

Planetary Boundaries & Regime Shifts

- finding a way forward -



A forest in transition to a new regime. View from Tam McArthur Rim of lodgepole pine and whitebark pine killed by mountain pine beetle within the prior 10 years, Deschutes County, OR, in the Deschutes National Forest. (photo: Garrett Meigs, OSU)

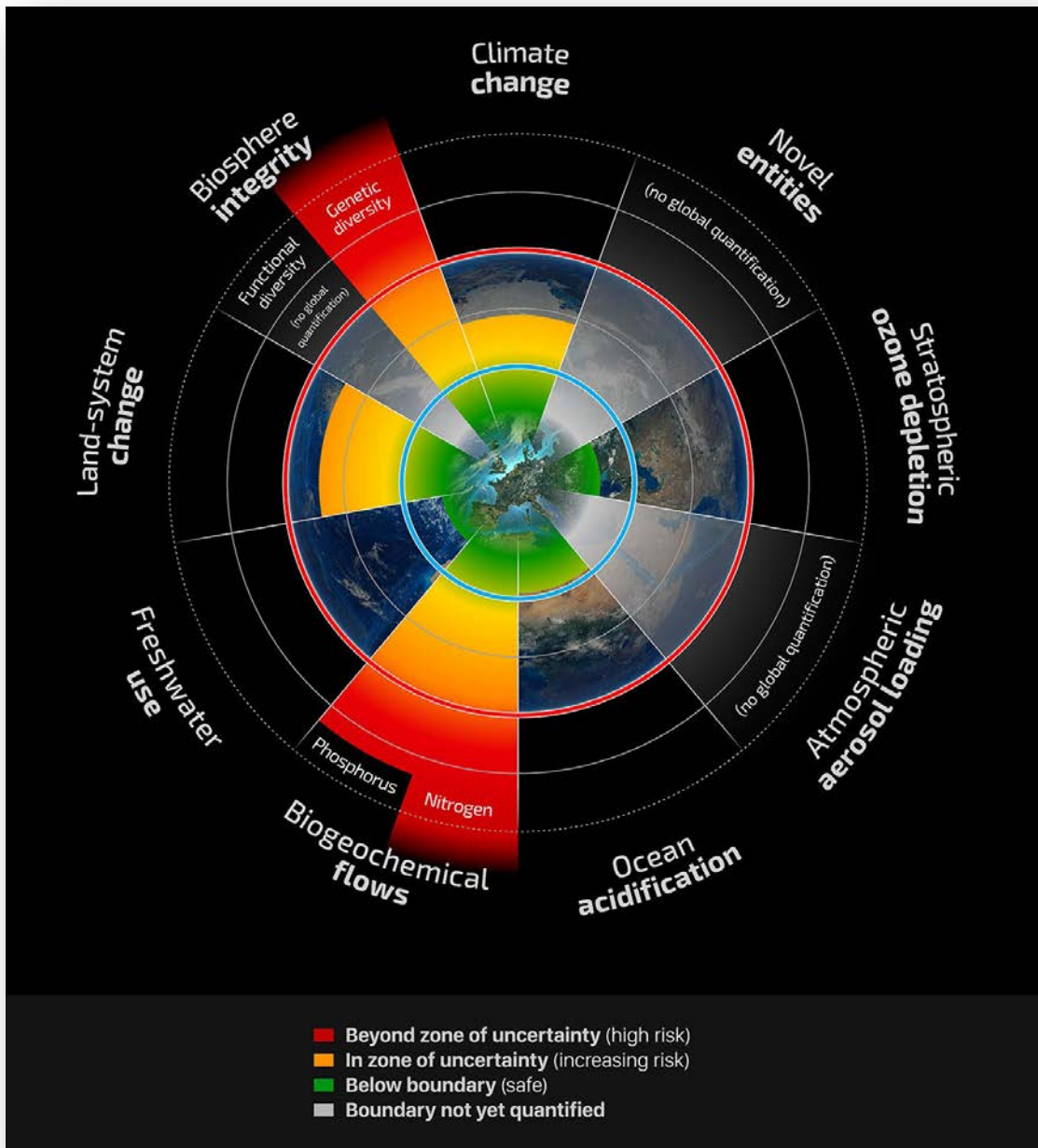
Global Change Ecology and Sustainability

BSC 2862 spring 2019
Stephen Mulkey, AKA Dr. Doom

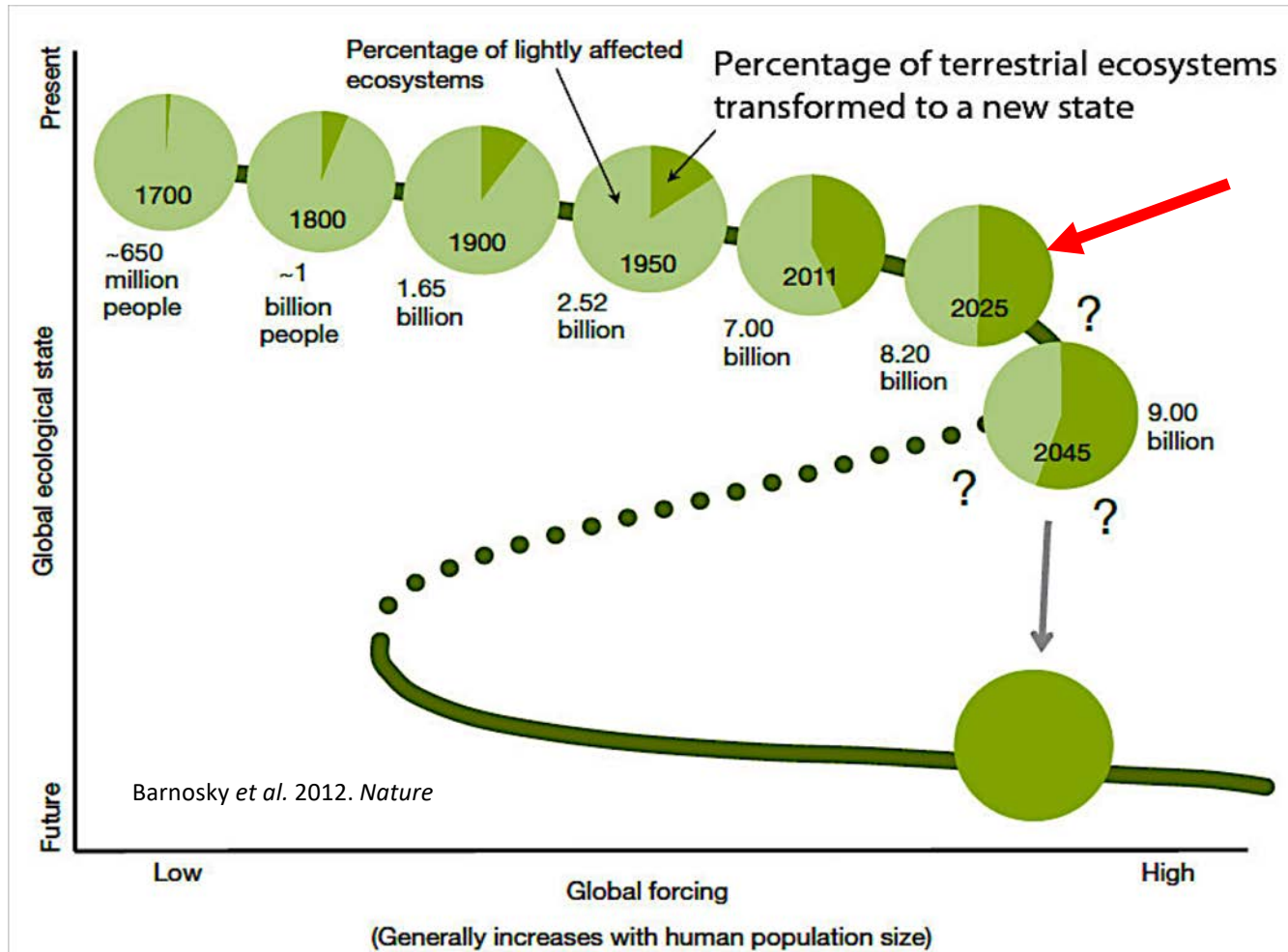


Planetary Boundaries

Rockström and Steffen et al. 2009. **A safe operating space for humanity.** *Nature* 46.

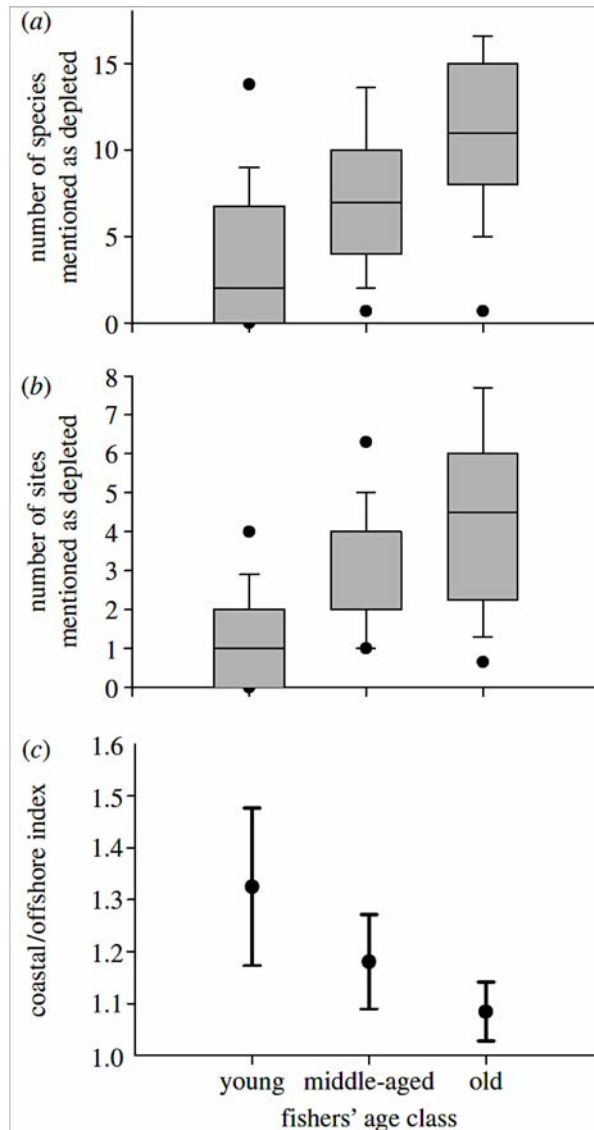
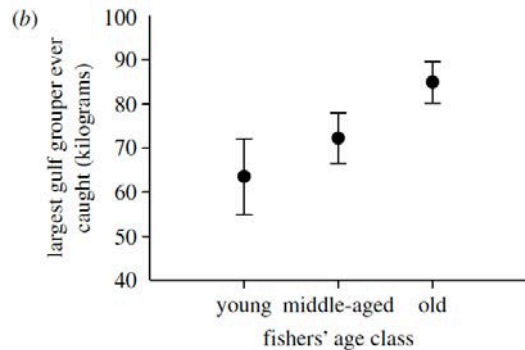
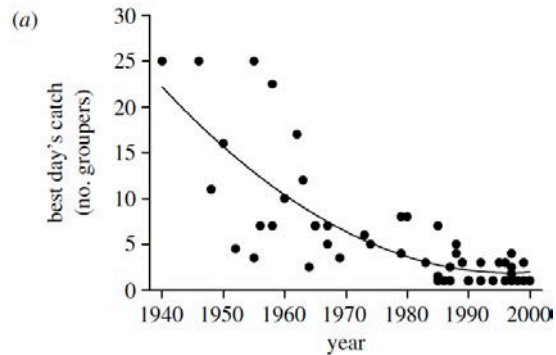


Approaching the Ecological Event Horizon



Shifting baselines of environmental perception

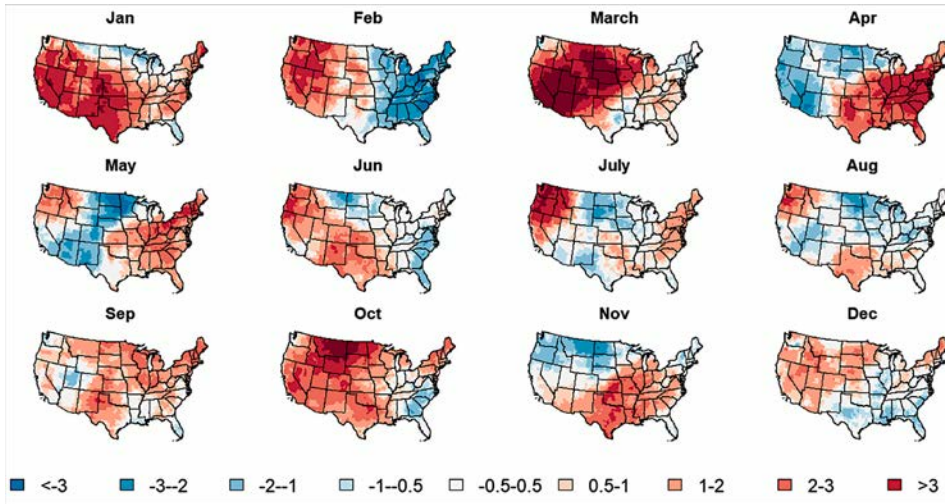
Younger generations of fishers lose awareness of what has been lost



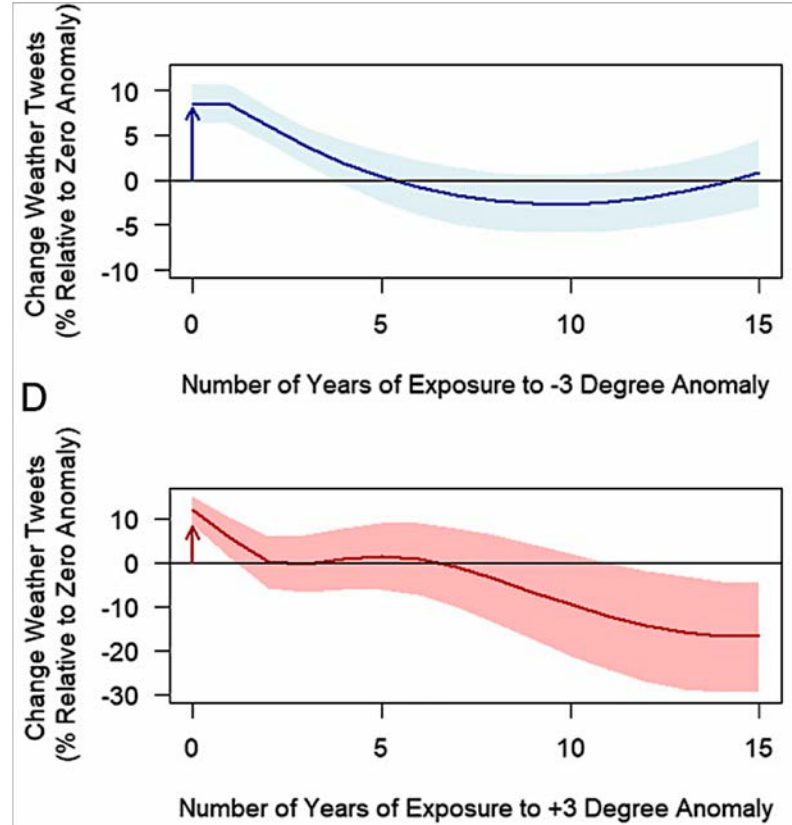
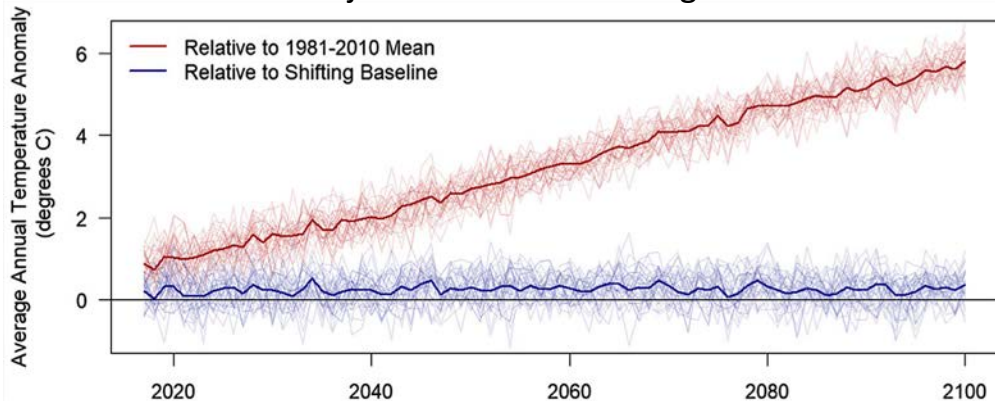
Andrea Saéñz-Arroyo et al. 2005. *Rapidly shifting environmental baselines among fishers of the Gulf of California.* *Proc. R. Soc. B* 272: 1957–1962

We are redefining “normal” climate

Change in average temperature 2011-2015 relative to 1981-1990. °C

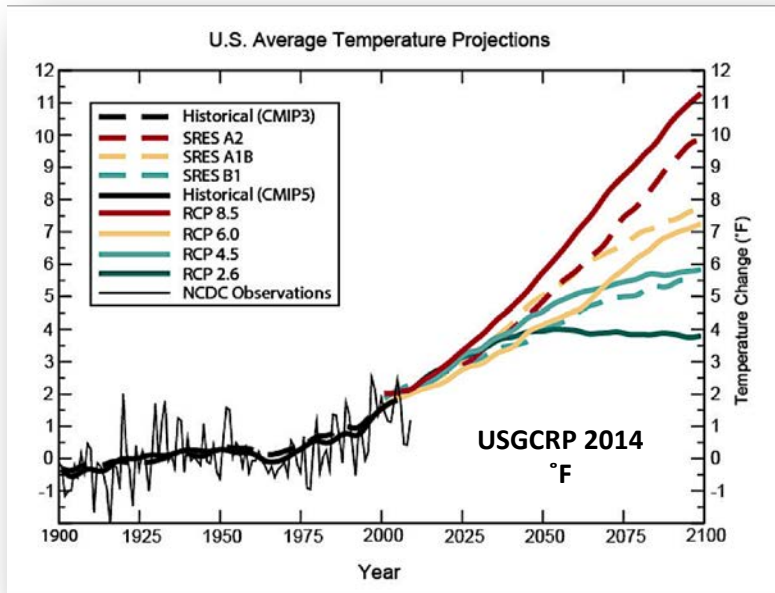


Projected effect of shifting baseline



Moore et al. 2019. ***Rapidly declining remarkability of temperature anomalies may obscure public perception of climate change.*** PNAS.
www.pnas.org/cgi/doi/10.1073/pnas.1816541116

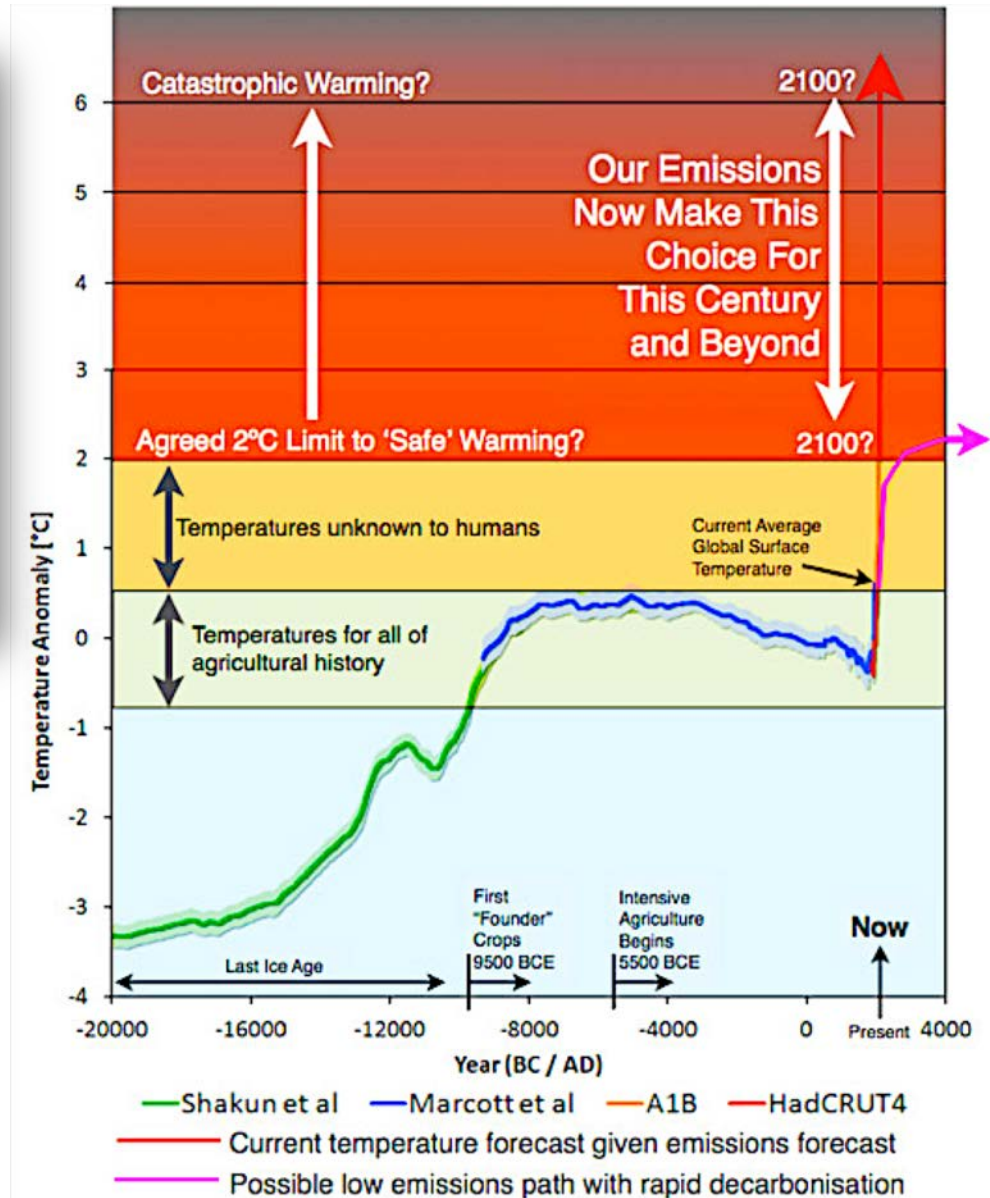
Our present emissions trajectory is catastrophic



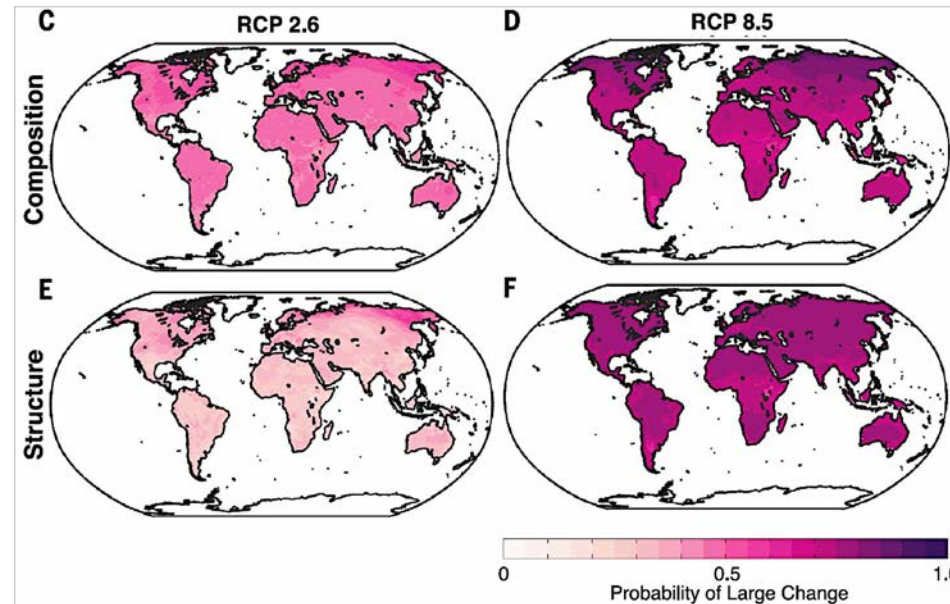
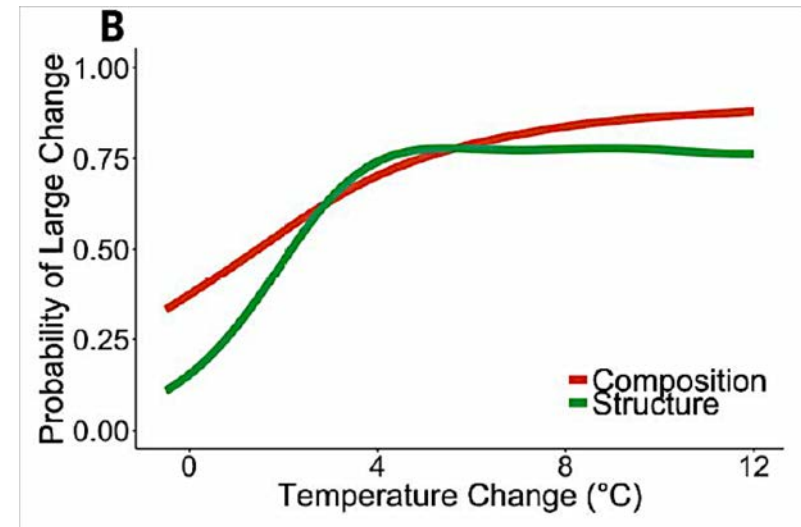
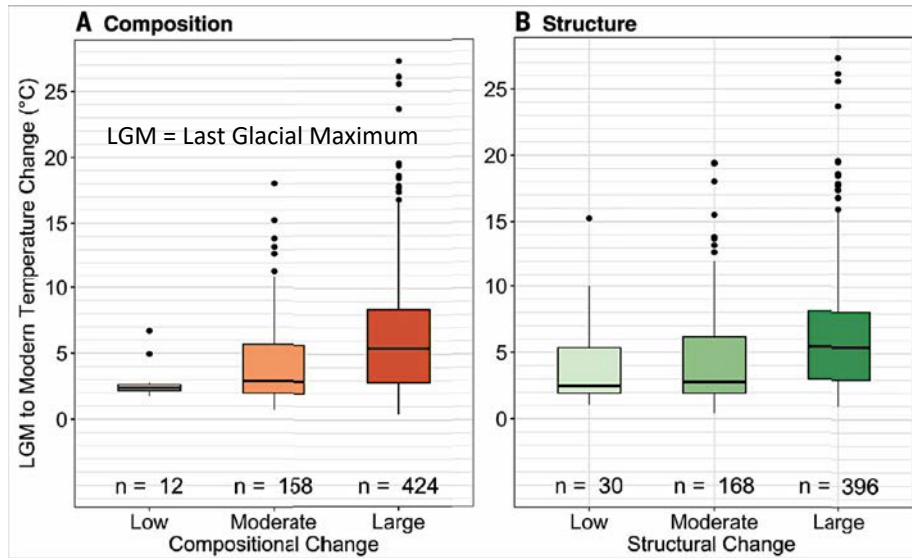
Global temperature rise by end of century:

> 5°C [9°F] – UK Hadley Center

~ 4.5°C -- IPCC Fifth Assessment 2014

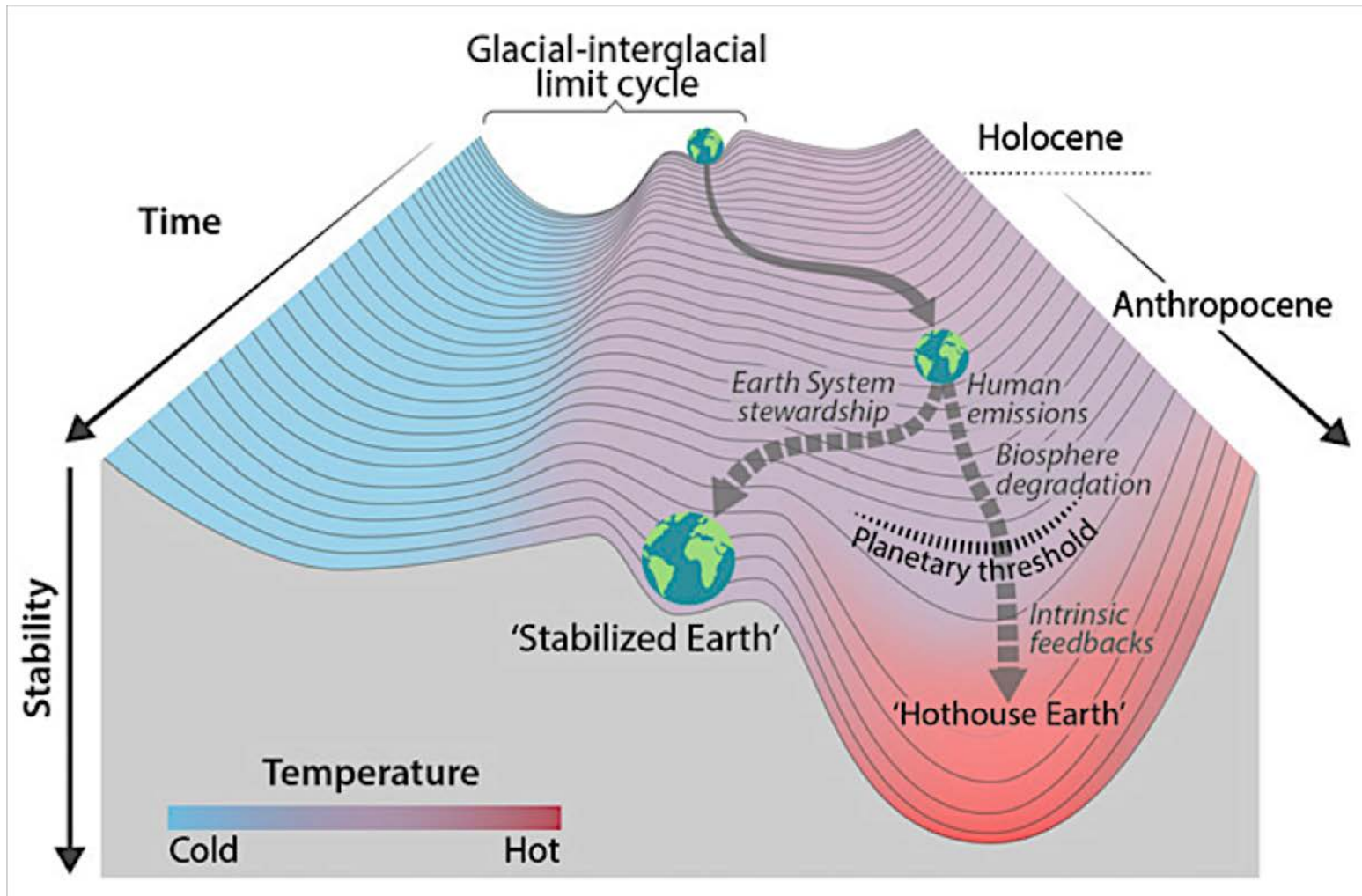


Global transformation of terrestrial ecosystems under climate change

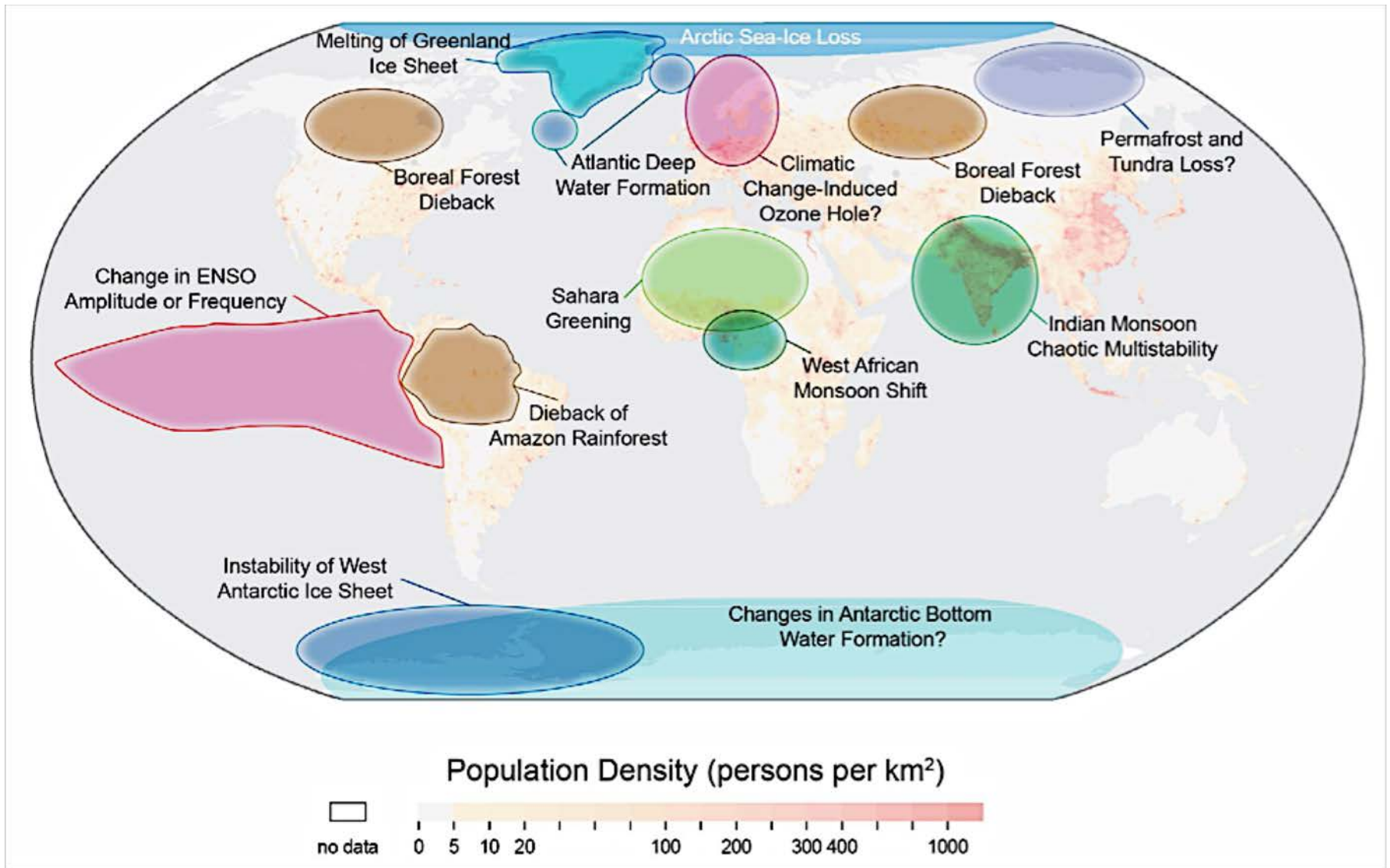


Nolan et al. 2018.
Science 361, 920-923.

Trajectories of the Earth System in the Anthropocene



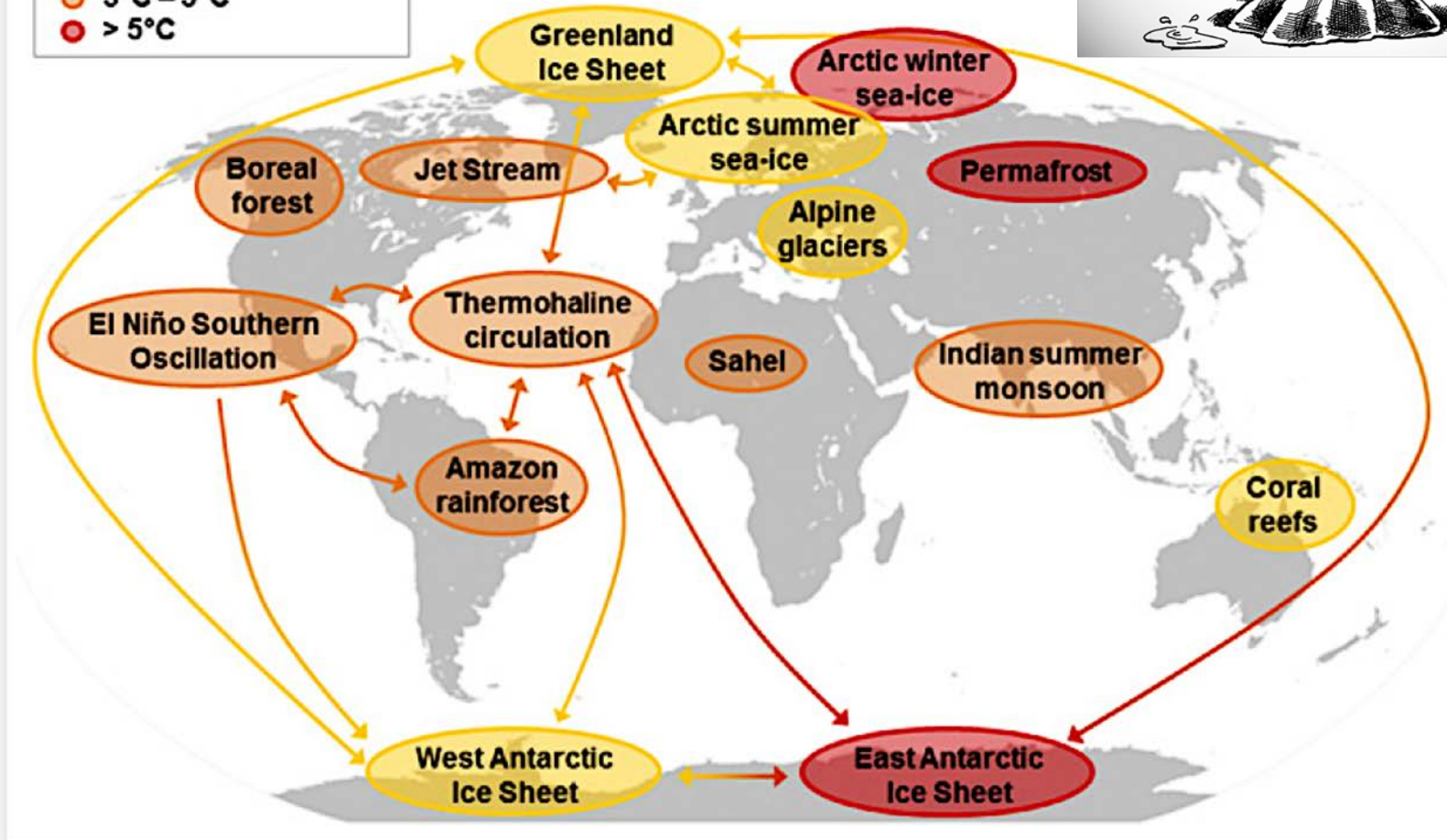
Tipping points in Earth Systems – Regime Shifts



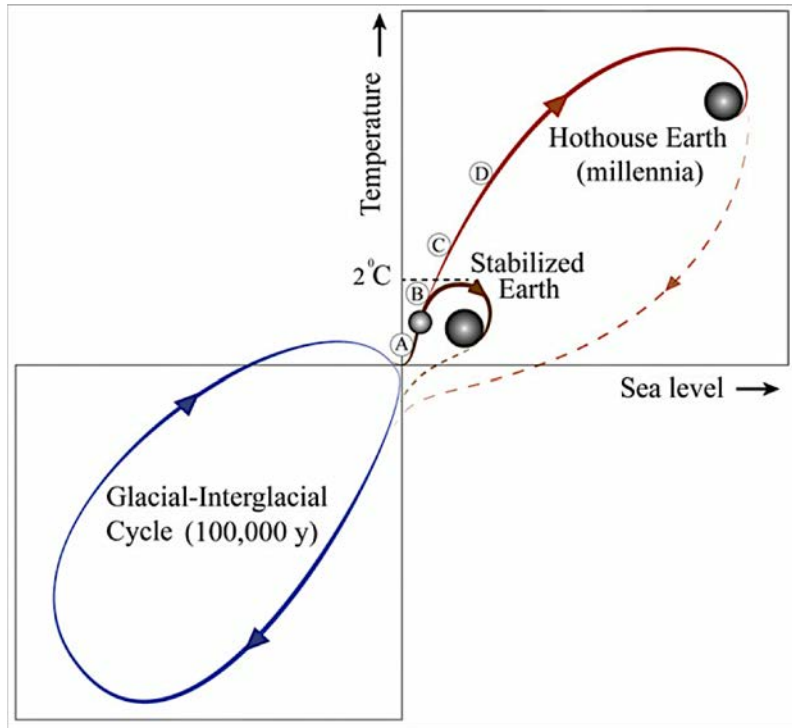


Tipping elements at risk:

- 1°C – 3°C
- 3°C – 5°C
- > 5°C



What is the threshold beyond which a stabilized Earth will not be possible? Is it 2°C?



Strength of selected feedbacks for ~2°C

Feedback	Strength of feedback by 2100,* °C
Permafrost thawing	0.09 (0.04–0.16)
Relative weakening of land and ocean physiological C sinks	0.25 (0.13–0.37)
Increased bacterial respiration in the ocean	0.02
Amazon forest dieback	0.05 (0.03–0.11)
Boreal forest dieback	0.06 (0.02–0.10)
Total	0.47 (0.24–0.66)

Thus, 2°C warming has an additional 0.47°C baked in

In addition to driving fossil emissions to near zero as immediately as possible, we must begin large-scale management of the biosphere. Many feedbacks can be transformed into a source of negative emissions.

Realistic fears

- All of the previous mass extinctions involved climate change produced by greenhouse gases. The end Permian extinction was driven mostly by GHGs which acidified the oceans and wiped out 96% of species
- We are currently adding GHGs to the atmosphere at a rate that is 7-10x faster than the end Permian extinction
- More than half of the GHGs have been emitted in the last three decades – 85% since the end of WWII
- At current rates of emissions we will reach 1.5°C before 2040 and 2°C before 2060
- At 2°C, major cities near the equator will become seasonally unlivable and even in northern latitudes heat waves will kill thousands each summer; marine heatwaves will wipe out >95% of warm ocean corals; the Arctic will warm 11-13°C. The Arctic ocean will be ice free in the summer and increasingly during the fall and spring
- At 2°C, the UN estimates that up to 400 million people will suffer water scarcity; heatwaves in India will increase several times and last up to 5x as long; the atmosphere will contain at least 500 ppm (411 ppm March 2019); sea level rise may stabilize at 130 ft creating a new coastline as far west as I-95 (this may take a couple centuries or more but the accelerating rate will force mass relocation of coastal populations by 2100)
- At 3°C, the area burned by wildfire will increase 6x in the US; food crises will be annual in much of the tropics; periodic crop failures will become routine; two or more global crop failures will occur simultaneously
- At 4°C, dengue fever will increase by 8 million cases; river flooding up to 30x in Bangladesh and 20x in India; damage from multiple simultaneous climate-driven disasters could pass \$100 trillion; conflict and warfare will double
- At 4°C, much of Africa, Asia south of Siberia, South America north of Patagonia, Australia, and the United States will be rendered permanently heat or drought stricken and marginally inhabitable; much of current croplands will become marginal or incapable of supporting crops
- The UN projects 200 million climate refugees by 2050 under BAU scenario
- Most of these changes will be effectively permanent on any meaningful human timescale; it will never be normal again
- The Earth System may be approaching a planetary threshold that will lock in a rapid pathway toward a Hothouse Earth. This pathway will be propelled by strong, intrinsic, biogeophysical feedbacks that we cannot control
- *The NDCs pledged in the Paris Accord would result in 3.2°C and almost no country is on track; There is no scenario that will stabilize temperatures below 2.0°C that does not entail immediate steep reductions in emissions.*

Full-spectrum Sustainability



- Building a sustainable civilization is the only way forward that produces an acceptable outcome
- We have all the tools that we need
- The social foundation is essential
- Acquiring the will to take action will cross a threshold. This must happen this decade
- There is reason for hope

Challenges and tools for sustainability – BSC2862

- Natural climate solutions – biosphere management – BECCS and current versions of negative emissions are wishful thinking
- Energy systems – true costs of non-renewables and likelihood of WWS and other renewable sources to meet the needs of a growing population
- Sustainability of urban ecosystems; concept of a circular economy
- The dangerous false promise of geoengineering and tech based negative emissions
- Mitigation and adaptation
- Economics and ethics of climate change mitigation; concepts of a no-growth economy
- Sustainability science and synergies among solutions
- Political polarization and populism; versions of a Green New Deal

It is time to panic – we must take action - now

“You can’t let people’s need for hope get in the way of the telling the truth.”

- David Wallace-Wells 2017

Rational fear is not paralyzing but is a necessary response that activates people to recognize danger and take action. Acute fear is rational. “It’s important to feel afraid of things that will kill us—that is healthy and good.” - Margaret Klein Salamon 2019

