Green Infrastructure Champions Program

This program is partially funded by the Rutgers New Jersey Agricultural Experiment Station, The Geraldine R. Dodge Foundation, and NJ Sea Grant Consortium and is a collaboration of the Rutgers Cooperative Extension Water Resources Program and the Green Infrastructure Subcommittee of Jersey Water Works.

JERSEY WATER WORKS
Smart infrastructure. Strong communities.

Sea Grant
NJ Sea Grant Consortium

The Geraldine R. DODGE FOUNDATION
IMAGINE A BETTER NEW JERSEY

RUTGERS
New Jersey Agricultural Experiment Station

Green Infrastructure Champion Training: Part 9

"Using Green Infrastructure to Promote Climate Resiliency"

June 7, 2019
Rutgers EcoComplex
Bordentown, NJ

Rutgers Cooperative Extension Water Resources Program
Christopher C. Obropta, Ph.D., P.E.

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New Jersey Agricultural Experiment Station

RUTGERS
THE STATE UNIVERSITY
OF NEW JERSEY

Special Thanks to
Dr. David A. Robinson
Distinguished Professor,
Department of Geography
&
New Jersey State
Climatologist
Rutgers University

Little Falls, NJ
11 August 2018

(Miguel Galo, Special to NorthJersey.com)

Climate or Weather???

Weather refers to the short-term phenomena

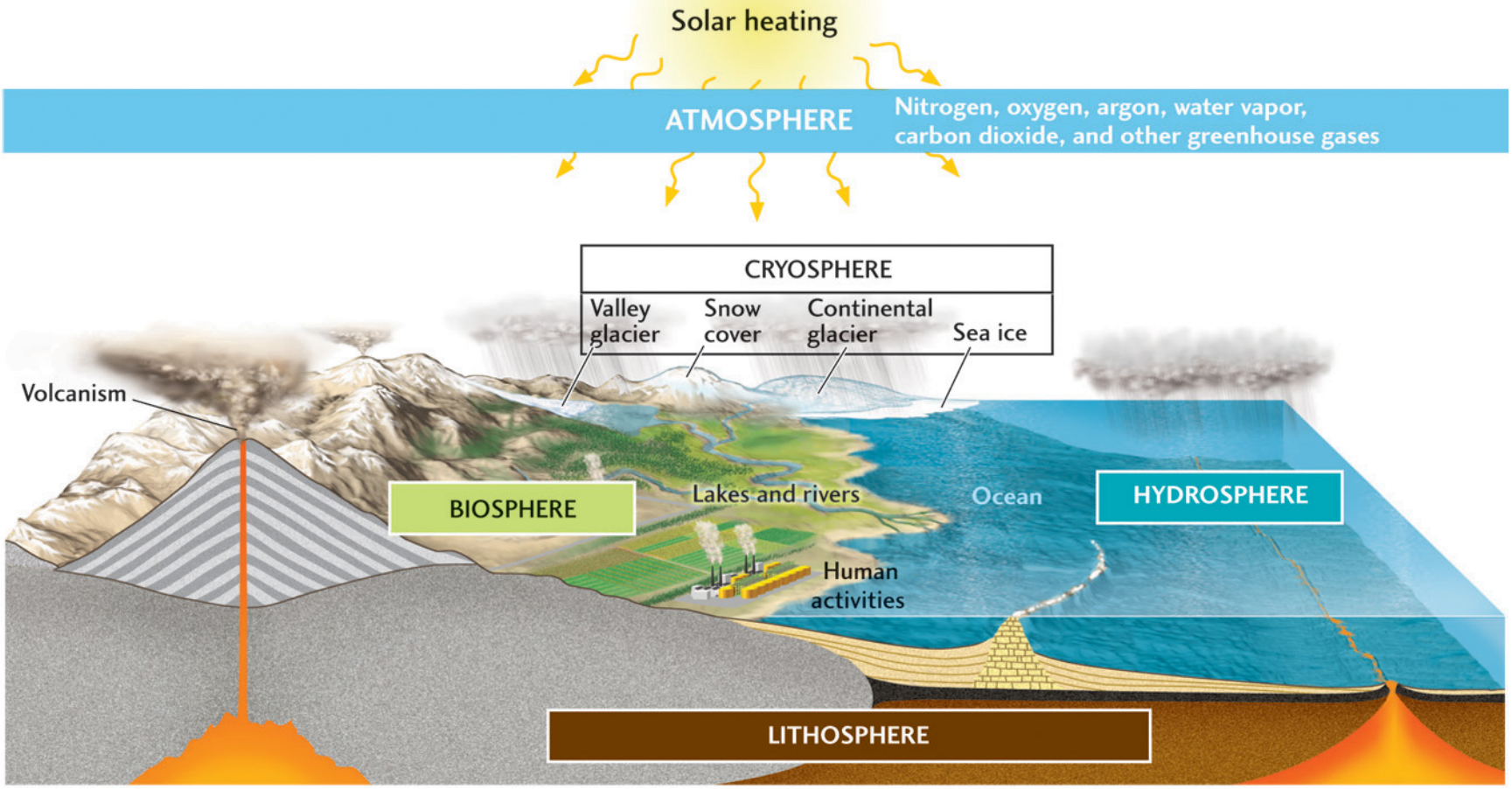
Climate refers to the long-term patterns

Better yet!

Climate is your personality…..

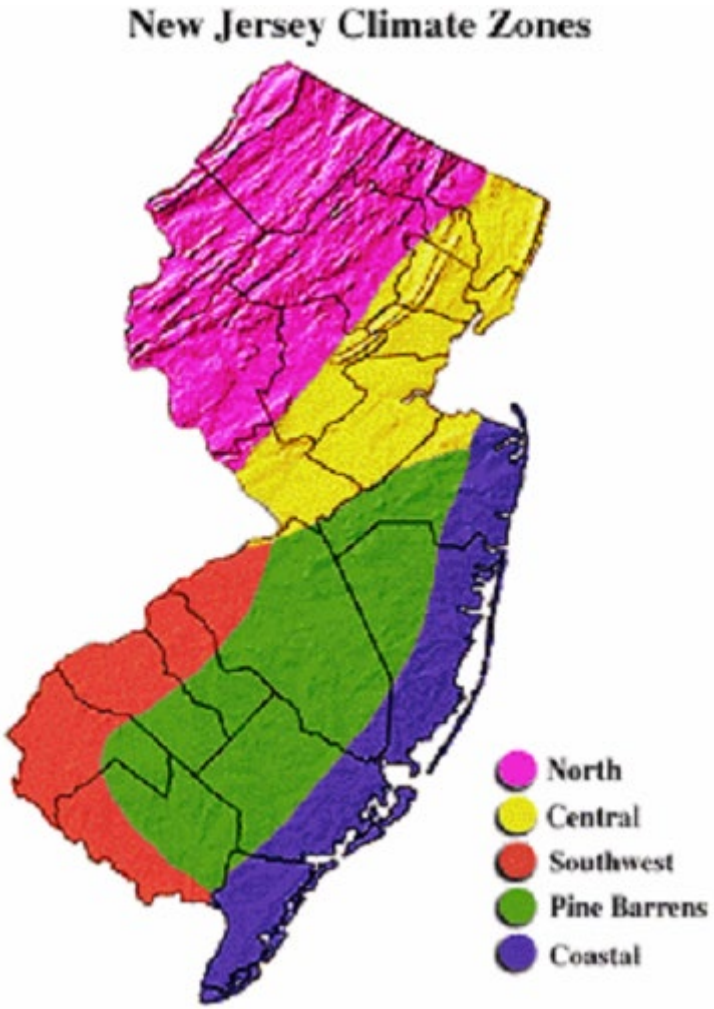
Weather is your mood……

The Earth's Climate



- The climate includes many components of the Earth's system and interactions between them.

Diversity: local controls on NJ's weather and climate



Ludlum 1983

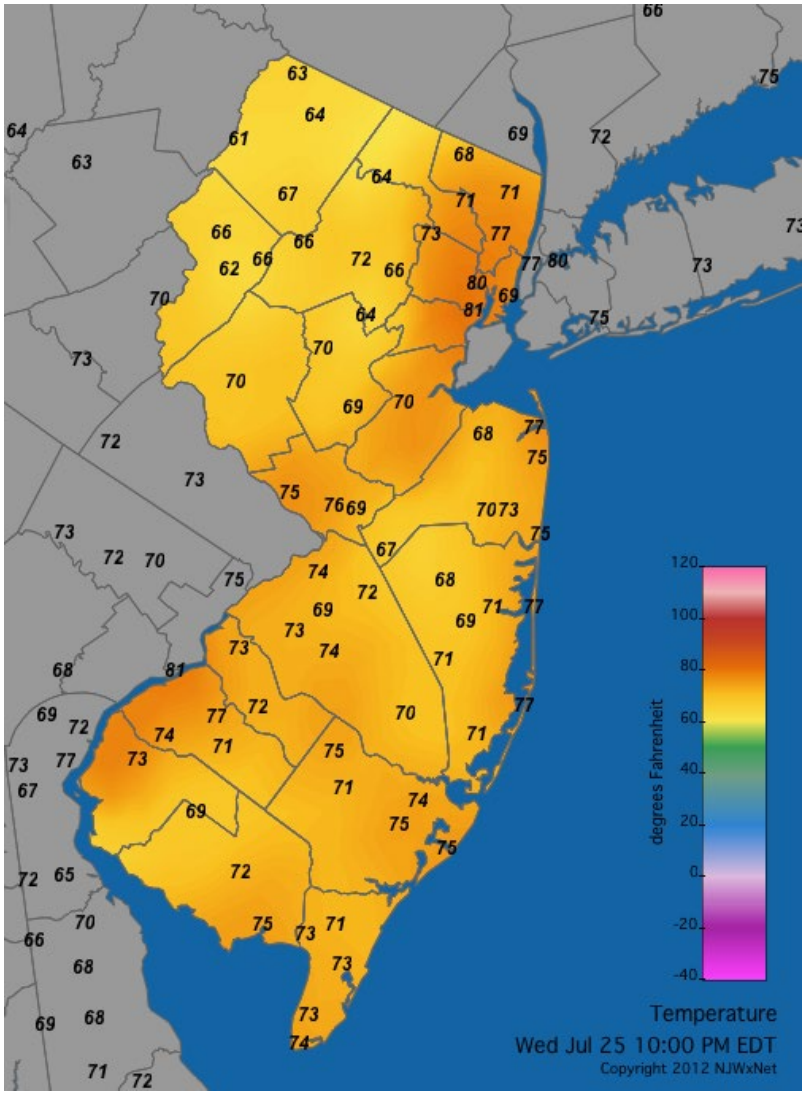
- Altitude
- Latitude
- Surface Conditions
- Land-Water Contrasts

Land cover matters!

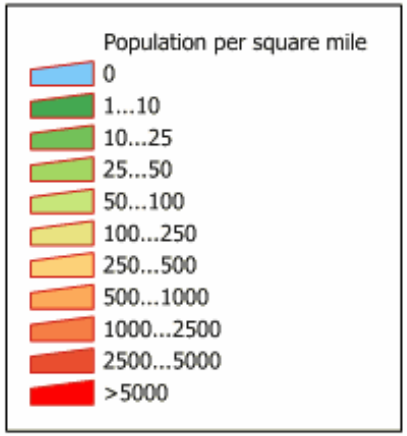
Trenton

Great Swamp

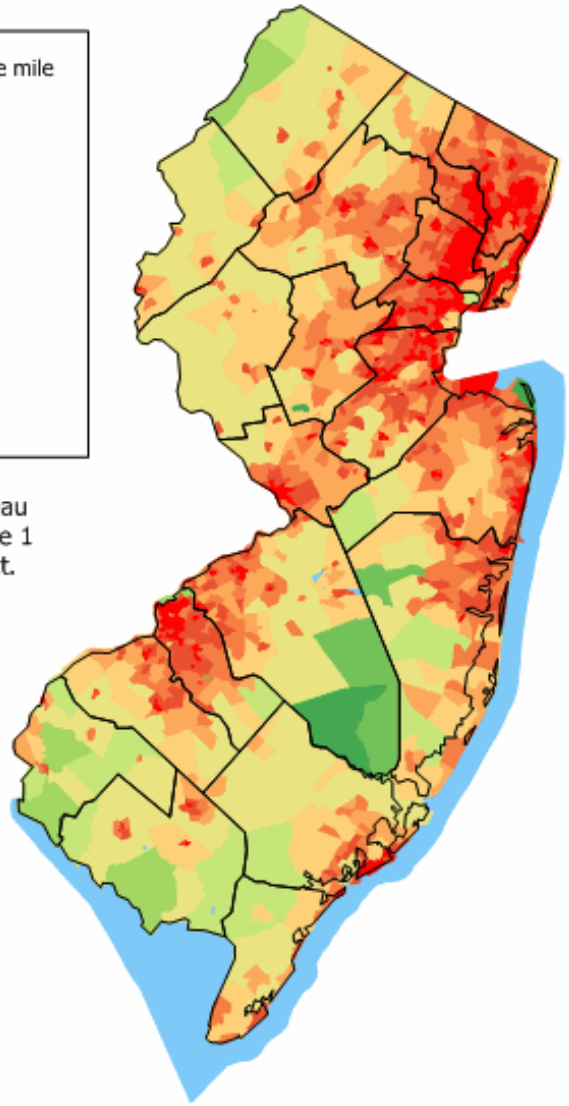
Heat waves and human health



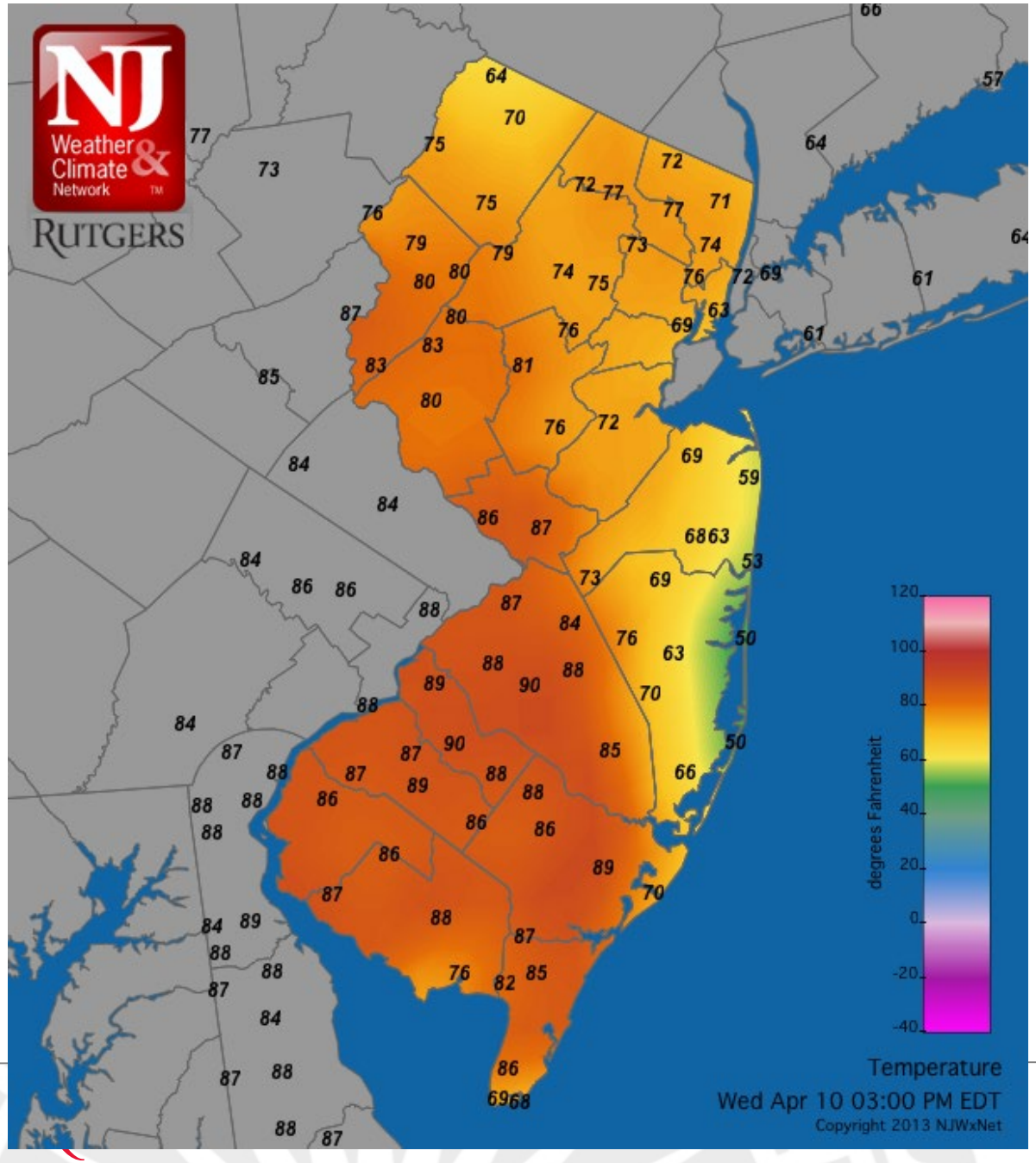
10 PM 25 July 2012



Source: U.S. Census Bureau
Census 2000 Summary file 1
population by census tract.



https://en.wikipedia.org/wiki/New_Jersey

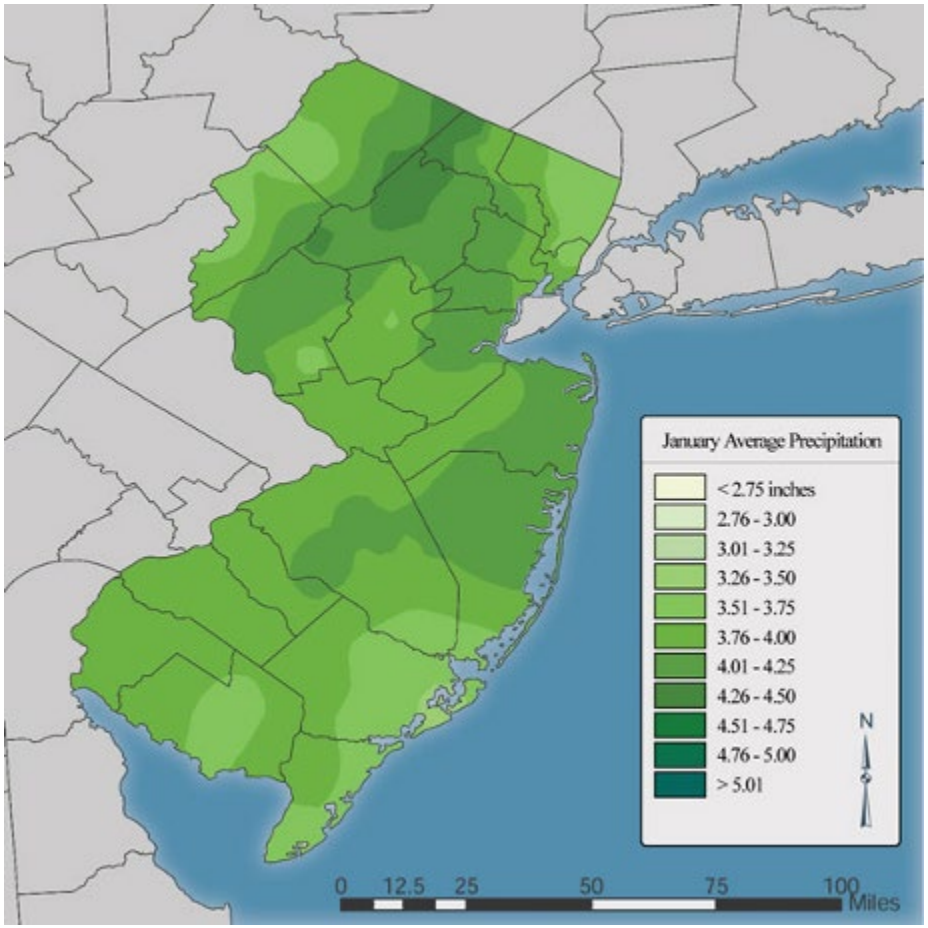


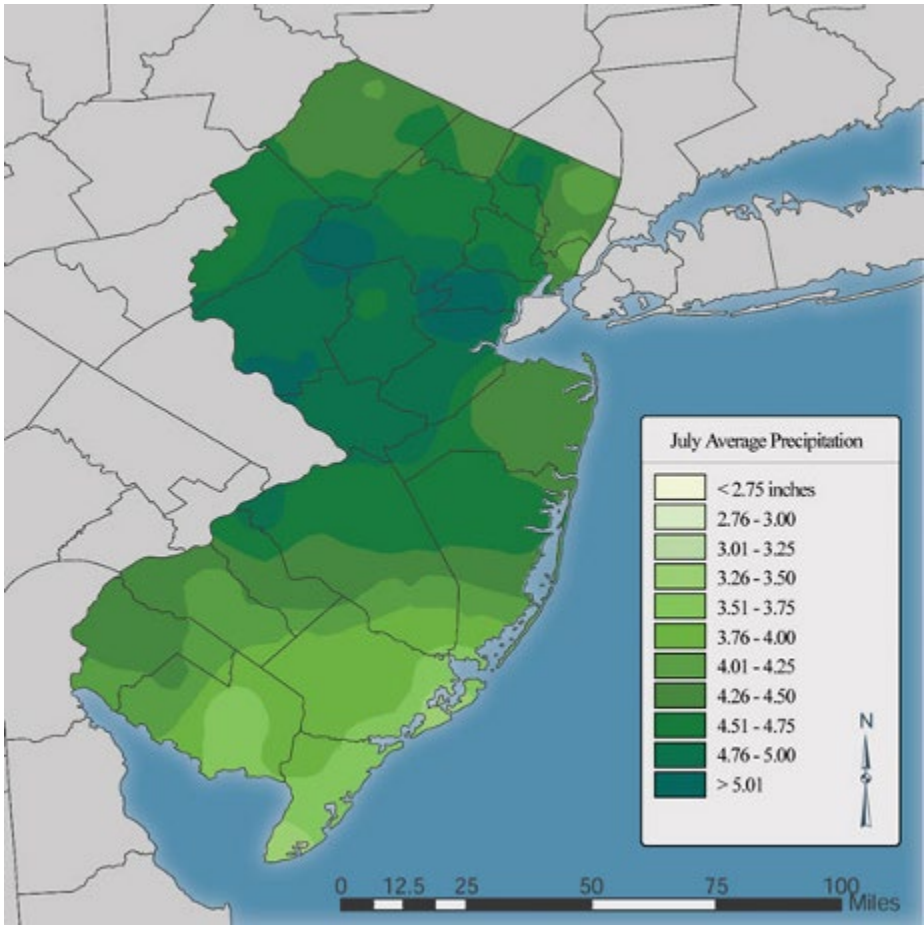
As does proximity to water

Sea Breeze and backdoor cold front:

April 10, 2013
3 PM

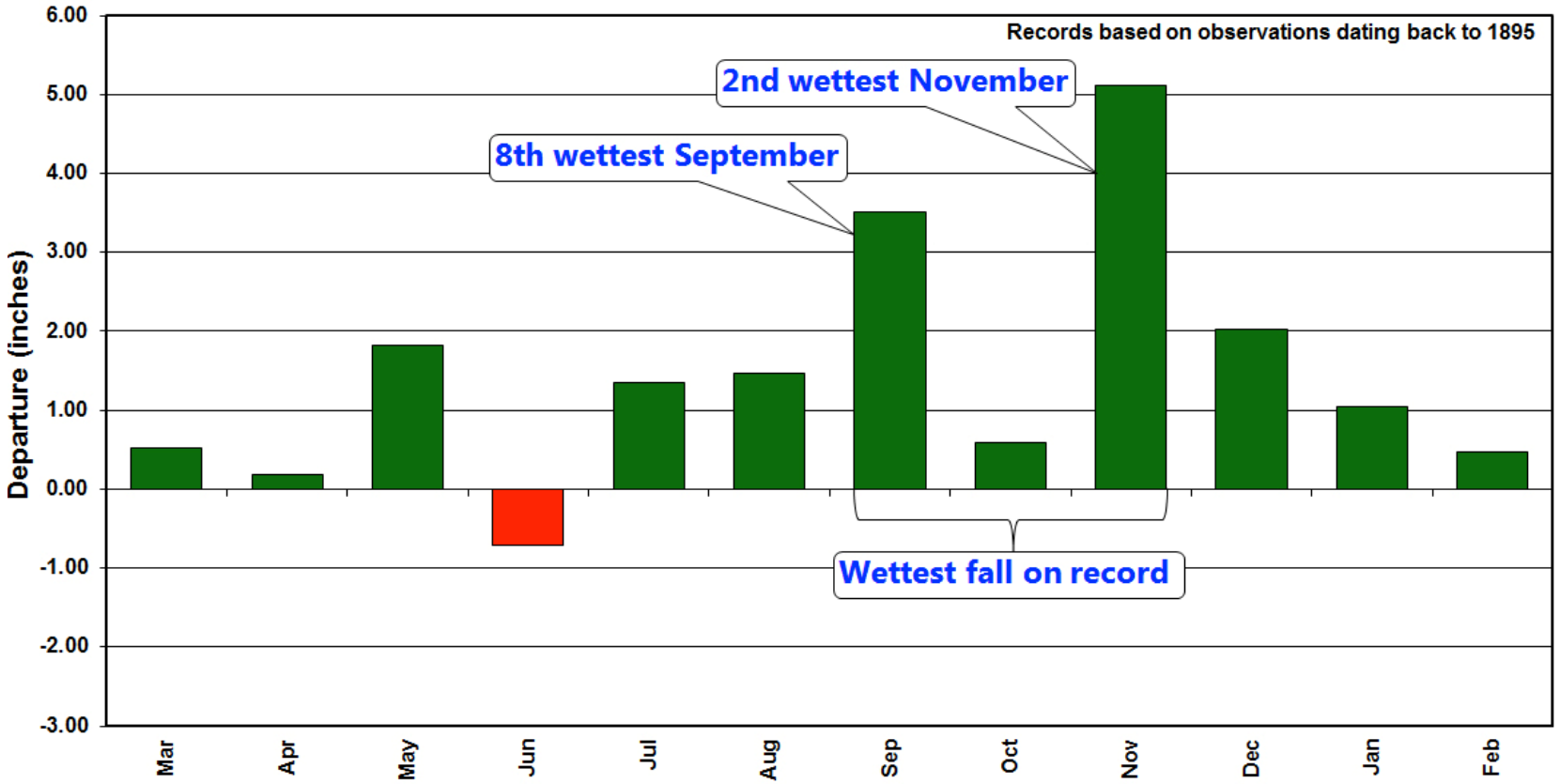
A precipitation rich state……





……most often

NJ Monthly Precipitation Departures: Mar 2018 – Feb 2019



Sometimes too much…

Brick Township: 13 August 2018

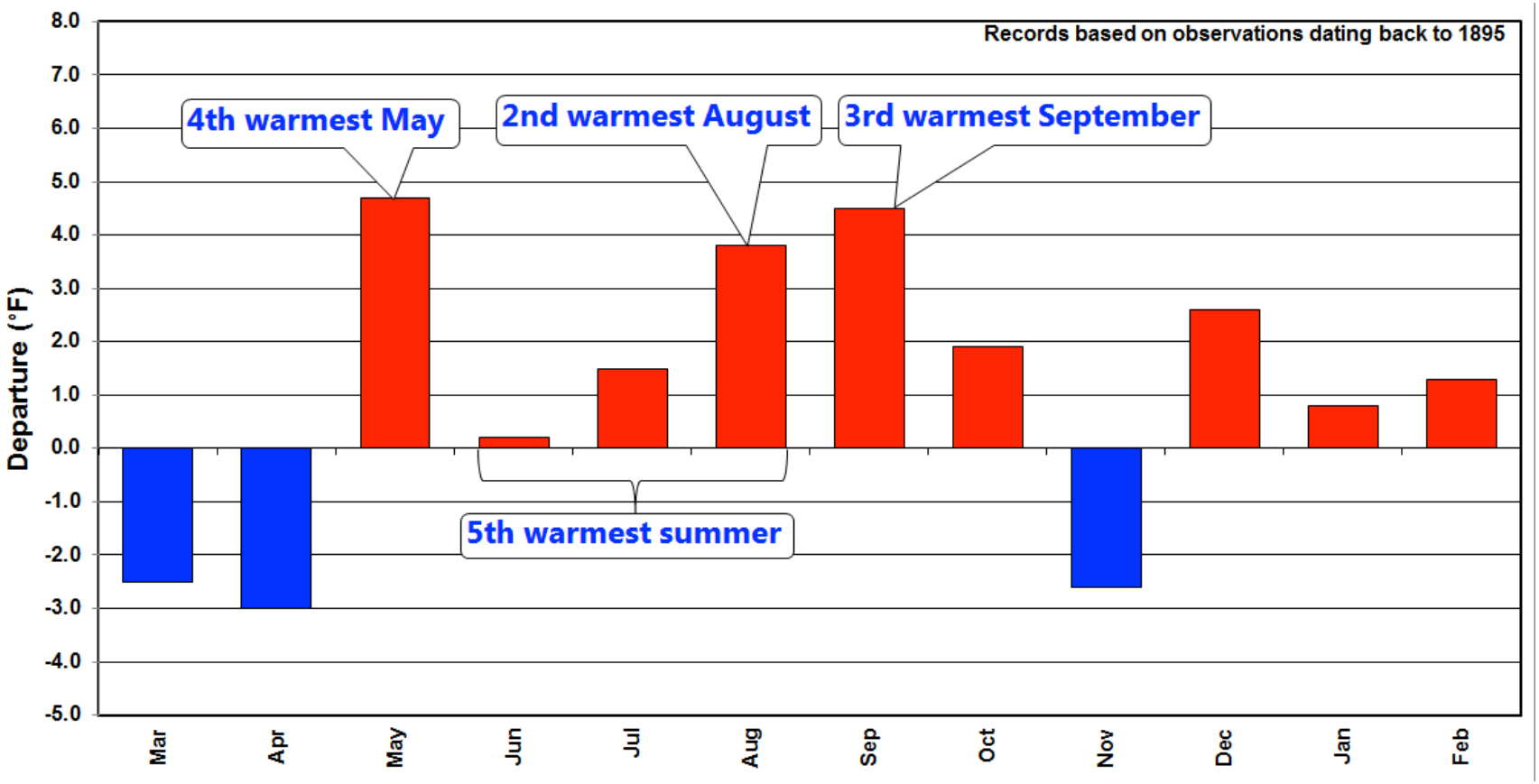
However sometimes too little……

J. McCrea/Star Ledger

Spruce Run Reservoir: March 2002

Appreciating Variations & Extremes

NJ Monthly Temperature Departures: Mar 2018 – Feb 2019

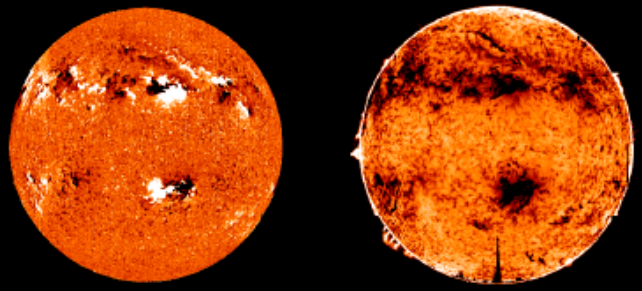


Causes of climate change

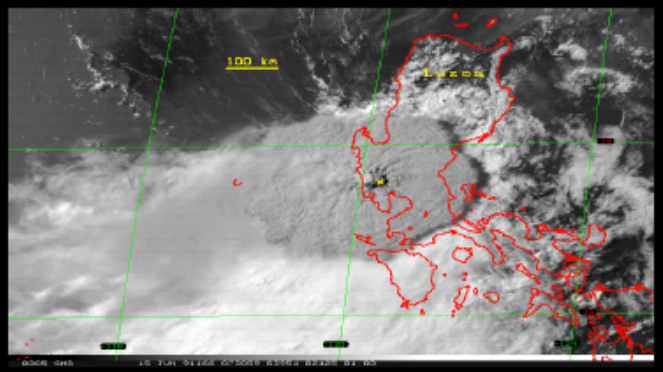
Natural mechanisms influence climate

Natural mechanisms

Changes in solar output →

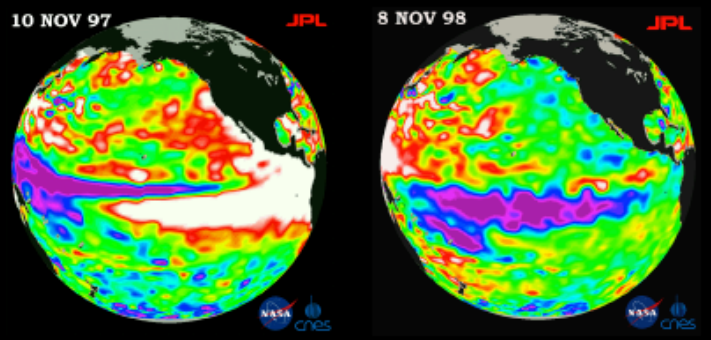


Changes in the amount of volcanic aerosols in the atmosphere →



Internal variability of the coupled atmosphere-ocean system (e.g., ENSO, monsoon systems, NAO)

→



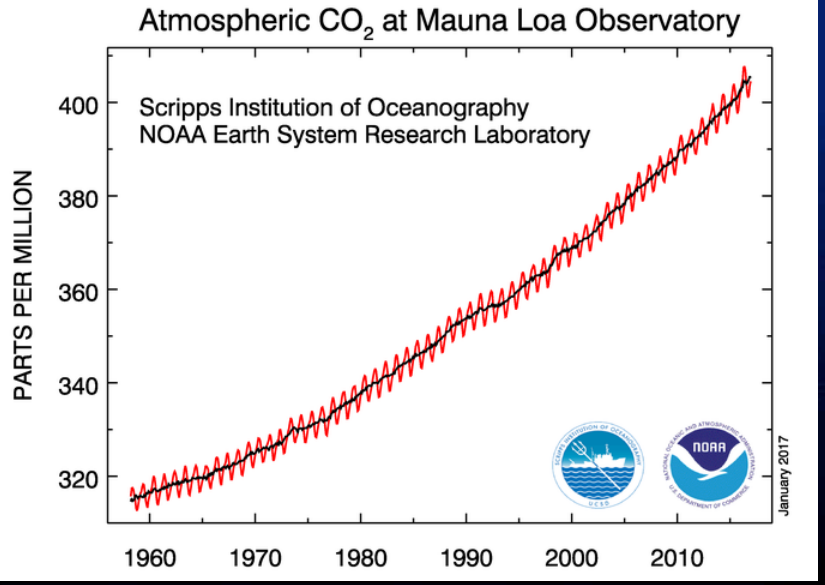
Human factors also influence climate

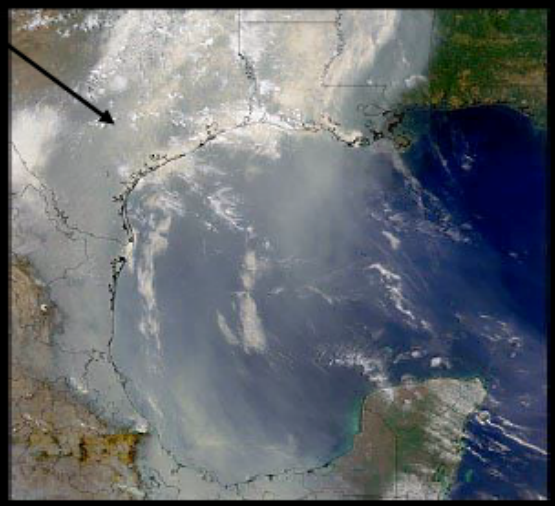
Non-natural mechanisms

Changes in the concentrations of atmospheric greenhouse gases

Changes in aerosols and particles from burning fossil fuels and biomass
- **coal (sulfate aerosols) – cooling**
- **biomass (black carbon) – warming**

Changes in the reflectivity (albedo) of Earth's surface and the hydrologic cycle





Smoke from fires in Guatemala and Mexico (May 14, 1998)

Physical Changes

- Deforestation
- Replace/transform natural landscape
- Urbanization
- Irrigation
- Harvesting
- Intensification

Feedbacks

- Energy Balance Changes
- Net Radiation and Partitioning Changes
- Boundary Layer Moisture changes
- Surface temperature changes
- Roughness change
- Albedo change
- Precipitation

Teleconnections

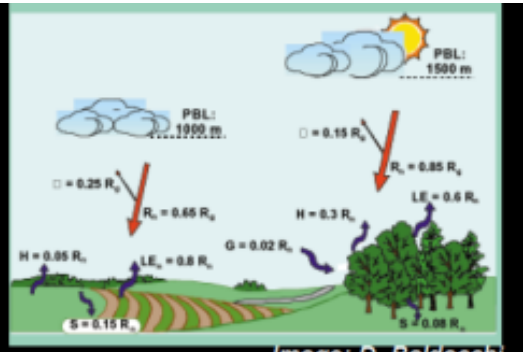


Image: D. Baldocchi

Effects/Impacts

- Basinscale Hydrological changes
- CO_2 changes (storage/emissions)
- snow cover

Dev Niyogi, Purdue U.

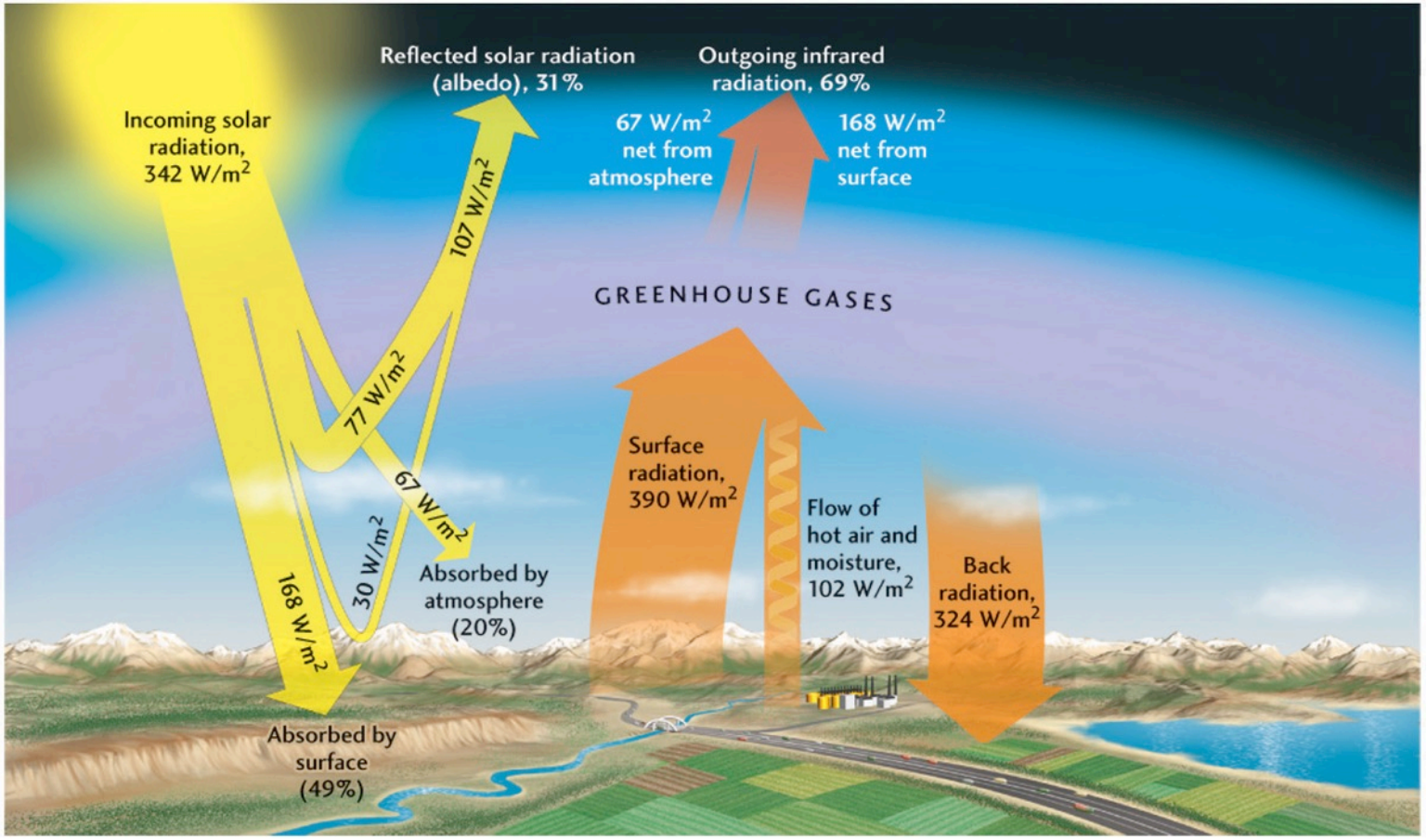
http://landsurface.org/

Is climate presently changing in NJ & elsewhere?

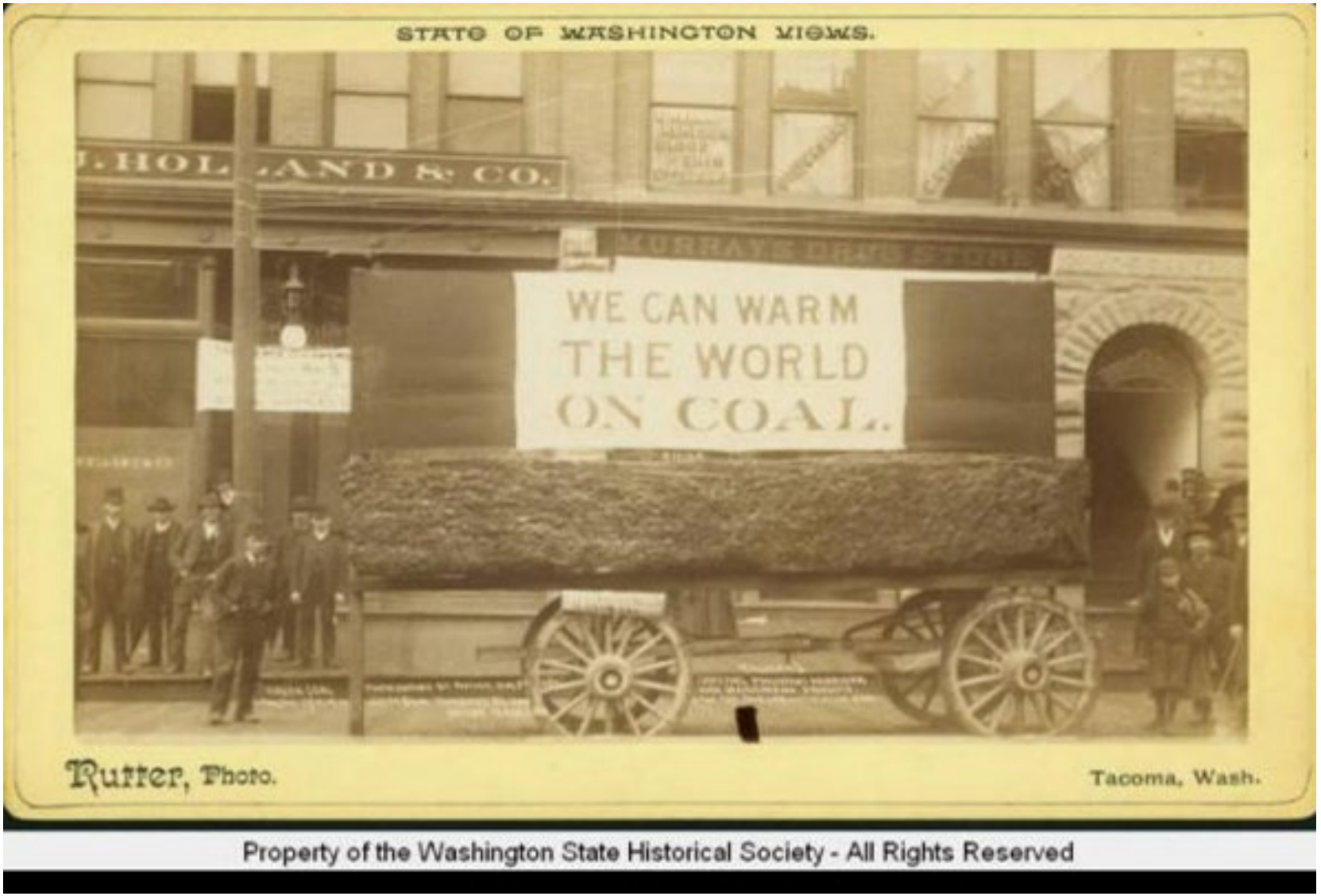
Preponderance of evidence suggests climate change is occurring and humans are responsible for a significant portion of recent changes

1. Theory
2. Observations
3. Models

Heat from the Sun



- The Earth reflects radiation not absorbed by the atmosphere & surface (lost heat).
- Strong ***greenhouse gases*** delay the exit of absorbed radiation back to the space (enhancing atmosphere & surface temperatures).



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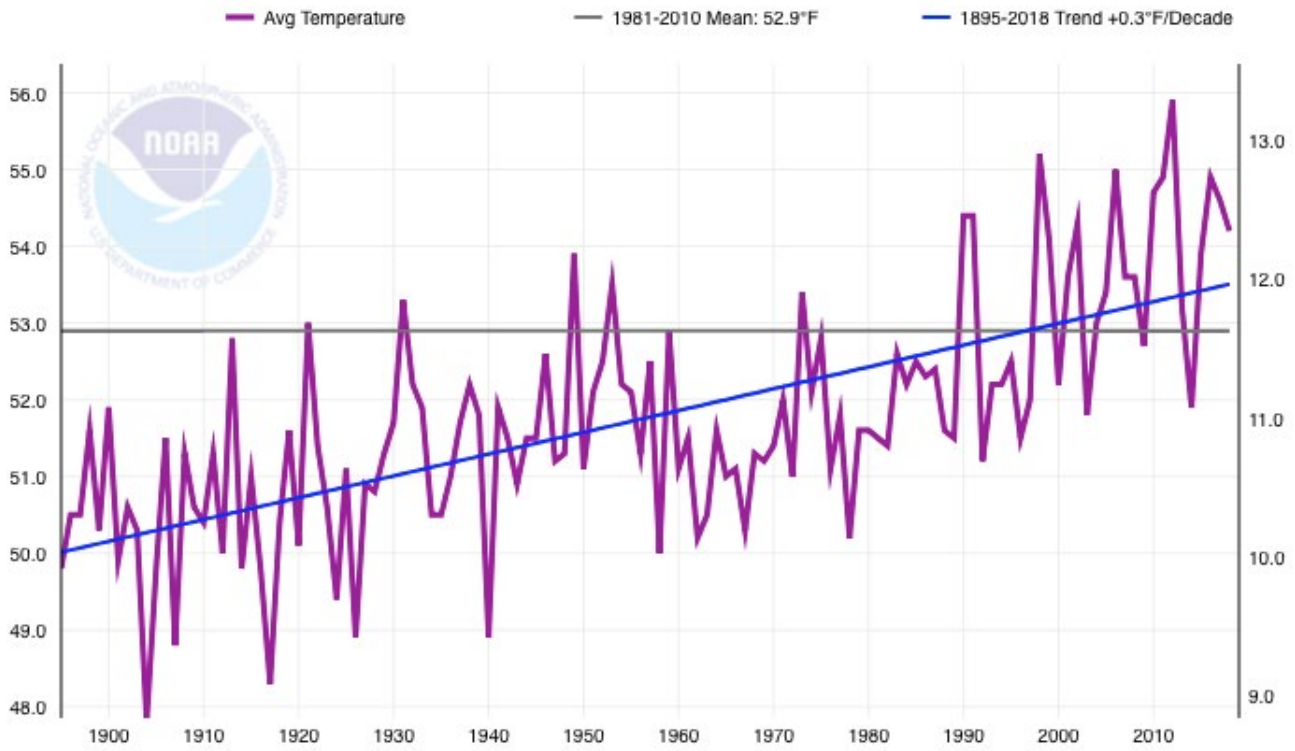
New Jersey annual temperature: 1895-2018



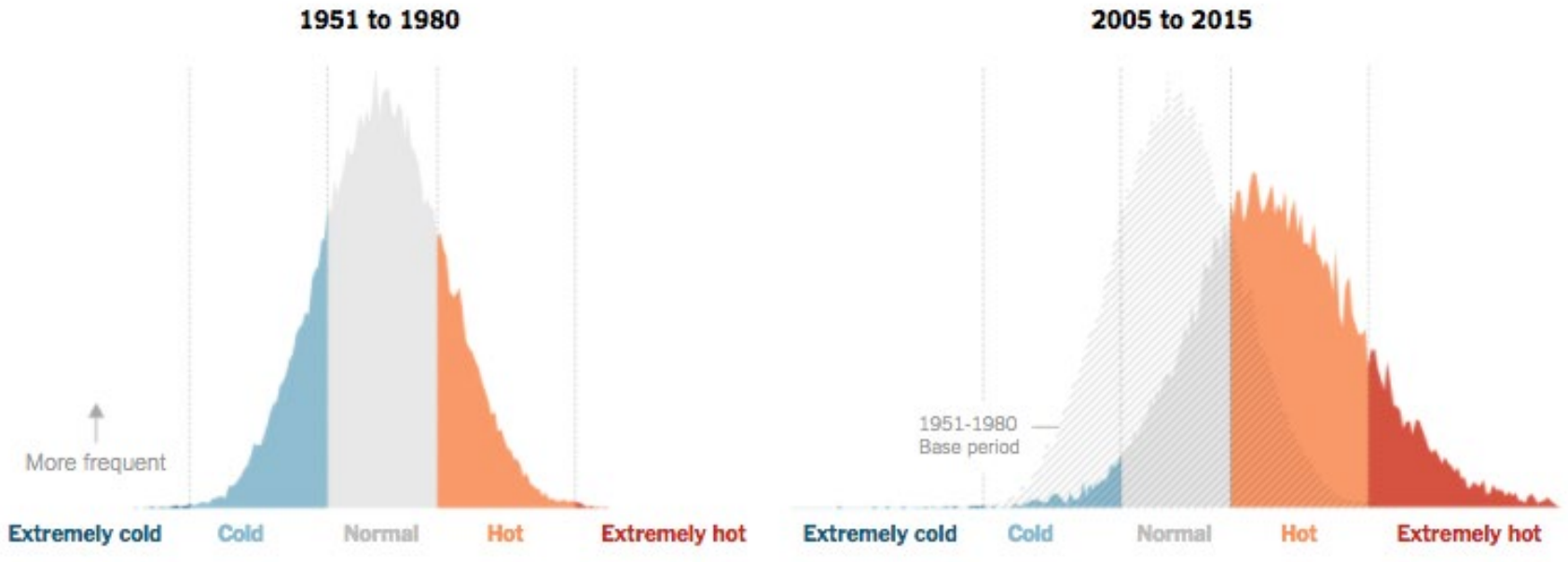
Long-term upward trend of 2.2° F per 100 years

6 of the 7 warmest years have occurred since 2006

2012 was the warmest year on record

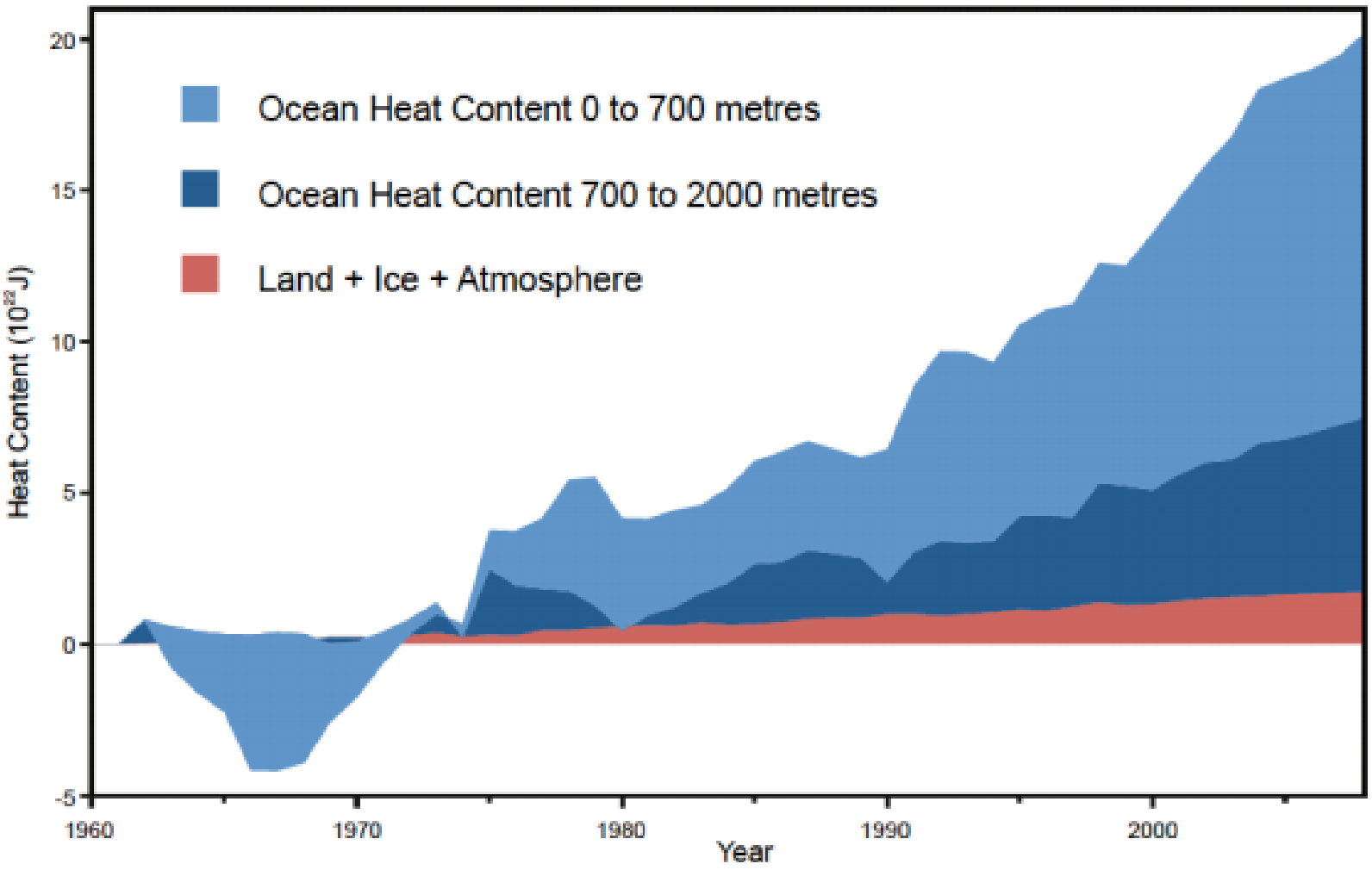
data source: National Centers for Environmental Information

A shift in the distribution of summer temperatures in the Northern Hemisphere

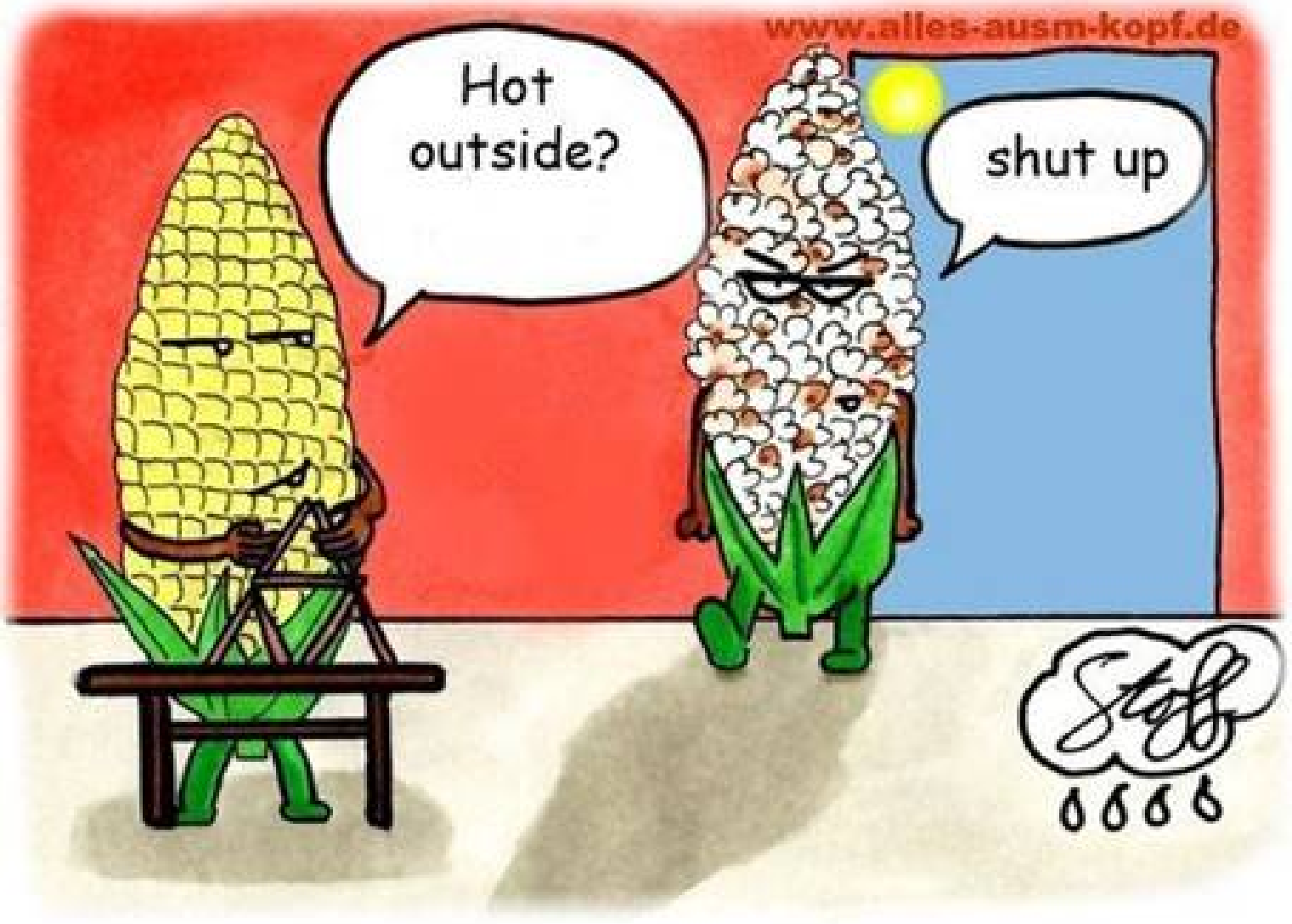


COLUMBIA UNIVERSITY EARTH INSTITUTE VIA MAKIKO SATO AND JAMES HANSEN
THE NEW YORK TIMES - NYTIMES.COM

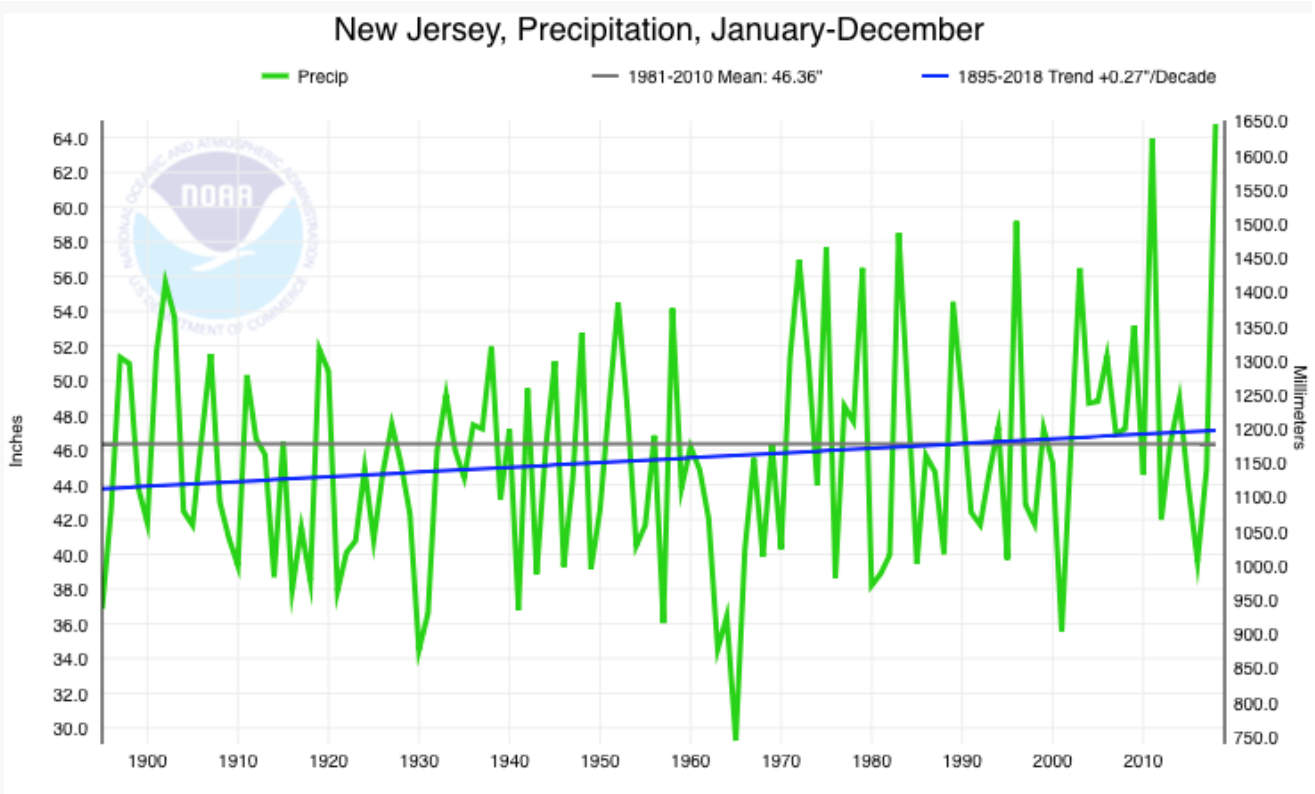
Where the anthropogenic-generated heat is going



Nuccitelli et al., 2012


www.alles-ausm-kopf.de
Hot outside?
shut up

New Jersey annual precipitation: 1895-2018



2018: wettest on record

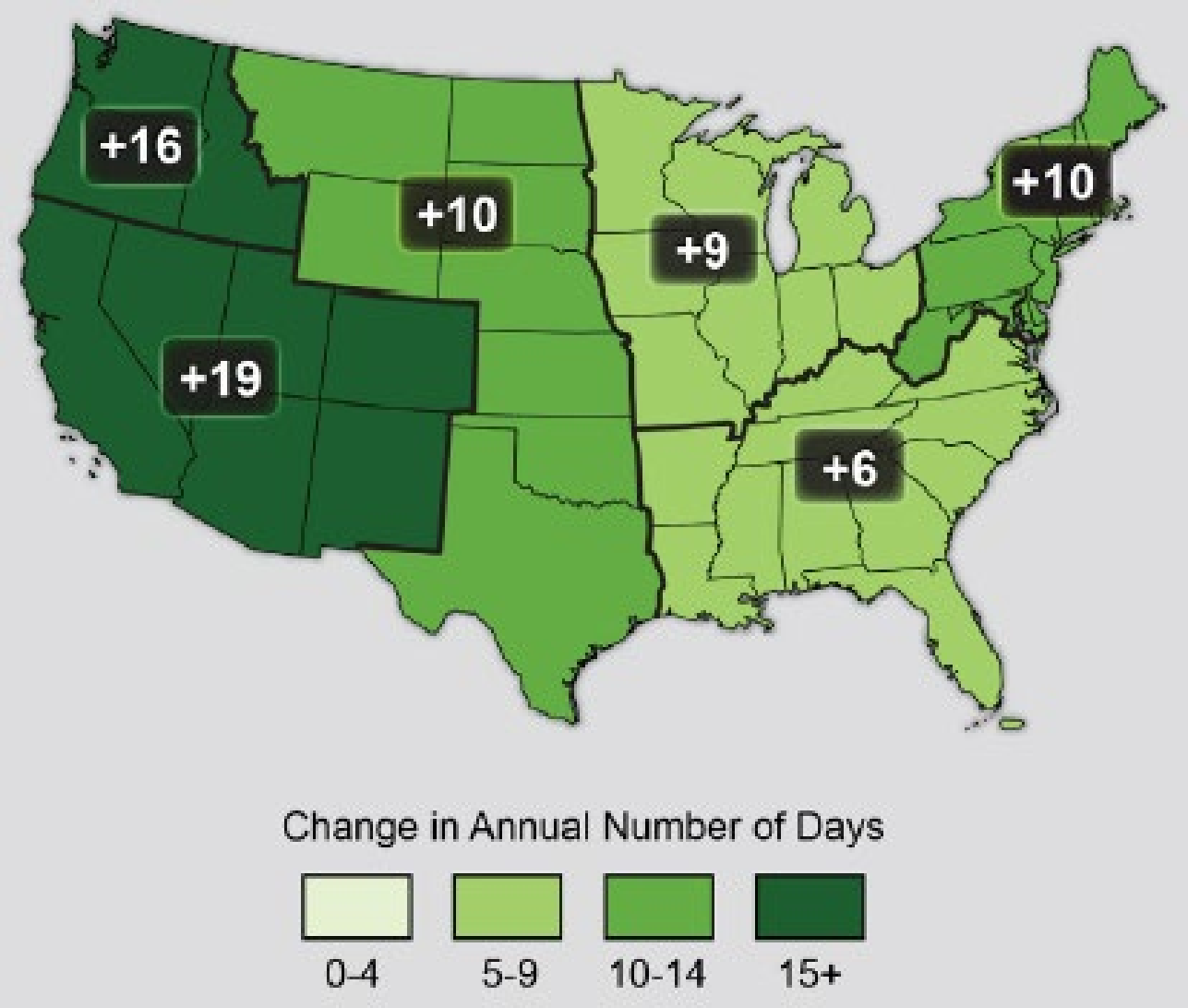
Large decadal variability (early 1960s drought, wet 1970s, very wet in last decade)

Most of the upward trend comes from changes in spring and fall

data source: National Centers for Environmental Information

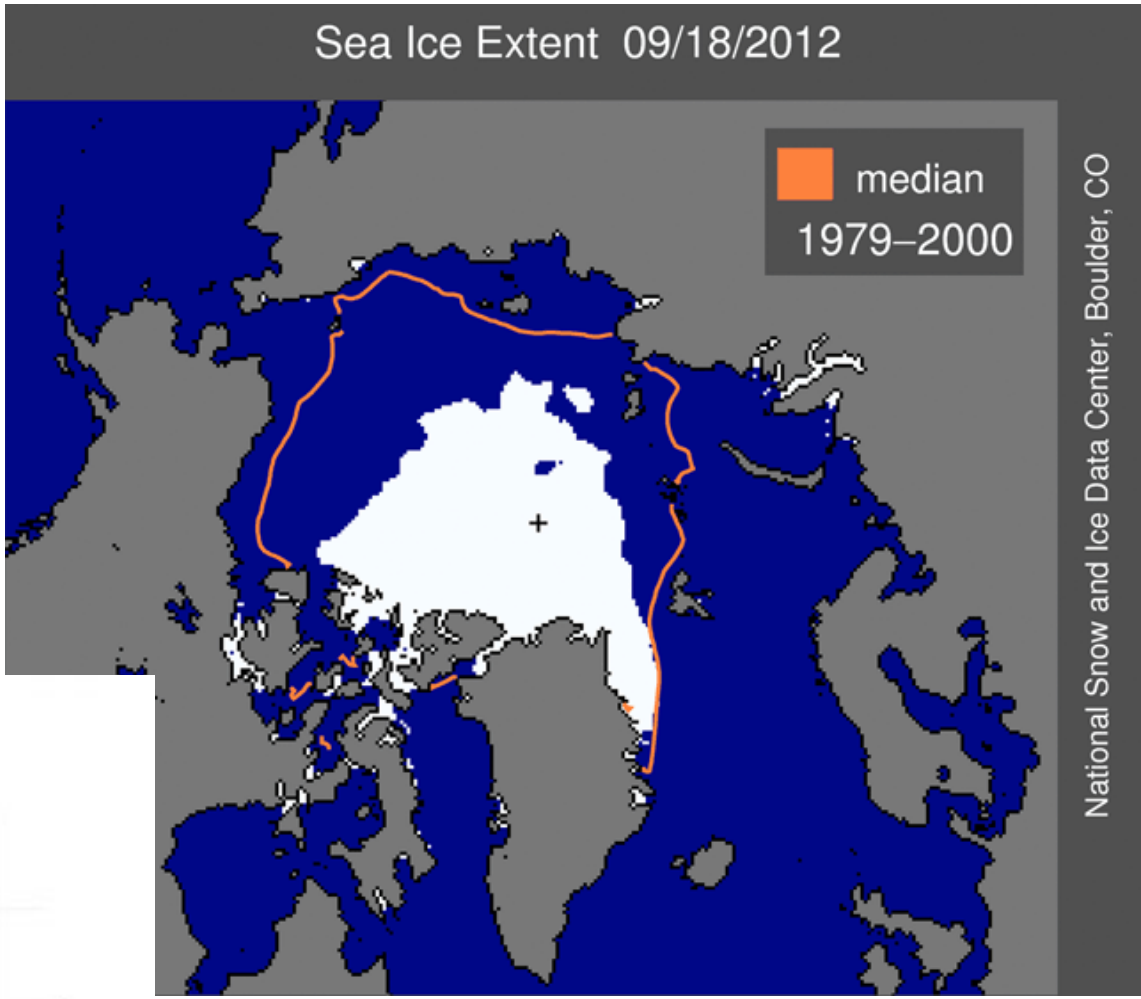
Increase in frost-free season length

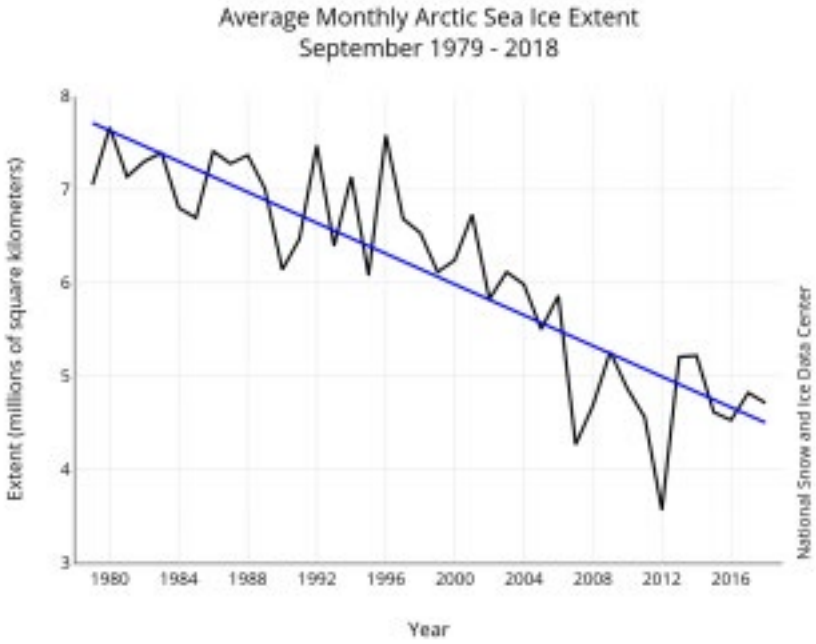
1991-2012 relative to 1901-1960



National Climate Assessment, 2014

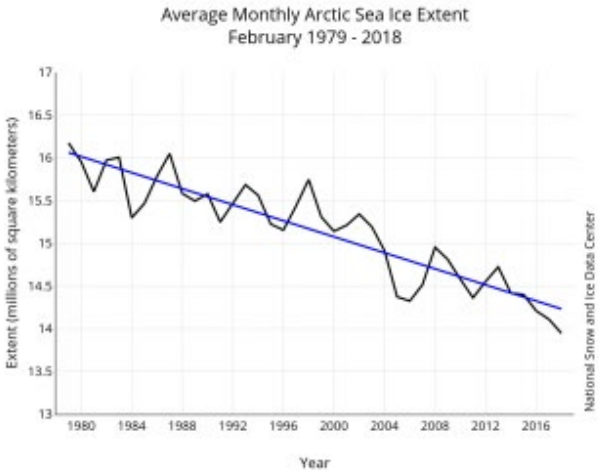
Arctic Sea Ice

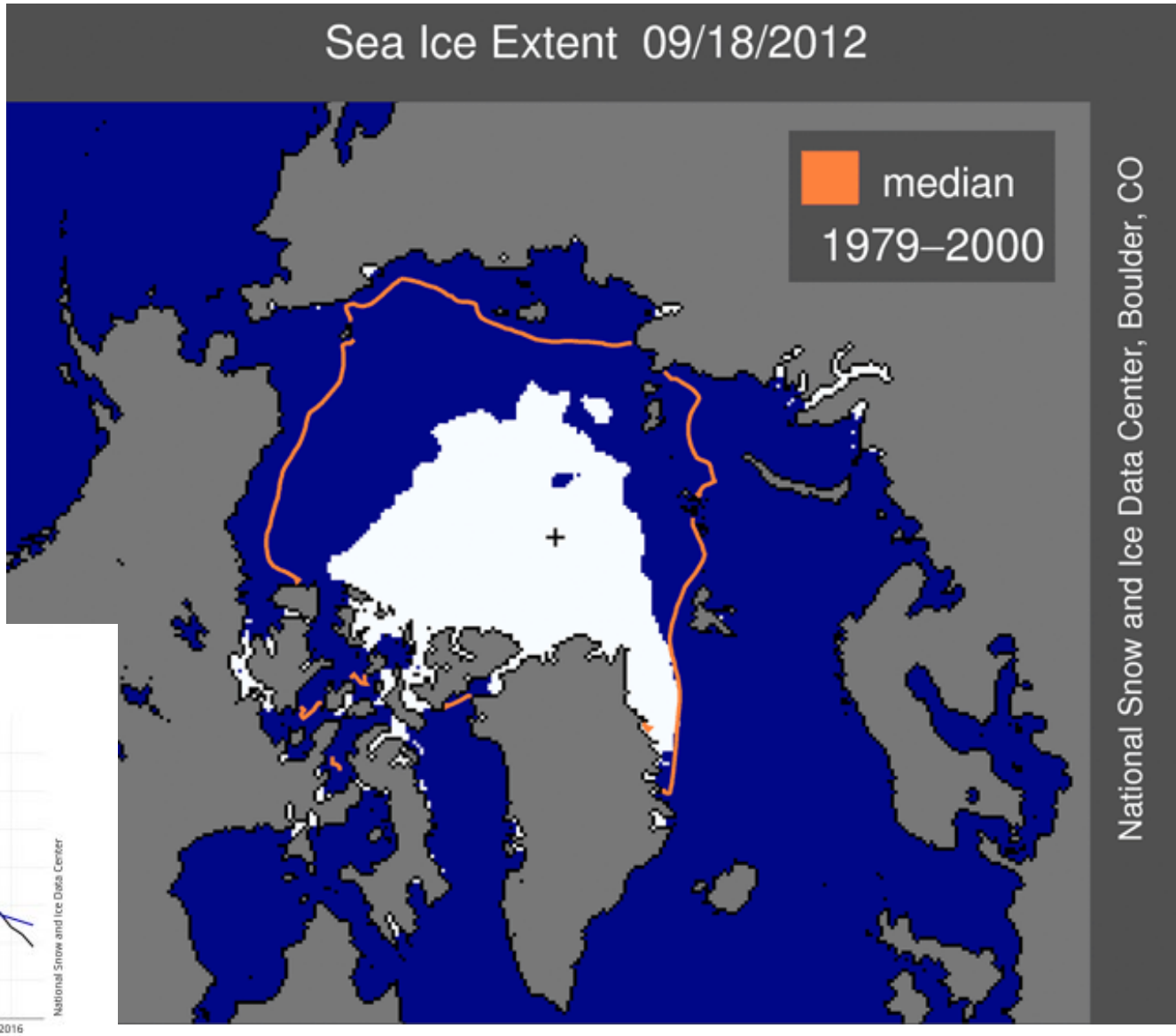




Stroeve et al EOS 2008

Arctic Sea Ice



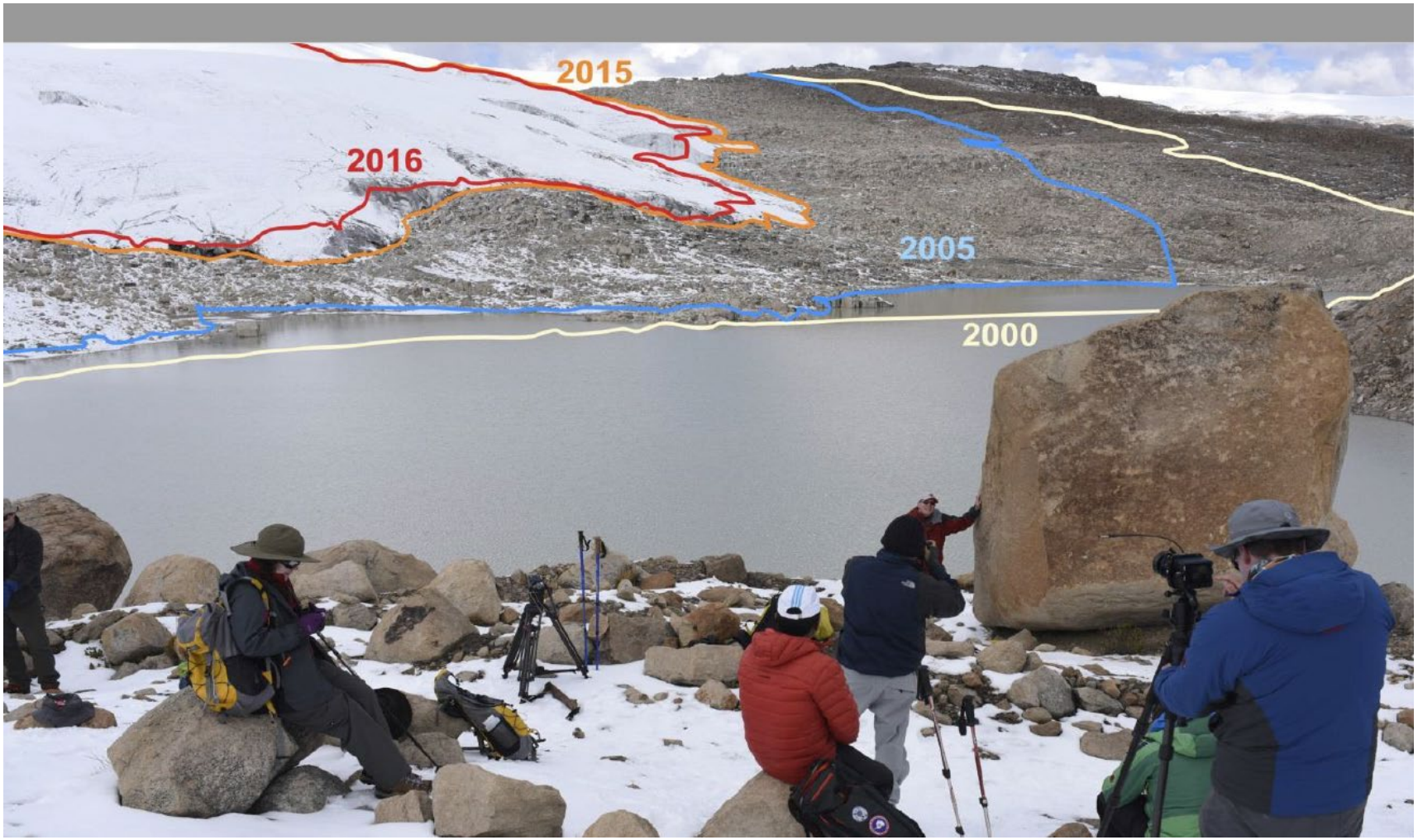


Stroeve et al EOS 2008

Peruvian Glacier Terminus

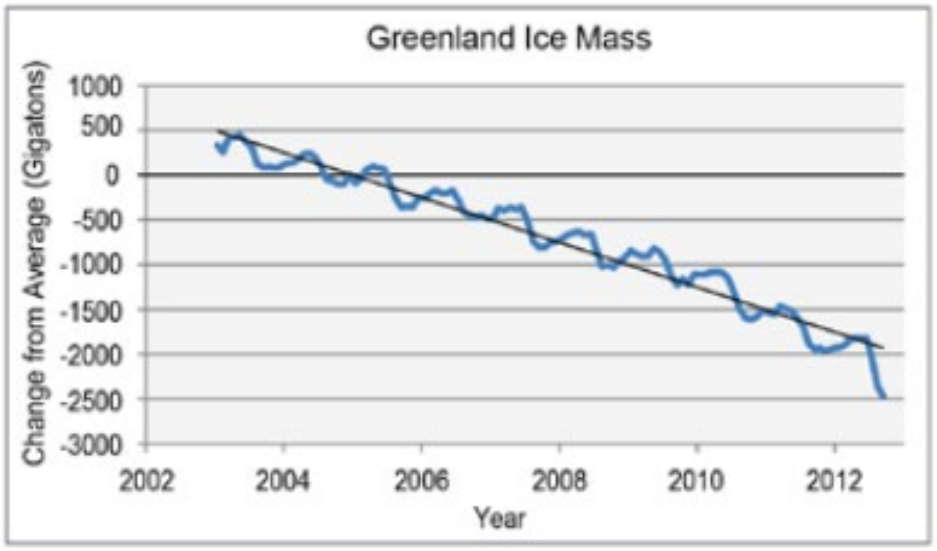
Courtesy of L. Thompson

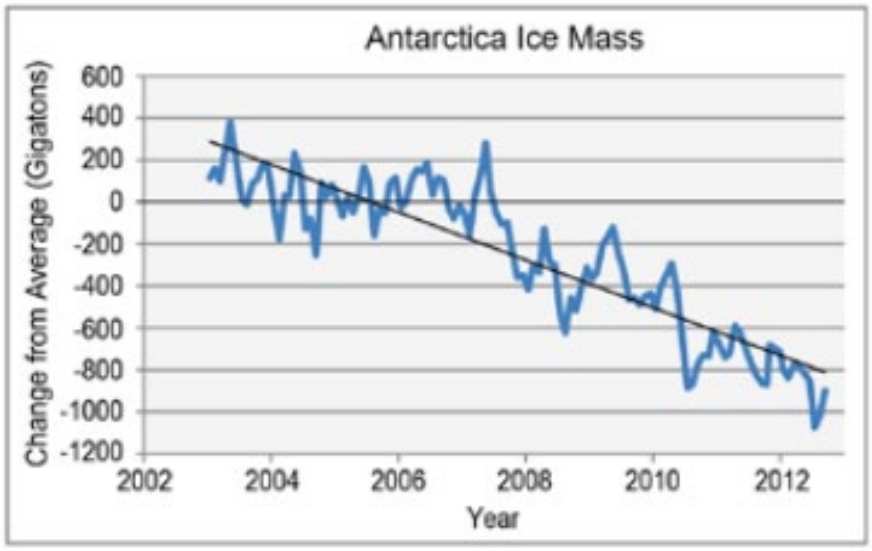
Peruvian Terminus Retreat



Courtesy of L. Thompson

Ice loss from the two polar ice sheets

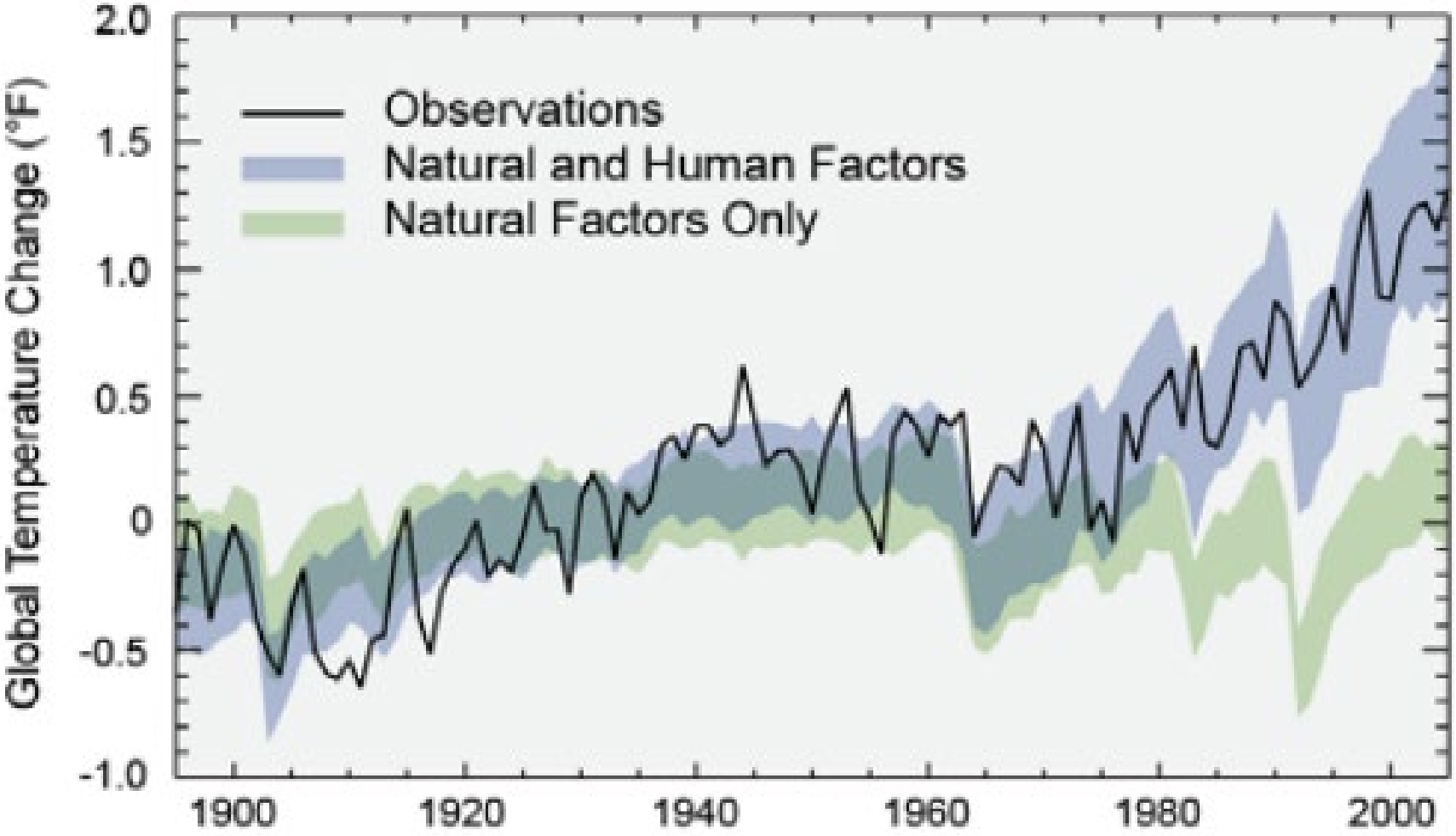




Based on GRACE satellite observations

From Wouters et al, 2013

Human and natural influences on 20th century global temperature



National Climate Assessment, 2014

adapted from Huber and Knutti, 2012

Our climate future

New Jersey's future climate

- Rising temperatures
- Steady or increasing precipitation
- Increasing variability and extremes
  - storms, flood, drought, heat…….
- Rising sea level

A change in extremes?

2 crest 21.0’ (nearby Blackwells Mills: 1921-present)

6 crest 16.2’ (1 May 2014 #7 crest 15.9’)

Manville

3 crest 19.2’

1 crest 21.2’

Future sea level in NJ: Miller & Kopp

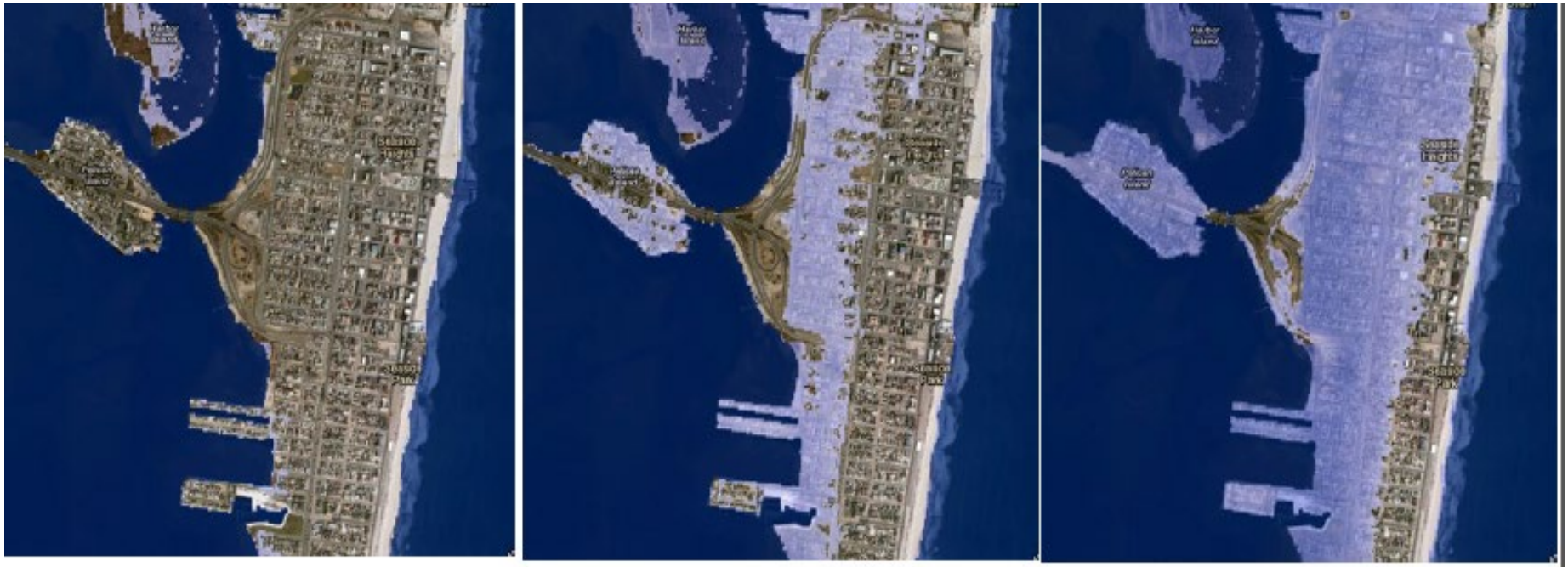
Total sea level rise projections for New Jersey.

	Total cm	Total inches	Total feet
2050 best	**40**	**16**	**1.3**
2050 low	23	9	0.7
2050 high	60	24	2.0
2100 best	**96**	**38**	**3.1**
2100 low	50	20	1.6
2100 high	147	58	4.8

All values with respect to a year 2000 baseline.

Based in the slighlty lower melting figures of Shepherd et al. (2012), subsidence rates of 1-2 mm/yr in excess of global, and dynamic oceanographic effects

Seaside Heights



1 foot
(likely by ~2040)

3 feet
(likely by 2090s)

6 feet
(~5% chance by 2100)

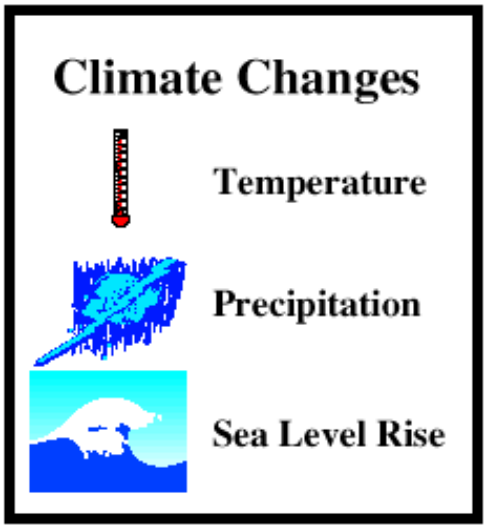
Maps available from http://slrviewer.rutgers.edu/ and http://sealevel.climatecentral.org/

Impacts of a changing climate

Weather & climate impact all aspects of life in NJ

- Agriculture/horticulture
- Ecology
- Water resources
- Public health & safety
- Energy
- Transportation
- Commerce

Potential climate change impacts



Health Impacts
Weather-related Mortality
Infectious Diseases
Air Quality-Respiratory Illnesses

Agriculture Impacts
Crop yields
Irrigation demands

Forest Impacts
Change in forest composition
Shift geographic range of forests
Forest Health and Productivity

Water Resource Impacts
Changes in water supply
Water quality
Increased Competition for water

Impacts on Coastal Areas
Erosion of beaches
Inundate coastal lands
Costs to defend coastal communities

Species and Natural Areas
Shift in ecological zones
Loss of habitat and species

EPA

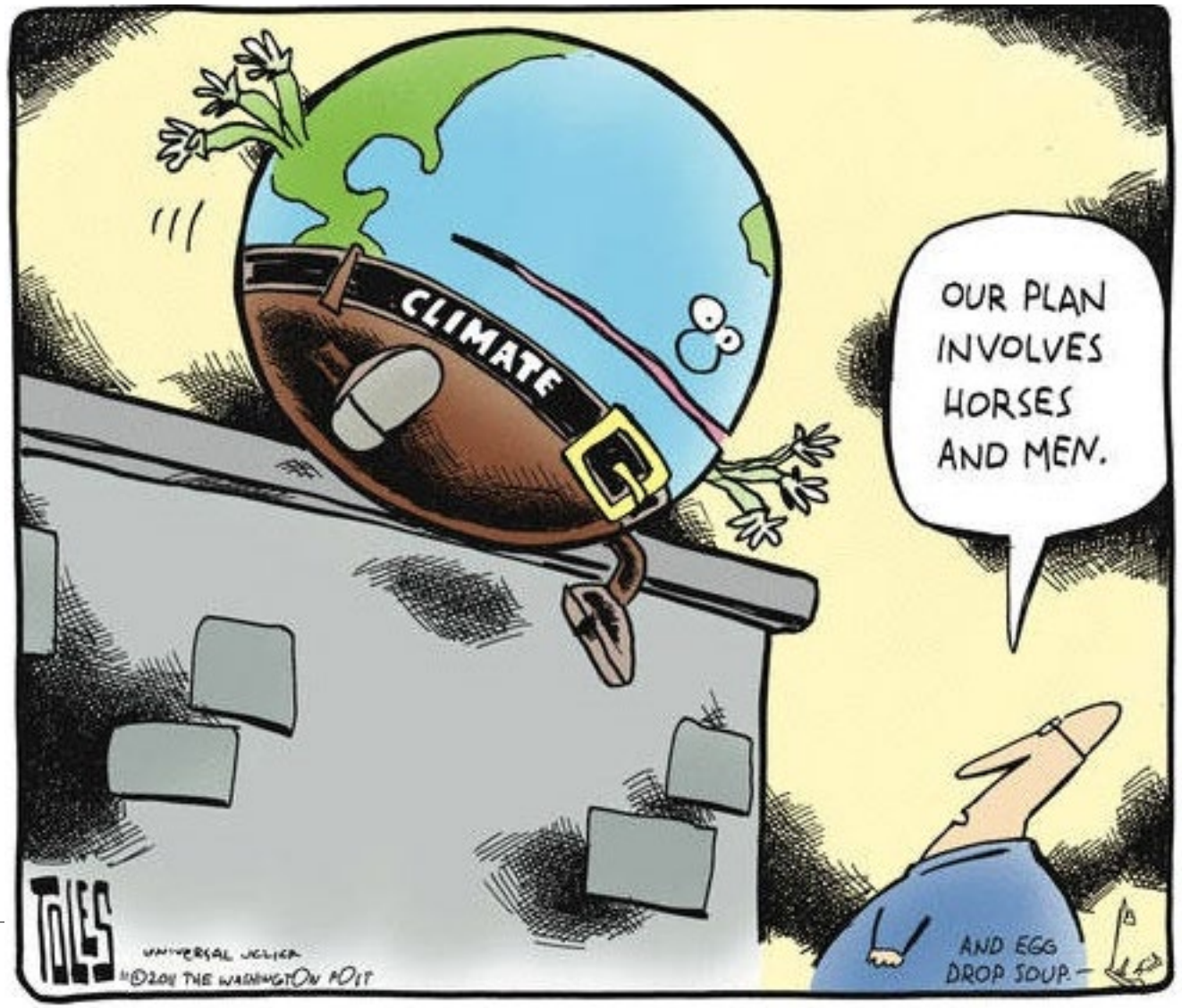
United States Environmental Protection Agency

A dilemma

Passaic flooding: March 2011

Managing climate change

Is there something we should be doing about this climate dilemma?



Challenges Requiring Attention

- Knowledge: Develop a better understanding of the details of future climate change.
- Mitigation: Reduce emissions of carbon dioxide and other greenhouse gases.
- Adaptation: Increase the resilience of society to climate change.
- Activism/Leadership: Raise public awareness of the challenges posed by climate change and the need to mitigate and adapt. Participate…..vote.

Once again thanks to Dave Robinson for letting me use his slides!
david.robinson@rutgers.edu
njclimate.org

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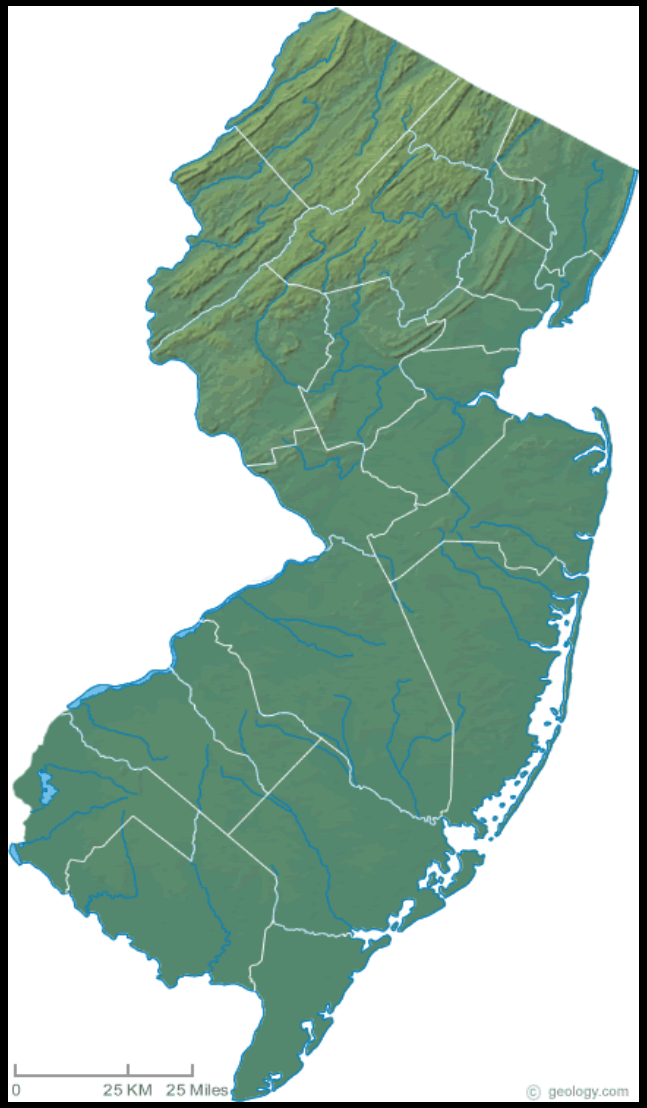
So what did we learn?

Climate change … it's real, it's happening now, and it's affecting New Jersey.

Climate Change in New Jersey

- More warm extremes and fewer cold extremes
- Heavy rains become more intense
- More frequent dry spells
- Rising sea level with increased frequency and intensity of coastal flooding



What do we do now?

- Reduce carbon emissions
- Convert to alternative sustainable fuels (solar and wind)
- Pray
- Manage stormwater runoff more effectively using sustainable practices
- Work together – only through cooperative and collaborative partnership will be successful

Climate Change in New Jersey

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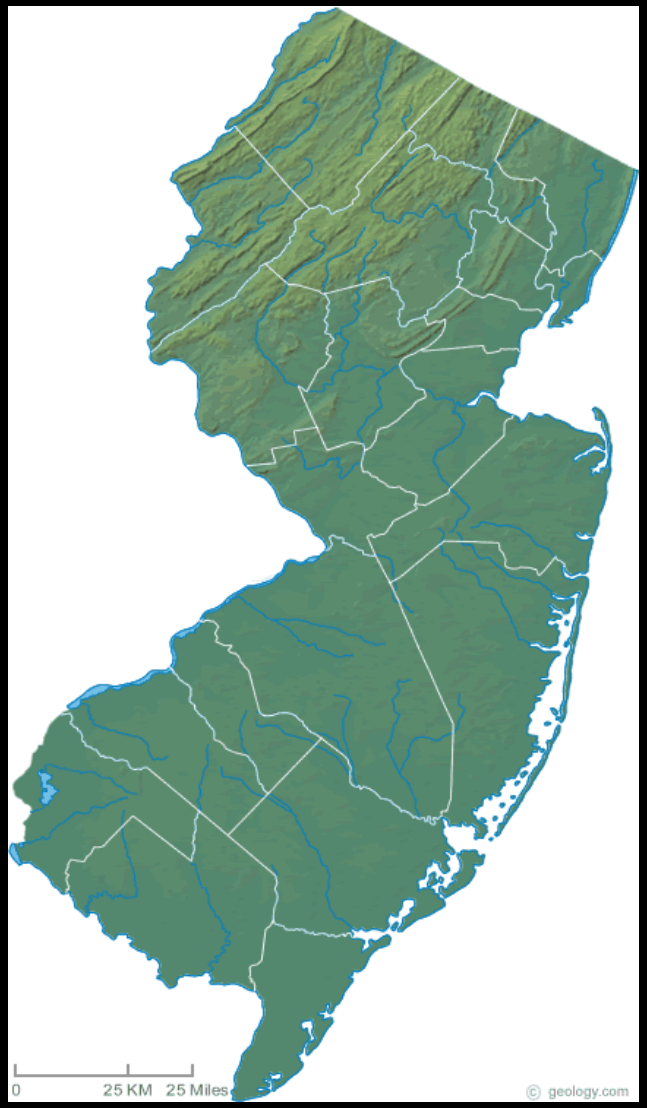

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Rainwater Harvesting - Functions

- Collecting, filtering and storing water from roof tops, paved and unpaved areas for multiple uses.
- Harvested water can be used for nonpotable or potable purposes after testing and treatment.
- Surplus water after usage can be used for recharging groundwater.
- Systems can range in size from a simple PVC tank or cistern to a contractor designed and built tank/sump with water treatment facilities.

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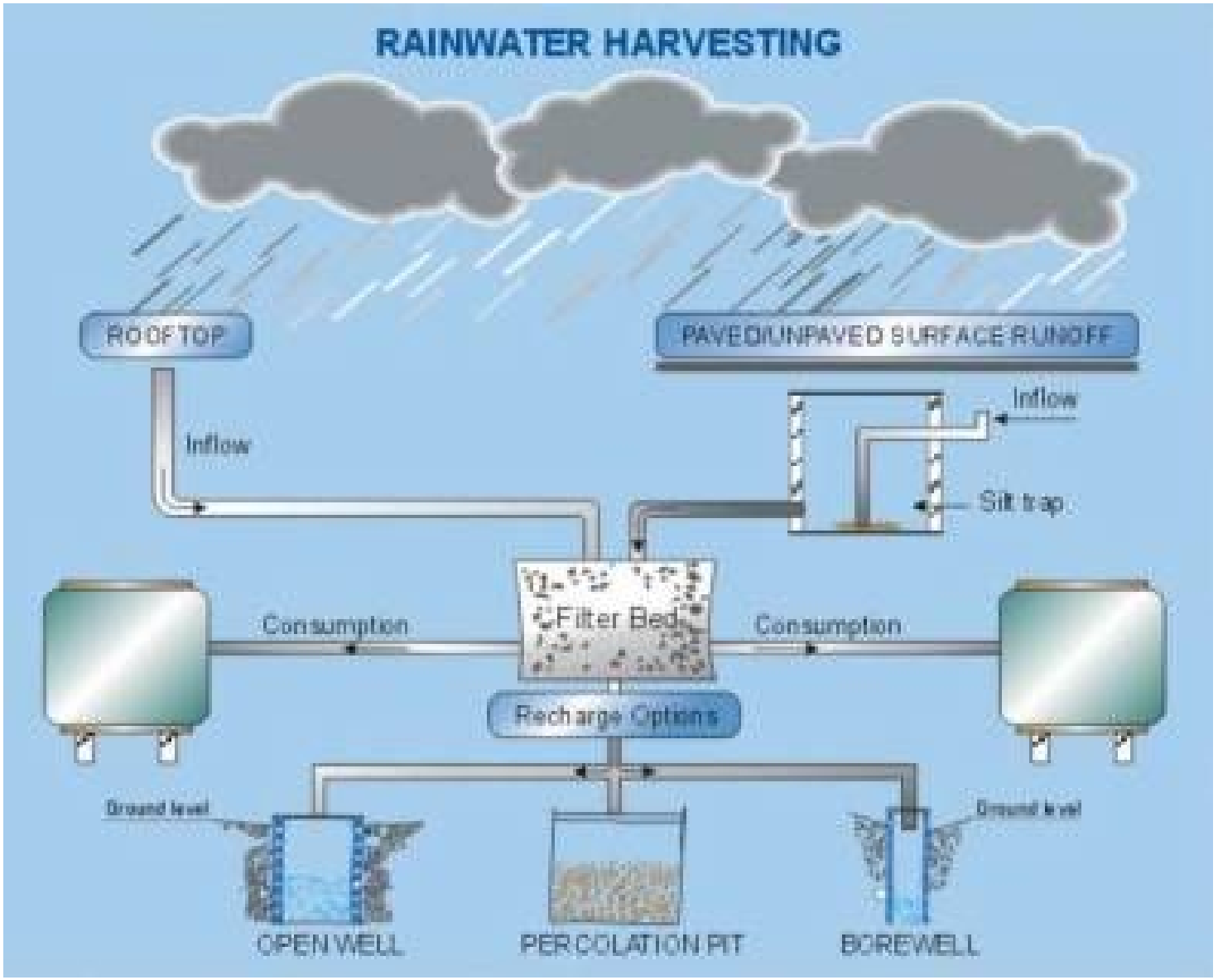
Rainwater Harvesting – Components



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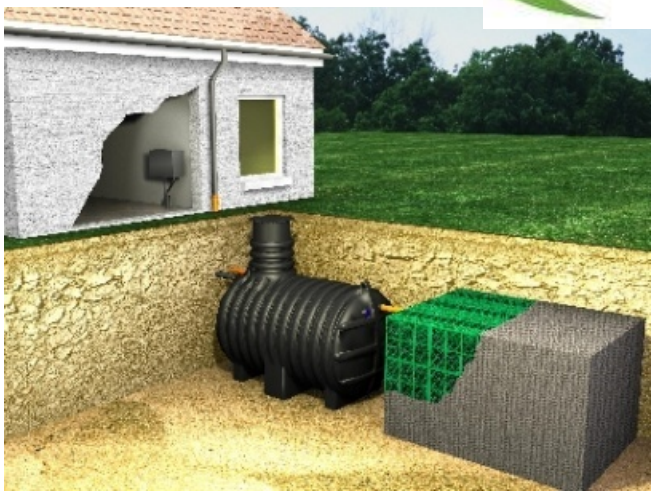

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Sizing

- The rule of thumb is 600 gallons of water per inch of rain per thousand square feet of catchment area.
- Not all the rain that falls can actually be collected. Efficiency is usually presumed to be 75% depending on system design and capacity.

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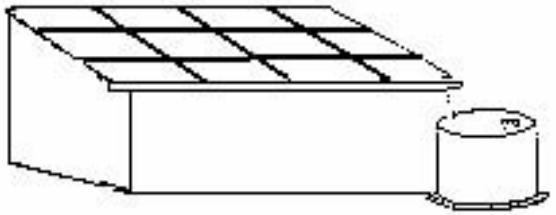
Sizing Formula

Here is the basic formula for calculating the potential amount that can be collected:

$$\frac{(\text{Catchment area}) \times (\text{inches of rain}) \times (600 \text{ gallons}) \times (.75)}{1{,}000 \text{ square feet}}$$

Design Example

The sample roof shown below has a catchment area that is 40 feet wide and 30 feet long. Hence, it has a 1,200 square feet roof (40 feet wide x 30 feet long). Assume that it rains 2 inches. We can now plug this information into our general formula (see equation above).



Catchment Area = 1,200 square feet

Amount of Rain = 2 inches

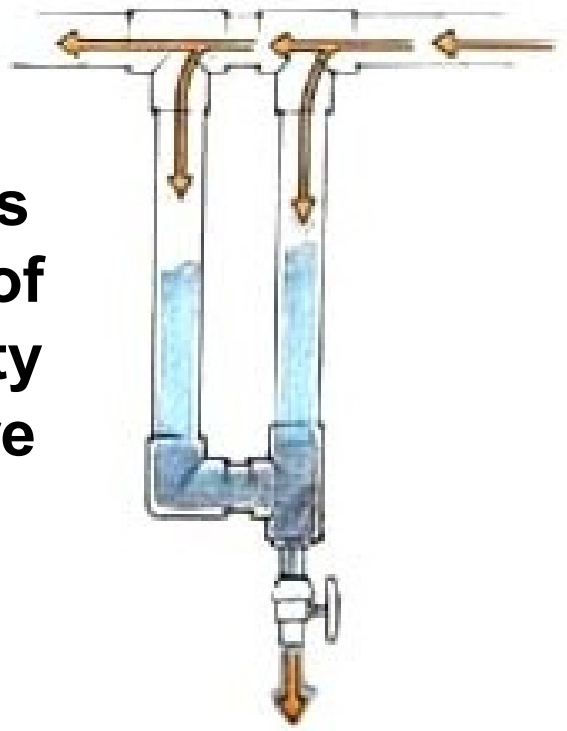
Gallons of water collected per inch of rain per 1,000 square feet = 600 gallons

Percent Efficiency = 75% or 0.75

$$\frac{(1{,}200 \text{ square feet}) \times (2 \text{ inches of rain}) \times (600 \text{ gallons}) \times (.75)}{1{,}000 \text{ square feet}} = 1{,}080 \text{ gallons}$$

First Flush Diverter or Roof Washer

The rule of thumb is one to two gallons of roof washer capacity for every 100 square feet of catchment area.



- **A one foot length of 6 inch diameter PVC pipe holds 1.5 gallons.**
- **A one foot length of 4 inch diameter PVC pipe holds 0.66 gallons.**

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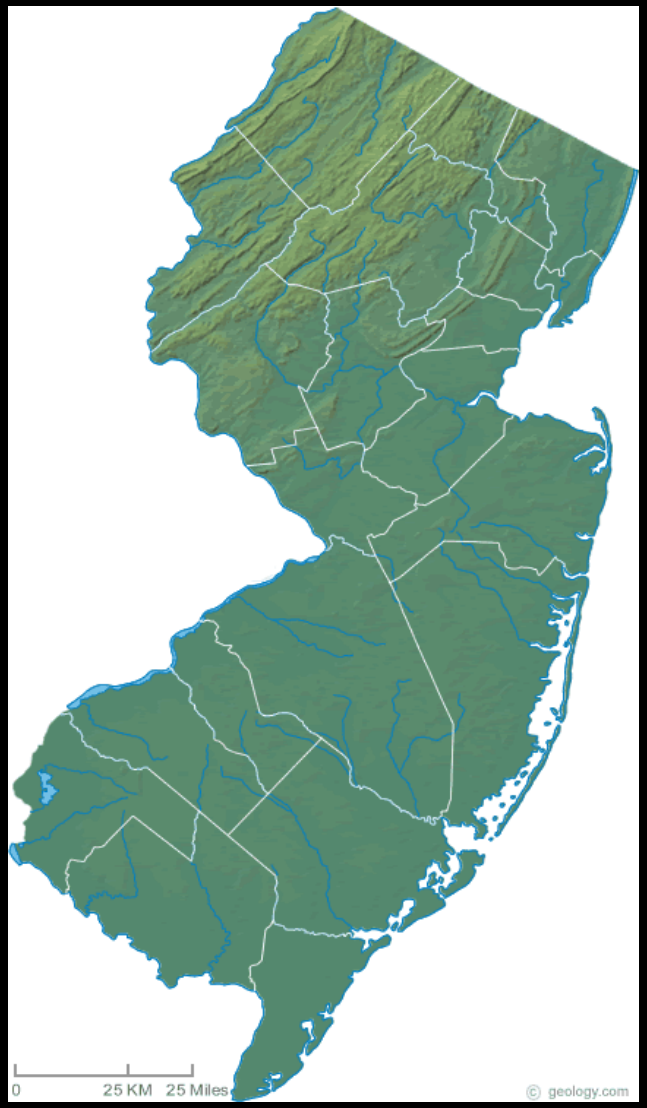
Construction

- The most stable place to position the cistern is against a stable wall on level ground as close to the downspout as possible.
- Gravity moves water downhill. Be sure there is available space for a downward pitch in all pipes.
- The cistern on its platform is the highest point of the garden but the lowest point of the system.
- The overflow pipe should be directed toward a rain garden not toward pathways or structures.
- The overflow pipe should flow from the cistern's highest point.
- The spigot should be at the cistern's lowest point.

Climate Change in New Jersey

- More warm extremes and fewer cold extremes
- Heavy rains become more intense
- More frequent dry spells
- Rising sea level with increased frequency and intensity of coastal flooding



KNOWN: The New Jersey Water Quality Design Storm is 1.25 inches of rain over two-hours and 90% of New Jersey rainfall events come in storms of less than 1.25 inches of rain

UNKNOWN: If “heavy rains become more intense” due to climate change in New Jersey, how much will the New Jersey Water Quality Design Storm increase?

The scientists just say it will be “more” but how do we design for “more”

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What if we size our green infrastructure practices for the next higher design storm – the two-year storm (3.3 inches of rain over 24-hours)?

Parameters	Two-hour design storm	24-hour design storm
Rainfall total	1.25 inches	3.3 inches
Drainage area	1,000 sq.ft.	1,000 sq.ft.
Infiltration during the storm	None	0.5 to 1.0 in/hr
Cost basis	Surface area	Surface area

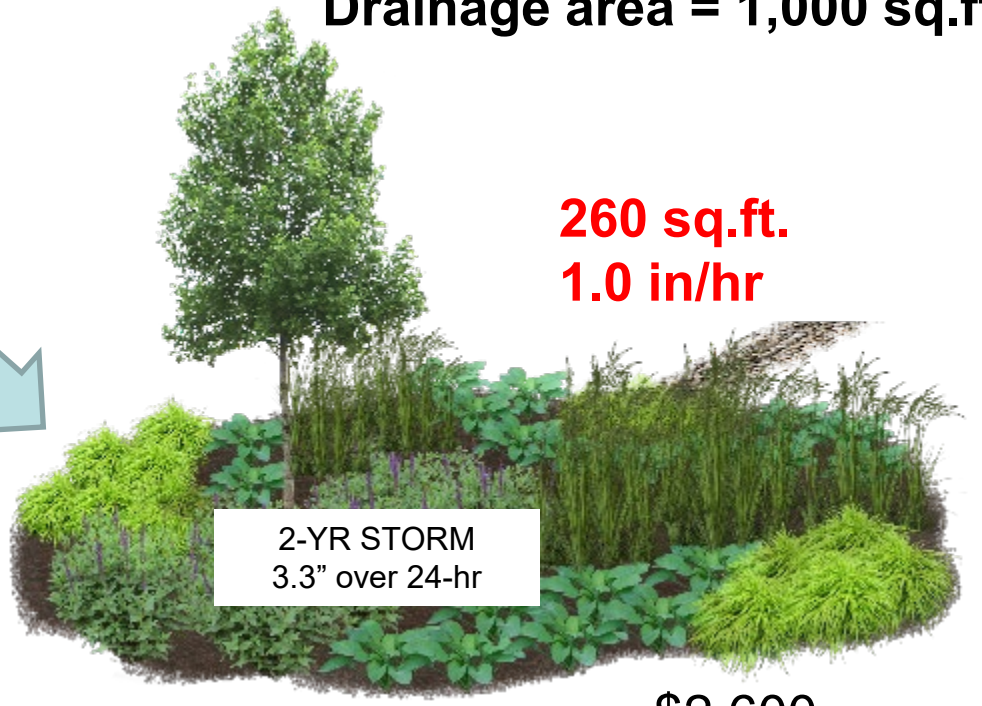
Climate Resilient Rain Garden

200 sq.ft.
0.0 in/hr

Drainage area = 1,000 sq.ft.

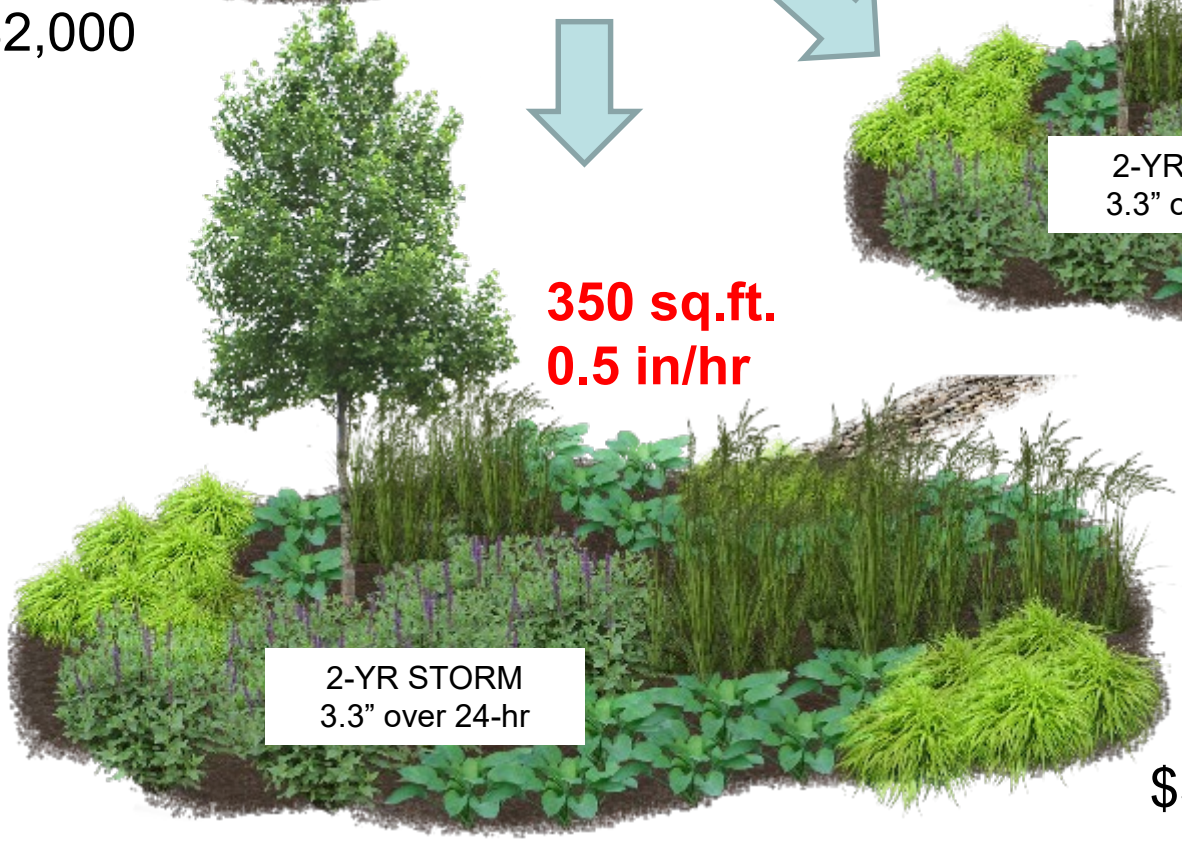
$2,000

260 sq.ft.
1.0 in/hr



$2,600

350 sq.ft.
0.5 in/hr



$3,500

Depth =
6.0 INCHES

Climate Resilient Rain Garden

260 sq.ft.
1.0 in/hr

Depth =
6.0 INCHES

260 sq.ft.
0.5 in/hr

Depth =
9.0 INCHES

$2,600

Results

Rain Garden Surface Area (sq. ft.)	Rain Garden Depth (in.)	Rain Garden Storage Volume (cu. ft.)	Rain Garden Capacity for 2-hr Rainfall (in.)	Cost ($)
200	6	100	1.25	2,000
260	6	130	1.56	2,600
350	6	175	2.10	3,500
260	9	195	2.34	2,600

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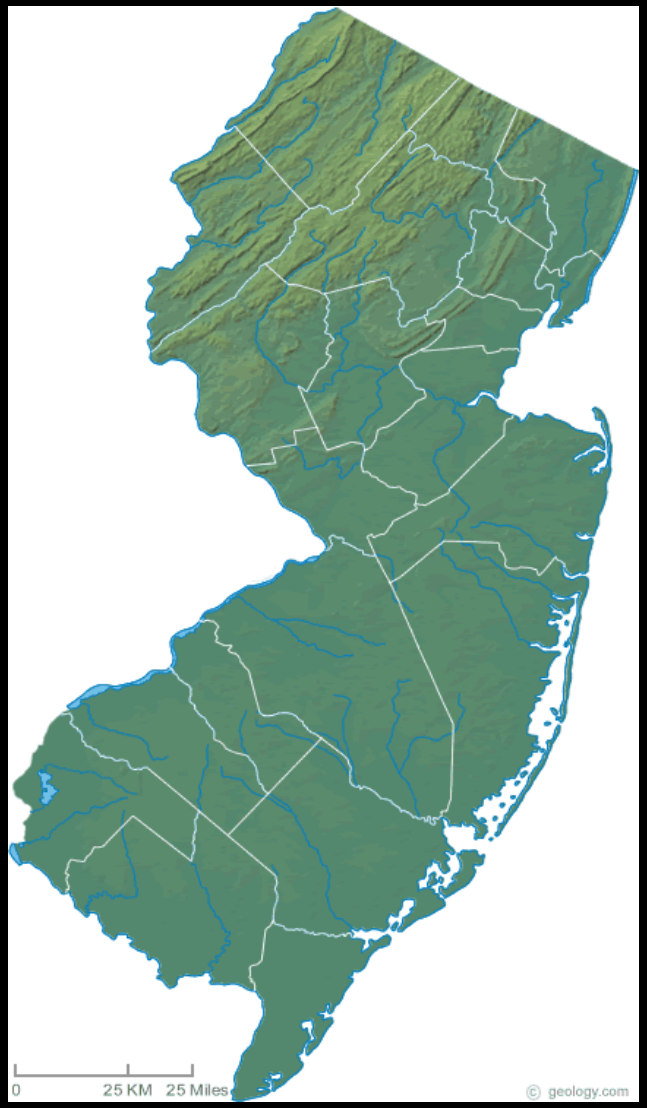
What if we combined roadside rain gardens with street trees?

Credit: Montgomery County, MD

Climate Change in New Jersey

- More warm extremes and fewer cold extremes
- Heavy rains become more intense
- More frequent dry spells
- Rising sea level with increased frequency and intensity of coastal flooding



NEW JERSEY BACK BAYS
COASTAL STORM RISK MANAGEMENT
INTERIM FEASIBILITY STUDY AND
ENVIRONMENTAL SCOPING DOCUMENT

1 March 2019

U.S. Army Corps
of Engineers
Philadelphia District

NJBB
NEW JERSEY BACK BAYS STUDY

NJDEP

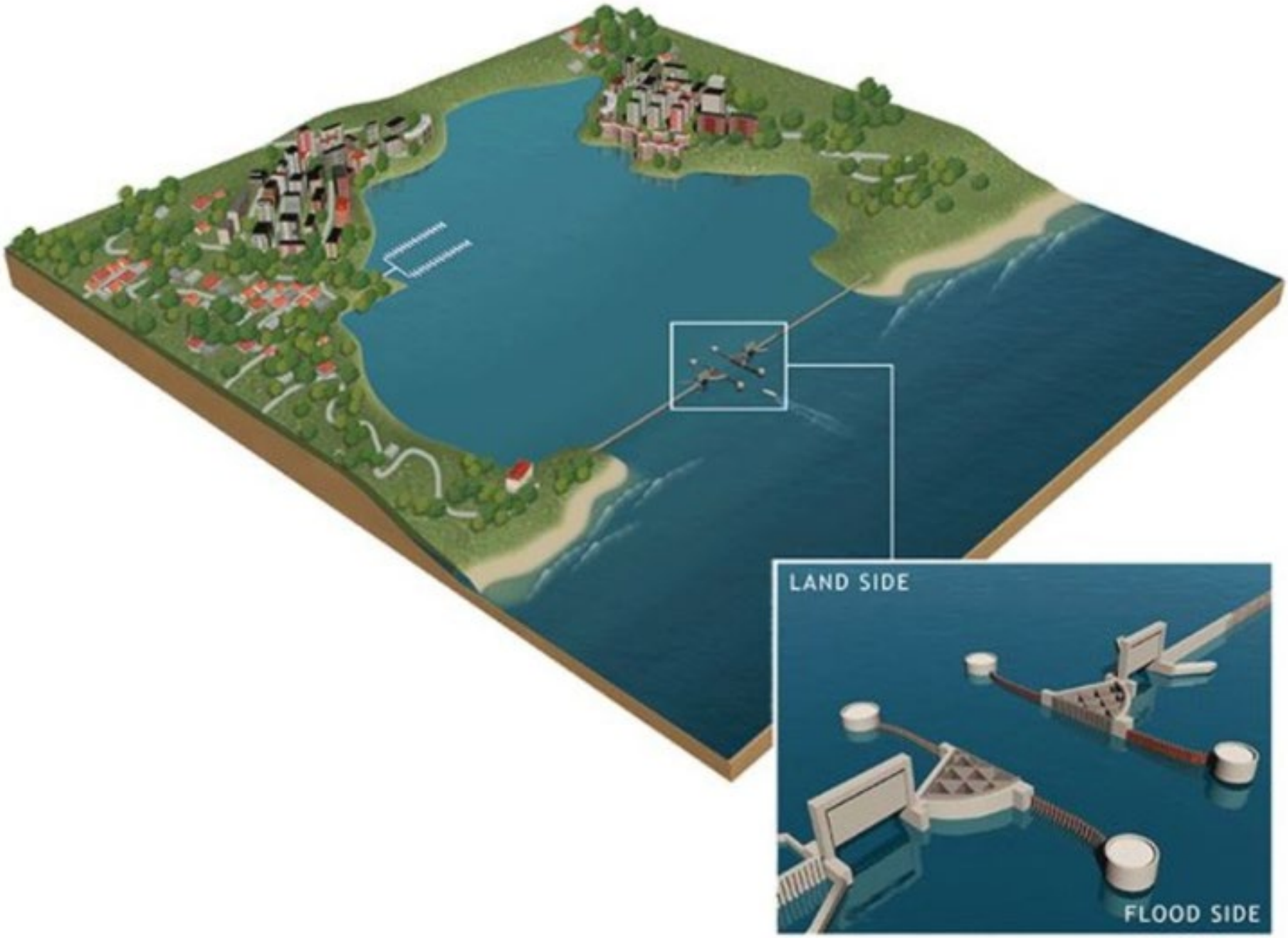
Examples of Measures
Under Consideration

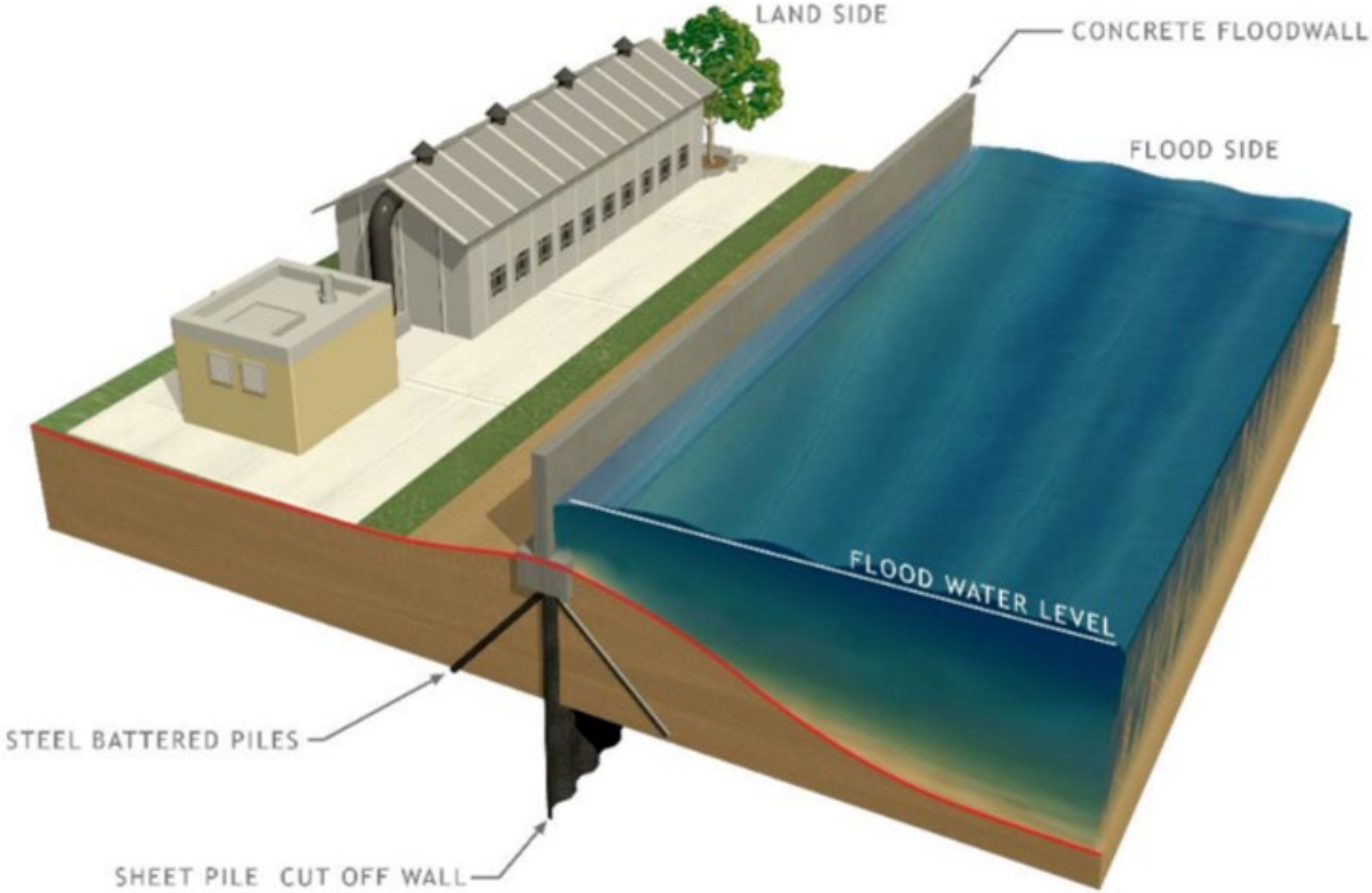
Structural Measures

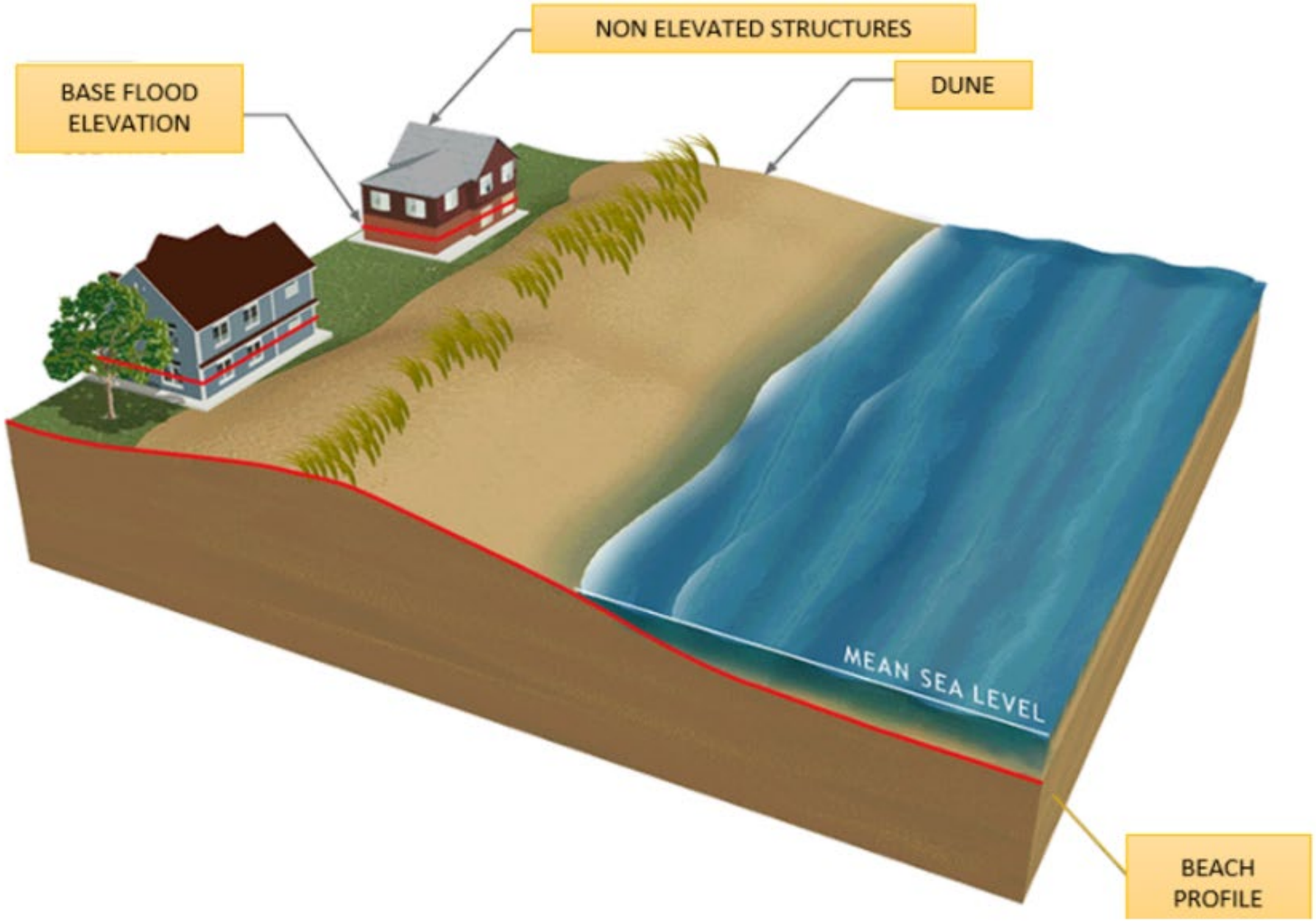
- Inlet Storm Surge Barriers
- Interior Bay Closures
- Raised Roads and Rails
- Levees
- Floodwalls (Permanent)
- Deployable Floodwalls
- Crown Walls
- Beach Restoration/Groins/Breakwaters
- Bulkheads
- Seawalls
- Revetments
- Stormwater System Drainage Improvements

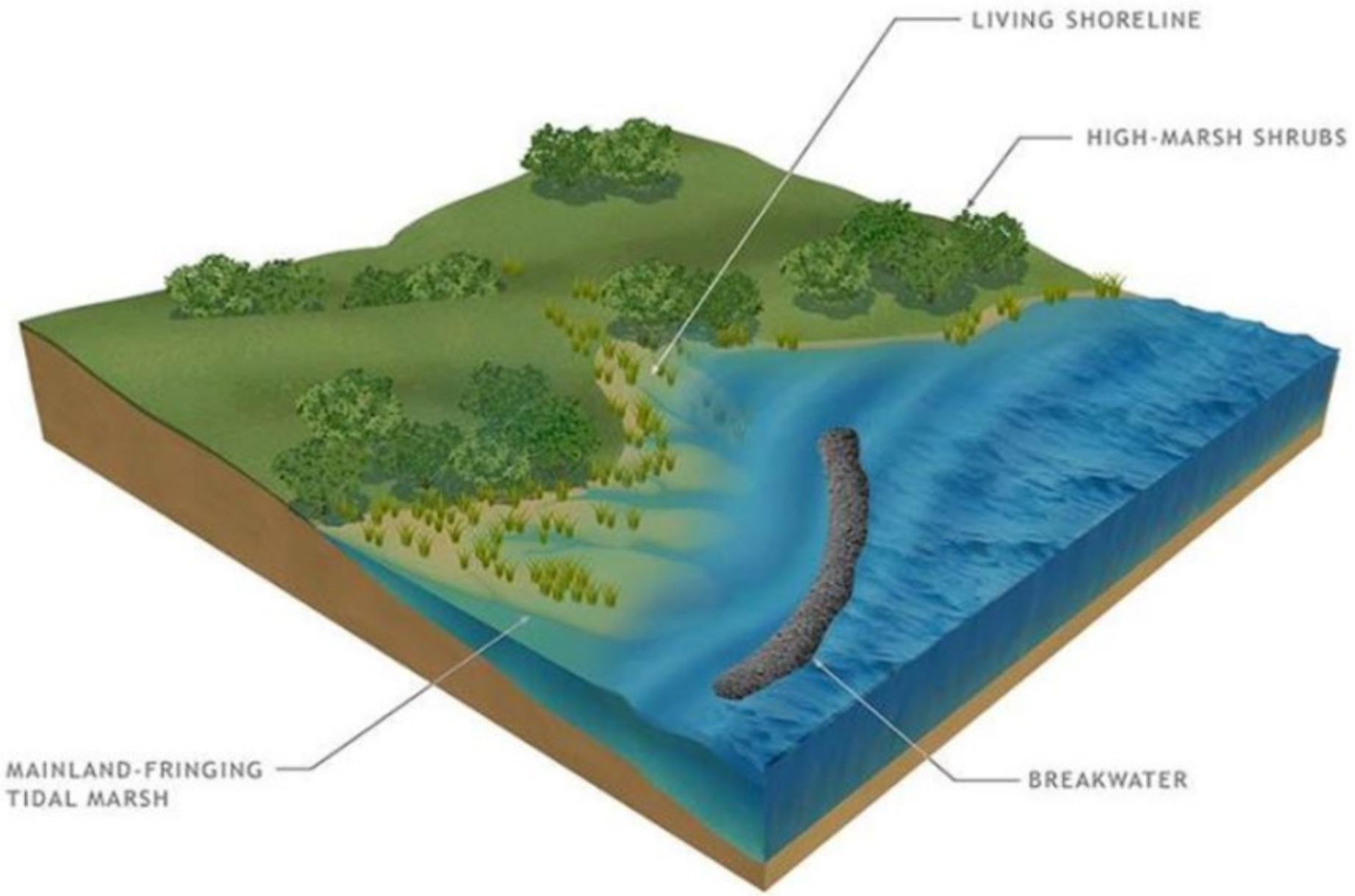
Natural and Nature-Based Features

- Living Shorelines
- Reefs
- Wetland Restoration
- Submerged Aquatic Vegetation (SAV) Restoration
- **Green Stormwater Management**


LAND SIDE
FLOOD SIDE


LAND SIDE
CONCRETE FLOODWALL
FLOOD SIDE
FLOOD WATER LEVEL
STEEL BATTERED PILES
SHEET PILE CUT OFF WALL


NON ELEVATED STRUCTURES
BASE FLOOD ELEVATION
DUNE
MEAN SEA LEVEL
BEACH PROFILE


LIVING SHORELINE
HIGH-MARSH SHRUBS
MAINLAND-FRINGING
TIDAL MARSH
BREAKWATER

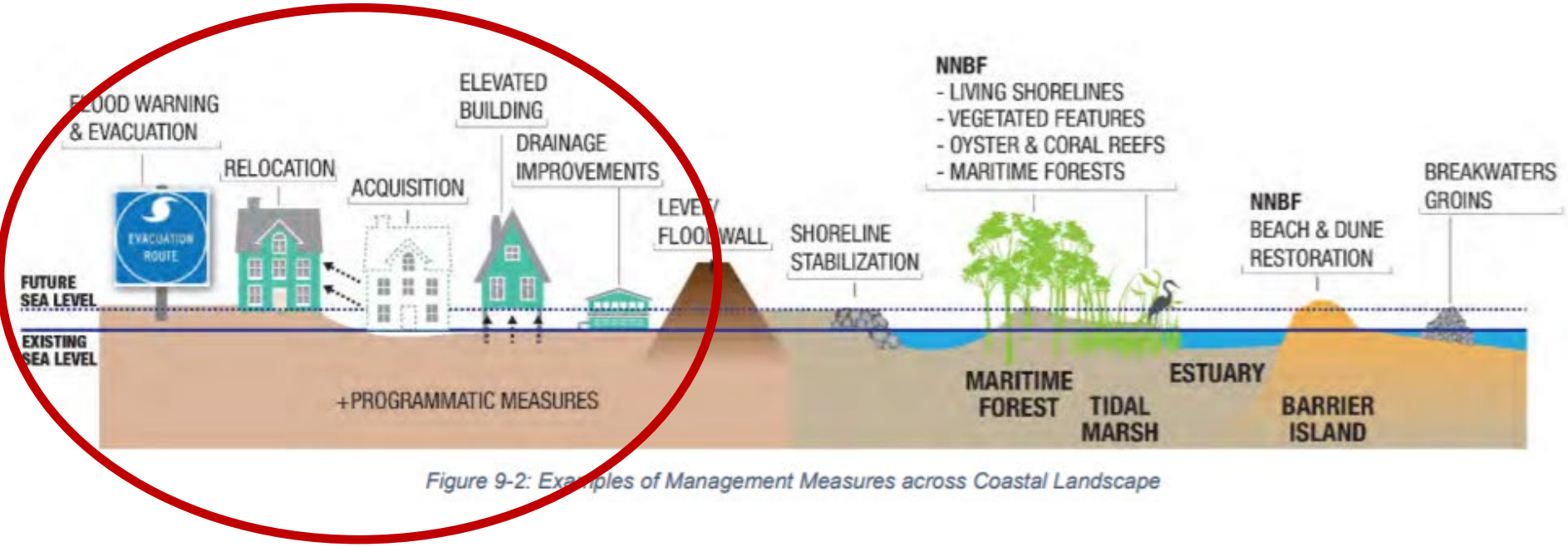
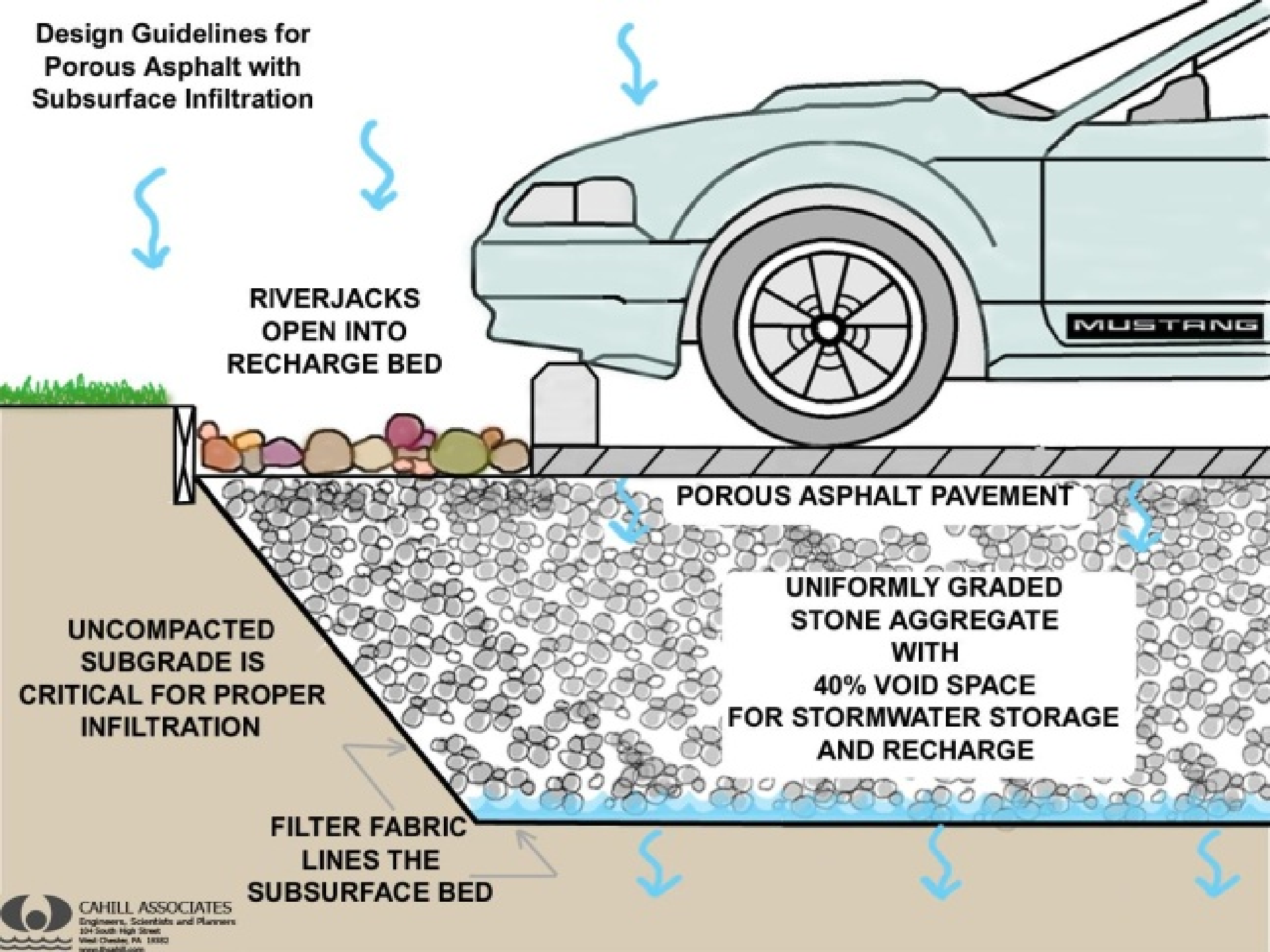


Figure 9-2: Examples of Management Measures across Coastal Landscape

Design Guidelines for Porous Asphalt with Subsurface Infiltration



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WE ARE DONE!
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Green Infrastructure Champions Program

This program is partially funded by the Rutgers New Jersey Agricultural Experiment Station, The Geraldine R. Dodge Foundation, and NJ Sea Grant Consortium and is a collaboration of the Rutgers Cooperative Extension Water Resources Program and the Green Infrastructure Subcommittee of Jersey Water Works.

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