Kates, R. W., C. Hohenemser, and J. X. Kasperson, 1985. "Introduction: Coping With Technological Hazards", Robert W. Kates, Christoph Hohenemser, and Jeanne X. Kasperson, eds., Perilous Progress: Managing the Hazards of Technology, Westview Press, pp. 1-19.

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Introduction: Coping with Technological Hazards

Robert W. Kates, Christoph Hohenemser, and Jeanne X. Kasperson

The realization that technological progress may be perilous is scarcely unique to our time. Even the ancient Greeks and Romans recognized that the same lead that improved their plumbing, architecture, ships, weapons, and jewelry also poisoned their miners, contaminated their wine, and polluted their water supplies (Nriagu 1983). Agricola in 1556 lamented the environmental depredation of mining regions in Europe:

> ...fields are devastated by mining operations...woods and groves are cut down...for timbers, machines, and the smelting of metals...then are exterminated the beasts and the birds...when the ores are washed, the water... poisons the brooks and streams,...destroys the fish, therefore the inhabitants of these regions on account of the devastation of their fields, woods, groves, brooks, and rivers,... find great difficulty in procuring the necessaries of life...it is clear to all that there is greater detriment to mining than the value of the metals which the mining produces (Agricola [1556]1950,8).

Similarly well-understood in its own time was the social devastation of the Industrial Revolution, including the expulsion of rural folk from the land, the replacement of natural rhythms with the mechanical discipline of endless belts, the exploitation of children in mine and factory, and the recurrent economic crises of widespread unemployment. The novels of Dickens and Zola graphically depict these horrors.

Until recently the voices of demographers, reformers, and muckrakers who chronicled this toll remained a distinct minority, whereas the majority viewed technology with awe and hope. Now, however, an increasingly technological society betrays some measure of disenchantment. A discernible popular and scientific ambivalence toward technology has emerged in the mix of responses to surveys on technological issues (LaPorte and Metlay 1975;Marsh and McLennan 1980;Miller, Prewitt, and Pearson 1980,61-66;Mitchell 1980) and in the research literature (Kates and Kasperson 1983). This ambivalence, if it persists, may well constitute a watershed that separates our time from centuries of virtually undivided commitment to industrial growth.

and $283 billion, equivalent to 8 to 12 percent of the gross national product (GNP).

Part of the effort to prevent, reduce, and mitigate hazards has been the emergence of a new "applied" discipline and profession concerned with the assessment and management of technological hazards. And with the assessors and the managers has come the development of a research program.

Modern research on the comparative management of technological hazards dates to a seminal paper of Starr (1969) relating social benefit and technological risk. Subsequent interest in Starr's findings spurred a colloquium by the National Academy of Engineering (1972) and a workshop of the Engineering Foundation (Okrent 1975). Meanwhile, the Scientific Committee on Problems of the Environment (SCOPE) sponsored international workshops in places as diverse as Woods Hole, Massachusetts (Kates 1978) and Tihany, Hungary (Whyte and Burton 1980). The publication of book-length reviews and texts on risk assessment (Lowrance 1976;Rowe 1977;Kates 1978) and a major casebook (Lawless 1977), circulated in 1974, followed. The impetus for new research endeavors developed in part through a series of workshops sponsored by the National Science Foundation (NSF) in 1977 (Kates 1977) and the subsequent establishment by NSF of its program on Technology Assessment and Risk Analysis (TARA). Under the auspices of the TARA program a committee of the National Research Council (1982) has prepared an overview of the research field. The program provided encouragement and support for the International Society for Risk Analysis, which publishes its own journal (<u>Risk Analysis</u>), a newsletter (<u>Risk Newsletter</u>), and the proceedings of its annual meetings (Covello et al. 1983;Covello, Menkes, and Mumpower 1985).

It is possible to quibble over the precise dating of the field (Otway 1980). Well before 1969 risk analyses of various types had appeared in such specialized fields as engineering, product safety management, industrial hygiene, and occupational medicine as well as in risk markets (insurance, stocks and bonds, and gambling). And by 1969, natural-hazards management (Burton, Kates, and White 1968) had enjoyed two decades of interdisciplinary research (Burton, Kates, and White 1968,1978) that addressed many of the same issues later examined for technological hazards. Yet an extensive (over 1000 citations) topical bibliography, spanning the years 1935-1983, includes only 41 entries with publication dates prior to 1969 (Covello and Abernathy 1983). Moreover, Starr's publication in <u>Science</u> was the first major paper to undertake explicitly the **comparative** analysis of technological hazards. The ensuing period has witnessed an exponential growth in the literature. Anyone who questions the staying power of this quasi discipline has only to note this voluminous output.

Comparative Research on Technological Hazards

Recent bibliographic forays speak to a flourishing research effort, particularly in recent years (Covello and Abernathy 1983; Kates and Kasperson 1983;Kasperson and Kates 1984). Indeed, if a recent literature survey conducted by the Hazard Assessment Group at Clark University's Center for Technology, Environment, and Development (CENTED) is any indication, the 1980s promise an inundation.

The group tapped its extensive library on technological hazards and selected for analysis 61 major books, published between 1970 and 1984, on comparative risk analysis. Insofar as 45 of the 61 titles have appeared in the period 1980-1984 and a number of additional volumes are in the wings, the 1980s have already eclipsed previous decades.

The survey is far from comprehensive. Limited as it is to English-language monographs and book-length collections of papers, it overlooks a vast international literature in books, in journal articles, and in reports from government, industry, and public-interest groups. Absent, too, are the risk assessments or case studies of specific technologies or hazards, such as the fifty or more risk assessment reports published each year by the National Research Council (1981). Critics may well find the list too long or too short and may lobby for exclusion or inclusion of this or that title, but such dissensions do not negate the utility of the survey. The selected volumes do represent a significant portion of the comparative research literature and thus they provide insights into the interests and concerns of an adolescent field.

Surveys of the volumes (Kates and Kasperson 1983;Kasperson and Kates 1984) have identified six recurring themes--(1) overviews of one or more areas; (2) risk estimation; (3) discussion of acceptable or tolerable risk; (4) risk perception; (5) analysis of regulation; and (6) case studies of specific technological hazards--as well as agenda for research. Table 1 lists the books in chronological order and summarizes the incidence of the six recurring themes that thread their various ways through the 61 volumes. We use these themes to take stock of the research to date and to assess the contribution of this volume to an already crowded field.

Overviews

Though fragmented and often inconsistent, the emerging literature on technological hazards contains some integrative overviews and evaluations of the field. Chapter 3 depicts the structure of technological hazards as a linked causal chain bounded by four managerial activities--hazard assessment, control analysis, strategy selection, and implementation and evaluation. Few volumes cover the full range of these activities. Most overviews point to methodological and conceptual shortcomings, but some seek to evaluate the socioeconomic, political, and cultural contexts that may have a bearing on the practice of hazard assessment. Thus Lagadec (1982) characterizes the "challenge of major risk" as a series of clashes between reason and democracy; Douglas and Wildavsky (1982) view the very selection of risks as a basic cultural choice, a deliberate decision to worry most about those dangers that threaten beliefs and values; and geographers assume a spatial stance and explore the regionalization of risk by defining hazard zones (Zeigler, Johnson, and Brunn 1983).

Risk Estimation

Consensus in the literature has it that risks are measures of the likelihood that particular adverse consequences will follow a hazardous event. Thus the estimated lifetime risk of an average

TABLE 1
Major book-length publications on comparative risk analysis (1970–1984)*

YEAR	AUTHOR(S) OR EDITOR(S)	OVERVIEWS	RISK ESTIMATION	ACCEPTABLE RISK	PERCEPTION	REGULATION	CASE STUDIES
1970	Calabresi					+	
1972	National Academy of Engineering		+	+	+		+
1972	Sinclair et al.		+	+	+		+
1974	Epstein and Grundy		+			+	+
1975	Chicken		+	+			+
1975	Environmental Studies Board		+	+		+	
1975	National Research Council		+	+			
1976	Ashford		+	+		+	+
1976	Lowrance		+	+	+		
1977	Council for Science and Society		+	+	+	+	+
1977	Kates	+	+	+	+	+	
1977	Lawless					+	+
1977	Rowe	+	+	+	+		
1978	Kates	+	+	+	+		+
1979	Goodman and Rowe	+		+	+	+	+
1979	Hammond and Selikoff		+	+		+	
1980	Conrad	+	+	+	+		
1980	Dierkes et al.	+		+	+	+	+
1980	Dowie and Lefrere	+		+	+		+
1980	Hovden		+	+	+		
1980	The Open University	+	+	+	+		
1980	Salem et al.		+	+	+		
1980	Schwing and Albers		+	+	+		+
1980	Whyte and Burton		+	+			
1981	Baram					+	+
1981	Berg and Maillie		+			+	+
1981	Crandall and Lave		+			+	+
1981	Ferguson and LeVeen		+			+	
1981	Griffiths	+	+	+	+		+
1981	Haimes	+		+	+	+	
1981	Lave		+	+		+	+
1981	Nicholson		+	+		+	
1981	Richmond et al.			+	+	+	
1981	The Royal Society		+	+	+	+	
1981	Siddall		+	+			
1982	Burton, Fowle, and McCullough	+	+	+	+	+	+
1982	Crouch and Wilson	+	+	+	+	+	+
1982	Douglas and Wildavsky	+		+	+		
1982	Fischhoff et al.	+		+			
1982	Green	+	+	+		+	+
1982	Hohenemser and Kasperson	+	+	+	+	+	+
1982	Inhaber		+				+
1982	Kunreuther	+	+	+	+		
1982	Kunreuther and Ley	+			+		+
1982	Lagadec	+		+		+	+
1982	Lave	+	+			+	+
1982	Lind		+	+	+		+
1982	National Research Council	+	+				+
1982	Poole					+	+
1982	Prentice and Whittemore		+				+
1983	Covello et al.		+		+		+
1983	National Research Council	+			+	+	
1983	Rescher	+	+	+	+		
1983	Rogers and Bates	+	+	+	+		
1983	Royal Society	+	+	+	+		
1983	Viscusi			+	+	+	+
1983	Zeigler, Johnson, and Brunn	+	+	+	+		+
1984	Deisler	+	+	+		+	
1984	Hadden					+	+
1984	Perrow	+		+	+		+
1984	Ricci, Sagan, and Whipple	+	+	+	+	+	+

American's dying in an automobile accident, for example, is 2-3 percent. Hazard assessment includes three distinct activities: (1) the identification of hazards likely to produce hazardous events, (2) the estimation of the risks of such events and their attendant consequences, and (3) the social evaluation or weighting of the risks so derived (Kates 1978). Terminology and concepts, however, differ slightly from author to author (Lowrance 1976;Rowe 1977;Kates 1978; Whyte and Burton 1980;National Research Council 1982).

The initial step, hazard identification, receives short shrift in most hazard assessment. One senses an inexplicable but undeniable confidence in a known and knowable pool of hazards that require measurement, evaluation, and management. The assessors turn at once to the business of estimating and quantifying risk and worry little about unknown hazards. Beginning with an identified hazard, this (now) initial task of estimation relies heavily on extrapolation from past experience, from experiments (usually with animal models), or from simulations (often with computer models). As extrapolations, and frequently imperfect ones, risk estimates inevitably entail scientific uncertainty, the handling of which is crucial. In Part 3 of this volume, we explore this problem in case studies of automobile accidents (chapter 8), airborne mercury (chapter 9), and nuclear power (chapter 10) and in an overall critique of hazard assessment methodologies (chapter 11).

Risk Acceptability or Tolerability

The third step in assessing risk is to determine which risks are tolerable to society. The frequent, and somewhat misleading question "How safe is safe enough?" has become the **acceptable risk** issue. **Acceptability,** as we suggest in chapter 3, is an unfortunate term, implying a degree of consent that rarely accompanies impositions of risk. **Tolerability** better captures most actual risk situations (Kasperson and Kasperson 1983).

Whatever the label, however, the determination of tolerability, in contrast to the estimation of risk, lacks scientific precision. The question "How safe is safe enough?" is primarily one of values. Most discussions of risk tolerability acknowledge that all human activity is inherently hazardous to someone or something, that even the absence of an activity, especially a useful one, may be hazardous. Most researchers would agree that collective efforts for managing a given hazard ought to be commensurate with the degree of threat--observed or perceived--posed by the particular activity or technology in question. Hence the priority lists, the classification schemes, and the taxonomies such as that in chapter 4. No one challenges society's need to focus on the important hazards. Disagreement rears with the inference that society should optimize (in economic terms) its investment in risk reduction via some common metric (for example, number of lives saved). Meanwhile, alternative approaches have proliferated. Initially, Starr (1969), taking into account both the benefits and the voluntary/involuntary nature of a given risk, inferred its "acceptability" as "revealed" in historical statistics of mortality. Stabilization of a level of mortality over time implies that society has accepted a certain degree of risk from a particular product or activity. Later, **risk/benefit analysis** sought to define the level of risk that is tolerable in return for a given benefit (National Academy of Engineering 1972;Environmental Studies Board 1975;Crouch and Wilson 1982). Most recently, in response to the mounting critique of revealed-preferences and risk/benefit analysis, several researchers have sought to define a "risk threshold," or **de minimis** level, below which risk should command no regulatory attention (Comar 1979;Wilson 1981;Eisenbud 1980;Okrent 1982;Starr and Whipple 1982).

The foregoing approaches entail serious methodological and ethical problems (Fischhoff et al. 1982). Because such attempts fall short when quantitative risk estimates are not available, alternatives have proliferated. One approach elicits directly from the public its preferences for various risks (this volume, chapters 5 and 12;Fischhoff et al. 1978;Slovic et al. 1979); another advocates direct public involvement in risk decisions through existing legal and political processes.

Risk Perception

Practicing risk assessors find all too often that their scientific findings diverge from popular perceptions of risk. In fact, both scientific risk assessment and popular perceptions derive from judgments, the former made with the assistance of formal and sometimes reproducible methodology, the latter elicited through more informal and perhaps broader cognitive processes. Considerable research, which has progressed from the speculative to the scientific, has gone into identifying and understanding the nature of perceived risk.

Pioneering studies by Slovic, Fischhoff, and Lichtenstein (1978) compare the perceived risk of many technologies and activities. Perhaps more than any other work, this research--represented in chapters 5 and 12 of this volume and in virtually all collections of papers on risk--has enhanced our awareness of risk perception. Other researchers (Vlek and Stallen 1981;Lee 1981) have employed comparable techniques and produced consistent findings. A major finding of most of this work is that lay people's judgments of risk are qualitatively similar to those of scientific experts but differ from the latter in many important details. Each group taps its own heuristics in making quantitative judgments, hence the discrepancies and the serious over- and under-estimates.

Two threads of evidence may explain the discrepancies in quantitative judgments about risks. An observed general tendency to underestimate the frequency of common events and to overestimate the frequency of rare events makes for a compression in the scale of probability judgments (Slovic, Fischhoff, and Lichtenstein 1979). Moreover, experts usually estimate risks in terms of mortality, whereas lay persons are more prone to consider other factors.

The structure of risk perception has also been studied via extensive attitudinal surveys (Otway, Pahner, and Linnerooth 1975; Vlek and Stallen 1981). The most widely studied single hazard is nuclear power, for which national surveys exist back to the early seventies (Louis Harris and Associates 1975 and 1976;Melber et al. 1977;Mitchell 1980). In the United States, overall risk has been subject to major broad-based surveys (Marsh and McLennan 1980), which have indicated that most Americans believe life is becoming riskier over time. A recent survey (Harris 1982) established

American concern and willingness to pay for environmental protection. Generally, most of the polls indicate an erosion of confidence in institutions charged with enforcing existing health and safety regulations. This disenchantment has produced a heightened perception of danger and a clamor for better protection--even in the face of an antiregulatory climate.

Regulation

The assessment of a new hazard and its inclusion in the repertoire of public perception demand a societal response. This response, conceptualized as **hazard management** (Kates 1977;Whyte and Burton 1980;Nicholson 1981;Hadden 1984) includes a spectrum of ways in which government, industry, private groups, and individuals control, reduce, avoid, or tolerate hazards. The literature on these actors and activities is decidely one-sided. Despite the reality that most decisions about risk are made by individuals, and many are made by corporations, the literature concentrates on the relatively few that are made by government or at its insistence. Exceptions are a book (Baram 1981) that considers the alternatives to regulation, such as legal remedies, taxation, and other incentives and a collection (Poole 1982) that comes out in favor of an extreme alternative to regulation--namely, true deregulation, or the abolition of regulatory agencies.

Case Studies

Rather frequently, experience with regulation comes through in the form of case studies. As is appropriate for a field with an indistinct and still emerging structure, the literature on technological hazards abounds with case studies conceived in varying frames of reference. Some authors use case studies to illustrate the methodology of risk estimation; others employ the framework of risk tolerability criteria; still others focus on the sequence and timing of regulation, and more generally, the structure of hazard management. Some case studies have no identifiable frame of reference and simply highlight the full range of issues in celebrated cases such as Love Canal, Three Mile Island, or DDT.

A major sourcebook for systematic comparison is that of Lawless (1977), whose analysis of 45 instances of technological shock provides a standardized look at the timing and interrelation of hazard identification, media coverage, and political, legal, and regulatory response. As in chapter 13 of the present volume, the overall record is one of failures in managing hazard after hazard.

Lawless's ambitious casebook stands unmatched in scope, but other volumes also make significant use of case studies. Crandall and Lave (1981) recruit trios of experts—a scientist, an economist, and a regulator—to pool their analyses of the scientific basis for regulating passive restraints, cotton dust, waterborne carcinogens, saccharin, and sulfur dioxide. A conference volume (Hammond and Selikoff 1979) tendered four perspectives on the management of vinyl chloride. Another conference (Nicholson 1981) invited cross-national comparisons of the handling of carcinogenic risk in Sweden, Canada, Norway, and Sweden. In a Canadian study (Burton, Fowle, and McCullough 1982), a series of case studies ranging from toxic shock syndrome to 2,4-5 T serves to clarify concepts and methodologies as well as to illustrate and inform risk management in Canada. Crouch and Wilson (1982) propose a "prescription for useful analysis" of nine cases ranging from nuclear power plant accidents to swine flu vaccinations. Parts 3 and 4 of the present volume include case studies of specific hazards--nuclear power, contraceptives, airborne mercury, polychlorinated biphenyls (PCBs), automobile accidents, and television--and certain hazard managers--the United States Congress and the Consumer Product Safety Commission--to test theory, validate a model of hazard structure, and enhance the process of managing hazards.

Analytic use of case studies contributes to the conceptual understanding of hazard and risk. Certainly, Lawless's (1977) uniform comparison of 45 cases, Lave's (1981) eight "decision frameworks," and Crouch and Wilson's (1982) "prescription" enhance the theoretical data base. Yet few of the numerous and varied case studies that pervade the literature really test hypotheses about the nature of hazard and its management.

Perilous Progress: Managing the Hazards of Technology

To a large extent, the present volume grew out of a workshop, convened at Clark University in the fall of 1976, to address research needs in a fledgling field. The book derives from a project conceived as a collaborative, interdisciplinary effort by the Clark Hazard Assessment Group and Decision Research of Eugene, Oregon. At one time or another the project commingled a biochemist, a geochemist, several geographers, two physicists, and several psychologists. Despite the disparate nature of their respective disciplines, participants worked to develop a common language. As to the extent to which they succeeded, the reader must judge!

Beyond the introduction, the book falls into into four parts, each with a brief overview to establish context and organization. Part 1, **Conceptualizing Hazards** contains four chapters that take a generic, comparative approach to the understanding, classification, and management of hazards. Part 2, **Measuring Consequences**, links two closely related chapters that measure the total burden of technological hazard in terms of human and nonhuman mortality and economic costs. Part 3, **Assessing Risks**, comprises three studies of specific hazards--automobiles, airborne mercury, and nuclear power--a critique of hazard assessment, and a discussion of risk tolerability criteria. Part 4, **Managing Technological Hazards** moves from a propositional inventory of 41 publications on hazard management to case studies of specific hazards and hazard managers. Four technological hazards--automobiles, PCBs, contraceptives, and television--take up a chapter apiece. Two additional chapters present analyses of two hazard managers--the Consumer Product Safety Commission and the United States Congress.

In the context of the comparative research the 19 chapters contribute to the major themes of the existing literature: Parts 1 and 2 in themselves constitute an **overview**; Part 3 provides cases and a critique of **risk estimation** and **risk tolerability** (or **acceptability**); chapters 5 and 12 address **risk** perception, and the case studies of six hazards and two hazard managers add to our stockpile of analyzed experience. Moreover, the volume enhances our understanding in a number of distinct ways.

Conceptual Development

Part 1 provides a framework for thinking about hazards and hazard management. Hazards, defined as "threats to humans and what they value," are causal chains linking human needs and wants to choice of technology and to threatening consequences (chapter 2). Hazard reduction and control take the form of disruptions or attenuations of causal chains. Hazard control in response to experienced or predicted harm is visualized in terms of feedback. Four managerial activities--hazard assessment, control analysis, strategy selection, and implementation and evaluation surround the causal chain (chapter 3). Judgments elicited from lay persons and experts allow for the characterization of hazard perception. Statistical analysis of these judgments suggests a reproducible structure that "explains" the sometimes unexpected facts of lay perception (chapter 5). A classification scheme that uses causal structure as its organizing principle, yields to a taxonomy of hazard that spans the full domain of "hazardousness" and through 12 causal descriptors accounts for 50-75 percent of the variance in perceptions of risk (chapter 4).

Comprehensiveness

The work described in Parts 1 and 2 is comprehensive in several respects. In contrast to much of the literature, analysis in terms of causal structure emphasizes hazard control rather than risk assessment (chapters 2 and 3). The discussion of hazard management (chapter 3) goes well beyond the paradigm of regulation and thus helps to correct an imbalance that pervades much of the literature of the 1970s. The 12-descriptor characterization of hazardousness underlying the classification of hazards considerably expands upon the conventional definition of risk as "probability of dying" (chapter 4). And the accounting of consequences in terms of mortality (chapter 6) and economic costs and losses (chapter 7) provides a summing that approximates the measurable burden of all technological hazards.

Empirical Grounding

The conceptualization of hazard and hazard management derives from an intrinsically empirical approach that taps several extensive data bases. The analysis of perception elaborates earlier work on nine cognitive dimensions and 30 hazards and now includes 18 dimensions and 90 hazards, each scaled by lay subjects (chapter 5). The causal classification of hazard is based on 12 descriptors and 93 hazards, each scaled by explicit reference to the scientific literature (chapter 4). A comparison of causal structure to perception (chapter 4) employs a separate set of 12 cognitive dimensions and 81 hazards judged by lay subjects and parallels closely the descriptors and hazards employed in the analysis of causal structure. The propositional inventory that gives way to managerial case studies (Part 4) derives from a survey of 41 studies of experience with

specific hazards or hazard managers (chapter 13). Finally, nine case studies, three of which emphasize risk assessment (chapters 8-10), and five of which address broader questions of hazard management (chapters 14-19), inform the analysis throughout the generic chapters in the volume.

Management Tools

The volume offers several potential tools for improving hazard management. The diagramming of causal structure provides a systematic way of identifying opportunities for hazard control, mapping the level of control by hazard stage, and assessing the timeliness and comprehensiveness of response (chapters 2 and 3). Feedback analysis permits a systematic approach to identifying cases in which hazard consequences are inadvertently increased rather than reduced (chapter 2). The classification of hazards by causal structure suggests means for identifying hazard management priorities, making quantitative comparisons of "hazardousness," and developing protocols for managing new hazards on the basis of success or failure in managing similarly classified old hazards. The linkage between lay perceptions and causal descriptors renders possible the prediction--based solely on analysis of causal structure (chapters 2, 4)--of public response to newly discovered hazards.

Informed Public Policy

Portions of the book may shed factual and conceptual light on the formulation of public policy. The disaggregation of economic costs and losses (chapter 7) can inform assessments of the burden of technological hazards and the equity of their distribution between the public and private sector. The taxonomy of hazards (chapter 4) can aid in designating which hazards should worry society. Chapter 12 proposes criteria and methods for determining tolerable levels of risk. How well we are coping with technological hazards can be evaluated in part via the historical mortality record (chapter 6) and the review of hazard management studies (chapter 13). Finally, the biases and presuppositions of experts come into play (chapter 11).

In June, 1979, at the end of the first decade of significant comparative research on technological hazard, we made the following prognosis:

> The 1970s saw the creation of vast amounts of legislation regulating the known domains of technological hazard. As the decade draws to a close, concern over such hazards continues unabated, while controversy increases over cost, adequacy, and management. Inconsistencies in law, regulation, and attitudes confront the nation with the need for continual reassessment.
>
> The coming decade, we predict, will be a period of such reassessment as we collectively decide to reduce many risks, accommodate others, and eliminate a few. (Harvey et al. 1979,15)

Nearly six years later this prognosis appears to be in full flower, albeit with some change in direction. A national administration, actively engaged in accommodating many hazards and reducing some, stands reluctant to take decisive regulatory action if it can be avoided or achieved by voluntary means. The new era seems to be one in which both the courts and the Congress are taking the lead in coping with technological hazards.

We did not believe in 1979, nor do we believe now, that decisions about hazards are the province of legislators, regulators, scientists, industrialists, and lobbyists. Decisions about hazards are, above all, public decisions. They demand broad-based scientific understanding, an appreciation of the differences between scientific and lay assessments, and a sense of the balance between peril and progress.

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