Introduction to Case Studies II: Greater New York City

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Advanced Methods for Participatory Scenario Planning

June 19, 2012

National Park Service Examples in New York City

- Gateway National Recreation Area
  - Sandy Hook Unit (NJ)
    - Sandy Hook Lighthouse
    - Fort Hancock
    - Recreational resources
  - Jamaica Bay Unit (NY)
    - Floyd Bennet Field
    - Fort Tilden
    - Jacob Riis Park
    - Canarsie Pier
    - Jamaica Bay Wildlife Refuge
  - Staten Island Unit (NY)
    - Fort Wadsworth
    - Miller Field
    - Hoffman and Swinburne Islands

Autumn Saltmarsh Landscape, Jamaica Wildlife Refuge

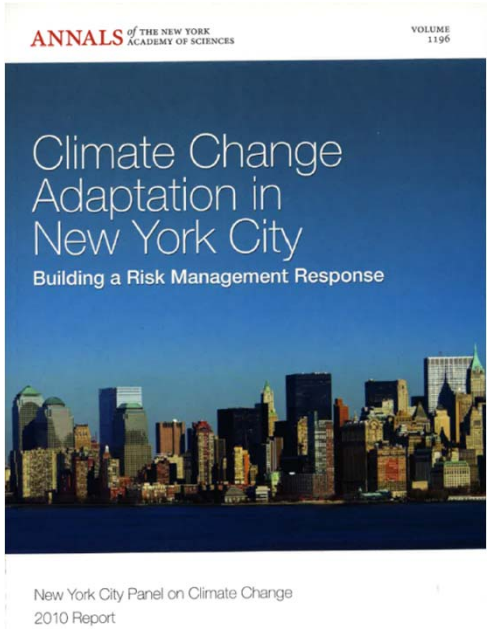
Battery Weed and Bridge, Fort Wadsworth

Source: Gateway National Recreation Area: Long-term Resource Management Under A Changing Climate. http://www.nps.gov/gate/parknews/upload/climatechangeoptimized.pdf

Climate Drivers for New York City

New York City Assessment in Context

- State Reports
  - E.g., Responding to Climate Change in New York State
  - New York State Climate Action Plan and Climate Action Council
  - New York State Sea Level Rise Task Force
- Regional Reports
  - New York City Panel on Climate Change



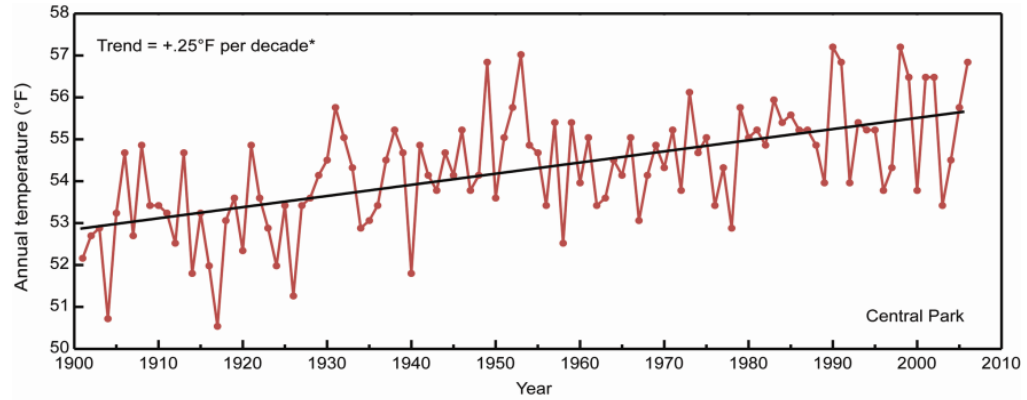
New York City Regional Climate

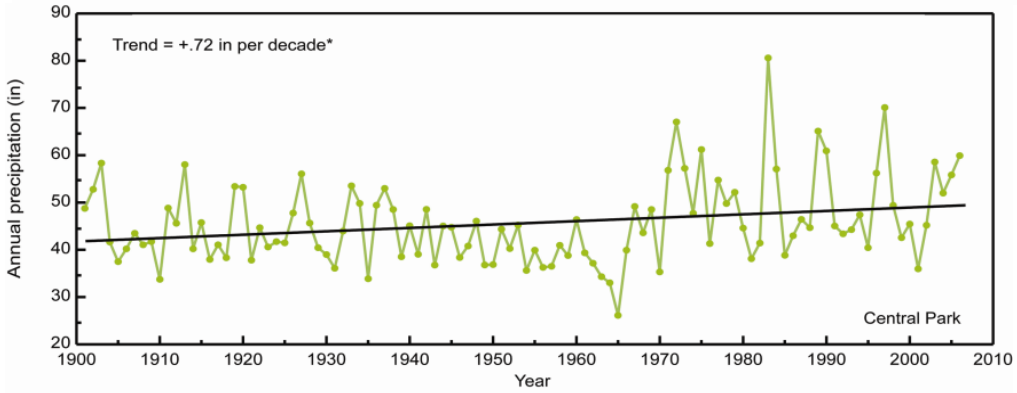
- Temperature
  - Range from an average of 33° F (January) to 76° F (July).
- Precipitation
  - Annual average of 43 inches, distributed evenly across the year
- Local climate features
  - High temperature extremes
  - Intense rainfall events (non-tropical)
  - Coastal storms (nor'easters and tropical cyclones)

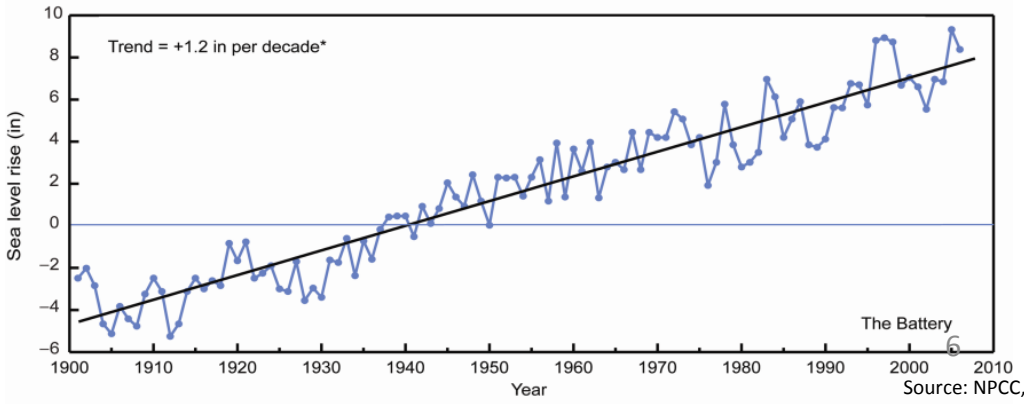
Hurricane Irene approaches the Northeast on August 28, 2011. Source: NASA

Observed Climate

- **Temperature**
  - Significant warming since 1970
- **Precipitation**
  - Interannual variability dominates long-term trend
- **Sea level**
  - Significant increase over the 20th century at the Battery





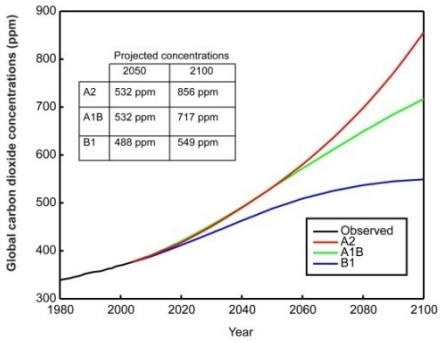


Observed climate in Central Park, New York City. Temperature data are not adjusted for urbanization effects. *Trend is significant at the 95% level.

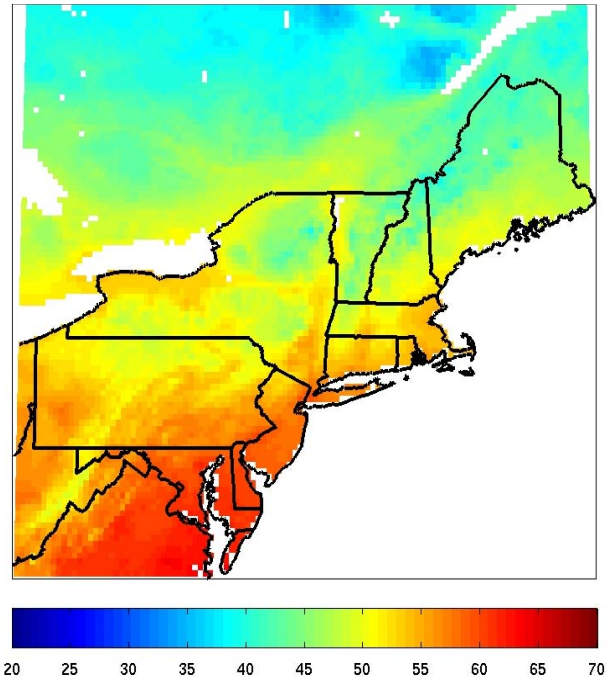
Source: NPCC, 2010

Climate Scenario Methods

- Regional climate projections are based on 16 GCMs (7 GCMs for sea level) and 3 emissions scenarios
  - Model output for the single gridbox covering New York City is used
- Future changes are presented for time slices relative to the 1971 – 2000 baseline period (2000 – 2004 for sea level)
  - Time slices are 30 year periods (10 for sea level) centered around a given decade, for example, the 2050s is 2040 – 2069.
- Model-based probability
  - The combination of GCMS and emissions scenarios produce 48 outputs for temperature and precipitation
  - For each scenario time period and variable, the results constitute a model-based probability function
- Bias-corrected, spatially downscaled output the 16 GCMs is used (Maurer, 2007)



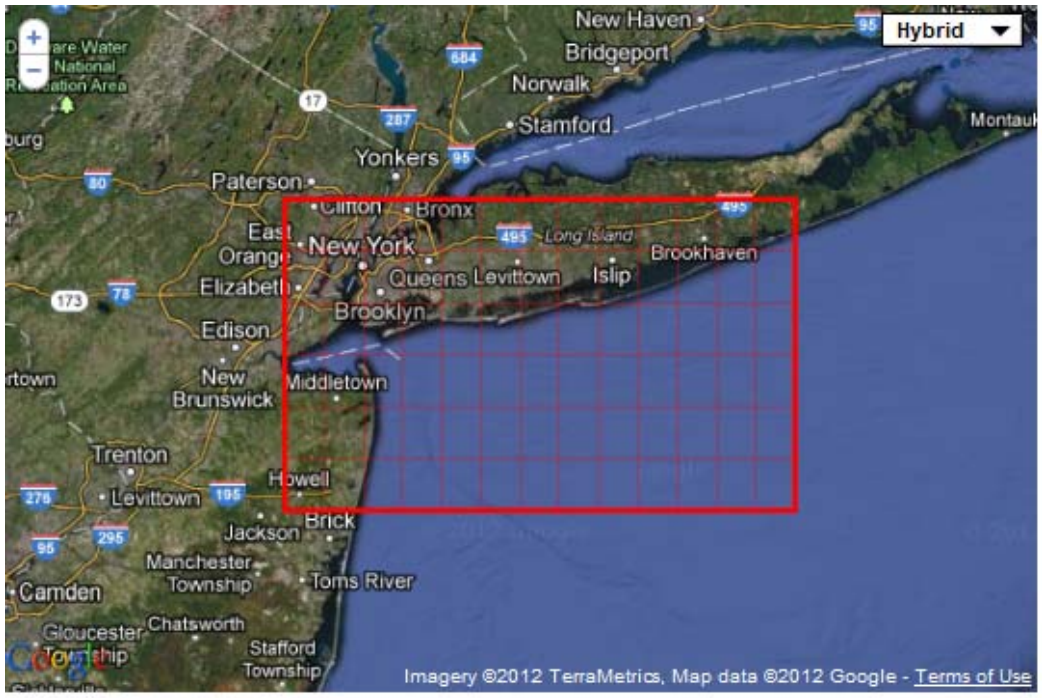
16 GCM A1B Annual Temperature 2040 – 2069 (°F)



Downscaling

- Statistical downscaling produces finer scale features than Global Climate Models (GCMs) using historical relationships between the large and small spatial scales

- Dynamical downscaling achieved by running a GCM at high resolution over a small spatial domain



Mean Annual Changes

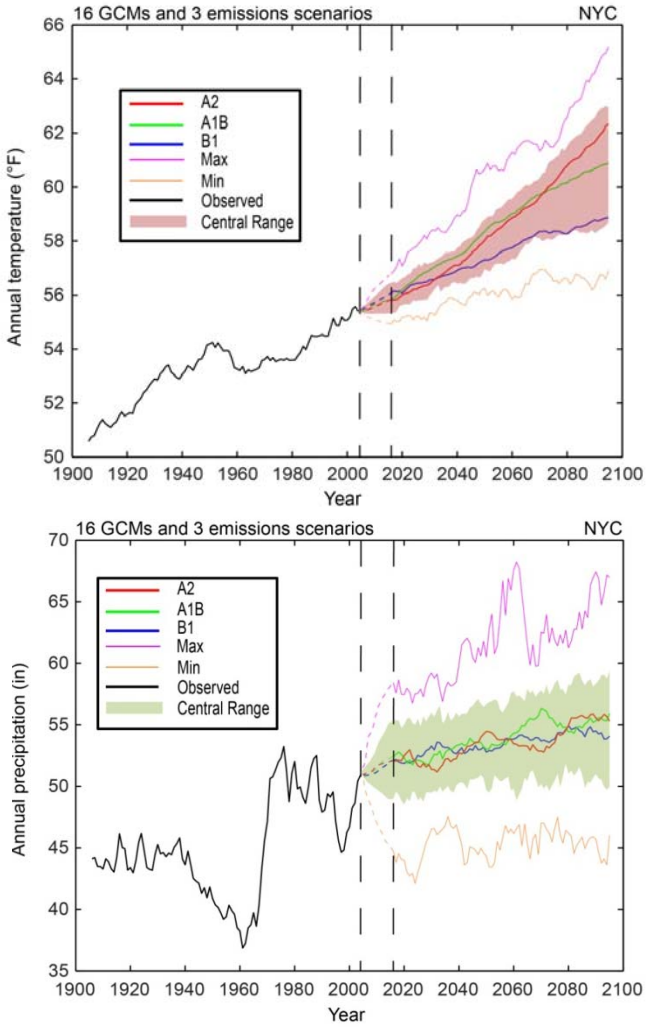
Baseline Climate and Mean Annual Changes

	Baseline 1971-2000	2020s	2050s	2080s
Air temperature Central range	54° F	1.5 to 2.5 ° F	3.0 to 5.0 ° F	4.0 to 8.0 ° F
Precipitation Central range	43 in	0 to +10 %	0 to +10%	0 to +15%
Sea level rise Central range	NA	+ 2 to 5 in	+ 7 to 12 in	+ 12 to 23 in
Rapid ice-melt scenario	NA	~ 5 to 10 in	~ 19 to 29 in	~ 41 to 55 in

Temperature and precipitation projections reflect a 30-year average centered on the specified decade; sea levels are averages for the specific decade. The baseline for temperature and precipitation is the most complete 30-year data period centered around the 1980s; the baseline for sea level is 2000 - 2004. Temperature and precipitation data are for New York (JFK) and New York (LGA) and sea level data are for the Battery, NY. Shown the middle 67% (central range) of values from model-based probabilities; temperatures ranges are rounded to the nearest half-degree, precipitation to the nearest 5%, and sea level rise to the nearest inch. Source: NOAA

Source: NPCC, 2010

Combined Observed and Projected Changes



Combined observed and projected temperature and precipitation. The three thick lines (green, red, and blue) show the average for each emissions scenario across the 16 GCMs. Shading shows the central range. The bottom and top lines, respectively, show each year's minimum and maximum projections across the suite of simulations.

Source: NPCC, 2010

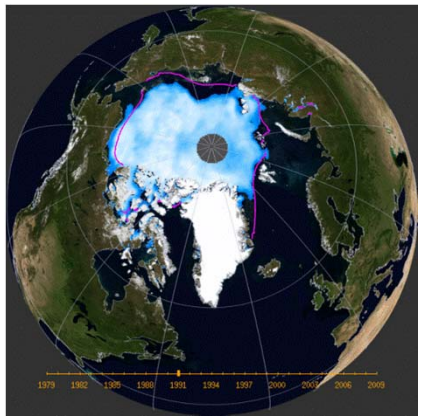
High Impact Sea Level Rise Scenarios

Two sea level rise scenarios were developed for New York City.

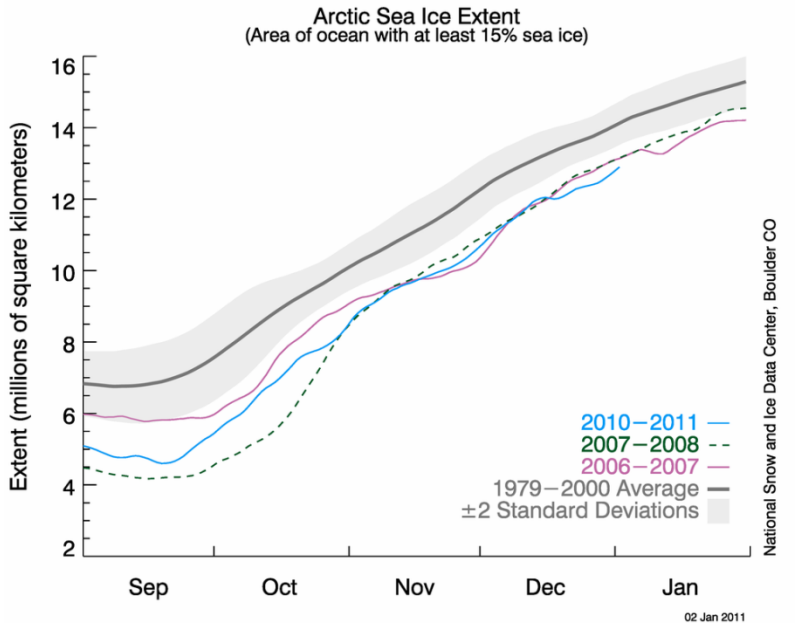
1) GCM model-based method used for sea level rise similar to what was done for temperature and precipitation. These projections include local and global components.

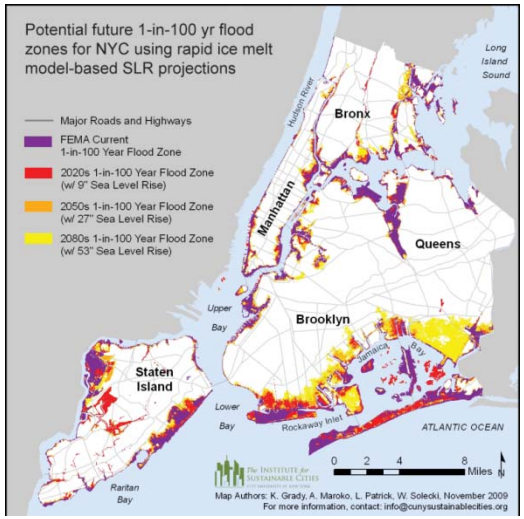
2) "Rapid Ice-melt scenario" was developed to account for the possibility that future changes in polar ice sheets are not captured by the GCMs and may accelerate melting beyond currently projected levels.

Minimum Sea Ice Extent 1979-2009



median minimum ice extent(1979-2009)





Source: NPCC, 2010

Quantitative Extreme Events

Quantitative Changes in Extreme Events

The central range (middle 67% of values from model-based probabilities) across the GCMs and greenhouse gas emissions scenarios is shown.

	Extreme Event	*Baseline (1971- 2000)*	2020s	2050s	2080s
Heat waves & Cold Events	# of days/year with maximum temperature exceeding: 90°F	*19*	23 to 31	31 to 47	38 to 66
	# of days/year with minimum temperature at or below 32°F	*72*	53 to 62	45 to 54	36 to 49
Intense Precipitation	# of days per year with rainfall exceeding: 1 inch	*13*	13 to 14	13 to 15	14 to 16
Coastal Floods & Storms	1-in-100 yr flood to reoccur, on average	*~once every 100 yrs*	~once every 65 to 80 yrs	~once every 35 to 55 yrs	~once every 15 to 35 yrs
	Flood heights (in ft) associated with 1-in-100 yr flood	*8.6*	8.8 to 9.0	9.2 to 9.6	9.6 to 10.5

Source: NPCC, 2010

Qualitative Extreme Events

Extreme Event	Probable Direction Throughout 21st Century	Likelihood[1]
Heat index[2]	↑	Very likely
Ice storms/ Freezing rain	↑	About as likely as not
Snowfall frequency & amount	↓	Likely
Downpours (precipitation rate/hour)	↑	Likely
Lightning	*Unknown*	
Intense hurricanes	↑	More likely than not
Nor'easters	*Unknown*	
Extreme winds	↑	More likely than not

Source: Columbia University Center for Climate Systems Research

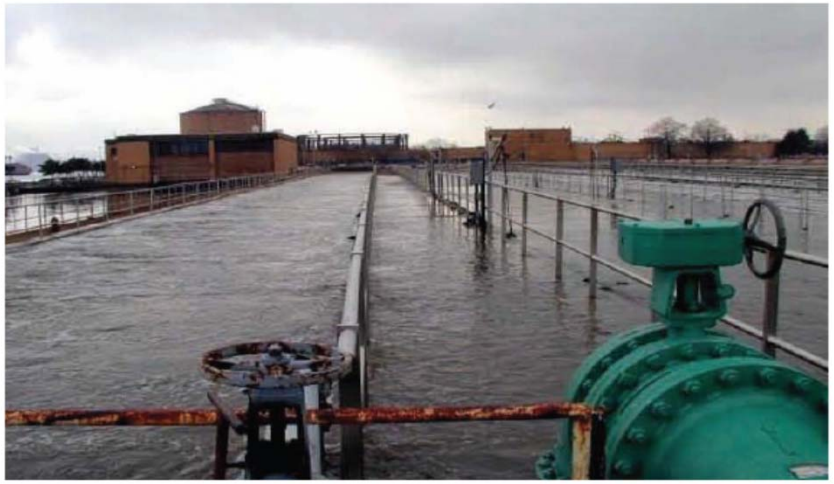
[1] Likelihood definitions found in the first section, "Definitions and Terms."

[2] The National Weather Service uses a heat index related to temperature and humidity to define the likelihood of harm after "prolonged exposure or strenuous activity" (http://www.weather.gov/om/heat/index.shtml).

Climate Impacts in New York City

Water

- Quality
  - Lower dissolved oxygen (DO)
  - Higher pathogen survivability
  - Increased contaminant concentrations
  - More extreme precipitation can cause more combined sewer overflows
  - Contaminated groundwater from saltwater intrusion in coastal areas
- Supply
  - Lower during extended dry periods
  - Conflicts between competing users
  - Saltwater intrusion can reduce freshwater supply

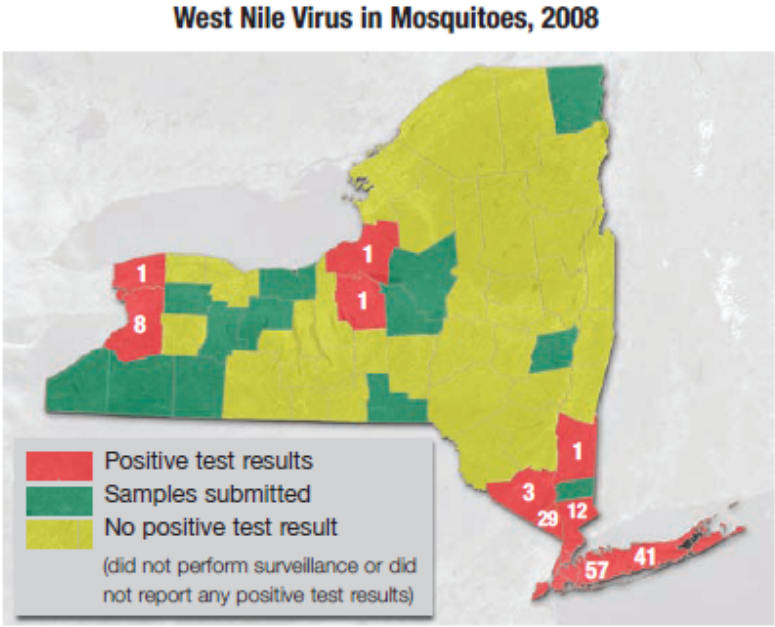


Treatment tanks overflowed at the Hunts Point (Bronx) WPCP during a March 2001 storm; unusually high tide elevations prevented discharge of treated sewage into the East River and caused back-up. Source: NYCDEP

Sources: Shaw et al. 2011, Zimmerman & Faris, 2010

Human Health

- Increase in heat-related illness & death
- Decrease in cold-related illness & death
- Increased stress and mental health impacts from extreme events
- Increased respiratory, gastrointestinal and cardiovascular problems
- Increased vector-borne diseases



Source: Kinney et al. 2011

NPS Facilities

- Cracking or buckling of building materials from more frequent temperature shocks
- Damage from more frequent floods
- More chemical weathering as higher concentrations of CO_2 produce more acid rain
- Mold growth from higher humidity and poor water quality during post-flood drying

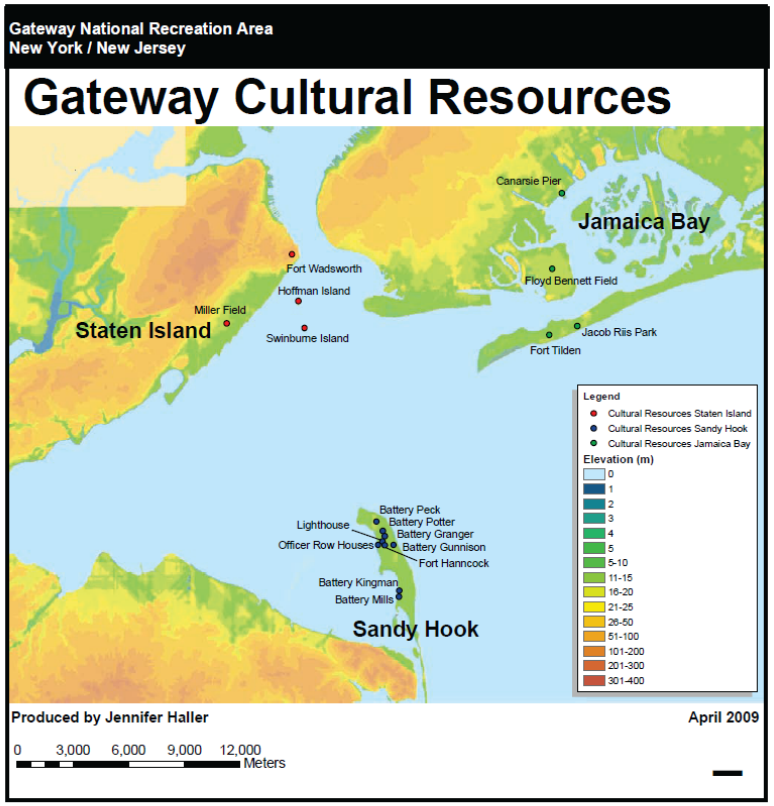


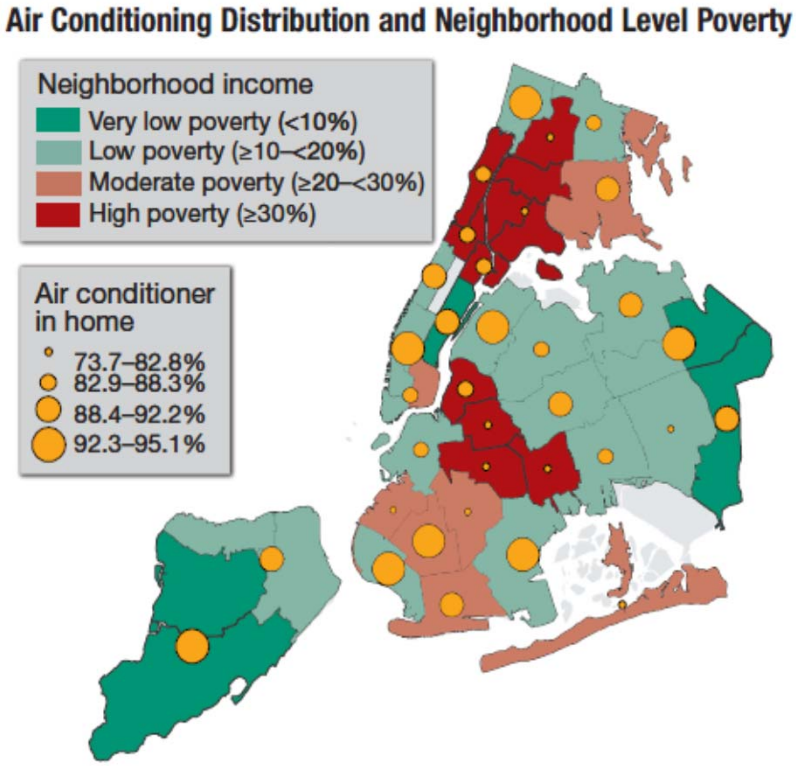
Figure 6. Elevation for key Cultural Resources at Gateway

This map shows potential impacts from sea level rise. As discussed in Section 2. Climate Change & Gateway, sea level rise may increase by 2 to 6.5 feet over the next century; these estimates remain uncertain. Nevertheless, Gateway's important cultural resources could be severely threatened by rising seas. Continuing to incorporate new climate science into planning at Gateway will help protect and preserve these resources over the long-term.

Sources: Colette, 2007; Brimblecombe et al. 2008; Gateway National Recreation Area: Long-term Resource Management Under A Changing Climate (http://www.nps.gov/gate/parknews/upload/climatechangeoptimized.pdf)

Energy & Transportation

- Energy
  - Increase in use of air-conditioning
  - Transformers and distribution lines vulnerable to extreme weather
  - Low-lying power plants and other energy facilities vulnerable to flooding and sea-level rise
- Transportation
  - More frequent mass transit delays
  - Transportation infrastructure materials could buckle and have to be replaced more often with more extreme heat
  - Low-lying transportation systems at risk from flooding and sea-level rise

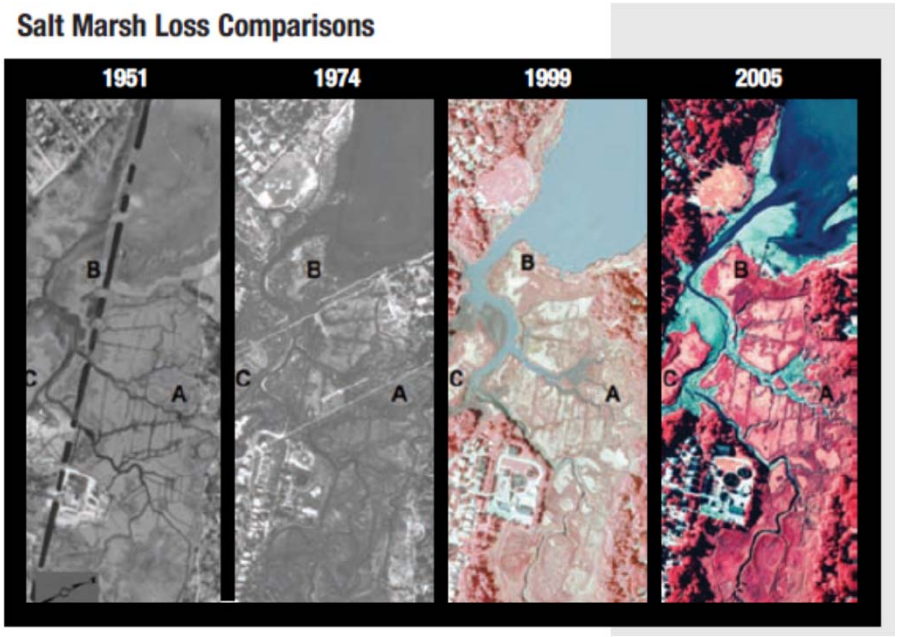


Neighborhoods with higher poverty rates have lower rates of in-home air conditioning than more affluent parts of city.

Sources: Hammer et al. 2011; Jacob et al. 2011

Coastal Zones

- Loss of barrier islands due to erosion, sea-level rise and increased development
- More frequent storm surge flooding
- Permanent inundation of low-lying areas
- Increased saltwater intrusion



Salt Marsh Loss Comparisons at Udalls Cove Park Preserve, Queens

Sea level rise may become the dominant stressor action on vulnerable salt marshes.

Sources: Buonaiuto et al. 2011, Hartig et al. 2002, Lathrop & love, 2007

Biota

- Loss of species diversity
  - Fish & shellfish
- Cold-water marine species moving northward out of NYS
  - Lobsters
- Warm-water marine species increasing
  - Blue claw crab
- Increase in invasive species and pests
- Loss of coastal marsh vegetation due to sea-level rise and saltwater intrusion

A red fox, just one of many species of animals who call Gateway home. Source: NPS

Sources: Buonaiuto et al. 2011; Edinger et al. 2008; Markham & Malcom, 1996: Menendez, 2009

Ecosystems

- Inundation of tidal marshland ecosystems from sea-level rise
- Higher storm tides and erosion
- Saltwater intrusion
  - Damage to freshwater wetlands
- Loss of habitat for shorebirds and various species of fish
- Loss of barrier island ecosystems

Fragmentation of Yellow Bar saltmarsh in Jamaica Bay. Source: NPS

Sources: Buonaiuto et al. 2011; Edinger et al. 2008; Markham & Malcom, 1996: Menendez, 2009