Adaptation to Climate Change: a rich and urgent research agenda

Rosina Bierbaum
October 15, 2008
NCAR Annual meeting
Climate Change: What do we know?

- Past is not prologue...and the pace of change is quickening
  - Infrastructure and natural resource management and planning based on the last 100 years of climate will be wrong
  - Design features of infrastructure and tolerances of species will be exceeded

- Committed to further climate changes
  - Adaptation is occurring, even if unplanned

- Degree of warming matters
  - Mitigation makes a difference

- It's not just the averages that matter...
  - Regional and local variances; seasonal changes; Extreme events

- Need a Portfolio Approach:
  - Adaptation and Mitigation—but there are interlinkages across the two!

- Adaptive Management is needed
  - In all sectors and regions

- Investment is not commensurate with the urgency of the problem...
  - Need integrative regional assessments involving stakeholders
  - Need prioritization of policy-relevant research needs across fields, not laundry lists
  - Need transformational not evolutionary change
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We are REALLY not addressing these!!!
Global average temperature is rising at an accelerating rate.
GLOBAL WARMING: Early Warning Signs

- Fingerprints and Harbingers
  - Heat waves and periods of unusually warm weather
  - Sea level rise and coastal flooding
  - Glaciers melting
  - Arctic and Antarctic warming
  - Spreading disease
  - Earlier spring arrival
  - Plant and animal range shifts and population decline
  - Coral reef bleaching
  - Downpours, heavy rainfalls and flooding
  - Droughts and fires

Reference website: http://www.climatehotmap.org

I. Risks to Unique and Threatened Systems
II. Risks from Extreme Climate Events.
III. Distribution of Impacts.
IV. Aggregate impacts.
V. Risks from Future Large-scale Discontinuities.

(IPCC, WG2, final 2001 and draft 2007, Modified from I. Burton, 2007)
Parry, et al., 2008
Negotiating conundrums

• How can sustainable development be enhanced while tackling climate change?
  • How can we deal with increasing competition for land, water, and water?
• How can we stop at a 450-550 ppm world?
  • A global deal? Or not? By when?
  • Where can innovation get us in the next 20-30 yrs? What is needed? What are people willing to do?
• Will we have or can we create ‘teachable moments’ & ‘transformative times’?
Development public R&D expenditure (in OECD)

Source: Doornbosch, 2006
Development private R&D expenditure (in OECD)

Source: Doornbosch, 2006
U.S. DOE Energy RD&D
1978-FY2009 Administration Request

Kelly Sims-Gallagher, Havard, 2008
The near-term challenge of scale

CO₂ Storage—550 ppm Stabilization Case

Monitored CO₂ Storage Today 2020 (550 ppm)
CO$_2$ Storage—550 ppm Stabilization Case

The mid- and long-term the challenge
Climate Change Funding by Agency from FY89 to FY08, Constant 2005 Dollars

Fiscal Year

Funding Amounts by Millions of Dollars
0 500 1000 1500 2000 2500

Legend:
- SI
- NSF
- NASA
- EPA
- USAID
- DOT
- DOI / USGS
- HHS
- DOE
- DOC / NOAA
- USDA

GCRP 2000—Draft Goals for the Second Decade: Developing and Applying Forecasts of Change at Scales Relevant to Decisionmaking

1. Extend our Knowledge of the Earth System

2. Evaluate Vulnerability and Resilience

3. Assess global change in the context of other environmental and social changes


5. Understand Global Change in Particular Locations: The Need for Integration

OSTP, 2000, draft report
CCSP Goals 2003

• **Goal 1**: Improve knowledge of past and present climate and environment, including natural variability

• **Goal 2**: Improve quantification of the forces bringing about changes in climate & related systems

• **Goal 3**: Reduce uncertainty in projections of how the Earth's climate and related systems may change in the future

• **Goal 4**: Understand the sensitivity and adaptability to climate and related global changes

• **Goal 5**: Explore the uses and identify the limits of evolving knowledge to manage risks and opportunities.
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The Revised Research Plan (one of the court-ordered documents released in May 2008) re-affirmed the current five goals…
NAS guidance on global change research
Impact Metrics that can be applied

1. The results of the program have informed policy and improved decision making.
2. The program has benefited society in terms of enhancing economic vitality, promoting environmental stewardship, protecting life and property, and reducing vulnerability to the impacts of climate change.
3. Public understanding of climate issues has increased.
Research Needs related to multiple stresses, extreme events, nonlinearities… (NRC & others, 2007)

Develop better models for drought and flood planning; improve tools for municipalities and generate methods for testing plans.

Use of Historical Records and “What If?” Scenarios to evaluate ‘break points’

Enhance monitoring/surveillance systems, early warning systems, evacuation routes & response mechanisms for extreme events

Need models that can provide quantitative predictions of the effects of multiple environmental stresses

Improve prediction of threshold effects such as climate/pest interactions; megadrought (climate threshold, ecosystem thresholds, cascading effects).
Analysis of Global Change Assessments: Lessons Learned

Chris Elfring

Mack McFarland
Committee Member

Joint BASC – CRC meeting
May 17, 2007

http://www.nationalacademies.org/basc/
Nested Assessment Concept

- Although it would be ideal to address climate change impacts and responses for each sector at local, regional, and national scales, it is unlikely that sufficient resources will be available to accomplish this.
- One option is to develop a broad conceptual framework or matrix that links local, sector-specific information to the larger-scale climate changes.
- Using a nested matrix approach, those areas or sectors that are highly vulnerable could be selected for a more focused integrated assessment that includes the demographic and institutional context as well as physical parameters.

Recommendation: CCSP should consider implementing this nested matrix concept in developing subsequent assessments.
Understanding and predicting physical climate change is progressing well.

- Declining observing capability

Inadequate human dimensions funding:
- $30 million; lack of collaboration

Inadequate progress
- in assessing impacts on human well being and vulnerabilities
- in providing knowledge to support decision making and risk analyses
- in communicating results and engaging stakeholders in a two-way dialogue

*Evaluating Progress of the US CCSP Program: Methods & Preliminary Results*
CLIMATE SECURITY ACT

- 2 Percent Annual Reductions in GHGs
- Investment in U.S. Forests and Soils
  Sequestration: $115B Through 2030
- Investment in U.S. Natural Resources
  Adaptation: $137B Through 2030

Kostyack, 2008
What Does Adaptation Really Mean on the Ground?

- Habitat Acquisition and Restoration
- Water Conservation & Pollution Prevention
- Wildlife Management
- Public Education and Outreach
- Scientific Research and Monitoring
- All Informed by Climate and Ecological Modeling

Kostyack, 2008
We can plan ahead.... or we can react

Wildlife can only react

But humans can anticipate

Scheraga, 2005
Adaptation options include: planning/management, technology, institutions, monitoring, & R&D

- Infrastructure to withstand new “extremes”
- Linking of reservoirs to enhance supply
- Seed banks, mass propagation techniques
- Emergency response plans
- Early warning alert systems / surveillance
- Incentives / Disincentives / insurance
- Prioritize lands to preserve
- Design of migration corridors
Climate Change: Adaptation Needs

Four essential categories of analysis needed to develop adaptation options

• Evaluate the impacts of Multiple Stresses on systems

• Conduct regional assessments

• Prepare for Extreme Events and their Consequences

• Explore the intersection of mitigation and adaptation
Climate Change: Adaptation Needs

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Linkage Between Climate and Air Quality

Impact on Ozone Formation of Changes in Climate vs. Changes in Emissions

1 hour ozone (ppb)
The 25 hotspots of high diversity of endemic species
Shifts in ecosystems for a 3 degree C increase.

green=forests; brown = grasslands; yellow=deserts

Source: Leemans and Eickhout, Global Environmental Change, 2004
The proportion of bird, amphibian and coral species falling in one of the 6 following categories: (i) threatened (according to The 2008 IUCN Red List) (orange); (ii) threatened and “climate-change-susceptible” (red); (iii) not threatened but “climate-change-susceptible” (yellow); (iv) Data Deficient and “climate-change-susceptible” (brown); (v) Data Deficient and not “climate-change-susceptible” (dark green); and (vi) neither threatened, Data Deficient nor “climate-change-susceptible” (light green).

Source: IUCN, 2008
Climate Change: Adaptation Needs

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Released, May 30, 2008

And, up for review July 14, 2008:


http://www.climatescience.gov/Library/sap/usp/public-review-draft/
Climate on the Move:
Changing summers in the Midwest

Impacts on the Midwest

- Public health and quality of life, especially in cities, will be negatively affected by increasing heat waves, reduced air quality, and insect- and water-borne disease.

- Under higher emissions scenarios, significant reductions in Great Lakes water levels will impact shipping, infrastructure, beaches and ecosystems.

- Increasing precipitation in winter and spring, more heavy downpours, and greater evaporation in summer will mean more periods of both floods and water deficits.

- While a longer growing season provides the potential for increased crop yields, increases in heat waves, floods, droughts, insects, and weeds will present increasing challenges to crops, livestock, and forests.

- Native species will face increasing threats from rapidly changing climate conditions, pests, diseases, and invasive species moving in from warmer regions.

Availability of irrigation water

Scholze et al. (2006)

Blue tendency to increase
Red tendency to decrease
Climate Change: Adaptation Needs

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Projected changes in extremes

**Precipitation intensity**

- **a)**
  - Lines represent different scenarios: A2, B1, A1B
  - Standard deviation over time from 1880 to 2080

- **b)**
  - World map showing precipitation intensity
  - Color scale from -3.75 to 3.75 standard deviations

**Heat waves**

- **c)**
  - Lines represent different scenarios: A2, B1, A1B
  - Standard deviation over time from 1880 to 2080

- **d)**
  - World map showing heat waves
  - Color scale from -3.75 to 3.75 standard deviations
Projected Increase in Heat Waves in Chicago

- **Lower Emissions**
- **Higher Emissions**

Example: Drilling Platforms vis-à-vis Hurricanes Katrina and Rita

3/4th of the 4,000 offshore oil and gas platforms (under MMS) were directly in the combined paths of the two hurricanes.
Leading up to each hurricane, virtually all Gulf coast production and import facilities and many of the region’s refining/processing facilities were evacuated or operations were otherwise suspended.
Global costs of extreme weather events from 1950–2006 (adjusted for inflation)

UNEP, 2008
Climate Change: Adaptation Needs

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• Explore the intersection of mitigation and adaptation
There are intersections between mitigation and adaptation…

and water is a linchpin....
The Land Use Implications of Stabilizing at 450 ppm When Terrestrial Carbon is NOT Valued

- Unmanaged ecosystems virtually disappear by the end of the century when carbon is not valued.
- The extent of crop land expands, but this is due at least in part to the fact that they are being forced into less productive lands by bioenergy crops' expansion.

**Reference Scenario**

**450 ppm Stabilization Scenario When Terrestrial Carbon is NOT Valued**
Switchgrass Production –
the “potential” for cellulosic biomass

GROWING ENERGY: How Biofuels Can Help End America’s Oil Dependence, Principal Author Nathanael Greene, NRDC, 2004,
http://www.nrdc.org/air/energy/biofuels/biofuels.pdf#search=%22greene%20lynd%20energy%20future%223
In short, we must figure out what Adaptation means and how to achieve it—adaptively!

It’s no longer a dirty word and we lost at least a decade...
The Opportunity for UCAR and its Members

• Initiate regional vulnerability assessments/scenarios analyses

• Evaluate multiple environmental stresses & climate change in concert and develop solutions that are robust

• Identify strategies to manage changes and build resilience in/across all sectors

• Help develop best practice toolkits for water management, land use change, city planning, etc.

• Train the next generation workforce in new ways!

• Improve the flow of information to support collective action and decisionmaking -- from the rotary club, to the Congress and the White House
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The Challenge: Sustainable Management of an Ever-Changing Planet