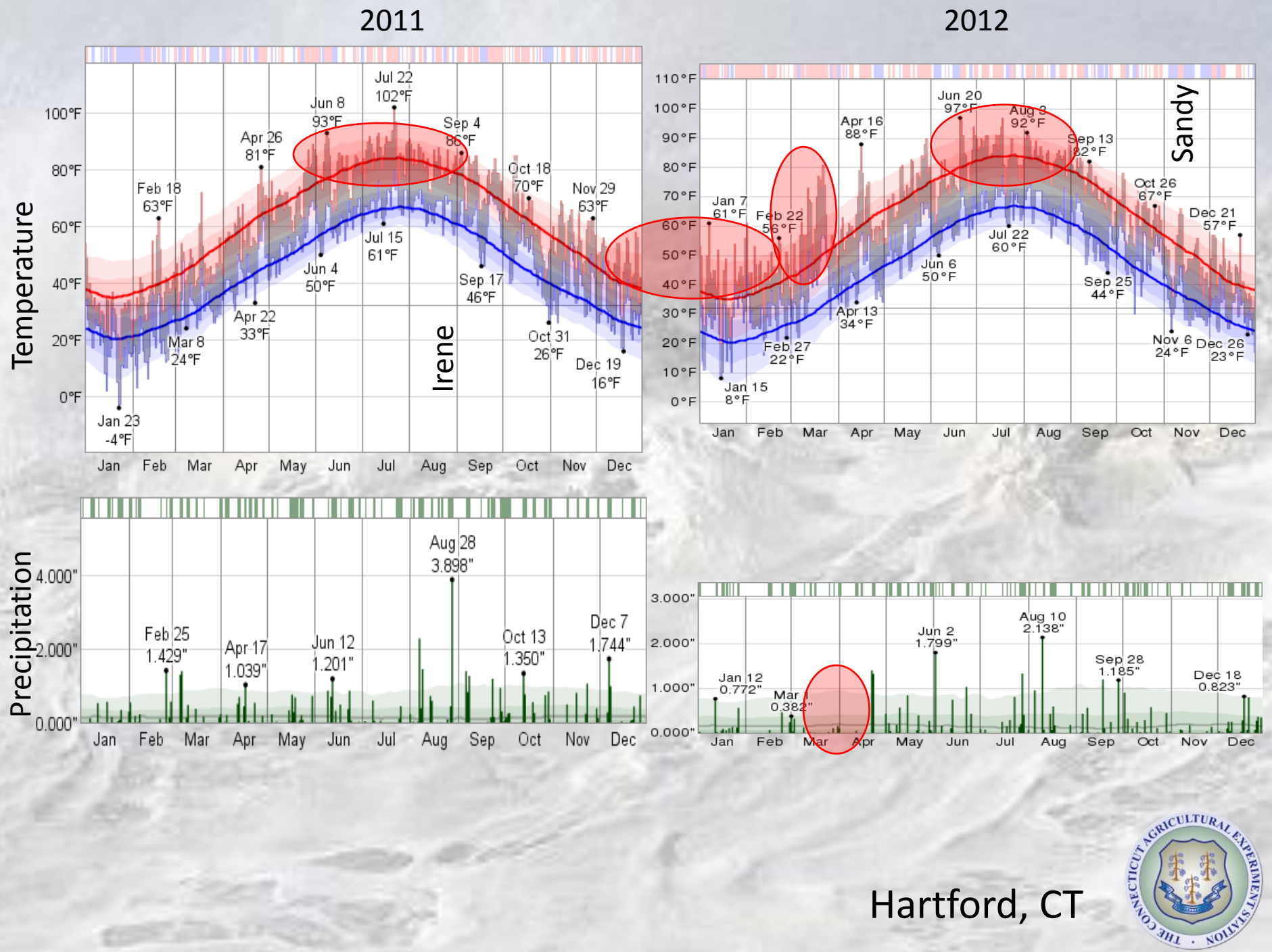
February 2013 Nor'easter:

Winter Storm Nemo

Blizzard of 2013






2011
2012
Temperature
Precipitation
Irene
Sandy
Jan 23 -4°F
Feb 18 63°F
Mar 8 24°F
Apr 22 33°F
Apr 26 81°F
Jun 4 50°F
Jun 8 93°F
Jul 15 61°F
Jul 22 102°F
Sep 4 86°F
Sep 17 46°F
Oct 18 70°F
Oct 31 26°F
Nov 29 63°F
Dec 19 16°F
Jan 15 8°F
Jan 7 61°F
Feb 22 56°F
Feb 27 22°F
Apr 13 34°F
Apr 16 88°F
Jun 6 50°F
Jun 20 97°F
Jul 22 60°F
Aug 3 92°F
Sep 13 82°F
Sep 25 44°F
Oct 26 67°F
Nov 6 24°F
Dec 21 57°F
Dec 26 23°F
Feb 25 1.429"
Apr 17 1.039"
Jun 12 1.201"
Aug 28 3.898"
Oct 13 1.350"
Dec 7 1.744"
Jan 12 0.772"
Mar 1 0.382"
Jun 2 1.799"
Aug 10 2.138"
Sep 28 1.185"
Dec 18 0.823"
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Hartford, CT
THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION

Summary

- Tropical Cyclones present unique challenges to trees*
  - wind, salt spray, and flooding
- Salt injury through foliage and soil
  - Drought-like symptoms
  - Chloride toxicity
- Salt and flood tolerance varies 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

*and the arborists who care for them