GOING TO EXTREMES: PROPOSITIONS ON THE SOCIAL RESPONSE TO SEVERE CLIMATE CHANGE

William R. Travis, *Climate Change* 98(2010): 1–19.

Even optimists worry, and this optimist has among his worries extreme climate change. I have no doubts that the climate is already changing, primarily due to human action, and that it will be extremely difficult to keep global warming below the consensus goal of 2˚C degrees warming. In so believing, I am clearly not alone, especially following the failure of Copenhagen to produce a significant agreement. Many concerned scientists and policy advocates are considering, albeit reluctantly, emergency prevention measures (geoengineering) that might change such fundamental global processes as photosynthesis or the radiative balance to slow the rate of climate change.

But compared to the willingness to consider geoengineering measures for climate change mitigation, there is still little consideration of adaptation to severe climate change. In part, this is due to the long-term neglect of climate change adaptation in general, as some policy advocates feared that attention to adaptation would undermine prevention efforts, and others emphasized its spontaneous or autonomous quality, thus not requiring active study or policy. And even scientists, who have long studied adaptation in the context of hazard studies or agriculture, understood that all adaptive measures have physical, economic, or institutional limits that diminish their effectiveness in the face of the challenge of severe climate change.

The Travis article is as important and worthy of discussion and followup as were the early articles on geoengineering. He begins by defining the meaning of severe or extreme climate change as change greater than the current scientific consensus (IPCC) of the likely (implying a 66–90 percent probability) range of global surface warming. If CO_2 levels double from pre-industrial levels during this century (a pace that would still require major efforts of emission reduction), the likely range of surface global warming would be between 2°–4.5°C; with a tripling of CO_2 levels (the pace of emissions growth just prior to the global recession), a likely range would be 2.5–6.4°C. Thus this consensus view implies that that there is a 5–17 percent chance of warming greater than 4.5°C with doubling, and 6.4 °C with tripling by 2100.[1] Then Travis draws upon the extensive hazards literature to explore adaptation responses to low-probability but high-consequence hazard events. He notes, however, the limits of this literature since it addresses adaptations to natural hazards (floods, droughts, storm surges, sea level rise, hurricanes, etc.) that are limited in their spatial extent, are viewed as "natural recurrent events," and are seen as the extremes of a stable climate, not indicators of a changing climate.

With this caution in mind, he explores six pathways of adaptive response familiar to readers of the hazard literature . While many of these are more intensive versions of current adaptations, e.g., higher sea walls, increased irrigation, expanded building codes and design standards, improved forecasts, catastrophecatastrophic insurance, and the like, several may be different from current practice and may even be surprising. So, for example, tipping point warning systems may be created, extensive weather modification will be practiced, multiple climate hazard catastrophic insurance may be provided, and efforts may be made to store or move

Figure 1. The proposed Climate Change Severity Index.
Drawing on earthquake and asteroid impact indices, Travis set the levels at thresholds of increasingly difficult and radical social responses.

Climate Change Severity Index	Description	Example Climate Phenomena	Social Responses	Additional population at Risk (billions)
ZERO	Means and extremes common to the recent (e.g., 30 year) climate	Current means and extremes	Those arrayed (more or less effectively) to absorb current variability	0
I	Small but statistically significant shifts away from the reference climate	Scientific detection of climate change (signal surpassing noise) not necessarily sufficient to elicit social responses	Little to none as first small changes are absorbed by excess capacity and buffer built into socio-technical systems	0
II	Palpable changes in the frequency - intensity - duration of climate events that begin to surpass informal and formal socio-technical adaptations	Noticeably more frequent, and more intense, climate events: like the 1988 U.S. drought and 2003 Europe heatwave	Adjustments in regulatory and technical systems such as shifted floodplain boundaries; storm surge evacuation zones; levee and dam enlargement, and changes in insurance coverage	.1 to .3
III	Extreme climate episodes rare in the past become typical; emergence of new types of extreme climate events or syndromes	Atlantic hurricane seasons like 2004/05, and the 2003 and 2005 European heat waves, become "typical" events. Frequent continental "mega-droughts" in North America and Asia and "exceptional droughts" in China; sea level rise .2-2 m / century.	Enlarged and novel intervention (e.g., weather modification) and protection schemes (e.g., new, encompassing sea walls; species relocation, and intra-continental water transfers)	.1 to 3
IV	New climate epochs: Large-scale discontinuities and permanent change in regional climates	Ocean circulation break down with significant cooling in N. Europe; intensified aridity in SW North America; sea level rise of 2+ m/century	Geo-engineering attempts to cool the climate and prevent discontinuities, reverse trends like ice sheet melting, or even to restore past conditions	3 to maximum future global population ($GloPop_{max}$)
V	Catastrophic climate change	Run-away greenhouse; Permian-like warm epoch	Social and ecological collapse	$GloPop_{max}$

endangered ecosystems. And such currently unlikely adaptations as fundamental revisions of water law or massive migrations away from the coasts might even be undertaken.

Travis also warns of maladaptations, the most common being the way in which short-term adaptation can lead to long-term increases in vulnerability. With various names such as the "catastrophe hypothesis," the "safe development paradox," and the "levee effect," climate changes, as they increase over time, are expected to encourage efforts to build or raise sea walls, levees, and dikes, or increase water supplies. But when sea level, storm surge, flood, or drought exceed the protective works, catastrophic losses often ensue. An outstanding example was metropolitan New Orleans and Hurricane Katrina, where new levees following Hurricane Betsy of 1965 encouraged settlement of some 150,000 households behind the new levees, only to be badly flooded when the levees failed when Katrina hit.[2]

Finally, Travis offers a new and potentially useful climate change severity index akin to the Modified Mercalli Scale of earthquake intensity, which is based on human perception of motions and the damage to structures rather than the physical Richter magnitude scale of amplitudes of seismic waves. The six point scale (see Figure 1) begins with level zero (the so-called normal 30-year average climate). Currently, we are in the early stages of level II, with more frequent and more intense events such as the 1988 U.S. drought or the 2003 European heat wave. This leads to a social response of applying or requiring intensified versions of current adaptations. Beyond level II, novel adaptations and behaviors emerge, including widespread weather modification, desalinization, water transfer, maximum sea walls, species relocation, and coastal retreat. At levels IV and V, adaptations are likely to fail, and there would probably be widespread use of geoengineering, and if the geoengineering is unsuccessful, societal and ecological collapse. But we are in level II, and there is now clear interest in adaptation as evidenced by a series of recent and important U.S. reports.[3] As Travis reminds us, extreme climate change needs to be included in these reports.

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NOTES

1. S. H. Schneider, "The Worst-Case Scenario," *Nature* 458(2009): 1104–1105.

2. C. E. Colten, R. W. Kates, and S. B. Laska, "Three Years after Katrina: Lessons for Community Resilience," *Environment: Science and Policy for Sustainable Development* 50, no. 5(2008): 36–47.

3. Center for Science in the Earth System (The Climate Impacts Group), Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, and King County, Washington. *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments* (Oakland, CA: ICLEI-Local Governments for Sustainability, 2007). http://cses.washington.edu/db/pdf/snoveretalgb574.pdf (accessed 5 May, 2010); W. E. Easterling, III, B. H. Hurd, and J. B. Smith, *Coping with Global Climate Change: The Role of Adaptation in the United States* (Arlington, VA: Pew Center on Global Climate Change, 2004), http://www.pewclimate.org/docUploads/Adaptation.pdf (accessed May 5, 2010); T. R. Karl, J. M. Melillo, and T. C. Peterson, eds., *Global Climate Change Impacts in the United States: A State of Knowledge Report from the U.S. Global Change Research Program* (New York: Cambridge Press, 2009); National Research Council, Panel on Adapting to the Impacts of Climate Change, *Adapting to Impacts of Climate Change* (Washington, D.C.: National Academies Press, forthcoming).

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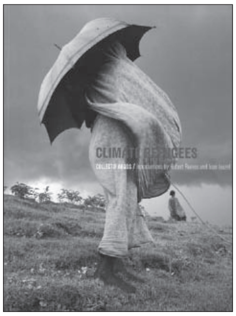

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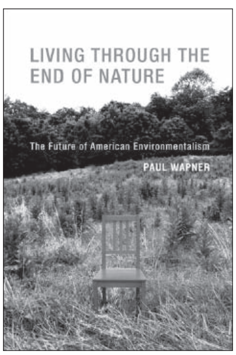

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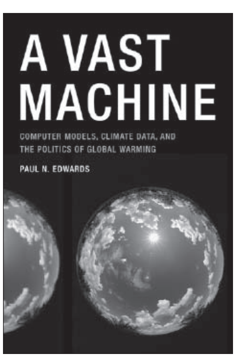

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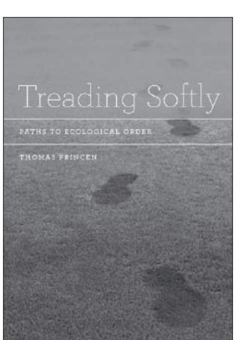

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