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Experiencing the Environment as Hazard

ROBERT W. KATES

Abstract: The environment as hazard has been under intensive study for some 20 years, and has mostly focused on natural hazards. Industrialized countries exhibit a pattern of declining death rates and increasing damage, despite substantial investment in technical means for coping. In developing countries, both damage and deaths are high. A conceptual model in which hazard events and consequences arise from the interaction of environment and society and are mediated by coping actions helps to explain these divergences. The observed and perceived experience are described for each of the model elements.

The paper concludes with an observation that for most people everywhere, on balance, the everyday is more secure, the exceptional may be less so; and with a deep concern that the central role of experience as social learning in coping with the hazards of the natural environment is a missing ingredient in coping with the newly created or recognized hazards of technology.

Environment is that which surrounds us, the ambience of individuals, of social groups, of our species. So all-pervasive is environment that in its totality it escapes our comprehension, at least in this mode of consciousness. Inevitably we fraction it and destroy it, to reconstruct it in more narrow comprehensible slices. How we choose to emphasize the environment—as nurture, haven, or home; as deprivation or stimulation to the senses; as myth or symbol; or as threat and hazard—is partly the essence of the conference. Our topic, the emphasis of the environment as threat or hazard, is no more or less pure than other emphases. Indeed, it is inevitable that each environmental plane we slice intersects with others. Thus, the environment as hazard is integral to the environment as nurture or resource; men encounter hazard in the search for the

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useful. The environment as hazard serves as a source of stimulation, and is rich in the mythical and the symbolic.

This choice of emphasis arises not out of some conceptual insight, but out of the accident of research thrust and the concern with applied human and social problems of man-environment interaction. Nevertheless, the study of *homo in extremis* is a useful focus for insights beyond the problems at hand. Reasoning from the extremes, be they of environmental stress or any other set of data, is an ancient and honorable practice of scientific and philosophical inquiry. In this paper, we consider each of the five major conference approaches to experiencing the environment, emphasizing what we know of each from our studies of the environment as hazard. We begin by describing these studies and our current concept of their underlying structure.

STUDIES OF THE ENVIRONMENT AS HAZARD

The environment as hazard has been under intensive study for some 20 years. Most attention has been given to the study of hazards of the natural environment, more recently to that of the made environment and little to that of the social environment. Participants in these studies have expanded from a small group of teachers and students at a single university (Chicago, 1955–61) to groups at several universities (Chicago, Toronto, Clark, and Colorado, 1962–68), to collaboration through the interested organizations of a single discipline (International Geographical Union, 1969–72), to international collaboration through many disciplines (Scientific Committee on Problems of the Environment, 1973–). While geographers have been prominent in the leadership of these studies, economists, engineers, psychologists, and sociologists have been active as well.

In specific terms, much of the early effort concentrated on flood studies in the United States, and as recently as six years ago, we had available substantial studies of other hazards only for North America and Britain. In these studies, we had followed a simple research paradigm which sought to: (1) assess the extent of human occupance in hazard zones; (2) identify the full range of possible human adjustment to the hazard; (3) study how men perceive and estimate the occurrence of the hazard; (4) describe the process of adoption of damage-reducing adjustments in their social context; and (5) estimate the optimal set of adjustments in terms of anticipated social consequences.

In general, these studies provided evidence for a pattern of declining death rates and increasing damage, despite substantial investment in technical means for coping with hazard. In so doing, they raised serious questions as to the efficacy of the prevailing approach to natural hazard loss reduction. But six years

ago we knew little as to the prevalence of this pattern in the nonindustrialized world and were at a loss for ways of systematically comparing hazards of varied origins and impact. Thus, we sought to organize, with the collaboration of many colleagues, a series of field studies, which when concluded told us in some detail about the ways in which people adjust to different hazards. They raised more questions than they answered, but they did outline some of the patterns of hazards and adjustments in roughly comparable form.

Specifically, we compared findings from local studies of: tropical cyclones in Bangladesh, the United States, Puerto Rico, and the Virgin Islands; droughts in Australia, Brazil, Kenya, Mexico, Nigeria, and Tanzania; floods in India, Malawi, Sri Lanka, the United Kingdom, and the United States; volcanoes in Costa Rica and the United States; and coastal erosion, frost, urban snow, volcanoes, and high winds in the United States. These studies, which comprised 28 studies at 73 sites and interviews with approximately 4,800 households, revealed the diversity of adjustments for coping with natural hazard.

Although five of the studies involved habitats where the vulnerability to extreme events is uniform, the others embraced a wide range of risk. The frequency of damaging events was high in some places and rare in others: In contrast to San Francisco and its decades without serious earthquakes, residents of Boulder reported high winds on an average of three times per year, and farmers in the Ganga flood plain noted floods once in five years on the average.

By design, the people interviewed were mostly men who were heads of their households, between the ages of thirty-seven and fifty-four with families. They varied in education from almost wholly illiterate pastoralists in northern Nigeria to sites in the United States where almost all those interviewed were at least high school graduates; in income from Shrewsbury, England, with perhaps $2,000 per capita yearly, and from Sri Lanka where the annual income is less than $200; in occupation the studies included sedentary farmers, shifting cultivators, fishermen, city laborers, artisans, small businessmen, manufacturers, teachers, and government workers.

In no sense, however, was the set of study areas representative of the world's population at risk; nor was it intended to be a statistically valid sample. Rather, it was a selection from different cultures and hazard situations, drawn partly by intent and partly by the fortuitous cooperation of investigators. The results permitted initial probing of the immense variety of the earth's patterns of hazard in the environment.

Seven sets of these studies were of sufficient breadth as to constitute studies of the national experience for a single hazard where the research paradigm was applied in a reasonably consistent and comprehensive manner. The comparative research design called for at least one comprehensive study in both a developing and industrial nation for each of several natural hazards, and for at

least one hazard of substantial human origin. To complete the set of studies, we had to draw upon United States experience in two cases, floods and hurricanes. We were not able to develop a comprehensive study of air pollution (the hazard of substantial human origin) in a developing country. Instead we drew upon some limited findings and reports from Mexico to provide some measure of comparative experience. The seven studies that emerged from the collaborative effort were studies of drought in Australia and Tanzania, floods in Sri Lanka and the United States, hurricanes in Bangladesh and the United States, and air pollution in the United Kingdom with supplementary data from Mexico. Detailed analysis for 21 sites has been published (White, 1974), and an overall synthesis will be published this year (Burton, Kates, and White, in preparation).

In addition to the studies of air pollution, which were consciously chosen to bridge hazards arising from the natural and made environment, a growing body of data dealing with the made environment or interaction between the natural and made environment has been collected in roughly the same tradition. These include studies of water quality (Baumann, 1969; White, Bradley, and White, 1972), water quality technology (Baumann and Kasperson, 1974), weather modification (Sewell, 1966, 1968), and work currently underway into the hazards of nuclear power production. Formal study of the hazards of the social environment has been limited to a few comparisons (Golant and Burton, 1969, 1970), reading the work of others, and some preliminary collection of statistics of hazard risk and occurrence. All of the foregoing can be integrated into a simple conception of the environment as hazard emphasizing the approaches of our conference.

THE ENVIRONMENT AS HAZARD: A CONCEPTUAL MODEL

In the terminology of this conference, the environment becomes hazard in the course of being acted upon by society, such interaction leads to the generation of hazard events, and consequences of those events, which in turn are reacted upon by individuals and societies seeking to cope with the threatening consequences. This process is shown schematically in Figure 1 and is elaborated on by drawing primarily from the natural hazard findings supported by insights from studies of the hazards of technology and the made environment.

In describing the environment as hazard in these categories, caution should be exercised in interpreting these. Acting upon, experiencing, reacting to—these are categories of convenience; they try to relate to the approaches of the conference organizers, and serve to order the presentation of finding

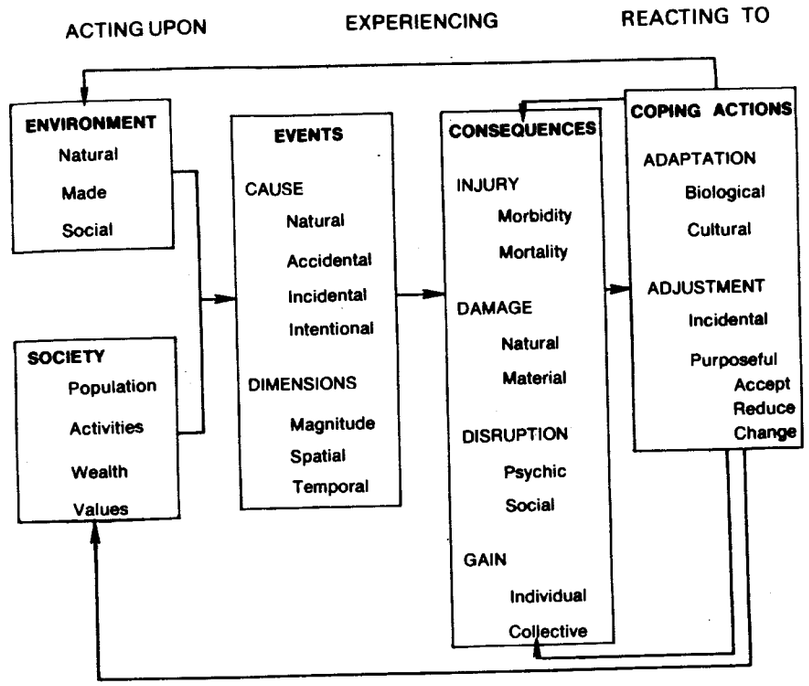

Figure 1. The environment as hazard.

and insight. But they are not a sequence of human behavior, neither in the world of life, or of hazard; the schema of such behavior escapes the dimensionality of graphics or words and at our best we only approximate it, in inner understanding.

Acting upon Environment: An Interactive View of Hazard

The earth suddenly shakes, houses collapse, people are buried in the ruins, fires start, disease spreads, the rescue teams move in. The world knows that an earthquake has occurred. The rains do not come, the crops (planted in expectation of rain) wither and die, the water holes dry up and the cattle fall ill, there is less food, the people perish. The world knows there is a drought. In the conventional wisdom, these events are ascribed to nature, to the environment, or to God.

Much of the content of natural hazard research, the way it is structured

and written and the information incorporated in it, arises from a set of ideas and definitions about the nature of natural hazard. The first idea views nature as neutral; catastrophic events are seen as human events, a product of man. If man is absent from an area in which an extreme natural event occurs, then he is not usually affected by it. Insofar as man is present, the density and distribution of population, the style and level of economy, the shape and size and character of his buildings, patterns of production, consumption, and leisure all affect in significant and powerful ways the consequences of the event. The most important idea, therefore, is that natural events are indeed natural and that hazards—the threat potential for man and his works—are by definition human phenomena. If we extend Bishop Berkeley's dictum, it can be said that not only is there no sound when the tree falls unwitnessed in the forest, but there is also no danger from falling trees.

A second fundamental idea is that interaction between man and nature involves many transactions, some of which are beneficial to man, others harmful. It is the harmful that we can hazards. Many elements in nature cannot be easily allocated to either beneficial or harmful categories. They may be both simultaneously. But it is the human search for the beneficial that often results in the harmful. Invariably, the events that cause harm can only be quantitatively, not qualitatively, distinguished from the normal circumstances of nature—the flood from the rains that water the plants, the storm from the winds that bring the moisture.

The idea that the search for utilization of natural resources creates hazard can be extended to both the made environment and the social environment that surrounds us. In making and using things, we create threat as well; buildings can burn, cars can hit, and drugs can poison. Similarly, in joining with others in complex social relationships, we become vulnerable to violence from war and crime, to illness from propinquity and social mixing, or to deprivation from unemployment and inflation.

Experiencing the Environment as Hazard: Events

The environments—natural, made, and social—are the sources of events that only necessarily become hazardous as they intersect human populations carrying on activities, possessing material wealth, and having values. Using the national studies of natural hazards, estimates of the population at risk from some of the major hazards considered are between 5% to 15% of the national population with two exceptions: drought in the peasant society of Tanzania (90%) and air pollution in the urbanized society of the United Kingdom (50%). These exceptions can be generalized: Hazard events of natural origin affect the

greatest number in rural societies; hazard events of the made and social environments affect the greatest number in urbanized societies.

The distinctions between events originating in natural, made, or social environments are constructs of the author; how is the cause or source actually experienced? Embedded in our language and our law is the distinction between the Act of God (or Nature?) and the Act of Man. The Acts of Man, in turn, can be seen as either intentional acts (with good or bad intentions) or accidents (with or without imputed negligence). We can also try to distinguish the accidental—a chance failure or unintended happening, from the incidental—what we might do without failure or intention in the course of the pursuit of other ends.

Historically, yesterday's Act of God frequently becomes today's Act of Man as more and more control and responsibility for environment is achieved or assumed. For many, the Act of God is not accidental, more intentional than Acts of Man. Thus, while the distinction may hold meaning in any given society, universal meaning for these categories appears unlikely.

Events not only have causes, they have generalized dimensions independent of their interaction with society. These dimensions describe the size and the spatial and temporal distributions of events with hazard potential. In turn, these dimensions seem to collapse into a continuum between the pervasive or chronic and the intensive or acute. *Intensive* hazard events are characteristically small in areal extent, intense in impact, of brief duration, sudden onset, and poor predictability. *Pervasive* hazards are widespread in extent, have a diffuse impact, a long duration, gradual onset, and can be predicted more accurately.

The sets of natural hazard events that fall most easily into the intensive class are earthquakes, tornadoes, landslides, hail, volcanoes, and avalanches; and those that fall into the pervasive class are drought, fog, heat waves, excessive moisture, air pollution, and snow. Other hazards are less susceptible to grouping, and examples can be found at both ends of the spectrum as in the case of floods, for example. These might be described as *compound* hazards, displaying mixed characteristics. Some flash floods are close to intensive events, while others—the great riverine and deltaic floods—are very close to pervasive events. Other events such as tropical cyclones, while less variable as between upstream and downstream flooding, have some characteristics of both and are intermediary between the polar events. We would further include among compound hazards extreme winds, blizzards, tsunamis, and sand and dust storms. The pervasive-intensive continuum provides a way in which we can make comparisons between hazards and seems to influence the resulting pattern of adjustment and choice.

A typology of the events of the made and social environments is yet to be

developed, but it seems possible that similar characteristics will be found. The distinction between acute and chronic disease in medicine, between rapid onset, short duration and slow onset, long duration (Wingate, 1972) suggests such similarity.

Experiencing the Environment as Hazard: Consequences

The consequences of events involve threats to person: morbidity and mortality, damage to activities and wealth both natural and man-made, disruption to psychic and social activities and well-being, and although often forgotten, the antithesis of the foregoing instances of individual and collective gain.

The ultimate experience with consequences of hazard is death, but fortunately, such experience is limited. In developed countries, the natural environment contributes little to what is primarily the burden of age and disease. Out of slightly less than two million Americans who died in each of recent years, perhaps 500 died as a consequence of natural hazard, 50,000 from the violence of others (war and crime) and of self (suicide), 100,000 in accidents with the made, built, and machine environments. More difficult to give quantitative expression to is the effect of environmental events on disease rates: natural and man-made radiation on birth abnormalities and malignancies; the pollutants of the made environment on respiratory diseases and cancer; the hazards of poverty and poor housing on childhood mortality; or the pace of society on cardio-vascular disease. In developing countries, these proportions may be reversed; as many have died from natural hazard in Bangladesh as from heart trouble in the United States. A graph of global disaster (Figure 2) suggests that disaster of the made environment is more frequent and less costly than natural disaster.

The monetary value of damage is considerable as well. Damage and preventive measures for natural hazard cost an estimated $10 billion per year in the United States; air and water pollution, $30 billion; accident, wage, and health, $25 billion; and fire losses, $2.5 billion.

Psychic and social disruption are poorly documented, although in an out-of-court settlement the Pittston Coal Company paid the survivors of the Buffalo Creek disaster $6 million over and above direct losses for community disruption, the first case so recorded. Individual and collective gains range from the grocer who temporarily profits from his competitor's flood or fire, to the sense of well-being and solidarity some communities and nations evidence when performing well in the face of a disaster.

To experience events does not imply experiencing consequences, although in common language, the events and consequences of many hazards are confused. Floods can mean high water flowing over the bank of a stream or

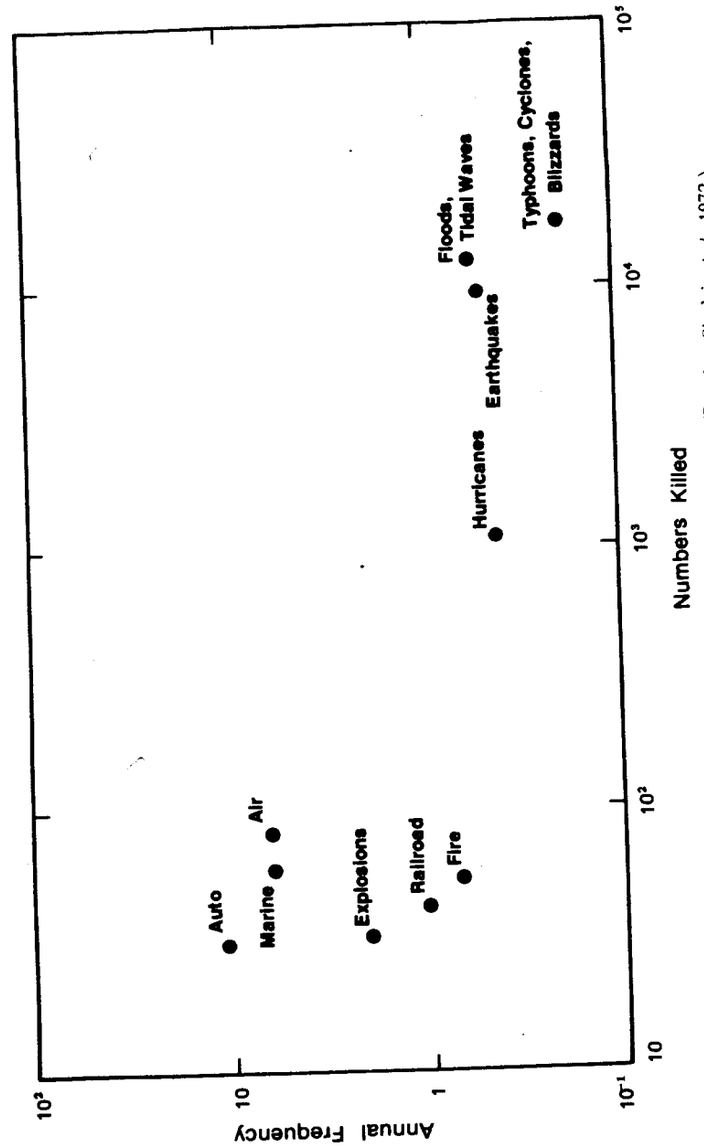

Figure 2. Comparison of risk from various types of disaster (world). (Based on Sinclair *et al.*, 1972.)

high water that drowns people, destroys buildings, washes away soil. All of us employ the familiar phrase, "It was only an accident, no harm done."

But, in many ways, it is important in understanding hazard experience to separate events from their consequences. For example, a puzzling problem of early hazard research was why experience of a recurring hazard event was not more strongly linked to the future expectation of such an event. The lack of such expectations seemed to become more rational on further analysis. It was discovered that, while there are many who felt that hazard events may recur, they also felt that they may not experience them, and even if experienced, they may not personally suffer the potential consequences (Kates, 1962). Similarly, a point of contention among highly skilled analysts of nuclear power hazard is whether the probability of accidental event sequences is independent of consequences and therefore multiplicative, or whether there are chains of closely linked events (common made failure) and consequences.

Reacting to the Environment as Hazard: Coping

People survive and indeed prosper in the face of environmental hazard because they cope with the hazard by adaptations and adjustments. Adaptations are long-run responses that are deeply ingrained as part of human biology or culture. Adjustments are short-run responses purposefully or incidentally adopted. Together they work to reduce the hazard consequences to some level of general tolerability.

Starr suggests that for developed countries there are two general levels of tolerance. One is related to voluntary exposure to death hazards at risks of 10^{-3} to 10^{-6} fatalities per hour of exposure and a thousandfold more stringent standard for involuntary exposure (Starr, 1972). Both levels of risk are related to the curve of potential benefits (Figure 3).

An example he cites is aviation safety. In the 1920s, risk from commercial aviation was about the same as general (private, pleasure) aviation today. But over that period, adjustments were developed to reduce such risk to the present level, which while maintained in the face of new aircraft, routes, etc., will probably not be diminished. Commercial aviation in its infancy, he implies, was a voluntary risk, as is general aviation today. Over time it becomes a necessity with stringent control until a balance is reached of societal risk and effort. Similarly, the low death rates from natural hazards in the United States may be close to the reasonably preventable annual minimum, and the focus is on reducing property damage losses and preventing catastrophic deaths, rather than further prevention of isolated deaths.

Adjustments take three major forms: measures to accept losses by bearing, sharing, or distributing losses; measures to modify events or reduce the vul-

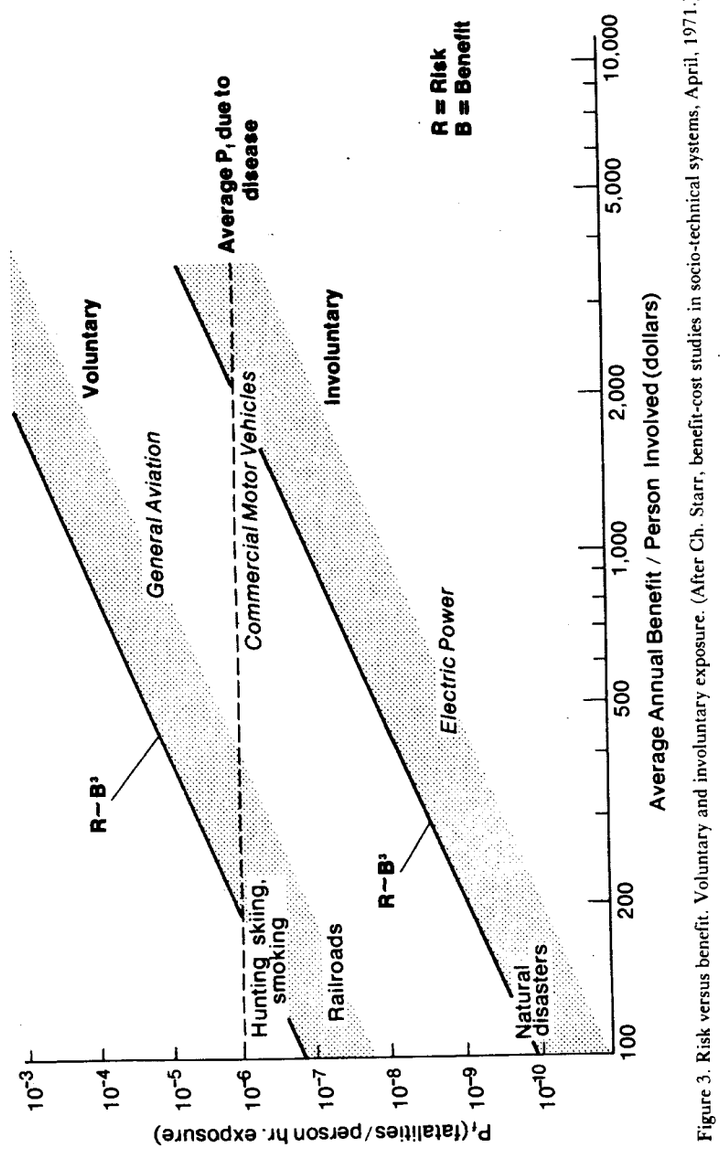

Figure 3. Risk versus benefit. Voluntary and involuntary exposure. (After Ch. Starr, benefit-cost studies in socio-technical systems, April, 1971.)

nerability of society to loss; and on rare occasions, changes in basic location or livelihood systems. These purposeful adjustments vary tremendously by hazard and society, but nevertheless are universally found. Almost all individuals and societies have more than one such adjustment at hand, though seldom is any individual or collective group aware of the entire range of adjustments. In the comparative study of natural hazards, separate adjustments enumerated range from a low of seven for drought in Yucatán to 263 for floods in Sri Lanka.

Over most of the globe, and for most of mankind throughout human history, there has been little or no external assistance. If drought or flood threatened, those directly affected were left to cope as best they could; the national government, if it existed at all, had at its command neither the resources nor the technical capacity to respond. Under such circumstances, individual and community adjustments flourish. Studies of folk or pre-industrial societies reveal the enormous ingenuity that is employed to develop and adapt adjustments to natural hazards.

On the Ganges delta lands in Bangladesh, farmers have developed many ways of protecting themselves against the hazard of cyclonic storms and the accompanying tidal floods (Islam, 1971, 1974). Small protective levies or bunds are constructed to keep out the sea water. Tanks are excavated for water supply, and the material removed is used to construct elevated platforms of refuge where people and livestock may find safety above the level of the surrounding flood waters. Shelter belts of trees are planted. Houses built of dried mud, wood, and grass are designed to withstand strong winds and some flooding. Special anchoring devices and supports are constructed. These adjustments are effective in saving property and preventing loss of life in the smaller cyclonic storms. When disaster strikes in the form of an extreme magnitude event, however, these adjustments are of no avail, and high loss of life results. Damage to property and livelihood may also be total, although the actual value of the losses in cash terms may be small as measured by international standards. Similar patterns, with less tragic consequences, are seen in the studies from Tanzania and Sri Lanka.

The pattern of folk or pre-industrial response to natural hazards may be characterized in general terms. The number of adjustments is large, and often a high rate of adoptions is found among individuals and communities. They often involve modifications of behavior or of agricultural practices more in harmony with nature than in attempts to control or manipulate environment. The adjustments are low cost and may often be added to in small increments. To this extent, they are flexible, easily increased, or reduced in scale. While in use, they may be closely related to social customs and supported by norms of behavior and community sanctions. Technological and capital requirements are commonly low. The adjustment pattern may require cooperative action by

community or local groups, but not depend at all on outside assistance either in the form of technical knowledge, financial assistance, or legal approval. The pattern of adjustments adopted is in this sense flexible and may vary quite drastically over short distances, according to local variations in hazard severity or cultural practice.

Although effective in preventing property losses and loss of life from low-magnitude hazard events, the folk or pre-industrial pattern is ineffective in the prevention of major disasters. When such events occur, a high level of government or social organization may be needed to intervene. At such time, national governments in pre-industrial societies commonly respond by offering relief, emergency food supplies, and assistance. The scale of this help may very well be small in relation to the losses suffered. It may be sufficient, however, to permit a population to recover slowly and become reestablished in the same hazard area. Theoretically, the available adjustments at individual and community levels continue to include any folk or pre-industrial choices, even in highly complex industrial societies. Commonly, however, these choices have ceased to be adopted and have been replaced by adjustments at the community and national levels.

In the modern industrial state, a different pattern has emerged as technological capacity to manipulate and manage the environment has grown and theoretical alternatives have developed at the national level. Governments have been drawn steadily into activities designed to protect citizens from natural hazards. The expanded role for national governments in modern states arises largely from the opportunities provided by new technology. The construction of dams, major irrigation projects, sea walls, the design of monitoring forecasting and warning systems with complex equipment, is clearly beyond the scope of individual action. The large indivisible capital requirements also place many such adjustments beyond the reach of community or regional resources.

What emerges, therefore, is a picture of great complexity in the many ways individuals and societies can react to hazard, but the range of purposeful adjustments does not account for the entire set of mechanisms that enable human beings to survive and even prosper in the face of extreme environmental variation. These include: (1) adjustments, the choice for which is never made because they are part and parcel of the habitual activity of daily and seasonal life and work; (2) activities whose purposes are varied and remote from hazard adjustment, but whose net functional effect is to diminish the burden of hazard; and (3) unconscious shifts in individual cognition and affect in the direction of reducing the perceived or felt sense of threat and loss. These habitual, incidental, and unconscious adjustments may rival and even prove more significant than the outcomes of more conscious choice.

PERCEIVING AND COGNIZING THE ENVIRONMENT AS HAZARD

Events, consequences, adaptations, and adjustments—these are the categories of a set of scientific observers. How are these perceived and cognized by those who live and work in areas of recurrent hazard? Again, we draw heavily on comparative studies of natural hazard, touching lightly on hazards of the made environment, even more lightly, on the social environment.

In a rough and ready way, the interaction we hypothesize between the environment and society is widely recognized. Most people can list clear advantages related to life, livelihood, and location for their site. Some, not all, will list the hazard as the principal disadvantage, and these are mainly in rural areas and areas of high vulnerability. Most also recognize that others in similar settings have similar problems with hazards, and some, mostly at rural sites, believe that there are sites somewhat less exposed than theirs, where they might earn as good a living.

It is uncommon to find people who are totally unaware or ignorant of risk from the natural hazards prevalent in their location. At the same time, the knowledge of events is often less than the best scientific record. Events more recent are better known than those farther removed in time. Events more frequent are better appraised than those that are not. Events with greater impact on everyday life and livelihood are more accurately assessed than those with trivial outcomes. All of this, up to a point—most people cannot extend their imagination beyond the commonly experienced; many see order in random events; some are blissfully ignorant.

Yet, in contrasts between the best scientific estimates of the magnitude and probability of events, there is less of a gap between trained observers and residents of hazardous areas than most surmise, and greater limitations on both the formally and informally trained than most realize. For example, we held an early hypothesis that one significant distinction between scientific and lay perceptions was the concept of probability and randomness (Burton and Kates, 1964). Our recent work, however, shows that, worldwide, 74% of our respondents choose the random explanation in a story format for the recurrence of events—hazards can occur at any time. Slovick, Tversky, and Kahneman (Slovick, Kunreuther, and White, 1964; Tversky and Kahneman, 1974), in their studies of cognitive bias, show subtle and significant biases in the appraisal of probability even by skilled and experienced scientists. Overall, in the hazard literature, the distinction between trained and untrained assessors has given way to varying, sometimes contradictory, interpretation—some choosing to focus on the relatively widespread knowledge and partial accuracy of folk appraisal, others on the divergence of such appraisal from the best scientific knowledge.

The most careful comparison comes from the London, Ontario, study (Hewitt and Burton, 1971; Moon, 1971):

> In the study of the hazardousness of London, Ontario, an effort was made to compare for the first time in a systematic way "lay" appraisals with more "objective" assessments across a range of hazards. Expectations of frequency of hazard events were investigated by asking respondents how often a given event could be expected to occur in the next 50 years. Responses are plotted in Figure 4 together with the objective estimates.
>
> Events were described as more likely to occur 5, 10, 15, or 20 times in 50 years rather than the odd values of 4, 7,.9, or 11, 14, or 16 and so on. A preference for round numbers is to be expected. The distributions of responses for tornadoes, hurricanes, and floods, all show a pattern highly sheered to the left. This coincides well with observed frequencies. While all three hazards are thought of as rare events, tornadoes appear to pose the greatest threat in the minds of London residents. This may be because of the dramatic effects of tornadoes that are frequently reported in the Midwest of the United States including areas in southern Michigan contiguous to southern Ontario. That 140 people consider that no floods will occur in the next 50 years is very likely due to the high degree of confidence placed in the Fanshawe Dam, which does reduce flood peaks. Most significant about tornadoes, hurricanes, and floods, however, is the fact that the subjective estimates of frequency coincide so closely with objective assessments.
>
> The expectations of frequency of ice storms and blizzards are quite clearly in a different category. Both have a bi-modal distribution with marked peaks toward each extreme. Ice storms are expected to occur between 1 and 5 times in 50 years by 86 people and between 46 and 50 times by 62 people. Similarly blizzards are expected to occur 5 times or less in 50 years by 148 people while 59 others expect blizzards to occur 46 times or more in 50 years. This suggests a major discrepancy in definition of ice storms and blizzards. Most dramatically in the case of blizzards, people tend to see them as common events occurring almost every year or as rare events occurring only a few times in 50 years. In neither case do the peaks of subjective frequency coincide with objective estimates based on the observed record. In fact the reverse is true, and the objective frequency tends to fall in an area of very low subjective expectation (Moon, 1971). The significance of these observations is that they strongly shape the propensity of individuals or households to adopt adjustments to specific hazards where the perceived frequency is low. Differing concepts of what a hazard signifies may also affect the receptivity of populations to warnings or other advise about adjustments. (Burton, Kates, and White, in preparation.)

Despite the large number of available actions for coping, many, but not most, know of one or more actions that can be taken to reduce damage from the hazard. Many take some positive action to reduce losses, but few take preventive action much in advance of the hazard event, and few choose a large number of adjustments. In general, more people bear losses than share losses, more accept losses than reduce damages. Of those that reduce damages, more seem to try to modify events than to prevent effects, and many more seek to reduce damages than change their livelihood or land use. Fewer still move their residence even when the hazard is severe, and those that do move are likely to be low-income farmers fleeing drought, dwellers in the path of lava flows, or residents of eroding coastlines. Our overall impression of human effort expended in coping is shown in Figure 5.

Consequences, like the events, are widely recognized. Some people, espe-

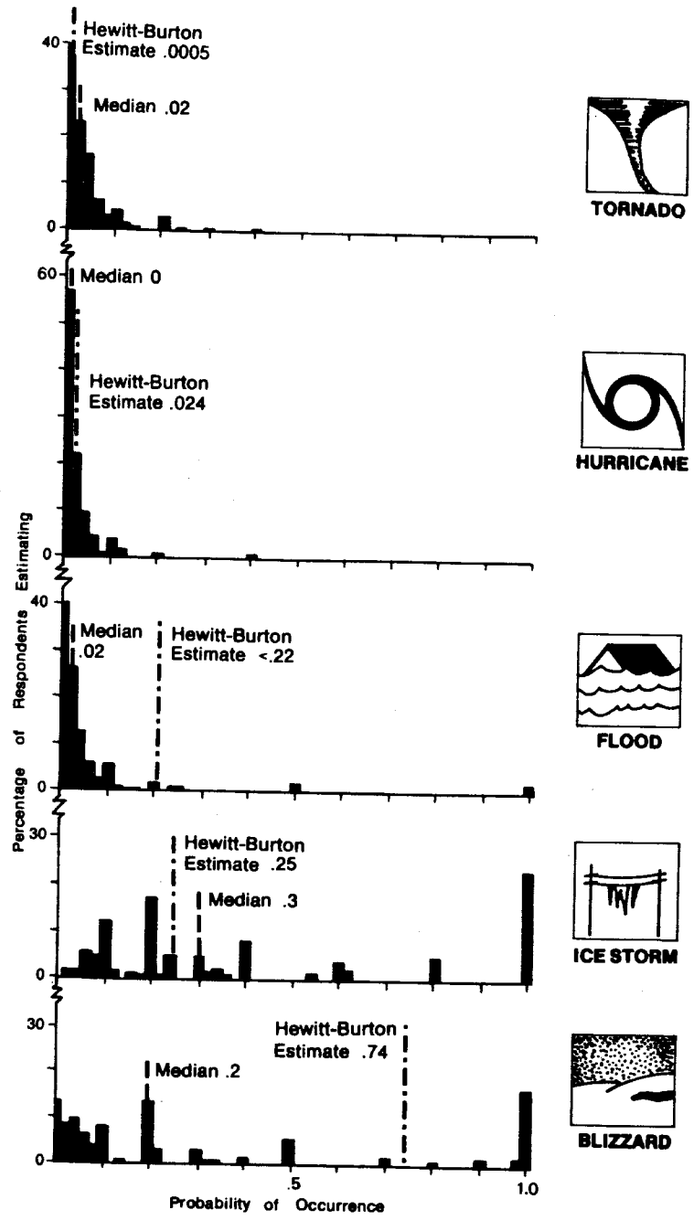

Figure 4. Experts and lay people: an appraisal of the hazardousness of London, Ontario.

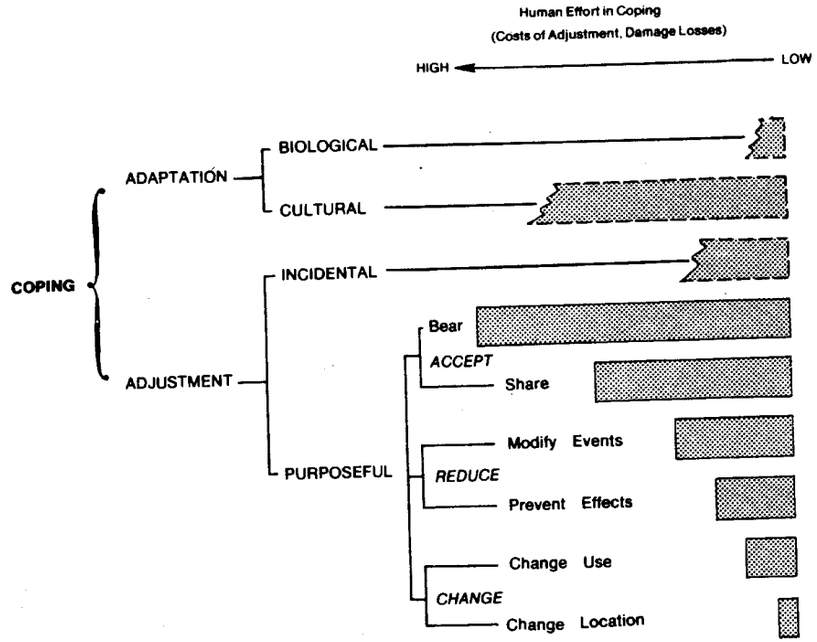

Figure 5. Coping actions and human effort.

cially at rural sites or places of high vulnerability, regard resultant damages as substantial. But everywhere, as with events, consequences are not easily seen to exceed experience, and collective experience does not necessarily portend individual fate. As with events, the gap between perceived consequences, between scientist and lay person, may be less than assumed. A list of 126 diseases has been scaled by both patients and doctors as to the seriousness of the disease with a rank correlation of .95 between both groups (Wyler, Masuda, and Holmes, 1968, 1970). Yet, if compared with the actual risk of death, the perceived seriousness of both patients and doctors is poor. Leukemia, cancer, multiple sclerosis, etc., are all perceived as more serious than the more frequent strokes and heart attacks.

These same researchers have tried to measure the seriousness of social readjustments, all of which may have some stress, but not all of which might be called hazards. While values may have changed somewhat in the seven years since the study was done, it is still sobering that divorce is viewed as more stressful than a term in jail, which in turn is viewed as more serious than a death in the family (Holmes and Rahe, 1967).

We know little of how the events and consequences from each domain of nature, *urb,* and society are comparatively appraised. Golant and Burton found that 58 Torontonians using semantic differential ratings discriminated between natural hazards, man-made hazards, and quasi-natural hazards of air and water pollution along factorial clusters of concepts related to disruptiveness, cause or source, and magnitude (Figure 6).

In a related study, they analyzed the risk avoidance of 206 respondents of 12 hazards classified as natural, physical (direct injury to person), and social (psychic-social distress). Hazard experience is compared with perceived seriousness (preferred risk avoidance) in Table 1. With the exception of auto accidents, the least experienced are the most feared. A similar study is now being done in Austria.

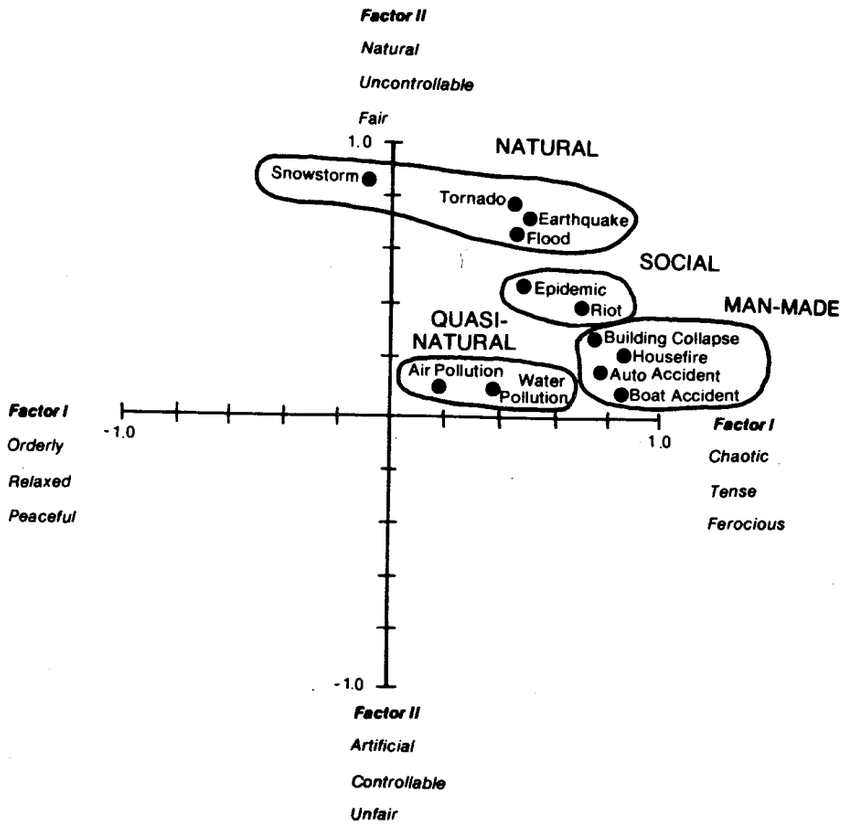

Figure 6. Some evidence for the causal distinction between natural, made, and social environmental hazard events is found in the groupings of the factor analysis of semantic scales of concepts and hazards. (Adapted from Golant and Burton.)

Table 1. Ranking of Hazards Based on Respondents (Total Sample) Greatest Avoidance Measures and Experience

Avoidance rank	Hazard	Avoidance No.	%	Experience No.	%	Experience rank
1	Auto accident	160	77.7	127	61.7	4
2	Attacked and robbed	127	61.6	11	5.3	12
3	Tornado	110	53.4	19	9.2	11
4	Forest fire	107	51.9	29	14.8	8
5	Earthquake	106	51.5	27	13.1	9
6	Failing in school or job	105	50.9	68	33.0	7
7	Illness	95	46.1	166	80.6	1
8	Loneliness	79	38.4	152	73.8	2
9	Flood	74	35.9	27	13.1	10
10	Public embarrassment	73	35.4	108	52.4	5
11	Being disliked by someone you admire	72	35.0	90	43.7	6
12	Thirst	55	26.7	128	62.1	3

The environment as hazard is perceived, cognized, acted upon and reacted to in varied ways. But, on a global level, there is some limited order and structure. The varied environments of hazard provide significantly different sets of events characterized as pervasive/chronic or intensive/acute. The perceived events reflect this intrinsic difference. Coping actions and resultant consequences vary with the flexibility of livelihood systems, and the available resources, knowledge, and efficacy of adjustments. These are structured by the nature of societal development.

Contained within the structure of environment and society is the "prison of experience" accounting for much of the variation in human behavior. In 1962 I described the prison of experience in relation to flood hazard:

> A major limitation to human ability to use improved flood hazard information is the basic reliance on experience. Men on flood plains appear to be very much prisoners of their experience, and the effect of such experience is not consistently in the direction of taking individual action to reduce flood damage.
>
> Improved flood hazard information would include data on floods greater than those flood plain managers have experienced. The observations in LaFollette and elsewhere suggest that managers have a great deal of difficulty conceptualizing and acting upon this information.
>
> Floods need to be experienced, not only in magnitude, but in frequency as well. Without repeated experiences, the process whereby managers evolve emergency measures of coping with floods does not take place. Without frequent experience, learned adjustments wither and atrophy with time.

> Conversely, limited experience encourages some managers to feel that floods are not so bad after all, and they lose their motivation to seek further for alternatives. With limited experience, other managers appear to decide that they have received the flood that Nature has had in store for them and that they will not have another flood for some time.
>
> Recently experienced floods appear to set an upper bound to the size of loss with which managers believe they ought to be concerned. Since much flood damage is caused by floods greater than have recently been experienced, this experience serves to negate the effect of improved information that seeks to expand the expectation of the flood plain manager.

Today, the prison of experience still seems central to perception and cognition but less rectangular and more trapezoidal in shape, being lesser and greater at the same time than the reality it could contain. The perceived experience of hazard is lesser than the reality—human memory being biased to the recent and impressionable; cognition, biased to the ordered and determinate. It is also greater than the reality we can share in the memory of others close to us, experience by empathy, myth, and symbol. But the distortions, whether they narrow or enlarge our perspective of experience, do not really provide in meaningful ways substitutes for experience. The bars, be they steel or rubber, contain us and in that we face some peril, for environmental hazard for which we have little or no relevant experience is increasing.

EXPERIENCING THE UNEXPERIENCED

For most people everywhere, on balance, the everyday is more secure, the exceptional may be less so. The life expectancy of people rises, rapidly in poor nations through increased survival of the young, slowly in rich nations pressing on a ceiling of medical, life, and environmental understanding. We live longer in America today than 50 years ago, die less of infectious disease, and more of stress, diet, and malignancy. Cars kill us more frequently than in the past, but other accidents less; the balance is in our favor. Least of all, we die from natural hazards. In this, we are fortunate. Deaths from nature have climbed elsewhere in the world, despite the relative constancy of 30 global disasters per year over the past 25 years (Dworkin, 1974).

In places of rapid social change, the social environment may be less secure but not necessarily less satisfying. Our own society appears somewhat more perilous in recent times. Crime rates, while dropping, are higher than we have been accustomed to; business failures and unemployment are up, while inflation is frightening. Global peace is obtained at the price of great peril, and the price of more restrained warfare continues to be high.

The hazards of the made environment seem to offer much recent concern, both to scientists and the public alike (Figure 7). Scientific reports of man-made

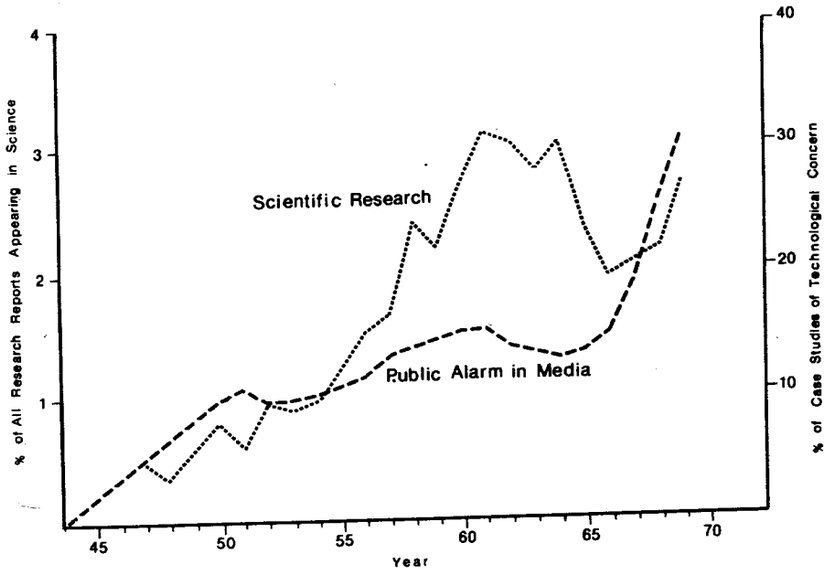

Figure 7. The graph of public alarm in the media is a 5-year running average of public alarm over technology based on 45 case studies of alarm as evidenced by major newspapers and periodicals (Lawless, in press). The graph of scientific research is based on analysis of research reports appearing in the interdisciplinary journal *Science* (Halverson and Pijawka, 1974).

environmental hazard have climbed more or less steadily until some 5% of all reports in *Science* concern them (Halverson and Pijawka, 1974). Public concern evidences similar trends: Forty percent of 45 major public alarms over technology peaked over the last four years (Lawless, in press). By and large, these newly created or recognized environmental hazards are too new to assess or measure their consequences; we have yet to experience their peril. Can we?

The central role of experience as social learning in coping with the hazards of the natural environment is a missing ingredient with newly created or recognized hazards of technology. Such risk appears removed from everyday experience; we are buffered by special assessors of hazards or guardians of the environment, both self- and societal-appointed. It is not clear from what we know that we can simply tell others about hazards, even when we are relatively sure about them. Experience with smoking and seat belts does not augur well for the prevention of less common risks through informational or educational activity. With such less common risks, the events and consequences are much more uncertain. Nor will the uncertainty be easily resolved; the hazards are too new and too many, they may affect many before we detect them, act upon us for a long time before we control them.

There are, of course, ways of substituting for experience. Science and poetry try to do so by analogue, metaphor, or simulation. We are asked to transfer experience in one realm to another. But we are indeed constrained by what we know, and there is question if we can know beyond the experiential.

We might ask how well we might fare by reflecting on how others fared in unknown lands. Martyn Bowden has reflected on this:

> Coping with risks of unknown magnitude is the challenge of the explorer (and to a lesser extent of the frontiersman). The former faces unknown regions peopled by fantasies, the latter is a heroic figure who leaves the comfortable and the known for a period of adaptation during a self-imposed disaster. The experiences of both tell us much about contemporary man's conceptions of unknown risks. Both were essentially uniformitarian through and through. The maps showed terrae incognitae in the regions traversed first by explorers; sailors crossed seas where serpents swam (on maps) to lands where dragons and gorgons dwelt; settlers of the west moved into regions labeled "desert"—the unknown lands, serpentine seas, and irreclaimable deserts were not parts of their adventurous imagery. Rather they projected into these regions what they wanted to find (usually a world familiar to them, an idealization, a simplification of the familiar world they had left). Terrae incognitae were really known by projection from the familiar, by principles of symmetry, latitudinal analog, projection, and extension of the known to the unknown. At the most, the unknown lands were simplifications, exaggerations of the known brought together, perhaps in unfamiliar combinations. (Bowden, personal communication, 1974)

More sophisticated analyses seemingly recognize the limitations of the known but cannot escape it. The Rasmussen report on reactor safety is an assessment of accident risks in U.S. commercial nuclear plants (U.S. Atomic Energy Commission, 1974). It attempts to estimate the likelihood of accidents that release large amounts of radioactivity to the environment and to assess the consequences of such releases. It deals with an event that begins with an accident the likelihood of which is estimated at 1 in 17,500 per reactor year. It draws upon the experience of perhaps 40 reactors for a total of 200 reactor years. To bridge the gap, it reconstructs all conceivable (to the assessor) sequences that could lead to the accident, working back from the unknown to the known; reducing the unknown accident rate to the known failure rates of small parts, bits of metal, pipes, and people. The logic is known as fault-tree analysis, and it cost $3 million. It is more rigorous and searching than sailors and frontiersmen; nonetheless it is still constrained by experience. To reduce the unknown into knowable parts or to extend the known into the unknown appear structurally alike.

It may be that the limits of experience are adaptive, for if we knew more of the perils, we would be less venturesome and deny ourselves the blessings of new lands or new power. But we become each day more clever at creating, recognizing, and disseminating threat; we lag in our ability to attend to and cope with threat. In the absence of experience, we may never know what happened.

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