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Climate Change: The Resilience Option

By Kenneth P. Green

> "The willow which bends to the tempest, often escapes better than the oak which resists it; and so in great calamities, it sometimes happens that light and frivolous spirits recover their elasticity and presence of mind sooner than those of a loftier character."
>
> —Albert Schweitzer

The Earth's climate is prone to sharp changes over fairly short periods of time. Plans that focus simply on stopping climate change are unlikely to succeed; fluctuations in the Earth's climate predate humanity. Rather than try to make the climate static, policymakers should focus on implementing resilience strategies to enable adaptation to a dynamic, changing climate. Resilience strategies can be successful if we eliminate current risk subsidies and privatize infrastructure.

Recent climate research tells us that our climate is not the placid, slow-changing system people assume it to be. Instead, it is prone to sharp changes over fairly short periods of time. Whether those changes are natural or caused by human actions, we now know that we live in a world of greater climatic risks. Previous generations did not think about, plan for, or factor in these risks when they sited their cities and decided how to build and manage them. While planning was done for weather in what was considered a largely predictable system, little thought was given to making cities resilient to climate variability. As efforts to reduce greenhouse gas (GHG) emissions fail, we need to consider alternative plans and actions to reduce the risks we face.

The United Nations Intergovernmental Panel on Climate Change (IPCC) has always discussed the idea of adaptation to climate change as a second- or third-best response—something to be done only after every possible effort has been made to reduce GHG emissions. Both governmental and environmental groups have generally been hostile to adaptation-based responses to climate change, as they view such approaches as surrender—an acceptance of the idea that GHG emissions will continue, that the climate will change, and that people will come to believe they can adapt. They fear that a focus on adapting to climate change would detract from a focus on mitigating emissions.

There will be arguments about mitigating GHG emissions for many years (and perhaps decades) to come, but our new understanding of how variable our climate can be suggests we should broaden our climate policy focus by

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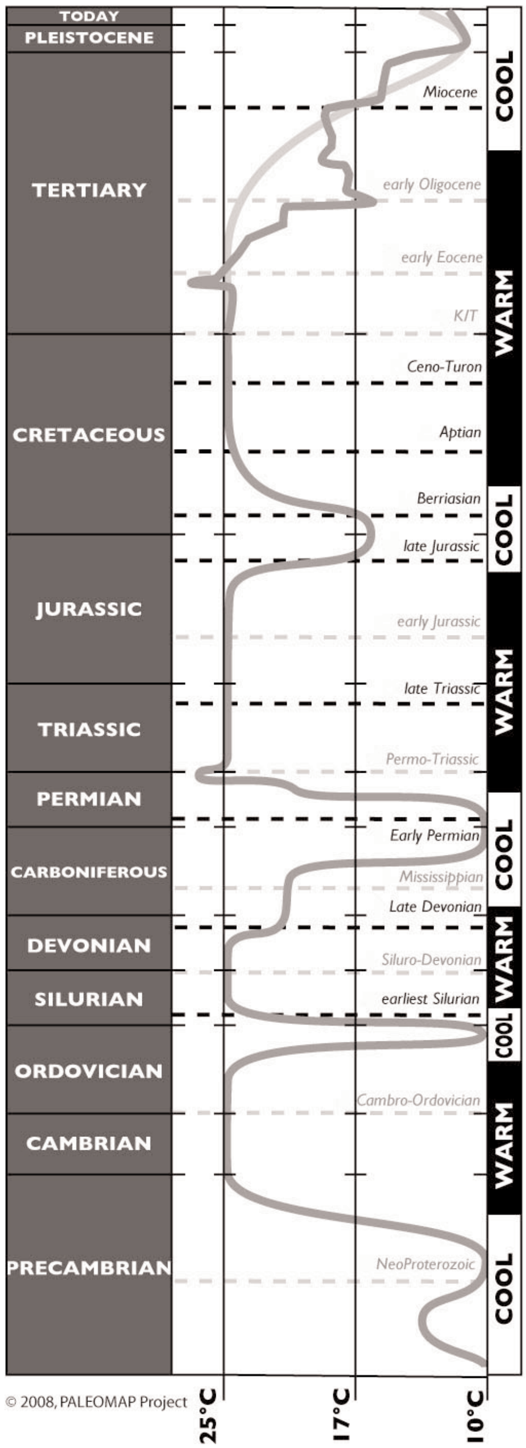
Key points in this *Outlook*:

- Climate change is almost impossible to stop.
- While working on that problem, we need to shift policymaking to resilience building and adaptation.
- This can be successful if we eliminate current risk subsidies and privatize infrastructure.

strengthening our efforts to facilitate adaptation. We should focus on building resilience as an approach to protecting ourselves from the risks of climate change as superior to a static approach that singles out only one possible climate influencer (the GHGs) and largely ignores natural climate variability.

FIGURE 1
EARTH'S LONG-TERM CLIMATE HISTORY



SOURCE: Christopher R. Scotese, "The Paleomap Project" (Paleomap website, 2002), available at www.scotese.com/climate.htm.

This *Outlook* discusses our variable climate and outlines an agenda for building climate resilience that can be implemented immediately and that could offer significant protection for future generations from climate variability.

Our Variable Climate

Whether viewed in long- or short-term periods, the Earth's climate history is one of variability, not stasis. Our planet has moved into and out of ice ages and warm periods for as long as we have evidence of historic climate. Figure 1 shows the longest-term picture of climate variability scientists have developed, which uses measured and proxy data. Proxy data consist of estimated temperatures (or other climate variables such as atmospheric moisture) developed by studying what are, in essence, climate fossils: tree rings, ice cores, fossil diatoms, boreholes, fossilized plant leaves, and so on. While proxy data should be considered less reliable than empirical data (meaning that the farther back we look, the more hazy the picture becomes), the scientific paleotemperature reconstructions clearly show the huge variability of the Earth's climate.[1]

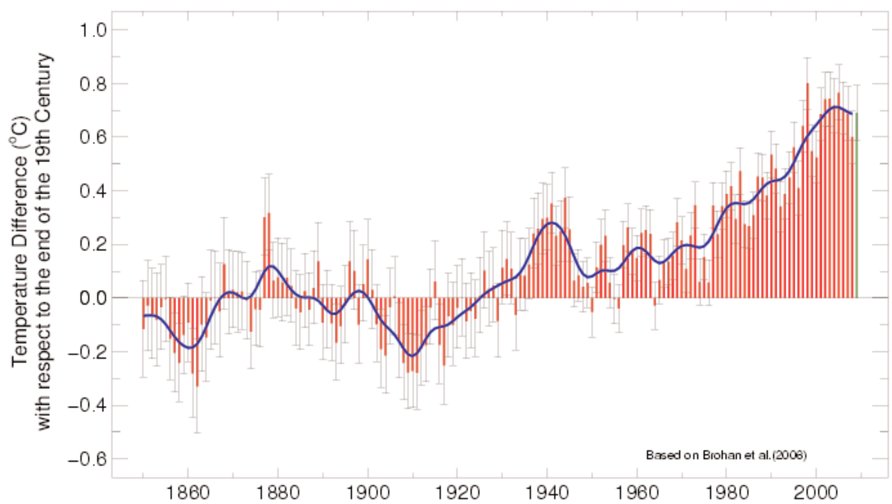
The causes of global climate change are a combination of astronomical, geological, oceanographic, geographical, and biological "forcings." Forcings are things that can change the Earth's balance of incoming and outgoing radiation, making the climate warmer or cooler. On the astronomic side of the equation are changes in solar output and cosmic wind, as well as the angle and inclination of the Earth with respect to the sun. On the geological side are variations in volcanic activity or oceanic GHG flux and the response of atmospheric water vapor to climate change. On the biological side of the equation are changes in GHG emissions caused by animals (termites, ruminants, humans) and the production and sequestration of atmospheric carbon by plants and other photosynthetic organisms (such as phytoplankton). On the geographical side, changes in reflectivity of the land through changes in land use and the emission of different amounts of reflective and absorptive particulate pollution can also affect the local climate.

For more recent time periods, scientists have data of slightly better reliability (though there are still problems with data quality). The land temperature record shows that the climate has indeed been changing in the last century. As figure 2 shows, according to the surface temperature record, there have been five stages of change since 1850, when measurements began. From 1910 to 1940, the Earth experienced a period of warming; from 1940 through 1970, a pronounced cooling; from 1970 to 2000 a pronounced warming; from 2000 to the present, the rate of warming has flattened out and begun to decline.

The last published report of the United Nations IPCC says that "[m]ost of the observed increase in global average temperatures since the mid-twentieth century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."[2] Others dispute this assertion, arguing that climate models are attributing too much influence to GHGs in the atmosphere.[3]

FIGURE 2

GLOBAL AVERAGE NEAR-SURFACE TEMPERATURES, 1850–JUNE 2009



SOURCE: UK Met Office, "Annual Global and Hemispheric Surface Temperatures," HadCrut3 data set, www.metoffice.gov.uk/climatechange/science/monitoring/temperatures.html.
NOTE: The solid bars show the global annual average near-surface temperature anomalies from 1850 to June 2009. The error bars show the 95 percent uncertainty range on the annual averages. The thick line shows the annual values after smoothing with a twenty-one-point binomial filter.

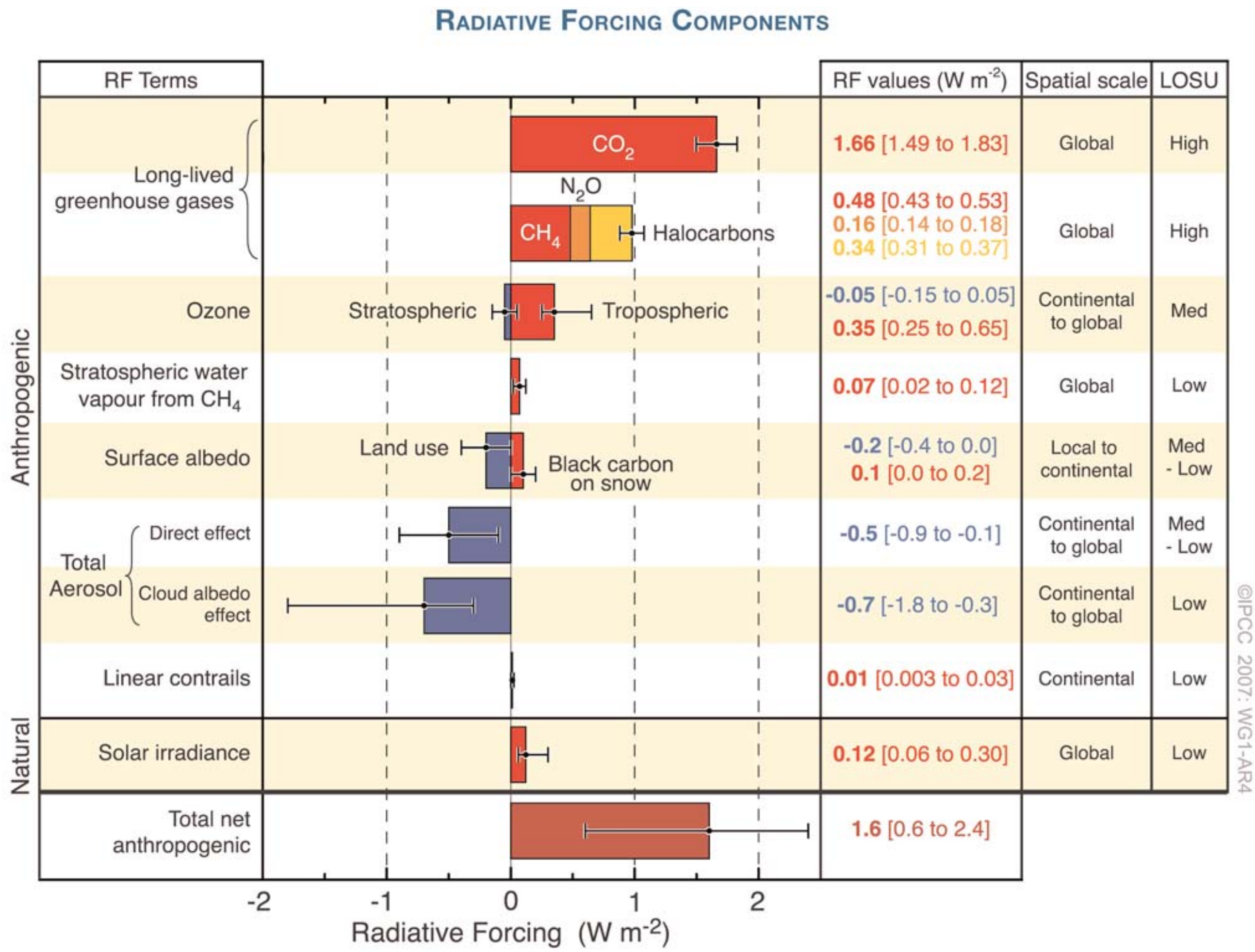
This *Outlook* does not focus on the question of climate change causality (there are plenty of studies that do), but it is fair to say that scientific understanding of which factors contribute to changes in the Earth's climate is still in a very early stage. Even the experts at the IPCC acknowledge this to be the case. Figure 3, from the Fourth Assessment Report of the IPCC, shows how limited scientific understanding of climate forcing really is. Scientific understanding of potential anthropogenic forcings is often medium-low to low. The same applies to scientific understanding of the nonbiological factors in climate change: articles disputing the role of solar output, cosmic ray flux, ecological GHG contributions, and responses are published on an ongoing basis.[4] From a policy perspective, the important policy question is less about the *cause* of climate variability than about the best response to climate variability, whether manmade or natural.

What Is Better, Climate Resilience or Climate Stasis?

In general, the mainstream response to the issue of climate change has been reactive, pessimistic, authoritarian, and resistant to change. Those alarmed about a changing climate would stand athwart the stream of climate history and cry "stop, enough!" Rather than working to cease human influence on climate, they want to find a way to make the climate stand still. This focus on creating climate stasis has led to policy proposals that would have been laughed at or dismissed as wacky conspiracy theories in the 1980s. But mainstream anti–climate change activists are proposing nothing less than the establishment of global weather control through energy rationing, regulations, and taxes, all managed by a global bureaucracy with a goal of leading humanity into a future that will become smaller, more costly, and less dynamic over time. Environmental groups, along with organizations like the United Nations IPCC, are calling for nothing less than imposing climate stasis on a chaotic system.

Consider the climate bill now before Congress: the Waxman-Markey *American Climate and Energy Security Act*. Waxman-Markey sets the ambitious target of reducing total U.S. GHG emissions by 83 percent below 2005 levels by the year 2050 (with intermediate benchmarks at 2020 and 2030). Thus, the cap and the allowances sold pursuant to it will be lowered from a peak of 5.4 billion tons in 2016 to just a little over 1 billion tons in 2050. As my colleague Steven F. Hayward and I have pointed out elsewhere, these targets are absurd.[5] From Department of Energy historical statistics

FIGURE 3
GLOBAL MEAN RADIATIVE FORCINGS, WITH LEVELS OF SCIENTIFIC UNDERSTANDING



SOURCE: IPCC, "2007: Summary for Policymakers," *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (New York and Cambridge: Cambridge University Press, 2007), 4, available at www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf (accessed September 28, 2009).

NOTE: Global average radiative forcing estimates and ranges in 2005 for anthropogenic carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). The net anthropogenic radiative forcing and its range are also shown. These require summing asymmetric uncertainty estimates from the component terms and cannot be obtained by simple addition. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional natural forcing but are not included in this figure due to their episodic nature. The range for linear contrails does not include other possible effects of aviation on cloudiness.

on energy consumption, it is possible to estimate that the United States last emitted 1 billion tons in the year 1910, when the nation's population was only 92 million people, per-capita income (in 2008 dollars) was only $6,196, and total GDP (also in 2008 dollars) was about $572 billion—about one-twenty-fifth the size of the U.S. economy today. By the year 2050, however, the United States is expected to have a population of 420 million, according to Census Bureau projections—more than four times the population of 1910. In order to reach the 83 percent reduction target, per-capita carbon dioxide (CO_2) emissions will have to be no more than 2.4 tons per person—only one-quarter the level of per-capita emissions in 1910.

When did the United States last experience per-capita CO_2 emissions of only 2.4 tons? From the limited historical data available, it appears that this was about 1875. In 1875, the nation's GDP (in 2008 dollars) was $147 billion, per-capita income (in 2008 dollars) was $3,300, and the population was only 45 million.[6]

My colleague Kevin A. Hassett, Hayward, and I have also written elsewhere about the problems with cap-and-trade and suggested that a revenue-neutral carbon tax would be preferable,[7] but that, too, represents an effort to impose stasis on a dynamic system simply using more efficient means. A carbon tax is, to be sure, vastly superior to a cap-and-trade system, but there are doubts that it is politically possible to enact one in a way that is actually revenue-neutral and is not abused by politicians who will look to tax those they dislike and rebate the taxes to groups they favor, namely, those that are most inclined to vote for their party.

A more forward-looking, optimistic, and free-market approach to the risks of climate variability accepts that the climate has been, is, and will be variable; focuses on the risks of variability; and looks for ways to build resilience in the face of that change, regardless of cause.

FIGURE 4
APPROPRIATE STRATEGIES FOR DIFFERENT STATES OF KNOWLEDGE

Knowledge of the nature and scope of risks and future conditions	*Amount of knowledge about intervention measures:* **Small**	**Great**
High	More resilience, less interception	Interception
Low	Resilience	More resilience, less interception

SOURCE: Adapted from Aaron Wildavsky, *Searching for Safety* (New Brunswick, NJ: Transaction Publishers, 1988), 122.

Aaron Wildavsky's Resilience Paradigm

Aaron Wildavsky, one of the great policy analysts of the late twentieth century, wrote extensively about the benefits of resilient social institutions. Wildavsky observed that possible risk-reduction interventions lie along a spectrum from resilient to interceptive. Resilient approaches maximize our ability to cope with risk by maintaining a dynamic, market-based, knowledge-building strategy. Interceptive interventions emphasize specific risk-reduction efforts that require certain specific actions and prohibit or restrict others.[8] But how do we decide, for a given risk such as climate change, whether an interceptive approach is more likely to provide greater safety than a resilient approach?

Wildavsky demonstrated that uncertainties about the likelihood or extent of any given risk and about the effectiveness of any intervention constrain risk-reduction decisions.[9] Figure 4 shows how uncertainties about the nature and scope of a risk and uncertainties about intervention measures and their effects constrain strategy selection, favoring certain approaches over others.

Employing both theory and empirical observation, Wildavsky observed that a strategy of interception is likely to be successful only in situations of truly excellent information. So, for example, for a power plant owner who knows that a particular part is going to burn out every 150 days, an interception strategy of replacing the part every 149 days to prevent the risk is likely cost-effective. But where less information exists, more resilient strategies are likely to succeed because interception will be either infeasible or expensive in such situations. If a power plant had eight thousand critical pieces of equipment that would create a fire upon failure, but the plant owner did not know the failure rates of each piece, trying to intercept the risk by replacing pieces before they failed would be enormously costly. Further, trying to have backup systems on all eight thousand pieces would be technologically difficult and probably not financially feasible. Instead, a strategy of resilience, such as implementing a sophisticated fire-response system, is more likely to be a feasible and efficient way of dealing with this risk.

In the case of climate change, our knowledge of the nature and scope of risks and future conditions is low, and our knowledge about how to intervene to head off specific risks is small. This suggests that contrary to current policy approaches that focus on mitigating GHG emissions largely to the exclusion of everything else, resilience should be considered the default climate strategy. As Wildavsky observed:

- Resilient systems build knowledge through research and build safety through efficient use of resources, enhancing the ability to respond to and reduce risks over time.

- Resilient approaches optimize use of local knowledge of specific and particular circumstances. Since resources are retained by individuals and firms in the social and economic system, people will instinctively reduce risks as they perceive them.

- Resilient approaches create spillover knowledge by building knowledge at local levels that can then be brought into play in other areas. Research is a natural part of resilient systems.[10]

Wildavsky illustrates these characteristics, drawing from the work of systems ecologists Kenneth E. F. Watt and Paul Craig. In one example, Wildavsky explains why a market-based system is more stable and, therefore, safer: the complexity and intricate nature of negative and positive feedback as conveyed through a market is a powerful stabilizing force whether that market is financial or involves the way energy is distributed through an ecosystem. Natural systems exhibit this complexity and rich feedback milieu, but so do economic systems:

> Systems of great complexity, with stability maintained by a lot of fast acting negative feedback loops are complex economies, with prices responding freely to trends in supply and demand. In such circumstances, we see very rapid introduction of new products, or replacement of old by new products.[11]

In yet another example, Wildavsky points out that ecological studies present cautionary findings with regard to poor specific risk-reduction investments:

> We are specifically concerned with stability of the entire system in contradistinction to stability of each component of the system. That is, we understand that in biological, economic, or any other kind of systems, the former can be maintained at the expense of the latter. Putting this differently, if the goal adopted is to preserve stability of particular system components, the ultimate consequence can be decreased stability in the entire system.[12]

To a large extent, the resilience option is the complete opposite of the climate-stasis approach; it focuses on decentralization, deregulation, and freeing markets to maximize resilience.

Managing Risks with Resilience-Building Policies

A vast range of risks has been discussed in the context of climate change, from flood to drought, threatened food supplies, more deadly insect-borne diseases, higher heat-related deaths, rising sea levels, and so forth. The risks discussed in this *Outlook* are not future probabilities based on empirical evidence and extrapolation. Rather, they derive from computer models of potential future change and are, therefore, not to be taken as known threats but rather as hypothesized threats made using relatively primitive modeling technology subject to the garbage-in, garbage-out problem typical of the breed. The risks are discussed here with that limitation in mind, as potential risks, without any measure of probability attached. Several approaches economists and policy analysts have identified could help increase social resilience to such risks.

Contrary to current policy approaches that focus on mitigating GHG emissions largely to the exclusion of everything else, resilience should be considered the default climate strategy.

Eliminate Risk Subsidies. Predicted damages associated with sea levels and storms are high because of the popularity of such locales for high-density business and upscale residential development. As a result, damages from extreme coastal weather events have been hugely expensive. The damages from Hurricane Katrina, for example, reached over $150 billion.[13] The question, however, is why was there so much value that was so badly protected against completely predictable events? Levees and sea walls were underdesigned. Many houses and businesses were not insured against flood damage. As Charles Perrow observes in *Our Next Catastrophe*, “Even in areas known to be hazardous, only about 20 percent of homeowners purchase flood insurance, and less than 50 percent of businesses purchase flood and earthquake insurance in risky areas.”[14]

The answer to that question lies, at least in part, in the presumed role of state and federal governments as the insurer of last resort. People know that in the event of a disaster, even if uninsured, the Federal Emergency Management Agency will give grants to let people recover from natural disasters such as hurricanes, floods, and storm surges. Without such assurances, we can assume that many people would be unwilling to face the risk of living in coastal areas that could be flooded by rising sea levels and would relocate to higher ground. Capital needed for businesses would also avoid areas of high risk due to sea-level rise, preventing further siting of high-value structures in vulnerable areas.

As researchers at the Wharton Risk Center observe:

> Highly subsidized premiums or premiums artificially compressed by regulations, without clear communication on the actual risk facing individuals and businesses, encourage development of hazard-prone areas in ways that are costly to both the individuals who locate there (when the disaster strikes) as well as others who are likely to incur some of the costs of bailing out victims following the next disaster (either at a state level through ex post [facto] residual market assessments or through federal taxes in the case of federal relief or tax breaks).[15]

Similarly, the CATO Institute points out:

> Government-provided programs for crop insurance and flood insurance, as well as other interventions in private disaster insurance markets, often are justified as necessary to overcome the failure of private markets to offer adequate and affordable disaster insurance. Defenders of government insurance programs claim that they reduce dependence on "free" disaster assistance and promote efficient risk management by property owners and farmers.
>
> But government policies are the cause of, not the cure for, the limited supply and narrow scope of private-sector disaster insurance. Demand for private coverage is low in part because of the availability of disaster assistance, which substitutes for both public and private insurance. Moreover, a government that cannot say no to generous disaster assistance is unlikely to implement an insurance program with strong incentives for risk management.
>
> The subsidized rates and limited underwriting and risk classification of federal government insurance programs aggravate adverse selection, discourage efficient risk management, and crowd out market-based alternatives.
>
> Federal tax policy reduces supply by substantially increasing insurers' costs of holding capital to cover very large but infrequent losses. State governments also intrude on insurance markets by capping rates, mandating supply of particular types of insurance, and creating state pools to provide catastrophe insurance or reinsurance coverage at subsidized rates. By reducing both the supply and demand sides of private insurance protection, government intervention leads to greater reliance on politically controlled disaster assistance and higher costs for taxpayers.[16]

Perrow makes the case that this is no better at the state level:

> State-mandated pools have been established to serve as a market of last resort for those unable to get insurance, but the premiums are low and thus these have the perverse effect of subsidizing those who choose to live in risky areas and imposing excess costs on people living elsewhere. In addition, the private insurers are liable for the net losses of these pools, on a market-share basis. The more insurance they sell, the larger their liability for the uninsured. Naturally, they are inclined to stop writing policies where there may be catastrophic losses (hurricanes in Florida and earthquakes in California). The Florida and California coastlines are very desirable places to live and their populations have grown rapidly, but these handsome lifestyles are subsidized by residents living in the less desirable inland areas in the state, and, to some limited extent, by everyone in the nation.[17]

If risk subsidies cannot be abolished entirely, at the very least, insurance companies should charge risk-based premiums. As Wharton researchers explain:

> Insurance premiums (whether public or private coverage) should, to the extent possible, reflect the underlying risk associated with the events against which coverage is bought in order to provide a clear signal to individuals and businesses of the dangers they face when locating in hazard-prone areas and [to] encourage them to engage in cost-effective mitigation measures to reduce their vulnerability to disasters.[18]

Privatize Infrastructure. Climate change could also pose a challenge for coastal or low-lying roadways, water-treatment facilities facing increased rainfall intensity, energy utilities facing increased summertime electricity demand, and so on. Governments are quite good at building infrastructure. After all, what politician does not enjoy a ribbon cutting ceremony for some new element of name-bearing infrastructure? But governments are dismal at maintaining infrastructure, as they generally fail to establish a revenue stream to maintain a system that provides feedback about whether a particular road should be raised or a water-treatment facility expanded or a power capability increased. A solution to these problems, as well as a potential source of revenue for cash-strapped state and municipal governments, is the privatization of infrastructure. While a few poorly executed privatization efforts have tarnished the name, the baby should not be thrown out with the bath water; privatization offers a host of benefits. A great deal of research on privatization in developing and developed countries demonstrates that, on the whole, privatization shows considerably more benefit than risk.

> It has long been known that certain types of risk are not suited to attempted prevention but instead must be met with the resilience needed to live with the risk. Climate change is one such risk that is virtually impossible to prevent.

In "An Assessment of Privatization," Sunita Kikeri and John Nellis conclude that "[i]n infrastructure sectors, privatization improves welfare, a broader and crucial objective when it is accompanied by proper policy and regulatory frameworks." Further, they observe that "ownership change in productive firms, as well as private investment in less than full ownership capacity, usually improves the financial situation of the firm and the fiscal position of selling government, increases returns to shareholders, and in the right policy circumstances, generates significant welfare benefits as well."[19] Private owners of infrastructure have a lot of investment tied up in getting a long-run stream of revenue from the infrastructure. Ensuring that future changes in climate do not disrupt that long-run cash flow is critical to their current financial performance.

Roadways. If roads are privately owned and tolled, road operators have a revenue stream to tap in order to raise, resurface, or recontour roadways to adapt to climate changes. If costs of such adaptation are high, tolls will rise, and at some point, an economic decision will occur about whether a road should be maintained or whether some alternate route should be developed. In some cases, people may indeed find their transportation options so limited that they must move away to a place with a less fragile climate. One can imagine something like this for some coastal roadways where there are no easy alternate routes, but it would probably be a fairly rare outcome. Still, if such situations did develop, this is a desirable outcome, as it is both economically efficient and reduces the likely cost of climate-related damages to structures.

Electricity Supply. As long as governments distort the prices consumers pay for energy with subsidies, fuel mandates, renewable power mandates, and the like, electricity markets cannot effectively adapt to changing climatic conditions. If electricity markets were fully deregulated, and if full costs were passed onto consumers, price signals would be created for the electricity provider in terms of expanding or decreasing capacity and for the consumer in terms of the real cost of living in an environment subject to energy-consuming heat waves (or cold snaps). Privatization would create incentives for electricity conservation and for the acquisition of energy-efficient appliances and devices without any need for specific governmental efficiency standards. Further, electric companies would be driven to connect with one another to ensure reliability to their customers rather than doing the minimum possible to satisfy regulators.

Water Supply. Full pricing of water and full privatization of the water supply, drinking water plants, and wastewater treatment plants would ameliorate many climatic risks incrementally over time, including flooding, seawater intrusion, and coastal and river pollution from storm runoff. Charging the full price for water, from supply to disposal, would create a price signal for consumers regarding the real risks they face living in hydrologically sensitive areas and create incentives for conservation while producing a revenue stream to allow for expanded capability or the securing of alternative supplies. At some point, again, high prices could simply lead people to move away from areas that are hydrologically costly, such as cities dependent on a single winter snow pack that shrinks or a single major river that suffers reduced flow.

Flooding. What is not achieved by removing insurance subsidies in flood-prone areas can be managed through the creation of privately administered hydrologic utilities, which would be financed by flood-protection fees charged to residents of flood-prone areas. Again, such a system creates a price signal that can show when it is and when it is not efficient to raise the height of a levee, for example, or to expand permeable surfacing requirements in development. The cost of paying for such activities would send the consumer a signal about the true cost of living in flood-prone areas and would ultimately lead those who could not afford to fully finance their level of risk to relocate to safer areas.

Trust in Resilience, but Tie Up Your Camel

In the event that climate change does tend toward higher estimates put forward by the United Nations and other groups, it is reasonable to consider insurance options that might help deal with such climate changes. Such options might include government investment in geoengineering research, investment in research and development to advance technologies allowing the removal of GHGs from the atmosphere, and possibly the creation of a climate adaptation fund to be used when state and local governments find themselves unable to cope with a given climate change, or even to compensate others should it ultimately be shown that U.S. emissions of GHGs have caused harm to other countries or the property of other individuals.

It has long been known that certain types of risk are not suited to attempted prevention but instead must be met with the resilience needed to live with the risk. Climate change is one such risk that is, as the world is increasingly observing, virtually impossible to prevent, whether it is manmade or natural.

As efforts to mitigate GHGs fail around the world, it is long past time to broaden the tools available to us in order to make our society resilient to climate risk. Rather than remain largely focused on the quixotic effort to reduce GHG emissions or to stand athwart the stream of climate and shout "stop, enough!" we should shift the majority of our policymaking attention to an agenda of resilience building and adaptation, two areas with which governments particularly struggle. Plan B for climate resilience should consist of an aggressive program of resilience building through the elimination of risk subsidies and the privatization of infrastructure. Other subsidies and regulations that make the overall economy more brittle in the face of climate change would also be ripe targets for removal, such as those which permeate energy and water markets.

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Notes

1. Christopher R. Scotese, "The Paleomap Project" (Paleomap website, 2002), available at www.scotese.com/climate.htm (accessed September 23, 2009).

2. International Panel on Climate Change, "2007: Summary for Policymakers," *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (New York and Cambridge: Cambridge University Press, 2007), 10, available at www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf (accessed September 23, 2009).

3. Richard S. Lindzen and Yong-Sang Choi, "On the Determination of Climate Feedbacks from ERBE Data," *Geophysical Research Letters* 36, no. 16 (August 2009); and Roy W. Spencer and William D. Braswell, "Potential Biases in Feedback Diagnosis from Observations Data: A Simple Model Demonstration," *Journal of Climate* 21 (November 2008): 5624–28.

4. Nir J. Shaviv and Ján Veizer, "Celestial Driver of Phanerozoic Climate?" *GSA Today* (July 2003), available at www.gsajournals.org/archive/1052-5173/13/7/pdf/i1052-5173-13-7-4.pdf (accessed September 24, 2009). See also Judith L. Lean and David H. Rind, "How Will Earth's Temperature Change in Future Decades?" *Geophysical Research Letters* 36 (August 2009), available at http://pubs.giss.nasa.gov/docs/2009/2009_Lean_Rind.pdf (accessed September 24, 2009).

5. Steven F. Hayward and Kenneth P. Green, "Waxman-Markey: An Exercise in Unreality," AEI *Energy and Environment Outlook*, no. 3 (July 2009), available at www.aei.org/outlook/100057.

6. It is possible that per-capita CO_2 emissions were never this low even before the advent of widespread use of fossil fuels: wood burning by Americans in the nineteenth century may have produced more than 2.4 tons of CO_2 per capita. Much depends on the emissions coefficient for wood burning and how, since wood is biomass rather than a fossil fuel, reforestation is credited in carbon accounting. In 1875, burning wood generated twice as much energy as fossil fuels.

7. Kenneth P. Green, Steven F. Hayward, and Kevin A. Hassett, "Climate Change: Caps vs. Taxes," AEI *Environment and Energy Outlook*, no. 2 (June 2007), available at www.aei.org/outlook/26286.

8. Aaron Wildavsky, *Searching for Safety* (New Brunswick, NJ: Transaction Publishers, 1988). Wildavsky used the terms "resilience" and "anticipation" rather than "resilience" and "interception." In adapting Wildavsky's framework to more recent risk-related issues, I have chosen to use "interception" because it corresponds better to common perceptions of how risk regulations work.

9. Ibid., 122.

10. Ibid.

11. Ibid., 114.

12. Ibid., 112.

13. Mark L. Burton and Michael J. Hicks, *Hurricane Katrina, Preliminary Estimates of Commercial and Public Sector Damages* (Huntington, WV: Marshall University Center for Business and Economic Research, September 2005), available at www.marshall.edu/cber/research/katrina/Katrina-Estimates.pdf (accessed September 24, 2009).

14. Charles Perrow, *The Next Catastrophe: Reducing Our Vulnerabilities to Natural, Industrial, and Terrorist Disasters* (Princeton, NJ: Princeton University Press, 2007), 37–38.

15. Erwann O. Michel-Kerjan, "Disasters and Public Policy: Can Market Lessons Help Address Government Failures?" *The National Tax Journal* (January 2007), available at http://opim.wharton.upenn.edu/risk/library/07-04.pdf (accessed September 24, 2009).

16. Cato Institute, "Disaster Assistance and Government Insurance," *Cato Handbook for Congress: Policy Recommendations for the 107th Congress* (Washington, DC: Cato Institute, 2003): 431–39, available at www.cato.org/pubs/handbook/hb107/hb107-40.pdf (accessed September 24, 2009).

17. Charles Perrow, *The Next Catastrophe: Reducing Our Vulnerabilities to Natural, Industrial, and Terrorist Disasters*, 38–39.

18. Erwann O. Michel-Kerjan, "Disasters and Public Policy: Can Market Lessons Help Address Government Failures?"

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