Green Infrastructure Champion Training: Part 10

# "Using Green Infrastructure to Promote Climate Resiliency"

May 22, 2020

~~Duke Farms~~

~~Hillsborough, NJ~~

**Via Webinar 10 am - noon**

Rutgers Cooperative Extension Water Resources Program

Christopher C. Obropta, Ph.D., P.E.

RUTGERS
New Jersey Agricultural Experiment Station

# 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, the Green Infrastructure Subcommittee of Jersey Water Works, and Duke Farms.*

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JERSEY WATER WORKS
Smart infrastructure. Strong communities.

Sea Grant
NJ Sea Grant Consortium

The Geraldine R. DODGE FOUNDATION
IMAGINE A BETTER NEW JERSEY

Duke Farms

**Chat with "smellor"**

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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

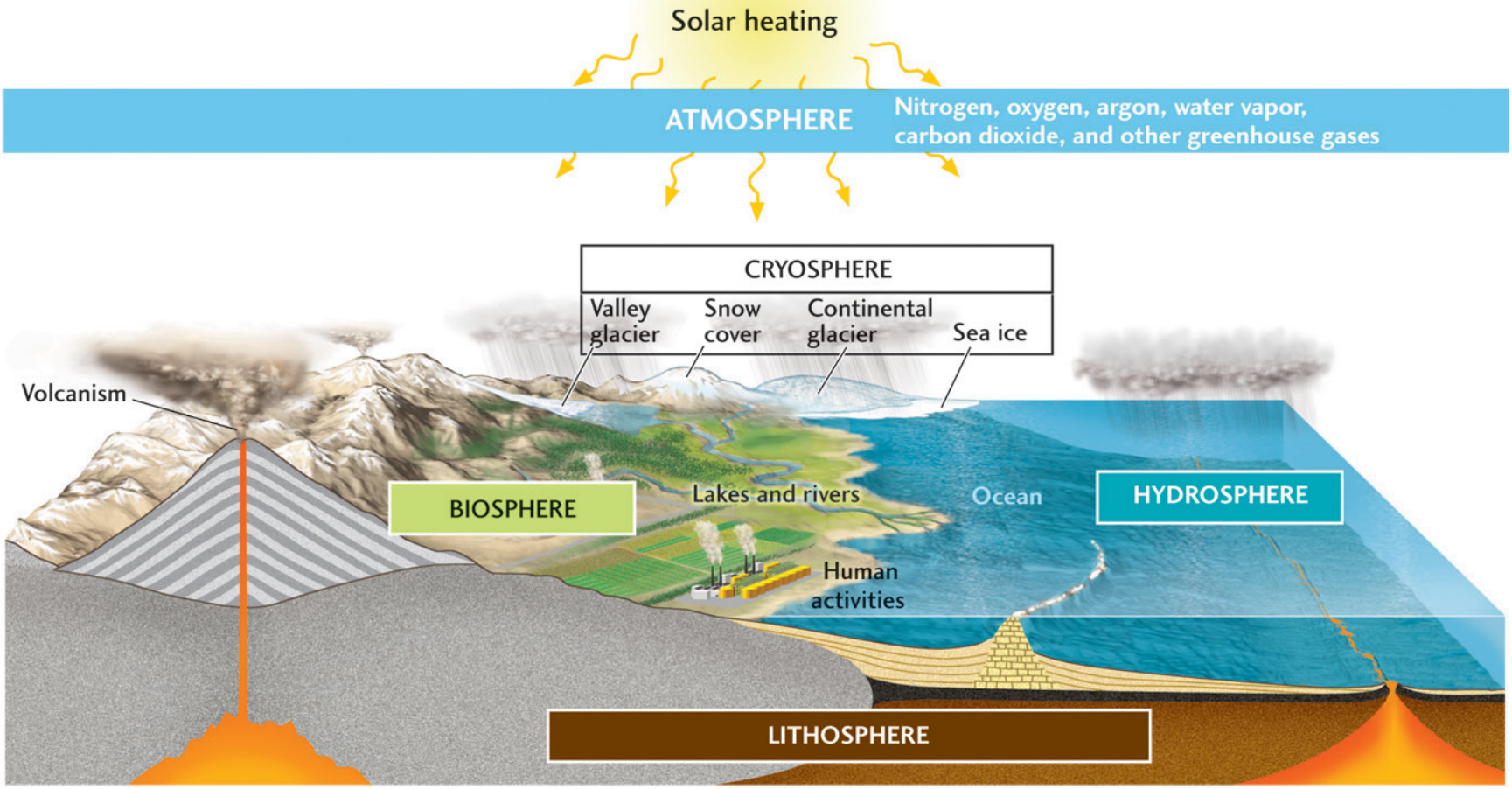
Climate refers to the long-term patterns

Better yet!

Climate is your personality…..

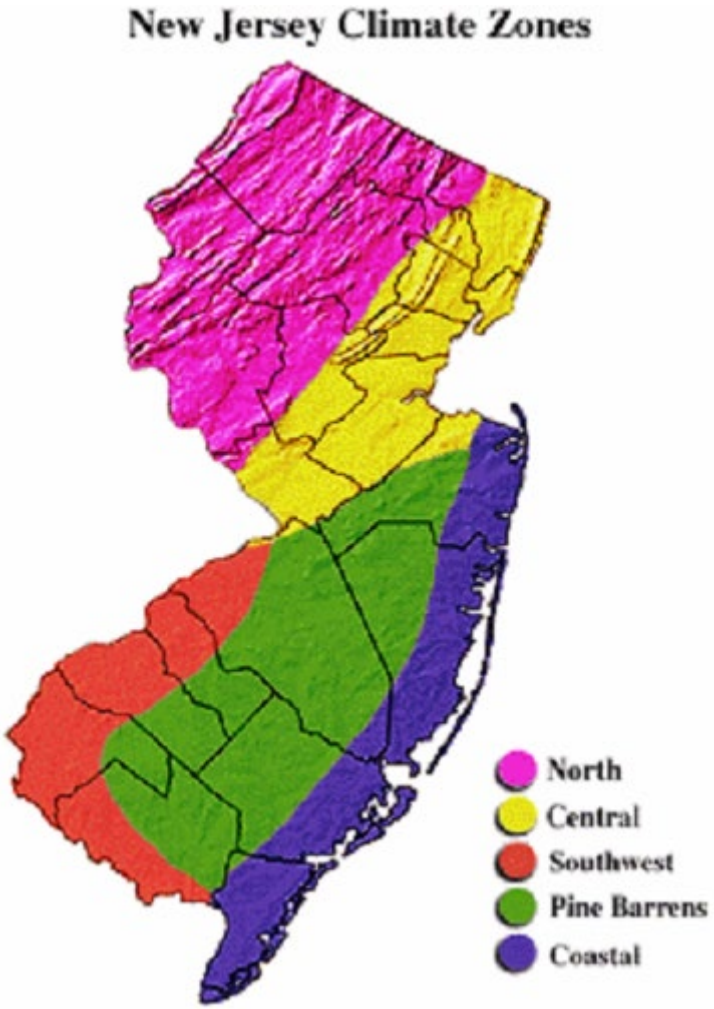
Weather is your mood……

# 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

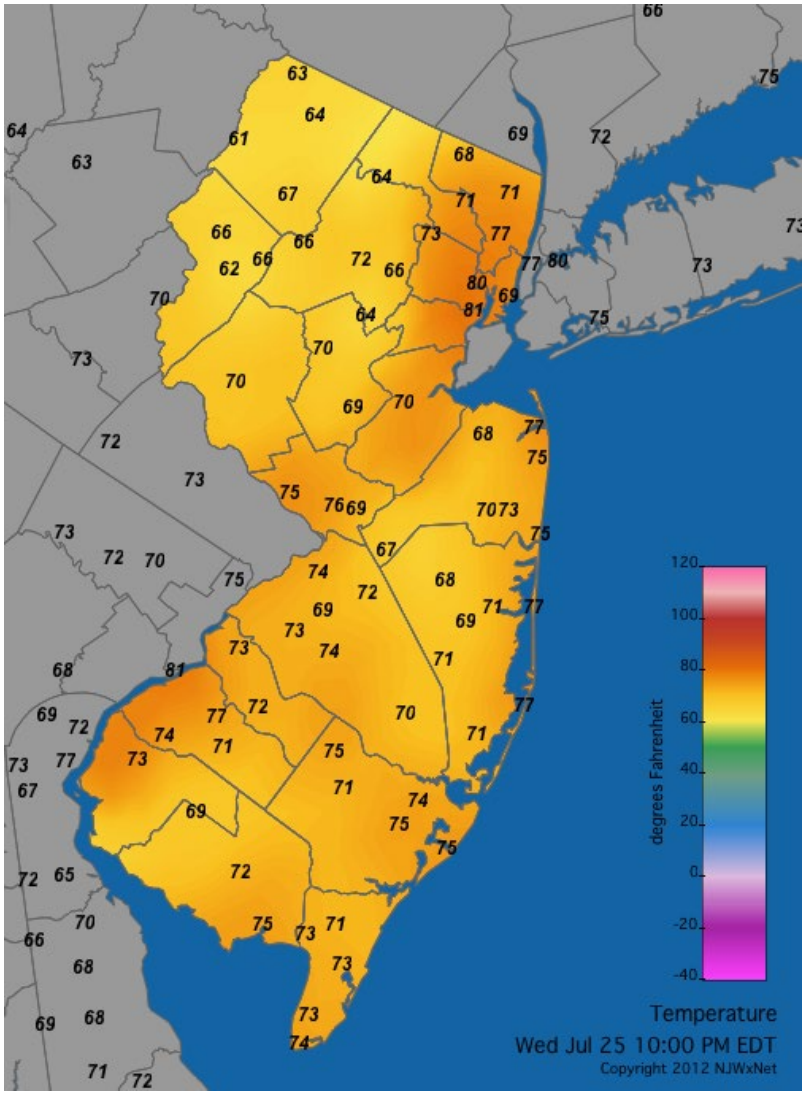
- Altitude
- Latitude
- Surface Conditions
- Land-Water Contrasts

# Land cover matters!

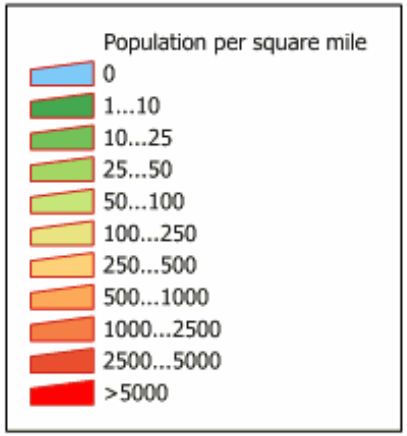
Trenton

Great Swamp

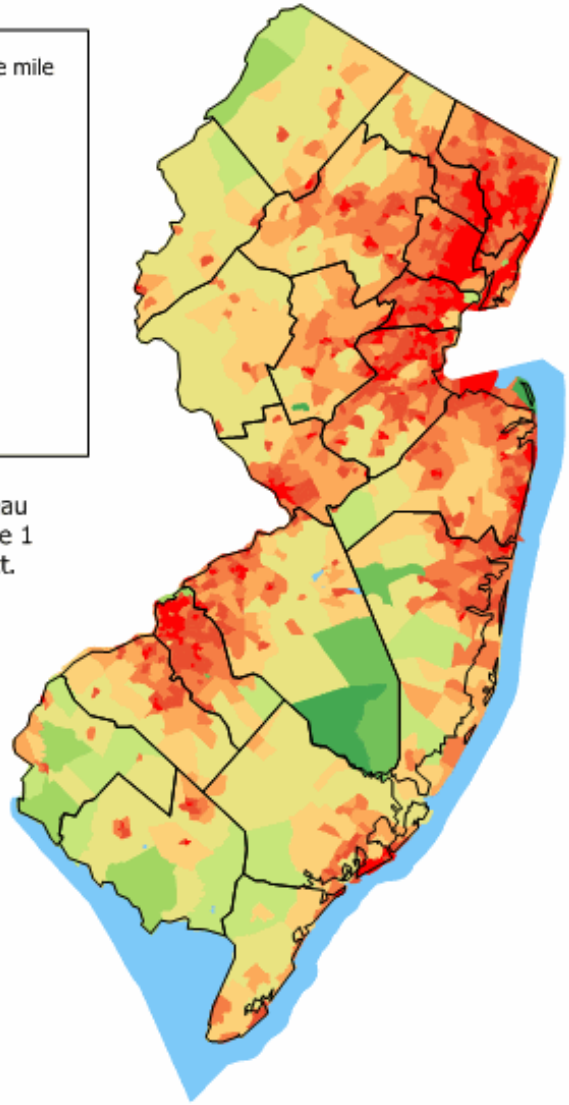
# Heat waves and human health



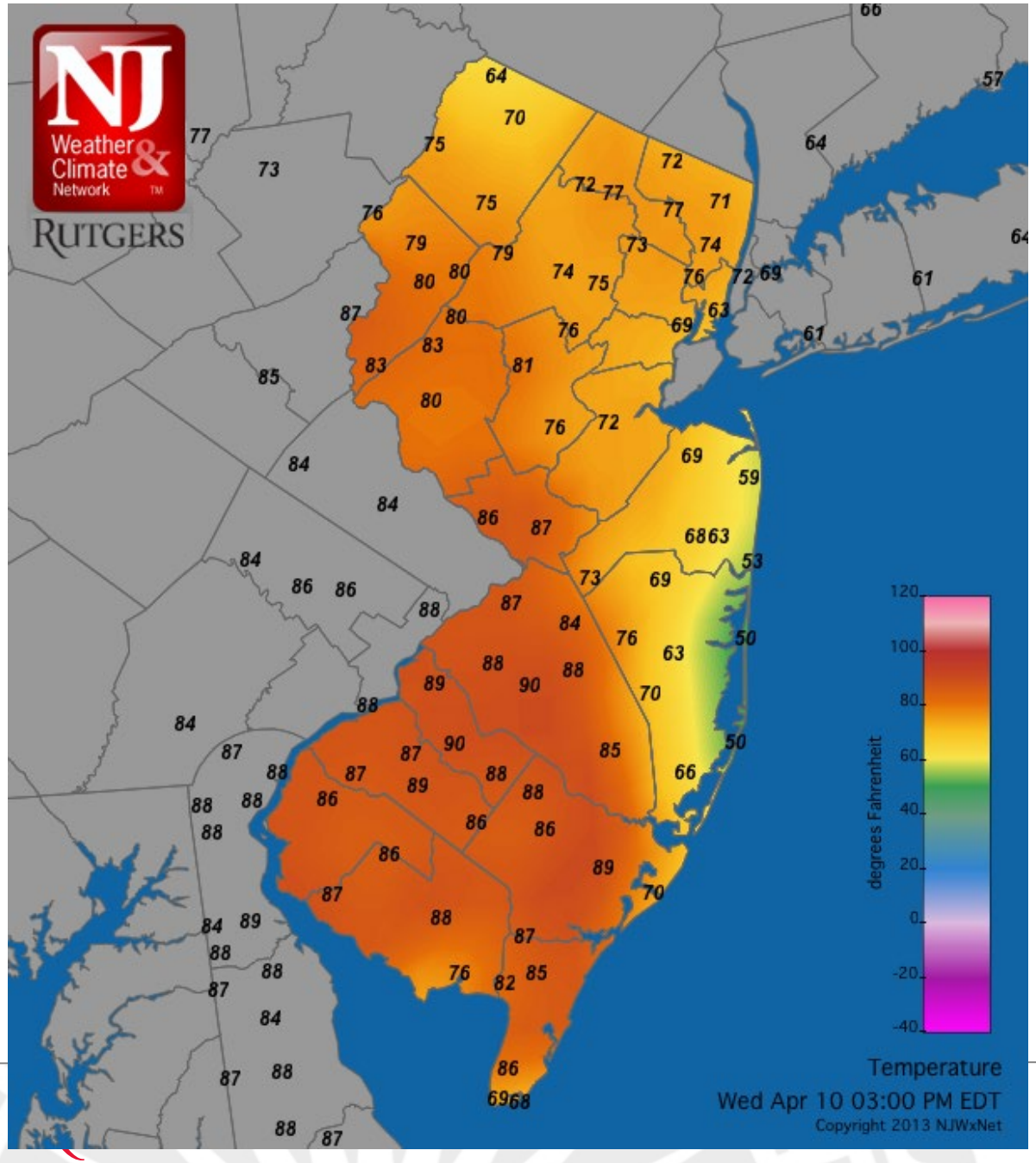

10 PM 25 July 2012




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



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

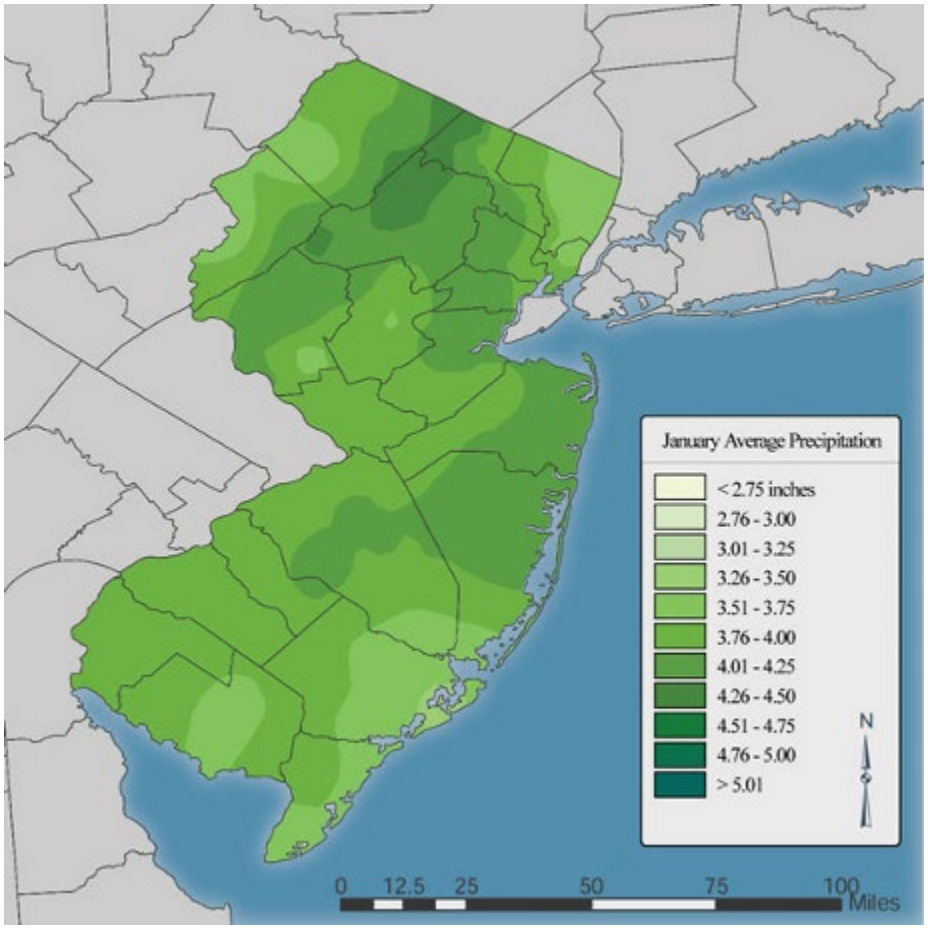


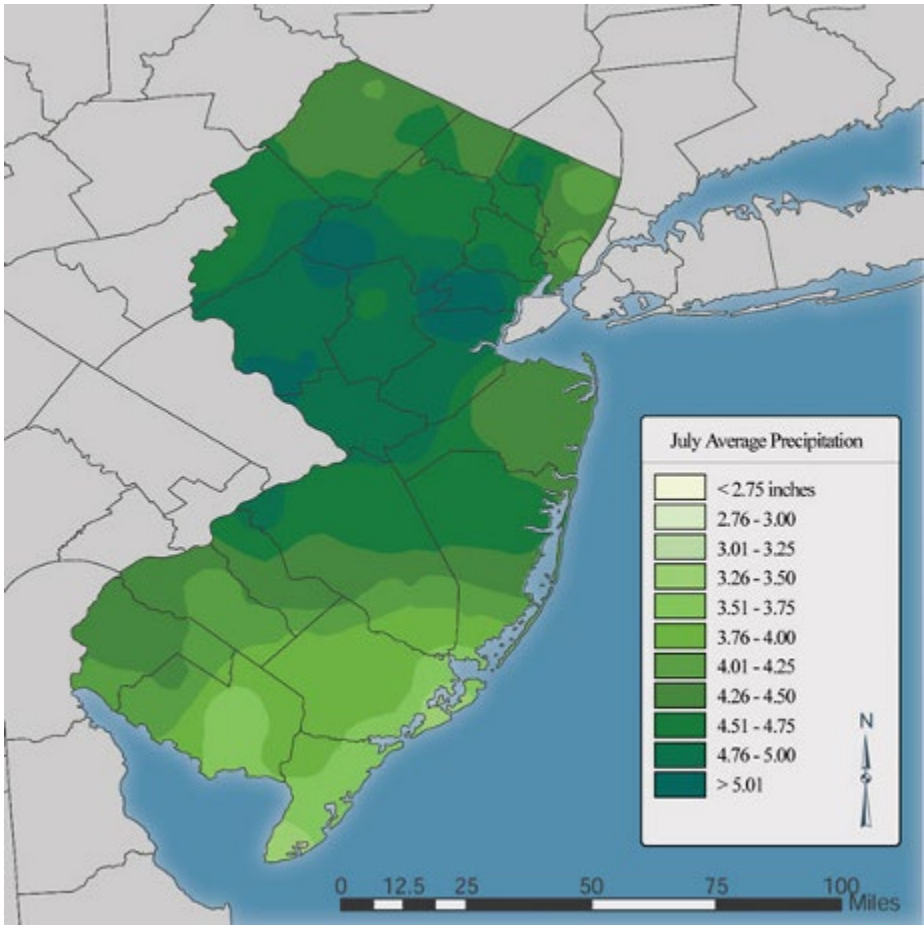

As does proximity to water

Sea Breeze and backdoor cold front:

April 10, 2013
3 PM

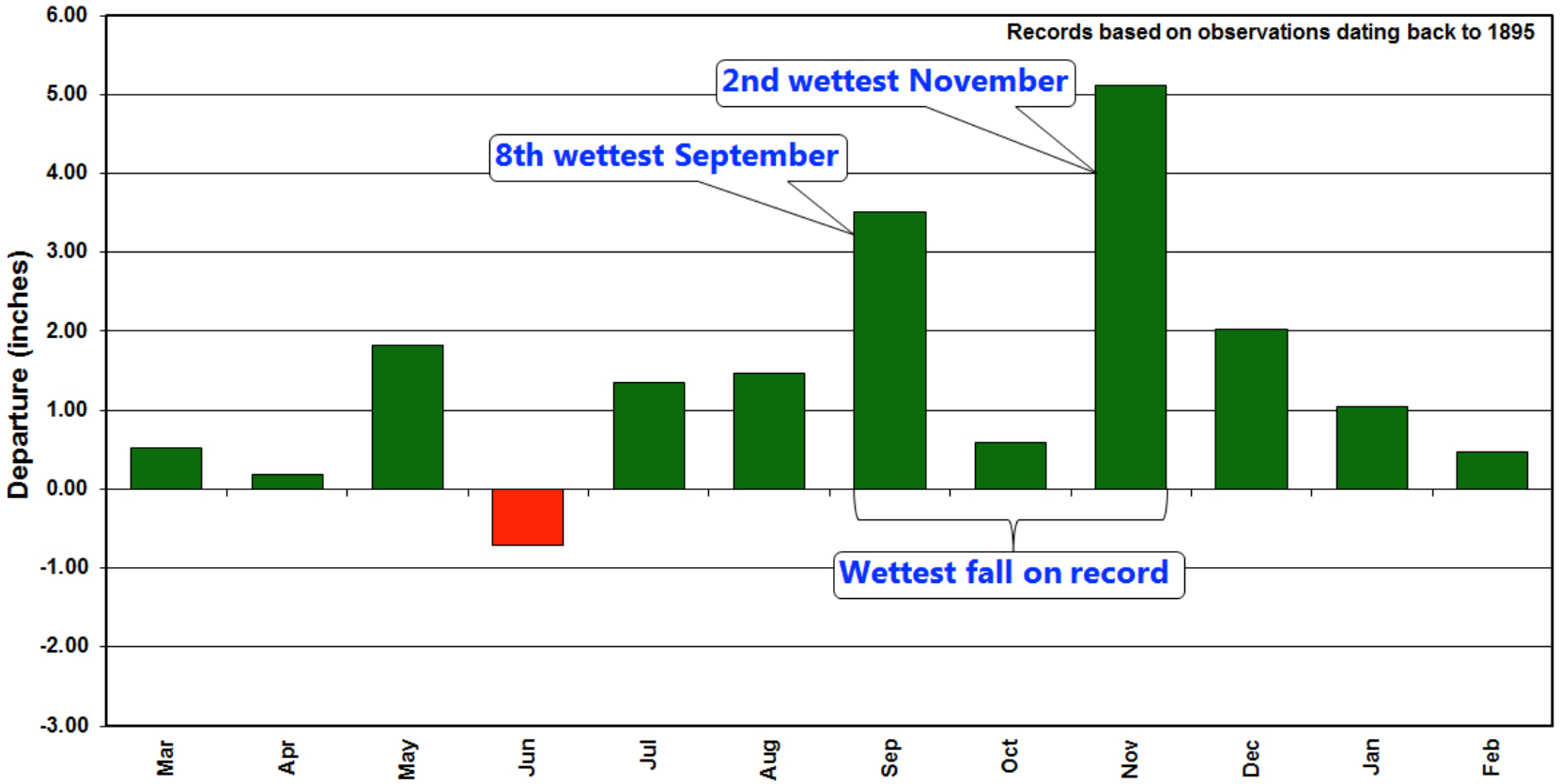
# A precipitation rich state……




……most often

# NJ Monthly Precipitation Departures: Mar 2018 – Feb 2019



# Sometimes too much…

Brick Township: 13 August 2018

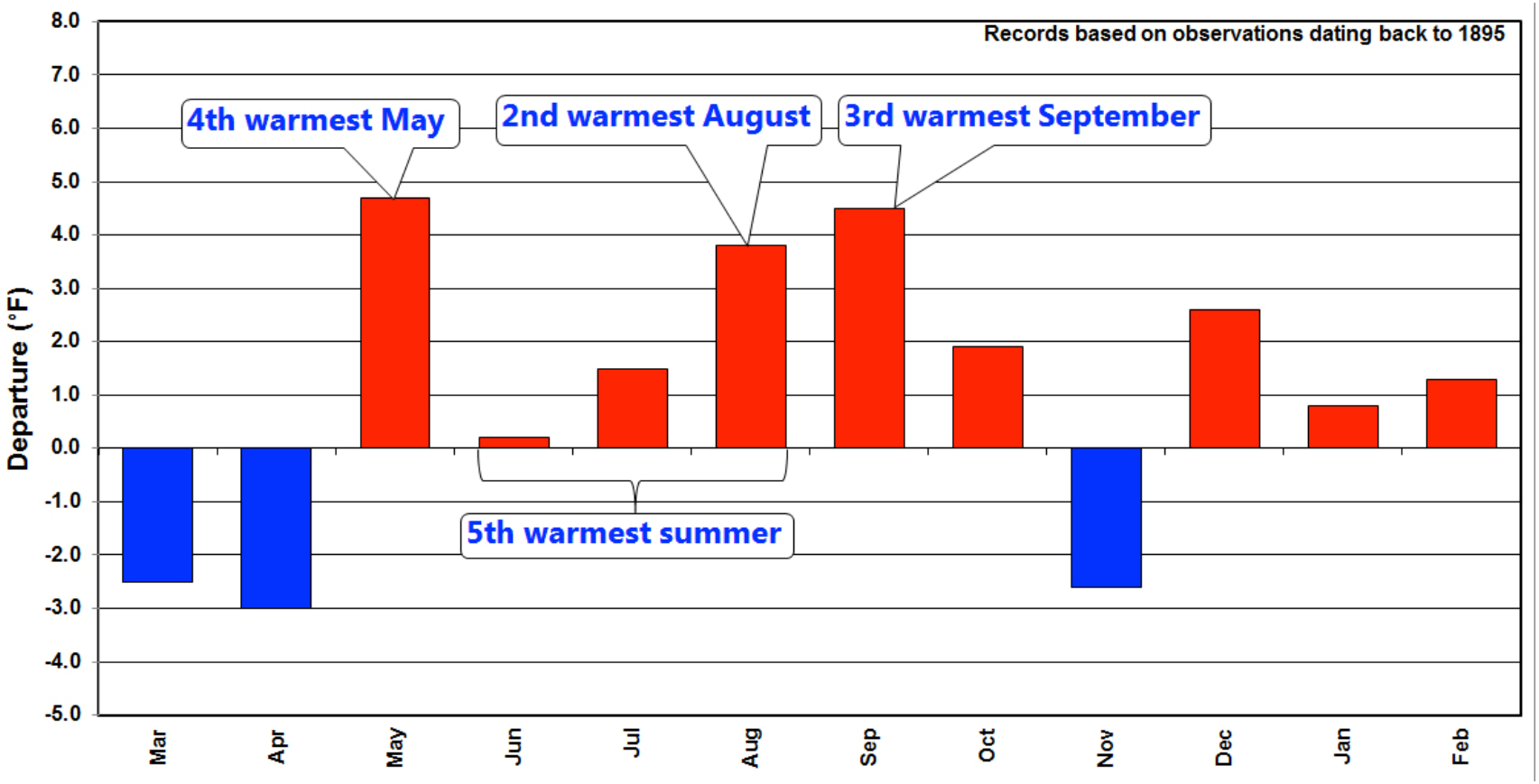
# However sometimes too little……

J. McCrea/Star Ledger

Spruce Run Reservoir: March 2002

# Appreciating Variations & Extremes

# NJ Monthly Temperature Departures: Mar 2018 – Feb 2019

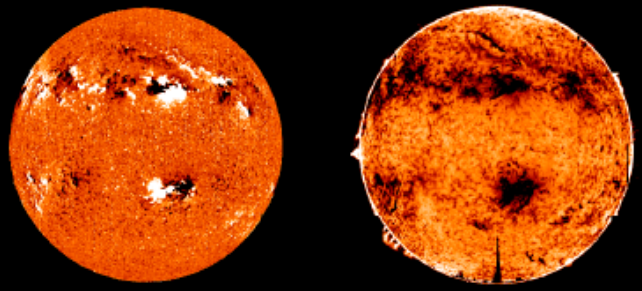


# Causes of climate change

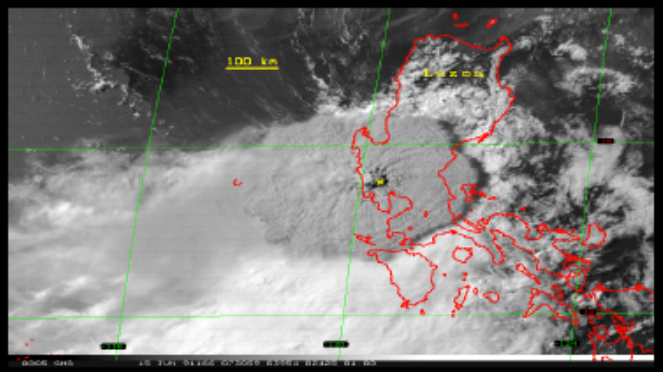
# Natural mechanisms influence climate

## Natural mechanisms

Changes in solar output →

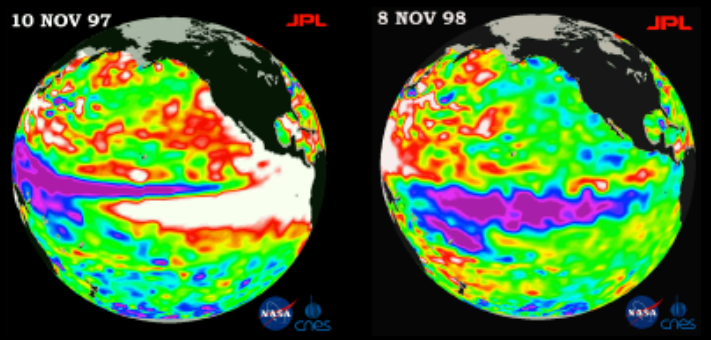


Changes in the amount of volcanic aerosols in the atmosphere →




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

→



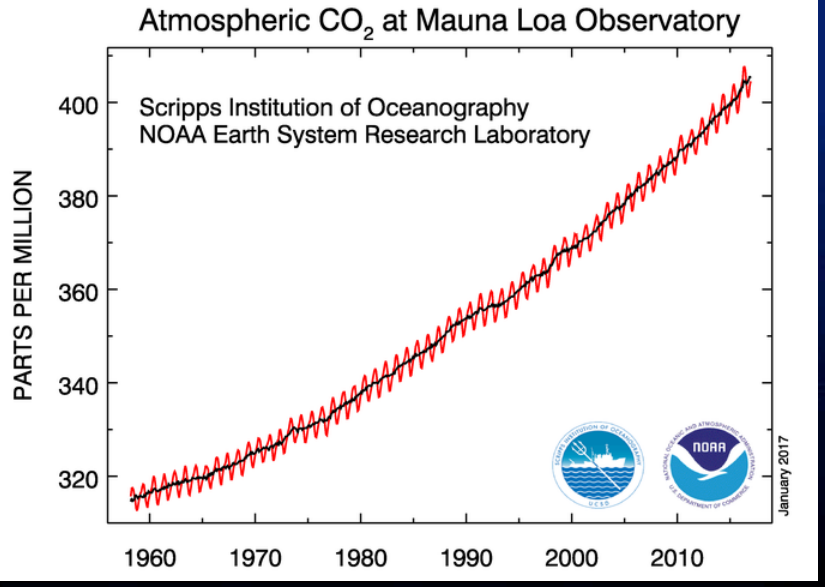
# Human factors also influence climate

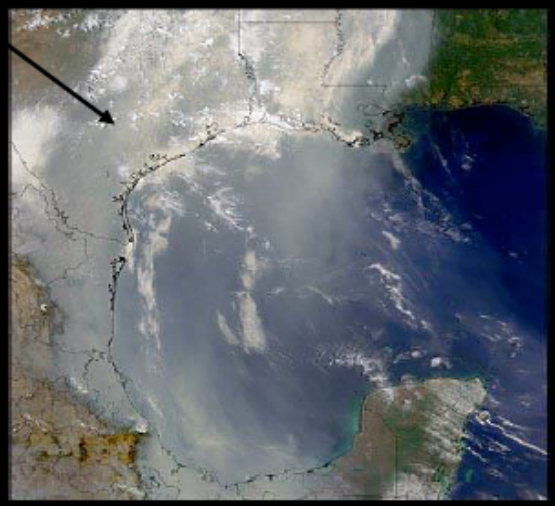
## Non-natural mechanisms

**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*

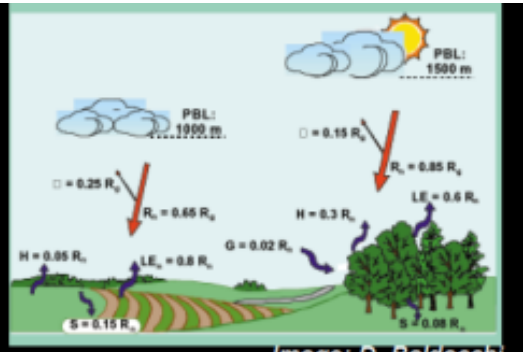



*Image: D. Baldocchi*

## Effects/Impacts

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

Dev Niyogi, Purdue U.

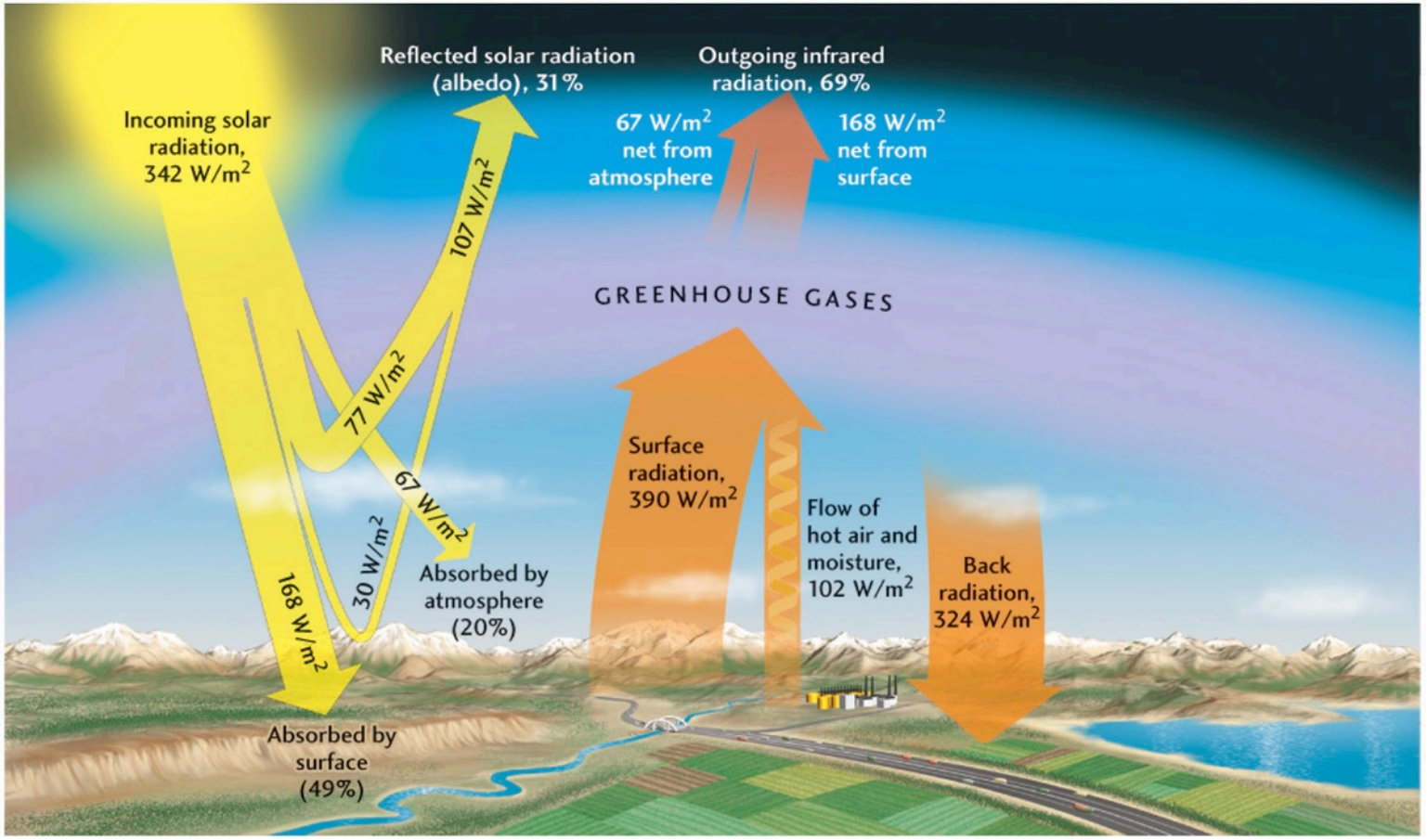
http://landsurface.org/

# Is climate presently changing in NJ & elsewhere?

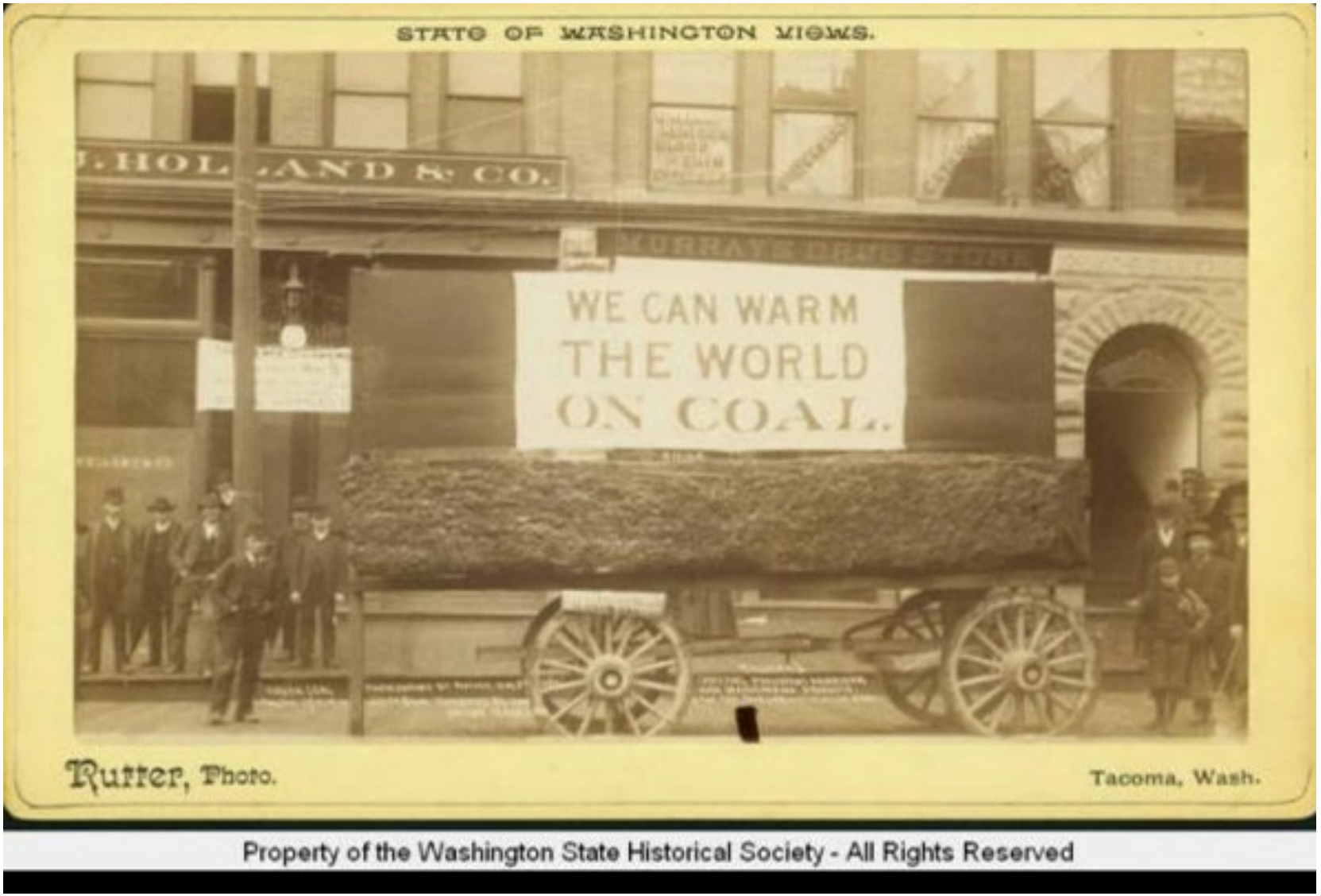
Preponderance of evidence suggests climate change is occurring and humans are responsible for a significant portion of recent changes

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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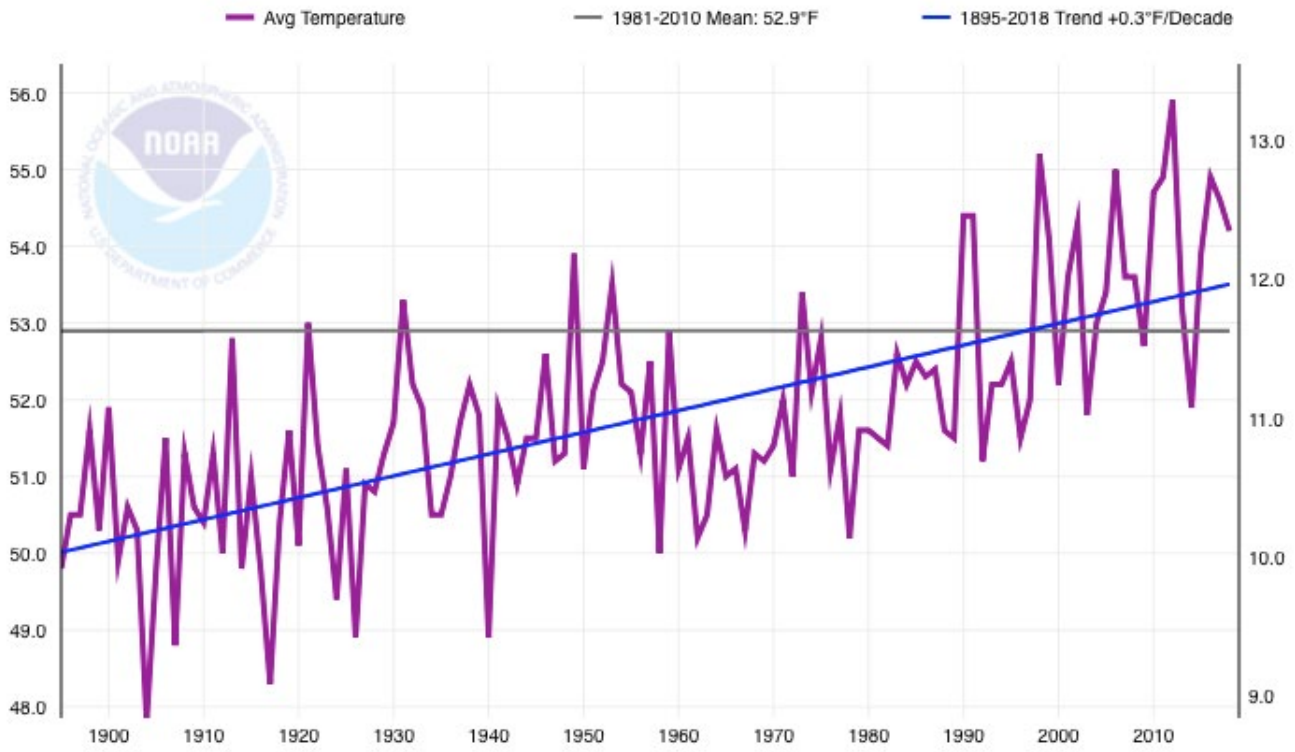
# New Jersey annual temperature: 1895-2018



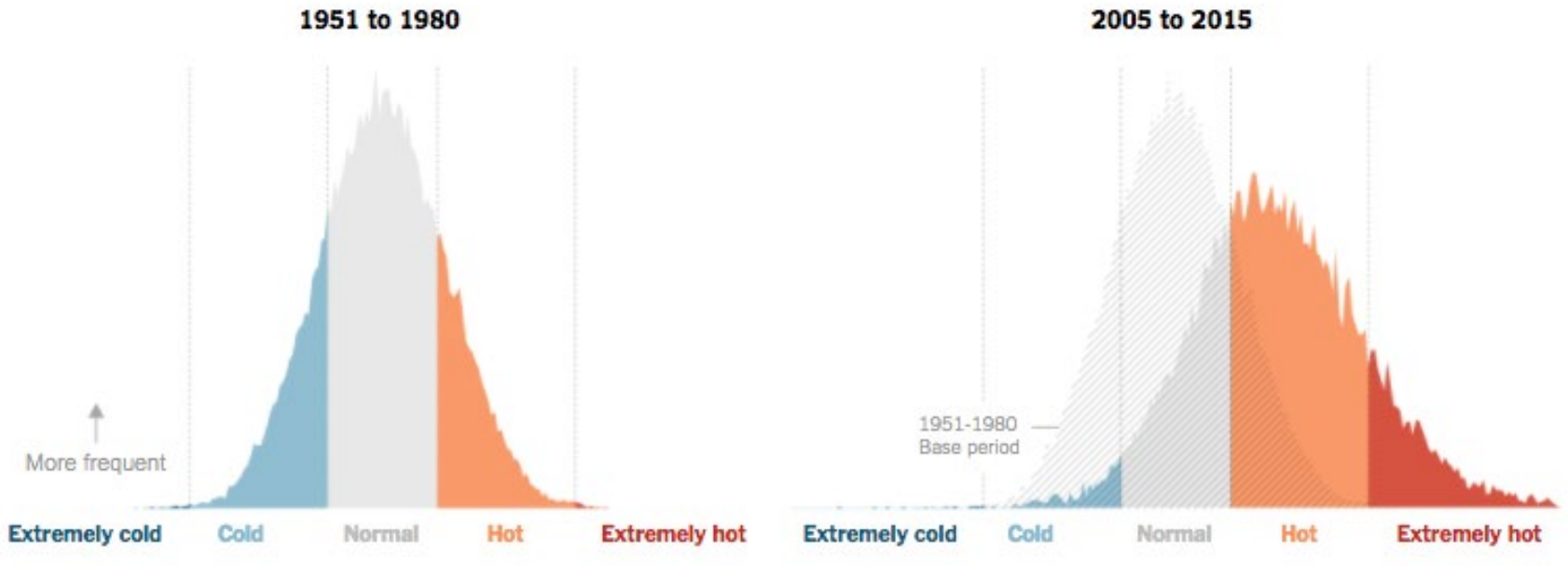

Long-term upward trend of 2.2° F per 100 years

6 of the 7 warmest years have occurred since 2006

2012 was the warmest year on record

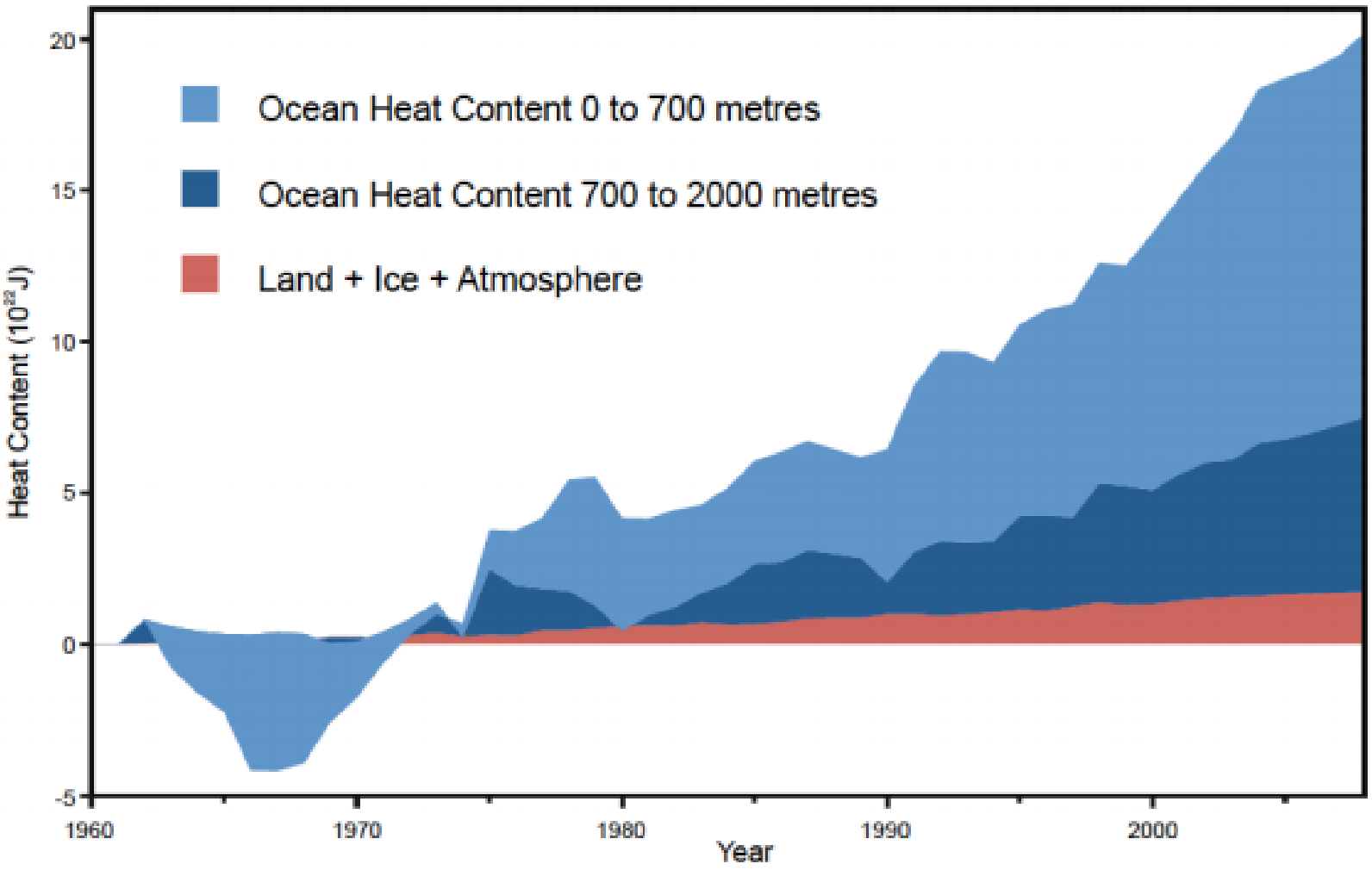
data source: National Centers for Environmental Information

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

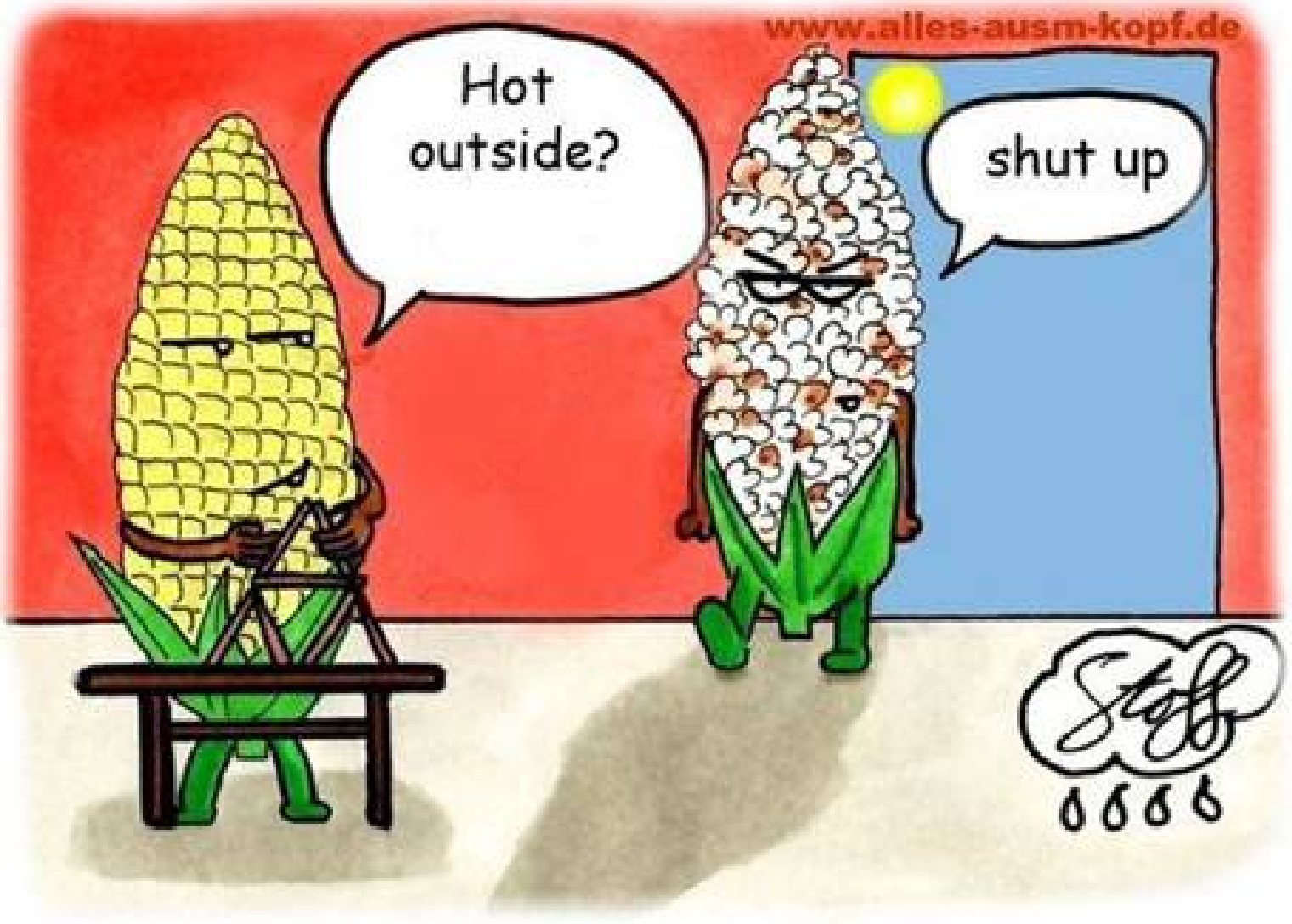



COLUMBIA UNIVERSITY EARTH INSTITUTE VIA MAKIKO SATO AND JAMES HANSEN
THE NEW YORK TIMES - NYTIMES.COM

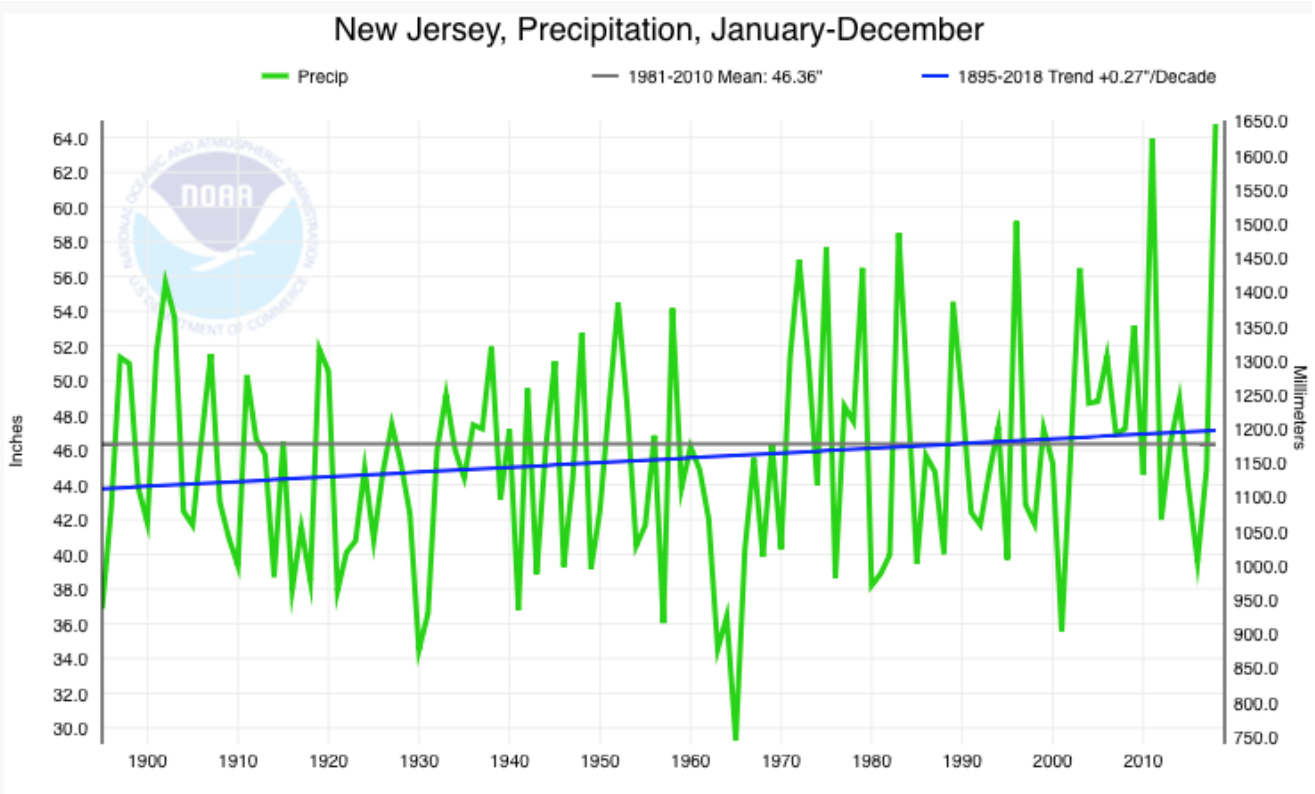
# Where the anthropogenic-generated heat is going




Nuccitelli et al., 2012


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

# New Jersey annual precipitation: 1895-2018




2018: wettest on record

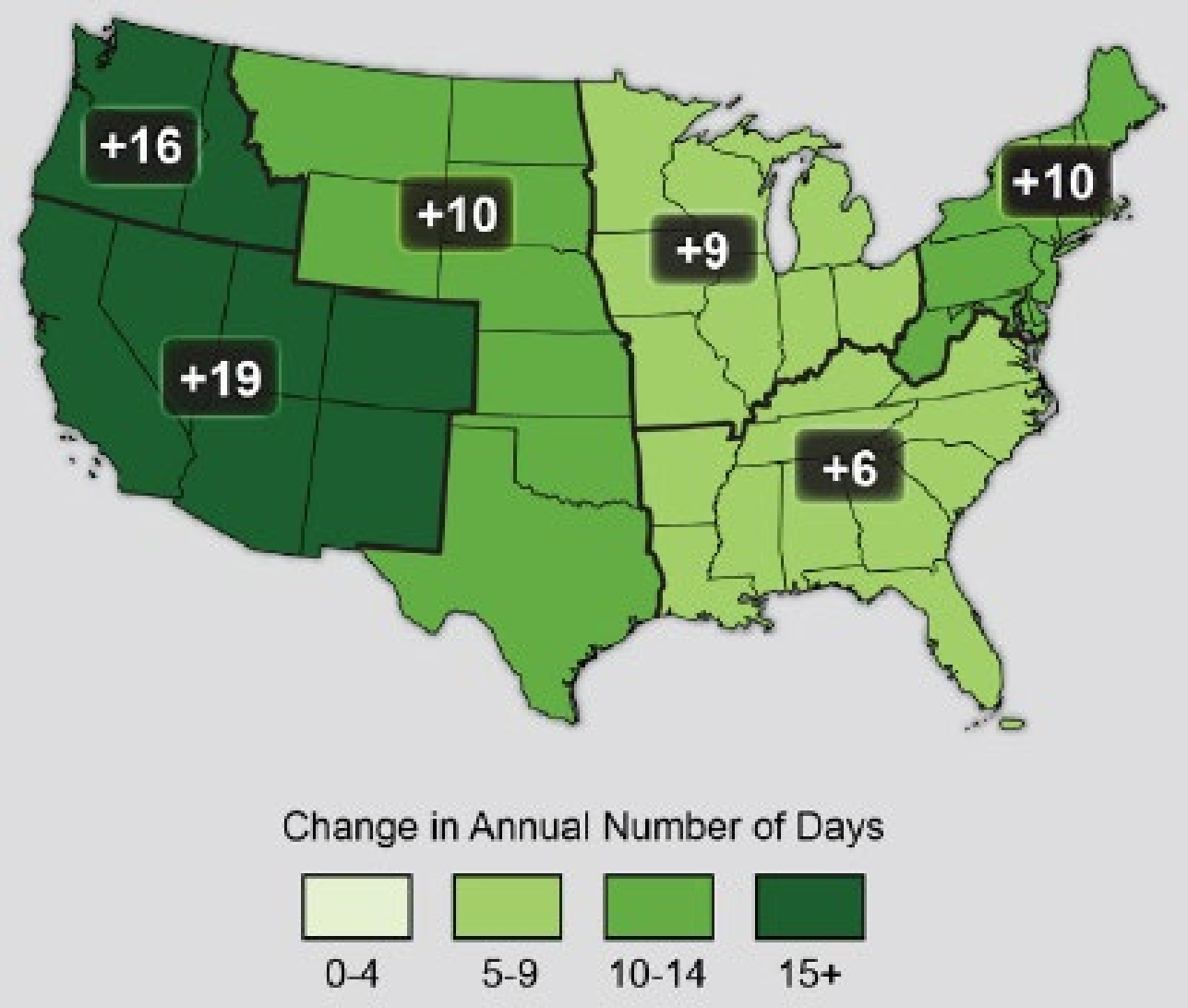
Large decadal variability (early 1960s drought, wet 1970s, very wet in last decade)

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

data source: National Centers for Environmental Information

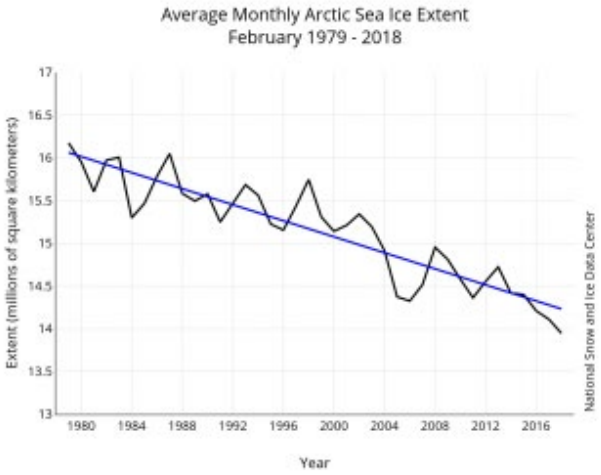
# Increase in frost-free season length

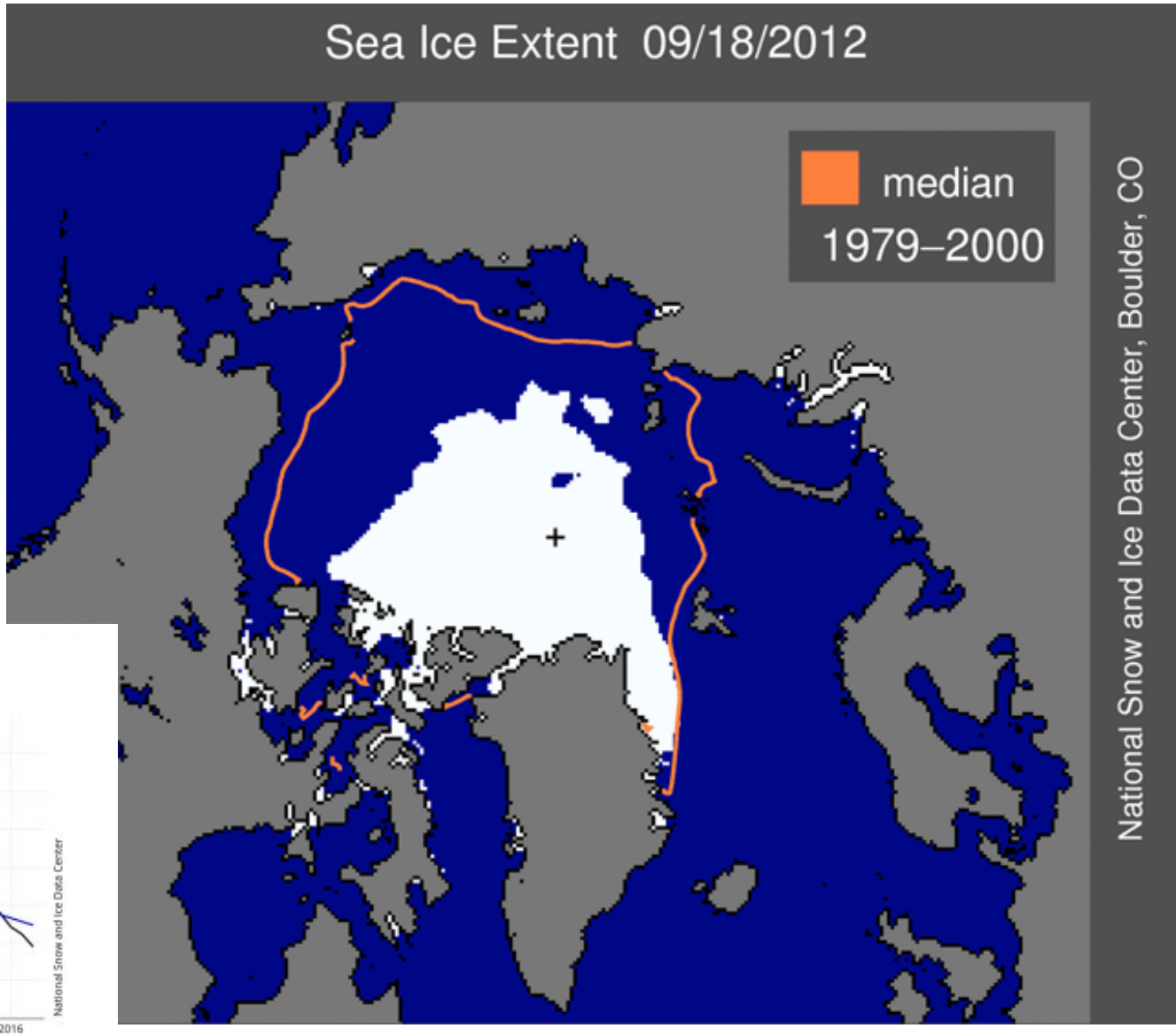
1991-2012 relative to 1901-1960




National Climate Assessment, 2014

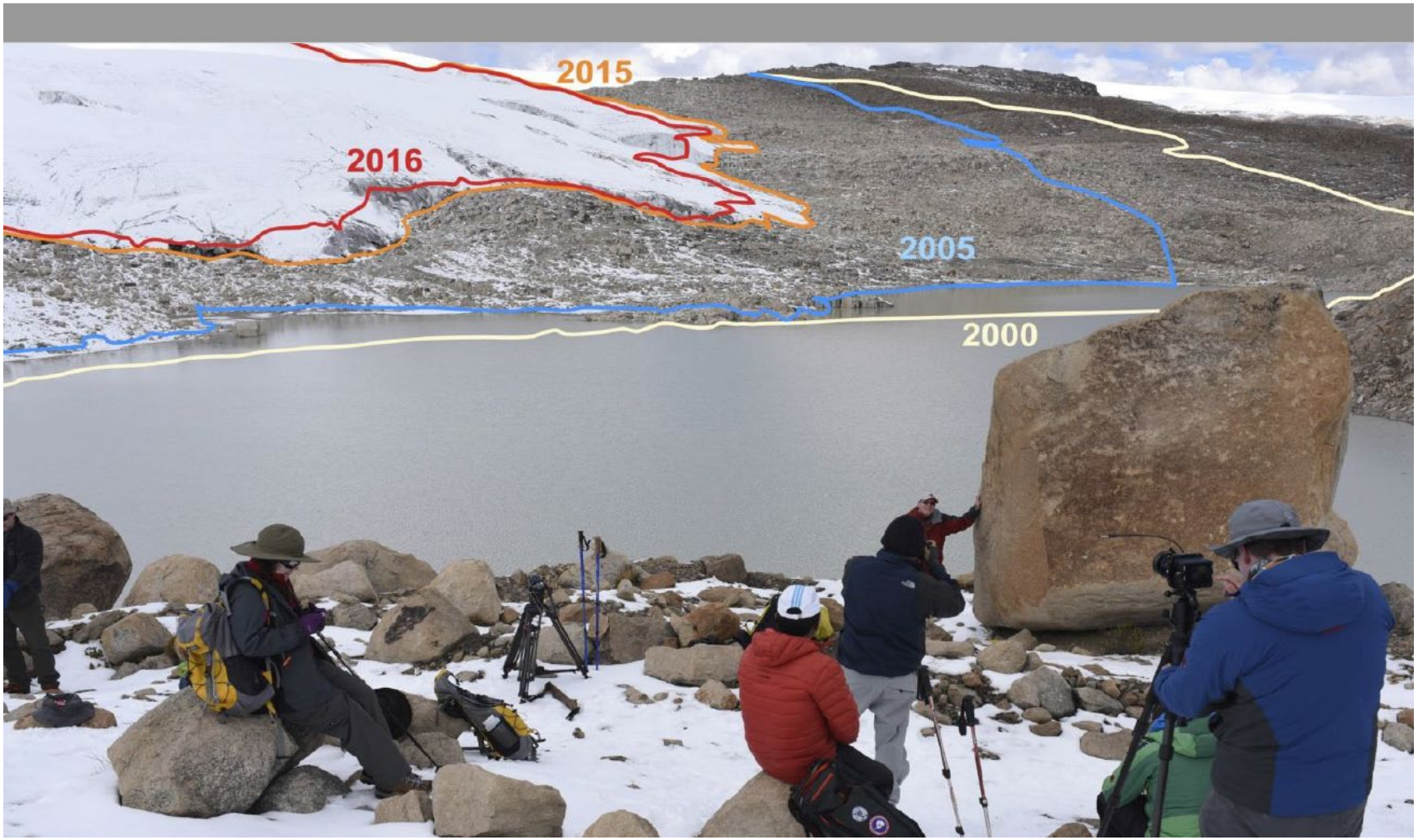
# Arctic Sea Ice



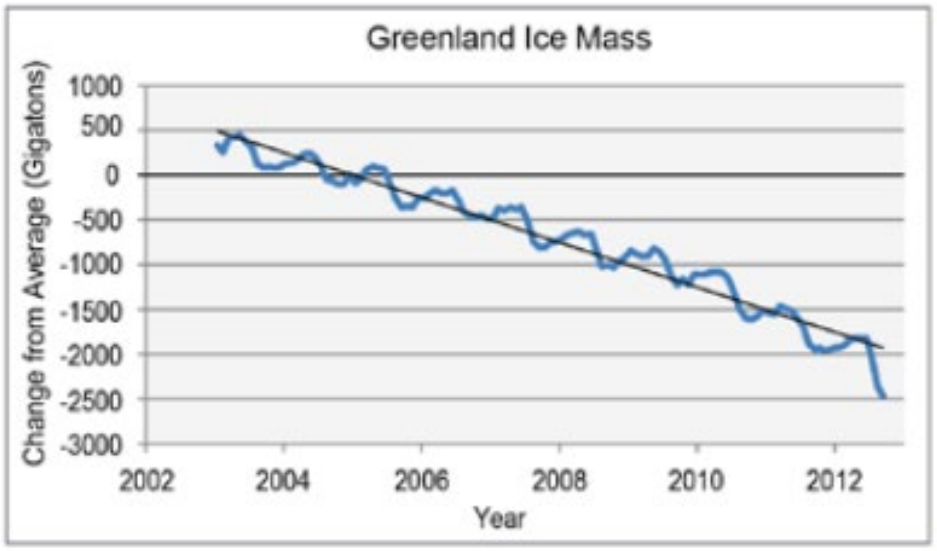

*Stroeve et al EOS 2008*

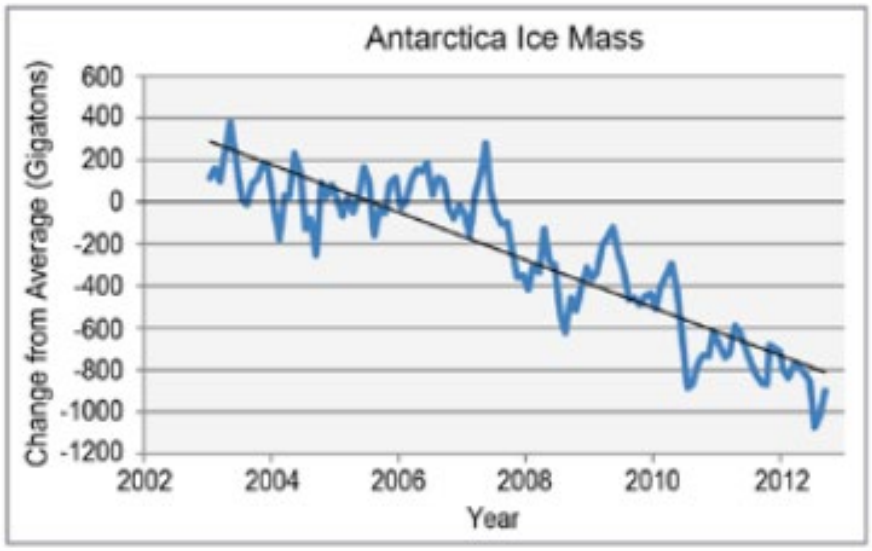
# Peruvian Terminus Retreat




Courtesy of L. Thompson

# Ice loss from the two polar ice sheets

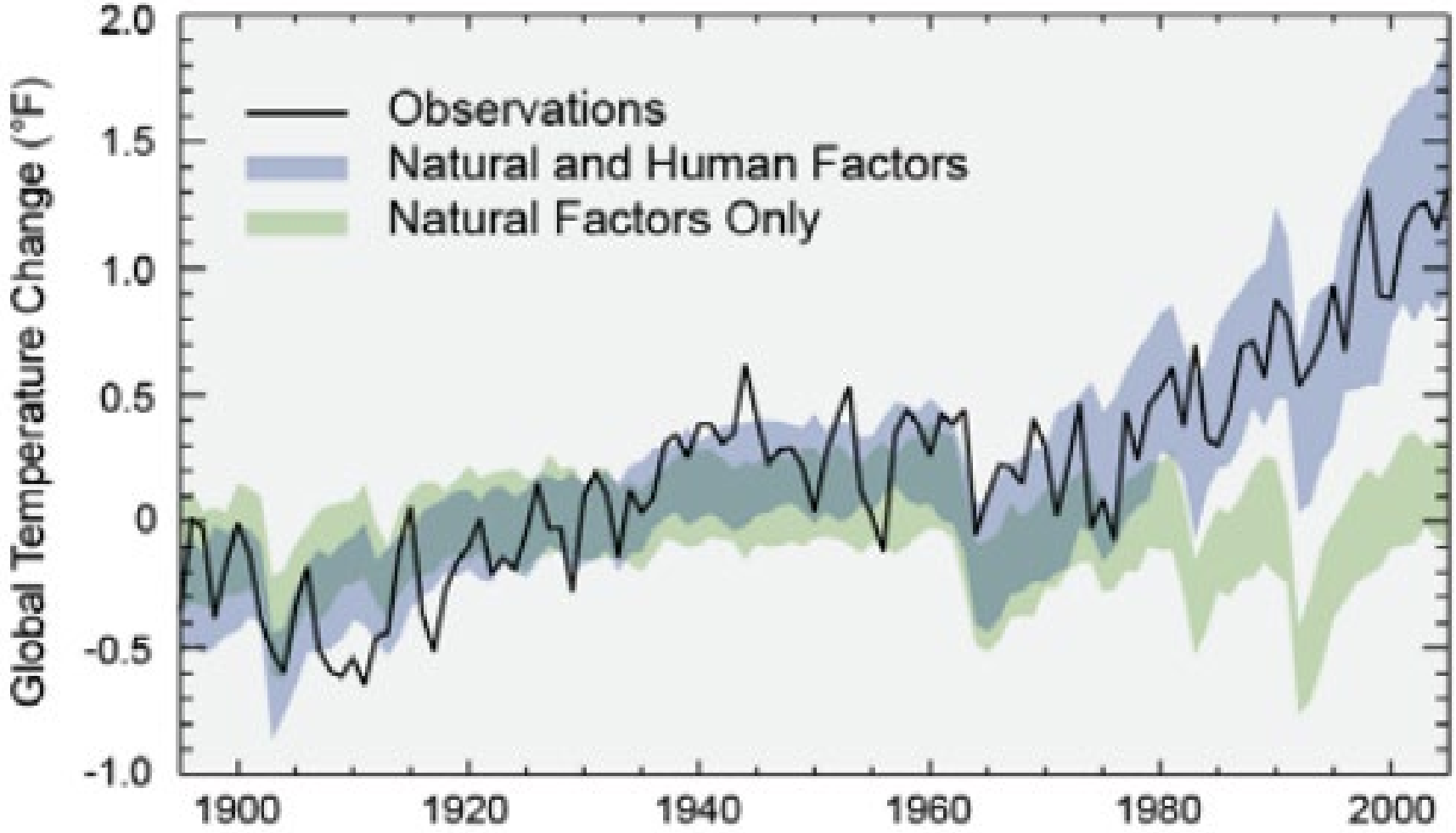



Based on GRACE satellite observations

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

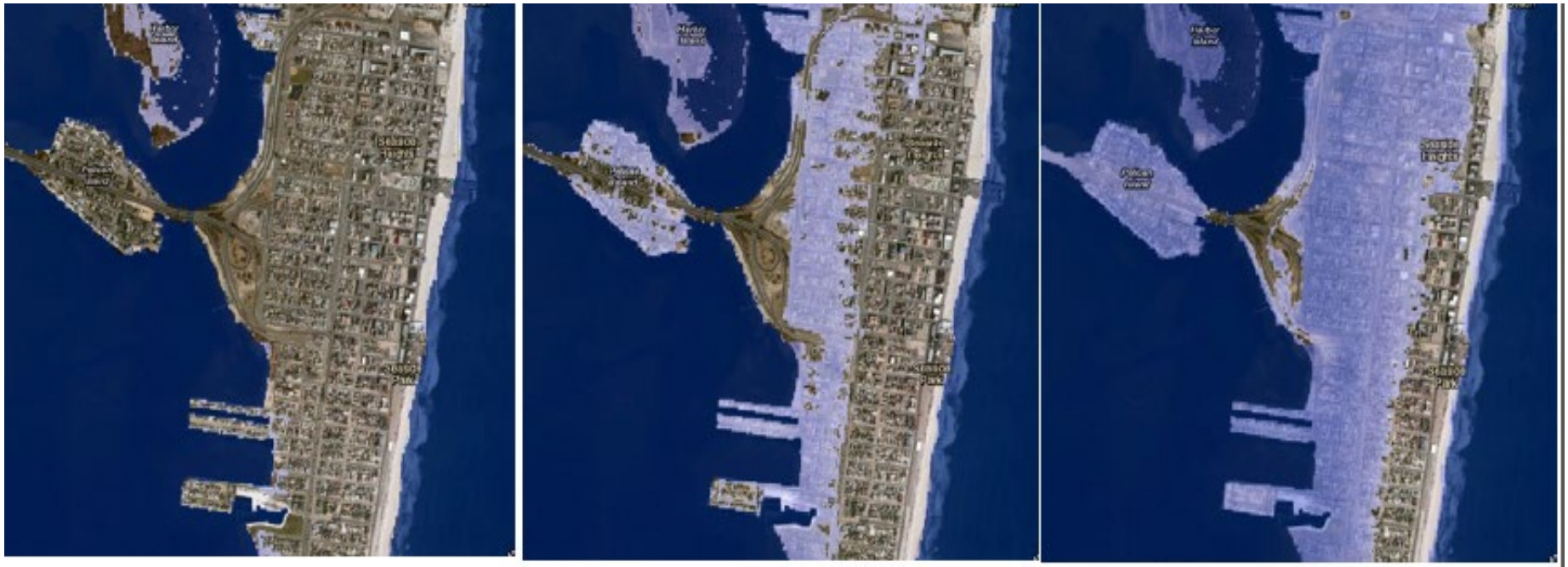
**Total sea level rise projections for New Jersey.**

| | 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)

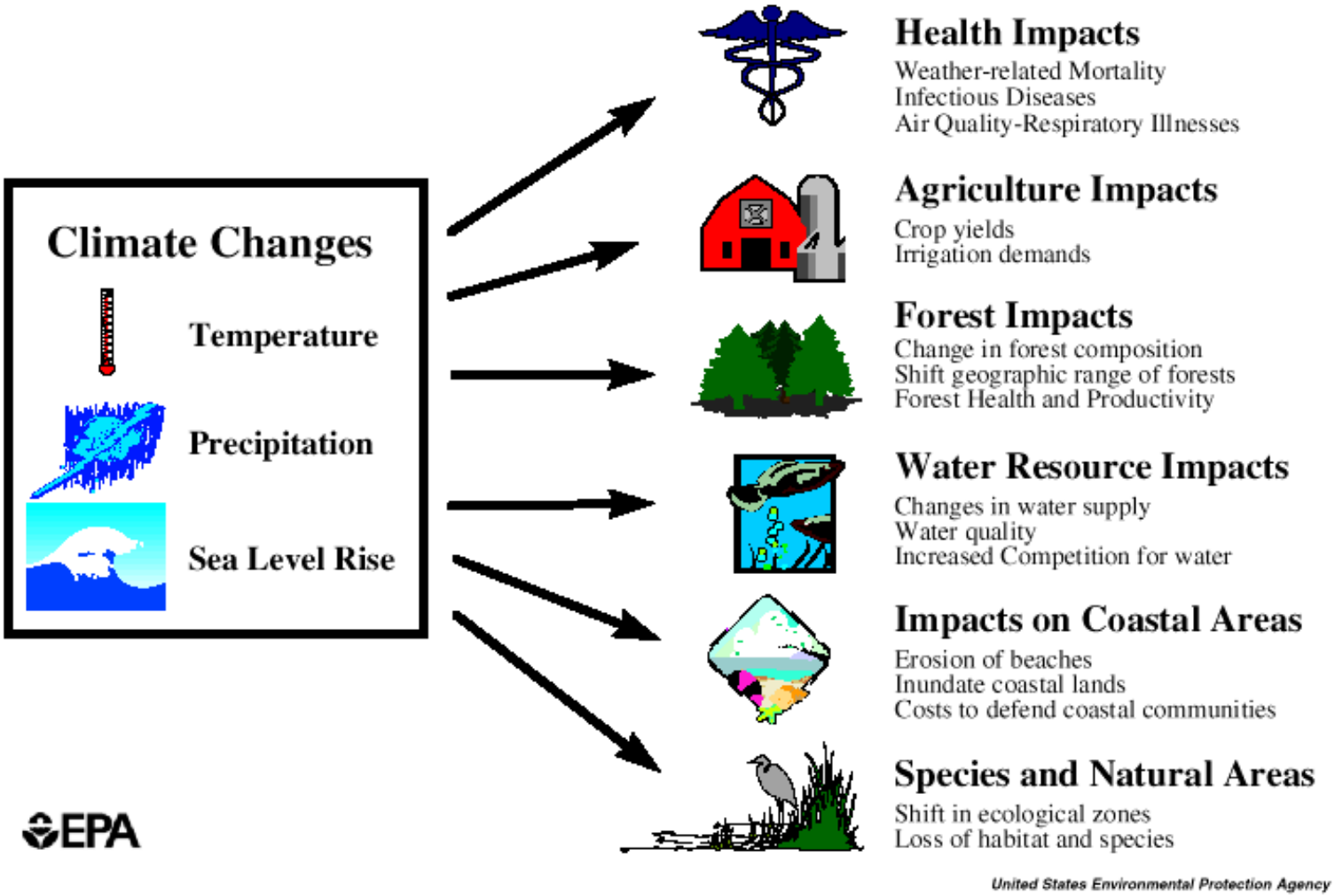
Maps available from http://slrviewer.rutgers.edu/ and http://sealevel.climatecentral.org/

# 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

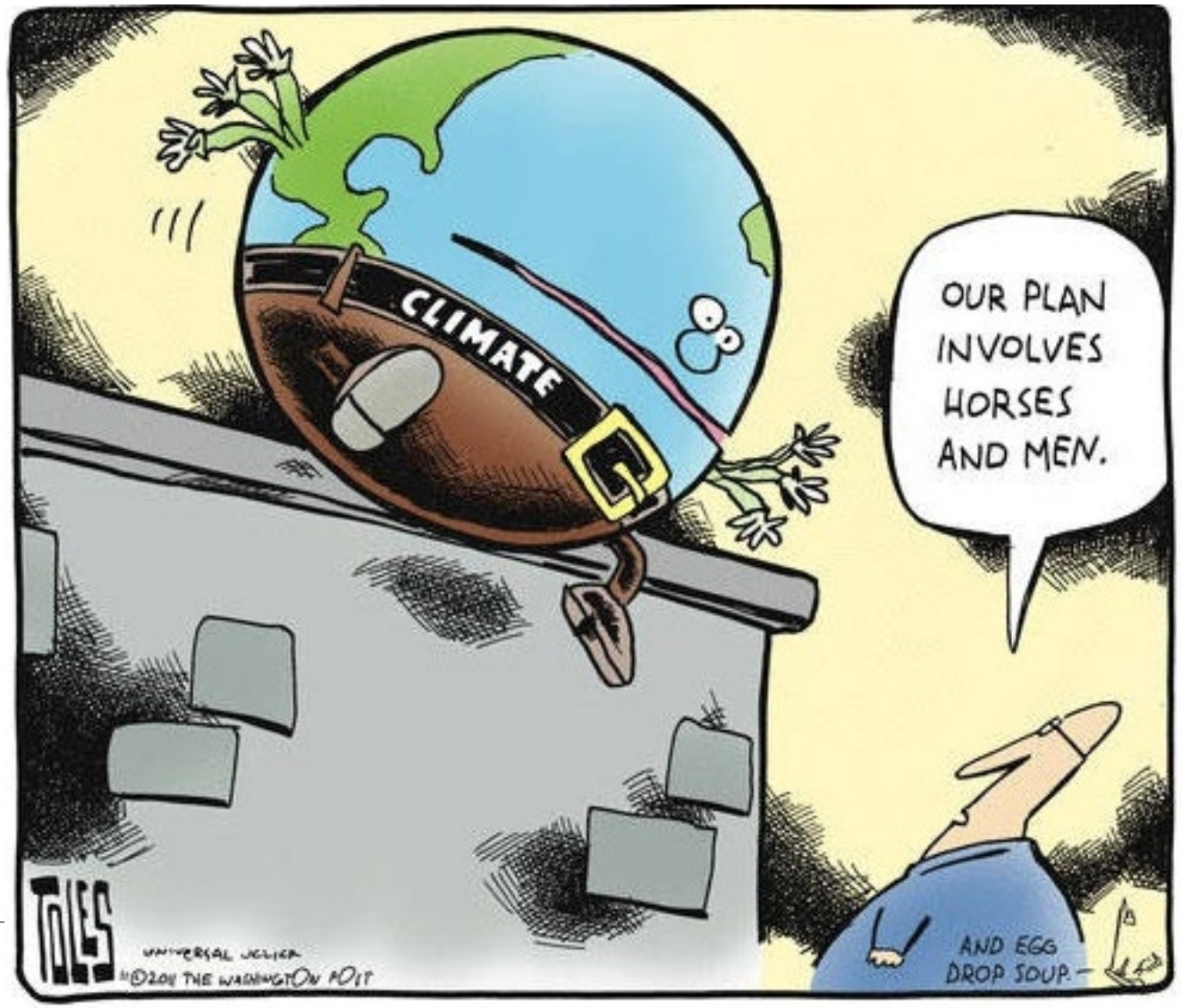


# A dilemma

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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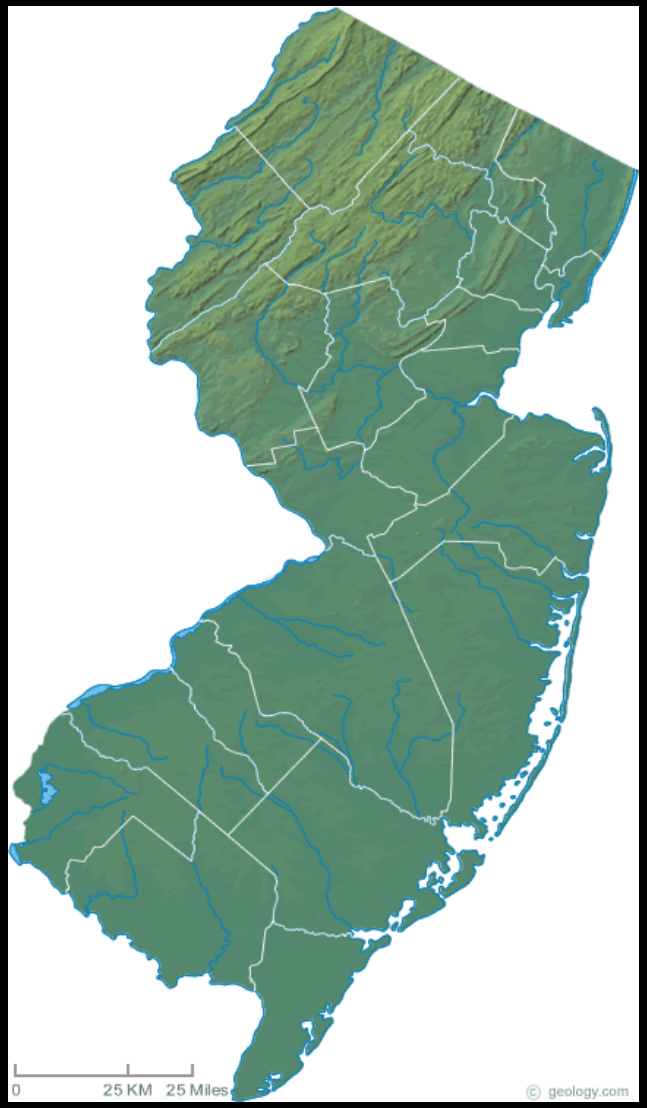
# So what did we learn?

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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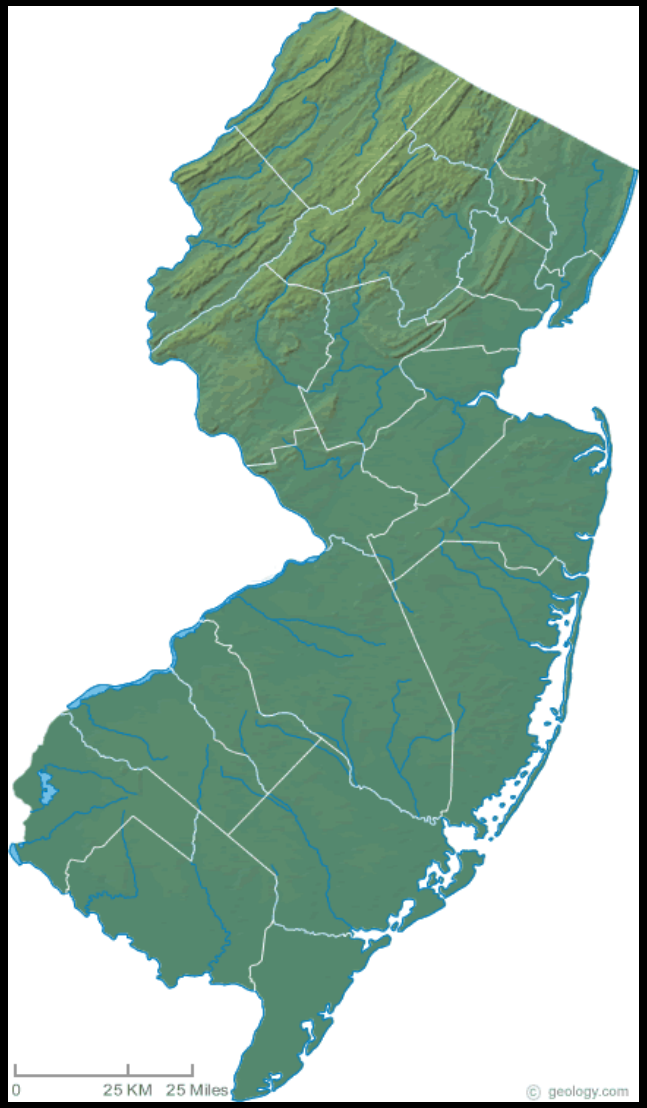

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# Rainwater Harvesting - Functions

- 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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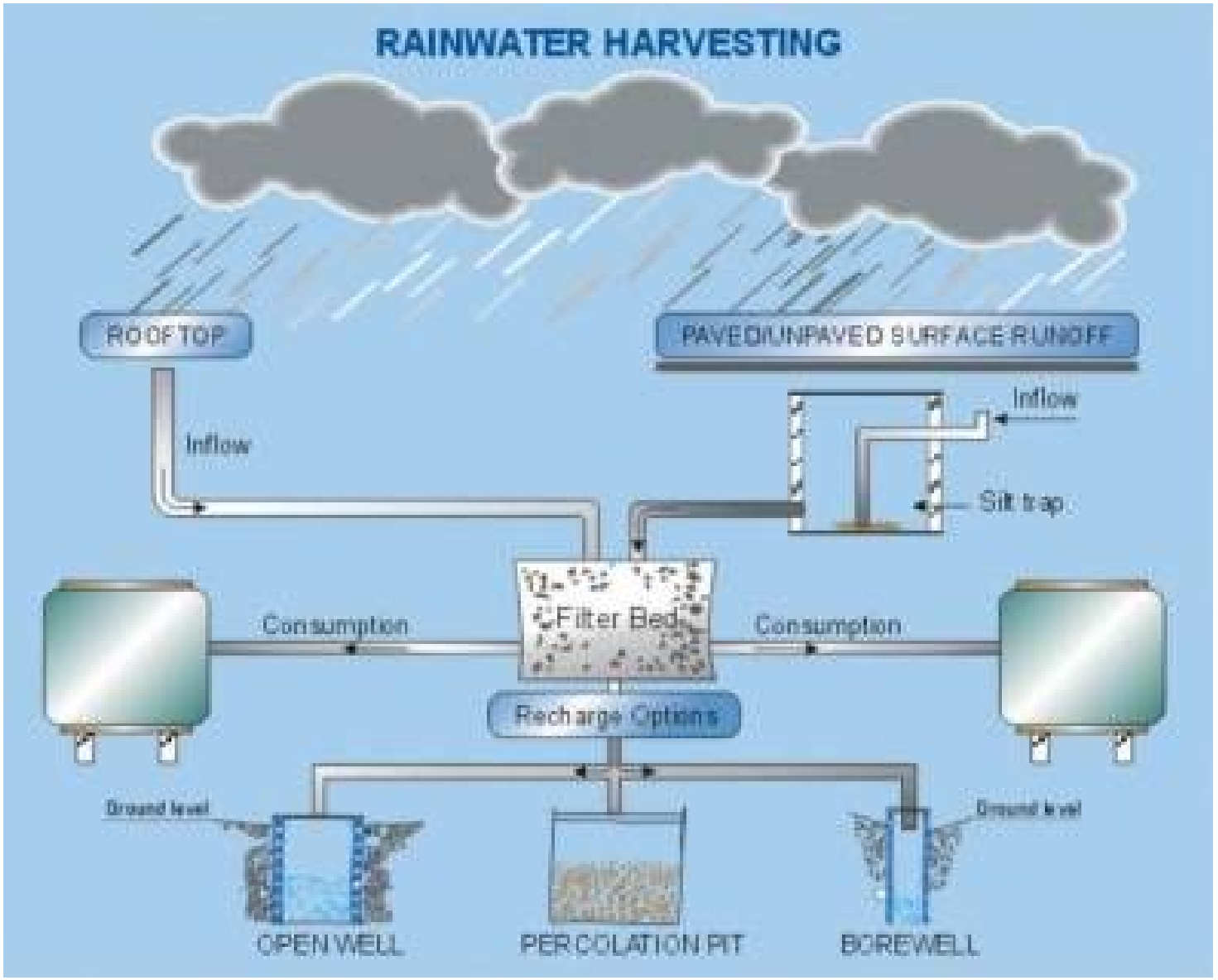
# Rainwater Harvesting – Components



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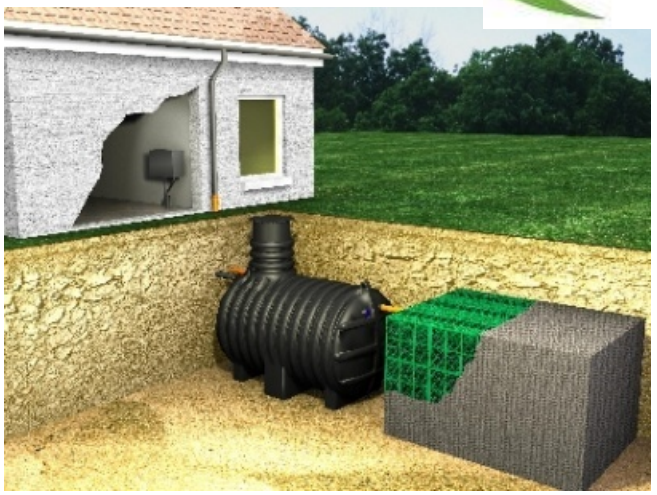

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# Sizing

- 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

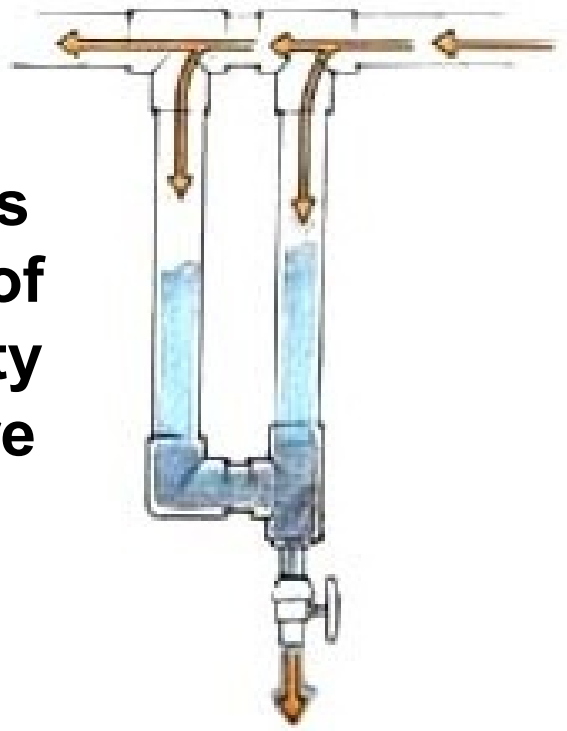
Gallons of water collected per inch of rain per 1,000 square feet = 600 gallons

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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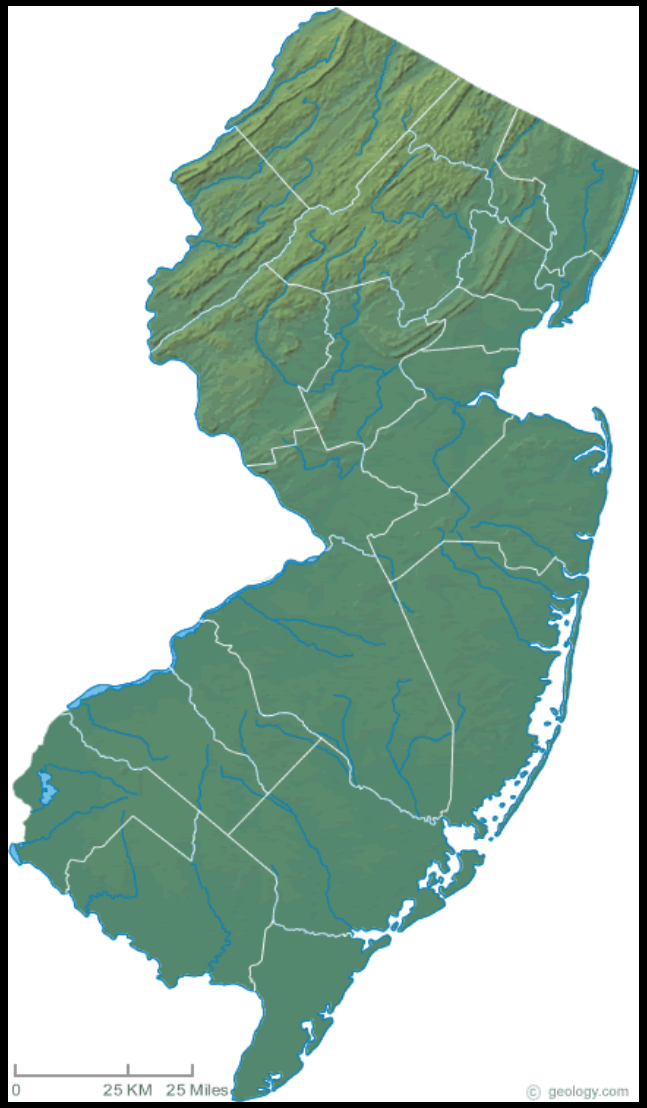
# Construction

- 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 |

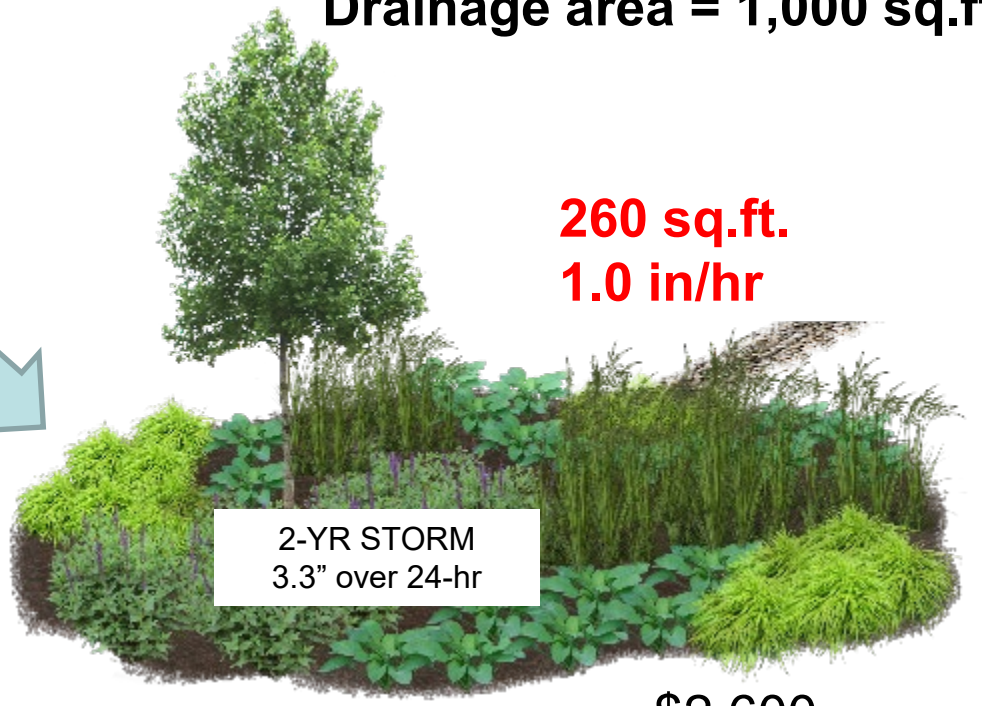
# Climate Resilient Rain Garden

**200 sq.ft.**
**0.0 in/hr**

**Drainage area = 1,000 sq.ft.**

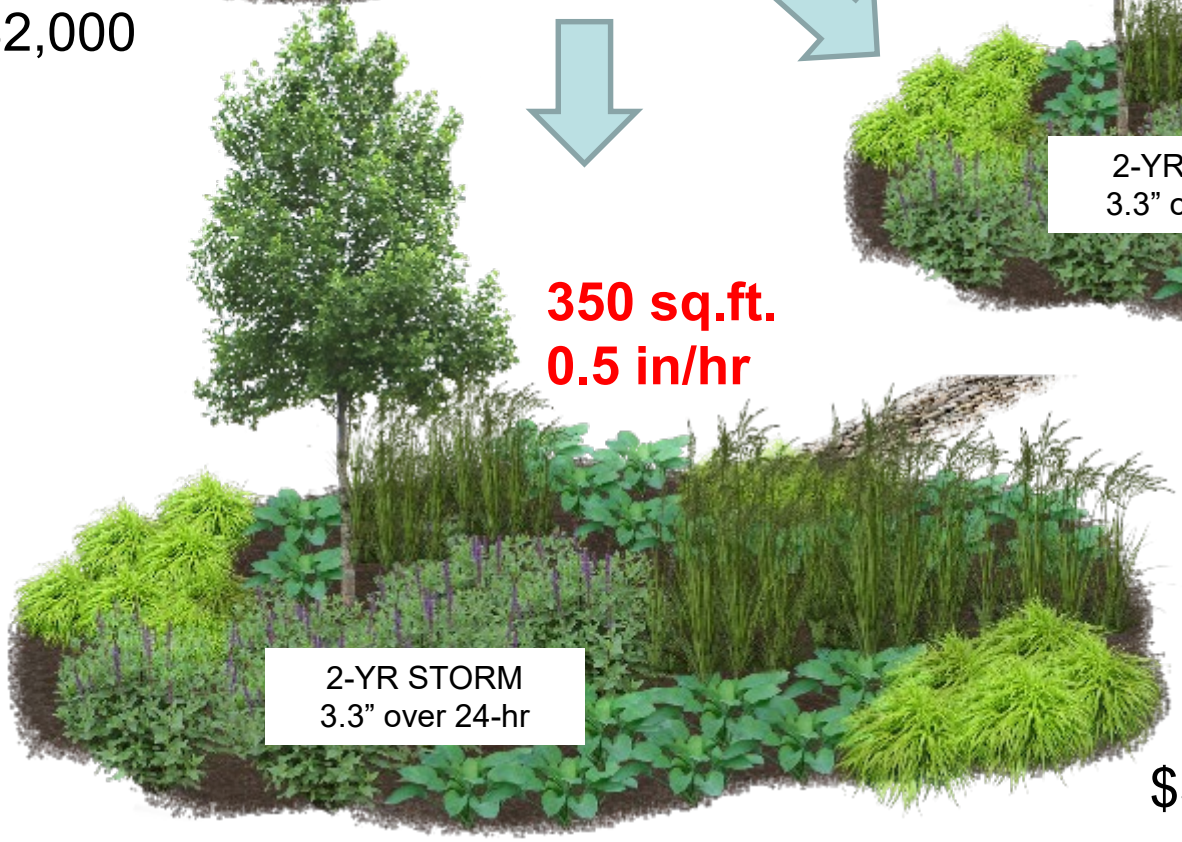
$2,000

**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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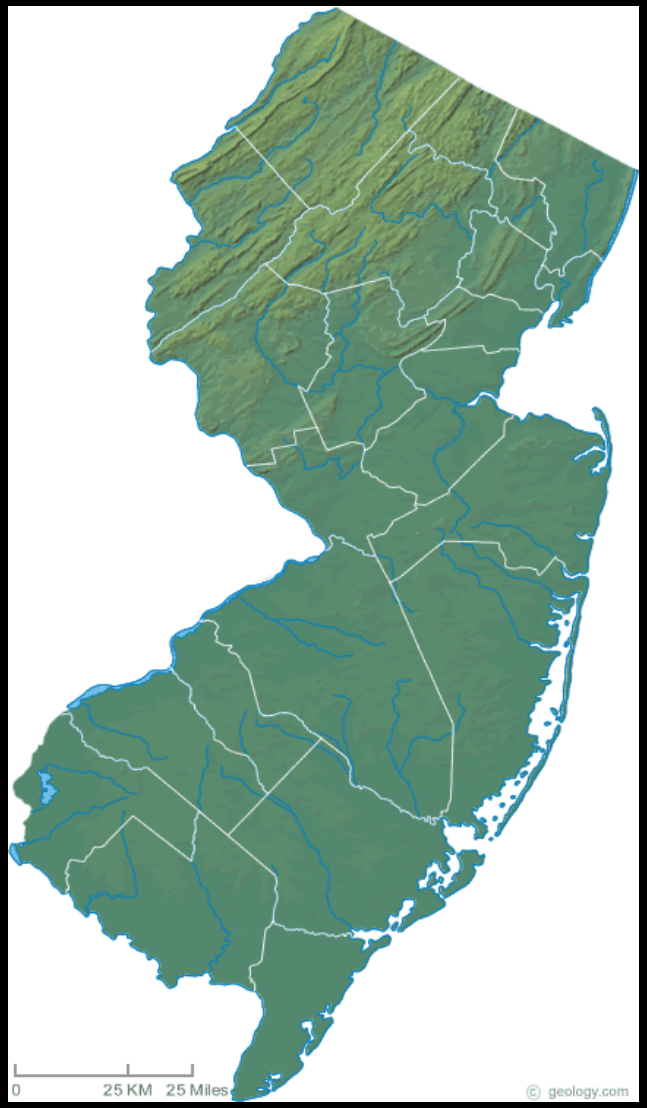
# What if we combined roadside rain gardens with street trees?

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

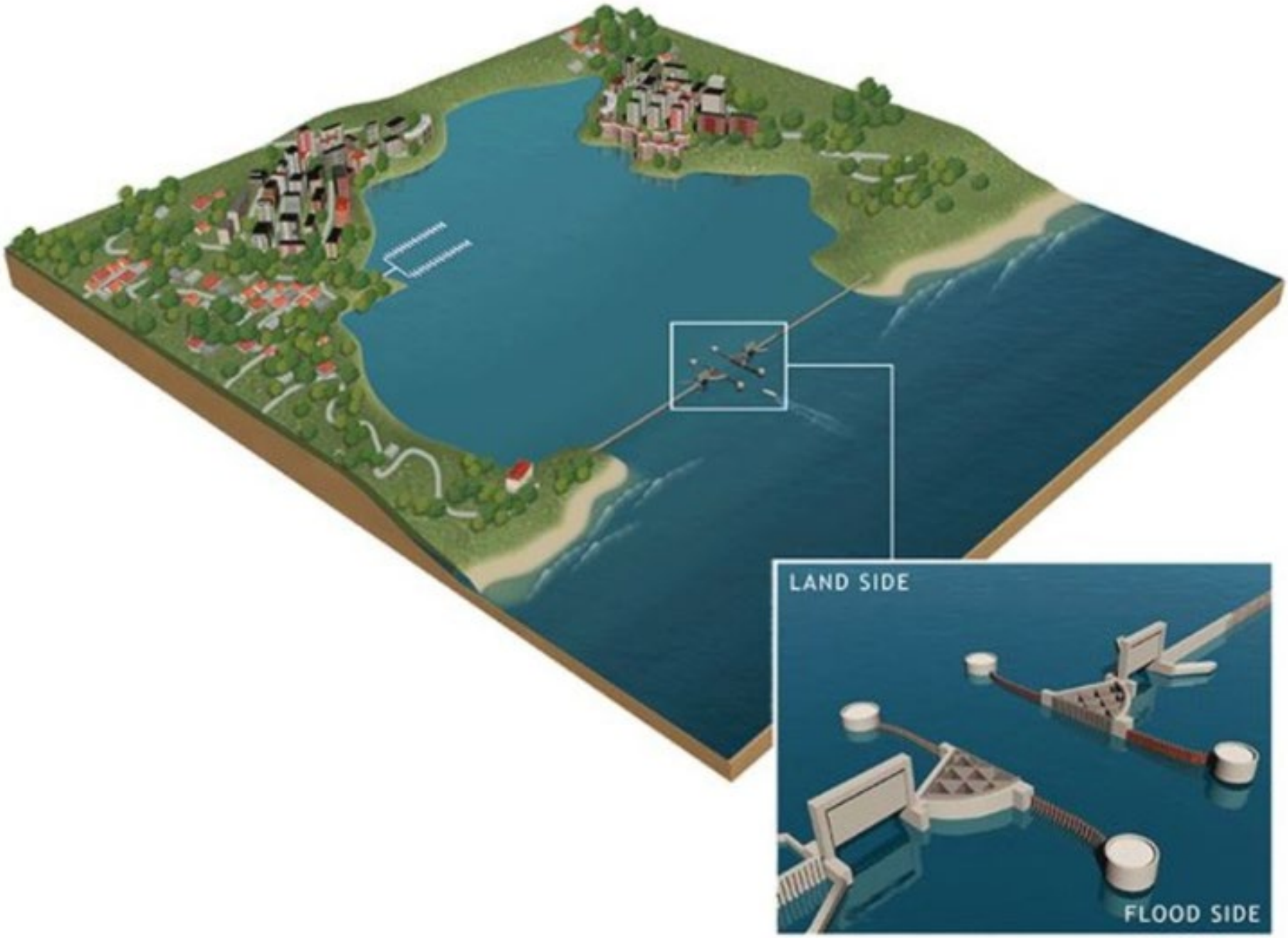
## Examples of Measures
## Under Consideration

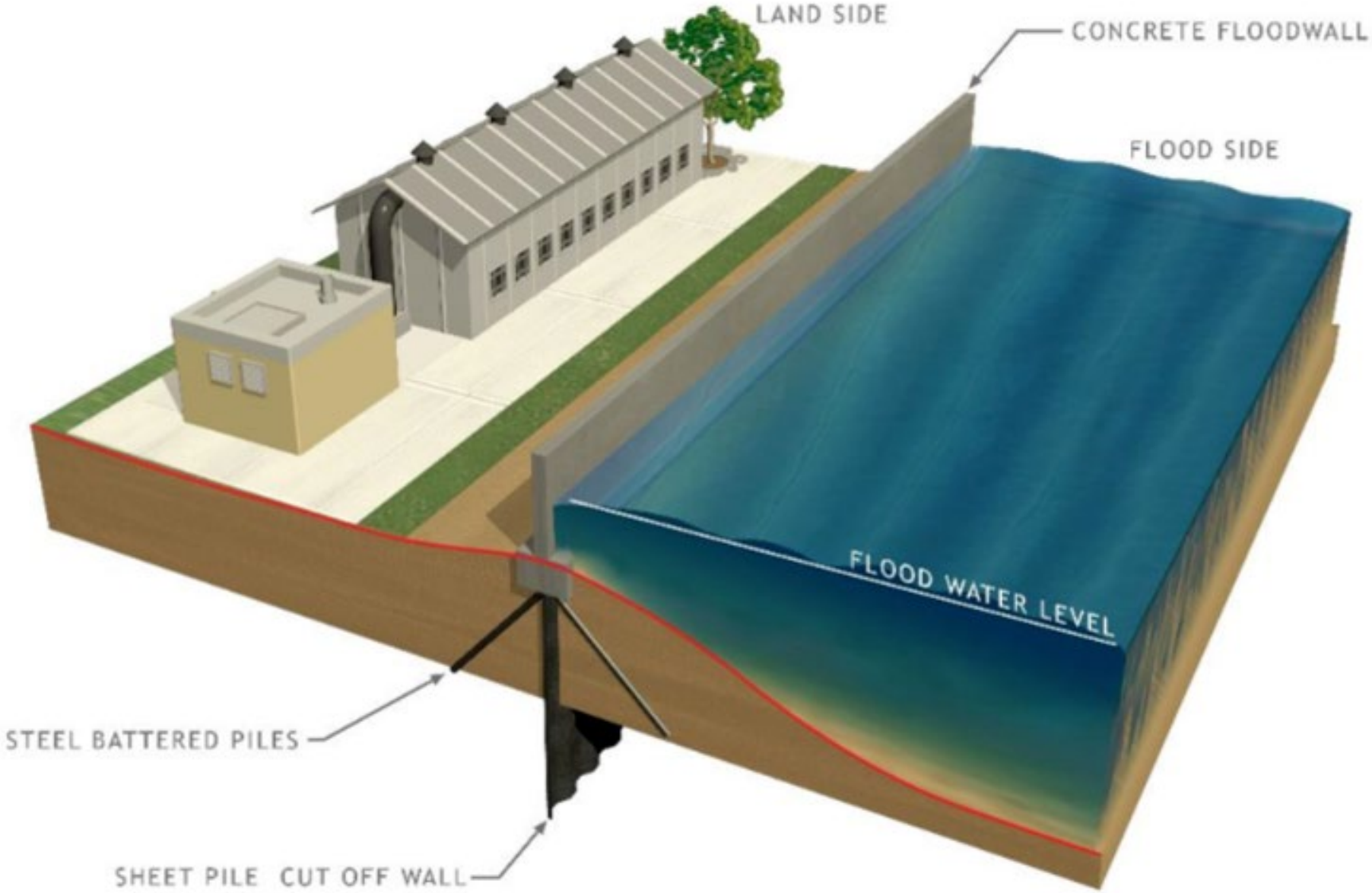
# Structural Measures

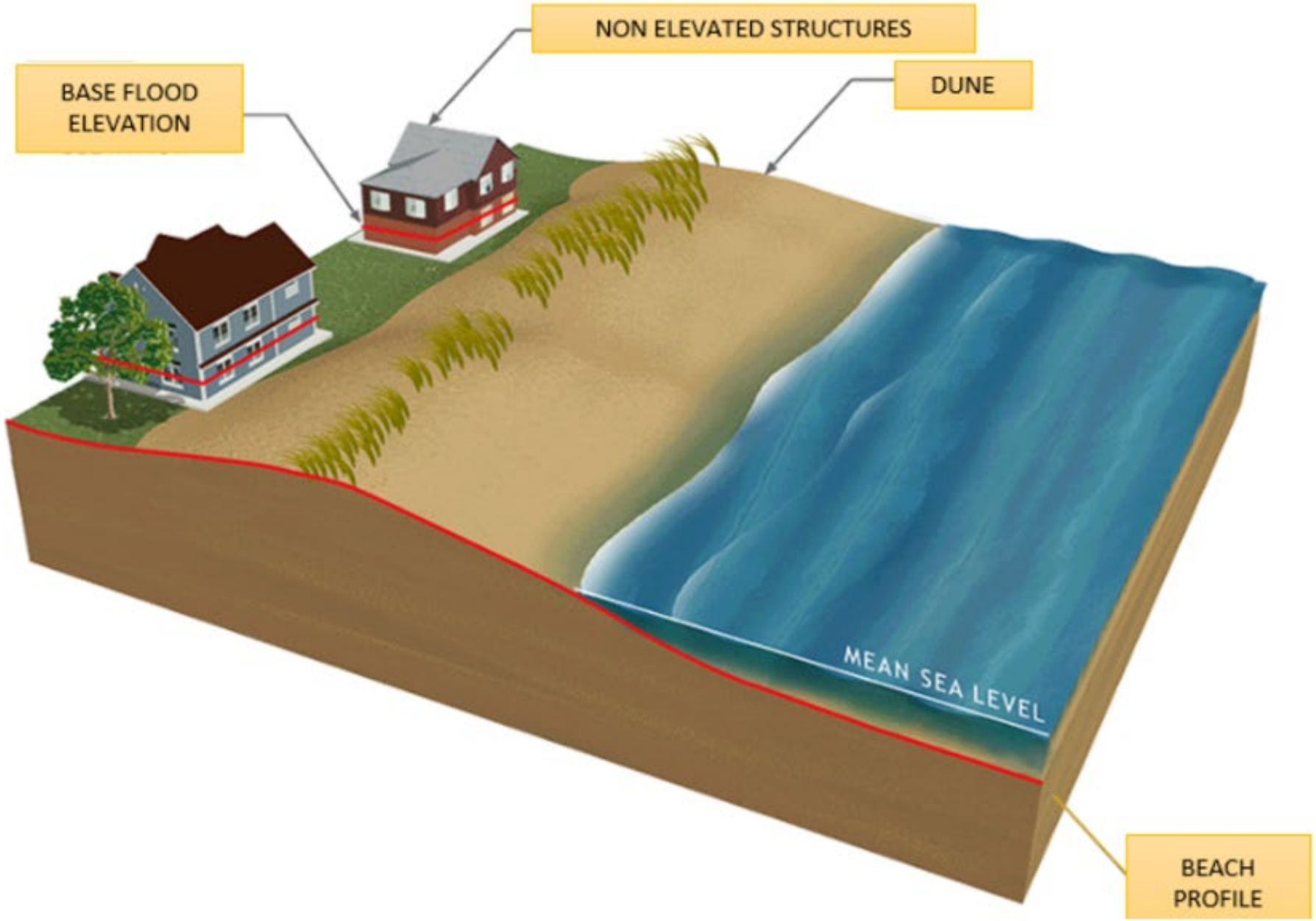
- Inlet Storm Surge Barriers
- Interior Bay Closures
- Raised Roads and Rails
- Levees
- Floodwalls (Permanent)
- Deployable Floodwalls
- Crown Walls
- Beach Restoration/Groins/Breakwaters
- Bulkheads
- Seawalls
- Revetments
- Stormwater System Drainage Improvements

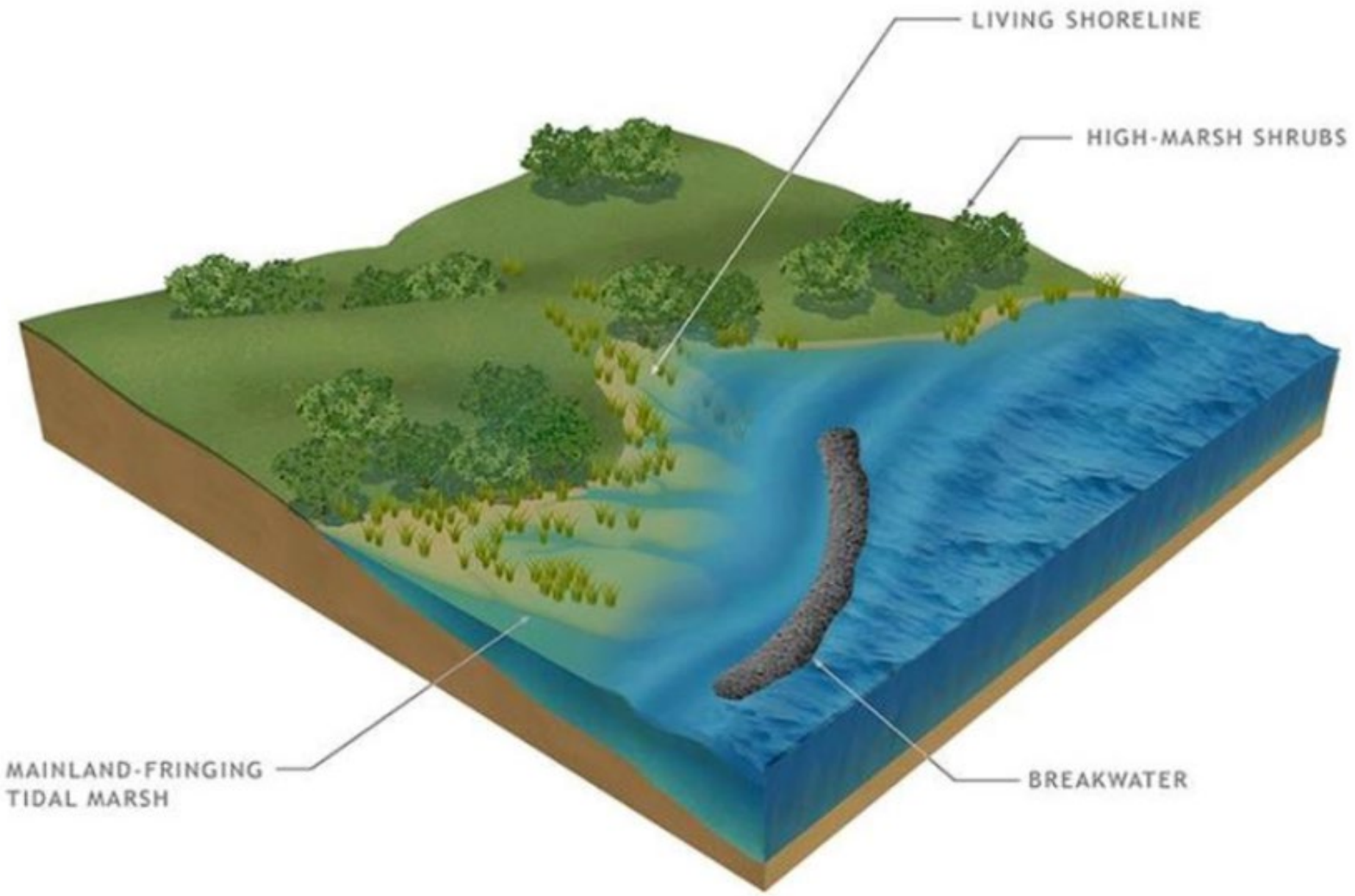
# Natural and Nature-Based Features

- 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

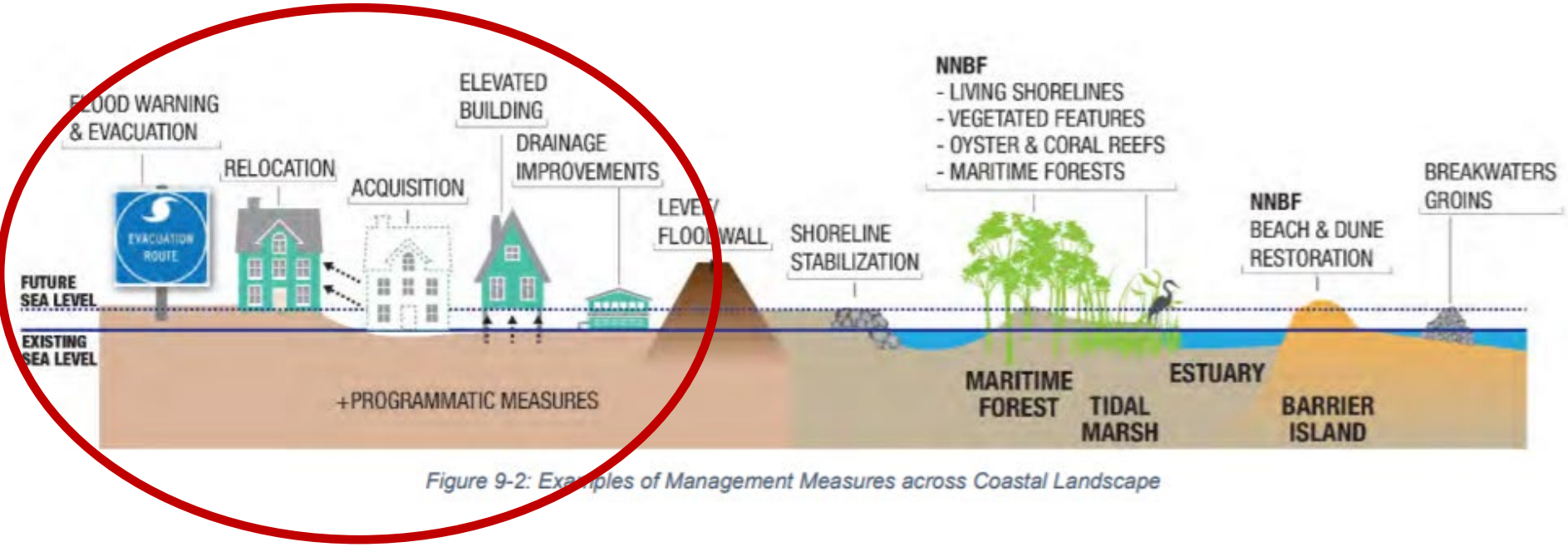
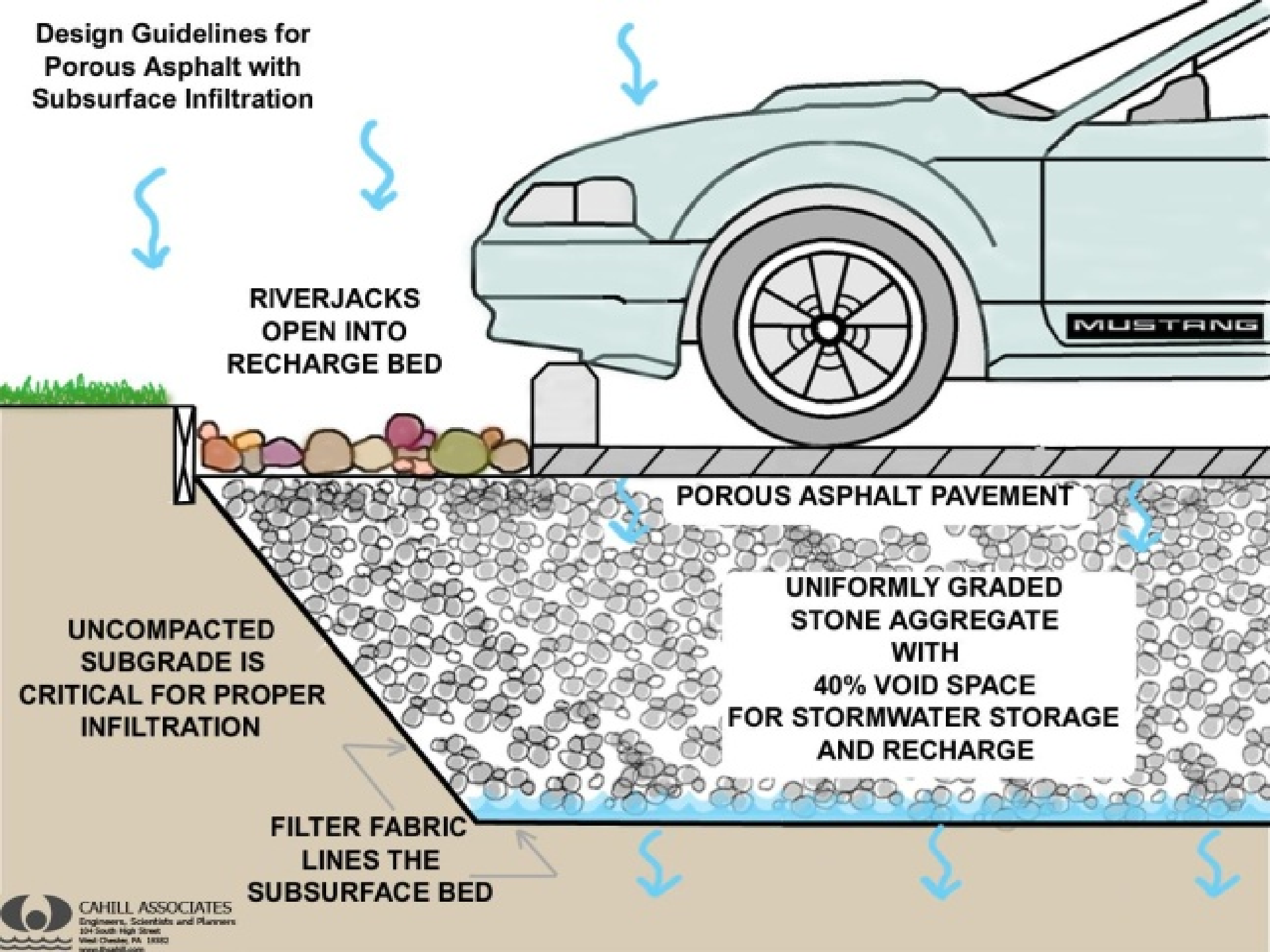



*Figure 9-2: Examples of Management Measures across Coastal Landscape*

# Design Guidelines for Porous Asphalt with Subsurface Infiltration

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# WE ARE DONE!
# Congratulations!

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# Green Infrastructure Champions Program

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