Low Cost Resiliency: Ecosystem Services and the Municipal Budget

Eric J. Walberg, AICP
Senior Program Leader, Climate Services

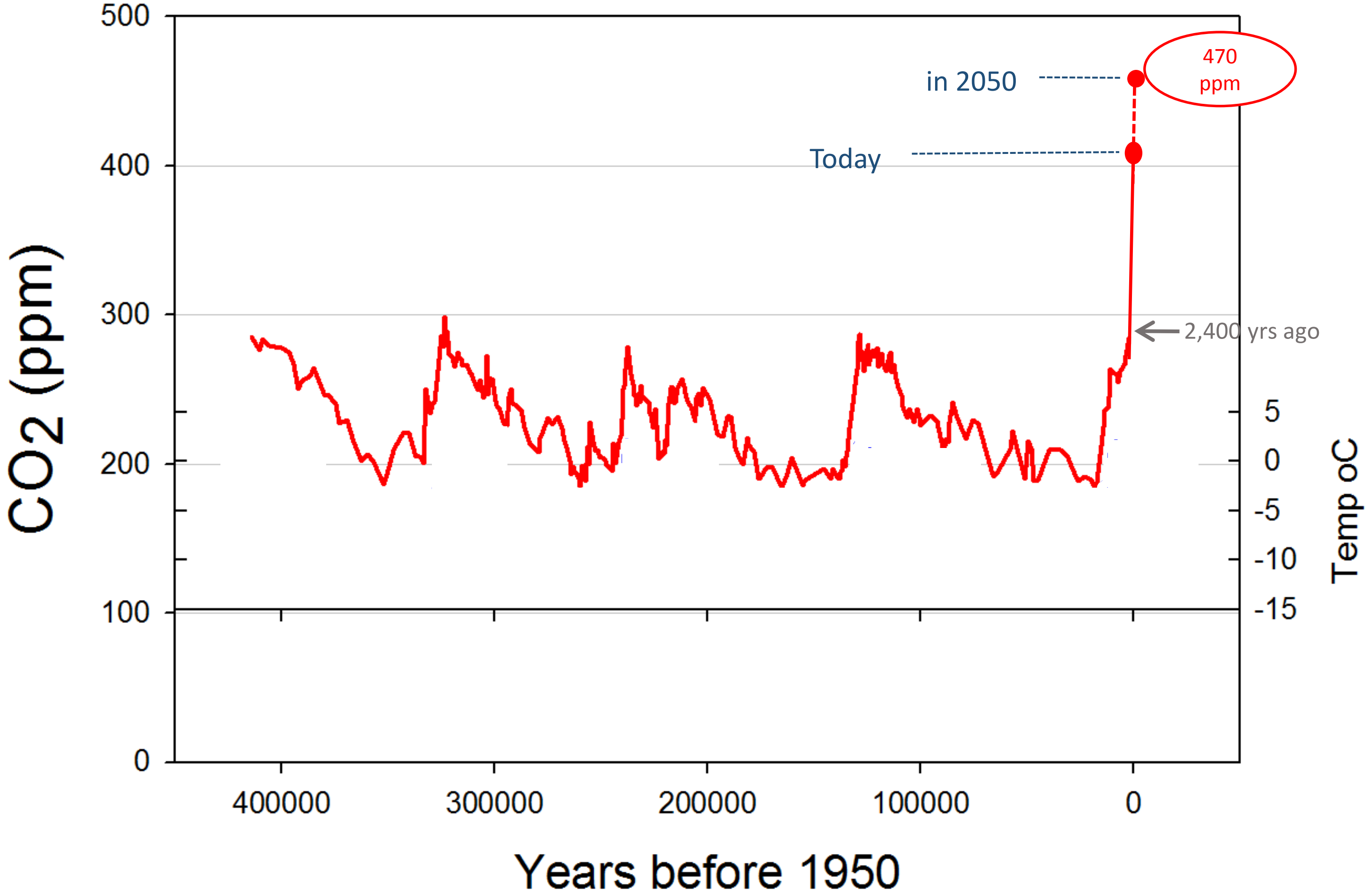
climate services

Manomet believes people can best address climate change by capitalizing on the multiple benefits provided by intact, healthy ecosystems.

manomet
Soaring Solutions. Grounded Science.

Changing Climate Context

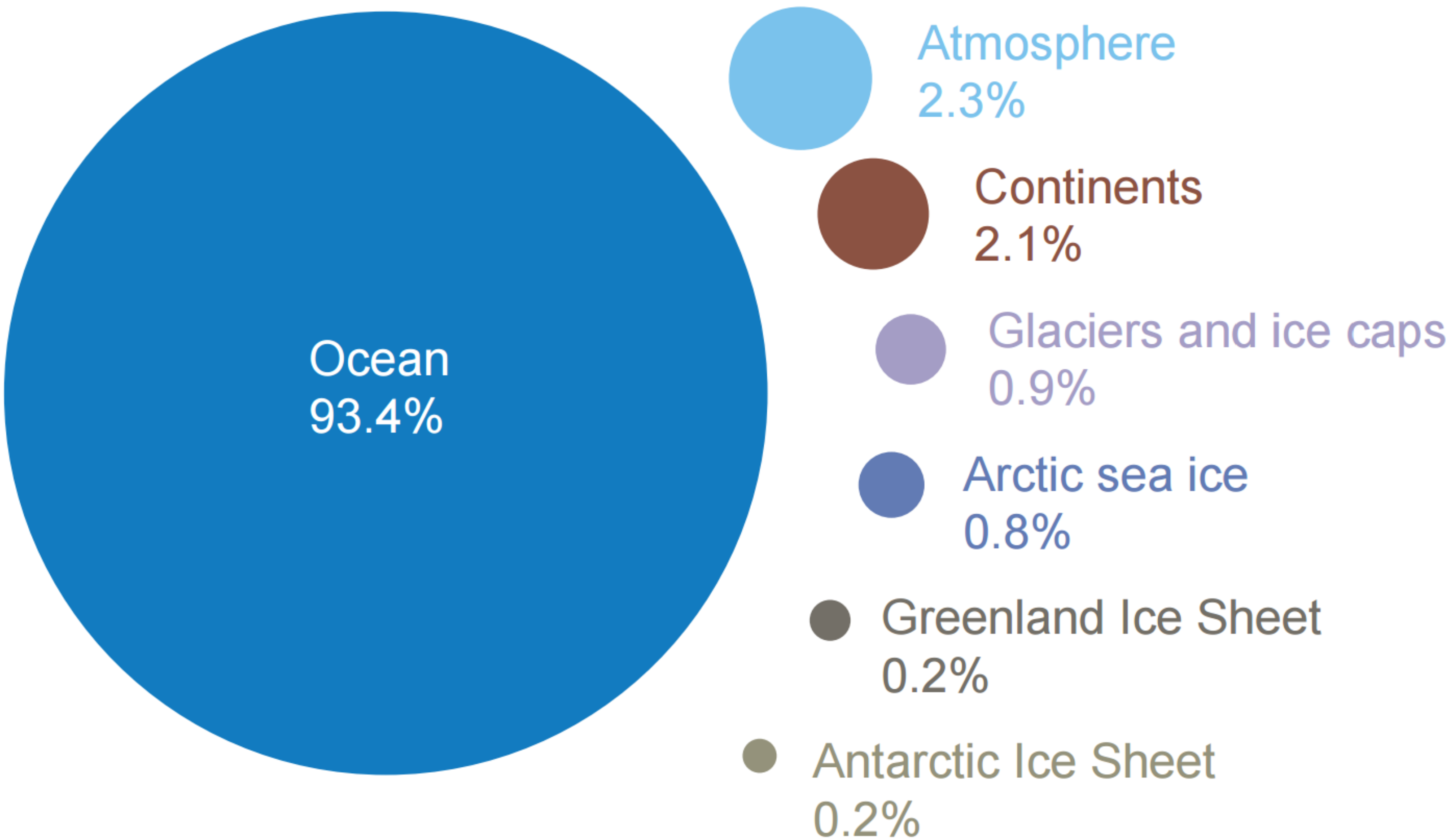
Actual (Antarctica) Ice Core Data



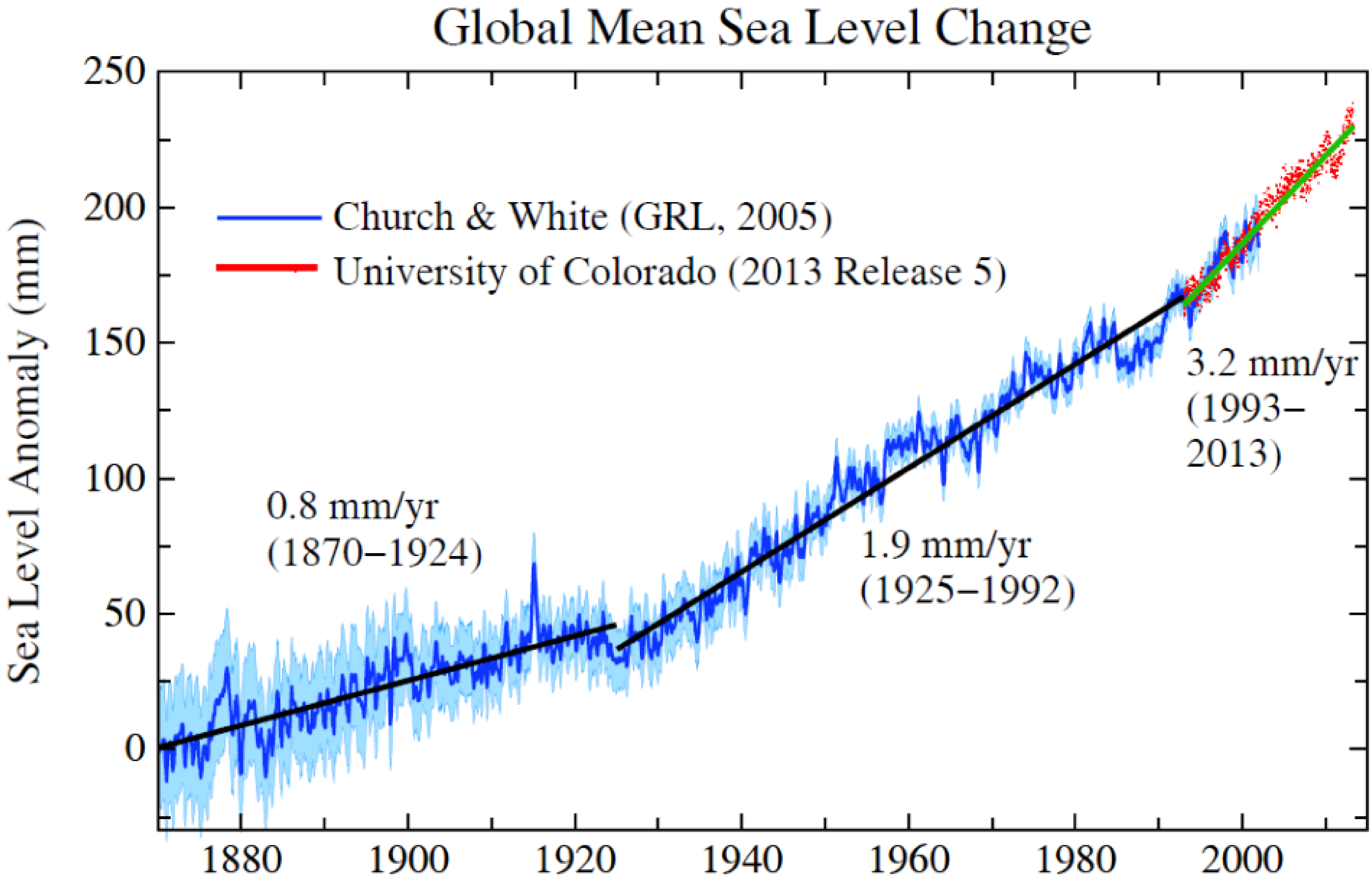
IPCC 2001

Source: IPCC, 2001: Climate Change 2001: The Scientific Basis

Majority of Warming Absorbed by Oceans



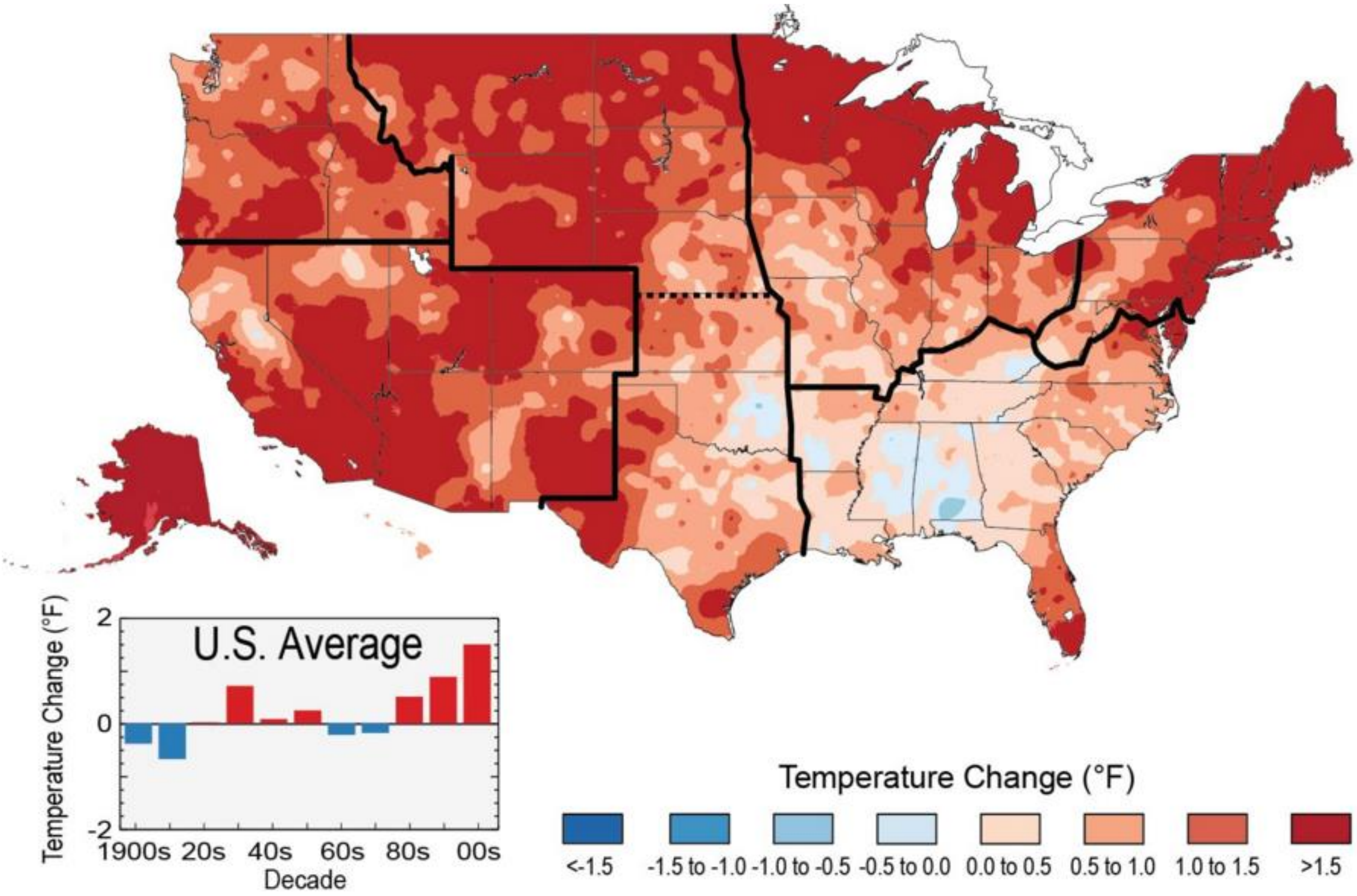
http://www1.ncdc.noaa.gov/pub/data/cmb/bams-sotc/2009/bams-sotc-2009-brochure-lo-rez.pdf (Data from IPCC 2007)



Accelerating rate of sea level rise during the past century.

Source: James Hansen: http://www.columbia.edu/~jeh1/2013/AGU.11December2013.pdf

Observed Temperature Change 1991 - 2012

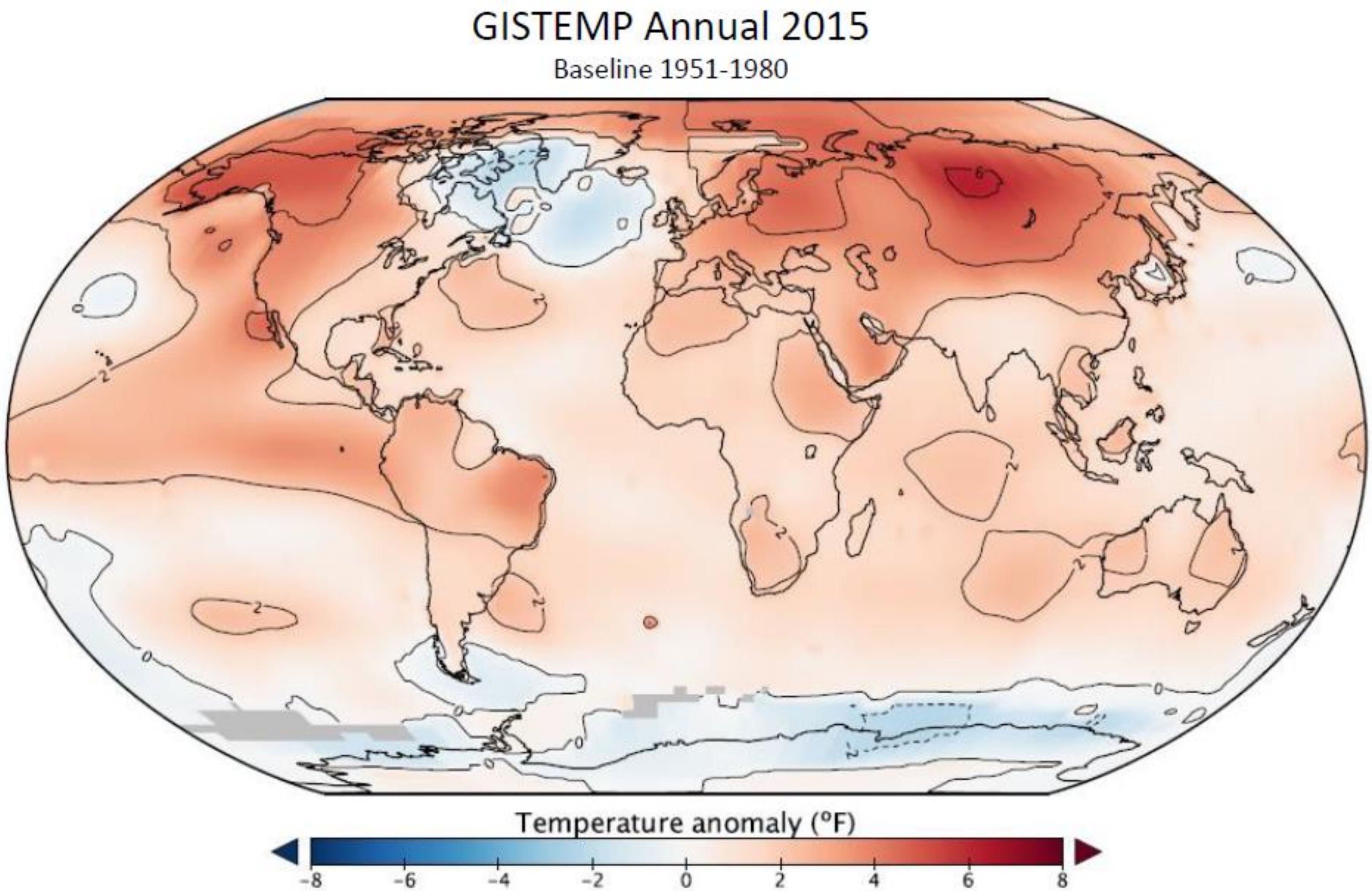


NCA 2014

NASA 2015 Global Temperature

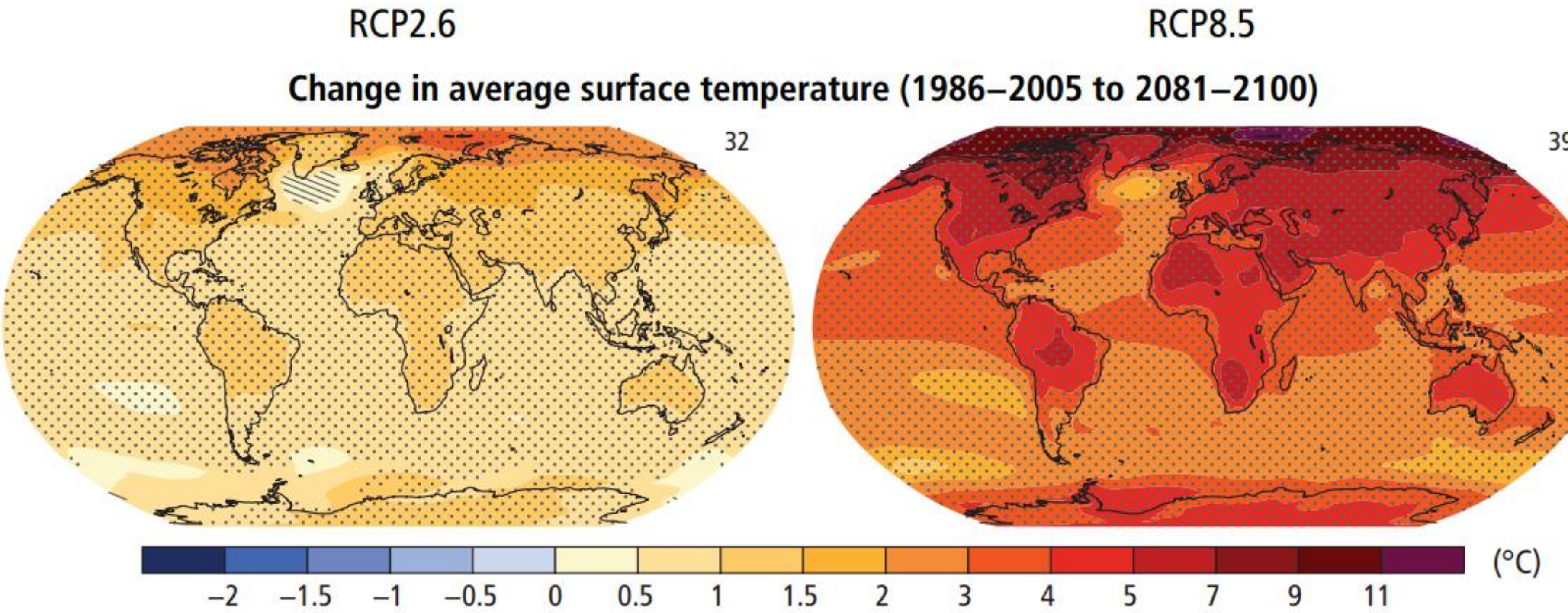
2015:
0.87°C / 1.57°F above 1951-80 average

Warmest year of NASA GISTEMP record

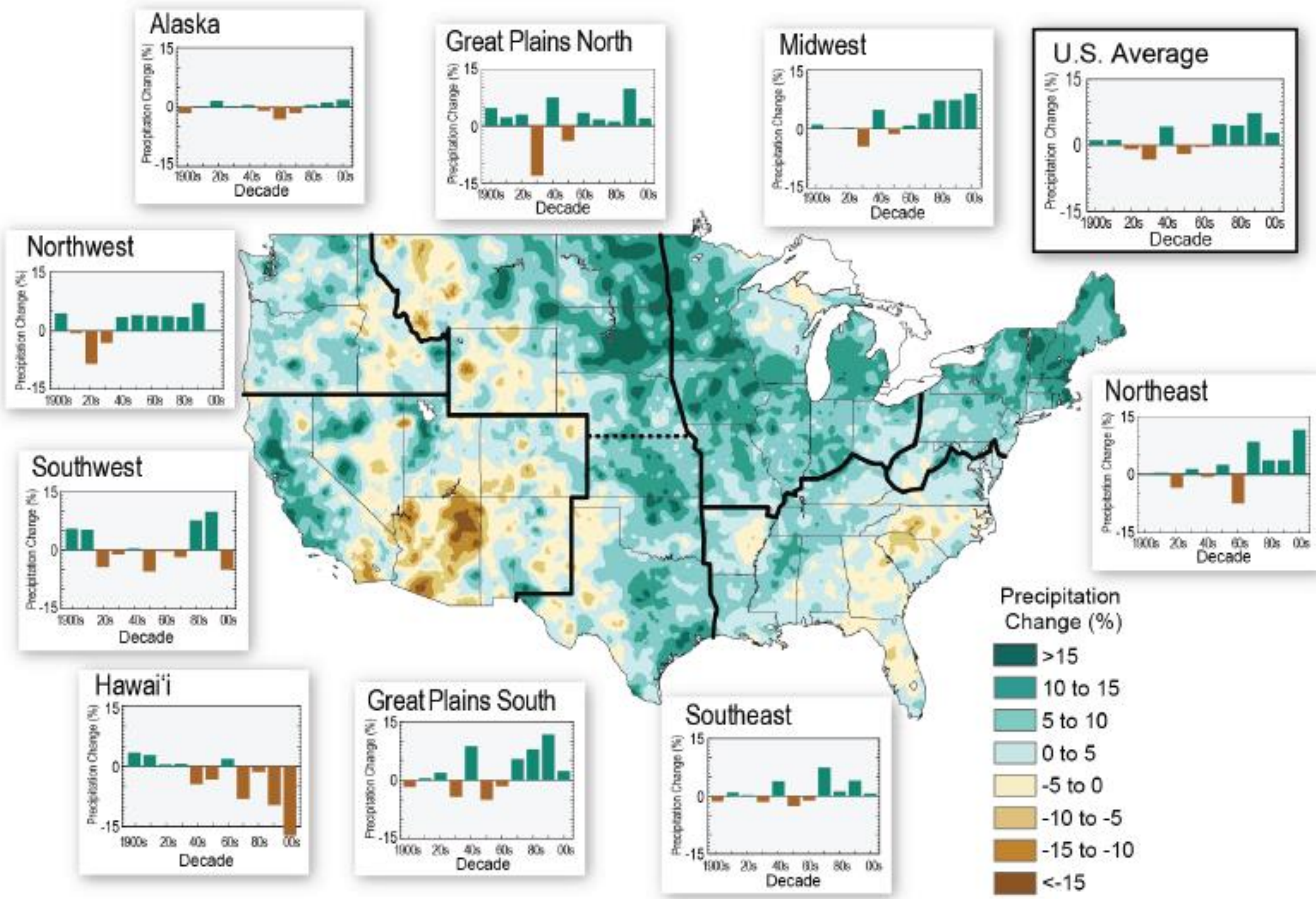


http://www.nasa.gov/sites/default/files/atoms/files/noaa_nasa_global_analysis_2015.pdf

Global Temperature Projections through 2100

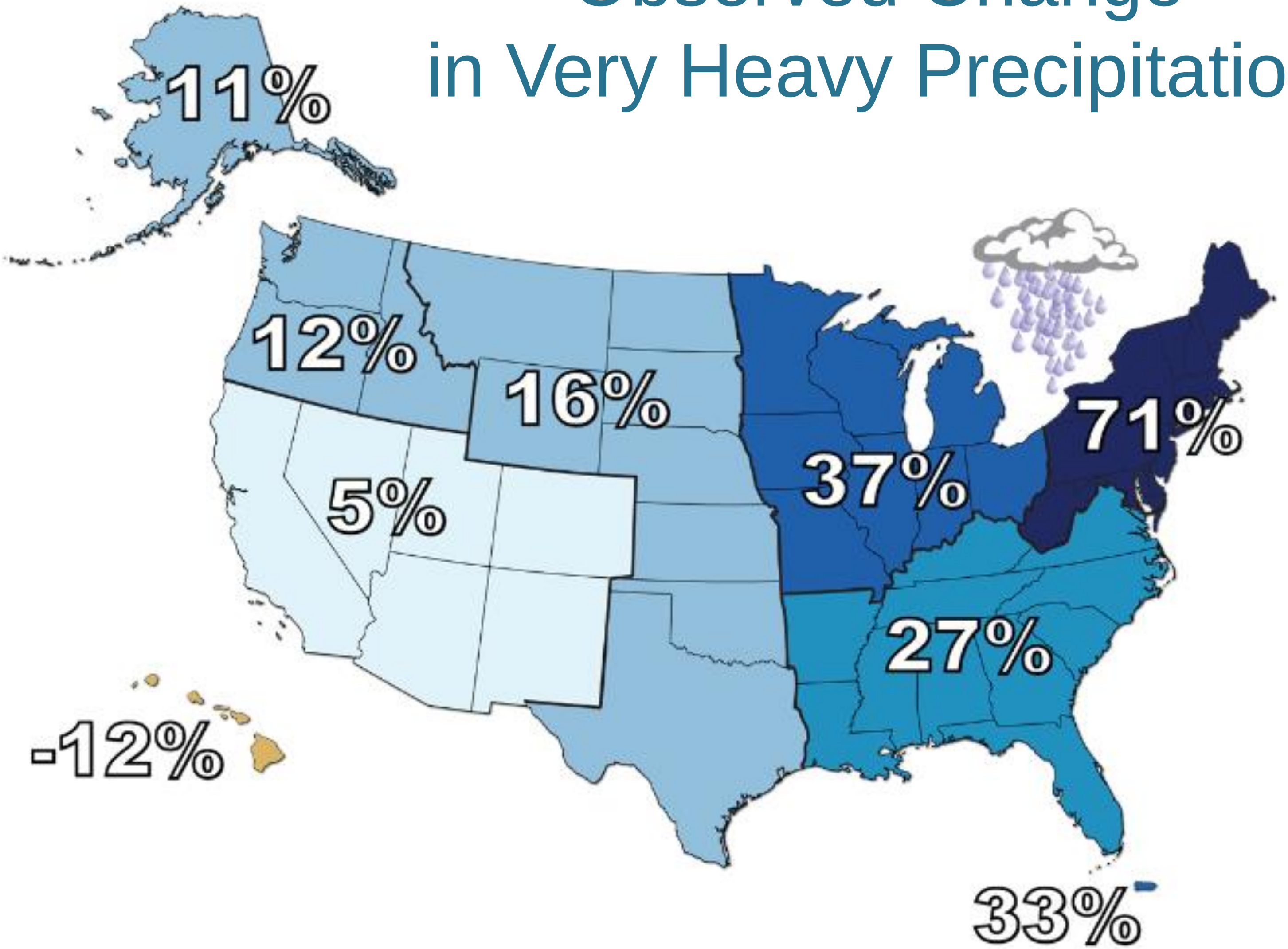


Observed U.S. Precipitation Change



Annual total precipitation changes for 1991-2012 (compared to 1901-1960 average)

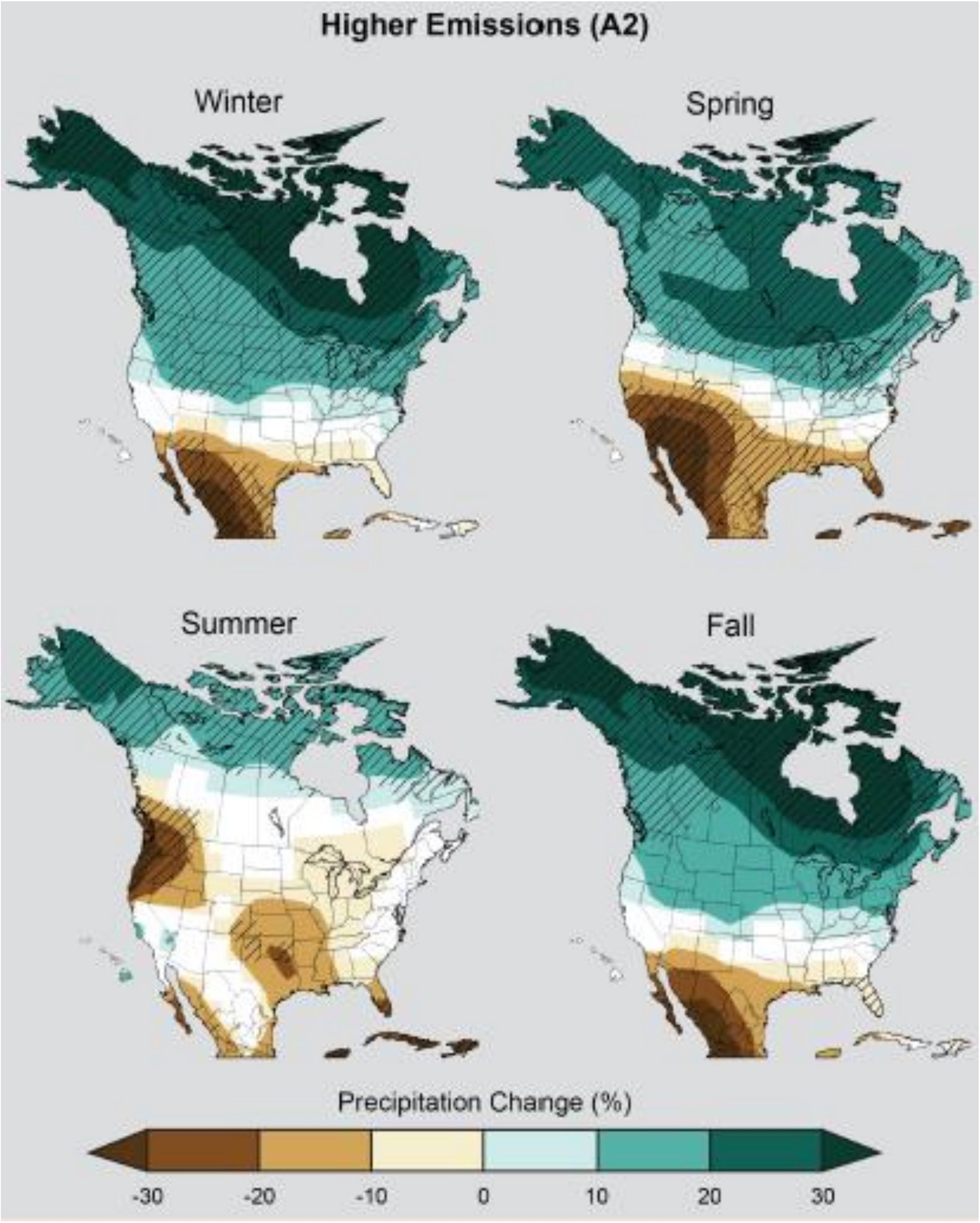
Observed Change in Very Heavy Precipitation



Percent changes in the amount of precipitation falling in very heavy events (the heaviest 1%) from 1958 to 2012 for each region.

NCA 2014

Projected Precipitation Change by Season

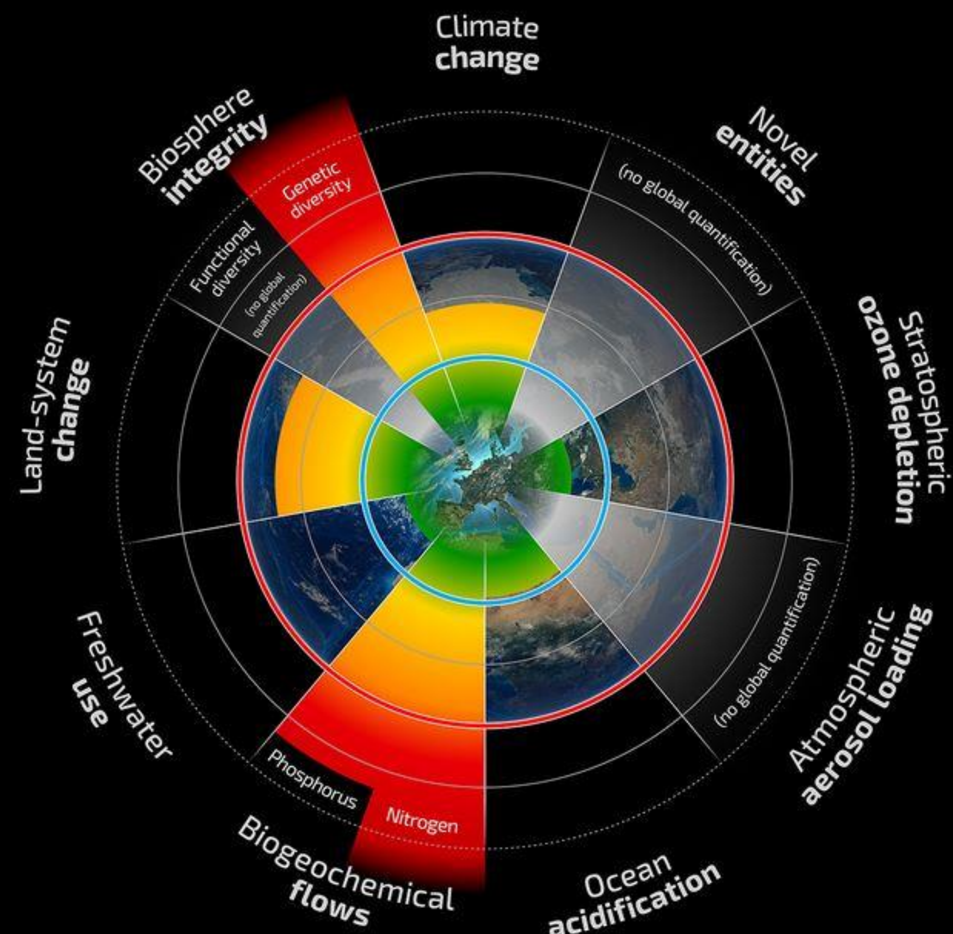


Source: Climate Change Impacts in the United States

Green Infrastructure and Multiple-Benefits Solutions

Planetary Boundaries

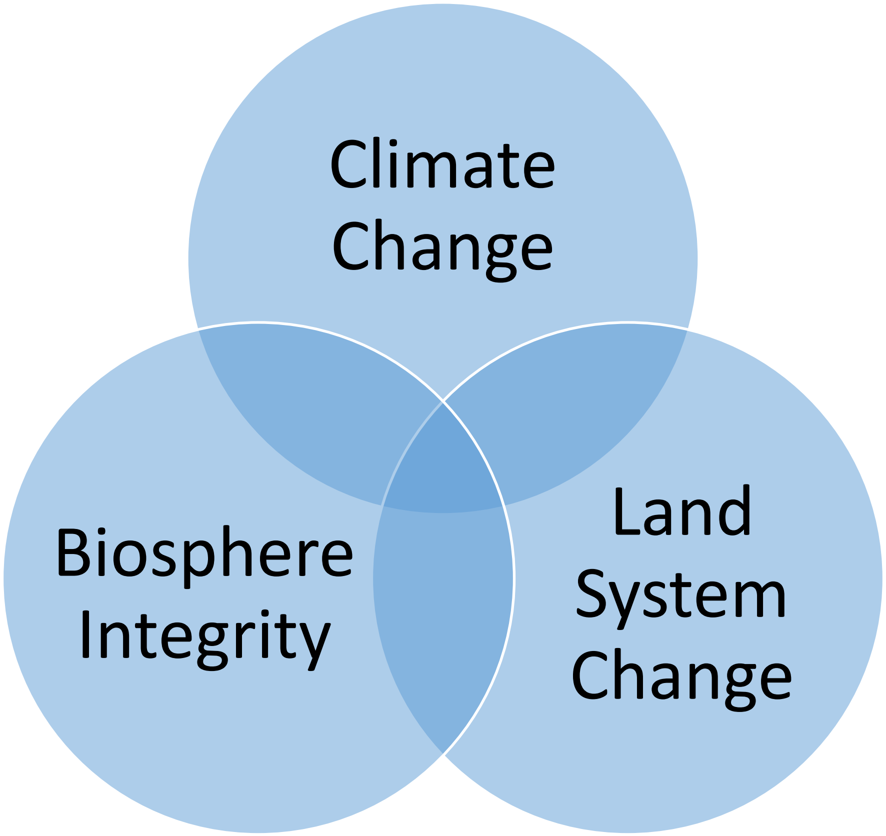
A safe operating space for humanity



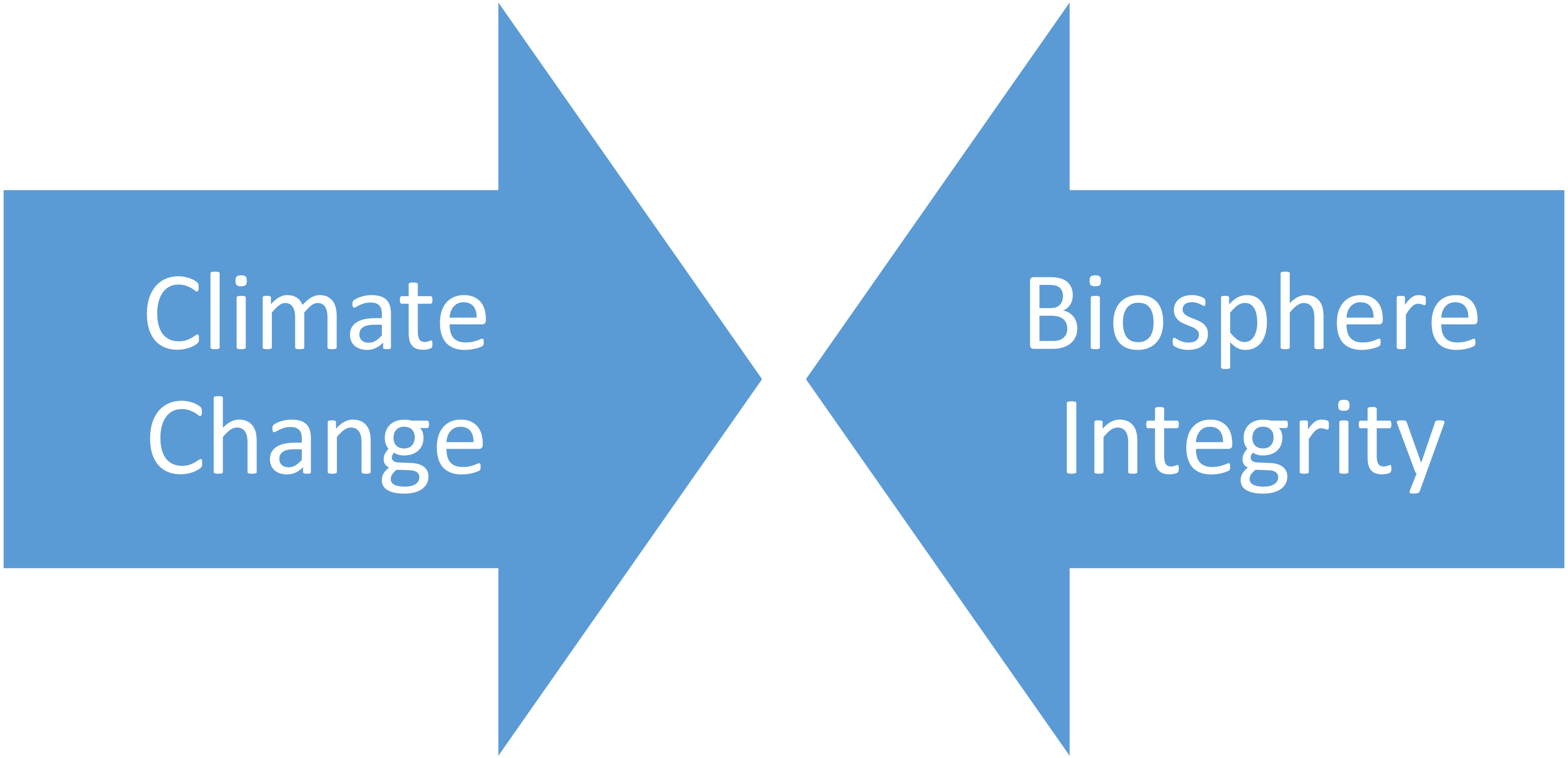
- **Beyond zone of uncertainty** (high risk)
- **In zone of uncertainty** (increasing risk)
- **Below boundary** (safe)
- **Boundary not yet quantified**

Source: Steffen et al. Planetary Boundaries: Guiding human development on a changing planet, *Science*, 16 January 2015.
Design: Globaïa

Focus on Three Boundaries



Interdependence



Source: Google Earth

Source:
http://www.boston.com/news/local/massachusetts/articles/2011/01/06/state_south_shore_officials_gauge_whether_area_qualifies_for_federal_disaster_aid/

Source:
http://www.boston.com/news/local/articles/2011/05/29/scituate_sea_wall_repairs_to_be_done_in_several_cycles/

Philadelphia CSO and the Triple Bottom Line

Green

Or Gray?

http://www.phillywatersheds.org/what_were_doing/green_infrastructure/programs/green-parks
http://www.phillywatersheds.org/what_were_doing/traditional_infrastructure

"The TBL analysis demonstrated that, in Philadelphia, for equal investment amounts and similar overflow volume reductions, supplementing gray infrastructure with GI provides many times the benefits in

- economic value,
- recreational opportunities,
- ecosystem enhancement,
- and reduced construction impacts,

compared to a single-purpose investment in traditional stormwater infrastructure."

Exhibit A.10.1. Philadelphia city-wide physical unit benefits of key CSO options: Cumulative through 2049[a]

Benefit categories	50% LID/GI option	30-ft tunnel option[b]
Additional creekside recreational user days	247,524,281	
Additional non-creekside recreational user days	101,738,547	
Reduction in number of heat-related fatalities	196	
Annual willingness to pay (WTP) per household for water quality and aquatic habitat improvements[c]	\$9.70–\$15.54	\$5.63–\$8.59
Wetlands created or restored (acres)	193	
Green collar jobs (job years)	15,266	
Change in particulate matter due to increased trees ($\mu g/m^3$)	0.01569	
Change in seasonal ozone due to increased trees (ppb)	0.04248	
Electricity savings due to cooling effect of trees (kWh)	369,739,725	
Natural gas savings due to cooling effect of trees (kBtu)	599,199,846	
Fuel used (vehicles for construction and operation and maintenance; gallons)	493,387	1,132,409
SO_2 emissions (metric tons)	(1,530)[d]	1,452
NO_x emissions (metric tons)	(38)	6,356,083
Carbon dioxide (CO_2) emissions (metric tons)	(1,091,433)	347,970
Vehicle delay from construction and maintenance (hours of delay)	346,883	796,597

Exhibit A.10.2. City-wide present value benefits of key CSO options: Cumulative through 2049 (2009 million USD)

Benefit categories	50% LID/GI option	30-ft tunnel option[a]
Increased recreational opportunities	\$524.5	
Improved aesthetics/property value (50%)	\$574.7	
Reduction in heat stress mortality	\$1,057.6	
Water quality/aquatic habitat enhancement	\$336.4	\$189.0
Wetland services	\$1.6	
Social costs avoided by green collar jobs	\$124.9	
Air quality improvements from trees	\$131.0	
Energy savings/usage	\$33.7	(\$2.5)
Reduced (increased) damage from SO_2 and NO_x emissions	\$46.3	(\$45.2)
Reduced (increased) damage from CO_2 emissions	\$21.2	(\$5.9)
Disruption costs from construction and maintenance	\$(5.6)	(\$13.4)
Total	**\$2,846.4**	**\$122.0**

a. 28-ft tunnel option in Delaware River watershed.

Manomet Projects

Taunton River Watershed

Climate Change Adaptation Plan

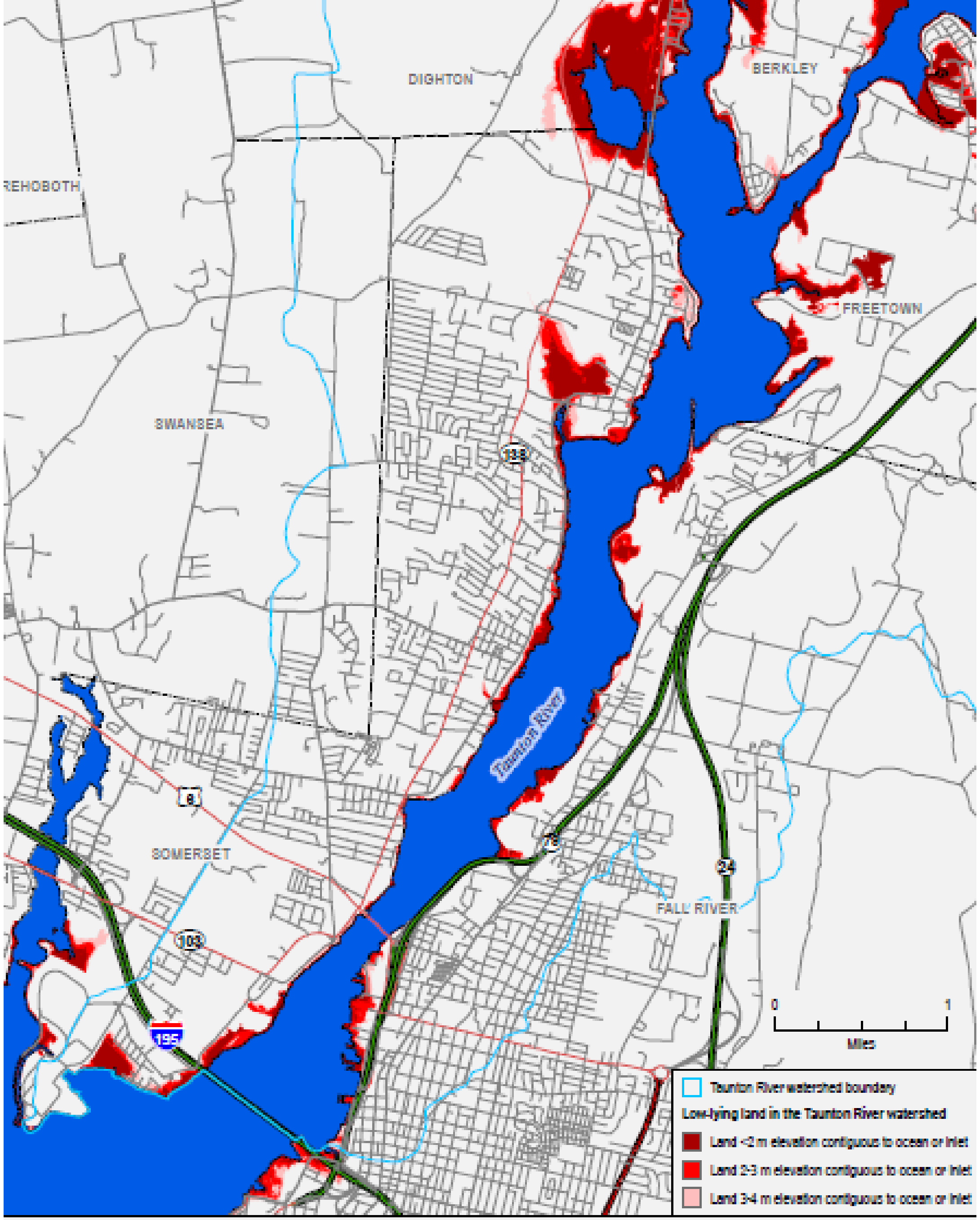
Manomet Center for Conservation Sciences
Loni Plocinski, William VanDoren, Eric Walberg

May 2013

Map 3
Stoughton
Holbrook
Rockland
Sharon
Avon
Abington
Brockton
Wrentham
Whitman
Pembroke
Foxborough
East
Hanson
Easton
Bridgewater
West
Plainville
Mansfield
Bridgewater
Halifax
Kingston
North
Attleborough
Norton
Plympton
Bridgewater
Plymouth
Attleboro
Raynham
Taunton
Middleborough
Carver
Rehoboth
Dighton
Berkley
Lakeville
Taunton River
Rochester
Freetown
Swansea
Somerset
Fall River
Acushnet
New Bedford
0
5
Taunton River watershed
State boundary

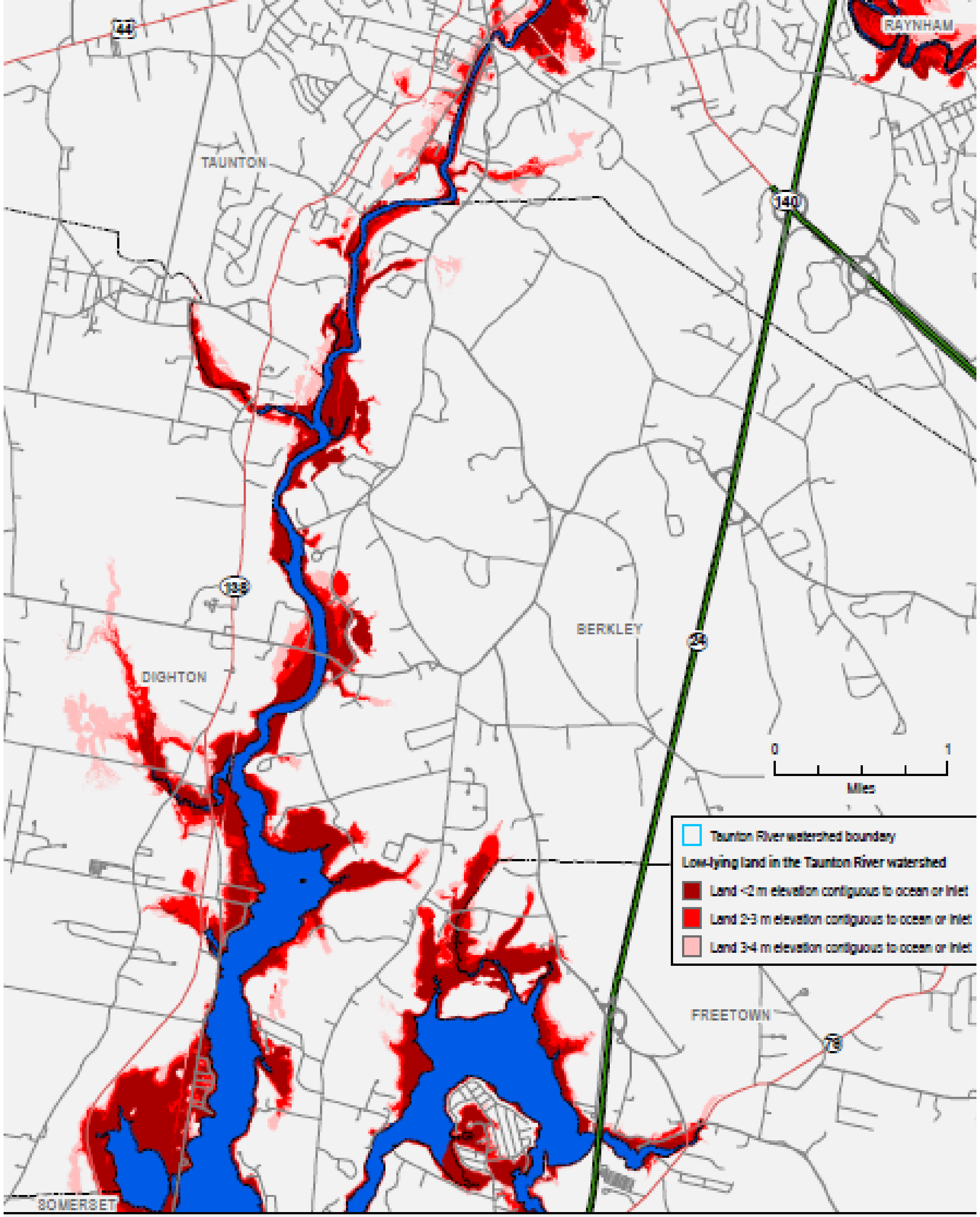
Taunton River Watershed Vulnerability

- Sea level rise
- Fresh water flooding
- Rising water table
- Water balance issues
- Environmental justice concerns

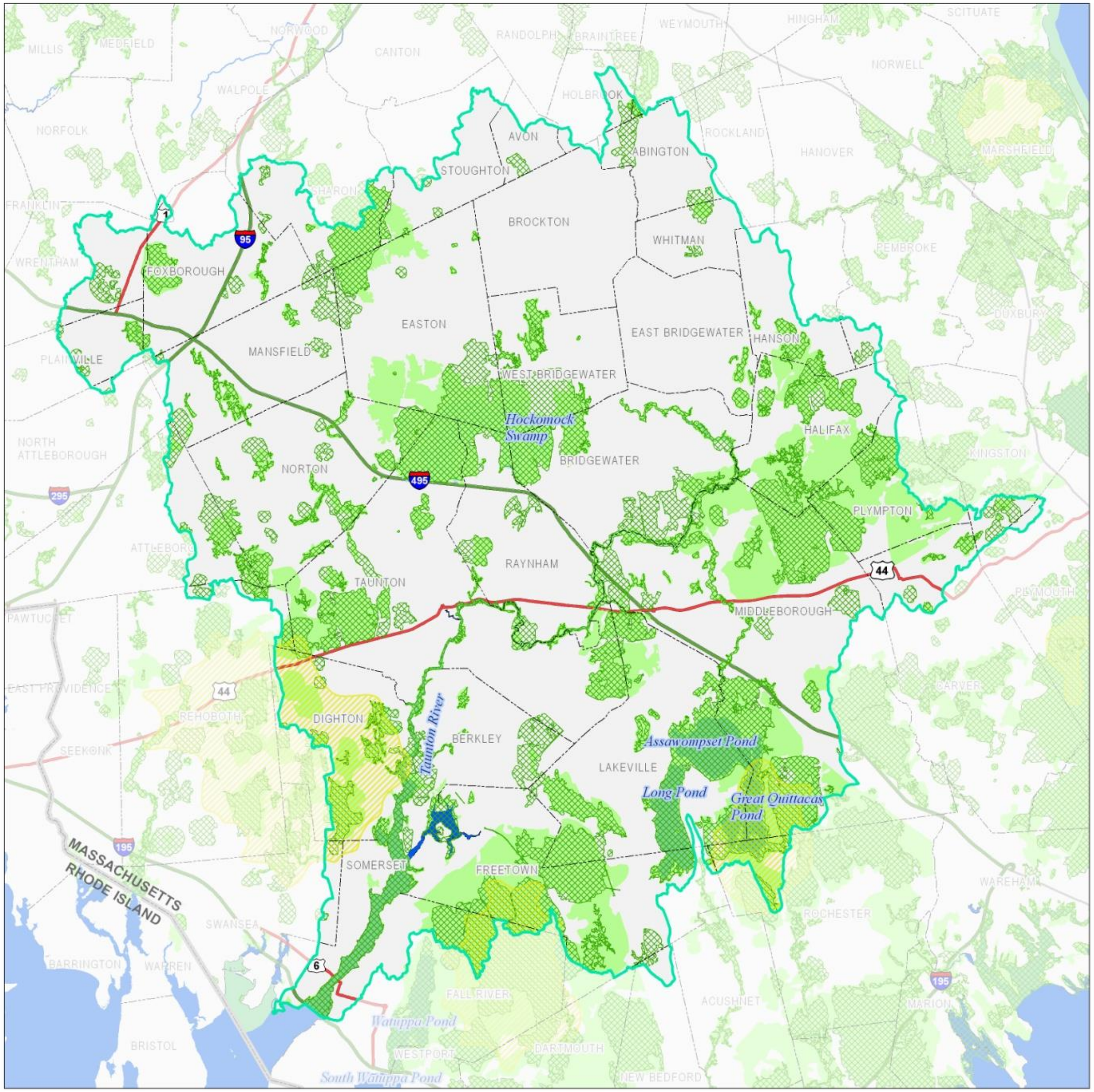


Map showing approximate areas of low elevations in and around the mouth of the Taunton River. 1 m resolution LiDAR data acquired from MassGIS and hydrologically processed using USGS NHD. Hydrography data combined from MassGIS DEP Wetlands and USGS NHD. Road data from MassGIS MassDOT roads. Watershed boundary from NRCS WBD dataset.

Source: Taunton River Climate Change Adaptation Plan, Manomet, 2013



Map showing approximate areas of low elevations in and around the mouth of the Taunton River. 1 m resolution LiDAR data acquired from MassGIS and hydrologically processed using USGS NHD. Hydrography data combined from MassGIS DEP Wetlands and USGS NHD. Road data from MassGIS MassDOT roads. Watershed boundary from NRCS WBD dataset.



Green Infrastructure Habitat Synopsis

for the

Taunton River Watershed

Figure 1

Ecosystems and associated wildlife populations in the Taunton watershed will be impacted by a mix of stressors associated with both climate change and continued urbanization of the watershed. The Massachusetts BioMap2 project incorporates climate change vulnerability considerations by incorporating strategies to improve resistance and resilience of significant ecosystems and species.

BioMap 2 Core Habitat comprises interior forest; habitat for species of conservation concern; priority natural communities; and the best examples of wetland, aquatic, and vernal pool habitats across Massachusetts. BioMap 2 Critical Natural Landscape includes large areas of predominantly intact blocks of natural vegetation (landscape blocks), upland buffers of aquatic and wetland core habitat, tern habitat, and undeveloped coastal areas that will support salt marsh migration. These areas provide habitat for wide-ranging species and support and maintain ecological processes, connectivity, and ecological resilience. Data from MassGIS (2011).

- NHESP/TNC BioMap2 Core Habitat
- NHESP/TNC BioMap2 Critical Natural Landscape

A different approach was taken in a recent analysis of resilient sites by The Nature Conservancy that identifies areas with geophysical features that are inherently supportive of high biodiversity. Areas of high estimated resiliency are likely to have characteristics (microclimatic buffering and connectedness) that maintain ecological functions and sustain an array of specialist and generalist wildlife species in the face of climate change, anthropogenic disruption, and other disturbances. Three focal areas that intersect the Taunton watershed were identified in the study. Data from TNC (2012).

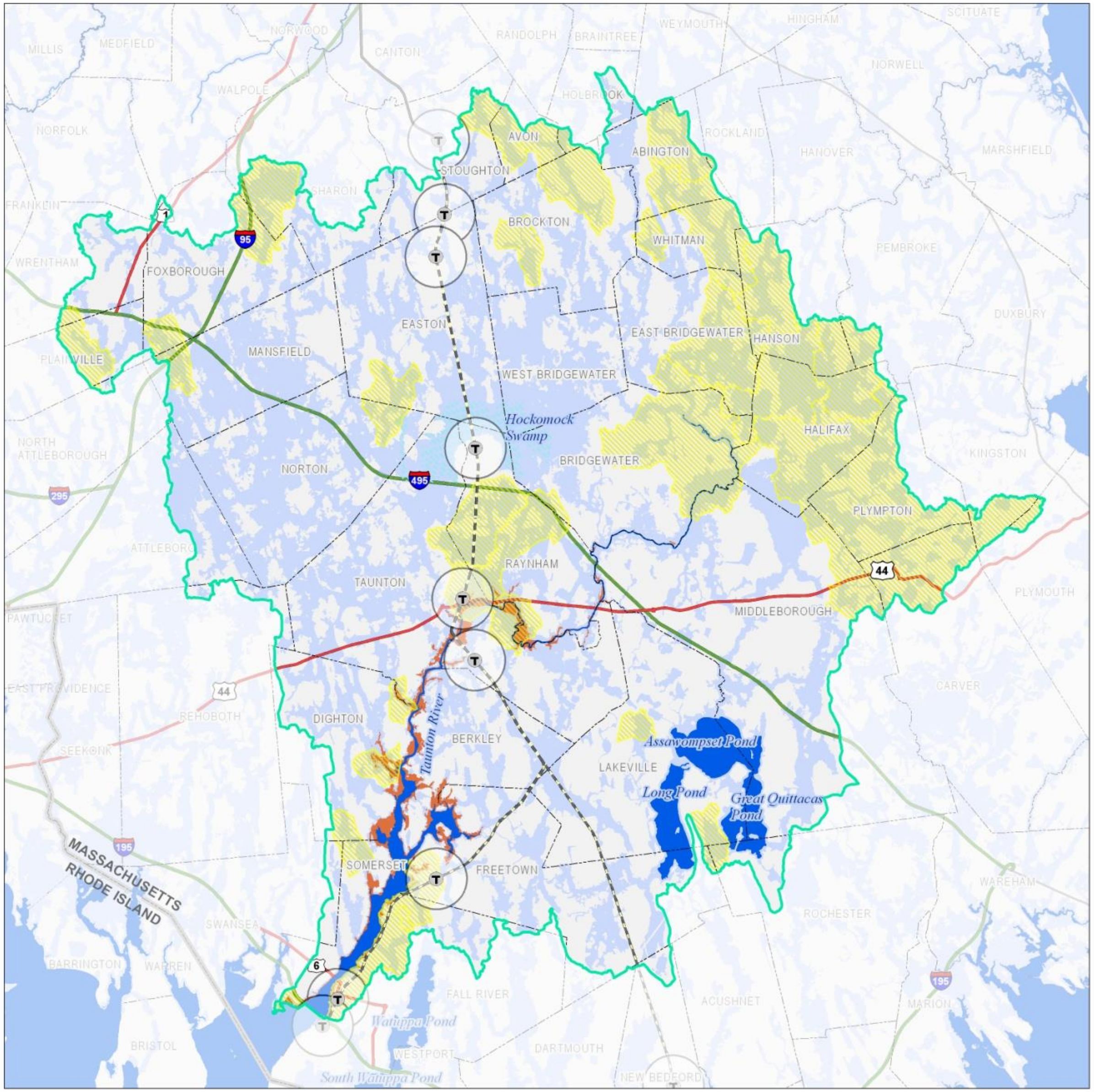
- Focal area of high estimated resilience

N

0 10

Miles

- Taunton River watershed boundary
- State boundary
- Town boundary



Green Infrastructure Hydrology Synopsis
for the
Taunton River Watershed
Figure 2

The redevelopment that will take place surrounding the transit stops associated with the South Coast Rail project will provide an opportunity for the incorporation of green infrastructure features to limit heat island effects, maximize the infiltration of stormwater and limit nonpoint source water pollution. Data from MassGIS (2008) and MassEOT (2009).

- South Coast Rail existing/proposed stations
- Walking-distance (1 mi) buffer
- Operational rail line
- Proposed SCR rail line

The estimated water balance of some parts of the Taunton River watershed is already negative relative to natural conditions. That is, withdrawals in some sub-watersheds result in a deficit of groundwater recharge relative to undeveloped conditions. As climate change alters precipitation patterns and development increases impervious surface area alteration to the area's natural hydrology will be exacerbated. These sub-watershed areas should be targeted for measures that maximize groundwater recharge. Data from Horsley Witten Group, Inc. (2008).

- Sub-watershed water balance ≤ 10%

Storm surge and sea level rise have the potential to affect low-lying areas along the mainstem of the Taunton River. LiDAR data was used to identify areas adjacent to the Taunton River that may be vulnerable. Flood proofing of existing structures, minimizing new development and increasing the width of riparian buffers are recommended for this area. LiDAR data from MassGIS (2012); analysis follows Hamann et al. (2008).

- Areas hydrologically connected to ocean ≤ 4 m elevation

Riparian areas and associated flood zones will be increasingly vulnerable to flooding due to climate change. Maintaining and restoring forest and natural vegetative cover in these areas can help to maintain natural stream processes and attenuate flooding from all but the most severe precipitation events. Data from MassGIS and FEMA (1997) and TNC Active River Area (2009).

- FEMA Flood Zones and TNC Active River Area

N

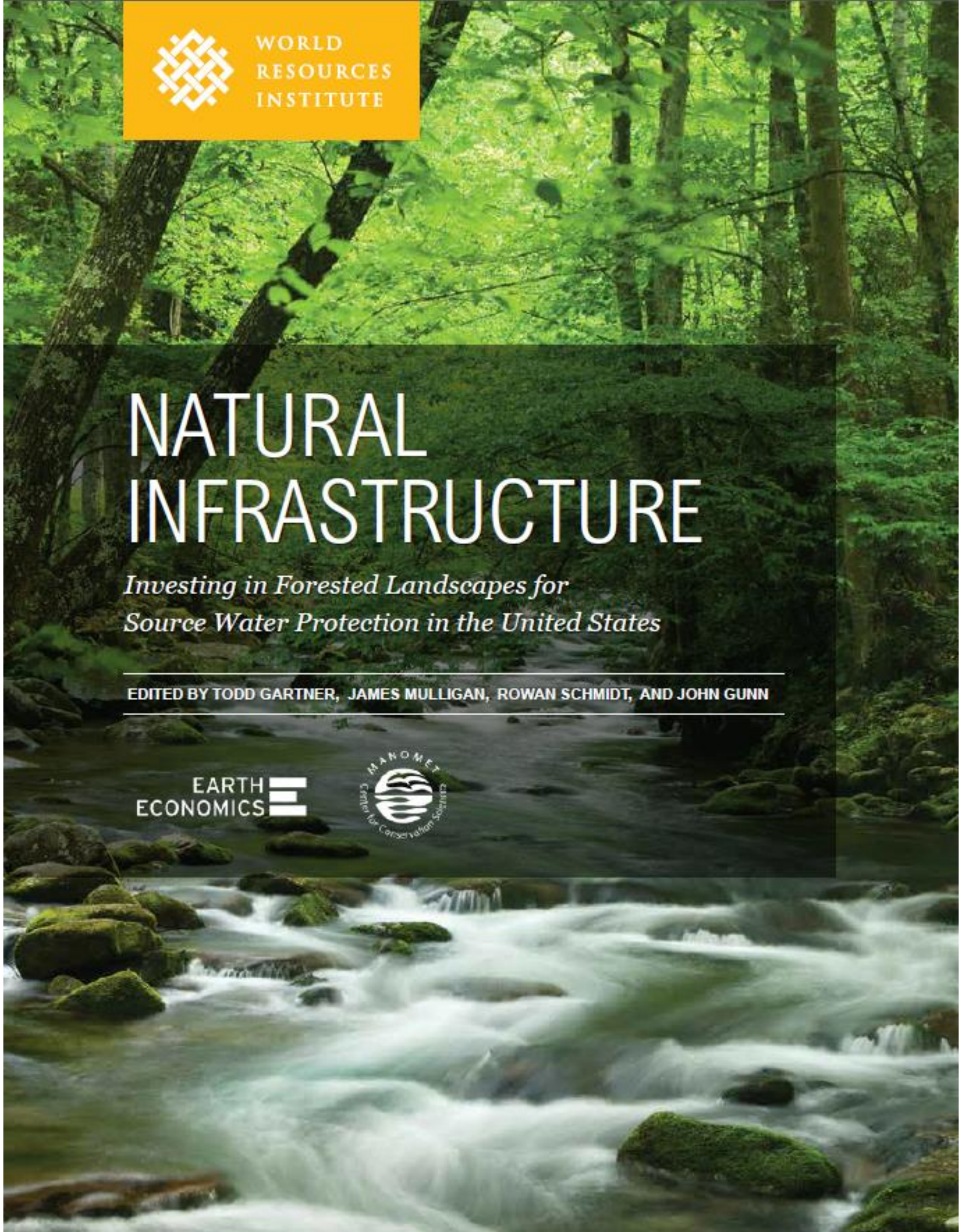
0 10

Miles

- Taunton River watershed boundary
- State boundary
- Town boundary

Taunton Green Infrastructure Project

- Ongoing effort building on Manomet Taunton Adaptation Plan
- Multi-agency: Federal, state, regional, local government, universities, non-profit agencies
- Development of GI plan that addresses CC resiliency,
- Case studies and cost/benefit analysis,
- Educational program targeted at local elected officials, staff, board members



WORLD RESOURCES INSTITUTE

NATURAL INFRASTRUCTURE

Investing in Forested Landscapes for Source Water Protection in the United States

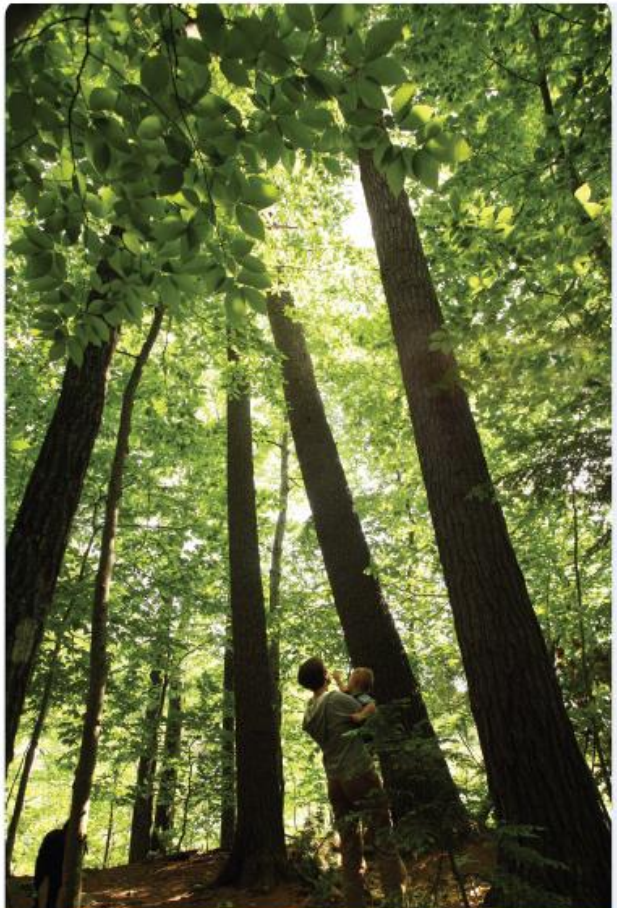
EDITED BY TODD GARTNER, JAMES MULLIGAN, ROWAN SCHMIDT, AND JOHN GUNN

EARTH ECONOMICS

MANOMET Center for Conservation Sciences

May 2012 NCI -2012-01

NATURAL CAPITAL INITIATIVE AT MANOMET **REPORT**



VALUING MAINE'S NATURE

Manomet Center for Conservation Sciences
14 Maine St., Suite 410, Brunswick, ME 04011
Contact: 207-721-9040 ext. 4, jgunn@manomet.org

SEPTEMBER 2014

The Value of Trees: An Assessment of Three Forests in Bath, Maine

The City of Bath, Maine (9,400 people and 25,000+ trees) has a long history of having healthy forests. A collaborative project of the City of Bath, Maine Forest Service, Manomet Center for Conservation Sciences, the U.S. Forest Service, and the Kennebec Estuary Land Trust measured the environmental and financial benefits of forests beyond beauty and aesthetics.

The analysis focused on three forests in Bath: trees in public areas, backyards, and along streets in Bath's downtown and urban center; Sewall Woods a 91-acre parcel permanently conserved by Kennebec Estuary Land Trust; and Butler Head, a 141-acre forest called Butler Head, owned and managed by the City of Bath.

A program developed by the US Forest Service called i-Tree calculated that trees within these three areas contributed over $1.3 million dollars of benefits to the Bath community.

Table 1 details the environmental and economic benefits of each property.

The Environmental and Financial Benefits of Trees at Three Properties in Bath, Maine.

	Downtown Bath	Sewall Woods	Butler Head	All Properties
Number of trees	15,015	20,700	11,800	47,515
Environmental Benefits				
Pollution removal (lbs/year)	16,058	6,000	4,409	26,468
Carbon Storage (lbs)	1,477,372,263	5,680,000	4,660,000	1,487,712,263
Carbon Sequestration (lbs/year)	417,518	260,000	196,000	873,518
Oxygen production (lbs/year)	626,277	18,480	13,880	658,637
Avoided runoff (gallons/yr)	756,736	656,744	391,204	1,804,684
Financial Benefits				
Pollution removal ($/yr)	$21,036	$15,800	$11,600	$48,436
Avoided runoff ($/yr)	$6,720	$6	$3	$6,730
Carbon Sequestration ($/yr)	$14,774	$9,240	$6,940	$30,954
Carbon Storage ($)	$738,686	$202,000	$166,000	$1,106,686
Total	$781,217	$227,046	$184,543	$1,192,806

Analysis was completed using i–Tree Eco, developed by the US Forest Service.

Thank You

Eric Walberg

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508-224-6521 / ewalberg@manomet.org