

Challenges & Opportunities in Ecosystem Science & Education

A View from the Obama White House

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**Keynote Presentation for the
40th Anniversary of the Ecosystem Center
Woods Hole • MBL • 5 June 2015**

Outline of the talk

- Environment and human well-being
- The great environmental challenges
- Related challenges in ecosystem science
- Related challenges in education/communication
- Federal-government opportunities and initiatives in these domains

Environment and human well-being

Human well-being is supported by three pillars:

- economic conditions and processes
employment, income & wealth (magnitude & distribution), markets, trade...
- sociopolitical conditions and processes
law & order, national & homeland security, governance, liberty, justice, equity, education, health care, science, culture & the arts...
- environmental conditions and processes
air, water, soils, mineral resources, the biota, nutrient cycles, climatic processes...

Environment & well-being (continued)

- Each of the three pillars is indispensable.
- We face major challenges in all three.
- Historically, the challenges in the economic and sociopolitical pillars have had higher priority in the public mind and the policy process.
- But the pillars are interdependent:
 - protecting the environment requires money, political stability, and functional institutions
 - disruption of environmental conditions & processes can have huge economic & sociopolitical impacts

The great environmental challenges

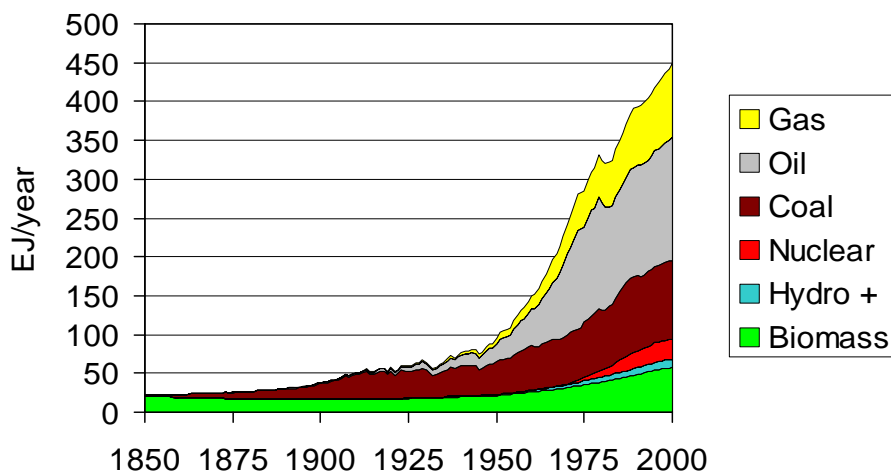
- Providing the energy our economies need without wrecking the climate our environment needs
- Adapting to the degree of climate change that can no longer be avoided
- Controlling and reversing the chemical alteration of the environment
- Managing the competing demands on the planet's land, water, & biota while preserving biodiversity
- Protecting the productivity & ecological integrity of the oceans

These are interconnected, interdisciplinary, international.

The Great Environmental Challenges:

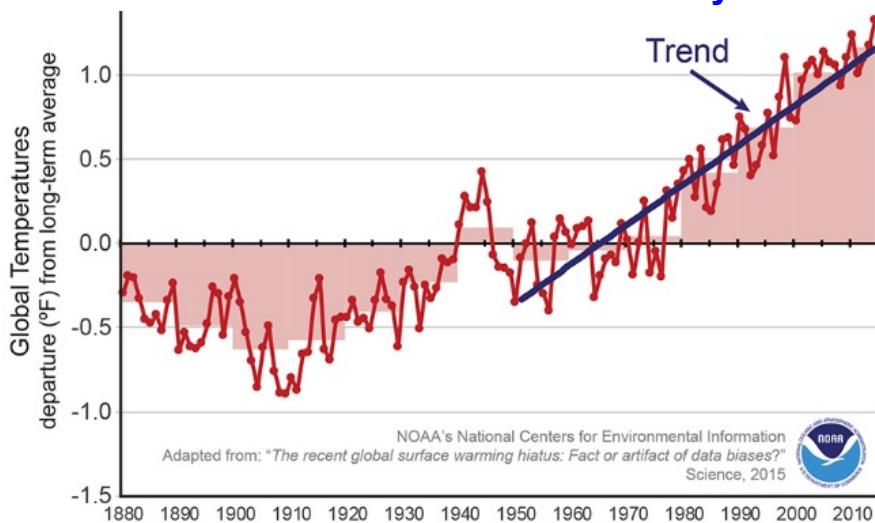
Energy and Climate

Growth of world population & prosperity over past 150 years brought a 20-fold increase in energy use.

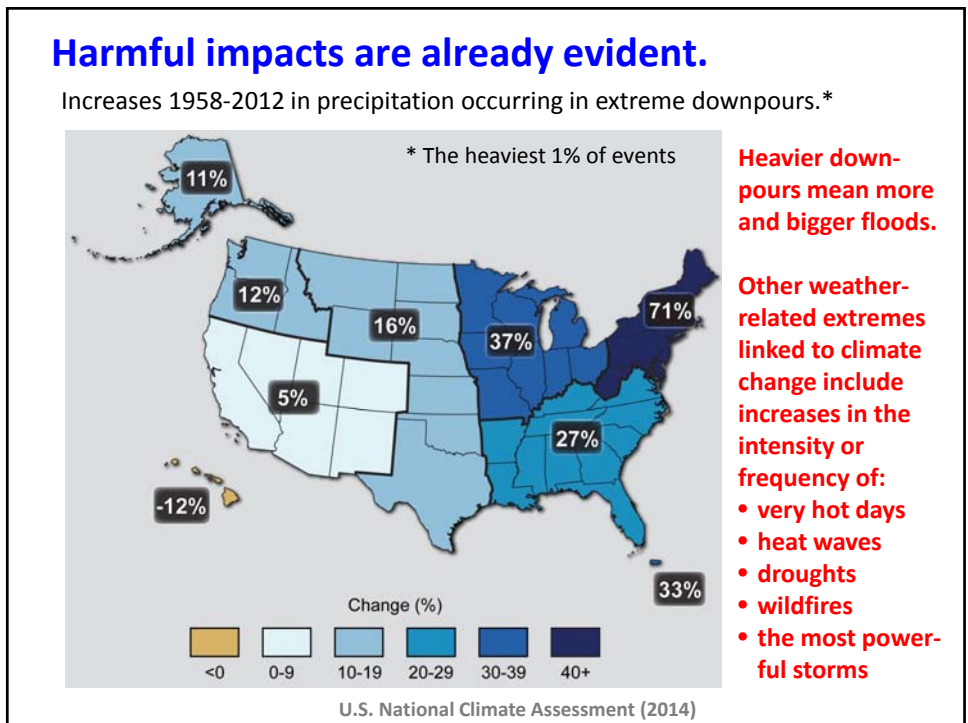
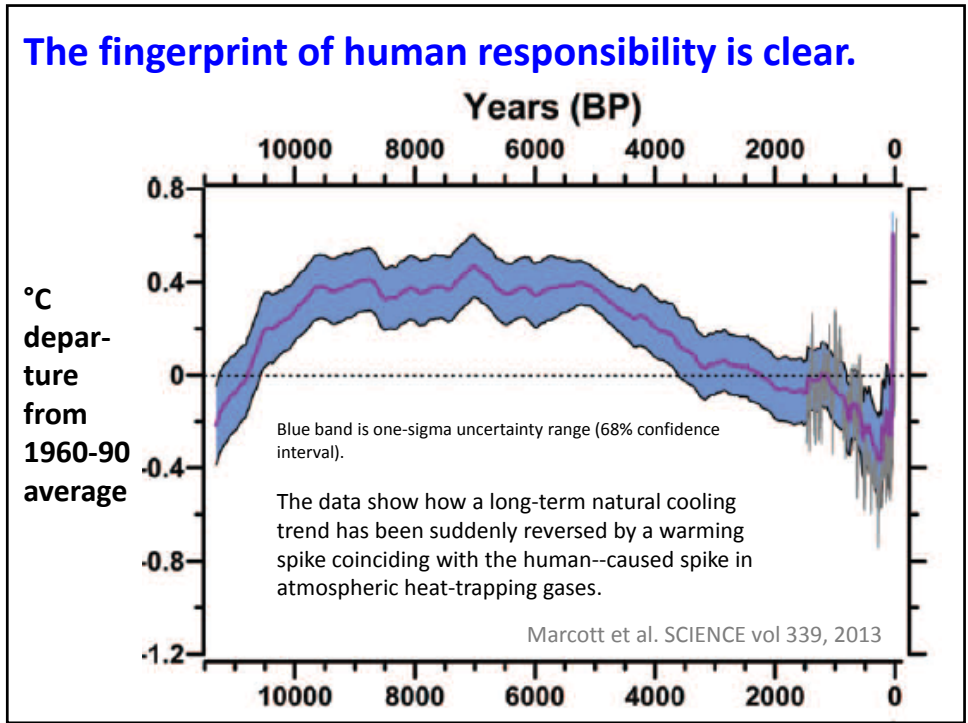


In 2015, the world still depends on fossil fuels for more than 80% of all its energy use. Nuclear & renewables supply the rest.

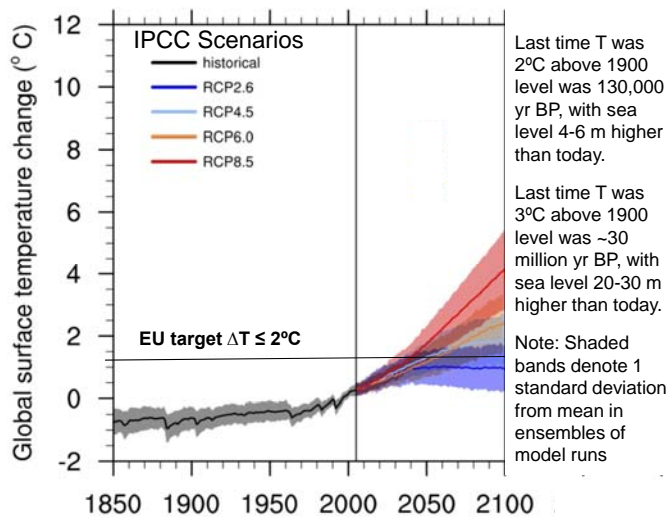
The global-average temperature closely tracks fossil-fuel use from the mid-20th century onward.



A NOAA paper published in yesterday's edition of SCIENCE updates the temperature dataset and finds no slowdown of warming since 2000.



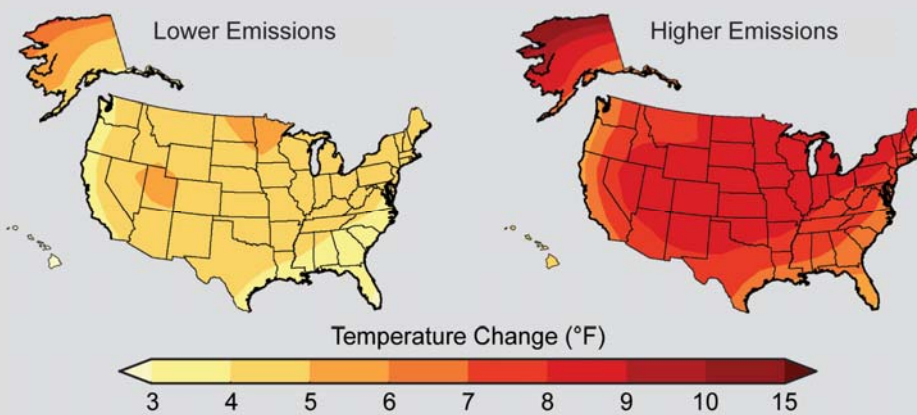
T and impacts grow for decades under all scenarios.



IPCC 2013

But the difference between low & high emissions is huge.

Change in average surface air temperature between 1970-1999 and 2070-2099



Adaptation & mitigation are both required.

There are only three options:

- Mitigation, meaning measures to reduce the pace & magnitude of the changes in global climate being caused by human activities.
- Adaptation, meaning measures to reduce the adverse impacts on human well-being resulting from the changes in climate that do occur.
- Suffering the adverse impacts and societal disruption that are not avoided by either mitigation or adaptation.

Concerning the three options...

- We're already doing some of each.
- What's up for grabs is the future mix.
- Minimizing the amount of suffering in that mix can only be achieved by doing a lot of mitigation and a lot of adaptation.
 - Mitigation alone won't work because climate change is already occurring & can't be stopped quickly.
 - Adaptation alone won't work because adaptation gets costlier & less effective as climate change grows.
 - We need enough mitigation to avoid the unmanageable, enough adaptation to manage the unavoidable.

The Great Environmental Challenges:

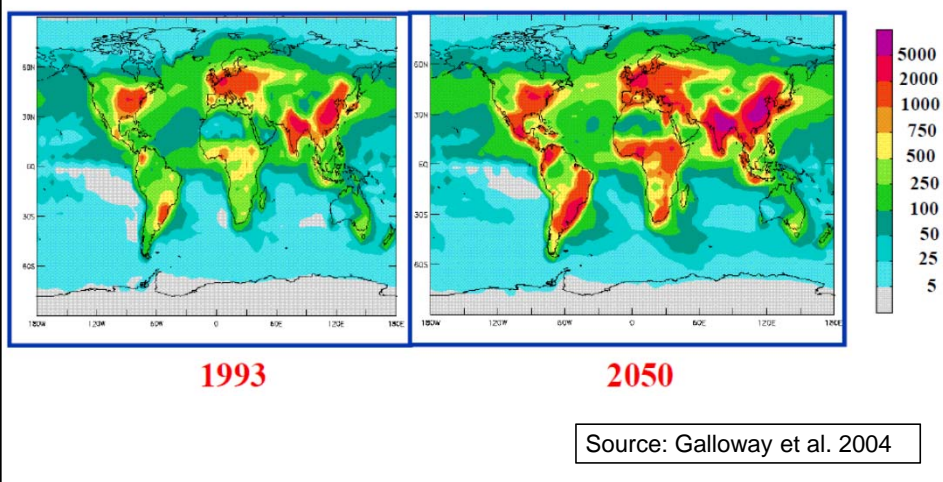
Chemical Alteration

Chemical alteration of ecosystems

- Acidification
- Nutrients (N, P, S) in the wrong forms, places, or quantities
- Hydrocarbons and their relatives (fuels, solvents, pesticides...)
- Trace metals
- Antibiotics and other drugs & drug residues

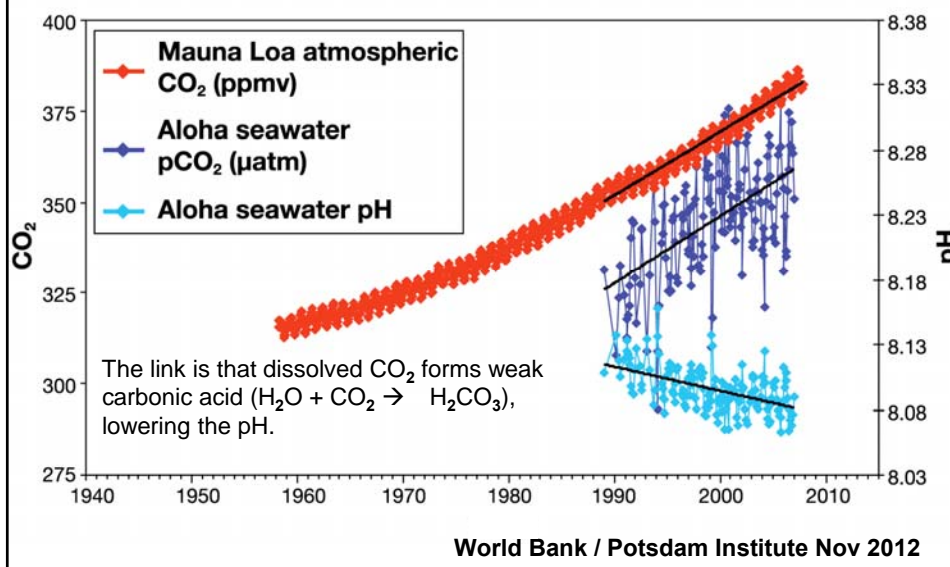
Reactive-nitrogen pollution

Wet and dry reactive nitrogen deposition from the atmosphere, early 1990s and projected for 2050 (mg N/m²-yr)



Acidification of the ocean

About 1/3 of CO₂ added to atmosphere is quickly taken up by the surface layer of the ocean (top 80 meters).



The Great Environmental Challenges:

**Competing Demands on Land,
Water, and Biota**

The competing uses

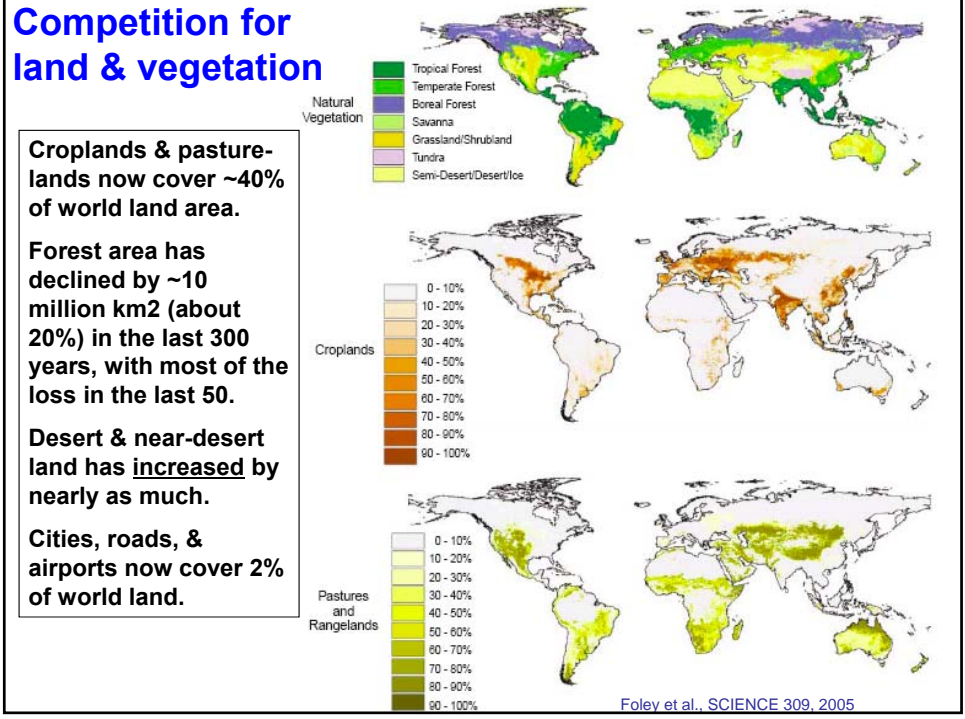
- land for housing, commerce, industry, and transport infrastructure
- water for homes, businesses, industry, power-plant cooling, fossil-energy development
- land, water, and plant productivity for food, forage, fiber, biofuels, chemical feedstocks
- land, water, & biota for recreation, beauty, solace of unspoiled nature, and ecosystem functions

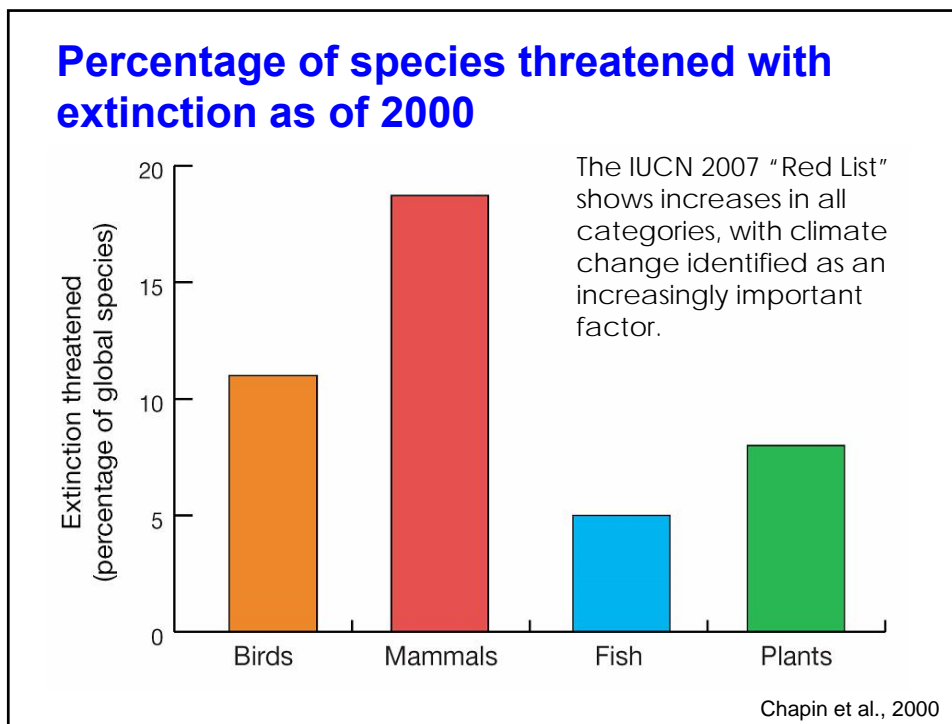
Key ecosystem functions

- regulation of water flows
- purification/detoxification of soil, water, air
- nutrient cycling
- soil formation
- controls on pests & pathogens
- pollination of flowers & crops
- biodiversity maintenance (genetic “library”)
- climate regulation (evapotranspiration, reflectivity, & carbon sequestration)

Competing uses for water vs availability

	cubic kilometers per year
Global available flow	12,000
Global withdrawals for human use	5,000
of which agriculture	3,500
...industry	1,000
...domestic	500
of which drinking water	5
Global desalting capacity	30
	cubic meters per person per year
Global average withdrawals per person	800
Nigeria...	50
China...	500
Mexico...	800
Italy...	1,000
United States...	2,000





The Great Environmental Challenges:

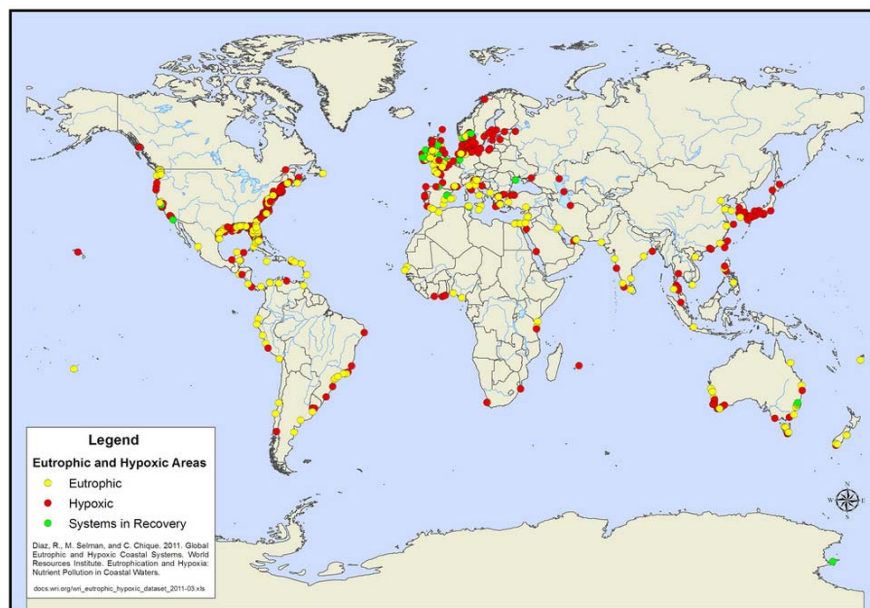
Protecting the Oceans

Anthropogenic threats to the oceans

- Pollution
 - nitrogen, phosphorus → dead zones
 - oil, pesticides → dead birds, fish, marine mammals
 - metals (cadmium, chromium, lead, mercury...)
 - plastics and other garbage
- Ocean-atmosphere interactions
 - climate change → sea-level rise, increased max storm power, altered storm tracks, ocean heating
 - Acidification
- Overfishing & destruction of marine habitat

Here, again, the threats are interactive.

Eutrophic and hypoxic (dead) zones from nutrient runoff



Related Challenges in Ecosystem Science

What more do we most need to know?

CLIMATE SCIENCE

- Improved understanding of climate “sensitivity” to human & natural forcings (including effects of particles, clouds)
 - Sensitivity means, in essence, how much average T increases under a doubling of atmospheric CO₂.
 - Improvements in this understanding will improve predictions.
- Better regional disaggregation of predicted changes in temperatures, precipitation, storm tracks, ice sheets

Will require continuing investments in paleo-climatology, basic climate physics, maintaining & improving our constellation of Earth-observation satellites, and running better climate models on faster computers.

What more we need to know (continued)

ECOLOGY

- Better understanding of ecological effects of regional climate changes, including
 - impacts on, feedbacks from, and adaptation possibilities for specific ecosystems, particularly...
 - Arctic ecosystems; tropical, temperate, and boreal forests; agricultural ecosystems; high-altitude ecosystems; coastal and marine ecosystems; and especially...
 - influences on carbon sources, sinks, & storage
- Will require continued and expanded investments in field studies and, especially, denser monitoring networks and increased international cooperation.

What more we need to know (continued)

MICROBIAL ECOLOGY

- Who is there?
 - What are the dimensions of microbial biodiversity (in soils, fresh water, sea water & sediments, in and on plants & animals)
- What are they all doing & how do they do it?
 - What are the roles of all these microbial species in regulation of environmental chemistry, other ecosystem functions & services, plant & animal physiology & pathology?
- How will global change affect them?
 - A mostly warmer, moister but in some places drier world? A more acidic ocean? More acidic soil? Other chemical changes?

What more we need to know (continued)

INTERDISCIPLINARY ASSESSMENT

- Better integrated assessments combining...
 - predictions
 - mitigation and adaptation options (character, capabilities, costs)
 - social dimensions
- Application of understandings from social science relating to risk perception, motivation, behavior

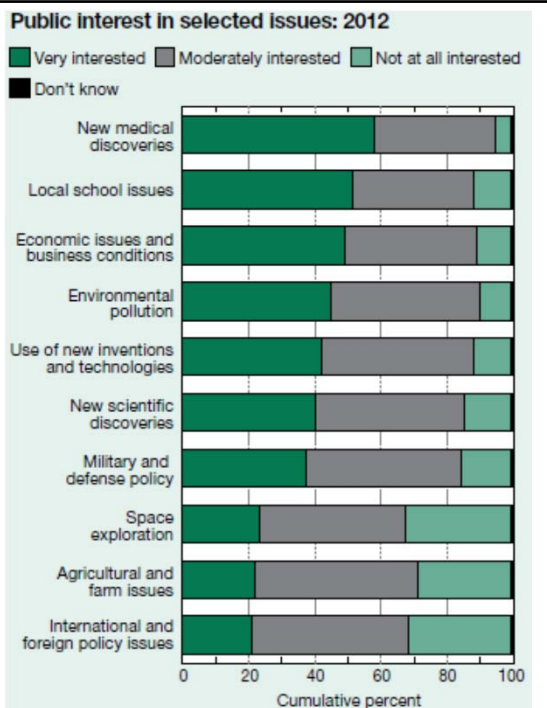
Will require additional effort in integrated-assessment methods and practice as well as in specifics of mitigation & adaptation options, along with increased integration of social & ecosystem sciences.

Related Challenges in Education & Communication

Public interest in environment

Behind the economy but way ahead of foreign policy!

National Science Board,
SCIENCE & ENGINEERING
INDICATORS 2014, Ch. 7



Public understanding about climate change

Benenson Poll Results, 1000 likely voters, January 2015

Q13. Which of the following best describes your view of climate change?

Climate change is a severe threat that we must start addressing now	48%
Climate change is an issue to address in the years ahead, but it's not urgent now	13%
Climate change may be happening, but it's a natural event that humans can't affect	31%
Climate change is not really happening	6%
Don't know	2%

Federal Government Opportunities & Initiatives

**“We will restore science to
its rightful place...”**

Barack Obama, January 20, 2009



OSTP, NSTC, and the USGCRP

NSTC is chaired nominally by the President, in practice by the OSTP Director.

The 4 principal NSTC committees are chaired by the respective OSTP Associate Directors.

Global Change Research: the USGCRP

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

COMMITTEE ON ENVIRONMENT & NATURAL RESOURCES		
AIR QUALITY RESEARCH (SC)	GLOBAL CHANGE RESEARCH/ CLIMATE CHANGE SCIENCE (SC)	US GROUP ON EARTH OBSERVATIONS (SC)
DISASTER REDUCTION (SC)	OCEAN SCIENCE & TECHNOLOGY (SC)	WATER AVAILABILITY & QUALITY (SC)
ECOLOGICAL SYSTEMS (SC)	TOXICS AND RISK (SC)	

COMMITTEE ON HOMELAND & NATIONAL SECURITY		
DECONTAMINATION STANDARDS TECHNOLOGY (SC)	FOREIGN ANIMAL DISEASE THREAT (SC)	NUCLEAR DEFENSE RESEARCH & DEVELOPMENT (SC)
DOMESTIC IMPROVED EXPLOSIVE DEVICES (SC)	HUMAN FACTORS (SC)	STANDARDS (SC)
ELECTRIC GRID VULNERABILITY (RWG)	INFRASTRUCTURE (SC)	

COMMITTEE ON SCIENCE		
AQUACULTURE (SC)	HUMAN SUBJECTS RESEARCH (SC)	RESEARCH BUSINESS MODELS (SC)
BIOTECHNOLOGY (SC)	LARGE SCALE SCIENCE (SC)	SCIENCE TO SUPPORT FOOD & AGRICULTURAL RESEARCH (TF)
DIGITAL DATA (RWG)	PHYSICS OF THE UNIVERSE (RWG)	SCIENTIFIC COLLECTIONS (RWG)
DOMESTIC ANIMAL GENOMICS (RWG)	PLANT GENOMICS (RWG)	SOCIAL, BEHAVIORAL, ECONOMIC SCIENCES (SC)
EDUCATION & WORKFORCE DEVELOPMENT (SC)	PRISON SCIENCE (RWG)	TRANSFORMER MOVEMENT OF RESEARCH MATERIALS (RWG)

COMMITTEE ON TECHNOLOGY		
AERONAUTICS (SC)	HYDROGEN & FUEL CELLS (RWG)	NANOSCALE SCIENCE, ENGINEERING & TECH. (SC)
BIOMETRICS & IDENTITY MANAGEMENT (SC)	INNOVATION & COMPETITIVENESS (SC)	NETWORKING & INNOVATION TECHNOLOGY (SC)
BUILDINGS TECHNOLOGY RESEARCH & DEV. (SC)	MANUFACTURING RESEARCH & DEVELOPMENT (RWG)	QUANTUM INFORMATION SCIENCE (TF)



Office of Science & Technology Policy
Executive Office of the President



The 13 agencies and departments in the US Global Change Research Program

Action on the energy-climate challenge

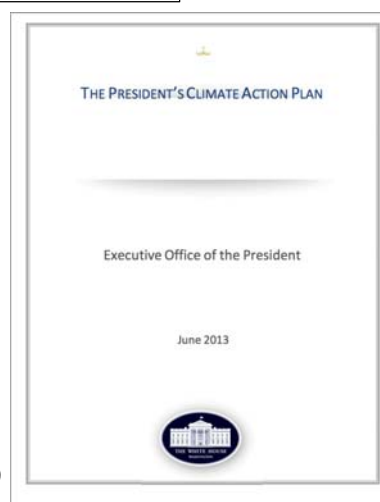
- \$80 billion for clean & efficient energy in the Recovery Act
- funding for Advanced Research Projects Agency – Energy (ARPA-E) and six new Energy Innovation Hubs
- first-ever fuel-economy/CO₂ tailpipe standards for light-duty vehicles, plus fuel-economy standards for trucks
- re-invigoration of US Global Change Research Program
- sustained budget increases for clean-energy & energy-efficiency R&D
- Quadrennial Technology Review QTR (2011, 2015) and Quadrennial Energy Review (phase 1 2014-15)
- Climate Action Plan (June 2013 to present)

The President's Climate Action Plan



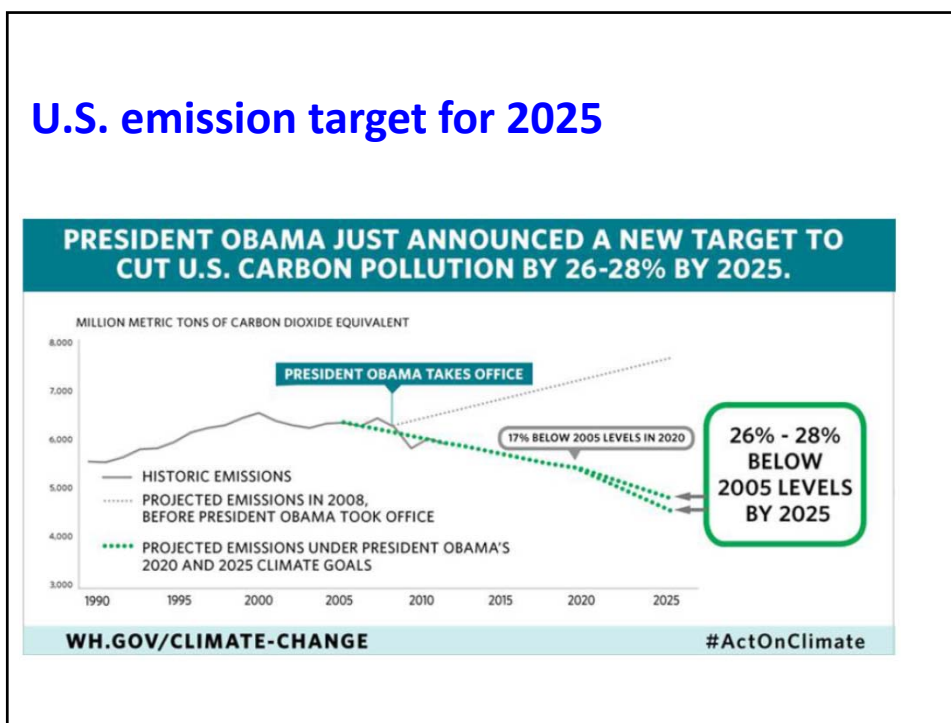
Georgetown University, June 2013

- Cutting carbon pollution in America (mitigation)
- Preparing the United States for the impacts of climate change (adaptation)
- Leading international efforts to address climate change



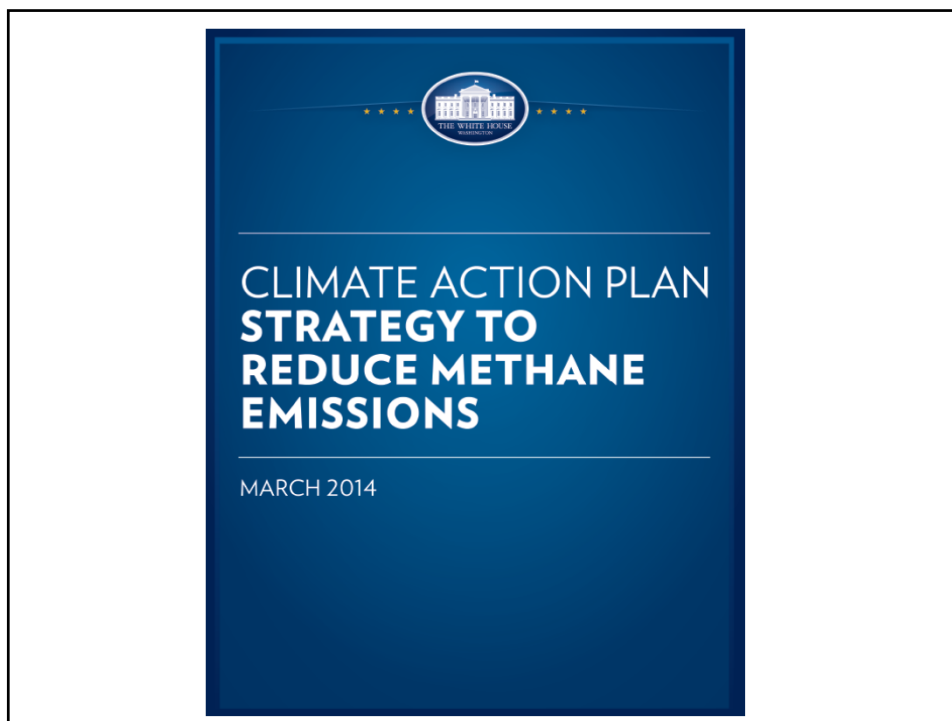
<http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf>

U.S. emission target for 2025



Progress: Climate-Change Mitigation

- Reducing carbon pollution from power plants
 - standards for cutting CO₂ from new power plants (Sept 2013)
 - and from existing power plants (June 2014)
- Reducing other greenhouse gases
 - interagency strategy to reduce methane emissions (March 2014)
 - EPA proposal on hydrofluorocarbons (July 2014)
 - 2025 target to reduce methane emissions from the oil and gas sector by 40-45% from 2012 levels along with various actions to reduce methane emissions going forward, including EPA regulation (January 2015)



Progress: Preparing for the Impacts of Climate Change

- Directing agencies to support climate preparedness/resilience
 - All agencies required to develop & implement plans for integrating climate preparedness/resilience into their missions, policies, programs, investments, and grants.
 - Agency plans were released in 10-14.
- Establishing internal & external task forces on resilience
 - Interagency Council on Climate-Change Preparedness & Resilience (~30 Federal agencies) and Working Groups established (11-13)
 - State, Local, & Tribal Leaders Task Force on Climate Preparedness & Resilience, comprising 26 elected officials from across the country; delivered recommendations to the Administration (11-14)

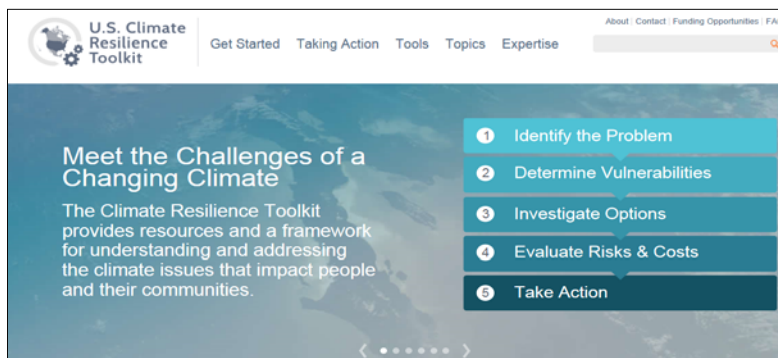
Progress: Preparing for the Impacts (continued)

- Managing flood, drought, & wildfire risks
 - National Drought Resilience Partnership (11-13)
 - 7 USDA Regional Agricultural Hubs for Climate-Change Mitigation & Adaptation (02-14)
 - USDA/ DOI National Cohesive Wildland Fire Management Strategy (04-14)
 - HUD \$1B National Disaster Resilience Competition (06-14)
 - Federal Flood Risk Management Standard (01-15)

Progress: Preparing for the Impacts of Climate Change

Mobilizing science and data for climate resilience

- Climate Data Initiative (03-14)
- 3rd U.S. National Climate Assessment (05-14)
- U.S. Climate Resilience Toolkit (11-14)



toolkit.climate.gov

Action on Managing Land, Water, and Biota

Better management starts with measurement

NATIONAL EARTH OBSERVATIONS STRATEGY

Executive Office of the President
National Science and Technology Council

JUNE 2012




NATIONAL PLAN FOR CIVIL EARTH OBSERVATIONS

PRODUCT OF THE
Office of Science and Technology Policy
Executive Office of the President




July 2014




REPORT TO THE PRESIDENT
SUSTAINING ENVIRONMENTAL
CAPITAL: PROTECTING SOCIETY
AND THE ECONOMY

Executive Office of the President
President's Council of Advisors
on Science and Technology

JULY 2011




- The government should institute and fund a Quadrennial Ecosystem Services Trend (QUEST) Assessment.
- OSTP and the State Department should lead in the development of the International Platform on Biodiversity and Ecosystem Services (IBPES)
- The \$10 billion spent annually by the USG on conservation & restoration should be reprogrammed to maximize protection of biodiversity and ecosystem services.
- Federal agencies with responsibilities related to biodiversity should be tasked to develop--and use in their policy-making--assessments of the value of affected ecosystem services.
- The NSTC should identify gaps in biodiversity inventories & ecological monitoring and develop strategies for filling them.



REPORT TO THE PRESIDENT ON
AGRICULTURAL PREPAREDNESS
AND
THE AGRICULTURE
RESEARCH ENTERPRISE

Executive Office of the President
President's Council of Advisors on
Science and Technology

DECEMBER 2012

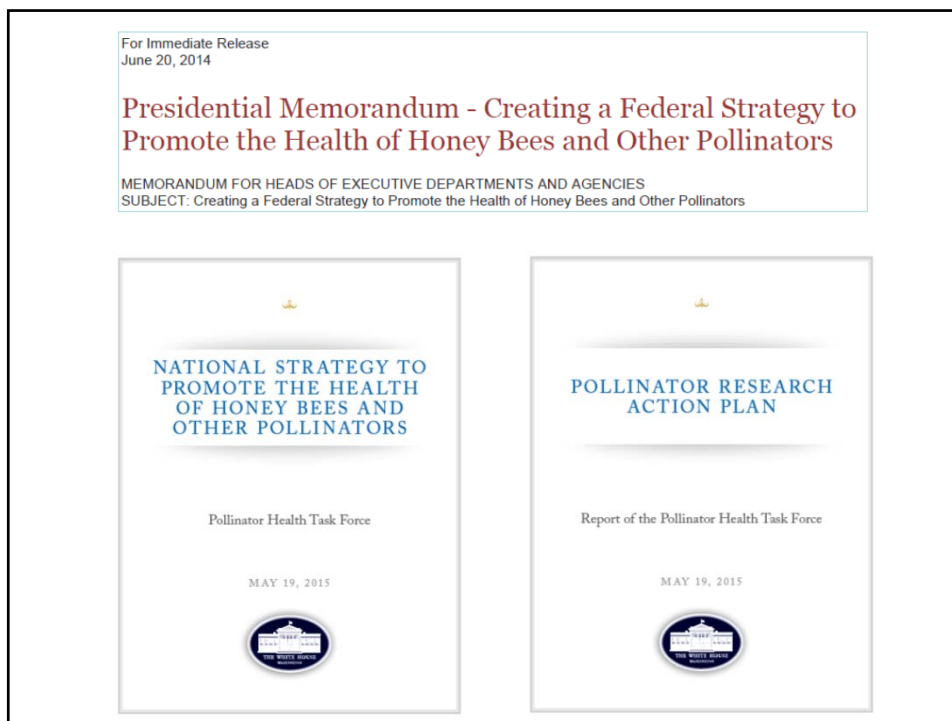


Addresses top seven scientific challenges for agriculture:

- Managing pests, pathogens, and invasive plants;
- Increasing the efficiency of water use;
- Reducing the environmental footprint of agriculture;
- Adapting to a changing climate; and
- Accommodating demands for bioenergy.

Calls for:

- Higher proportion of Federal agriculture research funds to be allocated through competitive grants;
- Rebalancing Federal research portfolio for less overlap with private sector and more focus on fundamental research and public-goods issues.



As a result of these reports..

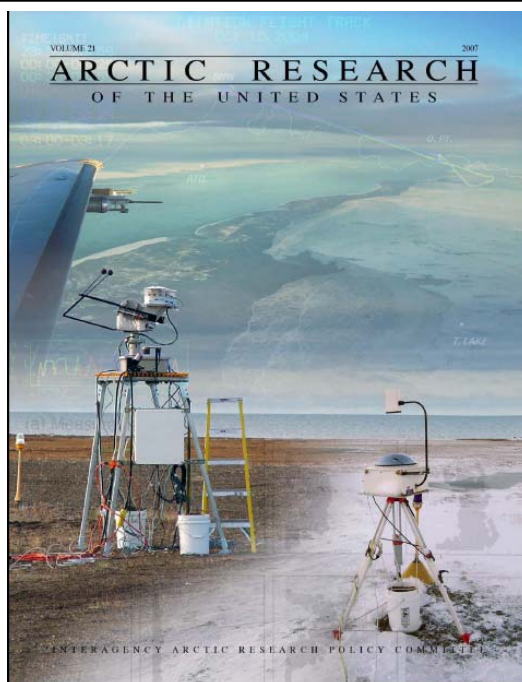
- U.S. Earth-observation satellite programs have been restructured with improved management and increased budgets (continuation dependent on Congress).
- There's \$550 million in the President's FY16 Budget for U.S. Department of Agriculture competitive grants, including \$450 million for competitively-awarded extramural research grants.
- There's \$82 million for a Pollinator Health Initiative (at USDA, EPA, and USGS).

Also on land / water / biota...

- The Administration is launching a multi-pronged initiative on the land-water-energy-agriculture-climate interaction (including collaborative efforts with China & India).
- A new research-funding thrust on microbiomes is under development.
- And research on and management of the Arctic as an integrated system is ramping up, with creation of a new interagency Arctic Executive Steering Committee and U.S. chairmanship for 2015-2017 of the 8-nation Arctic Council.

Arctic research: the Interagency Arctic Research Policy Committee

Engages NSF (lead), Agriculture, Commerce, Defense, Energy, EPA, HHS, Interior, Homeland Security, NASA, Nat'l Endowment for the Humanities, OSTP, Smithsonian, State, Transportation



Action on Protecting the Ocean

Action on the ocean: Signing the National Ocean Policy Executive Order (19 July 2010)



The 9 priority aims of the National Ocean Policy

- Four priority objectives to improve the way we do business:
 - ✓ Ecosystem-based management
 - ✓ Coastal and marine spatial planning
 - ✓ Inform decisions and improve understanding
 - ✓ Coordinate and support
- Five areas of special focus:
 - ✓ Regional ecosystem protection and restoration
 - ✓ Water quality and sustainable practices on land
 - ✓ Changing conditions in the Arctic Ocean
 - ✓ Ocean, coastal, and Great Lakes observations and infrastructure
 - ✓ Resiliency/adaptation to climate change and ocean acidification
- The NOP Implementation Plan has been through public comment and is in final revision

59 59



NATIONAL OCEAN POLICY IMPLEMENTATION PLAN

National Ocean Council

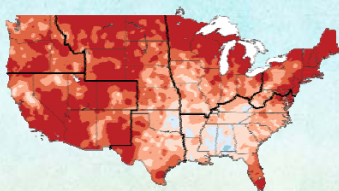
APRIL 2013

- Reduce coastal wetland loss
- Protect, conserve, and restore coastal and ocean habitats.
- Improve and conserve estuarine and coastal water quality.
- Strengthen and integrate ocean monitoring networks.
- Determine impacts of interacting stressors on ecological systems.
- Assess vulnerability to climate change and ocean acidification and develop and implement adaptation strategies.
- Establish collaborative framework & shared goals for ecosystem-based management.
- Strengthen coastal & estuarine restoration efforts.
- Protect sufficient habitat to ensure maintenance of ecosystem processes.
- Use increased monitoring & better forecasts to improve preparedness.

Action on Ecosystem-Science Education & Communication

Third National Climate Assessment

Climate Change Impacts in the United States



Dr. John P. Holdren

Assistant to the President for Science & Technology
Director, White House Office of Science & Technology Policy

October 1, 2014



Mandate & Process for the 3rd NCA

- Quadrennial National Climate Assessments mandated by 1990 Global Change Research Act; 1st assessment completed in 2000, 2nd in 2009.
- Prepared for Congress & the President with oversight by the US Global Change Research Program
- Directed by a 60-member Federal Advisory Committee
 - housed in NOAA, with a Technical Support Unit at the NCDC
 - harnessing 300 authors
 - entailing a multistage comment & review process that drew on the public, USGCRP agencies, and the National Academies

Date: | Name of Meeting:

63

Results of the 3rd NCA

- “Actionable science” showing how climate change is already affecting people where they live and work, what can be expected going forward, and what kinds of actions can reduce vulnerability and harm
- Provides unprecedented granularity on changes and impacts by geographic regions and economic sectors
- Underscores and updates findings of previous studies:
 - Global climate is changing in unnatural ways
 - Human activities are the main cause
 - Harm is happening now
 - How much more harm occurs depends on what we do

Date: | Name of Meeting:

64

The Climate Education and Literacy Initiative

- Launched in December 2014
 - Goal: enhance climate literacy of students and citizens across the United States
 - Commitments announced at the launch came from Federal agencies as well as academic and non-governmental entities
- Champions of Change for Climate Education and Literacy
 - Event held in February 2015 to honor leaders in climate education
 - Included roundtables with students and educators to hear their ideas on how we can collectively lift our game in climate education



Early Federal Progress on the Initiative

- Ongoing climate-science workshops for educators through NOAA Climate Stewards Education Project
- National Park Service (NPS) is developing a National Climate Change Interpretive Plan to assist employees, volunteers, and other partners in effectively conveying climate change concepts to Park visitors.
- Announcement of new challenge on teaching climate and energy through 100Kin10, NOAA, NASA, and DOE
- Sustainability and climate-preparedness training being developed for Federal Senior Executive Service and other Federal leaders
- DOE working with Association of Science-Technology Centers, The Wild Center, and the Alliance for Climate Education to develop Youth Climate Summits across the country and internationally

Climate Action Plan Resources for Educators

- Third National Climate Assessment
 - <http://nca2014.globalchange.gov>
 - Special page for educators: <http://www.climate.gov/teaching/2014-national-climate-assessment-resources-educators>
- Climate Data Initiative
 - <http://climate.data.gov> – climate data relevant to coasts, food, ecosystems, water, health, and other sectors – could be used by students and educators
- Climate Resilience Toolkit
 - <http://toolkit.climate.gov> – information, tools, training resources
- Quadrennial Energy Review
 - Focuses on energy infrastructure and identifies threats, risks, and opportunities for U.S. energy and climate security
 - <http://energy.gov/epsa/quadrennial-energy-review-qer>



<http://www.ostp.gov>