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Thoughts on Extreme Events

Reading the very interesting statements from ten different contributors has helped focus my thinking on extreme events. I'd like to respond to a number of common themes and assumptions, and try to fill in the occasional gap, with references to my own work where appropriate.

Common themes and/or assumptions

First, the background paper notes that the number of extreme events is increasing. Several contributors concur, noting that such events are more frequent and perhaps more severe than in the past. Although these assertions are plausible, I do not currently know enough to evaluate their truth. Are extreme events really more common and more severe now than before, or is this just our perception (based on media reports of events from all corners of the globe, and perhaps on risks of extreme events that could occur but have not yet occurred)? One could certainly argue (for example) that transportation is safer now than in the past, and that the risk of nuclear destruction or more traditional global warfare is lower now than it was 20 years ago. It is also true that our beliefs about the frequency of extreme events depend in part on how that frequency is measured (for example, the number of airplane crash fatalities per year versus the number of airplane crash fatalities per mile traveled). Extreme events are important regardless of trends in their frequency and severity, but it may also be important to assess what those trends are, and to what extent they depend on changes in technology, population, and so on.

A second theme is that the problem definition and/or the categorization and labeling of extreme events is important. Very similar issues appear in more "traditional" risk analysis. How risky particular hazards seem depends in large part on the way they are grouped together into risk categories. For example, the category "hazardous waste sites" is viewed differently from the smaller categories "Superfund waste sites" and "RCRA waste sites" and from the larger category "municipal and hazardous waste sites." In a recent paper in *Risk Analysis*, we noted that there are many different ways to categorize risks, and that some make more sense than others. Specifically, we argued that risks should be categorized based on the intended use of those categories (e.g., in risk-ranking exercises designed to inform risk-management decision making); that this may often lead to categorizations based on events relatively early in the causal chain (e.g., human activities, initiating events, and environmental loadings); that further sub-categorization is often necessary to meet additional goals; and that most exercises would benefit from the investigation of multiple alternative categorization schemes. Analogous reasoning may prove useful for the categorization of extreme events. Maybe not.

A third theme concerns the models that are appropriate for extreme-event decision making, and more specifically, whether the decision-analytic approach has much to offer in this respect.

Contributors have suggested (or I have interpreted them as suggesting) that other norms might be more appropriate, particularly when the events and the decisions that surround them are viewed as unique. Over the past year and a half, a working group at Carnegie Mellon has wrestled with similar questions when considering the "precautionary principle." Definitions of the precautionary principle abound, but the basic notion is that scientific uncertainty should not be used as excuse to postpone measures intended to protect public health and the environment when there is some risk of severe or irreversible damage (i.e., an "extreme event"?). Members of the Carnegie Mellon group are divided on how far you can push decision analysis when you are unable to adequately specify the various outcome and probability components of the problem (or perhaps even structure the problem correctly in the first place), and whether the precautionary principle can be (or should be) viewed as special case of the traditional approach. However, we are (mostly?) in agreement that the traditional Bayesian-decision-analysis approach may help to focus discussion (and perhaps negotiation) on the most important parts of a problem, by deconstructing the problem in a defensible manner. We are currently revising a paper on this topic for a special precautionary-principle issue of the *Journal of Policy Analysis and Management*. In today's global political climate, I don't think it makes sense to discuss extreme events without incorporating the precautionary principle into that discussion.

Fourth, several contributors note that there is (or should be) a link between extreme-event decision making and well-known research on risk perception (perhaps including people's mental representations of the relevant systems). I agree, but I would also note that almost all of this research has focused on risks to human health and safety, and not on risks to the environment. For example, I know of only three published psychometric studies on ecological risks, and all of these used the same set of attributes to describe the risks, and the same technique for analyzing the data. In the past year, we have been researching this topic, with new sets of attributes and risks, and with the goal of selecting ecological attributes for use in risk-ranking exercises. My point here is that it is simply too early to claim that we know exactly what attributes or factors affect people's judgments of ecological risks.

Other thoughts and connections

The background paper argues that there should be a greater effort to integrate the social and physical sciences. I will take this opportunity to note that the emerging field of "integrated assessment" is focused on precisely this point, with particular emphasis on global change (note that did not write global *climate* change, because that would be too narrow). There is a very active group centered at Carnegie Mellon and spanning 22 institutions in eight countries (the Center for Integrated Study of the Human Dimensions of Global Change, headed first by Hadi Dowlatabadi and now by Baruch Fischhoff). Among many other things, they have produced an integrated assessment model (ICAM 3) designed to foster insights into the linkages between physical and social systems, and how policy interventions might impact those systems. One idea that comes out of such modeling is that it might be useful to run real-world climate policy experiments over the next several decades to see how the various systems respond, and to use the results of these experiments to reduce uncertainty and to better calibrate the models, so that better policy decisions might be made at a later point in time. This is basically a policy version of taking actions to find out whether they have any effect (one of many interesting behaviors mentioned by Alex Kirlik).

A few contributors also mention the importance of false alarms. I agree that false alarms may be very important in some circumstances, but we should not assume that false-alarm effects

are always a key facet of decision making involving extreme events. By "false-alarm effect," I mean a sequence of events in which a false alarm (e.g., an evacuation that turns out to have been "unnecessary" because the feared event does not occur) leads to a decrement of response when the feared event does occur at a later point in time (e.g., an evacuation is ordered, but fewer people evacuate in a timely manner). Such effects may not be important for some extreme events precisely because the events (and the events that trigger warnings) are so rare that this sequence is *very* unlikely. About ten years ago, when I was in graduate school, I analyzed the potential for false-alarm effects due to dam-failure warnings and found this to be the case. Second, the existing data at the time suggested that real false-alarm effects are very difficult to document for natural hazards, in part because false alarms can often be re-framed as "near misses." Finally, we have collected some vignette-based data suggesting that people may be relatively unconcerned about false alarms, to the extent that they rate an "unnecessary" evacuation as being better than no evacuation at all. The maxim "better safe than sorry" is often used to explain this interesting (and perhaps unjustifiable) preference ordering. Such a position may be contrasted with that of decision makers whose jobs may be on the line in the event of a false alarm (perhaps due only to hindsight or outcome bias).

This distinction between the decision maker and the public highlights the role of accountability and the circumstances under which the incentives of the decision maker may not be aligned with those of the public. Hal Arkes notes that concerns over liability may decrease physicians' acceptance of decision aids, but it is also commonly believed that concerns over liability increase physicians' use of diagnostic testing. These differing effects point to the importance of distinguishing between the decision process and the information that is used as input to that process.

References

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