Southwest Climate Change Initiative (SWCCI)

Bear River
Climate Change Adaptation Workshop

May 26 and 27, 2010
Salt Lake City, Utah

Workshop Goal:

Identify management strategies that will help native plants, animals and ecosystems adapt to a changing climate and lay the groundwork for their implementation.

Workshop Objectives:

1. Provide background information on climate change and its effects in the Bear River Basin.
2. Introduce a framework for landscape-scale climate change adaptation planning.
3. Assess the impacts of climate change on a set of high-priority species and ecosystems.
4. Identify strategic management actions that will reduce climate change impacts.
5. Identify opportunities for ongoing learning, collaboration, and implementation of on-the-ground climate change adaptation projects in the Bear River Basin.

Desired Outcomes:

1. Shared understanding of the known current and potential future effects of climate change, through development of conceptual models, for Bonneville cutthroat trout and Bear River wetlands.
2. Identification of strategic actions to promote conservation resilience and realignment for Bonneville cutthroat trout and Bear River wetlands in the face of climate change.
3. Identification of opportunities to facilitate successful implementation of strategic actions.
4. Statement of research and monitoring needs for climate adaptation in the Bear River Basin.
5. Recommended next steps to be taken by natural resource managers of the Bear River Basin.

May 26: 8:30 AM -11:45 PM

8:30-8:40 Welcome
- Dave Livermore, *State Director, The Nature Conservancy, UT*

8:40-8:50 Southwest Climate Change Initiative (SWCCI) Overview
- Patrick McCarthy, *Director, SWCCI, The Nature Conservancy*

8:50-9:10 Statement of the Problem and Rationale for Workshop
- Gregg Garfin, *Director of Science Translation and Outreach, University of Arizona (Workshop Facilitator)*

9:10-9:40 Overview of Regional Climate Change Impacts: the Known, the Unknown, and the Uncertain

- Linda Mearns, *Senior Scientist, National Center for Atmospheric Research*

9:40-10:15 Overview of Past and Potential Future Trends in River/Stream Flows in the Bear River Basin

- Joe Barsugli, *Western Water Assessment, University of Colorado*

BREAK: 10:15 - 10:30 AM

10:30-11:00 Overview of Ecological Consequences of Climate Change

- Dr. Frederic H. Wagner, *Professor Emeritus, Utah State University*

11:00-11:30 Overview of Conservation Adaptation Planning

- Molly Cross, *Climate Scientist and Adaptation Specialist, Wildlife Conservation Society*

11:30-11:45 Implementing a Framework for Adaptation Planning: Future Climate Scenarios, Goals & Logistics for Remainder of the Workshop

- Gregg Garfin & Molly Cross

LUNCH: 11:45 – 12:45 PM (PROVIDED)

12:45 - 4:30 PM, W/ BREAK FROM 3:00 – 3:15 PM

12:45-4:30 Conservation Target Break-out Groups (separate rooms): Session One

- Bonneville Cutthroat Trout Facilitator: Patrick McCarthy
- Wetlands Facilitator: Molly Cross

Objectives for the two groups include:

- *Identify management objectives*
- *Refine the conceptual ecological model*
- *Assess impacts of two future climate change scenarios*
- *Complete Table 1: Climate Change Impacts (in participant packet)*

DAY ONE ADJOURN: 4:30 PM

HAPPY HOUR: 4:30 PM (AT THE SAME LOCATION AS THE WORKSHOP)

<u>MAY 27, 2010, 8:30 AM -12:00 AM W/ BREAK FROM 10:15 – 10:30 AM</u>

8:30-12:00 Conservation Target Breakout Groups: Session Two

<u>Objectives for two groups include:</u>

- *Identify management intervention points*
- *Identify strategic actions for climate change adaptation*
- *Complete Table 2: Identification of Strategic Actions (in participant packet)*
- *Review management objectives*
- *Evaluate level of urgency/priority and identify opportunities for implementation*
- *List research and monitoring needs*

LUNCH: 12:00 – 1:00 PM (PROVIDED)

<u>1:00 – 4:30 PM</u>

1:00-2:00 Break-out Groups Re-assemble in Large Room and Report Back (Gregg)

- Each group presents/reviews their priority strategic actions
- Facilitated summary and synthesis

2:00-3:00 Opportunities for Strategic Action Implementation: Integrate and evaluate top priority actions considering barriers and key uncertainties, e.g., cost, social, political, regulatory, lack of knowledge, and opportunities for implementation.

Mini-breakout groups meet for 10 minutes to discuss barriers and opportunities, followed by report-out and whole-group discussion.
Facilitator: Gregg Garfin

<u>Outcomes:</u>

- *Barriers to implementing strategic actions*
- *Opportunities for overcoming barriers to implement the actions*
- *Suggest lead agency and timeline*

BREAK: 3:00-3:15 PM

3:15-4:00 PM Facilitated Discussion on Emerging Themes, Implementation and Next Steps (Moderators: Joan Degiorgio and Joel Tuhy)

<u>Outcomes:</u>

- *What strategies might apply to all targets?*
- *What work planned or underway will be affected by climate change?*

4:00-4:20 Participant Feedback on Workshop Process and Outcomes

4:20-4:30 Closing Remarks: Joan Degiorgio and Patrick McCarthy

PLEASE COMPLETE EVALUATION FORM!! THANK YOU!!

WORKSHOP ADJOURNS: 4:30 PM

Climate Change and the Great Basin

Jeanne C. Chambers

USDA Forest Service, Rocky Mountain Research Station, Reno, NV

Climate change is expected to have significant impacts on the Great Basin by the mid-21st century. The following provides an overview of past and projected climate change for the globe and for the region. For more detailed information, please see the list of references and recommended links.

Global Climate Change

There is scientific consensus on the key elements of climate change:

Earth has a natural greenhouse effect: Water vapor, carbon dioxide, methane, and other gases slow the loss of heat to space, making the planet warm enough to support life as we know it.

Amounts of almost all greenhouse gases are increasing as a result of human activities. Since 1750, atmospheric carbon dioxide has increased 32 percent and methane has increased 150 percent. In the absence of significant changes in human activities, atmospheric concentrations of greenhouse gases will continue to increase.

Earth's surface has warmed about 0.6 °C (1.1 °F) since 1900. This warming is most likely a consequence of the increase in greenhouse gases, but other factors cannot be completely ruled out. Most of the warming observed since 1950 is likely due to human activities. Other related changes, such as decreases in snow cover and ice extent, increases in global average sea level, and altered rainfall patterns, also have been observed.

Great Basin 20th Century Climate Change

The climate of the Great Basin has changed during the past 100 years. Observed 20th century changes include:

Region-wide warming of 0.3 to 0.6 °C *(0.6° to 1.1 °F) in 100 years*—This warming, while widespread, has varied across the region (Wagner 2003). Minimum temperatures have increased more than maximum temperatures and variability in interannual temperatures has declined. As a result, the probability of very warm years increased and very cold years declined.

Increase in precipitation across most of the Great Basin—Annual precipitation has increased from 6 to 16 percent since the middle of the last century. Interannual variability in precipitation also has increased, with an increase in the probability of extreme high-precipitation years. This has been reflected in increases in streamflow across the region, especially in winter and spring (Baldwin and others 2003).

Decline in snowpack since about 1950—Trends in April 1 snow pack have been negative at most monitoring sites in the Great Basin. Elevation and mean winter temperature have a strong effect on snowpack with the warmest sites exhibiting the largest relative losses. In the warmer mountains, winter melt events have a strong negative effect on April 1 snow pack. Snow pack decline in the dry interior, which includes the Great Basin, has been among the largest observed, with the exception of central and southern Nevada (Mote and others 2005).

Earlier arrival of spring affecting streamflow and plant phenology—The timing of spring snowmelt-driven streamflow is now about 10 to 15 days earlier than in the mid-1900s, and there has been an increase in interannual variability in spring flow (Baldwin and others 2003, Stewart and others 2004). Phenological studies indicate that in much of the West, the average bloom-date is earlier for both purple lilac (2 days per decade based on data from 1957 to 1994) and honeysuckle (3.8 days per decade based on data from 1968 to 1994) (Cayan and others 2001).

Future Climate Change in the Great Basin

Projected warming for the West ranges from about 2 to 5 °C (3.6 to 9 °F) over the next century (Cubashi and others 2001). Regional estimates for areas such as California indicate that the upper value may be as high as 7 °C (12.6 °F) for some areas (Dettinger 2005). The degree of change will depend on the increase in CO_2 by 2100 and will vary across the Great Basin due to the large differences in topography. Projected changes in precipitation in the West are inconsistent as to sign and the average changes are near zero (Cubashi and others

2001). The losses in snow pack observed to date are likely to continue and even accelerate with more rapid losses in milder climates and slower losses in high elevation areas (Mote and others 2005).

Overview of Climate Change Impacts

Water resources—A reasonable scenario for western stream flows is change in the current seasonal proportionality of flows: increased winter flow, reduced and earlier spring peaks, and reduced summer and fall flows. The change in absolute flows will depend on the actual increase in precipitation relative to the degree of warming and its effects on evapotranspiration. Most watersheds in the Great Basin exhibit high natural variability in unregulated streamflow (Hurd and others 1999) and this variability may increase. In summer, lower flows coupled with higher variability may negatively affect various water uses (hydropower, irrigation, fish, recreation, and so forth). In winter, hydropower production could increase to take advantage of increased winter streamflow.

Agriculture—Many crops will grow better with higher CO_2 and a longer growing season before temperatures substantially increase, provided there is sufficient water. However, some weedy species and pests will have similar advantages. Low-value irrigation crops may have difficulty competing for less abundant irrigation water.

Native ecosystems—Similar to agricultural systems, growth of many native species (those with C3 photosynthetic pathways) is likely to increase provided there is sufficient water. Higher levels of CO_2 increase production and water-use efficiency of C3 native grasses but may increase the invasibility of cheatgrass and other annual grasses (Smith and others 2000, Ziska and others 2005). Other invaders, including perennial forbs and woody species, may be similarly advantaged. Increased temperatures will likely extend fire seasons with more fires occurring earlier and later than is currently typical, and this will increase the total area burned in some regions (McKenzie and others 2004). If climate change increases the amplitude and duration of extreme fire weather, we can expect larger and more severe fires. In more arid parts of the Great Basin, the frequency and extent of fires is likely to be higher in years that promote the growth of fine fuels (high fall, winter and spring precipitation) and as a result of fuel accumulation during the previous growing season (Westerling and others 2006). Progressive invasion of cheatgrass, which has greater flammability and fire spread than natives, is likely to continue to increase fire frequency and extent (Link and others 2006). Continued expansion of pinyon-juniper species and increases in tree densities could result in an increase in high severity crown fires, especially under drying scenarios (Miller and others, in press). Infectious diseases and insect outbreaks could increase under several different warming scenarios (Logan 2006).

Biodiversity and species at risk—As temperatures increase, species shifts are likely to occur. Inhabitants of high elevation zones will likely experience shrinking habitats and local extinctions will probably increase (Wagner 2003) among mammalian, avian, and butterfly species (Murphy and Weiss 1992). If climate change favors invasive species, then certain native species are likely to be displaced. If the fire severity and burn area increase, shifts in the distribution and abundance of dominant plant species could occur that may also affect the habitat of some sensitive plant and animal species (McKenzie and others 2004). An increase in infectious disease and insect outbreaks also could place certain species at risk.

Winter sports—Warmer winter temperatures and increased winter precipitation are projected to delay the beginning of the winter sport season, shorten the length of the season, and increase the likelihood of rain during the season. The impacts will be greater for mid-elevation areas than for higher elevation areas.

Research and Management Questions

Research and management questions revolve around the need to improve our ability to accurately predict the effects of climate change on the environment and, consequently, on human and natural systems.

Social and economic

How do land use and climate change jointly affect social and economic dynamics?

How do the combined effects of land use and climate change affect ecosystem services, and the capacity of the landscape to support communities and economies?

What institutional options exist for improving the application of global-change science results in land use and water use decisions?

Water resources

How will the loss of snow pack and change in stream flows affect water resources?

How will the change in climate variability (duration of droughts; frequency and magnitude of extreme events) affect water management?

How will the loss of snowpack and change in stream flows affect aquatic and riparian ecosystems?

How will the increase in climate variability affect aquatic, riparian, and upland ecosystems?

Native ecosystems and species at risk

What are the past fire responses to long-term trends in temperature and drought?

How does climate variability between years and decades affect the frequency, severity, and extent of wildfire?

What are the relationships among elevation, climate change, and the responses of native species?

What are the relationships between climate change and invasion by non-native species?

How does climate variability affect colonization, migration, local population extinction, and range expansion of sensitive plant and animal species?

What are the relationships among climate change, infectious disease, and insect outbreaks?

Existing Programs and Resources

National efforts

NOAA Climate Program Office. http://www.climate.noaa.gov [2007, July 17]

U.S. Environmental Protection Agency Climate Change Science. http://www.epa.gov/climatechange/index.html [2007, July 17]

U.S. Global Change Research Program http://www.usgcrp.gov/usgcrp/default.php [2007, July 17]

USDA Forest Service, U.S. Global Change Research in the USDA Forest Service. 21 Oct. 2007. http://www.fs.fed.us/ne/global/fsgcrp/index.html [2007, July 17]

U.S. Geological Survey, Global Climate Change Research. http://geochange.er.usgs.gov/

http://pubs.usgs.gov/fs/climate-change/index.html [2007, July 17]

U.S. Climate Change Science Program. http://www.climatescience.gov [2007, July 17]

University of California, Santa Cruz, Department of Earth and Planetary Sciences. Paleoclimate and Climate Change Research Group. http://www.es.ucsc.edu/~lcsloan/ [2007, July 17]

University of Wisconsin Milwaukee, U.S. National Phenological Network. 14 Mar. 2007. http://www.uwm.edu/Dept/Geography/npn [2007, July 17]

Regional efforts

U.S. Geological Survey, Earth Surface Dynamics. Climate Change Science. 27 Mar. 2007. http://geochange.er.usgs.gov/ [2007, July 17]

University of Washington, Joint Institute for the Study of the Atmosphere and the Ocean. Climate Impacts Group http://www.cses.washington.edu/cig/ [2007, July 17]

Desert Research Institute, Division of Earth and Ecosystem Science. 2006. Nevada Desert FACE Facility. http://www.dees.dri.edu/Projects/lynn_ndff.htm [2007, July 17]

National Environmental Observatory Network. Intermountain Regional Observatory Network. http://www.neoninc.org/ [2007, July 17]

Consortium for Integrated Climate Research in Western Mountains http://www.fs.fed.us/psw/cirmount/ [2007, July 17]

The Western Mountain Initiative – A Network of Mountain Protected Areas for Global Change Research. 8 Feb 2007 http://www.cfr.washington.edu/research.fme/wmi/index.htm [2007, July 17]

References

Baldwin, C. K.; Wagner, F. H.; Lall, U. 2003. Water Resources. Pages 79-112, in Wagner, F. H. (editor). Rocky Mountain/Great Basin Regional Climate-Change Assessment. Report of the U.S. Global Change Research Program. Utah State University, Logan, UT: IV 240pp.

Cayan, D. R.; Kammerdiener, S. A.; Dettinger, M. D.; Caprio, J. M.; Peterson, D. H. 2001. Changes in the onset of spring in the western United States. Bulletin American Meteorological Society. 82: 399-415.

Cubashi, U.; Meehl, G. A.; Boer, G. J. 2001. Projections of future climate change. Pages 525-582, In Houghton, J. T. et al. (editors). Climate Change 2001: The Scientific Basis. Contribution of the Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Dettinger, M. D. 2005. From climate-change spaghetti to climate-change distributions for 21st century California. San Fancisco Estuary and Watershed Science. 3: 1-14.

Hurd, B.; Leary, N.; Jones, R.; Smith, J. 1999. Relative regional vulnerability of water resources to climate change. Journal of the American Water Resources Association. 35: 1399-1409.

Link, S. O.; Keeler, C. W.; Hill, R. W.; Hagen, E. 2006. Bromus tectorum cover mapping and fire risk. International Journal of Wildland Fire. 15: 113-119.

Logan, J. A. 2006. Climate change induced invasions by native and exotic pests. Extended Abstract, Keynote Address for the 17th

USDA Interagency Research Forum on Gypsy Moth and Other Invasive Species, Annapolis, MD, 10-13 January 2006.

McKenzie, D.; Gedalof, Z.M.; Peterson, D.L.; Mote, P. 2004. Climate change, wildfire and conservation. Conservation Biology. 18: 890-902.

Miller, R. F.; Tausch, R. J.; McArthur, D. E.; Johnson, D.; Sanderson, S. C. [In press]. Development of post-settlement piñon-juniper woodlands in the Intermountain West: A regional perspective. Gen. Tech. Rep. RMRS-GTR-TBD. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Mote, P. W.; Hamlet, A. F.; Clark, M. P.; Lettenmaier, D. P. 2005. Declining mountain snowpack in western North America. Bulletin of the American Meteorological Society. 86: 39-49.

Murphy, D. D.; Weiss, S. B. 1992. Effects of climate change on biological diversity in Western North America: Species losses and mechanisms. In: Peters, R. L.; Lovejoy, T. E., eds. Global warming and biological diversity, Castleton, NY: Hamilton Printing: Chapter 26.

Smith, S. D.; Huzman, T. E.; Zitzer, S. F.; Charlet, T. N.; Housman, D. C.; Coleman, J. S.; Fenstermaker, L. K.; Seeman, J. R.; Nowak, R. S. 2000. Elevated CO_2 increases productivity and invasive species success in an arid system. Nature. 408: 79-81.

Stewart, I. T.; Cayan, D. R.; Dettinger, M. D. 2004. Changes in snowmelt timing in western North America under a 'business as usual' climate change scenario. Climate Change. 62: 217-232.

Wagner, F. H., ed. 2003. Preparing for a changing climate- the potential consequences of climate variability and change. Rocky Mountain/ Great Basin regional climate-change assessment. A report of the Rocky Mountain/Great Basin Regional Assessment Team for the U.S. Global Change Research Program. Logan, UT: Utah State University. 240 p.

Westerling, A. L.; Hidalgo, H. G.; Cayan, D. R.; Swetnam, T. W. 2006. Warming and earlier spring increase U.S. forest wildfire activity. Science. 313(5789): 940-943.

Ziska, L. H.; Reeves III, J. B.; Blank, B. 2005. The impact of recent increases in atmospheric CO_2 on biomass production and vegetative retention of cheatgrass (*Bromus tectorum*): implications for fire disturbance. Global Change Biology. 11:1325-1332.

Additional Information on Global Climate Change

Houghton, J.T.; Ding, Y.; Griggs, D.J.; Noguer, M.; van der Linden, P.J.; Dai, X.; Maskell, K.; Johnson C.A., eds. 2001. Climate change 2001: The scientific basis. contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). New York: Cambridge University Press. 944p.

National Research Council. 2002. Abrupt climate change: Inevitable surprises. Washington, DC: National Academy Press. 200 p. plus appendices.

National Research Council. 2005. Radiative forcing of climate change: Expanding the concept and addressing uncertainties. Washington, DC: National Academy Press. 190 p. plus appendices.

National Research Council (NRC). 2006. Surface temperature reconstructions for the last 2,000 Years. Washington, DC: National Academy Press. 196p.

U.S. National Academy Committee on the Science of Climate Change. 2001.Climate change science: An analysis of key questions. Washington, DC National Academy Press. Available: http://Newton.nap.edu/html/climatechange/ [2007, July 17].

U.S. Environmental Protection Agency. Office of Policy. 1998. Climate Change and Nevada. EPA 236-F-98-007o. (Available for all states.)

Bear River Basin Climate and Hydrology Scenarios

Time frame: 2041-2070 compared to 1971-2000

IPCC SRES Emissions Scenario: A2 (“medium-high emissions”)

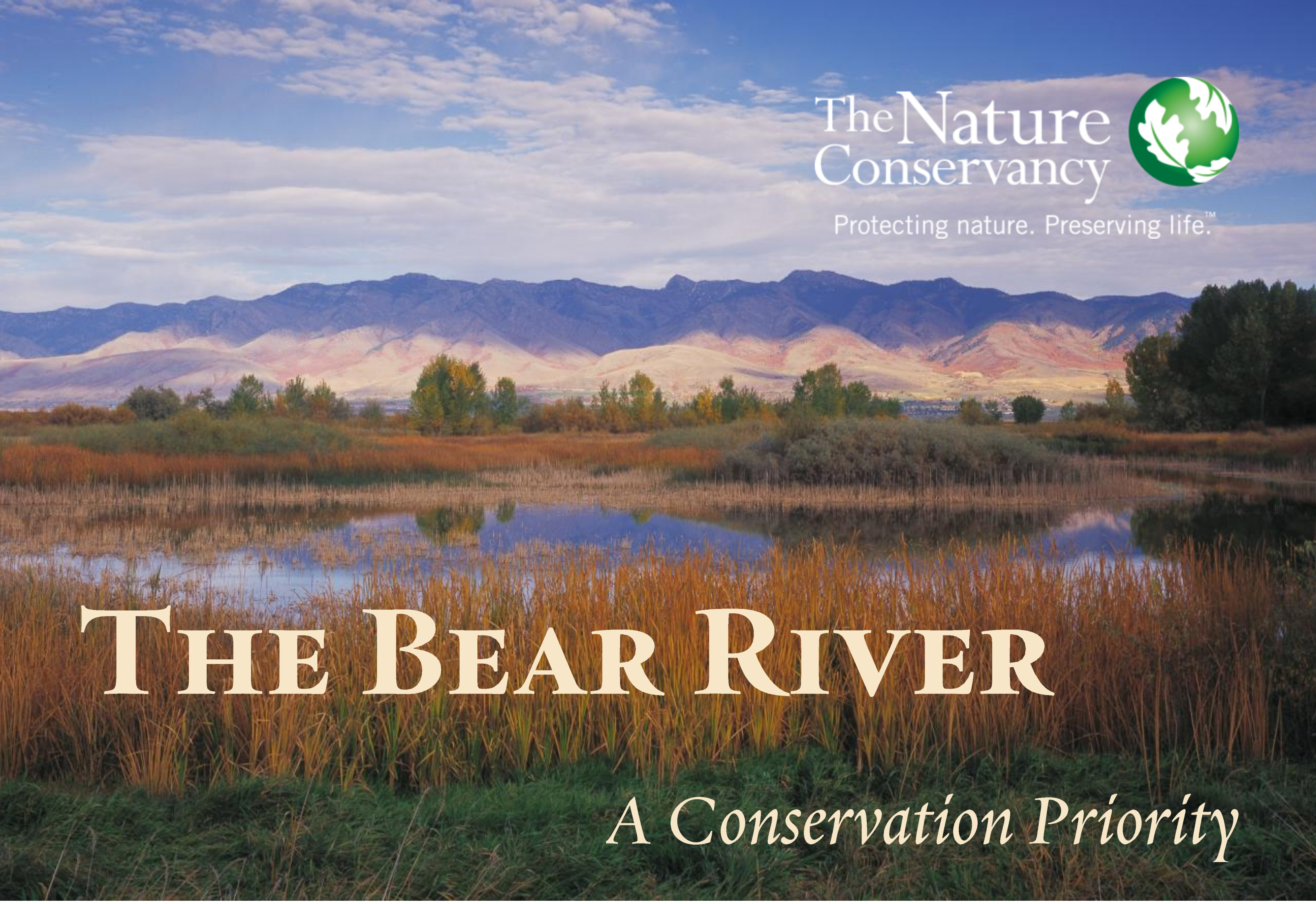
Hydrology modeling output is based on “natural flows,” unaltered by diversions and reservoir storage, but the modeling output does not take into account groundwater-surface water interactions

Main Scenario

Season	Precip %	Temp °C	Temp °F	Runoff	Snowpack	Seasonal Flows
Annual	1.6	3.5	6.3	5-18% decrease, with runoff timing arriving earlier by 1-3 weeks	Later fall accumulation, with –10 to –15% lower peak accumulation, and melt out arriving 2-4 weeks earlier	Summer low flows –10%, Summer high flows –25% Winter flows increase by 30-50%, due to an increasing fraction of winter precipitation coming as rain
Winter	13	2.5	4.5			
Spring	-6	3.5	6.3			
Summer	-15	4.5	8.1			
Fall	0	3.5	6.3			

Alternative Scenario

Season	Precip %	Temp °C	Temp °F	Runoff	Snowpack	Seasonal Flows
Annual	-3	2.7	4.9	5-13% decrease, with runoff timing arriving earlier by 1-2 weeks	Later fall accumulation, with –15 to –20% lower peak accumulation, and melt out arriving 2-4 weeks earlier	Summer low flows –15%, Summer high flows –50% Winter flows increase by 30-50%, due to an increasing fraction of winter precipitation coming as rain
Winter	-5	2.7	4.9			
Spring	10	2.0	3.6			
Summer	-20	3.0	5.4			
Fall	3	3.0	5.4			



The Bear River

A Conservation Priority

On its 500-mile journey through Wyoming, Idaho and Utah, the nature of the Bear River changes with the landscape through which it flows. It begins as a tiny stream at the dramatic crest of the High Uintas. Then it winds and loops on its journey through high elevation rangeland and pastoral farm land, creating wetlands and riparian woodlands along its floodplain. Finally, it flows through a thick marsh oasis to its destination at the Great Salt Lake.

Vital to both human and natural communities, the Bear River provides critical wildlife habitat, and serves as the largest water source feeding globally important habitats at the Great Salt Lake. The quantity and quality of water in the Bear River is crucial to the health of the Lake ecosystem, which supports millions of migratory shorebirds and waterfowl each year.

The Bear River provides a home for numerous species of nesting and migratory diving and dabbling ducks, colonies of snowy egret, white-faced ibis and great blue heron and many shorebirds, including long-billed curlew and migratory and nesting greater sandhill crane. The Bear River system also supports the at-risk Columbian sharp-tailed grouse, Bonneville cutthroat trout and northern leatherside chub.

The Need for Concerted Action

A number of entities have recognized the conservation value of the Bear River and have taken action to protect it-- there are three National Wildlife Refuges on the Bear-- but these efforts have historically focused on smaller-scale planning and projects to tackle localized problems. The development of a river-wide vision and conservation strategy is needed now to address the growing threats to the Bear's flows and habitats, to coordinate and prioritize conservation efforts, and to ensure a sustainable river system for future generations.

Going Big on the Bear

In 2009, many organizations and stakeholders interested in conserving the Bear River's waters and habitat came together to create a blueprint for a healthier river system (see participants list on page 8). They chose to use The Nature Conservancy's science-based planning framework to create a system-wide assessment and plan to address the most important conservation priorities (see sidebar). This brochure describes the findings and recommendations of the resulting Conservation Action Plan (CAP).

Conservation Action Planning

Over the past 15 years, the Conservancy has developed an integrated, science-based approach to planning, called the Conservation Action Planning (CAP) Process. CAP has been used successfully for more than 1,000 conservation projects worldwide. The CAP is a biologically driven process that guides project teams to identify effective conservation strategies. This innovative system helps conservation practitioners focus on the most important protection needs, and allows them to identify the most cost effective and inclusive strategies for lasting success. The CAP also provides an objective, consistent and transparent accounting of all information developed through the process.

For more information, please visit conservationgateway.org.

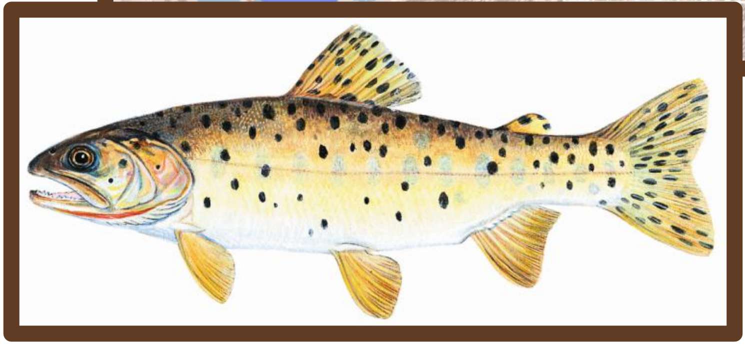
Photos: Great blue heron © Gary Crandall; (Front Page) Bear River © Steve Mulligan

Bear River Conservation Action Plan (CAP)

The Bear River CAP effort provided a forum for systematically identifying and understanding the key species and ecological systems most in need of conservation, the suite of factors that either sustain or degrade them, and the strategies needed to effectively protect them. Key components of the CAP process are described briefly in the following paragraphs.

Step 1. Conservation Targets: Focal Elements for Conservation

The Bear River CAP process began by selecting a series of focal targets – the species and ecosystems that represent and encompass the biodiversity of the Bear River. Targets form the backbone of the full CAP by serving as the central elements upon which viability and threats analyses are built and to which conservation strategies are tied. Four main focal conservation targets - riparian, wetland, aquatic and grassland systems - were selected to represent and encompass the biodiversity of the Bear River system[1]. The CAP team has determined that conservation of these targets will secure an ecologically functional system for all biodiversity dependent on the river.



These four key systems are some of the most limited in the West. For example, in Utah, riparian areas cover less than 0.2% of the landscape, aquatic systems 0.1%, grasslands 3.5% and wetlands 0.2%, and a substantial portion of these wetlands occur within the Bear River drainage. Each of these systems provides essential habitat for the many bird and fish species listed above. They are four of the ten most at-risk habitats identified in Utah's Wildlife Action Plan.

[1] Although an important component of biodiversity within the Bear River Watershed, sagebrush habitats have had much attention and conservation action by government agencies, local working groups, universities and conservation groups. Therefore the sagebrush steppe systems were not included with this CAP. The CAP team has determined that conservation of these targets will secure an ecologically functional system for all biodiversity dependent on the river.

Step 2. Viability Assessment: Determining Target Health

In the second phase of CAP planning, expert teams defined a set of Key Ecological Attributes (KEAs) and associated indicators for each target. These attributes are features of a target's biology or ecology that are critical to the survival of the target for the next 100 years.

For example, KEAs for the lower Bear River mainstem riparian target included riparian vegetation presence and composition. Teams rated the current condition of each KEA as very good, good, fair, or poor. Below is an example of these key ecological attributes for the riparian target and definitions:

Key Attribute	Poor	Fair	Good	Very Good	Current Rating	Desired Rating
Riparian vegetation presence	0-25% of available floodplain (potential riparian habitat) occupied by riparian vegetation	25-50% of available floodplain (potential riparian habitat) occupied by riparian vegetation	50-75% of available floodplain (potential riparian habitat) occupied by riparian vegetation	75-100% of available floodplain (potential riparian habitat) occupied by riparian vegetation	Fair	Good
Vegetation composition	0-50% native	50-75% native	75-90% native	90-100% native	Poor	Good

Very Good: Functioning at its ecologically desirable status. Requires little human intervention.

Good: Functioning within its range of acceptable variation. May require human intervention to maintain this status.

Fair: Outside its range of acceptable variation. Requires human intervention. Vulnerable to serious degradation if left unchecked.

Poor: If condition remains for extended period, restoration or prevention of extirpation will be practically impossible.

Photo: Bear River near Battle Creek © Scott T. Smith

KEA current condition scores for each target were then averaged to arrive at an overall viability rank for the target. The following table summarizes the viability analysis:

	Conservation Targets	*Viability Rank*
	Current Rating	
1	Upper Bear Wetlands	Fair
2	Upper Bear Riparian Main Stem (historic floodplain from Evanston to Thomas Fork)	Poor
3	Upper Bear Riparian Tributaries (downstream from Evanston)	Fair
4	Upper Bear Aquatic (tributaries and main stem below Evanston)	Fair
5	Middle Bear Wetlands	Fair
6	Middle Bear Riparian Main Stem	Fair
7	Middle Bear Riparian Tributaries	Fair
8	Middle Bear Aquatic Main Stem	Fair
9	Middle Bear Aquatic Tributaries	Fair
10	Lower Bear Wetlands	Fair
11	Lower Bear Riparian Main Stem (includes tributaries to Bonneville bench and Malad)	Poor
12	Lower Bear Riparian Tributaries (from benches to headwaters)	Very Good
13	Lower Bear Aquatic Main Stem	Fair
14	Lower Bear Aquatic Tributaries (from main stem to Bonneville Bench)	Fair
15	Lower Bear Grasslands	Fair
	Project Biodiversity Health Rank	Fair

Key Finding

CAP findings indicate the river's systems are generally in fair condition, but identified important areas for restoration and improvement, especially in the upper and lower Bear riparian areas. The Bear River through Cache Valley still retains very good size and connectivity characteristics. Much of the Bear River, however, is privately owned and development pressures from urban sprawl and commercial expansion are increasing, so conservation action is needed now before conditions further deteriorate.

Step 3. Threats: Identifying Factors Affecting Targets

The next phase of the CAP was the identification of critical threats. Experts identified the top threats to each target and then rated each threat as low, medium, high or very high in terms of its relative "contribution" to the effect on the target and the degree to which the threat was irreversible. To complete the threats assessment, all threats across all targets were compiled into a "threats scorecard" and an overall threat rank was calculated for each threat. The table below shows the threat scorecard for the highest ranked overall threats on the Bear River.

	Threats Across Targets	*Overall Threat Rank*
	Project-specific threats	
1	Residential development	Very High
2	Water allocation policies	Very High
3	Invasive species	Very High
4	Inappropriate grazing and agricultural practices	Very High
5	Dams and diversions	High
6	Mining and energy	High
7	Commercial development	High
8	Credit Reserve Program is not extended or adequately funded	High
9	Rip-rap/other stream bank stabilization	High
10	Storm water	High
11	Waste water	High
	Threat Status for Targets and Project	Very High

High: Threat is likely to seriously degrade the ecological system over much of the area.

Very High: Threat is likely to destroy the ecological system over much of the area.

Key Finding:

Residential and commercial development are some of the highest ranked threats. These are primarily concerns in Idaho and Utah (Cache County is expected to double its population by 2035). Water allocation policies, how water is stored and used for power and agriculture, also can negatively impact the natural system.

Step 4. Strategies: Critical Conservation Actions

After carefully reviewing and examining the targets' viability and threats and the priority conservation needs rising from these analyses, the partners recommended a broad array of 13 objectives and numerous strategies designed to achieve the objectives. The objectives are listed below:

	Objectives
1	A multi-state team is in place to implement CAP strategies.
2	The most problematic invasive species are identified, mapped, and action taken to stop their spread. Educated landowners are active participants in these efforts.
3	Grazing and other agricultural practices are not negatively affecting conservation targets in priority areas.
4	Residential and commercial development has been guided away from high priority conservation sites.
5	The main stem riparian target improves from poor to fair condition.
6	Tributaries provide good aquatic conditions that support native species.
7	Wetlands, riparian and aquatic targets have adequate water to maintain the system in good to fair condition.
8	Wetland, riparian and aquatic targets have been enhanced by achieving water quality goals.
9	Impacts are minimized from recreational use/development.
10	Impacts are minimized from mining and energy as the result of science-driven locations.
11	The Conservation Reserve Program (CRP) is extended, adequately funded, and implemented to benefit grasslands.
12	New analysis has been conducted to understand the impact that climate variability has on the conservation targets.
13	The loss of shrub-steppe habitat due to fires has been minimized.

Key Finding:

Because of the size of the Bear River system, our initial efforts will target priority areas in which to secure easements, provide adequate water, work with landowners to promote better grazing systems and address invasive species. A first priority action is to work cooperatively to map areas that are most intact, exist adjacent to already protected areas, and meet other key criteria.

Next Steps: Building Toward the Future

Over the next ten years, the original CAP team intends to build on this foundation by working with partners to refine our plan through implementation. We will share the CAP process and its products, building a broader, deeper network of collaborators who are working toward the vision of a Bear River that can sustain its ecological systems and support wonderful and diverse wildlife.

Our basin-wide approach will provide a template for the protection of working rivers throughout the West, particularly with growing demands on water and increasingly arid conditions. Our action plan will help bring partners together to synchronize their conservation work in a way that will sustain the natural environment while providing water for people.

Because adaptive management is, by its nature, never finished, this CAP framework is by no means complete. This is a *working* CAP that will be continually refined as our knowledge of the river system expands and our conservation strategies are implemented and tested.

We invite you to share in our efforts to put this framework into action. Please contact Joan Degiorgio (jdegiorgio@tnc.org) at The Nature Conservancy for more information.

Planning Process Participants

Thanks to the following groups for their guidance and participation in this effort:

PacifiCorp

U.S. Fish and Wildlife Service

Utah Division of Wildlife Resources

Utah Division of Environmental Quality

Idaho Department of Environmental Quality

Trout Unlimited

Bridgerland Audubon Society

Wild Utah Project

Ducks Unlimited

Institute for Watershed Science

Sagebrush Steppe Regional Land Trust

USDA Forest Service

Photo: Canoeing the Bear River © Richard Mueller

Bear River Climate Change Adaptation Workshop
Summary of Conservation Features

At the Bear River Climate Change Adaptation Workshop, we will apply an adaptation planning framework to develop strategic actions for two different types of conservation features (a species and an ecosystems). Bonneville cutthroat trout and wetlands will be the focus of the adaptation planning exercises conducted during breakout sessions.

These features were the subject of the Bear River Conservation Action Plan (CAP) that produced a snapshot of their ecological health but did not assess their vulnerability to climate change, although that was identified as a threat. This workshop provides the opportunity assess that potential threat. The CAP based its conservation targets on the Utah Comprehensive Wildlife Conservation Strategy where wetlands were identified as one of ten key habitats of greatest conservation need. Bonneville cutthroat trout is a Tier 1 at-risk species in the Conservation Strategy.

A short description of each features is below.

<u>Bonneville Cuthroat Trout:</u>

Bonneville cutthrout trout (BCT) occupy roughly 35% of their historic range. Much of the remaining BCT life history diversity occurs in the Bear River watershed in Utah, Idaho, and Wyoming, which supports the healthiest remaining migratory populations and comprises the last large river habitat still available to the subspecies. Bear River populations are unique in that they comprise resident and fluvial life forms. These alternative life history strategies have contributed to BCT resiliency in the face of non-native species invasions and marginal habitat quality. Unfortunately, irrigation diversions in the Bear River block upstream spawning migrations and kill downstream migrants in irrigation canals. Additionally, poor water quality and impaired riparian conditions have degraded aquatic habitats throughout the watershed. As a result, many historically important spawning tributaries and mainstem habitats are currently inaccessible or uninhabitable for BCT. BCT is subject of a Range-Wide Conservation Agreement and Strategy.

<u>Wetlands:</u>

A large proportion of the region's wetlands occur in the Bear River watershed. These include a variety of wetland types which can be generalized into three broad categories. The first includes the wetlands of the upper Bear, created by flooding of the adjacent floodplains by the Bear River through Rich County, Utah and Cokeville Meadows National Wildlife Refuge in Wyoming. The second category is wetlands created by abandoned Bear River oxbows, most of which retain a hydrologic connection with the Bear River, such as the Bear River Bottoms through Cache County, often dominated by emergent marsh-type vegetation and wet meadows. Thirdly, there are extensive wetlands associated with managed features such Cutler Reservoir (Cutler Marsh) and the Bear River Migratory Bird Refuge at the delta of the Bear River and the Great Salt Lake, also dominated by emergent marsh, shallow water wetlands, and extensive mudflats.

These wetlands support a large number and diversity of birds, including shorebirds, waterfowl and passerines. For example, five percent of the world's population of white-faced ibis use these wetlands.

-

Bear River Climate Change Adaptation Workshop Definitions

1. **Adaptation to climate change:** An adjustment in natural systems in response to a changing climate in order to moderate adverse impacts or capitalize on novel opportunities (IPCC 2007). Adaptation involves anticipating the influence of climate change and using this information to make proactive choices to achieve objectives.

2. **Adaptive capacity:** The ability of a system to adjust, to moderate, to take advantage of, or cope with novel conditions (IPCC 2000). Enhancement of an ecosystem's adaptive capacity reduces the system's vulnerability and/or strengthens its ecological resilience through management or mitigation.

3. **Adaptive strategies:** Actions to take to build resistance build resilience or facilitate the response of natural features to change. For example, improvement in habitat connectivity enables species populations to move to more suitable habitats as the climate changes.

4. **Climate change impacts (hypotheses of change):** Hypotheses or assumptions about how climate change will affect conservation features and their ecological attributes (e.g., *significantly reduced snow pack will alter the spring and summer hydrologic flow regime for a riparian ecosystem*).

5. **Climate projection:** A *projection* of the response of the *climate system* to *emission or concentration scenarios* of *greenhouse gases* and *aerosols*, or *radiative forcing* scenarios, often based upon simulations by *climate models*. Climate projections are distinguished from *climate predictions* in order to emphasize that climate projections depend upon the emission/concentration/ radiative forcing scenario used, which are based on assumptions concerning, e.g., future socioeconomic and technological developments that may or may not be realized and are therefore subject to substantial *uncertainty* (IPCC 2007).

6. **Climate system:** The climate system is the highly complex system consisting of five major components: the *atmosphere*, the *hydrosphere*, the *cryosphere*, the land surface and the *biosphere*, and the interactions between them. The climate system evolves in time under the influence of its own internal dynamics and because of *external forcings* such as volcanic eruptions, solar variations and *anthropogenic* forcings such as the changing composition of the atmosphere and *land use change*. (IPCC 2007).

7. **Conceptual ecological model:** Illustration of the climatic, ecological, social and economic factors that affect a selected species or ecosystem. It is a box and arrow diagram that represents relationships, helping planners and managers to understand and communicate impacts of climate change on conservation features.

8. **Downscaling:** Downscaling is a method that derives local- to regional-scale (10 to 100 km) information from larger-scale models or data analyses. Two main methods are distinguished: *dynamical downscaling* and *empirical/statistical downscaling*. The dynamical method uses the output of regional *climate models*, global models with variable spatial resolution or high-resolution global models. The empirical/statistical methods develop statistical relationships that link the large-scale atmospheric variables with local/regional climate variables. The quality of the downscaled product depends on the quality of the driving model (IPCC 2007).

9. **Driver:** An environmental factor that causes a change in an organism, community, ecosystem, or other ecological component of the landscape.

10. **Ensemble:** A group of parallel model simulations used for *climate projections*. Variation of the results across the ensemble members gives an estimate of *uncertainty*. Ensembles made with the same model but different initial conditions only characterize the uncertainty associated with internal *climate variability*, whereas multi-model ensembles including simulations by several models also include the impact of model differences. (IPCC, 2007)

11. **Exposure:** The degree, duration, and/or extent to which a system is in contact with a climatic or other environmental perturbation, often depicted by analysis of historic climate or climate projection data (such as changes in temperature and precipitation).

12. **Feasibility:** Capability of a strategy being implemented, considering ease of implementation, availability of an experienced lead person, institutional support, ability to motivate key constituencies, and ability to secure necessary funds.

13. **Intervention points:** Places in the system that we can influence through management and conservation actions, e.g., *grazing management or invasive species management.*

14. **Mitigation:** A human intervention to reduce the *sources* or enhance the *sinks* of *greenhouse gases* (IPCC 2007).

15. **Objective:** Biological outcomes we are trying to achieve. Quantitative and measurable statement of success for a conservation feature based on its viability or threat reduction, e.g.: *By 2025 ensure good base-flows in summer so that no sections of the Blue River go dry (50-75 CFS) in dry years*.

16. **Refugia:** Physical environments that are less affected by climate change than other areas and thus offer a refuge from climate change.

17. **Resilience:** Degree to which a system rebounds, recoups or recovers from a disturbance or stimulus. An example of a resilience strategy is to restore riparian areas along streams experiencing increased intensity of drought, helping to maintain water quantity and quality.

18. **Resistance**: Degree to which an ecosystem can resist the influence of climate change and forestall its undesirable effects (adapted from Millar et al. 2007), *e.g., reduce effects of climate change for animals by improving their ability to migrate by creating large management units and broad corridors* (Joyce et al. 2009).

19. **Sensitivity**: Degree to which a system or species is affected by or responsive to climate change.

20. **Strategic actions:** Actions necessary to address the most important impacts of climate change or human responses, e.g., *aggressively manage snowpack with snow fences, cover and shade of snowpack/drifts, or windbreaks.*

21. **Uncertainty:** The degree to which a value (e.g., the future state of the *climate system*) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined concepts or terminology, or uncertain *projections* of human behavior. Where uncertainty in specific outcomes is expressed (as in Table 1), the following likelihood ranges are used to express the assessed probability of occurrence (IPCC 2007):

    - virtually certain >99%;
    - extremely likely >95%;
    - very likely >90%;
    - likely >66%;
    - more likely than not > 50%;
    - about as likely as not 33% to 66%;
    - unlikely <33%;
    - very unlikely <10%;
    - extremely unlikely <5%;
    - exceptionally unlikely <1%.

    Where uncertainty is assessed more quantitatively then the following scale of confidence levels is used to express the assessed chance of a finding being correct:

    - very high confidence at least 9 out of 10;
    - high confidence about 8 out of 10;
    - medium confidence about 5 out of 10;
    - low confidence about 2 out of 10; and
    - very low confidence less than 1 out of 10.

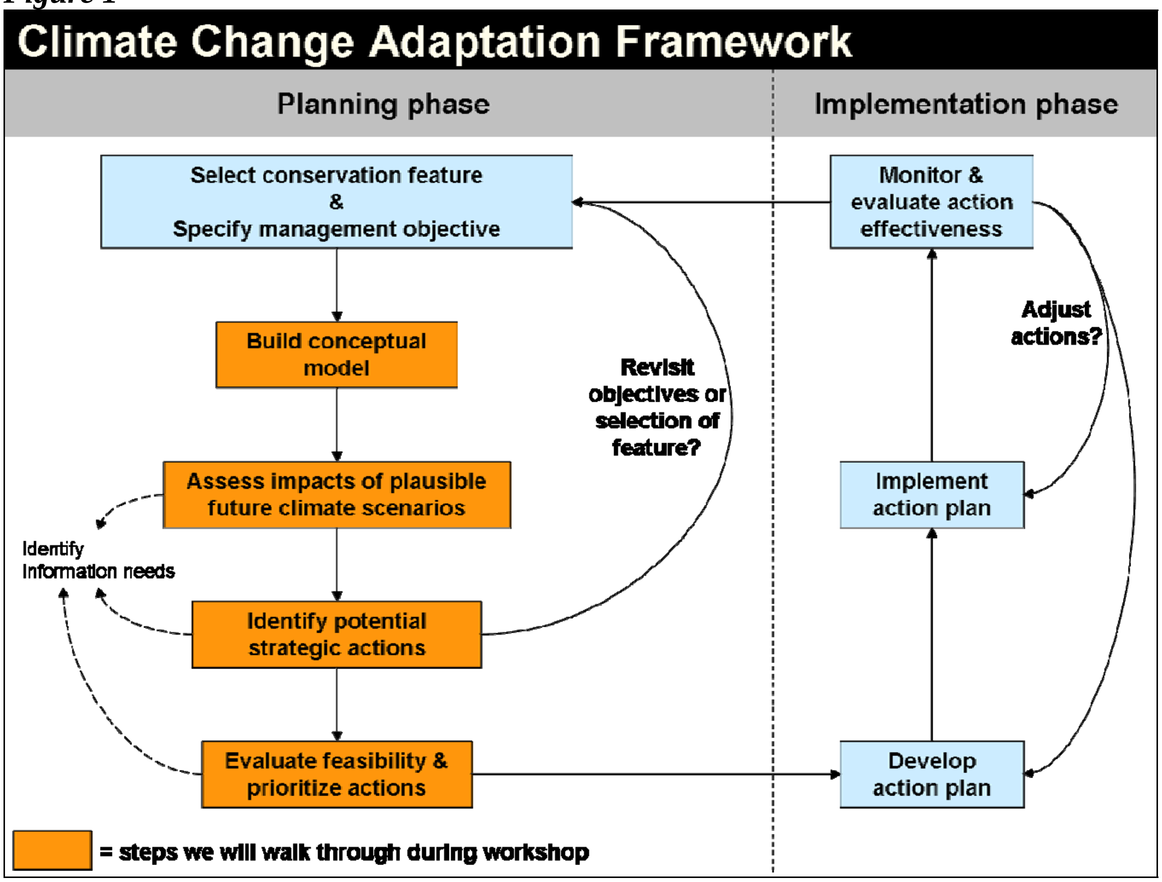
22. **Vulnerability**: the degree to which a system is susceptible to and unable to cope with adverse effects of climate change, including climate variability and extremes (IPCC 2007). Vulnerability is a function of exposure, sensitivity, and adaptive capacity.

Climate Change Adaptation Framework

Bear River Climate Change Adaptation Workshop
Southwest Climate Change Initiative
May 26 and 27, 2010

At the workshop, we will present an iterative framework for developing strategic actions for climate change adaptation[1]. The climate change adaptation framework is designed for collaborative application in a given landscape by a multidisciplinary group of managers, conservation practitioners and scientists, and includes the following steps (Figure 1):

Figure 1



1) **Select feature targeted for conservation** (e.g., species, ecological processes, or ecosystems) and **specify an explicit, measurable management objective** for that feature;

[1] The Climate Change Adaptation Framework presented here is adapted from Cross et al. (in review) and The Nature Conservancy's "Conservation Action Planning Guidelines for Developing Strategies in the Face of Climate Change" (October 2009). The Cross et.al. paper can be found in this notebook's Background Papers.

2) **Build a conceptual model** that illustrates the climatic, physical, ecological, and socio-economic drivers that affect the selected feature;

3) **Assess impacts of plausible future climate scenarios**:

    a. Use the conceptual model to assess climate change impacts (i.e., develop hypotheses of change) by examining how specific changes in climate variables might directly or indirectly influence the selected feature, for each scenario of future climate conditions being considered.

    b. Consider how human responses to climate change (e.g., solar and wind power development, construction of dams for increased water storage, etc.) may influence the selected feature.

    c. Assess the likely impact of climate change relative to other known impacts or threats, and identify which climate-induced impacts are most critical to address to achieve the stated management objective.

4) **Identify potential strategic actions in light of climate change**:

    a. Identify intervention points—those places in the system that we can influence through management and conservation actions.

    b. Brainstorm potential strategic actions that can be taken at those intervention points to achieve the stated objective under each climate scenario.

    c. Determine whether the management objective or the selection of the feature needs to be revisited: Does climate change fundamentally change the landscape? Do the management objectives for that feature need to change? Will the feature even be found in the same location in the future? Does our view of the landscape and boundaries need to change?

5) **Evaluate feasibility of potential strategic actions and prioritize** according to factors such as: cost; social and political feasibility; potential for positive effects or risk of unintended negative consequences for other features or objectives; and robustness to uncertainty in future climate.

6) **Develop action plan** outlining priority strategic actions to be implemented.

7) **Implement action plan**;

8) **Monitor and evaluate action effectiveness** and progress toward objectives—adjust or reevaluate actions if needed to address system changes or ineffective actions.

The Nature Conservancy's Climate Change Adaptation Program: C*onservation solutions to climate change problems*

The Nature Conservancy
Protecting nature. Preserving life.

The Need

Earth's climate is changing, putting the plants, animals and natural communities we care about at risk and undermining the vital benefits that nature provides to people. We are already observing changes that pose urgent and serious threats to many of the places we protect and to the billions of people who depend on healthy ecosystems for water, food and livelihoods. As climate change continues, the risks to people and to our conservation mission grow larger and more severe. Our conservation mission and commitment to delivering long-term benefits for both people and nature give us a direct stake in developing and implementing strategies that can sustain nature in the face of unavoidable impacts. Impacts are already hitting coasts and water resources that are of vital importance for both biodiversity and people, and so these are areas for immediate action.

Our Goal

We aim to enhance the resilience of people and nature to climate change impacts by protecting and maintaining ecosystems that, even under changed climate conditions, can support biodiversity and continue to deliver the full suite of services that nature provides to people. We want such ecosystem-based approaches to be widely adopted as a proven and positive solution for climate change adaptation. Our commitment to adaptation is reflected, internally, in the rapidly growing list of domestic and international conservation projects that are integrating resiliency components. Externally, the Conservancy recently announced a three-year $25 million commitment to the Clinton Global Initiative to test and prove the cost-effectiveness of ecosystem-based strategies for safeguarding nature and vulnerable human communities.

The Opportunity

Ecosystem-based adaptation strategies can improve water and food security and reduce vulnerability to natural hazards while also protecting biodiversity. This creates an exciting opportunity to integrate conservation into new climate policies and sustainable development plans. By aligning incentives and financing for nature-based solutions, we can dramatically increase the scope and scale of ecosystem-based adaptation. Billions of dollars have been pledged to support adaptation actions. We can show how to turn those resources into tangible global impact that benefit both people and nature. We have proven conservation tools to build on like reef-resilience and ecological flows. And because we speak from experience, not theory or ideology, the Conservancy is positioned as an important and influential advocate for public policies and funding internationally and especially in the U.S. Our constructive relationships with the private sector also raise the possibility that we could work in partnership with insurance or other business sectors that share an interest in reducing the risk of climate impacts to people and nature.

Our Strategies

- Making the case and setting global priorities for ecosystem-based adaptation by clearly defining what ecosystem-based adaptation is and is not, and showing where and what the needs and opportunities are.
- Building the know-how and can-do among practitioners and partners by supporting priority demonstration projects, facilitating learning, and developing tools and methods that others can use.
- Cultivating commitment, funding and capacity for ecosystem-based adaptation in other institutions like government agencies, development agencies, humanitarian/aid NGOs.
- Promoting public/private partnerships for ecosystem-based adaptation that deliver large-scale benefits for people and nature.

For more information about TNC's Global Climate Change Team and the Adaptation Program, please contact

Jon Hoekstra, Director, Climate Change Program; jhoekstra@tnc.org; 206-343-4345 x 324

NCAR

Overview of Regional Climate Change: The Known, the Unknown, and the Uncertain

Linda O. Mearns
National Center for Atmospheric Research

Webinar for TNC Workshop

Bear River

Utah, Idaho, Wyoming

May 10, 2010

Outline

- Current climate change
- Future climate change
  - The climate system
  - What we know about future climate change
  - The issue of spatial scale of scenarios
  - Portraying information about future climate change including probabilistic information

Increases in Greenhouse Gases

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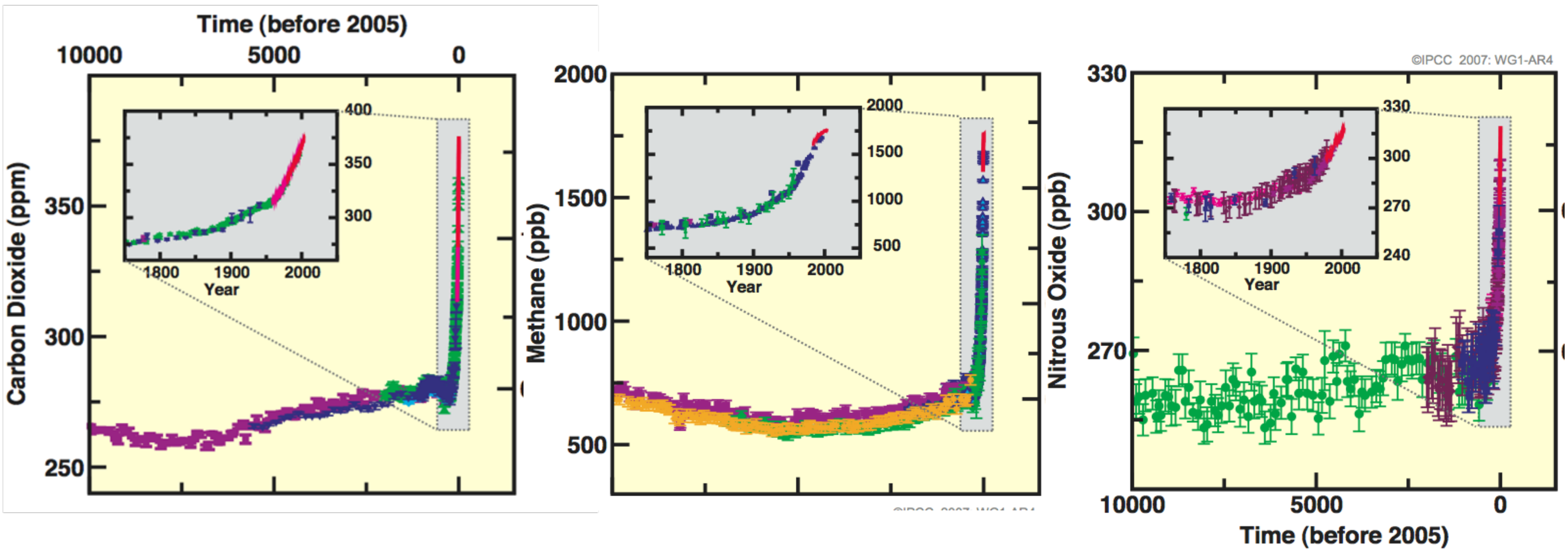
The current concentrations of key greenhouse gases, and their rates of change, are unprecedented.

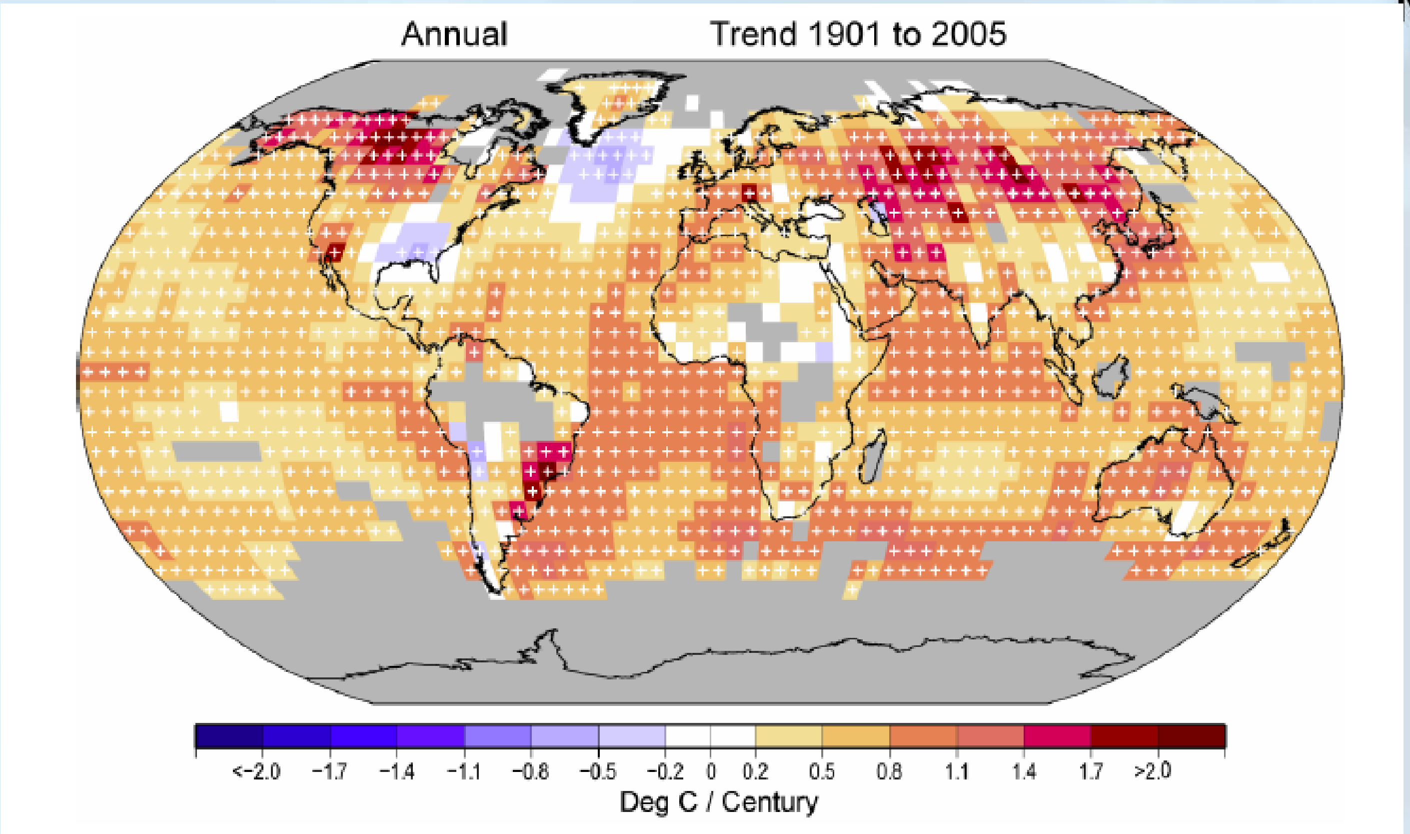


Carbon dioxide

Methane

Nitrous Oxide

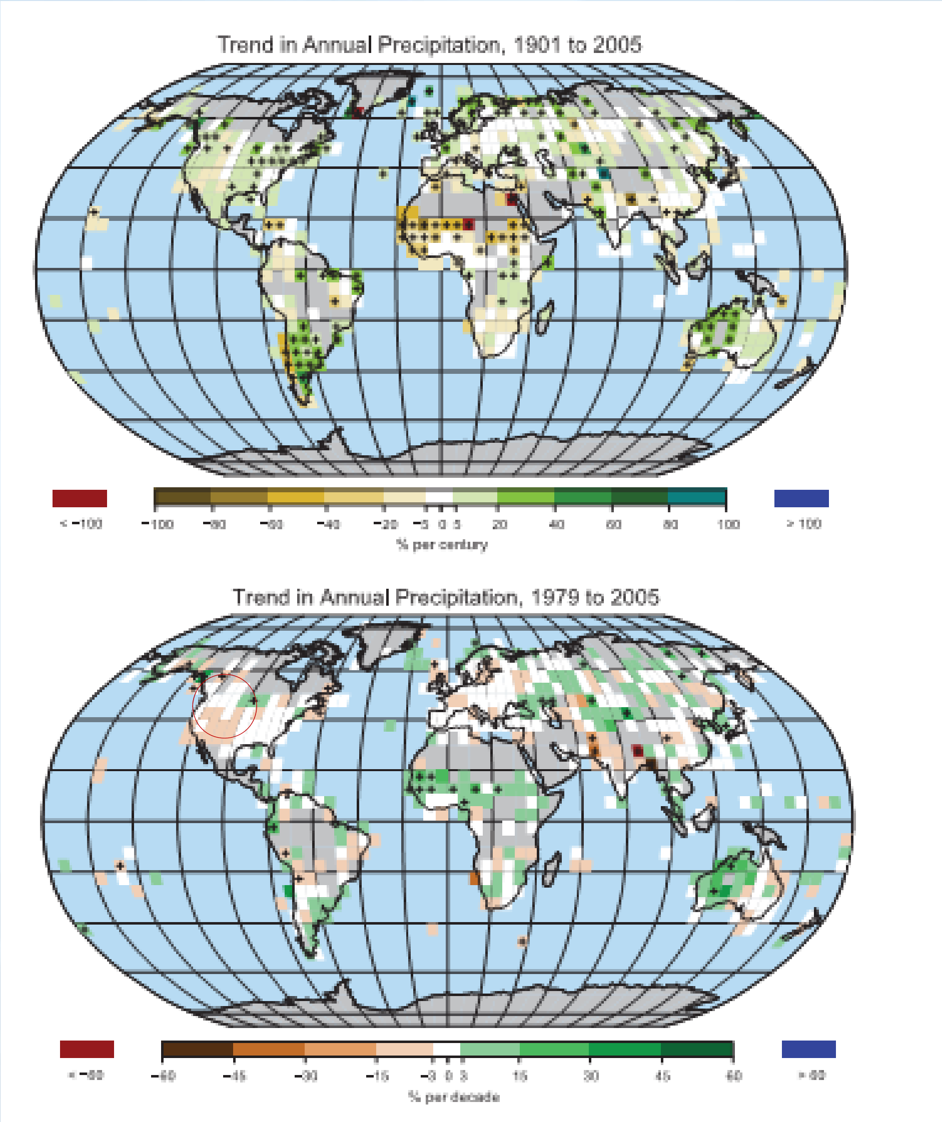
The World Has Warmed



Globally averaged, the planet is about 0.75°C warmer than it was in 1860, based upon dozens of high-quality long records using thermometers worldwide, including land and ocean.

Eleven of the last 12 years are among 12 warmest since 1850 in the global average.

Observed Changes in Precipitation



Increasing Confidence in the Science Based on Statements in the IPCC Reports

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•**IPCC 1990**: **The observed increase [*in temperatures*] could be largely due to natural variability; alternatively this variability and other man-made factors could have offset a still larger man-made greenhouse warming.**

•**IPCC 1995**: **The balance of evidence suggests a discernible human influence on global climate.**

•**IPCC 2001**: **There is new and stronger evidence that most of the warming observed over the last 50 years is due to human activities.**

•**IPCC 2007**: **Most of the observed increase in global temperatures since the mid-20th century is very likely (90%) due to the observed increase in greenhouse gas concentrations. Discernible human influences include ocean warming, continental-average temperatures, temperature extremes and wind patterns.**

Future Climate

Uncertainties about Future Climate

- The future trajectory of emissions of greenhouse gases (based on uncertainties about how the world will develop economically, socially, politically, technologically)
  - Explored through the development of scenarios of future world development
- How the climate system responds to increasing greenhouse gases.
  - Explored through use of climate models
  - Spatial scale at which climate models are run is an additional source of uncertainty
- The natural internal variability of the climate system

Future Concentrations of Greenhouse Gases in the Atmosphere

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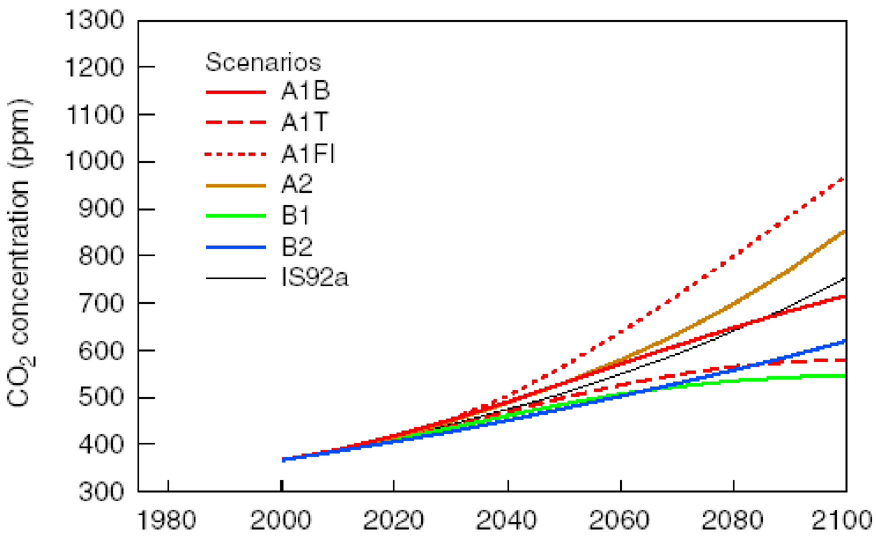
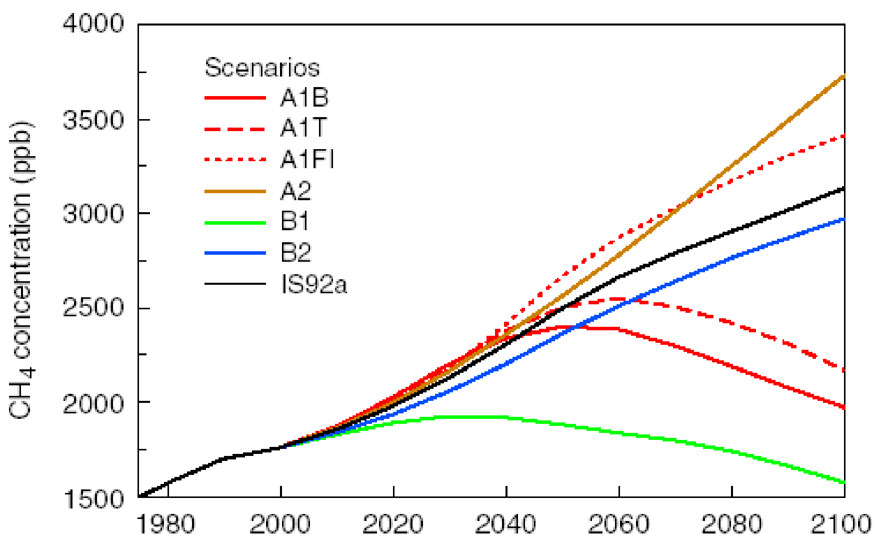
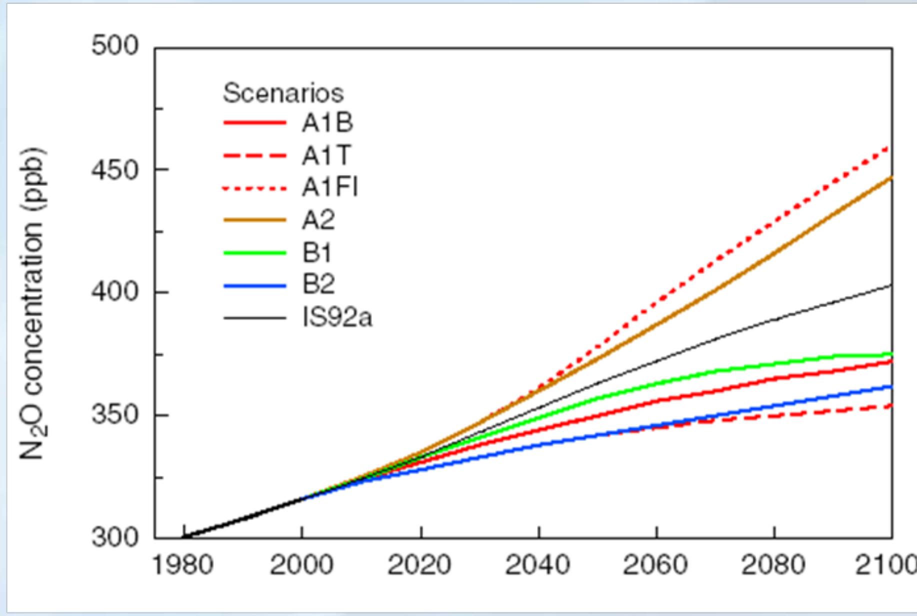
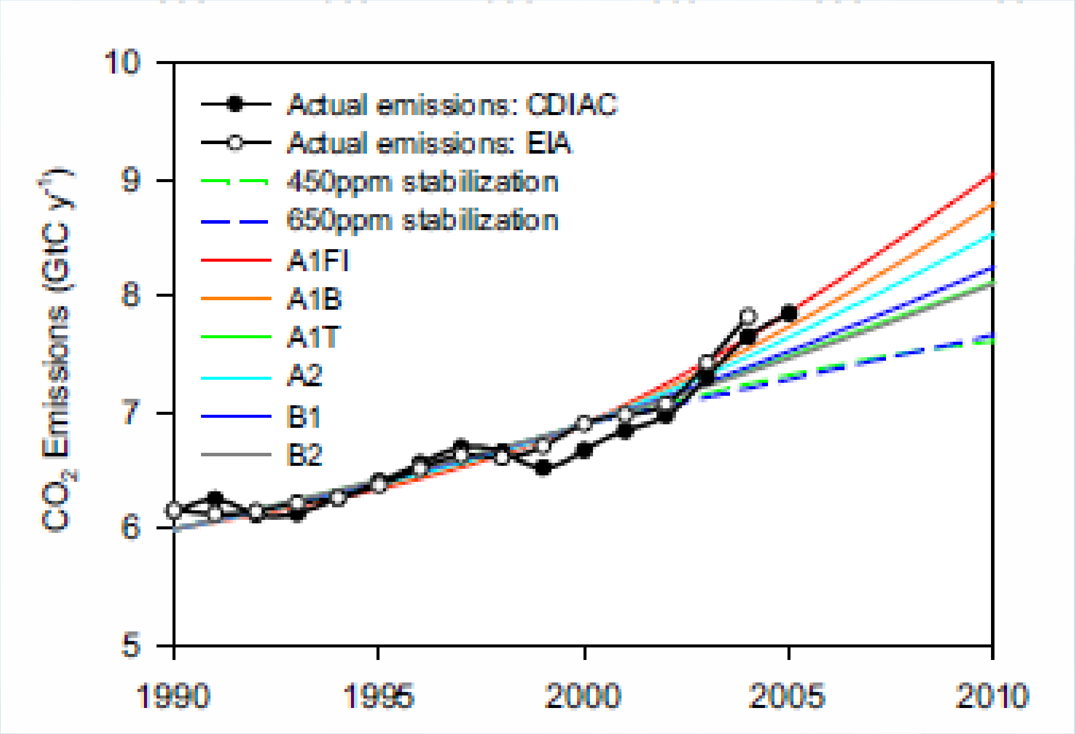




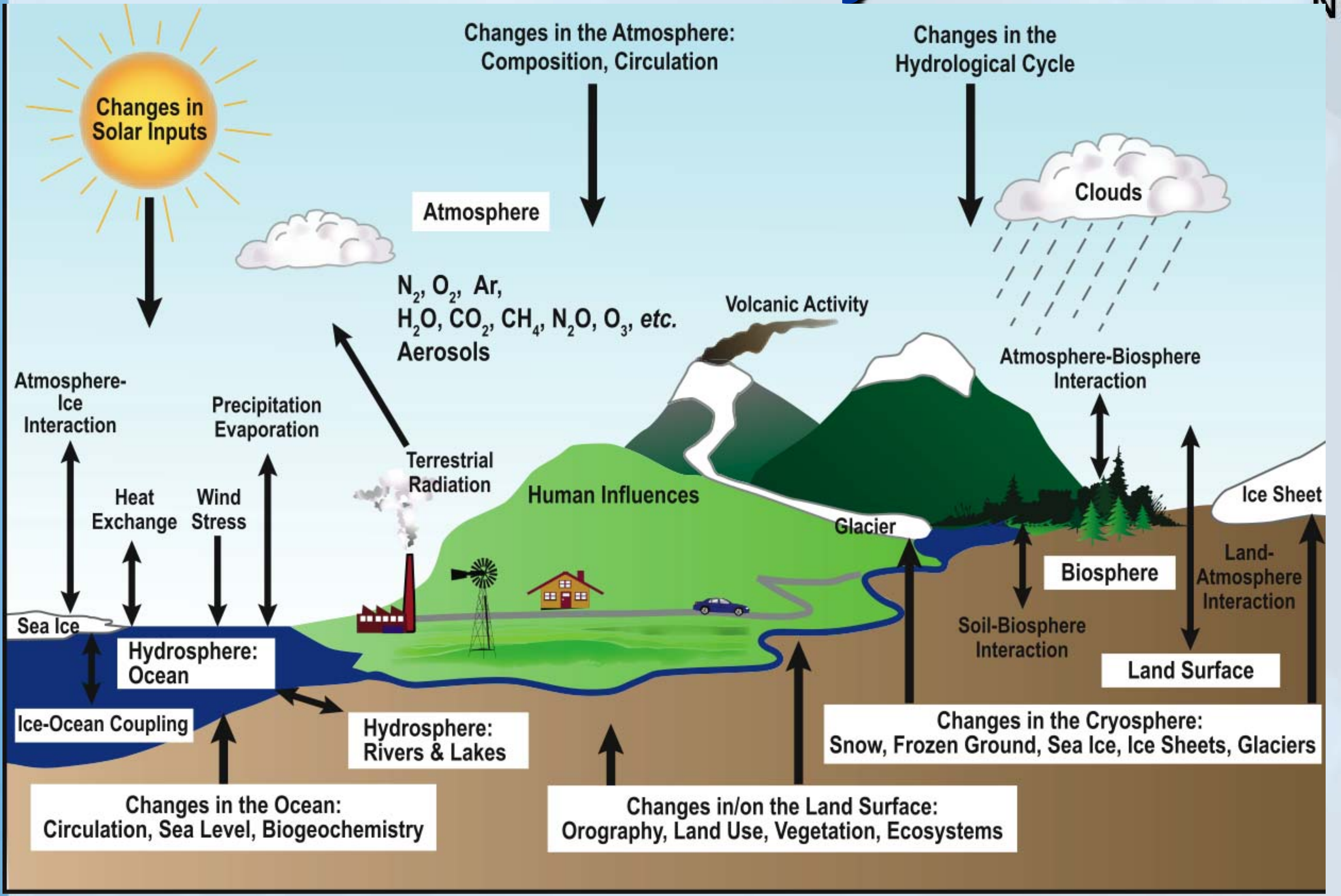


Current Trends in CO2 Emissions



Raupach et al., 2007

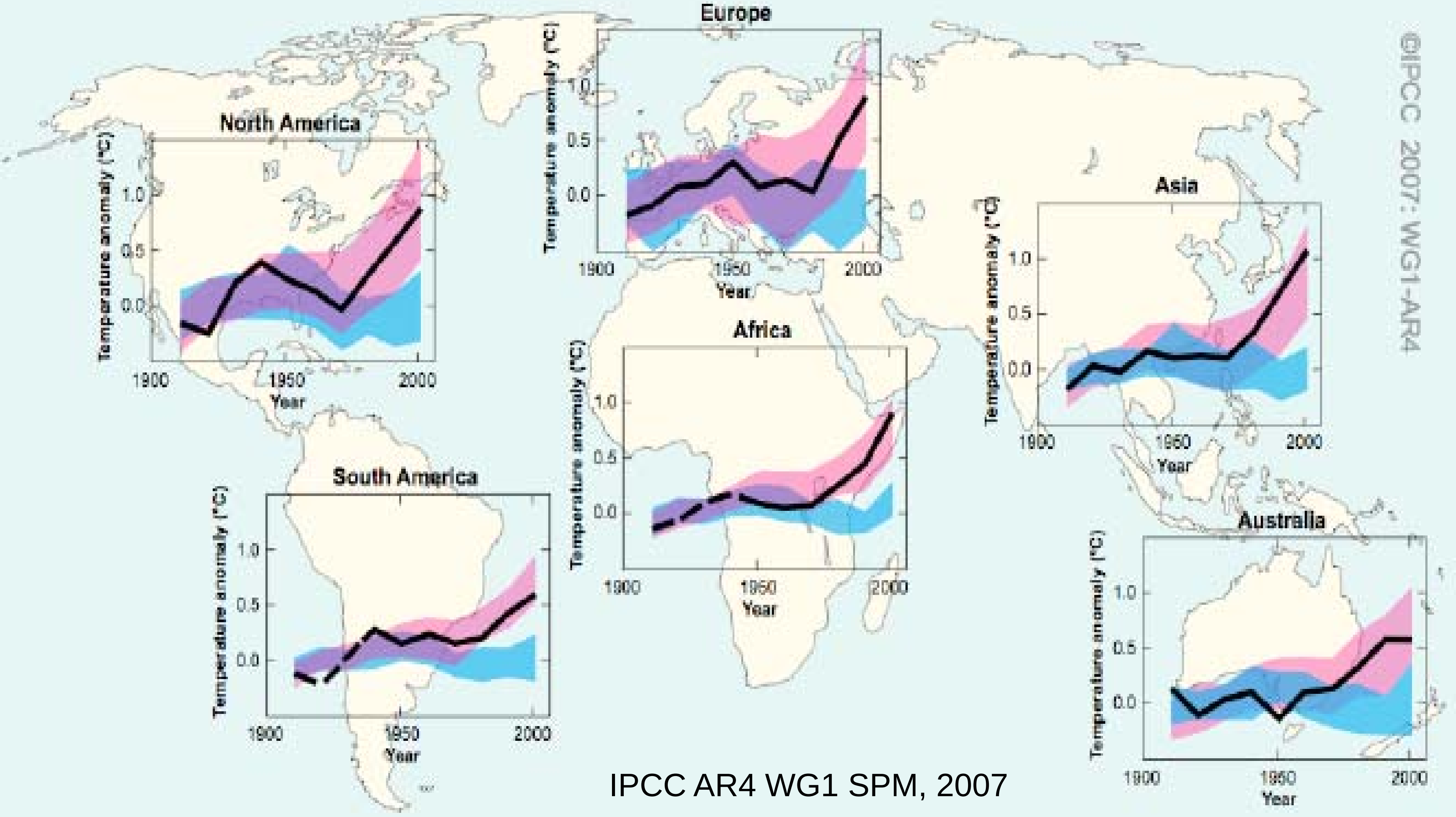
The Climate System



NCAR

How do we simulate this?

Computer models match observed ΔT on all continents

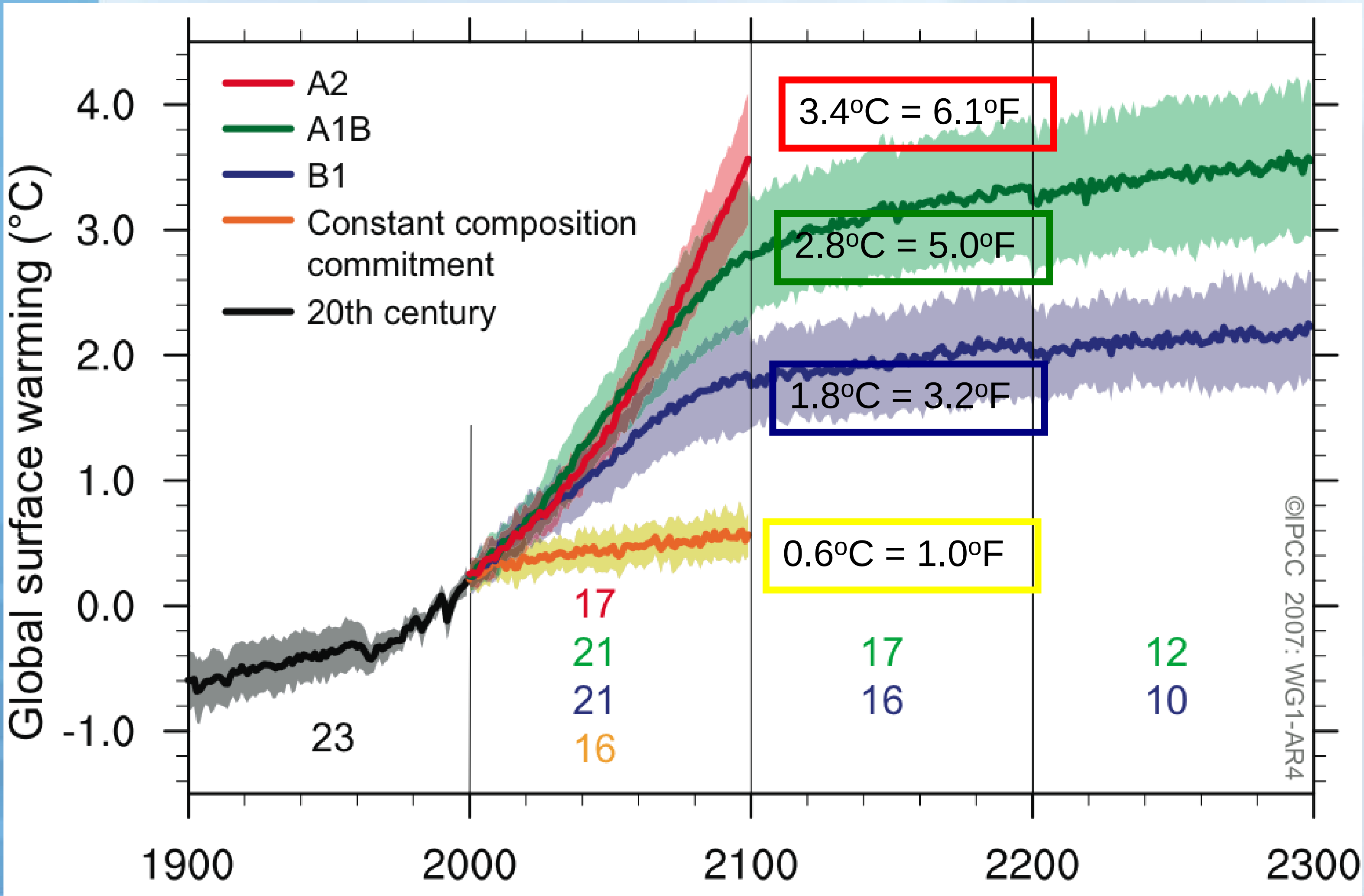


IPCC AR4 WG1 SPM, 2007

Black lines are decadally averaged observations. Blue bands are computer models with natural forcings only. Pink bands are computer models with human + natural forcings.

The Future

Warming will increase if GHG increase. If GHG were kept fixed at current levels, a committed 0.6°C of further warming would be expected by 2100. More warming would accompany more emissions.



CO2 Eq

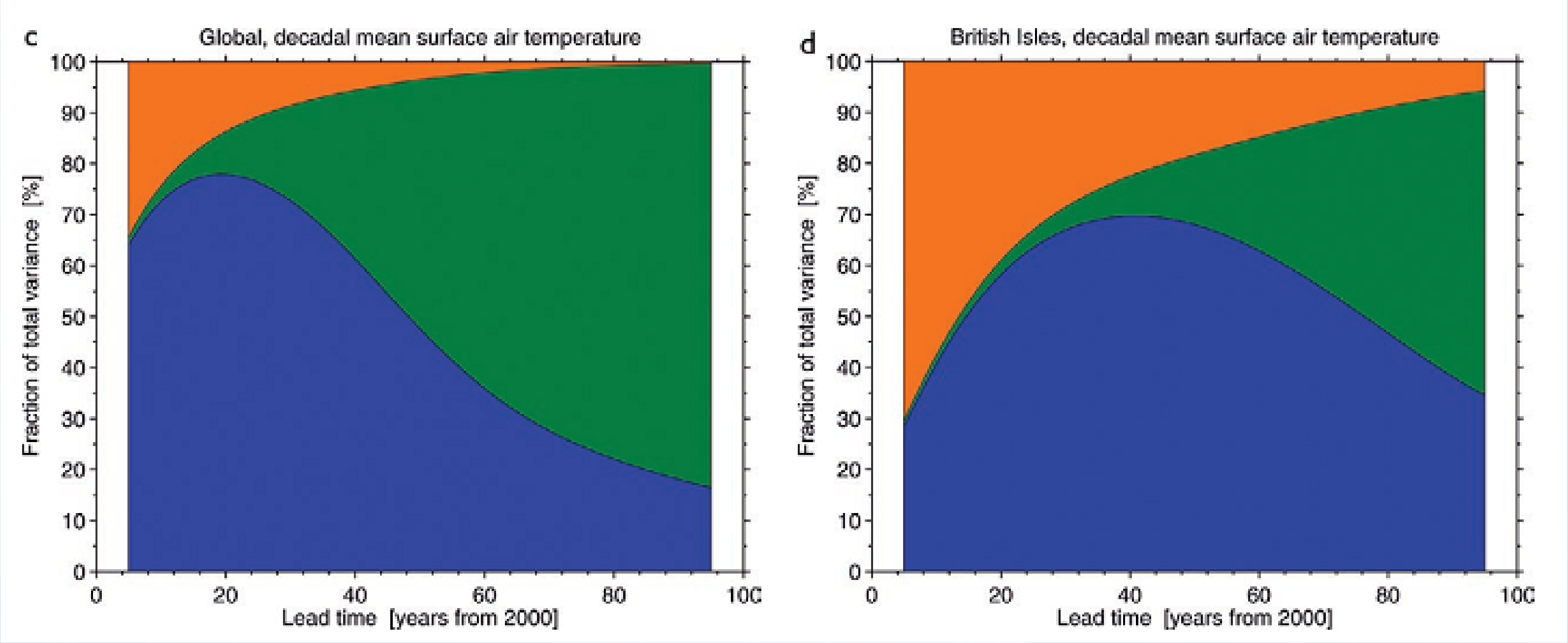
850

600

400

Uncertainty on Regional Scales

Fraction of total variance in decadal mean air temperature predictions explained by the three components of uncertainty



Internal variability

Orange = internal variability
Green = emissions scenario uncertainty
Blue = model uncertainty

Hawkins and Sutton, 2009

Deep uncertainties we can't readily quantify

- Incomplete knowledge of physical processes
- Model structure (including important feedbacks within the climate system)
- Catastrophic extreme events - e.g., collapse of the Greenland Ice Sheet

Why quantification of uncertainty is important

- Because the uncertainties are not going away any time soon
- Because we need to make decisions under conditions of uncertainty
  - Many resource managers need this information (but doesn't have to be probabilistic information – can be a range of scenarios)

North American Projections (end of 21st century, assuming A1B scenario)

- Based on 21 global climate model results – expert judgment of model results
- Always note model limitations (e.g., coarse spatial resolution of models, ~ 2 deg.)

Temperature and precipitation changes with model agreement

(2080-2099 minus 1980-1999) A1B Scenario

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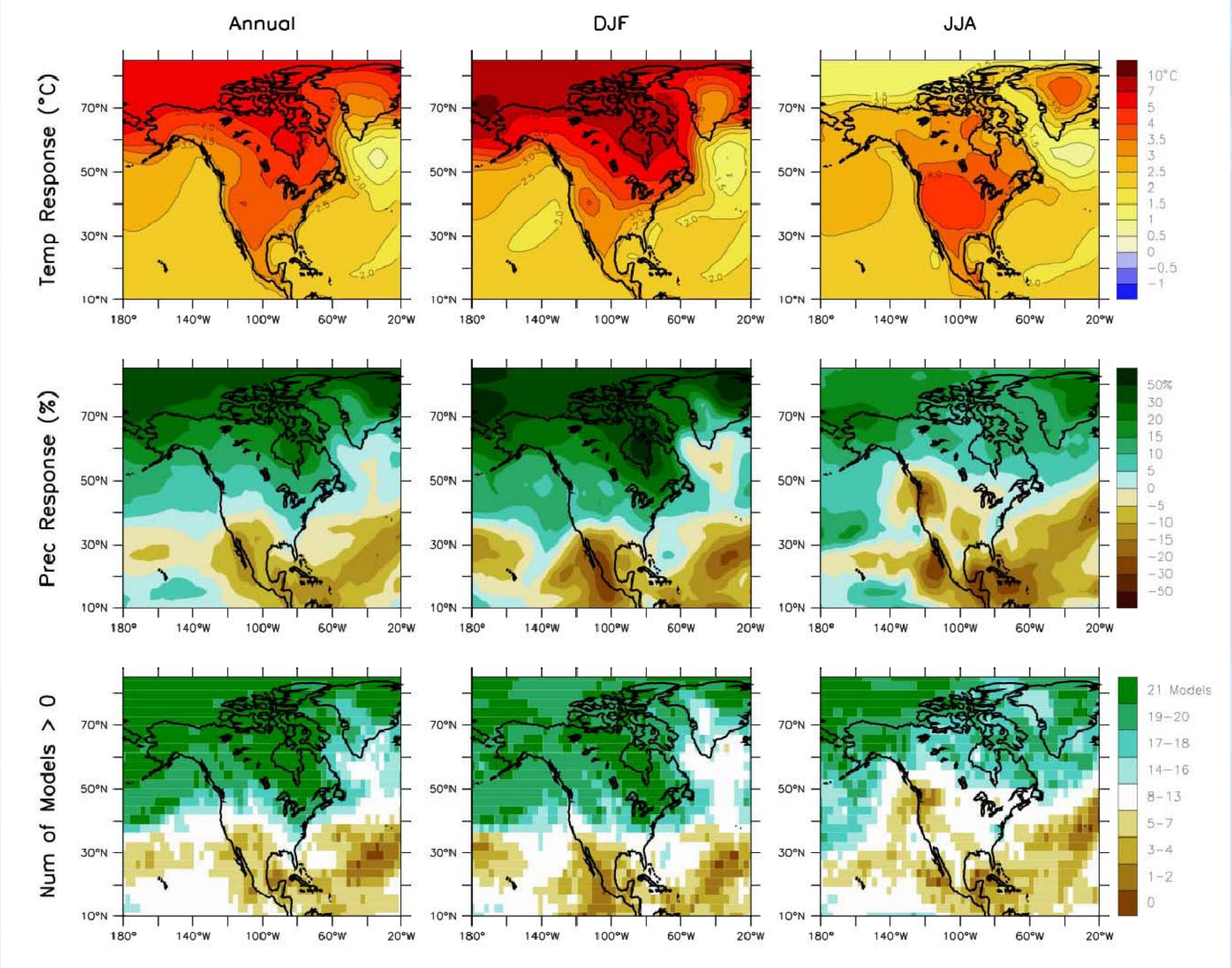
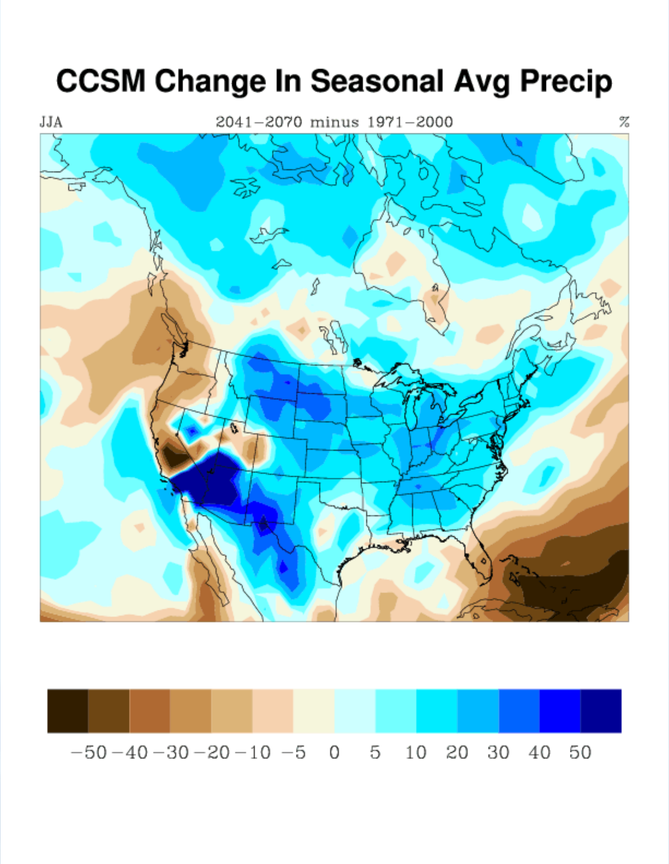
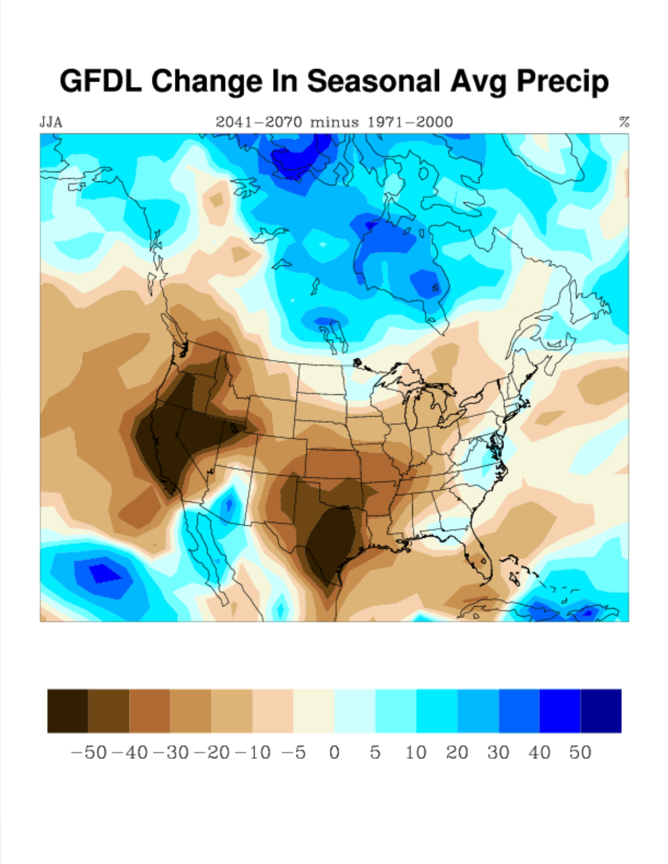
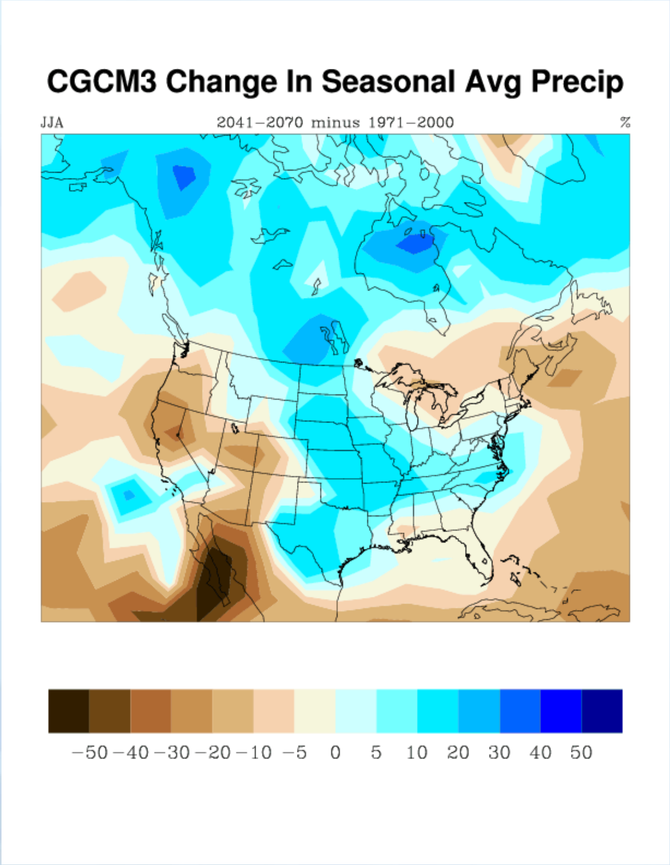


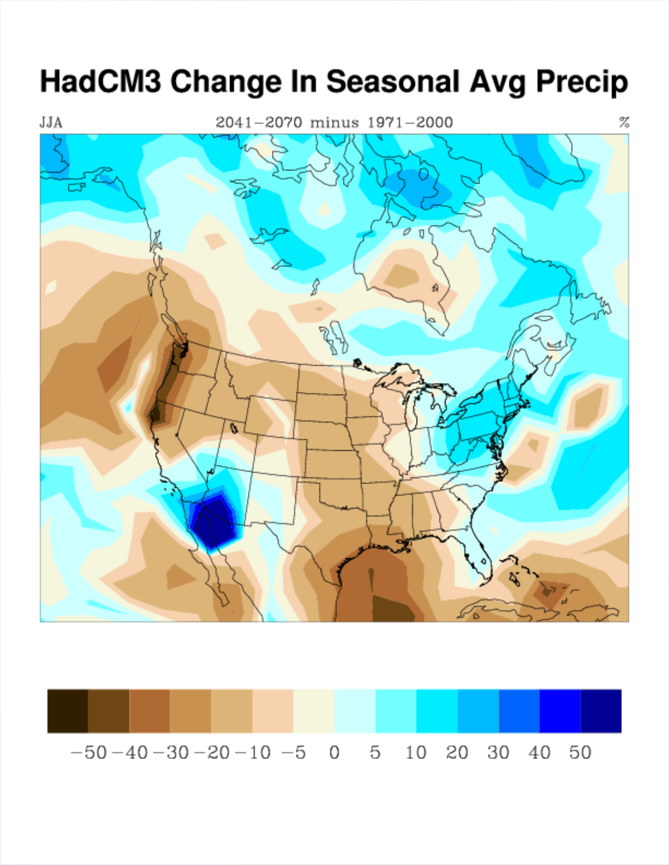
Global Model Change in Precipitation - Summer





Global Model Change in Precipitation - Summer



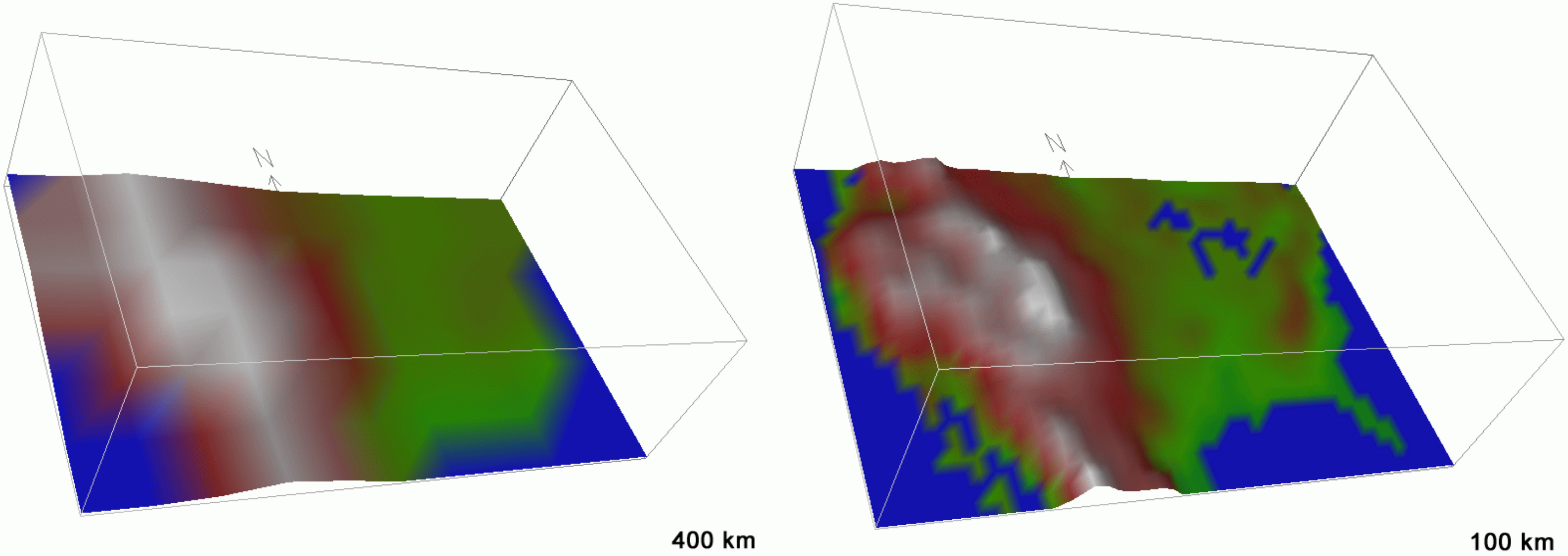


Uncertainty due to Spatial Scale of Climate Simulations

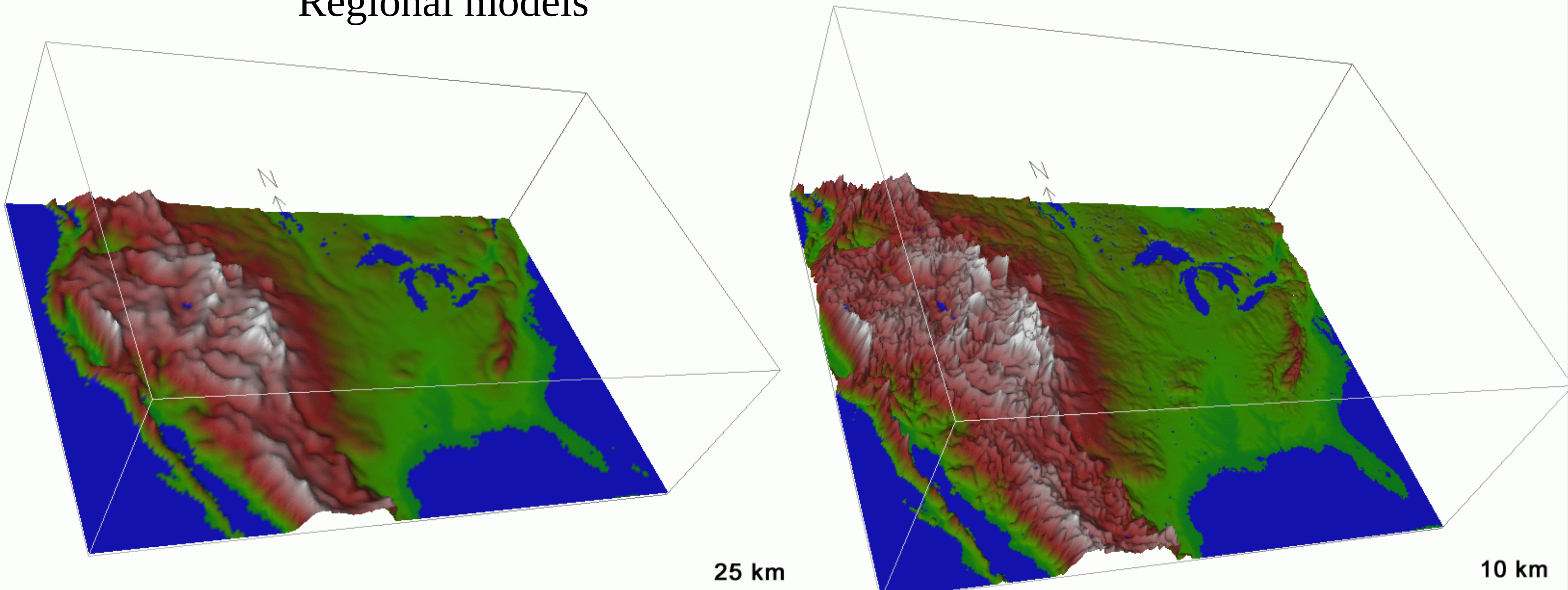
Dynamical Downscaling

- What about higher resolution information about climate change?
- Global models run at about 200 km (120 mile) spatial resolution - what resolution do we need for adaptation purposes
- How to balance the desire for higher resolution with the other major uncertainties (future emissions, general response of climate system).

Global Climate Models



Regional models



What high resolution modeling is really useful for

- In certain specific contexts, provides insights on realistic climate response to high resolution forcing (e.g. mountains)

Regional Modeling Strategy

Nested regional modeling technique

- Global model provides:
  - initial conditions – soil moisture, sea surface temperatures, sea ice
  - lateral meteorological conditions (temperature, pressure, humidity) every 6-8 hours.
  - Large scale response to forcing (100s kms)
- Regional model provides finer scale (10s km) response

The North American Regional Climate Change Assessment Program (NARCCAP)

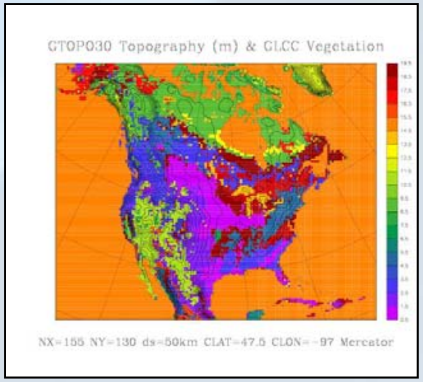
NCAR

www.narccap.ucar.edu

- Explores multiple uncertainties in regional and global climate model projections

  4 global climate models x 6 regional climate models

- Develops multiple high resolution regional (50 km, 30 miles) climate scenarios for use in impacts and adaptation assessments

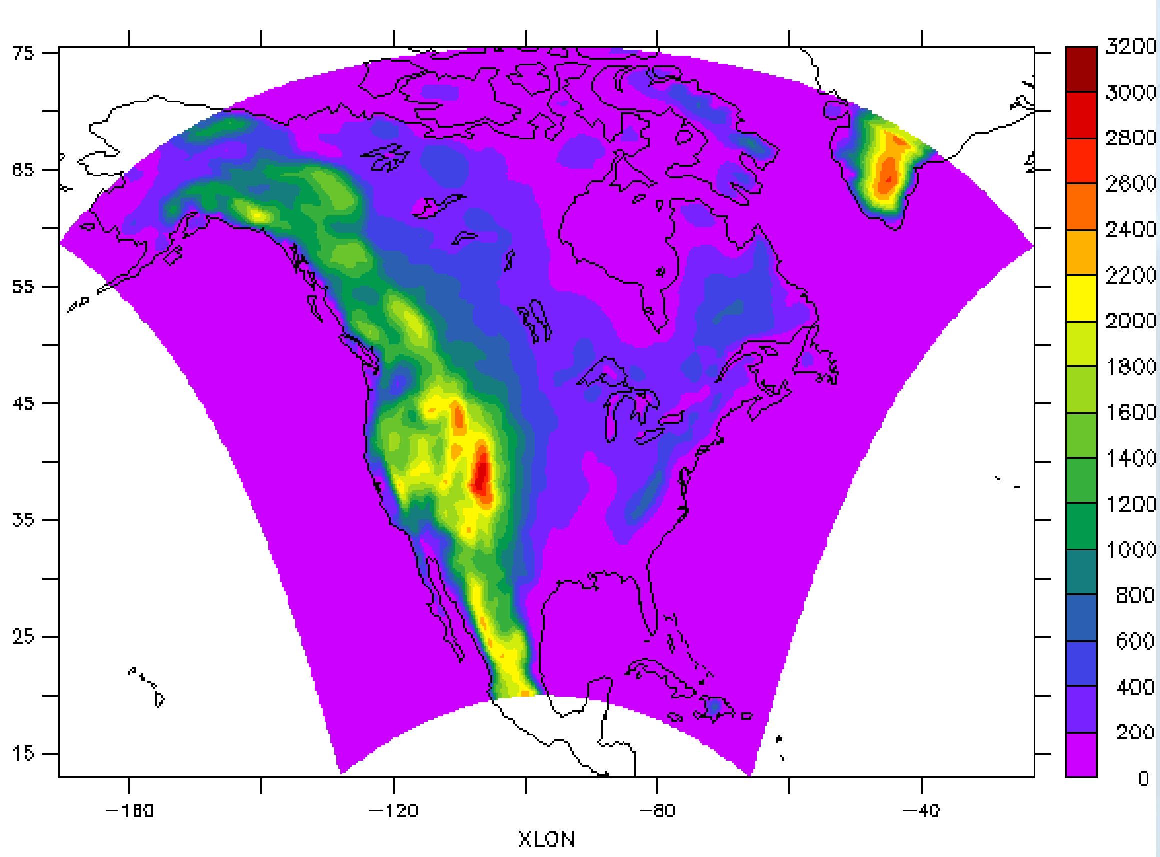


- Evaluates regional model performance to establish credibility of individual simulations for the future

- Participants: Iowa State, PNNL, LNNL, UC Santa Cruz, Ouranos (Canada), UK Hadley Centre, NCAR

- Initiated in 2006, funded by NOAA-OGP, NSF, DOE, USEPA-ORD – 4-year program

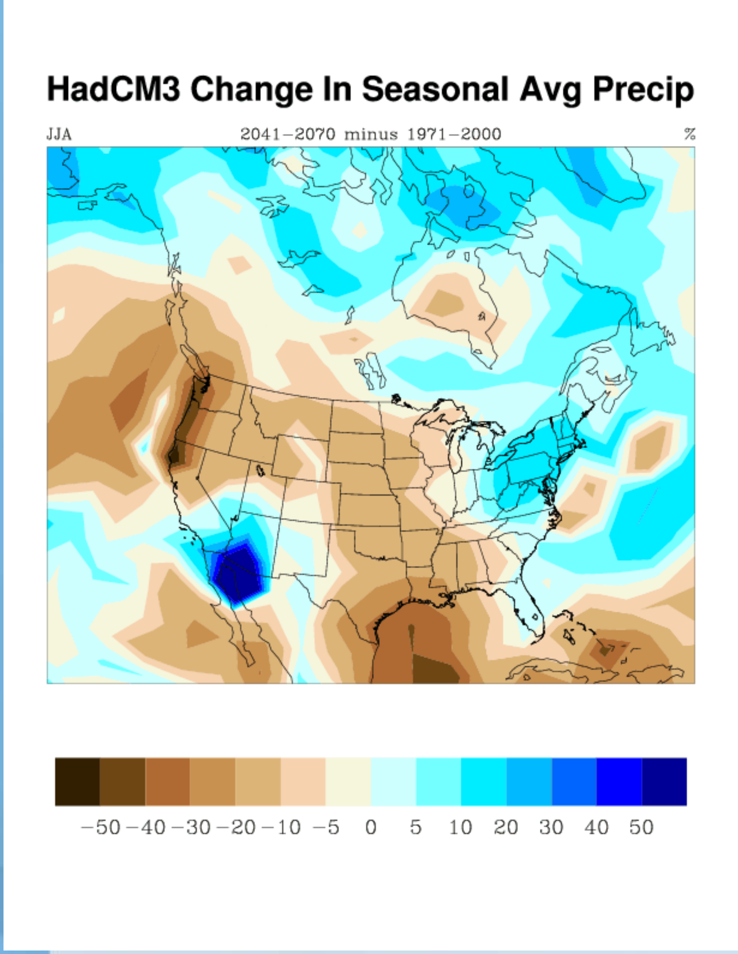
NARCCAP Domain



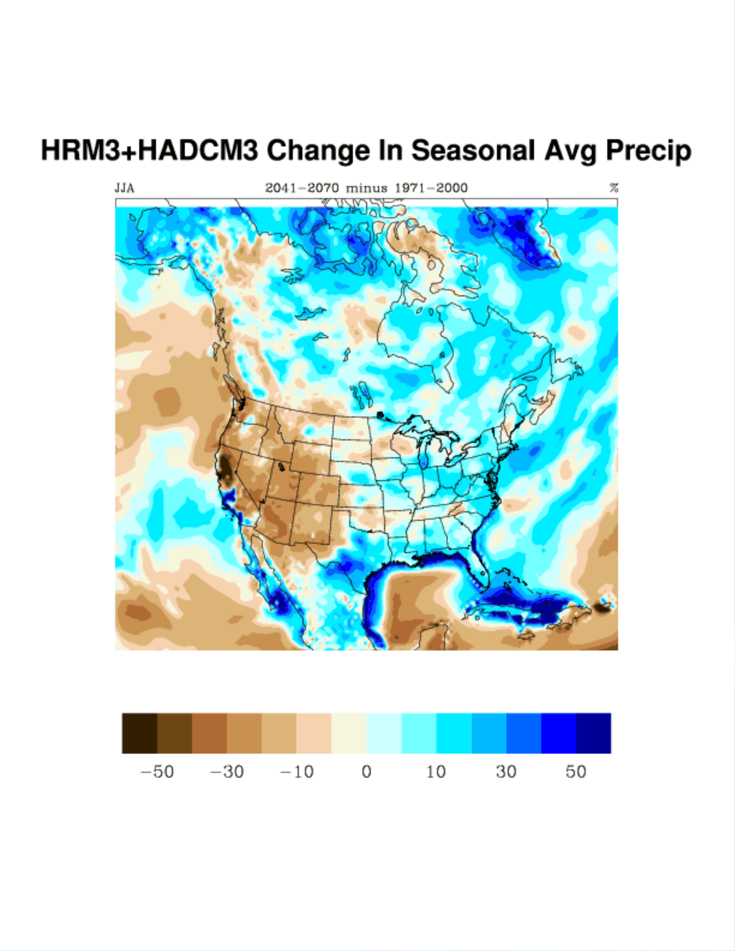
HT

Change in Summer Precip
UK Models

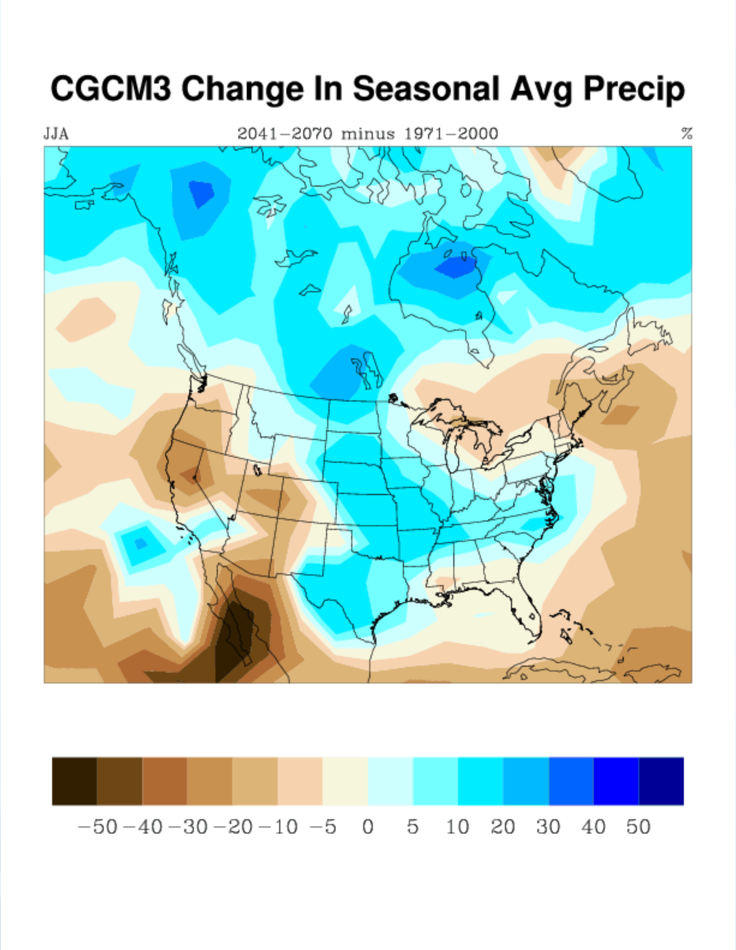
Global Model

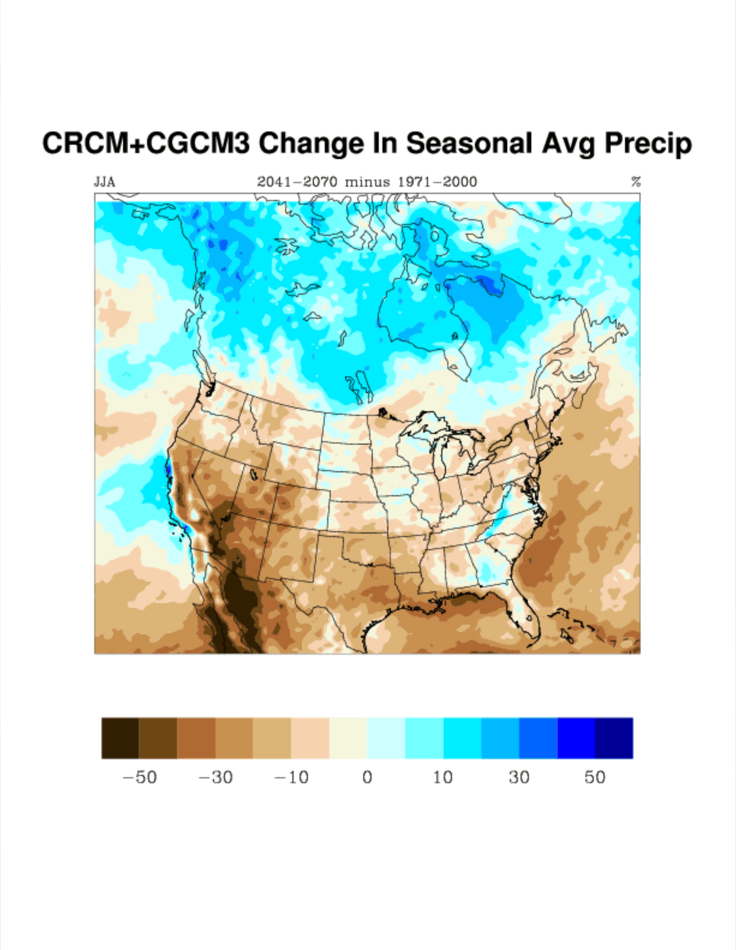


Regional Model



Change in Summer Precip
Canadian Models





Displaying Information about Future Climate – Methods

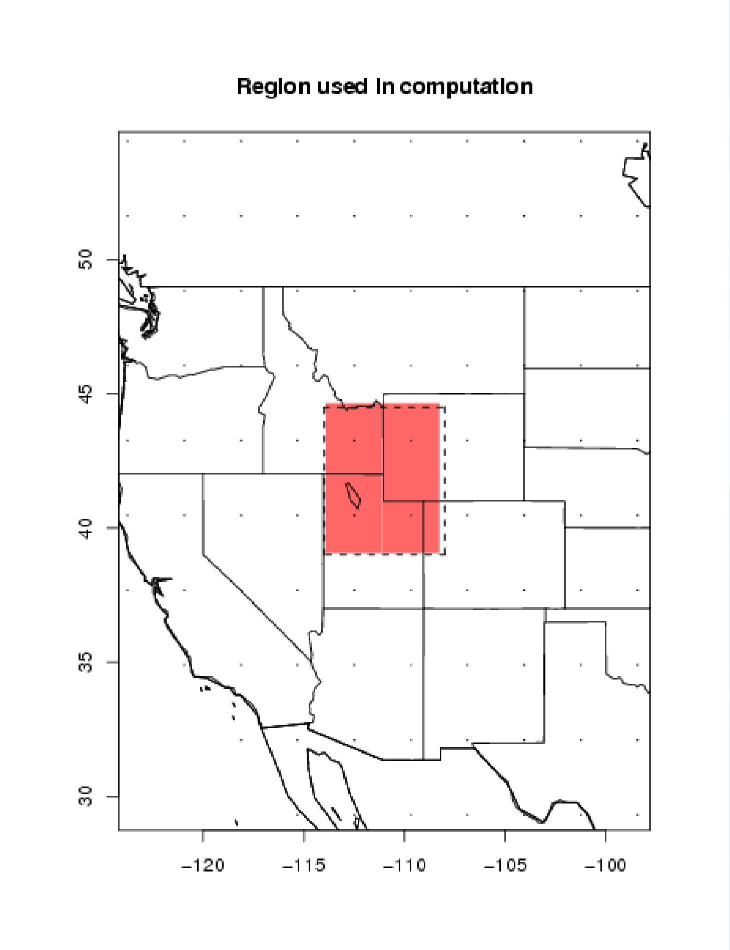
- Probabilistic approach
- Ranges of changes
- Presenting some ‘representative’ full scenarios

Quantification of Uncertainty in Probabilistic Terms

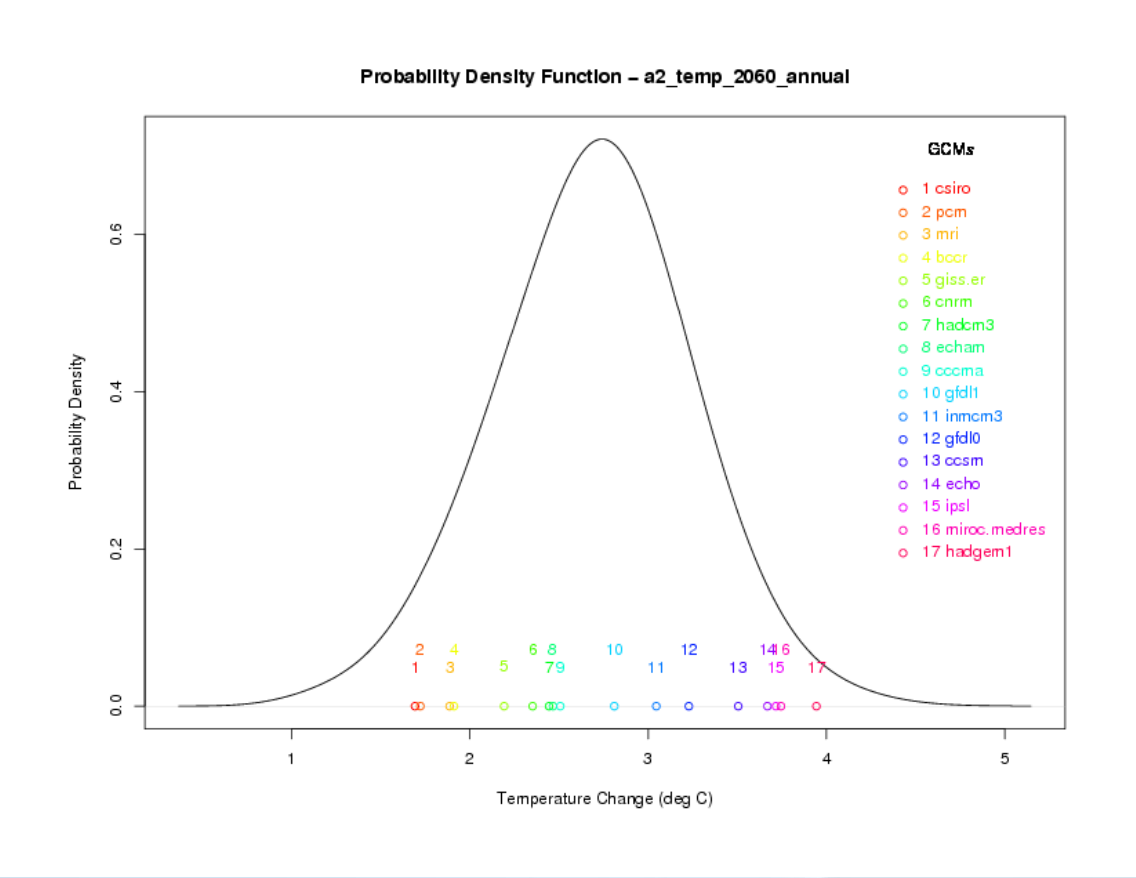
Approaching the Scale Where People Live

- Regional scale probabilities
- Multi-model ensembles (21 models)
- Based on methods developed by Tebaldi et al., 2004, 2005

Bear River Large Region



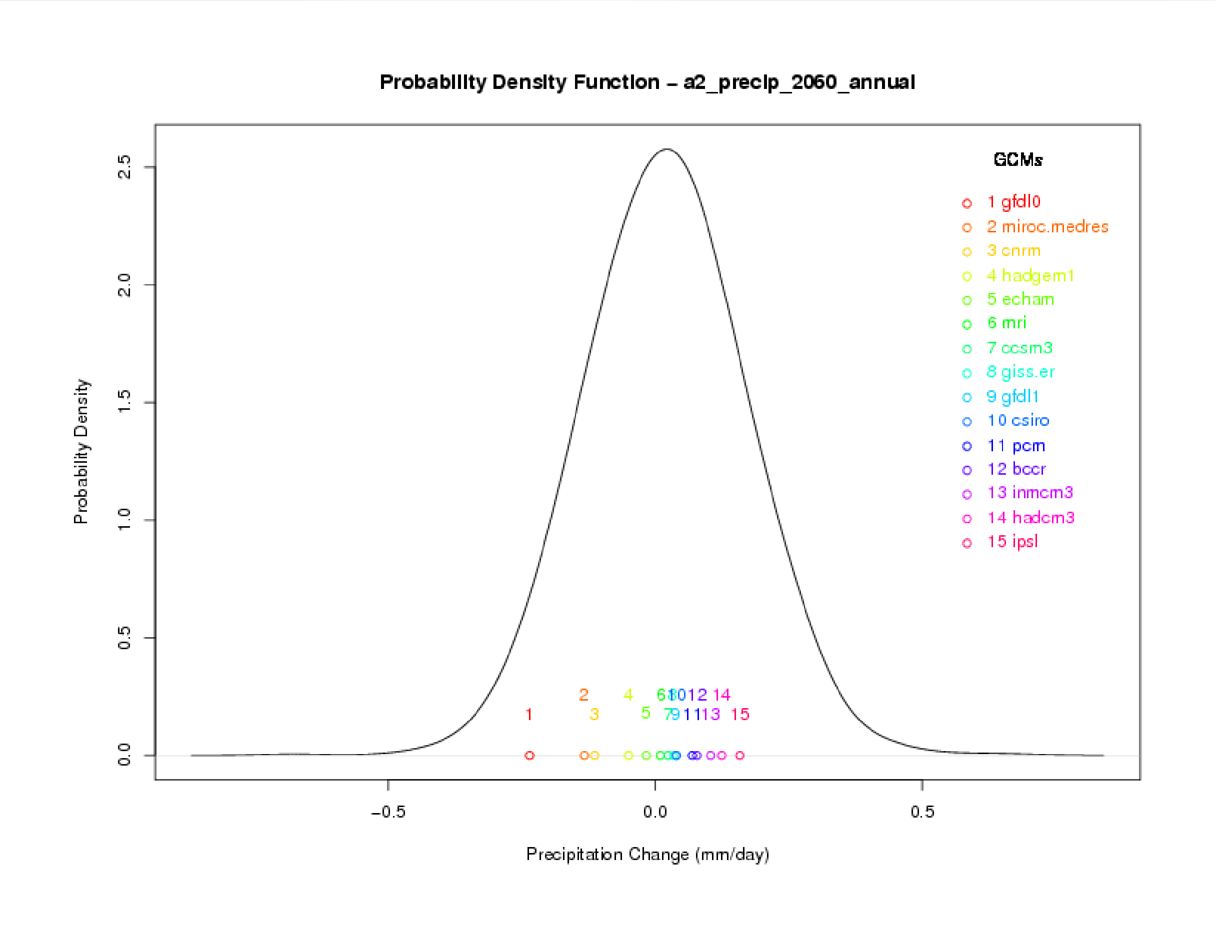
Probabilities of Climate Change



Bear River Area – ~ 2060 vs. present

Temperature change – deg. C

Probabilities of Climate Change



Bear RIver Large Area – ~ 2060 vs. present
Annual Precipitation Change – mm/day

Quantiles of % Change in Precipitation based on GCMs

Percentile	5	25	50	75	95
Annual	-14	-5	+1	8	17
Winter	-12	3	12	20	36
Summer	-45	-25	-12	2	23

Bear River Region

But probability distributions are no better than their underlying assumptions

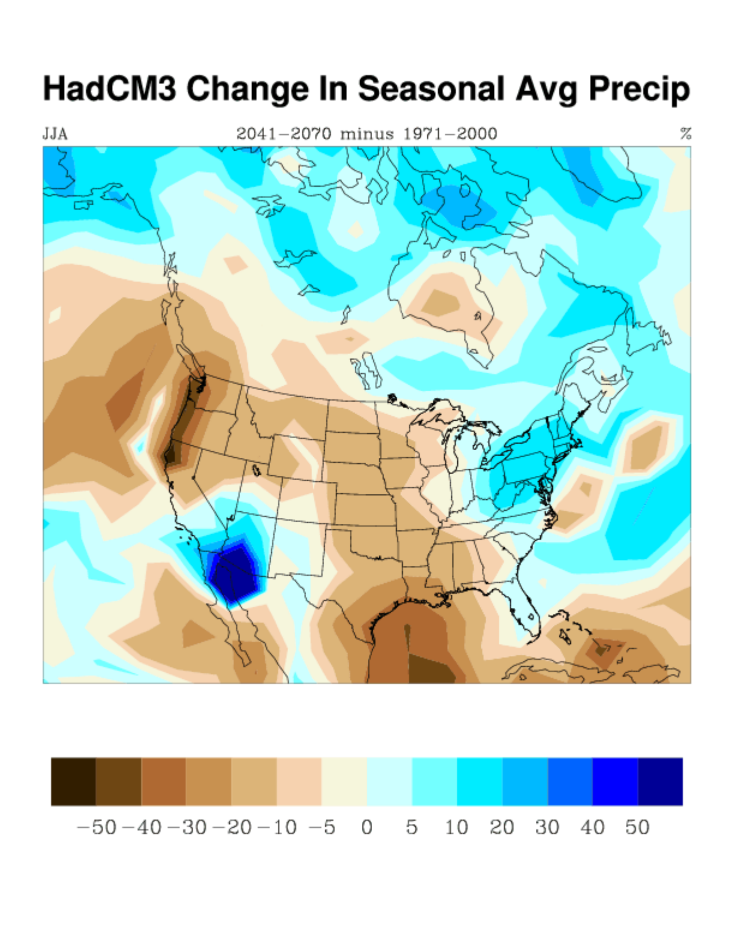
Most of the research is providing examples of methods development, not useable forecasts

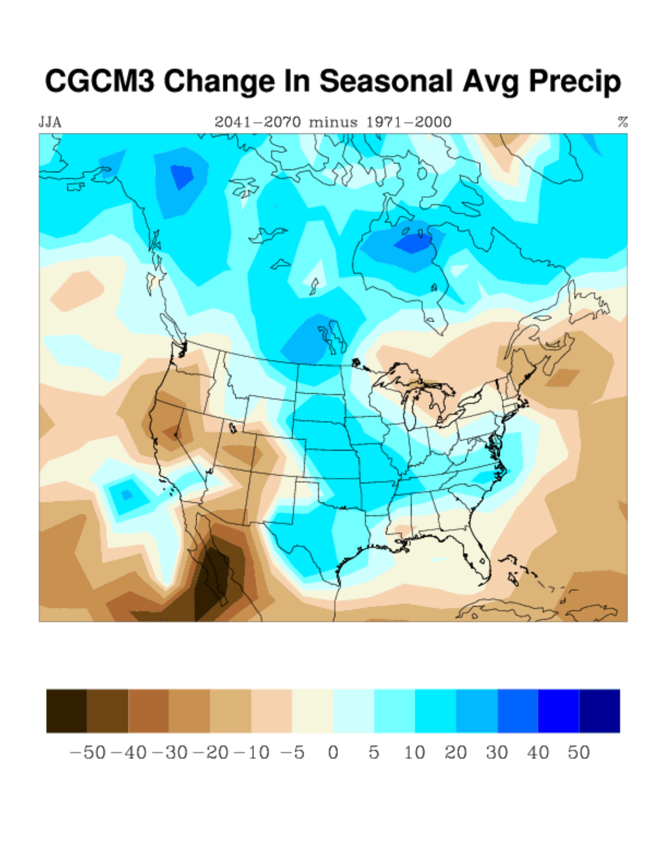
But can provide useful way of summarizing information about future for generating insights

NYC Adaptation Plan – application of simple ranges

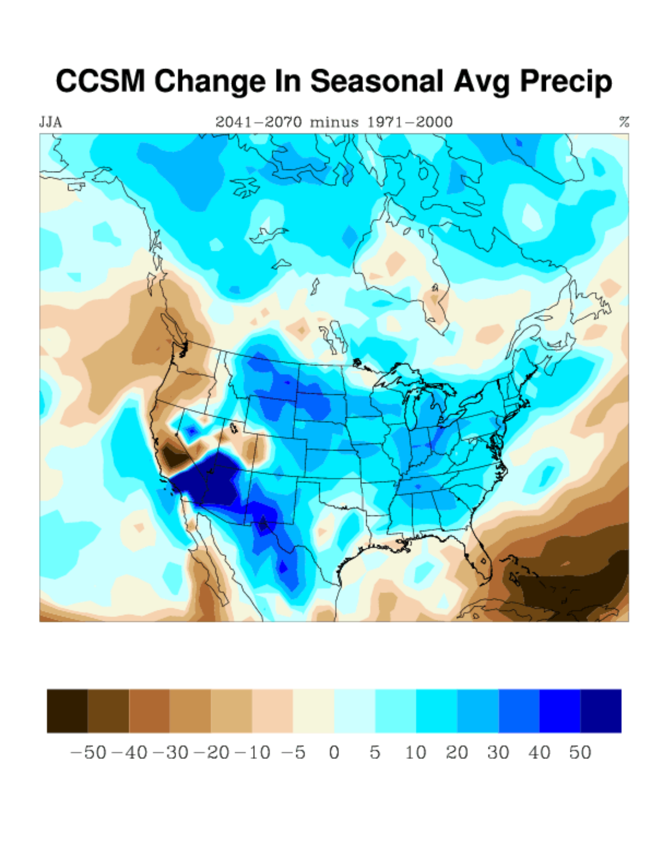
- Climate change information taken from global models – ranges given for different decades (e.g., 1.5--3°F increase and 0—5% increase in precipitation, sea level rise of 2—5 inches by the 2020s).
- Adaptation plans have been made using this type of climate change information

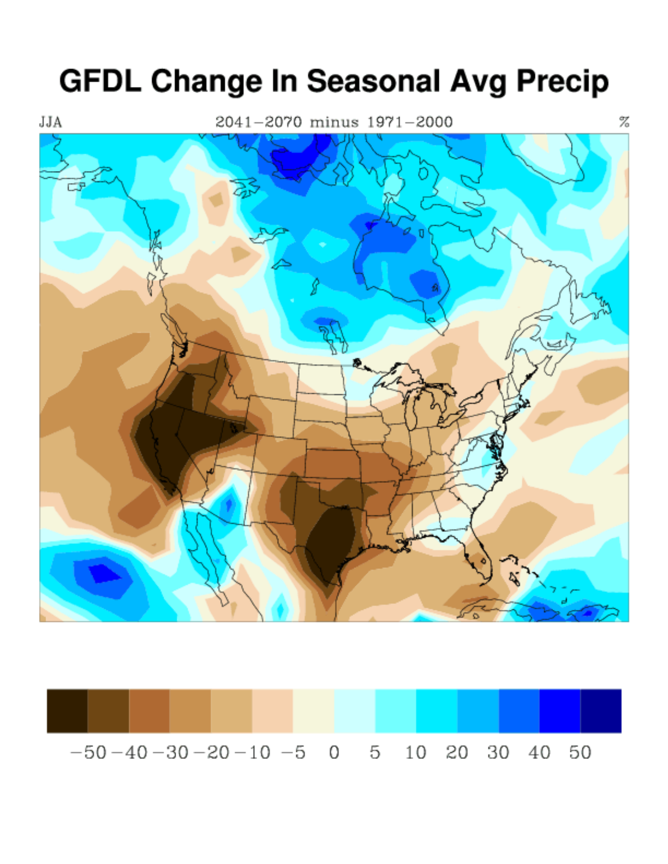
Presenting Multiple Scenarios





Global Model Change in Precipitation - Summer





When to use which kind of representation of the future

- Tough question
- Depends on stakeholders' needs, expectations
- Ideally should be determined together
- More on this during the workshop

Do we need to reduce uncertainty in order to make decisions about climate change?

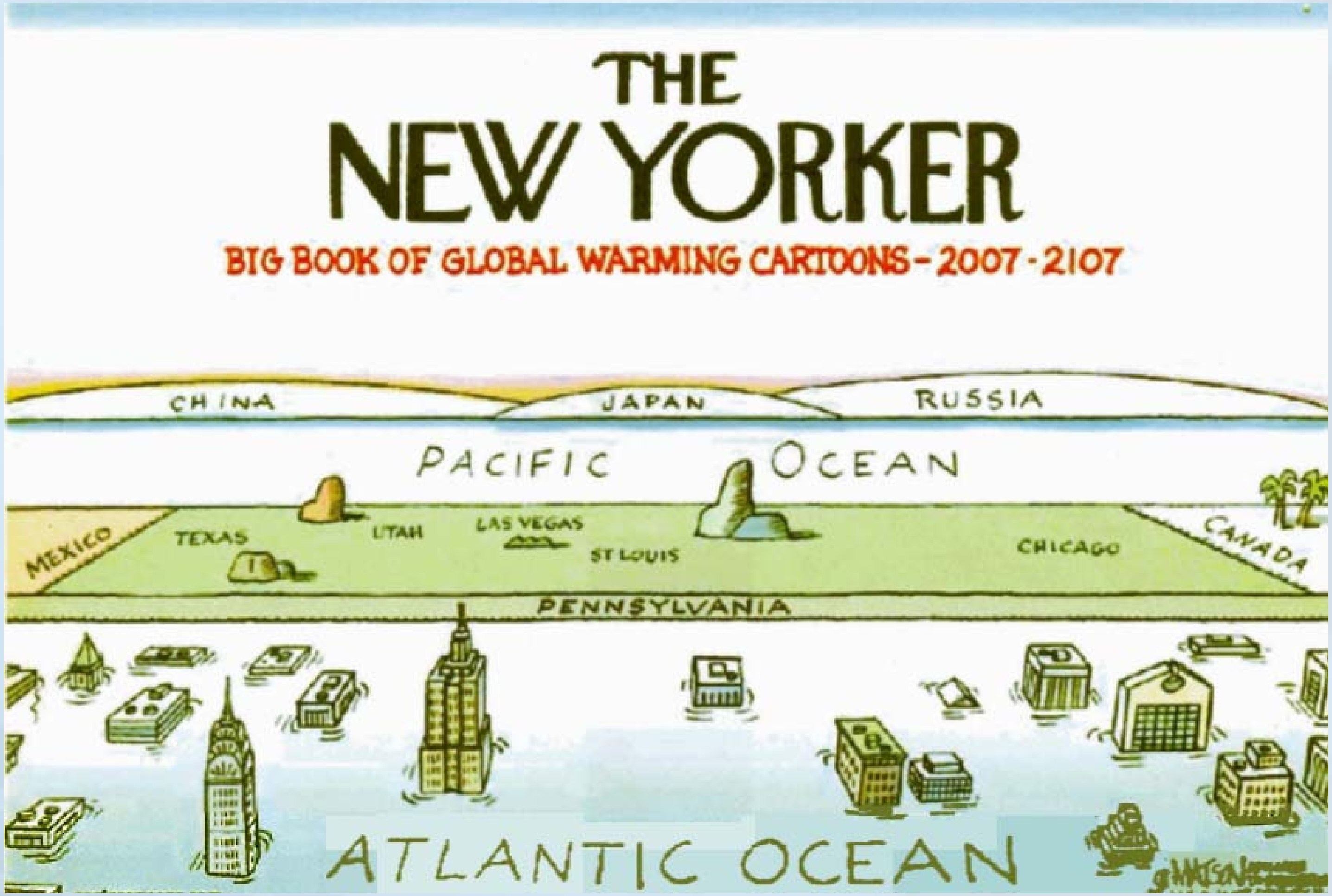
Is it sometimes the case that there is too much uncertainty about climate change to make any decisions?

No, better to figure out how to make decisions that are robust given the uncertainty that currently exists

Important to make decisions regarding adaptation that are flexible, that can be adjusted as we learn more about climate change in the future

What is the danger of false certainty?

NCAR



THE NEW YORKER
BIG BOOK OF GLOBAL WARMING CARTOONS - 2007 - 2107
CHINA
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UTAH
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CHICAGO
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PENNSYLVANIA
ATLANTIC OCEAN

Southwest
Climate Change Initiative

Information and Tools for Natural Resources Management in a Changing World

The Climate Change Challenge

Scientists agree that the **Earth's climate has already been disrupted irrevocably** by the accelerated release of greenhouse gases into the atmosphere. In fact, climate change is already well underway in the southwestern U.S.—perhaps more so than anywhere else in North America, outside the northernmost latitudes—and it is already affecting native plants, animals and habitats in ways we can see and measure. The challenge to the conservation community is to manage our forests, grasslands, deserts and rivers to **build resilience and to reduce the adverse impacts** of climate change.

Now is the time to prepare for more change. Any action we take now to understand the local effects of climate change and to build ecosystem resilience will help us, over time, protect our natural areas and the clean water, clean air, and wildlife habitat they provide. The Nature Conservancy has joined with the Climate Assessment for the Southwest, National Center for Atmospheric Research, Western Water Assessment, Wildlife Conservation Society, USDA Forest Service, and the University of Washington to form the Southwest Climate Change Initiative (SWCCI). Our aim is to **provide information and tools to conservation practitioners for climate adaptation in vulnerable landscapes in Arizona, Colorado, New Mexico and Utah**.

Managing for Resilience and Change in the Southwestern United States

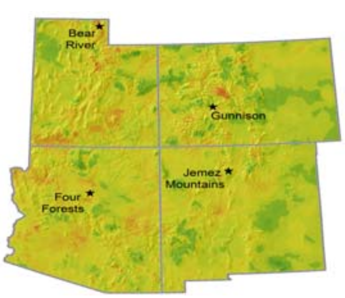
To meet our goal of informing and accelerating climate adaptation in the region, the SWCCI plans to:

- **Assess past and projected climate change and its effects on species, habitats and ecosystems.** This analysis, to be completed in late 2010, will assess past and projected changes in temperature and precipitation, and their effects on the region's natural diversity. Our final report will also make recommendations for climate-smart conservation in the region.

- **Establish demonstration projects at four vulnerable landscapes**: the Bear River Basin in Utah, the Four Forests Restoration Initiative area in Arizona, the Gunnison Basin in Colorado, and the Jemez Mountains in New Mexico. At each landscape, we are developing science-based vulnerability assessments and adaptation strategies; creating local partnerships that promote, facilitate, and help raise funds for adaptation action; and developing and promoting on-the-ground adaptation projects that will build resilience to rapid environmental change.

- **Document and share knowledge, tools, methods and lessons learned** within the region and with a global network of adaptation practitioners through Web and print publications and tools.

Interim Results at Demonstration Landscapes



The aim of each of four SWCCI landscape workshops – and the months of work that preceded and followed them – was to **build understanding of how climate change may affect ecosystems** and **identify strategies that natural resource managers can use to address rapid climate change**. Each workshop fostered dialogue between scientists and managers about how to adjust objectives and strategies for effectiveness in a warmer, world with more frequent and extreme droughts.

Each workshop raised awareness and understanding among stakeholders, and each produced a report that documented:

- ✓ Observed and projected regional and local changes in temperature, precipitation, hydrology, and extreme weather events.
- ✓ Observed and projected climate change effects on key species and habitats.
- ✓ Rapid vulnerability assessments for key species and habitats.
- ✓ Recommendations for "climate-smart" management objectives for key species and habitats.
- ✓ Lists of priority and "no-regrets" climate adaptation strategies: conservation activities that will produce benefits under multiple plausible climate scenarios.
- ✓ Opportunities for collaboration and funding to accelerate the pace of climate adaptation.

Next Steps: Action to build resilience to rapid change

Following up on the workshops, The Nature Conservancy is working with partners, including the US Forest Service, Colorado Division of Fish and Wildlife and local NGOs, to build resilience on the ground.

- ✓ In the **Jemez Mountains**, climate adaptation strategies have been integrated into the SW Jemez Strategy, a multi-year, multi-million dollar forest restoration project.
- ✓ In the **Gunnison Basin**, a new Gunnison Climate Working Group is helping member agencies make their work more "climate-smart."
- ✓ Northern Arizona's **Four Forest Restoration Initiative** is integrating climate science into its landscape-scale forest restoration plan.
- ✓ In the **Bear River Basin**, partners are working to sustain trout habitat as the climate warms and droughts become more frequent and severe.

Lessons Learned: What we've discovered that could be applied to other landscapes

- We know enough about climate change to take local action: Though there is uncertainty regarding the pace of climate change, the conservation community has enough information to act now to reduce the most likely adverse impacts.
- "Climate-smart conservation" means adjusting the pace, scale and sequencing of management activities: Many of the tools that managers use to restore and maintain ecosystems can contribute to climate change adaptation – but the scale, sequencing, priority and cost of these strategies will likely need to be adjusted if objectives are to be met.
- In some cases, current management objectives will be unattainable; we must be agile and adjust our sights: The large scope of ecological change expected under the most probable climate change scenarios means that some forest and watershed management objectives may need to be adjusted.
- Conservation organizations are already doing a lot to restore and maintain ecosystems—but climate change means we must do more, and do it smarter: Land management agencies may need to increase the scale, scope and pace of management interventions – and to reconsider where and how to make them –to prepare the landscape.
- To conserve ecosystems and species, we must understand how their environments are changing: More than ever, success will require that monitoring and adaptive management are integrated into landscape planning and management. In a changing environment for which there are no analogs in the historical record, ecosystems are bound to respond in unpredictable and surprising ways, calling for well-informed and nimble responses by managers.
- The workshops represent the beginning of a long-term process for understanding and responding to the challenge of climate adaptation for species, habitats and ecosystems. Workshops are good starting point, but more time, thought and energy will be required to build consensus for – and begin implementing – resilience-building strategies.

For More Information

For more information about the Southwest Climate Change Initiative, visit http://nmconservation.org or contact project director Patrick McCarthy at (505) 988-1542 ext. 217 or pmccarthy@tnc.org.

The Nature Conservancy
Protecting nature. Preserving life.™

Canyonlands Research Center

Communities that rely on the lands of the Colorado Plateau and waters of the Colorado River are facing a crisis. Increasing temperatures and prolonged droughts, coupled with increasing human impacts and demands, will dramatically affect this landscape and its resources in the near future. Yet scientists, policy makers, land managers and ranchers lack adequate information to make decisions about how best to prepare for the looming ecological and water supply changes.

Science-Based Solutions

The Canyonlands Research Center will establish an innovative science collaborative and research site to provide decision-makers with information about climate and land use interactions on the Colorado Plateau. Based at the Conservancy's iconic Dugout Ranch, the Canyonlands Research Center will help to inform and influence arid land use policies, addressing issues such as diminished Colorado River water quantity and quality, species loss and invasive species. The Center will also develop and share new, sustainable land use practices to help protect the natural and human communities of the Colorado Plateau and other arid land systems around the world.

Colorado Plateau: Nowhere Else on Earth

The Colorado Plateau is becoming one of our country's most popular and conflicted regions – a coveted remnant of American wilderness, a hotbed of growing human pressures and an at-risk home for unique species and systems.

Flanked by the Rocky Mountains on the east and the Great Basin on the west, the Colorado Plateau spans 76,000 square miles across southeastern Utah, northern Arizona, northwestern New Mexico and southwestern Colorado. Elevation ranges are steep, stretching from below 2,000 feet to almost 13,000 feet. And although it is a desert, the Plateau contains two of the continent's largest rivers, the Colorado and the Green, channeling water to millions of people in seven U.S. states and Mexico. With five of the country's fastest-growing cities ringing the region, tourism and recreation are growing exponentially.

By virtue of its complex geology and specialized land forms, the Plateau supports numerous species found nowhere else in the world. Plants are the most biologically diverse group, with 300 endemic species found only on the Plateau. The region also provides critical habitat for some of the West's most charismatic species including desert bighorn sheep, pronghorn and mountain lions as well as a wealth of aquatic species, such as the endangered Colorado pikeminnow and humpback chub.

Crisis in the Making

Decades of change and use are taking their toll on the Plateau, and mounting ecological problems are now compromising this region's lands and waters. Invasive plants and animals, recreation, development and inappropriate grazing are disrupting ecosystems, threatening water resources and devastating native species. More than 150 of the Plateau's plant and animal species are considered at risk, and 27 species are currently listed as Endangered or Threatened.

Scientists predict that the Colorado River Basin is on track for severe drought, far worse than at any time in the last century. Higher temperatures, combined with prolonged droughts, will reduce soil moisture causing a decrease in plant cover and soil stability on

©Tom Till

lands that are already compromised by activities such as grazing and recreation. Loose soils lead to more wind-deposited dust on western snowpacks, accelerating snowmelt and decreasing runoff—threatening the quality and quantity of Colorado River water. Decreased soil moisture will also lead to a loss of native vegetation and wildlife habitat, as well as an explosion of invasive species such as cheatgrass.

New Hope & Real Answers

Designed to address the most pressing challenges facing rural Utah, the Canyonlands Research Center will provide new information about how temperature, rainfall and land uses combine to effect the productivity and health of natural resources on the Colorado Plateau. Researchers are focusing on the relationships between climate and local issues such as Colorado River water supplies, grazing, recreation and invasive species. Scientists and stakeholders will use this outdoor laboratory to develop land management strategies that aid ranchers, communities, agencies and policy makers in their efforts to sustain the region's lands and waters.

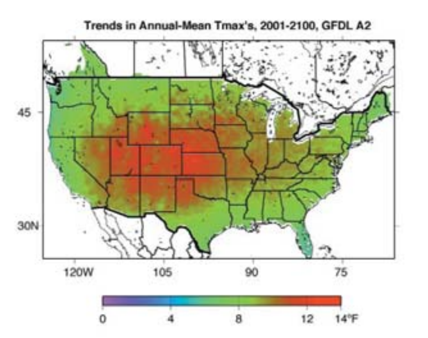
• **Ideal Location:** With The Nature Conservancy's Dugout Ranch at its core, the Canyonlands Research Center site spans lands managed by the USDA Forest Service, Bureau of Land Management and Canyonlands National Park, giving scientists the opportunity to study wide gradients of elevation, ecology and land-use histories. The Center is also situated along the boundary of the Southwestern monsoon climate zone, making it particularly sensitive to climatic variation.

• **The Right Science:** The Center brings together scientists, public land managers, ranchers and other local stakeholders to answer the questions that will define the future of this region's environment and economy. Research topics are designed to translate into land management tactics and strategies that will produce tangible results. Answers generated at the Center will help rural Utah as it strives to:

- Maintain multiple land uses that meet human needs in an ecologically-sustainable fashion.
- Ensure adequate water quantity and quality.
- Control invasive species, which promote massive fires and degrade streams and soils.

• **Powerful Partnerships:** The Center is formed by a suite of diverse partners who support the importance of its mission and research. Current partners include: The Nature Conservancy, Utah State University, U.S. Geological Survey, National Park Service, USDA Forest Service, Bureau of Land Management and Indian Creek Cattle Company.

More Rapid Warming in the West



According to the Rocky Mountain Climate Organization and the Natural Resources Defense Council, the American West has warmed 70 percent more than the planet as a whole. The West's most pronounced temperature increase is in the Colorado River Basin, which has warmed more than twice as much as the global average.

Without science-based answers and new actions to prepare for higher temperatures and longer droughts, this region's natural resources could falter. The Canyonlands Research Center will provide practical solutions to help Utahns adapt now and sustain livelihoods and communities as well as critical lands and waters.

Graphic courtesy of U.S. Geological Survey

For More Information:

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