

# America's CLIMATE CHOICES

AT THE NATIONAL ACADEMIES



NATIONAL RESEARCH COUNCIL  
OF THE NATIONAL ACADEMIES



## Adapting to the Impacts of Climate Change



America's  
CLIMATE  
CHOICES



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<http://americasclimatechoices.org>

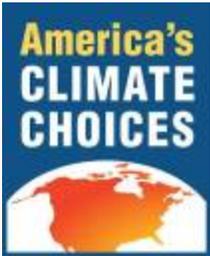
THE NATIONAL ACADEMIES

*Advisers to the Nation on Science, Engineering, and Medicine*



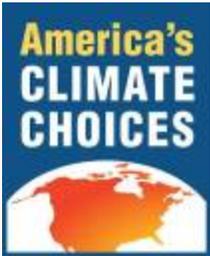
# The National Academies

- A private, non-profit organization charged to provide advice to the Nation on science, engineering, and medicine.
- National Academy of Sciences (NAS) chartered in 1863; The National Research Council (NRC) is the operating arm of the NAS, NAE, and IOM.
- NRC convenes ad hoc committees of experts who serve pro bono, and who are carefully chosen for expertise, balance, and objectivity
- All reports go through stringent peer-review and must be approved by both the study committee and the institution.
- Full text and PDF summaries of reports available at <http://americasclimatechoices.org>



## Request from Congress

“...investigate and study the serious and sweeping issues relating to global climate change and make recommendations regarding what steps must be taken and what strategies must be adopted in response to global climate change, including the science and technology challenges thereof.”

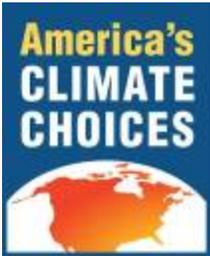


## NRC Study “America’s Climate Choices”

What can be done to:

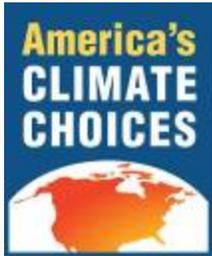
- **Limit** the magnitude of climate change?
- **Adapt** to the impacts of climate change?
- **Advance the science** of climate change?
- **Inform effective decisions** about climate change?

*A final report* will look across the realms of all four panels



## Charge to the 'Adapting' Panel

- What short-term actions can be taken to adapt effectively to climate change?
- What promising long-term strategies, investments, and opportunities could be pursued to adapt to climate change?
- What are the major scientific and technological advances needed to promote effective adaptation to climate change?
- What are the major impediments to effective adaptation to climate change, and what can be done to overcome these impediments?
- What can be done to adapt to climate change at different levels and in different sectors?



## Panel Membership

**Katharine L. Jacobs** (*Co-Chair*), Arizona Water Institute\*

**Thomas J. Wilbanks** (*Co-Chair*), Oak Ridge National Laboratory

**Bruce Baughman**, IEM, Inc.

**Roger N. Beachy**, Donald Danforth  
Plant Science Center\*

**Georges C. Benjamin**, American  
Public Health Association

**James L. Buizer**, Arizona State University

**F. Stuart (Terry) Chapin III**, University  
of Alaska

**W. Peter Cherry**, Science Applications  
International Corporation

**Braxton Davis**, South Carolina Dept.  
of Health and Environmental Control

**Kristie L. Ebi**, IPCC Technical Support Unit  
WGII

**Jeremy Harris**, Sustainable Cities Institute

**Robert Kates**, Independent Scholar

**Howard Kunreuther**, University of  
Pennsylvania, Wharton School of Business

**Linda Mearns**, National Center for  
Atmospheric Research

**Philip Mote**, Oregon State University

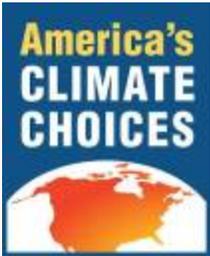
**Andrew Rosenberg**, University of New  
Hampshire

**Henry G. Schwartz, Jr.**, Jacobs Civil (retired)

**Joel B. Smith**, Stratus Consulting, Inc.

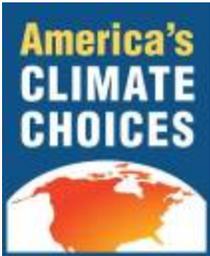
**Gary Yohe**, Wesleyan University

\*resigned during the study process to take policy-making position in federal government

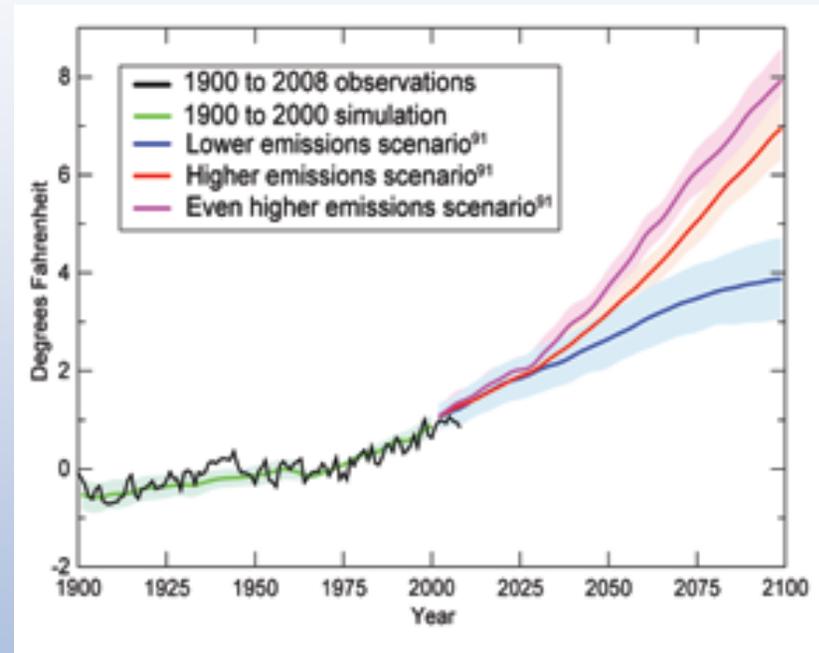
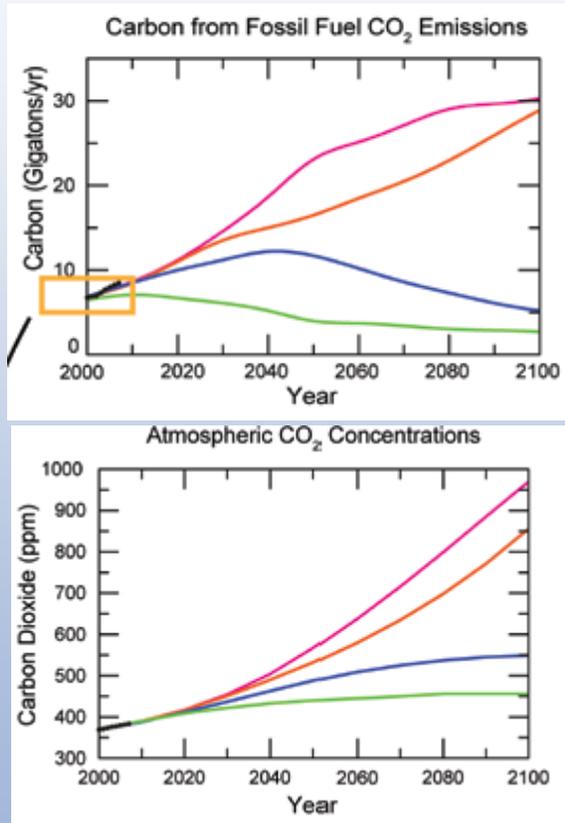


# Characteristics of Change

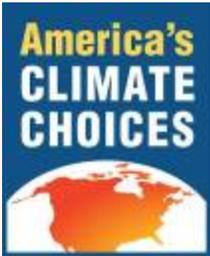
- Place - based
- Highly Variable
- Certain that impacts and vulnerability will occur, but their magnitude is less certain because of:
  - the manifestation of climate change and
  - policy decisions that are taken here and abroad
- It follows that responses must be iterative and responsive to new information.



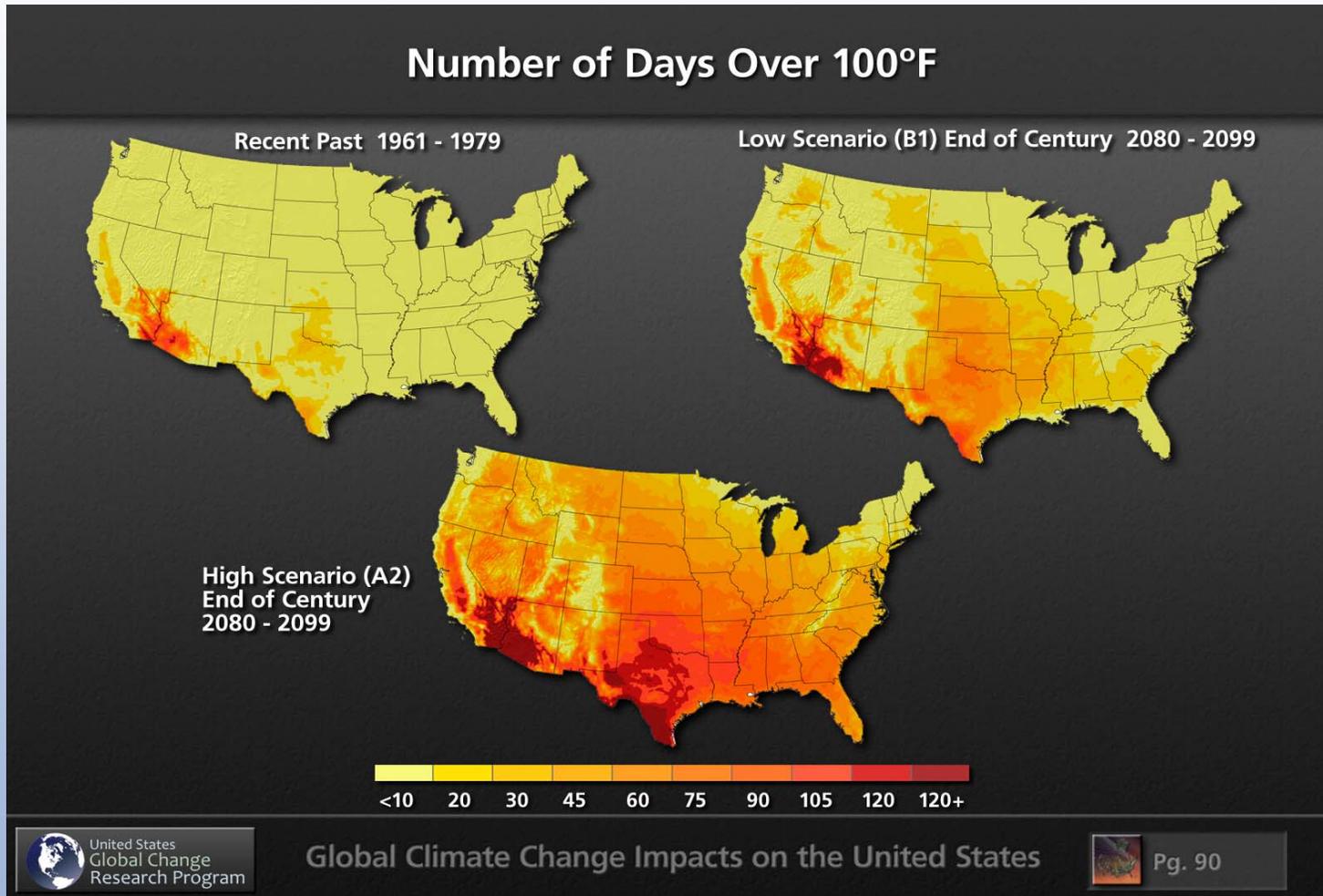
# Two Representative Futures: High and Low Emissions (SRES)

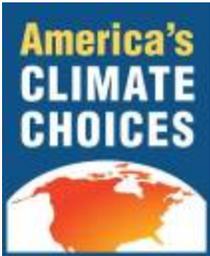


Source: USGCRP (2009); pg. 23.



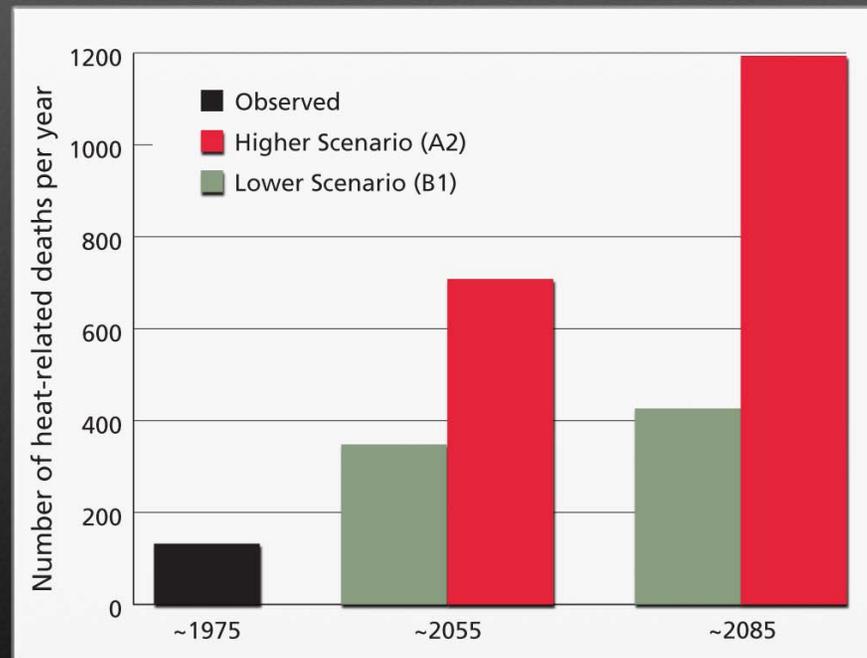
# For example: The Number of Days over 100°F

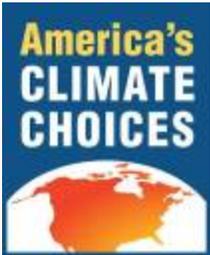




# Representative Implications

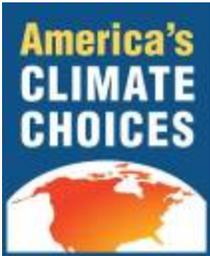
Projected Increase in Heat-Related Deaths in Chicago



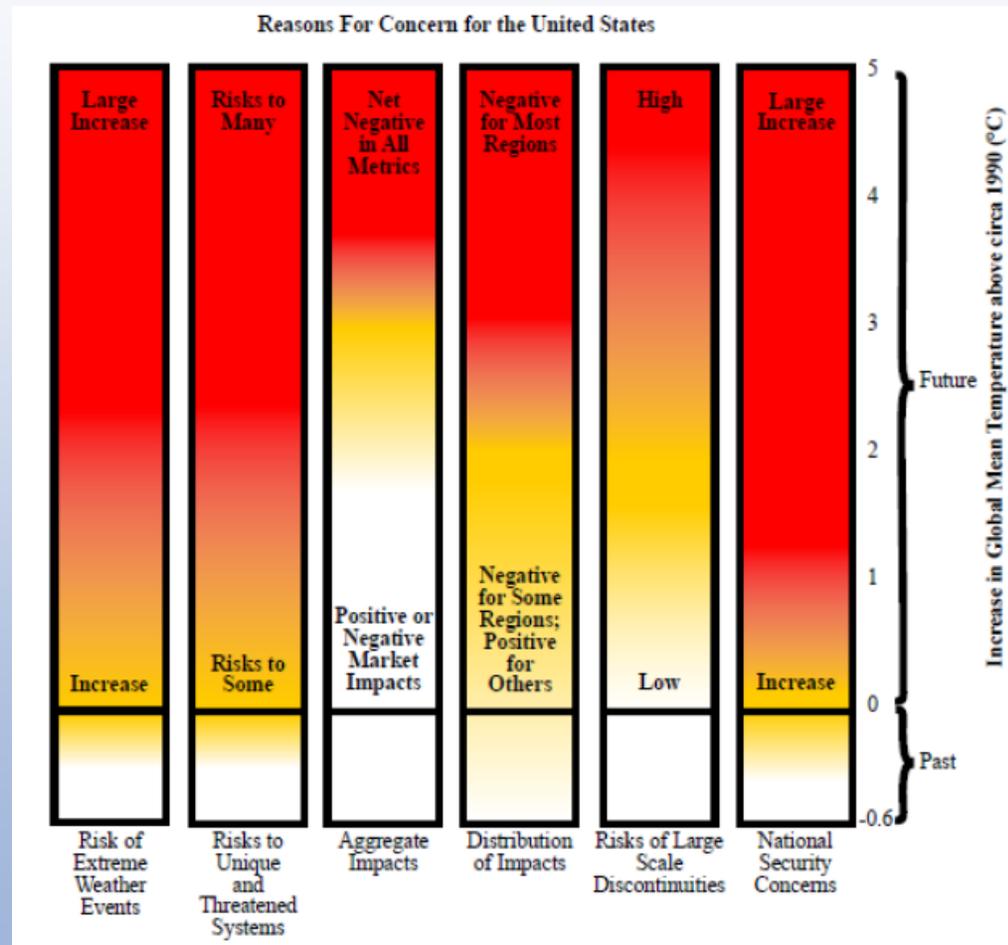


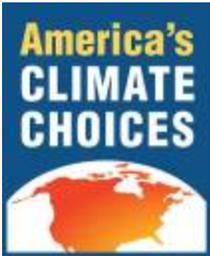
# Geographic Diversity

United States Census Regions	Climate-Related Impacts								
	Early Snowmelt	Degraded Air Quality	Urban Heat Island	Wildfires	Heat Waves	Drought	Tropical Storms	Extreme Rainfall with Flooding	Sea Level Rise
<b>New England</b> ME VT NH MA RI CT	•	•	•		•	•		•	•
<b>Middle Atlantic</b> NY PA NJ DE MD	•	•	•		•	•	•	•	•
<b>East North Central</b> WI MI IL IN OH	•	•	•		•	•		•	
<b>West North Central</b> ND MN SD IA NE KS MO	•		•		•	•		•	
<b>South Atlantic</b> WV VA NC SC GA FL DC		•	•	•	•	•	•	•	•
<b>East South Central</b> KY TN MS AL			•		•	•	•	•	•
<b>West South Central</b> TX OK AR LA		•	•	•	•	•	•	•	•
<b>Mountain</b> MT ID WY NV UT CO AZ NM	•	•	•	•	•	•		•	
<b>Pacific</b> AK CA WA OR HI	•	•	•	•	•	•	•	•	•



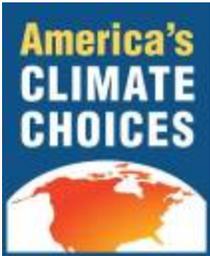
# An Alternative Representation: Reasons for Concern





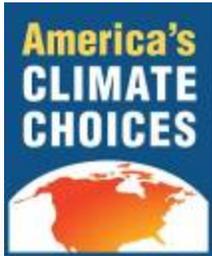
# What Can We Do?

- **All of us: adopt a risk management approach as a strategy for preparing ourselves for an uncertain future:**
  - **Consider a range of possible future climate conditions in adaptation planning**
  - **Identify adaptation options to reduce vulnerabilities**
  - **Implement adaptations that make sense now**
  - **Become more adaptive in planning for the future**



# The Adaptation Panel Offers Some Suggestions

Climate change	Impact	Possible adaptation action	Federal	State	Local govt.	Private sector	NGO / Individ.
Higher temperature and reduced precipitation	Insufficient water supplies	Enhance supplies through traditional supply approaches including dams, larger reservoirs and other storage facilities, importing water or transferring water between basins (IPCC4; IPCC3; CALI; NRC). Other approaches include increasing system redundancy to ensure backup supplies, sharing integrated facilities between jurisdictions and sectors, obtaining a portfolio of multiple sources of water, including reuse of municipal wastewater (IPCC4; IPCC3; USGS; NRC; CCAWS)	■	■	■		
		Purchase alternative supplies through water trading and exchange (USGS; IPCC4). Store water during wet years or seasons (conjunctive management).		■	■	■	
		Participate in water supply protection through watershed management, including protecting surface water sources and groundwater recharge zones	■	■	■	■	■
		Encourage water harvesting and gray water use (NRC; IPCC4; CALI; IPCC3). Design sites to minimize water requirements (e.g. low water use landscaping) and retain gray water and storm water on site for landscape purposes (NRC; CALI; IPCC4)	■	■	■	■	■
		Regulate water use more stringently, restrict specific uses of water, adopt best practices for conservation and demand management in all sectors (CALI; CUWCC; IPCC3; IPCC4; NRC; USGS; CCAWS)	■	■	■	■	■
		Consider reform of water allocation by: allocating a percentage of available supplies rather than a fixed volume, establishing a water rights entitlement for the environment, downsizing or abolishing parts of a system, updating monitoring and accounting of water rights systems, creating market reforms to allow interstate trading, and compensating rights holders and assisting in transition (FPB)	■	■	■	■	■
		Design pricing policies to encourage water conservation and to respond to drought or long-term storage conditions (CCAWS)	■	■	■	■	
	Inadequate water for ecosystems	Use water banking and other market mechanisms to augment supplies, regulatory or incentive programs to protect or enhance instream flows to support habitat, environmental mitigation programs to offset damage caused by new projects, contracts to access water during dry years, etc. to ensure supply (USGS; IPCC4)	■	■	■	■	■
		Revise/update environmental regulations to facilitate resolution of competing demands for water in light of changing conditions, e.g. adaptive management	■	■	■		
		Purchase water rights for environmental protection (5-1)		■	■	■	■
Decreased snow pack in West and Northeast	Enhance reservoir storage and aquifer storage capacity, reoperation of reservoirs, water transfers, vegetation management to enhance water storage and manage timing of runoff from watersheds	■	■	■			



## Short-term Options

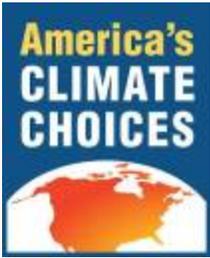
### Ecosystem & Changes in Hydrologic Cycle

Less precipitation/droughts:

- Manage for high water-use efficiency & drought-tolerant species in drought areas;
- Establish guidelines to protect against stream drying;

Heavier precipitation:

- Plant flood-adapted species to reduce peak flows & erosion;
- Manage reservoir releases to provide cold water downstream;
- Reforest riparian areas with native species to create shaded thermal refuges



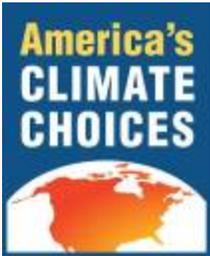
## Short-term Options



### Energy Sector & Changes in Hydrologic Cycle

Less precipitation/droughts:

- Develop electric power generation strategies that are less water-consuming;
- Establish incentives for water conservation in energy systems;



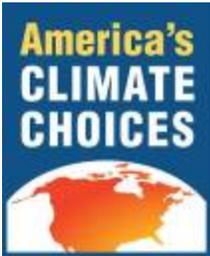
## Short-term Options



### Coasts & Changes in Hydrologic Cycle

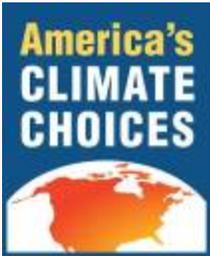
Heavier precipitation/increased flooding:

- Improve stormwater management systems and infrastructure;
- Improve storm readiness for harbors and marinas;
- Eliminate public subsidies for future development in high hazard areas along the coast;
- Use natural shorelines, setbacks, and buffer zones to allow inland migration of shore habitats and barrier islands over time;



## Synergies and Trade-offs

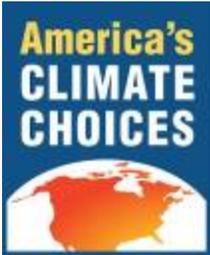
- Water issues illustrate synergies/trade-offs across sectors;
- Pest management in agriculture (avoid elimination of natural predators or increase diversity of natural predators);
- Most improvements to ecosystem services have co-benefits for human health (vice versa)
- Reducing costs and increasing reliability of electricity reduce socio-economic vulnerability
- Mitigating for shore erosion and flooding benefits all sectors (urgency increased with SLR)
- Land-use planning can reduce GHG emissions



## Choosing and Implementing Short-term Options

- Low-cost and easily deployed
- Offering co-benefits (e.g., limit GHG emissions and reduce vulnerability, or meet other sustainability goals, etc.)
- End or reverse maladapted policies and practices
- Avoid narrowing future adaptation options





## Early experience of climate change planning & actions

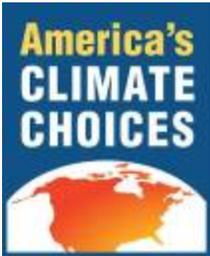


### Actions taken by urban leaders

- Chicago, IL
- King County, WA
- Los Angeles, CA
- Miami Dade County
- Milwaukee, WI
- Nassau County, NY
- New York City
- Phoenix, AZ
- San Francisco, CA

Image: Mississippi River Delta NASA  
<http://www.nasaimages.org/luna/servlet/detail/nasaNAS~10~10~82943~18916>  
1:Mississippi-River-Delta

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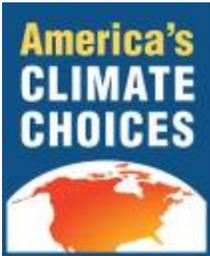


## Early experience of climate change planning & actions



### Example 1: Gulf Coast

- At risk from sea level rise and storm surges;
- Great social vulnerabilities;
- Many stressors and risks mutually reinforcing;
- Short-term flood control measures result in greater long-term vulnerability (i.e. maintaining status quo might increase long-term risk);
- Long-term adaptation builds relocation into smart-growth plans;
- Remove incentives for maladaptation.

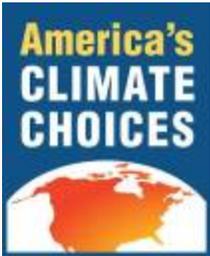


## Early experience of climate change planning & actions

### Example 2: Alaska

- Coastal and River communities experience erosion;
- Due to these risks communities are planning to relocate;
- Serious institutional barriers prevent progress;

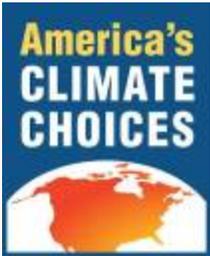




## Lessons Learned

- Great leadership or urgency is need to initiate comprehensive climate change planning (e.g., NYC leadership or Alaska urgency)
- Address multiple interacting stresses and time scales of response
- Avoid maladaptation and foreclosure of future options
- Monitor results and manage adaptively

Successful plans/actions tend to integrate adaptation planning into programs that address broader societal goals

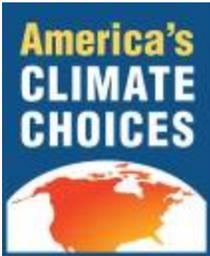


## Adapting in the Longer-Term Is Likely to Face Bigger Challenges:

**Some climate changes might require transformational adaptations such as:**

- **Movements of people and facilities away from vulnerable areas**
- **Changes in ecosystem and land management**

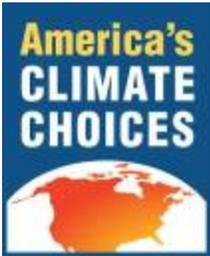
**Managing risks for the long term calls for contingency planning for relatively severe impacts, combined with monitoring and research strategies**



## Adapting in the Long-term (I)

Adopt a risk management approach as an insurance policy against an uncertain future

- Consider a range of possible future climate conditions in adaptation planning
- Identify vulnerabilities to climate changes
- Identify adaptation options to reduce vulnerabilities
- Implement adaptations that make sense now
- Become more adaptive in planning for the future

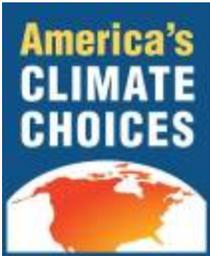


## Adapting in the Long-term (II)

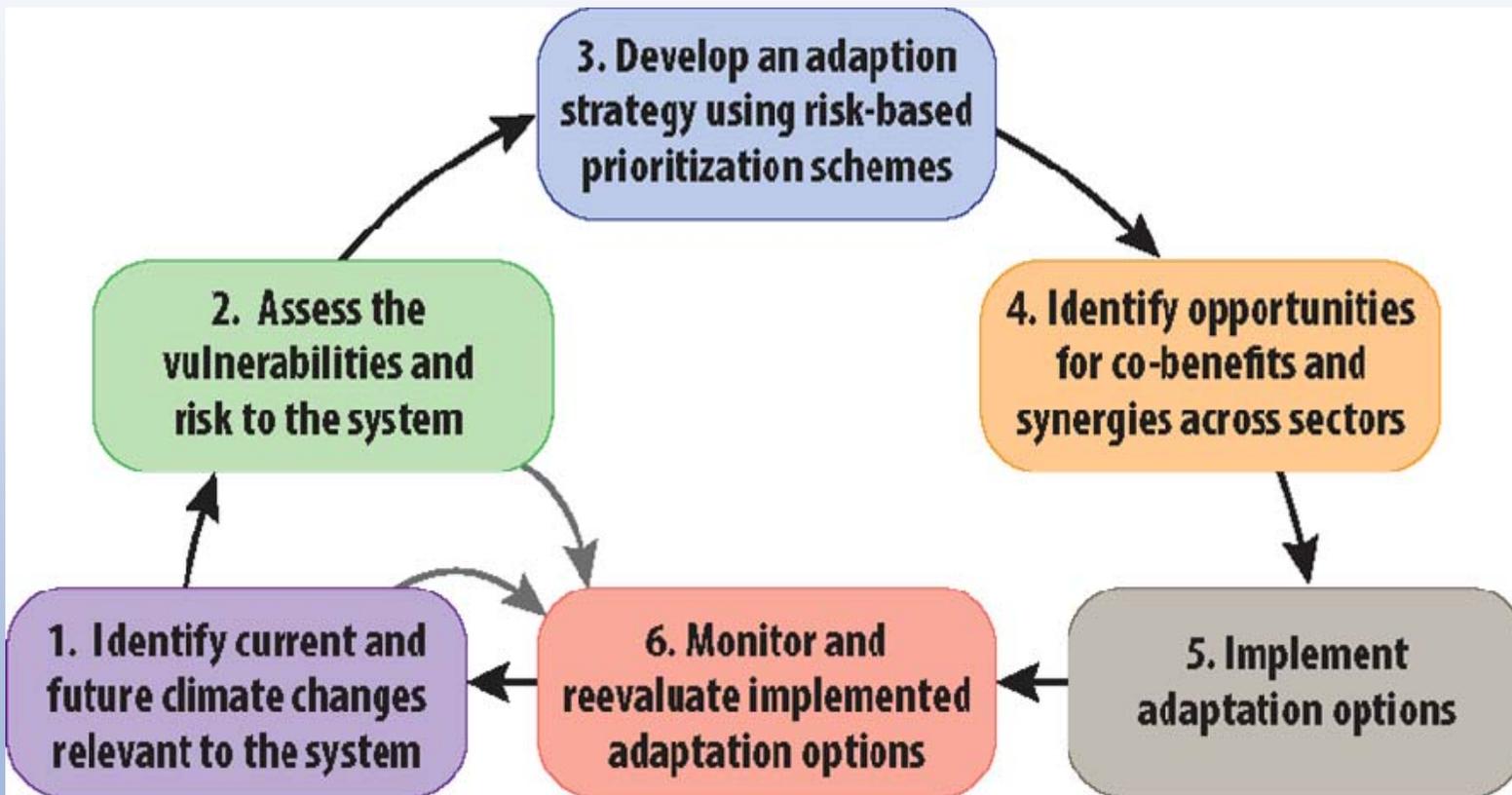
Adaptation is an ongoing process that involves:

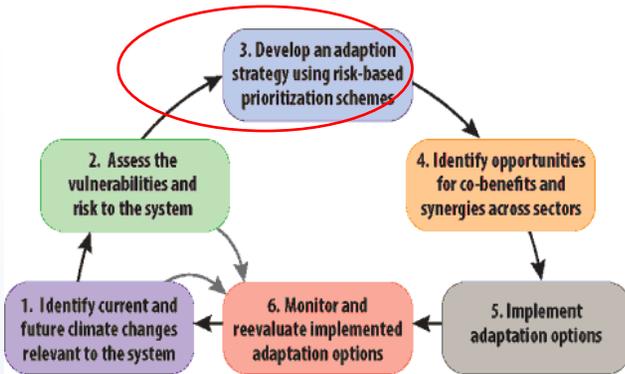
- Improving information systems about impacts and adaptation
- Working across institutional and social boundaries
- Improving institutions and policies
- Reviewing regularly the effectiveness of current risk management strategies

Effective adaptation **combines** a strong federal government adaptation program with grassroots-based, bottom-up efforts to capture the ingenuity and uniqueness of local adaptations while coordinating and communicating these efforts at a national level.



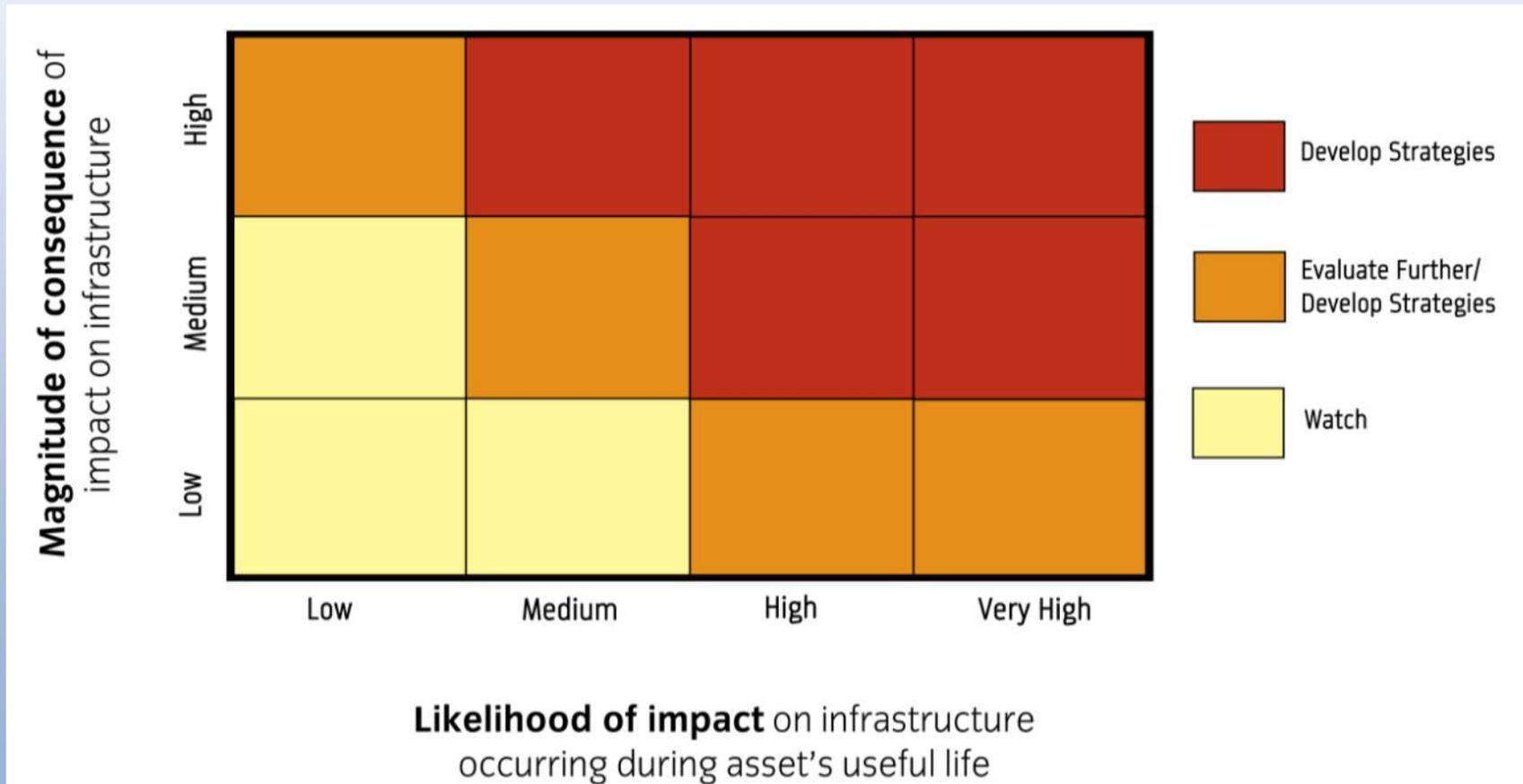
## Adapting in the Long-term: A Risk Management Approach

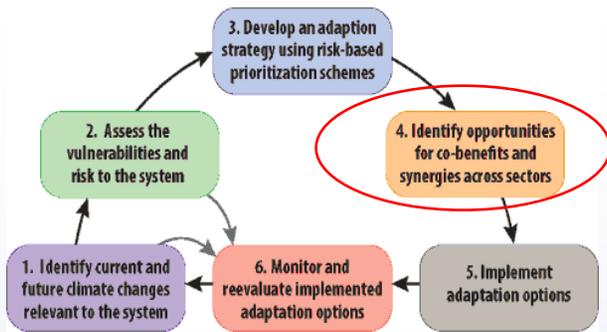




## Adapting in the Long-term: A Risk Management Approach

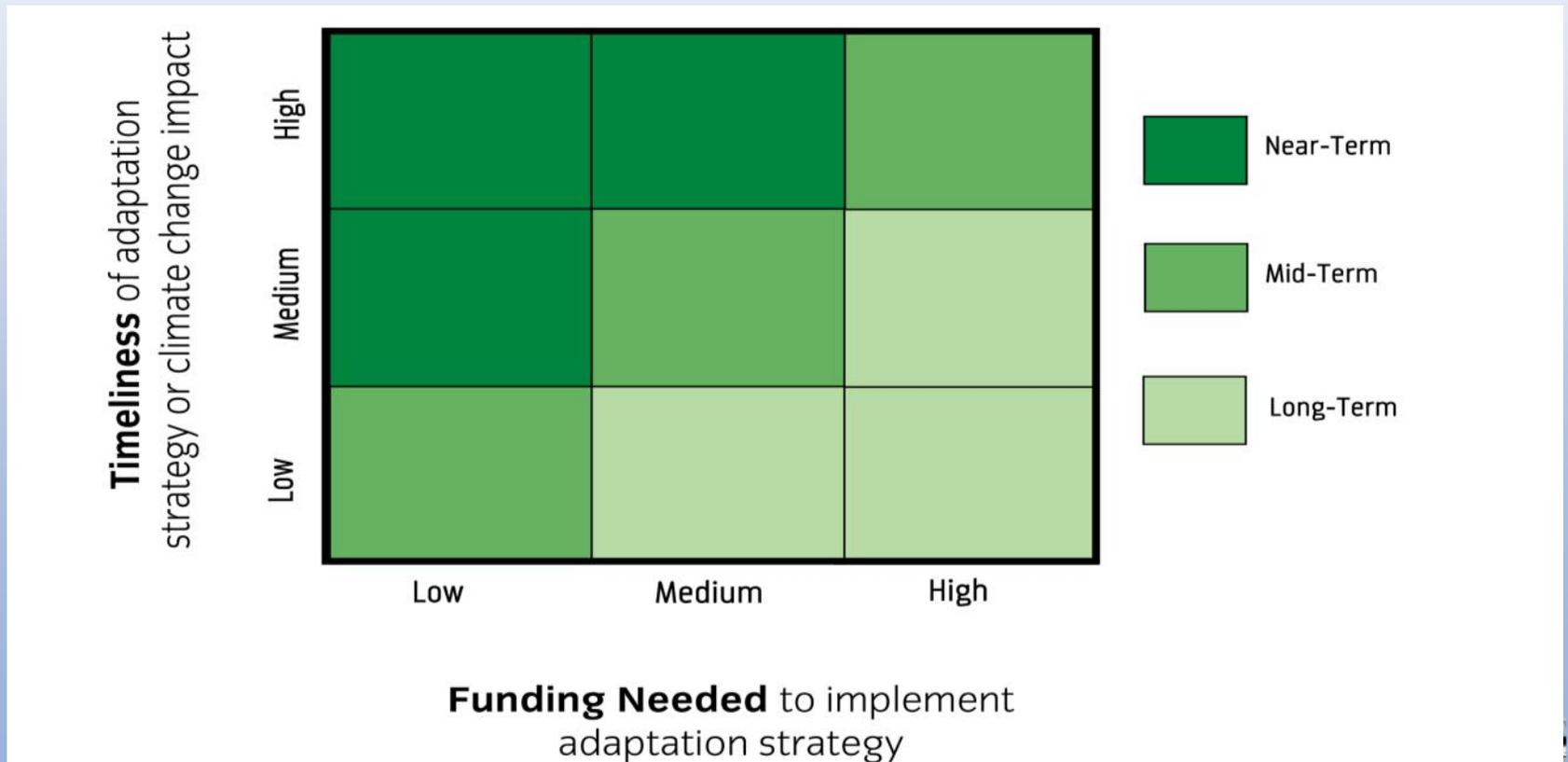
2 & 3. Choose and prioritize adaptation according to risk;

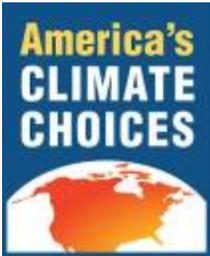




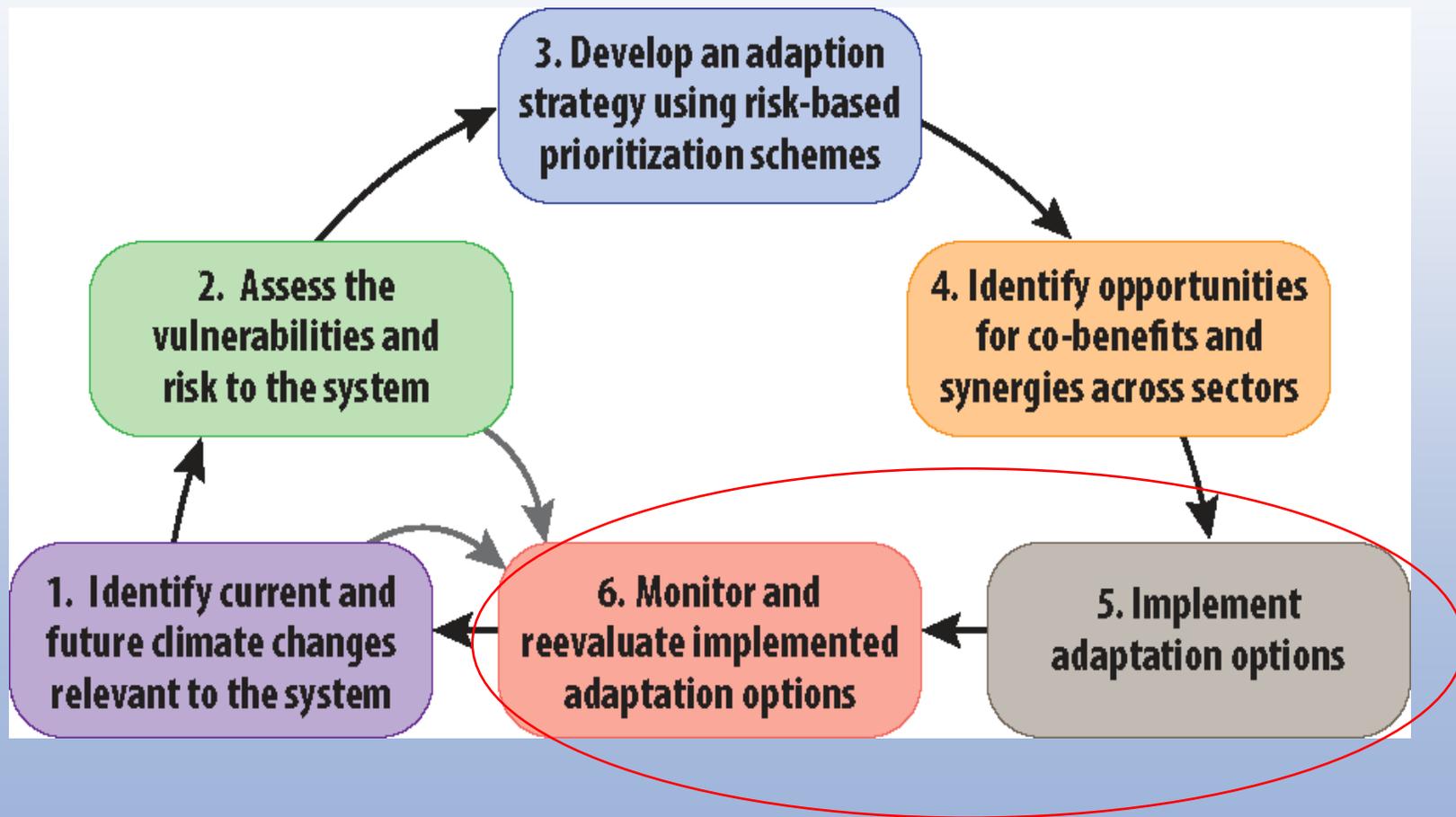
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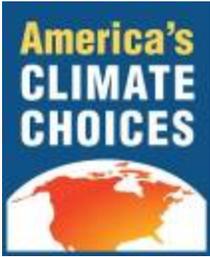
### 4. Identify opportunities for co-benefits and synergies across sectors;





# Adapting in the Long-term: A Risk Management Approach

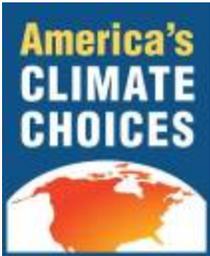




## The Panel also Recognized Challenges

### Adaptation options:

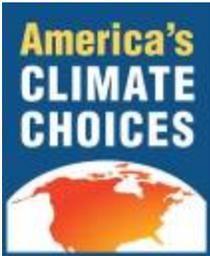
- **Attribution:** difficult to document effects of adaptation in reducing impacts.
- **Diversity:** adaptation is context and place specific
- **Knowledge base:** limited research on adaptation
- *Therefore, it is difficult to evaluate costs, benefits and effectiveness of specific measures.*



## Moving Toward A **National** Strategy:

**Effective adaptation will combine a strong federal government adaptation commitment with grassroots-based, bottom-up efforts to capture the ingenuity and uniqueness of local adaptations while coordinating and communicating these efforts at a national level.**

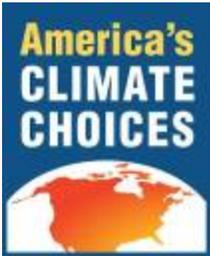
- **Engage decision-makers and stakeholders across the branches and scales of government, sectors, and other parts of U.S. society**
- **In a true nation-wide partnership**
- **To set the framework and direction for a national adaption program, drawing on what each party does best**
- **Including re-examining current policies that may inhibit adaptation**



## Moving Toward A **National** Strategy:

### Roles of the federal government:

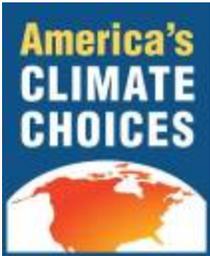
- **Facilitate cooperation and collaboration across different levels of government and between government and other parties**
- **Provide technical and scientific resources to the range of parties carrying out vulnerability assessments and adaptation planning**
- **Re-examine policies that may inhibit adaptation**
- **Support scientific research in climate change adaptation to strengthen risk management: better options, better information about options, better tools for informing decisions**
- **Practice adaptation in its own programs**



# National Adaptation Strategy

## Role of state and local governments:

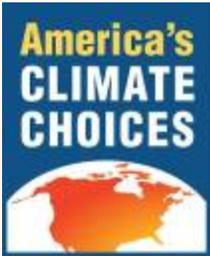
- Make most key decisions about resources and land-use planning
- Prepare for and responding to natural disasters
- Assess vulnerabilities to climate change
- Plan and implement adaptation options (as most adaptation is local)
- Build and share knowledge base for future adaptation
- Engage and coordinate with federal government



# National Adaptation Strategy

## Role of NGOs and private sector:

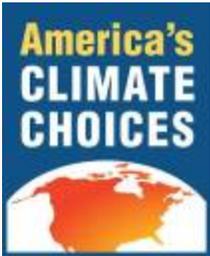
- Voluntary adaptation by private sector provides opportunity to learn.
- Private sector might have greater adaptive capacity.
- Consulting companies provide adaptation knowledge.
- NGOs are key partners in developing adaptation knowledge and experience.



## Moving Toward A **National Strategy**:

**Any national adaptation program that emerges from the Strategy will itself need to be adaptive:**

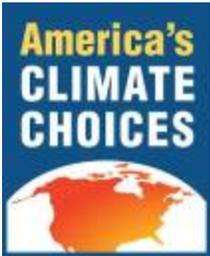
- **Responding to changing conditions**
- **Informed by ongoing information collection and dissemination about climate change impacts and adaptation experiences**
- **Working across institutional and social boundaries**
- **Reviewing on a regular basis the effectiveness of current risk management strategies**



## R&D Priorities for a **National** Adaptation Strategy (I):

**We have a painfully limited base of knowledge about adaptation to climate *change*:**

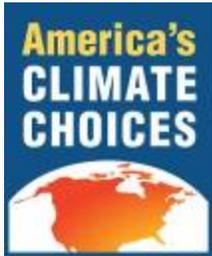
- **Need to improve capacities for *adaptation analysis and assessment*, e.g.:**
  - **Improved knowledge of likely impacts and vulnerabilities**
  - **Improved understandings of multiple stressors, impact thresholds, behavioral dimensions of adaptation, and cross-sectoral interactions**
- **Need to improve our *menu of options and our knowledge of their costs, benefits, potentials, and limits***
  - **Sectoral priorities**
  - **Information about successes and best practices**



## R&D Priorities for a **National** Adaptation Strategy (II):

**Need to improve our knowledge about *how to implement and manage adaptation*, e.g.:**

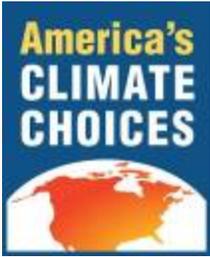
- **Deploying and using systems to monitor emerging climate change impacts and emerging adaptation experiences to inform reassessments of risk management strategies**
- **Paying particular attention to possible needs for “transformational” adaptations if climate change is relatively severe, including contingency planning for options that are not currently considered feasible: retreats from vulnerable areas? possible revision of water rights policies?**



# R&D Priorities for a **National** Adaptation Strategy (III):

Some possible guidelines for meeting Science & Technology needs for climate change adaptation:

- Involve a wide range of S&T users and stakeholders in setting research agendas
- Meet R&D needs through multiple contributors, not just the federal government: a *national* strategy, not a *federal* strategy
- Encourage the co-evolution of science and experience
- Encourage, inform, and utilize *autonomous* adaptation as well as *planned* adaptation



# For more information:

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Report is available online at [www.nap.edu](http://www.nap.edu).