Agriculture and forestry climate change impacts and adaptation planning – moving beyond gradual and average change

Steven Rose (EPRI)

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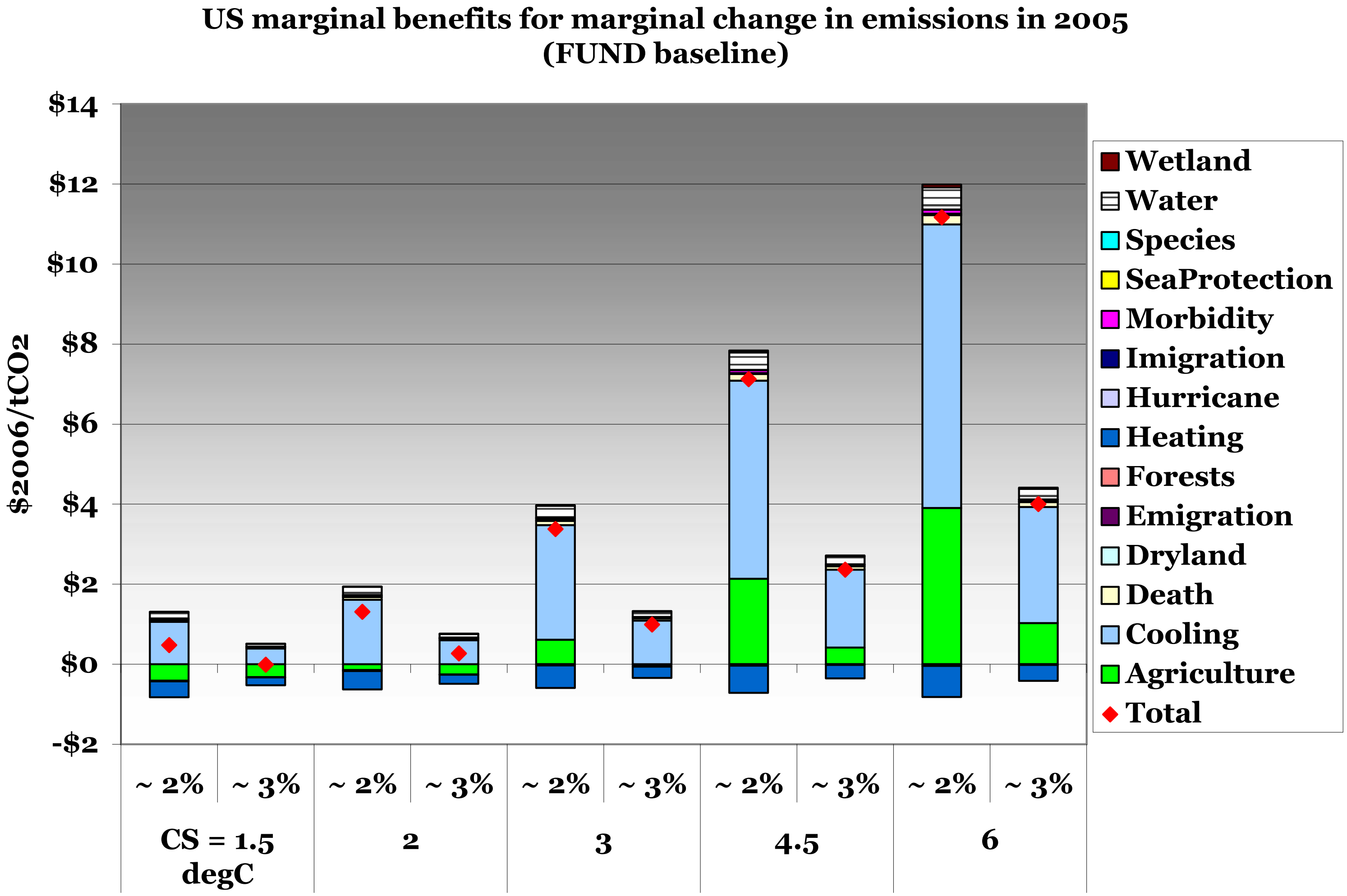
Session objective

- Move beyond evaluating average and gradual biophysical changes
- Characterize and evaluate uncertainties in…
  - Observed and projected biophysical conditions (climate, weather, water, ecosystems)
  - Impacts and adaptation responses and effectiveness
- Develop a fuller characterization of the risks to agriculture, forests, and unmanaged ecosystems
- North American focus – to simplify scope

Currently capturing gradual changes in temperature levels, rate of change, and CO2 fertilization
(e.g., incremental monetized US damages/benefits)



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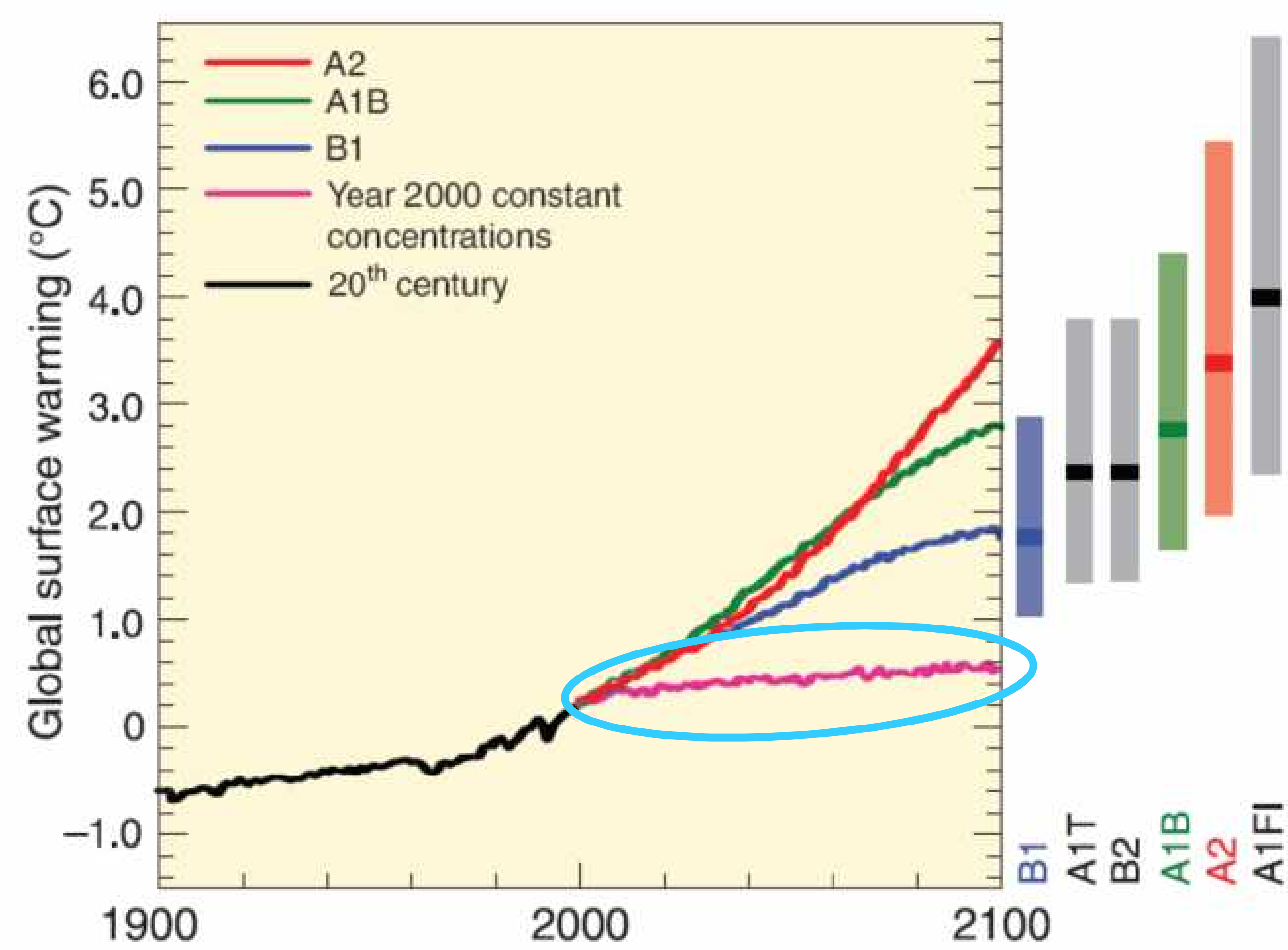
Some reasons for all of us to consider ag/forest impacts, and want to do better

- Inevitability of climate change
- Variability, extreme weather, disturbance
- Implications
  - Baselines – emissions/sequestration, land use, production levels, ecosystem functions
  - Climate change damages/mitigation benefits
  - Adaptation policy – non-autonomous
  - Mitigation/stabilization (offsets, carbon cycle) and renewable fuels potential

Are impacts and adaptation inevitable? (i.e., is climate change inevitable?)



Even with atmospheric concentrations fixed at 2000 levels, global average temperature is expected to increase 0.3 to 0.9 °C by 2090-2099 relative to 1980-1999 (IPCC WGI, 2007)

Why?

Climate inertia

Source: IPCC (2007)

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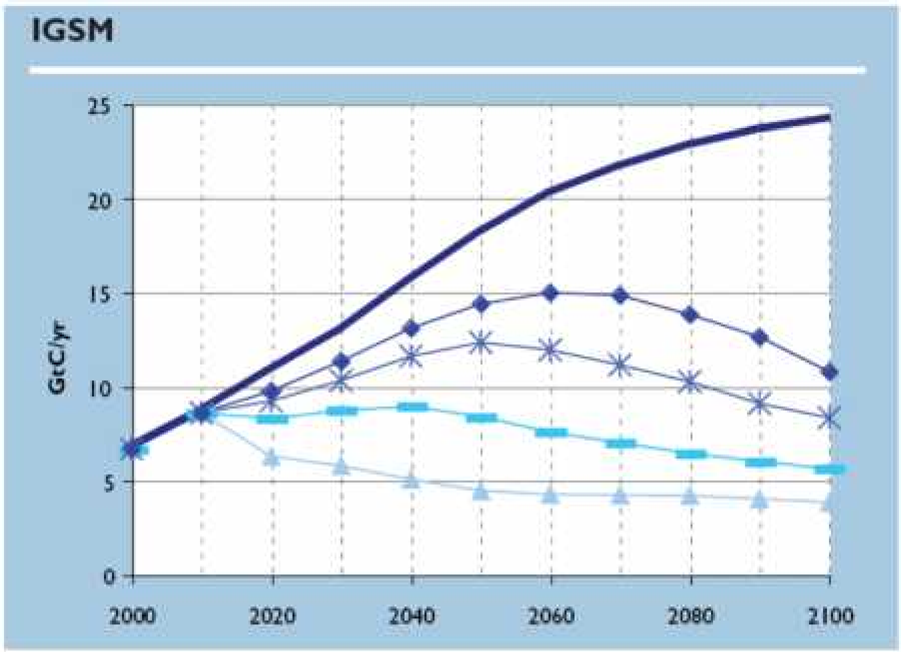
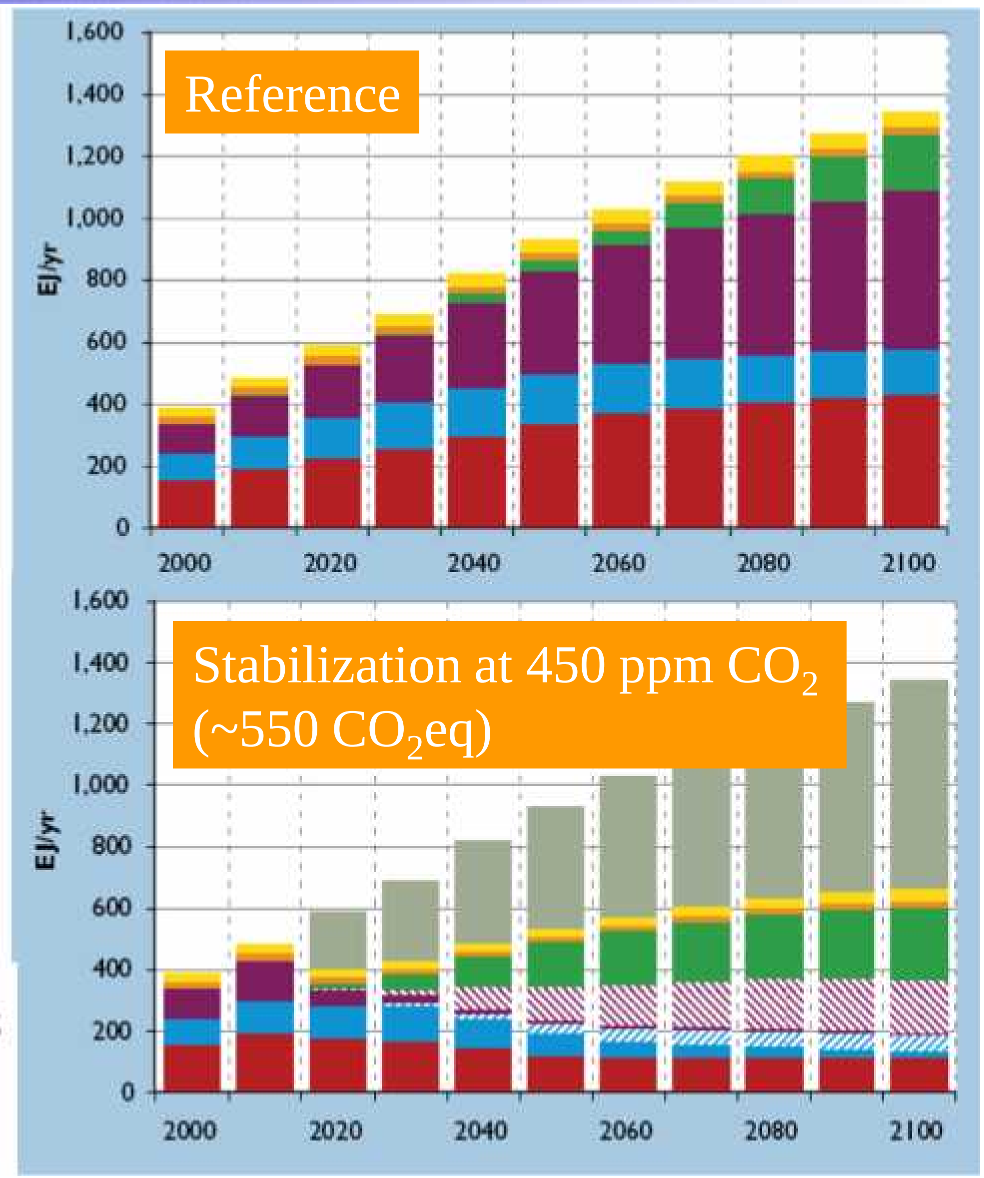
Inevitability part 2 – economic inertia and significant transformation

Global primary energy consumption →



Source: Clarke et al. (2007), CCSP SAP 2.1a

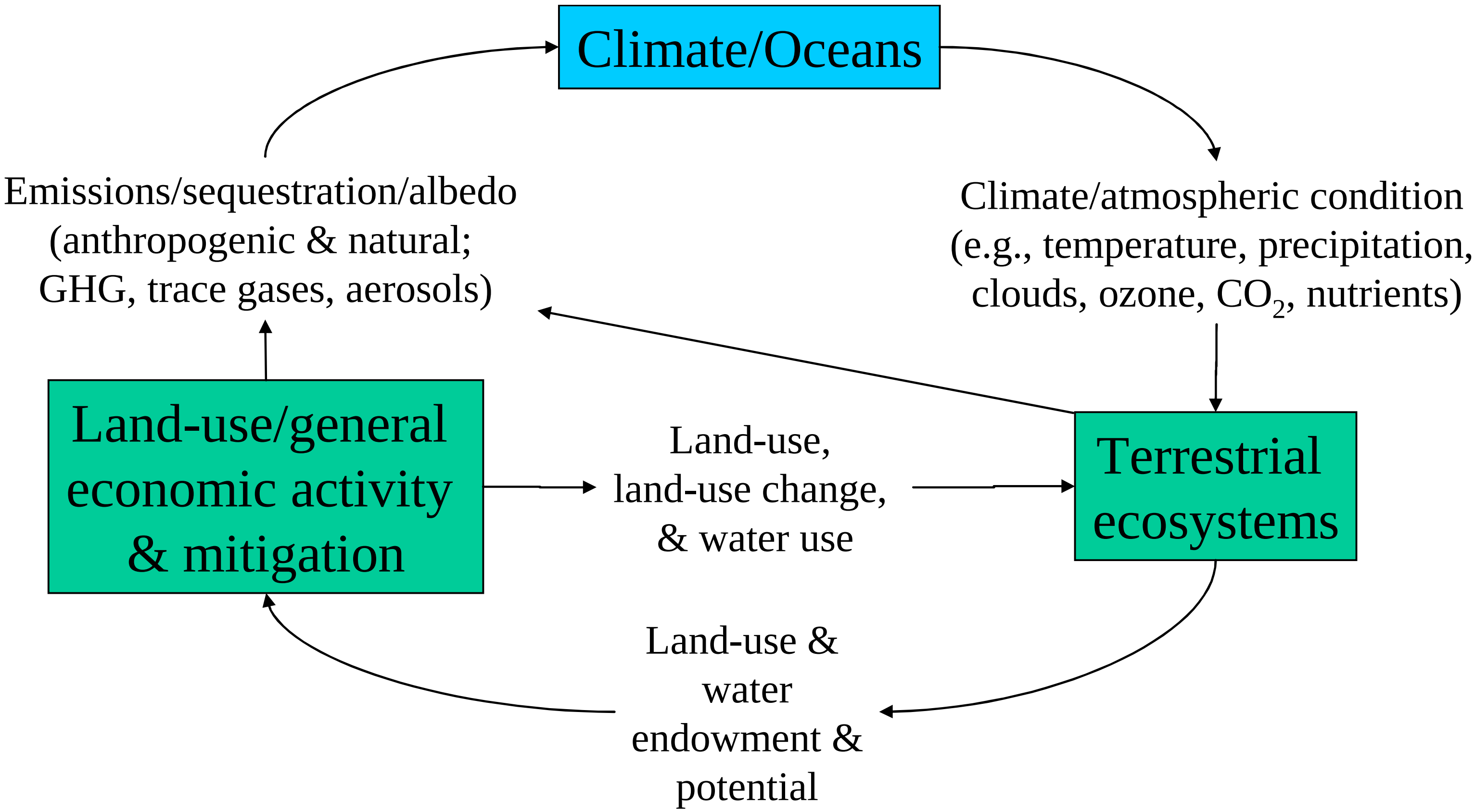


How much will agriculture and forestry "need" to adapt?

- Depends on…
  - Level of mitigation – reduction in global climate change risk
  - Potential local climate and weather change risk – not just levels and rates
  - Capacity to adapt
  - Relative impacts on other regions
- Both autonomous and nonautonomous adaptation
  - Autonomous: current land owner capacity and knowledge allows for responses that abate or exploit impacts
    - e.g., crop selection and changes in fertilizer or water management practices
  - Nonautonomous: planned adaptation where institutional or policy actions facilitate adaptation
    - e.g., subsidy programs, extension, infrastructure development, and R&D investment
- What should be the objective of adaptation?
  - Maintain production levels?
  - Maintain income levels?
  - At what scale? Unique regional climate change and adaptation capabilities imply distributional implications

Source: Rose and McCarl (2008)

Closed system with uncertainties throughout

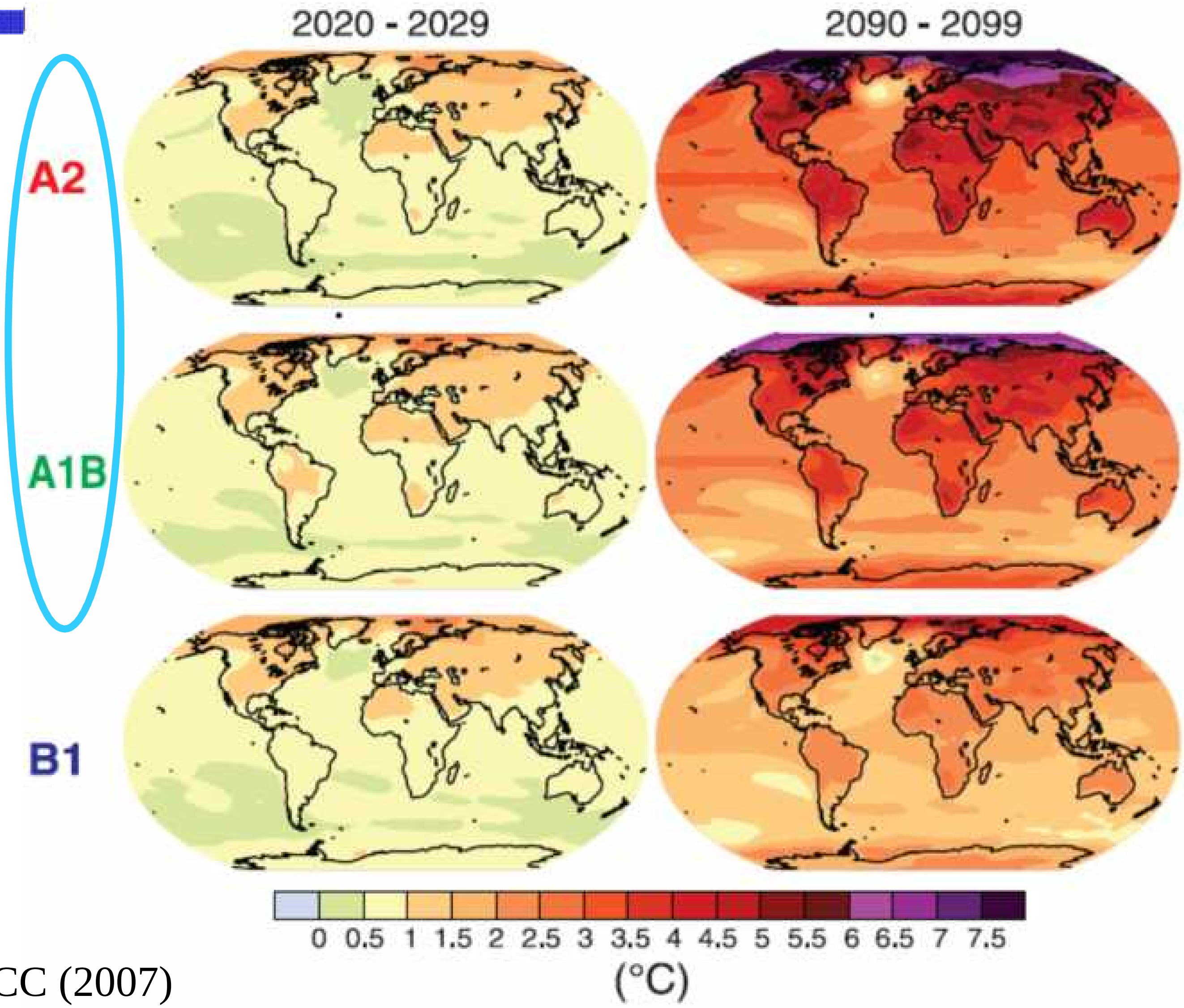


Uncertainties in linkages and across scales (global to regional to local)

Risk = probability x <u>magnitude</u>

Source: Rose et al. (2008)

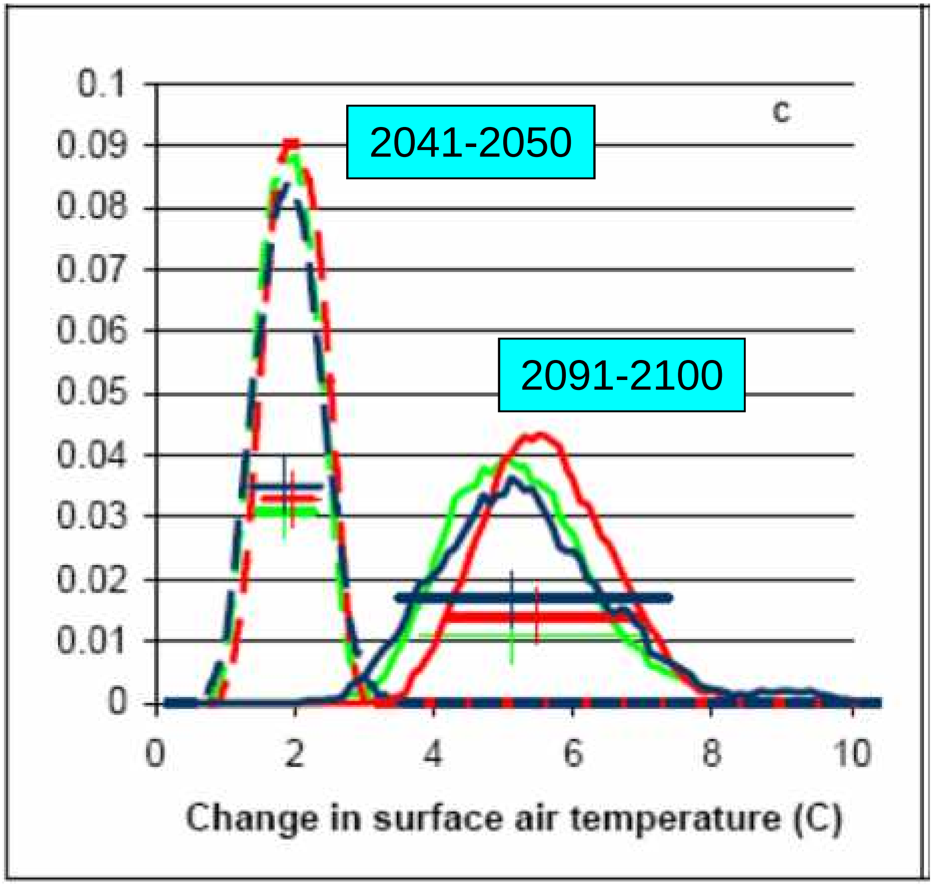
Building the risk picture – potential future regional temperature changes



Source: IPCC (2007)

Uncertain global climate change

Global climate



Source: Sokolov et al. (2009)

Potential future regional climate (e.g., A2 climate scenarios)

Temperature Change (deg C per century) same as deg F per fifty years.

	DJF	MAM	JJA	SON
Western N. Amer.(WNA)	4 to 6	2 to 7	3 to 8.5	2 to 7.5
Central N. Amer. (CAN)	4 to 6	2 to 8	3 to 7	2.5 to 8
Central America (CAM)	1.7 to 4.5	2 to 4.5	2 to 5.0	2.5 to 5.0

Precipitation Change (% per century) half it per fifty years.

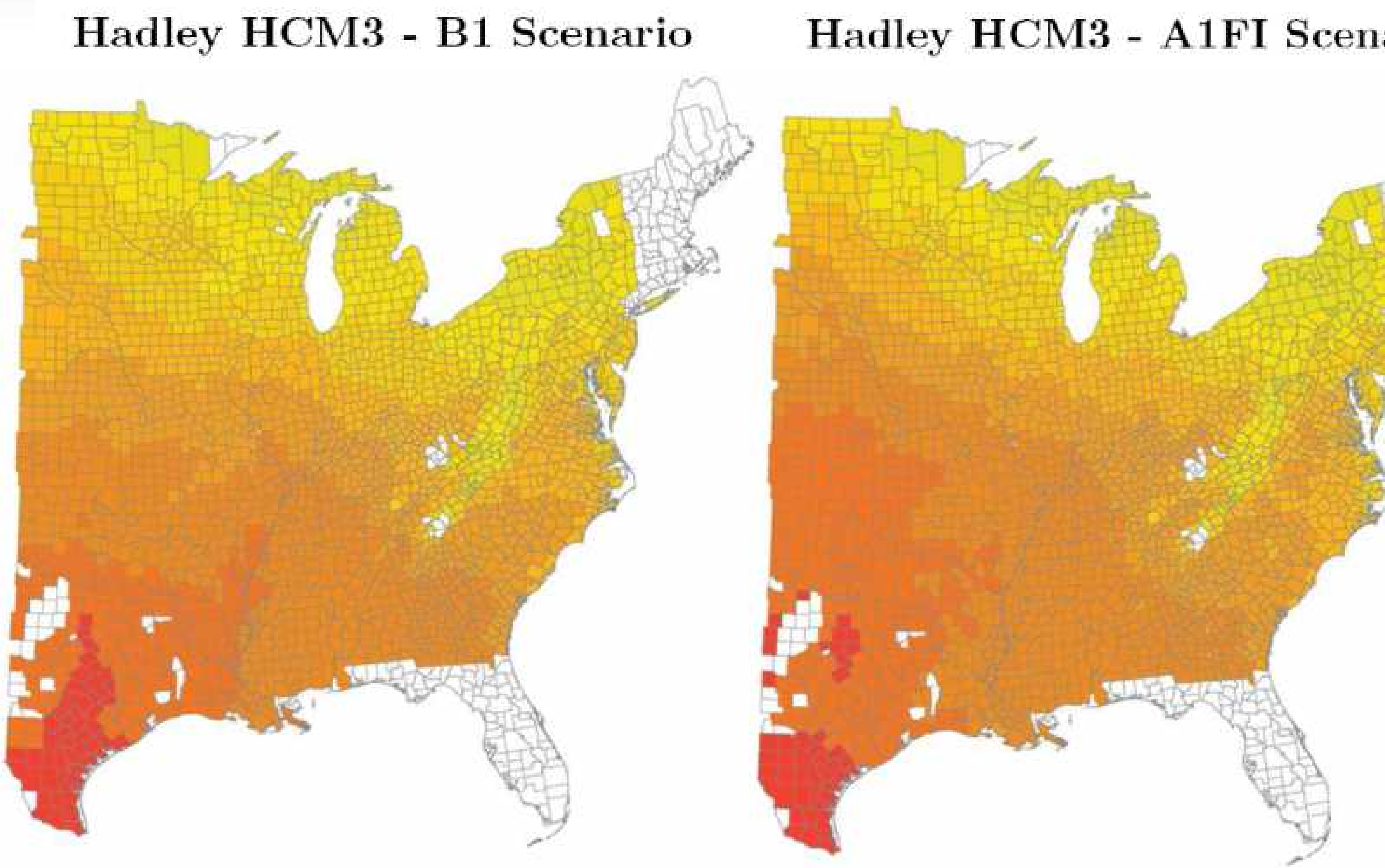
	DJF	MAM	JJA	SON
Western N. Amer.(WNA)	-5 to 20	-5 to +15	-15 to +10	-30 to +10
Central N. Amer. (CAN)	-10 to 10	-5 to +15	-20 to +10	-30 to +5
Central America (CAM)	-75 to -15	-60 to +15	-55 to +15	-35 to +20

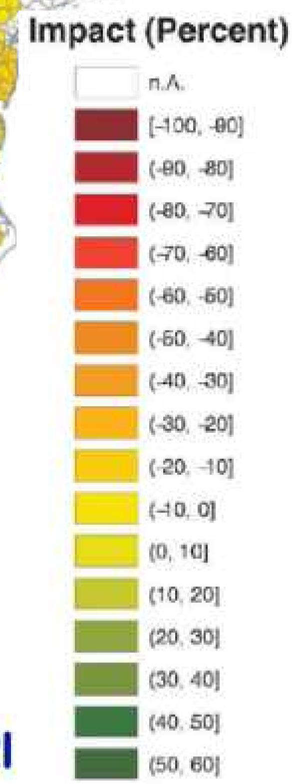
Source: North (2008)

Crop	Grain Yield: Temperature (1.2°C) [1]	Grain Yield: CO_2 (380 to 440 ppm) [2]	Grain Yield: Temp/CO_2 Combined Irrigated	Evapotranspiration: Temp (1.2°C) [3]	Evapotranspiration: CO_2 (380 to 440 ppm) [4]
	% change				
Corn – Midwest (22.5°C)	-4.0	+1.0	-3.0	+1.8	
Corn – South (26.7°C)	-4.0	+1.0	-3.0	+1.8	
Soybean – Midwest (22.5°C)	+2.5	+7.4	+9.9	+1.8	-2.1
Soybean – South (26.7°C)	-3.5	+7.4	+3.9	+1.8	-2.1
Wheat – Plains (19.5°C)	-6.7	+6.8	+0.1	+1.8	-1.4
Rice – South (26.7°C)	-12.0	+6.4	-5.6	+1.8	-1.7
Sorghum (full range)	-9.4	+1.0	-8.4	+1.8	-3.9
Cotton – South (26.7°C)	-5.7	+9.2	+3.5	+1.8	-1.4
Peanut – South (26.7°C)	-5.4	+6.7	+1.3	+1.8	
Bean – relative to 23°C	-8.6	+6.1	-2.5	+1.8	

Source: CCSP SAP 4.3 (2008)

Potential corn yield changes 2020-2049
Location of mitigation and bioenergy feedstocks?



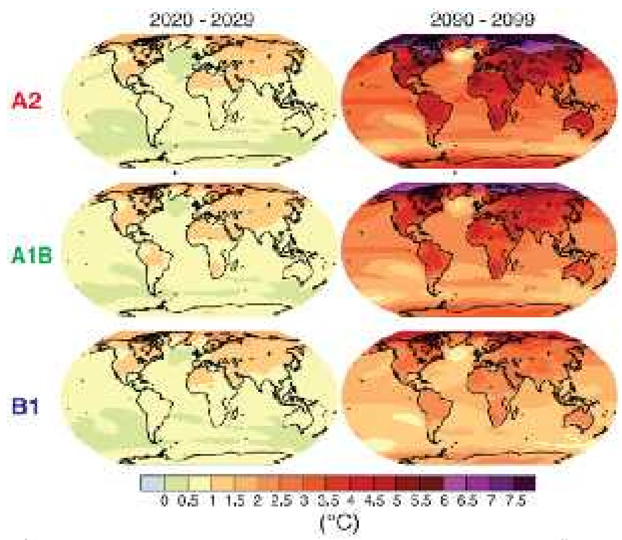


Source: Schlenker and Roberts (2008)

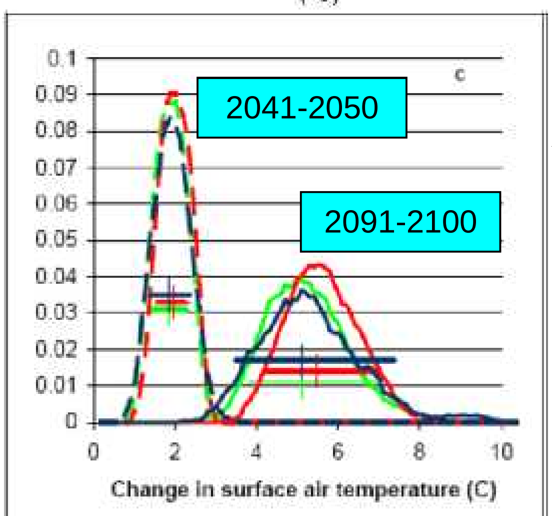
Moving forward with characterizing ag/forest climate change risk

Global climate →

Source: IPCC (2007)



Source: Sokolov et al. (2009)



Regional and local climate and weather change risks

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Terrestrial ecosystem risks

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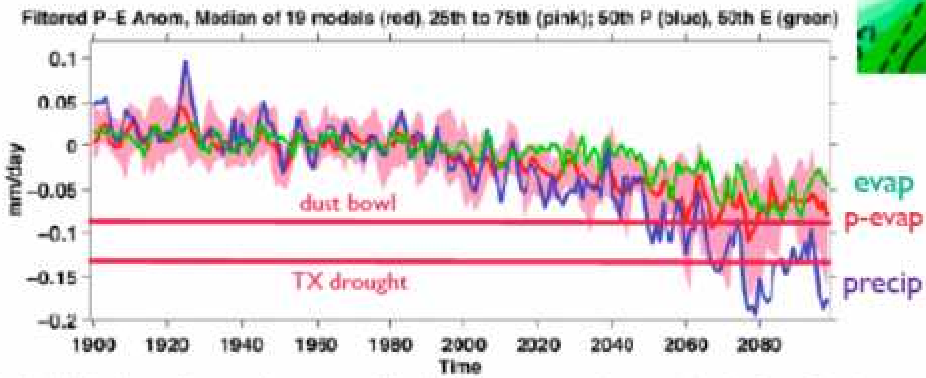
Behavioral and policy Responses & net impacts

Socioeconomics define both

Building a better characterization here, depends on the biophysical pieces above

Also need to consider extreme events

Climate Model Results: Future SW Moisture



Region Included

Fig. 1. Modeled changes in annual mean precipitation minus evaporation over the American Southwest (125°W to 95°W and 25°N to 40°N, land areas only), averaged over ensemble members for each of the 19 models. The historical period used known and estimated climate forcings and the projections used the SResA1B emissions scenario. The median (red line) and 25th and 75th percentiles (pink shading) of the *P* – *E* distribution among the 19 models are shown, as are the ensemble medians of *P* (blue line) and *E* (green line) for the period common to all models (1900–2098). Anomalies (Anom) for each model are relative to that model's climatology from 1950–2000. Results have been 6-year low-pass Butterworth-filtered to emphasize low-frequency variability that is of most consequence for water resources. The model ensemble mean *P* – *E* in this region is around 0.3 mm/day.

SEAGER et al., *Science*, 2007

BOTTOM LINE: MUCH LESS WATER IN THE SOUTHWEST

Session structure

- *Characterizing Historic Patterns and Trends and the Future Threat or Opportunity*
  – A biophysical characterization of risks in terms of potential exposure to changes in the distributions of
    1. Climate and weather (Budong Qian), and
    2. Ecosystem function (Linda Joyce, Dennis Ojima)

- *Decision-Making and Managing Risk*
  – Modeling of potential behavioral responses and risk management of the biophysical risks (Robert Beach, Bob MacGregor)