Kates, R. W., ~~1~~967. "Geography: The Case for the Specialized Generalist in a Science of Environment", Social Science and the Environment, pp. 53-72.

Geography: The Case for the Specialized Generalist in a Science of Environment

ROBERT W. KATES

There is a breed of geographers who are mugwumps. They sit astride the social and natural sciences, mug faced toward one and wump solidly planted in the other. There is real need for more such people. This paper presents an extended example of their work related to a major concern of the Environmental Science Services Administration, describes where and why they may be found in geography, and concludes with some suggestions for their encouragement, care, and feeding.

WHAT IS AN ENVIRONMENTAL SCIENCE?

It should be no reflection on our sponsoring organization to begin with serious doubts as to what is meant by environmental science. I am not sure whether it is the science of ambience as a literal translation would suggest or the scion of ambivalence, as reflected by its operational definition in the multitude of organizations, programs, centers, disciplines, and ideas that are increasingly clustered 'neath the banner of environmental science. In fact, in a just-published monograph of edited papers entitled "Man's Response to the Physical Environment," I find that I seemed to have ignored the existence of ESSA-style environmental science and described the environmental disciplines as being of two main groups:

> . . . those related to public health and sanitary engineering, and those related to design—architecture, landscape architecture, city and regional planning.
>
> . . . public health and sanitary engineering became first environmental health disciplines and more recently environmental sciences, expanding into ecology and bio-medical engineering.[1]

[1]Robert W. Kates, "Stimulus and Symbol: The View From the Bridge," *Journal of Social Issues*, 22, 4, 1966, pp. 21-28.

I suggest uncertainty in the meaning of environmental science because, public relations magic notwithstanding, in the straightforward meaning of language, there are none who can fully occupy the chair of environmental science. By definition, this should be the science of surroundings, by implication something must be environed, and that is obviously man or at least some other form of lifelike organism. If you accept this construction, then I suggest that while there is no environmental science existing as a monistic discipline, geography is clearly one of the environmental sciences, arising directly out of its four traditions.

THE FOUR TRADITIONS OF GEOGRAPHY

William Pattison has described four traditions of geography that have been used increasingly to define the field, replacing more difficult and constrictive singular definitions of former years.[2] These are a spatial tradition, an area studies tradition, a man-land tradition, and an earth science tradition.

Geography as an earth science has made significant contributions toward understanding both distributional and process elements in the study of geomorphology, climatology, and vegetation. However, as an earth science, independent of prime human orientation, it finds fewer practitioners today than previously in this country. While geography may still persist in many educational institutions as a physical science, its justification for doing so will increasingly lie in a second tradition, namely that it is human-centered, in the man-land tradition or the study of man and nature.

From at least the time that the phenomenal George Perkins Marsh published his great work in 1864, entitled *Man and Nature or Physical Geography as Modified by Human Action*,[3] there has been a strong geographic tradition concerned, first, with the interrelationship between man and his natural environment and increasingly with all environment both man-made and natural. The leading hypotheses concerning this relationship have shifted, sometimes dramatically, through the years. What flourished as causal relationships in the heyday of environmentalism came to be replaced by such terms as possibilism and probabilism anticipating our present statistically oriented Monte Carlo era. But the

[2]William Pattison, "The Four Traditions of Geography," *Journal of Geography*, LXIII, 1964, pp. 211-216.

[3]George Perkins Marsh, *Man and Nature or Physical Geography as Modified by Human Action* (Cambridge: Harvard University Press, 1965).

central focus never faltered—a clear concern with the transactions between man and environment—a concern that the nearest discipline to this tradition, ecology, has never really demonstrated.

Ecology, with its historical roots in plant and animal study has tended to focus on nonhuman communities and thus proven less useful for students of human response to the environment. Many ecologists seem to share a sense of threat from human activity, wherein population growth and urban sprawl threaten the very existence of their main focus of study. It would seem to be metaphorically proper to note that ecology has yet to accept the notion of human climax so that geography might be properly seen (as noted by Barrows) as human ecology.[4]

The spatial tradition is concerned with the locational attributes of phenomena and mainly those of human orientation and activity, often economic activity. The area-studies tradition has sought to synthesize the distinctive characteristics of place and region. All four traditions contribute to geography as an environmental science. By definition the man and nature tradition with its modern extension to all environment is most relevant. But the other traditions add to geographic insight. The earth science tradition carries over into present-day graduate training whereby most apprentice geographers are required to have a minimal acquaintance with environmental parameters that no other social science requires. Space itself, albeit an abstract concept, is very much a part of environment. The central question of the spatial tradition, why are things where they are, is obviously relevant to environmental science. In the study of place and region, geographers more often than not find themselves defining such regions in terms of the quality of the surroundings, although this trend is less pronounced than in previous years.

Geography, drawing from all of its four traditions, has tended to create the mugwump intellectual personality that I identified initially. But the role of the self-anointed generalist, never one to win wide acceptance, has become increasingly suspect in the light of great progress in both the natural and social sciences. One need only examine the concepts still found today in many physical geography or economic geography courses at the college level to observe failure to understand and incorporate within them many of the exciting advances in earth science or economic theory. If I had to stand on my discipline as defined by the textbook that I used in my first geography course 10 years ago,

[4]Harlan A. Barrows, "Geography as Human Ecology," *Annals of the Association of American Geographers*, Vol. 13, 1923, pp. 1-14.

I would not be here today. But in the intervening 10 years, two developments have occurred, one internal to geography and the other external to it, that enable me to suggest with confidence the unique capabilities of geography as an environmental science.

The past ten years have seen two revolutions in geographic thought: the quantitative and behavioral revolutions. The quantitative revolution, just beginning at the time when I opened up my first textbook, has now successfully carried the field and is being routinely institutionalized in geographic research and training. Burton has described it as follows:

> In the past decade geography has undergone a radical transformation of spirit and purpose, best described as the "quantitative revolution." The consequences of the revolution have yet to be worked out and are likely to involve the "mathematization" of much of our discipline, with an attendant emphasis on the construction and testing of theoretical models. Although the future changes will far outrun the initial expectations of the revolutionaries, the revolution itself is now over. It has come largely as the result of the impact of work by non-geographers upon geography, a process shared by many other disciplines where an established order has been overthrown by a rapid conversion to a mathematical approach.[5]

The behavioral revolution is more limited and it is only in its early tages at present. It is marked by the self-conscious development of eography as a behavioral science, and it is only within the last few ears that geography began to hold dual membership in the earth cience and behavioral science divisions of the National Research Council nd the AAAS. It involves geographic training in and expanded knowldge of the theory and method of sister behavioral sciences—psychology, nthropology, sociology, economics, and political science. In research it akes increased use of behavioral science techniques on traditional georaphic problems. The effects of both the full-blown quantitative and ascent behavioral revolutions have been to provide additional rigor of ethod and thought to the generalist disposition of geography's displinary stance.

The need for such a generalist stance, especially when combined ith qualities of rigor, has also increased during the past 10 years, hich have seen a veritable explosion of knowledge and technological apability. This expansion has led to a deep and fundamental tension. he practice of science increasingly requires intense specialization.

[5]Ian Burton, "The Quantitative Revolution and Theoretical Geography," *The nadian Geographer*, VII, 4, 1963, pp. 151-162.

Direction, planning, and utilization of science demand breadth of vision. Thus there may yet be a place for the disdained mugwump.

All of the foregoing, the traditions of geography relevant to environmental science, the internal revolutions and the external needs, can be best illustrated in a brief description of our work on a problem very close to ESSA's concern: research into human adjustment to natural hazard.

HUMAN ADJUSTMENT TO NATURAL HAZARD

Why and how men live in areas of recurrent natural hazard have been fundamental questions for a decade of research initiated and directed by Gilbert F. White of the University of Chicago, and towards which Ian Burton of the University of Toronto and myself, as well as others, have contributed. In approaching this problem, we have followed Barrows' advice and see geography as human ecology, or the study of the adjustment of man to the environment. In this view, man can and does interfere with the world that surrounds him. He can isolate himself from many aspects of the natural world, change others, and adjust in varied ways to his environment.

We thus have accepted an anthropocentric notion of human dominance coupled with a deep concern to understand the implications of human actions in order to take responsibility for them. We recognize severe limitations on such understanding as well, and, to the extent that theory has governed the main thrust of our research, it is a theory of man with bounded capability. Within this model, man, while capable of powerful actions, possesses severe epistemological limits on both his ability to perceive and understand the world around him and decide upon the appropriate courses of action[6] These limitations arise from both nature and culture and provide the bounds within which rational action may take place. We try to study these bounds, and thus we have sought to identify the view on natural hazard of the inhabitants of hazardous areas. Initially, these were the attitudes of floodplain residents.[7–14] Since

[6]H. A. Simon, *Models of Man: Social and Rational* (New York: John Wiley, 1957).

[7]Barrows, see footnote 4.

[8]Ian Burton, *Types of Agricultural Occupance of Flood Plains in the United States*, Dept. of Geography, University of Chicago, Research Paper, No. 75, 1962.

[9]Ian Burton, A Preliminary Report on Flood-Damage Reduction, *Geographical Bulletin*, Vol. 7, No. 3, 1965, pp. 161-185.

[10]Robert W. Kates, *Hazard and Choice Perception in Flood Plain Management*, Dept. of Geography, University of Chicago, Research Paper, No. 78, 1962.

ıen, in our own work and that of others associated with us, we have ‹tended our study of hazard to coastal storms, drought, snow, tsunamis, ırthquakes.[15–19] Over the last six years some 3,000 personal interviews ere obtained from occupants of natural hazard zones. In addition to ıe use of both structured and unstructured interviews, thematic aper-ption tests, content analyses of news media, models of decision making, ıd new and extended uses of probability theory have been employed as ell as the more traditional geographical methods of land-use mapping nd air-photo analysis.[20] In other words there has been a wide adoption f behavioral science techniques, not new in themselves, but also not itherto employed extensively in geographical research.

The tradition of man and environment study in geography, our hilosophical stand on the bounded rationality of man, and the method-logy just described, have provided a kind of research paradigm into ɪng-term human adjustment to natural hazard. Under this paradigm e have worked toward five goals: (1) to assess the extent of human oc-upance in a hazard zone, (2) to identify the full range of possible hu-ıan adjustments to the hazard, (3) to study how man perceives and esti-ıates the recurrence of hazard, (4) to describe the process of the adop-ion of damage-reducing adjustments, and (5) to seek new techniques of

[11]F. C. Murphy, *Regulating Flood-Plain Development*, Dept. of Geography, Iniversity of Chicago, Research Paper, No. 56, 1958.

[12]W. R. D. Sewell, *Water Management and Floods in the Fraser River Basin*, Dept. of Geography, University of Chicago, Research Paper, No. 100, 1965.

[13]Gilbert F. White, *Choice of Adjustments to Floods*, Dept. of Geography, Uni-ersity of Chicago, Research Paper, No. 93, 1964.

[14]Gilbert F. White, et al., *Changes in the Urban Occupance of Flood Plains in he United States*, Dept. of Geography, University of Chicago, Research Paper, No. 7, 1958.

[15]Ian Burton and Robert W. Kates, "The Perception of Natural Hazards in Resources Management," *Natural Resources Journal*, III, 3, 1964, pp. 412-441.

[16]Ian Burton, et al., *The Shores of Megalopolis: Coastal Occupance and Human Adjustment to Flood Hazard* (C. W. Thornthwaite Associates, Laboratory of Clima-ology, Publications in Climatology), Vol. 18, No. 3, Elmer, New Jersey, 1965.

[17]Robert W. Kates, "Human Adjustment to Earthquake Hazard," *The Great Alaska Earthquake of 1964 Human Ecology* (Forthcoming).

[18]John F. Rooney, An Appraisal of the Urban Snow Hazard, Unpublished Ph.D. hesis, Clark University, 1965.

[19]T. F. Saarinen, *Perception of Drought Hazard on the Great Plains*, Dept. of Geography, University of Chicago, Research Paper, No. 106, 1966.

[20]Gilbert F. White, "Environmental Attitudes and Public Policy," *Environmental Quality in a Growing Economy* (Baltimore: Resources for the Future, Inc., 1966).

analysis for determining the optimal set of adjustments in terms of social and economic criteria.

We hope to publish shortly a more extensive summary of our efforts towards these goals, but I would like to convey very briefly some of our findings and their implications.

THE HUMAN OCCUPANCE OF HAZARD ZONES

We have not attempted to measure in a systematic way the amount of settlement or human occupance of hazard zones. An atlas of natural hazard might help in the definition of the hazard problems but would seem of little use in seeking solutions. Considering the great effort in data collection involved in such a project and the problems of definition, we have consciously rejected such an approach. However, in trying to study the trends in hazard zone occupance we have had the occasion to make a number of such estimates. Thus we know there are approximately 1,040 cities on floodplains in the United States, and there are 200 such communities (population over 1,000) located in Canada.[21,22] Five percent of the area of the United States is subject to flood.[23] There are 125,000 structures on the outer shore between Maine and North Carolina at an elevation less than 10 feet above mean sea level.[24] Twenty million people in 1960 lived in seismic zone 3, the area defined by the Uniform Building Code as subject to high seismic damage.[25]

Of much greater significance than these scattered estimates are the trends that have shown up to date. In general these indicate an intensification over time of settlement in high hazard areas, and for certain hazards the rates of settlement increase in hazard zones exceed those of surrounding safer zones.

TYPES OF HUMAN ADJUSTMENT TO HAZARD

For any given natural hazard there is a wide range of possible adjustment. But in choosing among such adjustments the full range is rarely, if ever, given serious consideration. To illustrate this range, Figure 1 depicts a schema of potential human adjustment to earthquakes developed in connection with an analysis of the Alaska earthquake of 1964.

[21]Burton, see footnote 9.

[22]White, et al., see footnote 14.

[23]U. S. House Representatives, *A Unified National Program for Managing Flood Losses*, House Doc. No. 465, 89th Cong., 2nd Session, 1966, p. 12.

[24]Burton, see footnote 16.

[25]Kates, see footnote 17.

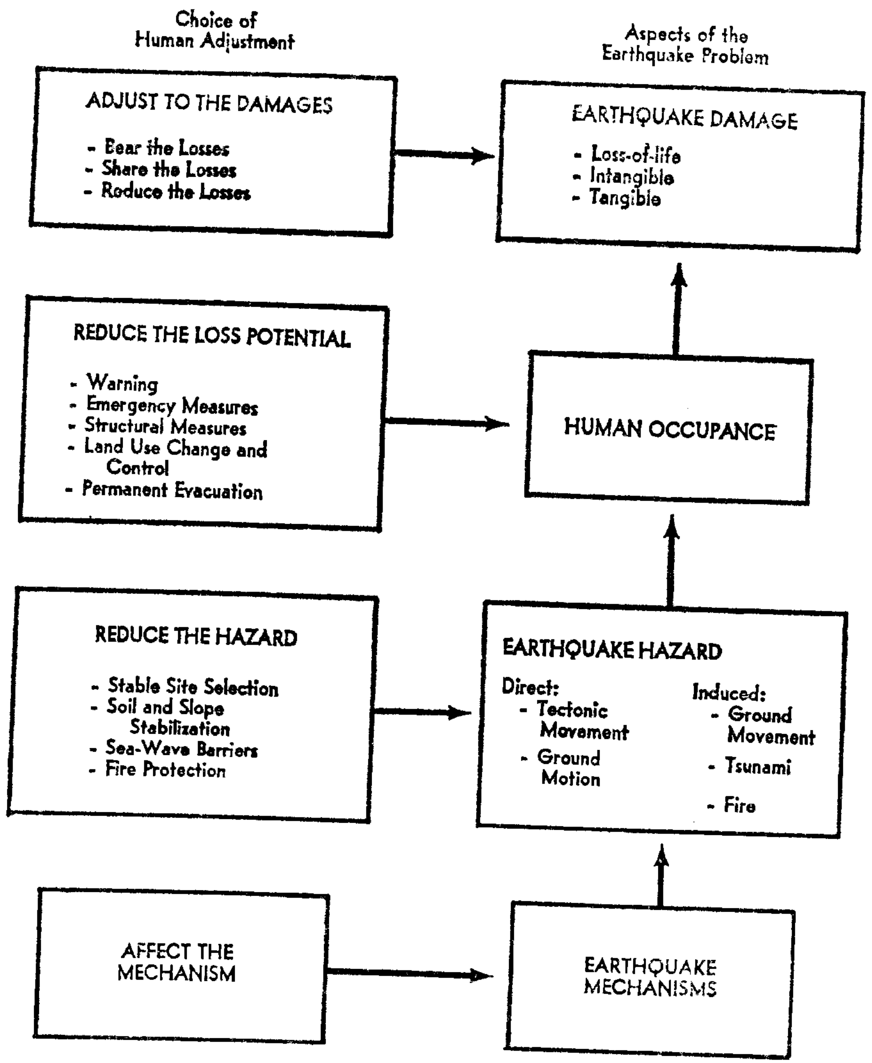

FIGURE 1. Potential Human Adjustment to Earthquakes

Three aspects of earthquakes are identified: the *mechanisms* of earthquakes; earthquake *hazard*, defined as the physical surface manifestations of the earthquake event particularly harmful to man; and earthquake *damage*, the actual harmful effects of earthquakes on man that result from hazard affecting *human occupance*.

For each aspect of the earthquake problem there is a variety of adjustments available, at least in theory. It may be possible some day to affect earthquake mechanisms that presently we do not fully understand. More reasonably, we can attempt to reduce the hazard by seeking ways to counter direct or induced earthquake hazard. Stable sites can be selected, soils or slopes can be stabilized. We can erect sea wave barriers against tsunamis, develop special fire protection systems in the face of the exceptional fire hazard generated by earthquakes.

Another set of strategies affects the loss potential of human occupance. By a variety of governmental carrots and sticks, we can encourage human behavior leading to the reduction of losses: providing warning and encouraging response to such warnings, requiring earthquake-resistant structures, and changing the land use of particularly hazardous areas. We also can adjust in some fashion to the damages themselves by either bearing the losses, which is the most common form of adjustment, or sharing them either by national policy as in Alaska, or through charities and the Red Cross. In minor ways it is even possible to reduce losses by developing rapid responses to the initial disaster.

As with all the hazards that we have studied, it seems to be useful to distinguish between those adjustments which seek to rearrange or control nature and those which involve a rearrangement or alteration of human behavior. The former has been called by Alvin M. Weinberg, the technological fix, and the latter, social engineering.[26] In the schema of human adjustment to earthquakes the technological fix is found in the lower half of the diagram and social engineering comprises the upper section.

We have been encouraged by our geographical tradition to study, in particular, social and behavioral adjustments to extend our knowledge of these alternatives. At the same time, we have been trying to identify the impact of the technological adjustnents related to natural hazard on human behavior and society. In general, we have found that when the technological fix is carried out in isolation without adequate reference to broad social considerations, these adjustments often lead to an aggravation of problems rather than their amelioration. The benefits received are often short run, and while these adjustments lead to the elimination of numerous small losses, they often add to the potential cost of losses of a catastrophic nature or to new costs incurred in combatting unforeseen side effects.

[26]White, see footnote 20.

THE ESTIMATION AND PERCEPTION OF HAZARD

Much of our effort has been expended in trying to define the hazard awareness of the inhabitants and users of hazard zones as well as of the scientific and technical community. In general, we reject the notion that the dimensions upon which meteorologists, for example, measure drought or seismologists measure the energy release of earthquakes are the dimensions that are relevant to understanding human behavior in such areas. Thus we have attempted to study the contrast between the hazard perception of professionals and nonprofessionals. The professionals we define as those in an occupation that commands a continued attention to one or more natural hazards and nonprofessionals as those for whom hazards are incidental to their main pursuits.

We find, interestingly, that nonprofessionals seem to possess a higher degree of hazard awareness than is commonly assumed by professionals. Total ignorance of hazard is really very rare although the frequency and the probability of a hazardous event are often misconstrued. Fundamentally, there seems to be for the nonprofessional a desire to make the world knowable and phenomena determinate and this is often done in the form of an assumed cycle. Parenthetically, one might note that professionals are not free of this desire but are at least subject to stringent criticism.

On the other hand, professionals, while able to incorporate statistical capabilities in their estimates of the frequency and magnitude of events, do not perform as well as expected by the nonprofessionals. This unreliability can be explained by the events themselves that infrequently occur in short periods of record. But the difficulty is compounded by the fact that professionals often mislead nonprofessionals in much the same way as medical doctors do. Doctors are paid to make complex medical judgments and everybody can recognize the importance of the patient's having confidence in the physician. Thus the doctor's patient, the engineer's client, or the environmental science service user may receive a final judgment that does not fully reveal the uncertainty involved. Finally the language that professionals use unwillingly contributes to the nonprofessional's confusion, e.g., the hydrologist's 100 year flood is often taken to reinforce the belief that a flood may only occur once every 100 years. More than mere language or semantic confusion, fundamental differences exist between professionals and nonprofessionals and this seems to be related to the tolerance for uncertainty. Nonprofessionals tolerate uncertainty poorly and resort to different forms

TABLE 1. Common Response to the Uncertainty of Natural Hazards*

Eliminate the Hazard		*Eliminate the Uncertainty*	
Deny or Denigrate its Existence	Deny or Denigrate its Recurrence	Making it Determinate and Knowable	Transfer Uncertainty to a Higher Power
"We have no floods here, only high water."	"Lightning never strikes twice in the same place."	"Seven years of great plenty . . . after them, seven years of famine."	"It's in the hands of God."
"It can't happen here."	"It's a freak of nature."	"Floods come every five years."	"The government is taking care of it."

*From: Ian Burton and Robert W. Kates, "The Perception of Natural Hazards in Resource Management," *Natural Resources Journal*, Vol. 3 (January, 1964), No. 3, p. 435.

of eliminating it. Some years ago we tried to distinguish some general categories of the responses as shown in Table 1.

THE PROCESS OF HUMAN ADJUSTMENT

In our desire to both understand and improve human adjustment to natural hazard, we try to study carefully the process by which adjustments of the type shown in Figure 1 come into being, and are adopted, utilized, and maintained. The full range of adjustment is seldom utilized and this can be clearly shown by contrasting Figure 2, which shows a reconstruction of adjustment to earthquakes in Alaska prior to 1964, with Figure 1, which outlined the whole range of potential adjustments. The major established adjustment in Alaska was in the use of seismic zone 3 standards of the Uniform Building Code in the major towns.

A fundamental question is the variation in human adjustment found in hazard areas and the factors to which these variations can be related. In our studies of floods, we have found variation in adjustment related to flood frequency. Figure 3 contrasts the distribution of the human responses of perception, interpretation, future expectation, and adjustment to hazardous events along the shore with less frequent riverine flood situations. In all cases, the less frequently inundated floodplain respond-

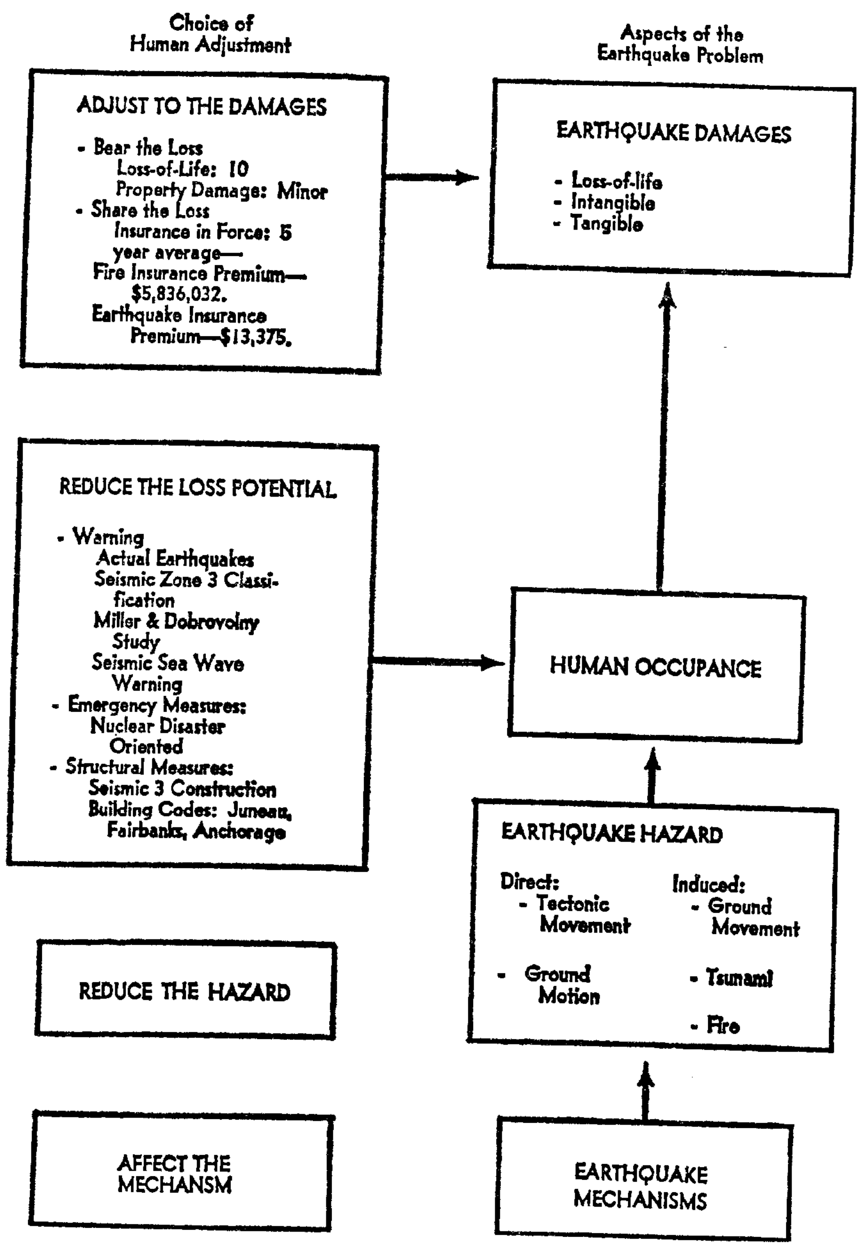

FIGURE 2. Actual Human Adjustment to Earthquakes
Alaska, Pre-1964

ents display greater variation in response. Even stronger relationships are found when frequency is measured by the perceived frequency of events rather than the usual measures of the scientific-technical community.

In the types of adjustment chosen by professionals, there is a strong preference exhibited for the technological fix arising from belief, I think, in the efficacy of technology and distrust of social engineering. Dams, if they are built well, can be trusted; warning systems that involve human beings cannot. A more subtle form of this bias seems to appear in the approach of ESSA to the problem of earthquake prediction.[27] The discussion at a recent conference on earthquakes prediction began with detailing the scientific and instrumental capability of ESSA. In contrast, a social system analytic approach would work backwards from an initial question as to what kinds of responses to warnings can human beings make? Then, what kinds of warnings are most desired? Finally, what kinds of scientific and instrumental capabilities are required to provide such warnings?

THE SEARCH FOR THE BEST ADJUSTMENTS

We have sought and are still seeking to apply methods of operations research and systems analysis to the problem of the choice of optimal adjustments to various natural hazards.[28,29] However, this is not a major effort, partly because other disciplines are better prepared to handle this problem and partly because of our judgment as to the inherent limitations of these methods. Cost benefit analysis, program budgeting, systems analysis, and various rational economizing approaches seem to be most useful where the problems are well defined in terms of risk probabilities and where the various streams of benefits and costs can be readily identified. Frankly, we have found that there are few natural hazard problems that will meet the data needs required for these approaches. One example of this limitation is the choice of an appropriate interest rate that has figured heavily in discussions of cost-benefit analysis of floodplain adjustments. We have found that differences in the appropriate interest

[27] Environmental Science Services Administration, *ESSA Symposium on Earthquake Prediction* (Washington: GPO, 1966).

[28] White, see footnote 13.

[29] Robert W. Kates, *Industrial Flood Losses: Damages Estimation in the Lehigh Valley*, Dept. of Geography, University of Chicago, Research Paper, No. 98, 1965, p. 26.

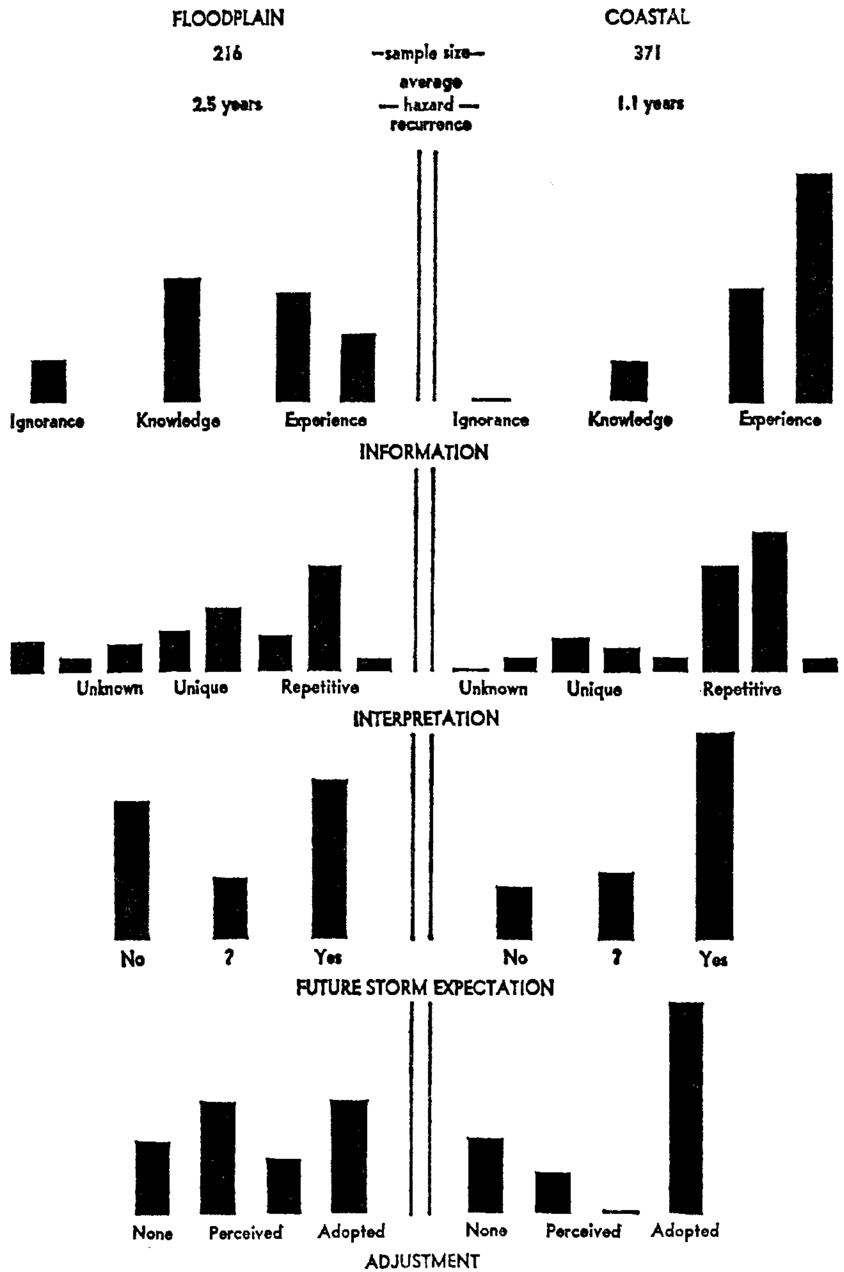

FIGURE 3. Variation in Major Hazard Parameters, Floodplain and Coastal Respondents

rate prove to be far more amenable to analysis than the much more serious difficulties of interpreting the hydrologic record.

THE NATURAL HAZARD PROBLEM IN THE FUTURE

This brief outline of work that has extended over the past decade provides a base from which to examine some implications of these studies for the future. The major finding is briefly this: natural hazards in their more violent and extreme forms will not be subdued by man in the foreseeable future. Their impact upon society will increase both absolutely and relatively in the future. Absolute increase, both in terms of real property damage and loss of lives, will result from the spread of man and his works into the high hazard zones. In the aggregate, the rate of this spread may be simply the function of the growth of wealth and population or it may be more rapid than the general increase as some of our evidence to date suggests. However, there is no indication that the existence of hazard (beyond very high rates of occurrence) acts to discourage or slow down such settlement.

Relatively, hazards have increased for three reasons:

1. The extension of reporting systems and the instantaneous communication of disasters from the most remote parts of the world by information media tend to increase the perceived occurrence of natural hazards. Disasters, in this way, are seen to increase relatively.

2. In an age of powerful technology, we will become increasingly intolerant of natural hazards. As we gain more and more control over nature, we have become less accepting of those aspects of nature that we fail to control. Thus, we will probably expend relatively greater proportions of our resources in seeking such control.

3. As affluence and greater responsibility for social welfare spread throughout the world, there is a growing tendency by society to share in the losses of individual members when these are caused by unpreventable hazards. Such sharing is exemplified by the Alaska earthquake where the funds from the federal government and the Alaska state government for relief and reconstruction may have well exceeded the actual damages suffered in that state.

With an increased burden of natural hazards, both real and apparent, foreseen for the indefinite future, our research does not lead to optimistic conclusions. Whatever optimism we may have had as we began this work has been tempered by the knowledge that there are clear limits by which the burden of natural hazards can be reduced even through the most optimal set of human adjustments. In the case of loss of life, there is evidence that these losses can be substantially reduced. To a large extent this has been achieved in North America through more effective forecasts and warning devices, disseminated to a highly mobile population, housed in substantial types of structures. However, there are real limits to anticipated reductions of property losses from natural hazards. I would estimate that even with the most enlightened policies we might be able to reduce such losses only by 30 percent on a national scale. To do even this, we will have to develop policies to deliberately bias our institutional arrangements in the direction of reducing hazard potential. New technology will have to be rapidly applied, and the whole range of adjustments will have to be considered.

Faced with this large burden of property damages, we will increasingly seek to share these costs, probably through a major insurance scheme. Philosophically, we can view the burden of losses from hazard as a kind of natural rent imposed upon us for the use of the earth, and as such we should recognize it as a continuing charge and plan for it. A serious paradox is that in spreading the cost among all of society, we may remove the encouragement to try to reduce part of the damage toll. This comes about in much the same way as auto theft insurance leads to indifferent attitudes in regard to locking the car.

FUTURE RESEARCH

The increasing burden of natural hazard that we foresee encourages us to attempt to extend our work in three additional directions:

1. The reduction in loss of life from natural hazard in North America is yet to take place in most of the world. Thus, we see a need to extend this geobehavioral approach to natural hazard study, cross-culturally. In doing so, we are mindful that knowledge gained about potential human adjustment to hurricanes may have little carry-over in the context of East Pakistan and the Bay of Bengal typhoons.

2. We question the existence of a natural hazard syndrome. Do men react to natural hazards in ways distinct from the other types of threats and uncertainty that characterize human existence? Are the insights that we have developed applicable to the quasi-natural hazards, man-made hazards disseminated by natural means (pesticides, air, soil, and water pollution)?

3. Basic research is indicated into those phenomena that, in retrospect, seem to be major determinants of human adjustment. These are: uncertainty, crisis, and technology. We need to understand much more about human tolerance for uncertainty and how men choose in uncertain situations. The role of crisis as a motivating force has never been adequately developed. Finally we need to ponder the implications of our preference for technology, which, while it extends our capability for existence in hazardous areas, may also intensify the catastrophic loss potential.

NEEDED: A SPECIALIZED GENERALIST

I have dealt at considerable length with the nature of geography to try to convey to you some sense of the discipline, one that is really not very well known. I have dealt at even greater length with the substantive content of our work on natural hazards to give you a flavor for the kind of research that interests some geographers. Now I would like to generalize, in my conclusions, what I think I have learned from these experiences about the role social and behavioral scientists should play in a developing environmental science.

Social scientists are capable of doing basic research on environmental problems. They should not be thought of as mere handmaidens to physical scientists. Although I have limited contact with governmental agencies, I sense this kind of attitude developing, especially in mission-oriented agencies, like ESSA, that also have a strong basic research tradition entirely in natural science. The role of social scientists in such agencies is envisioned as related to its mission orientation rather than the basic research frontier. The need for social scientists under these conditions is recognized but only for specific purposes. They help justify the budget by conducting program budgeting studies, or they may be used to improve the dissemination of services by conducting surveys and the like. Until there is recognition of the existence and need for *basic* research into human interaction with the environment, environmental science will not attract the top quality social and behavioral scientists it needs and will be the poorer for it.

A corollary need is for fairly continuous and active interchange between natural and social scientists as they pursue environmental problems. I do not have grandiose notions about the potential of interdisciplinary research. I have seen few successful cases of such research although I have heard that they are much desired. I suspect that good interdisciplinary effort requires the participants to be sympathetic towards each other, and such empathy is not gained merely because individuals are assembled together on a research project. It arises out of mutual like and respect and the day-to-day shared confrontation with difficult and knotty problems. Occasionally out of such a coming together, a special and rare type of synthesis occurs.

A case in point is the Harvard Water Program, based at Harvard University, that brought together engineering and economics under the sure hand of a political scientist. The product of that union was two major books and many papers setting forth a host of new systems analytic techniques for water resource development.[30,31,32] More important in terms of the lessons to be learned from that experience is the synthesis of method and outlook that took place. The product is neither engineering nor economics; it is something far better. It could have never been produced by the usual interagency techniques that see the engineers sitting in isolation from the economists preparing papers that are finally placed side by side in some kind of cover. It required weekly and sometimes daily meetings in which each group had to learn at least the major metaphors of the other, and only then were they able to learn to create their own unique metaphors. I have been struck by the beneficial aspects of even much more limited interaction with physical scientists arising from my own experiences with the committee on the Alaska earthquake and the Task Group on Human Dimensions of the Atmosphere.

Even if a turn toward basic social science research on the environment was made and an invitation was forthcoming to social and behavioral scientists to become full-fledged participants in the concerns of environmental science, there would be few that would come forth. Here again the experience of the committee on the Alaska earthquake is instructive. Since 1964, we have yet to find a single scientist who specializes in earthquake related phenomena. Yet those social scientists whom we were able to recruit because, by chance, they had some relationship with research on the Alaska earthquake or Alaska itself, contributed greatly to the projected comprehensive report on this great geophysical event.

[30]A. Maass, et al., *Design of Water-Resource Systems* (Cambridge: Harvard University Press, 1966).
[31]Maynard M. Hufschmidt and Myron B. Fiering, *Simulation Techniques for Design of Water-Resource Systems* (Cambridge: Harvard University Press, 1966).
[32]Kates, see footnote 29.

Natural scientists, if they hope to make environmental science complete, must not only invite but encourage social and behavioral scientists to develop an interest in the environment and its problems. It goes without saying that social scientists who will take part in such an endeavor must be deeply steeped in the lore of their own disciplines. But if they are to be successful, they must develop, even though belatedly, substantive interest in the environment itself. It may be personal prejudice, but I feel this lack of substantive interest provides a sterile aspect to the otherwise quality research found in the products of the large research-for-hire corporations.

Substantive interest can come in two ways. In the case of geography we have a strong tradition in environmental science. It may develop in other ways as well. The Disaster Research Center at Ohio State University is a major center for the behavioral study of natural hazard disasters and is staffed by sociologists basically interested in the study of organizations in stress. In addition to their continued interests in the study of organizations, some of these scientists, through contact, have also developed interest in natural hazard research for its own sake.

To increase the development of a substantive interest in the problems of the environment will require investment and direction. If I were asked how interested agencies could increase the supply of capable people in this area, at lowest possible cost, I would suggest that they take a look at the experience of Resources for the Future, Inc. This organization, interested in increasing the number of social scientists concerned with problems of resource management, has held an annual competition for doctoral dissertation fellowships in the social science aspects of resource management. I was one of the first group that received that award, and one has only to review case histories of others to see how this foundation, with a relatively modest investment, has been able to insure a steady flow of social scientists with life-long interests in resource problems.[33]

I would also argue for modest but continuous support for the field of geography. We are, as I noted, a discipline that is neither widely known nor widely understood. In part, this arises from the fact that we have suffered from broad, sometimes fuzzy, generalist orientations, that have not led to many theoretical understandings of the kind that are so prized today within all the sciences. In part, it is a sheer function of

[33]Resources for the Future, Inc., *Fellowship Programs in National Resources and Urban Economics, 1960-1965*, 1966.

numbers, for, as a professional organization, we number only around 4,000. And in part, it arises from the ambiguous place we occupy as we stand poised on the threshold between the physical and social sciences. We find ourselves often in second-class citizenship in the corridors of power of both the social and physical sciences.

It is my suggestion, however, that all of the foregoing, when combined with the new quality of vigor increasingly found in geographical research, provide a special opportunity to broaden the base of environmental science. Combining this new vigor of method and thought with a longstanding specialized interest in the environment, the generalist orientations of geographers now become a real asset. Small numbers in the geographical discipline make it an easy one to know for those who wish to do so. The skills and competences of its practitioners can be readily identified and the centers of strength are known to all. Most important, its very ambiguity in the halls of science permit it to uniquely connect these halls with linkages that are at the very heart of any notion of what constitutes environmental science.

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DISCUSSION

DAVID HICKOK

Professor Kates has made his case for the specialized generalist in the sciences of environment. In general, I think we may concur, at least to a certain degree; but I would like to offer my degree of concurrence in the following way. First, the attendants at this meeting recognize the need for a marriage of the physical, social, economic, and political sciences in order to provide balanced policy and program responses on the part of government—federal, state, and local.

Now some of this polygamous arrangement may be a shotgun wedding; but, like usual shotgun weddings, it is a marriage of necessity in our complex world today. We might reflect, however, that the interdisciplinary approach, alluded to by Professor Kates, is not new. The great scientists, Burroughs, Edison, and their colleagues, frequently met to discuss what today we term environmental concerns.

There is a connection of interdisciplinary action, however, which is frequently overlooked; and this I'd like to discuss with you. There is an old drummer's adage, "You've got to know the territory." To the drummer, "territory" meant not just the physical environment he covered but also its people. Those concerned with the sciences of human environment or, more specifically, the ecology of man and his relationships with his environments, may profit from the lesson of the drummer.

It's obvious that the diversity of the environments of man are infinite. Equally obvious is the fact that the behavioral patterns of the animal species of man, in all his varied habitats, are also infinite. I mention this because I feel that too frequently discussants of environmental sciences, whether physical, biological, social or political, discuss their specialties in general terms because they "don't know the territory."

This nation requires national goals—economic, social, and scientific. National goals influence the missions and objectives of all levels of governmental, academic, and business activity. The more recent concern, particularly in the Congress and in such organizations as the Resources for the Future, shows us a real need for relating national goals to regional goals.

Thinking back to the condition of this country in the 1930's, we may remember a real wedding of the economic, social sciences, and technological capabilities taking place in research, in planning, and in program action, all guided by the political decision-making process to improve the lot of the people in the Great Depression. More recently, in the 89th Congress, we have seen a new experimental approach to regional planning. The Appalachia program was formulated, followed by similar federal-state partnerships in other regional commissions now forming in New England, the Great Lakes, the Ozarks, the Atlantic Coastal Plains, and in the Four Corners area of the Southwest. In addition, the Water Resources Act of 1965 formally established another dimension of the regionalism experiment; that is, the River Basin Planning Commission. Alaska is the site of another approach: following Bureau of the Budget recommendations, the Federal Field Committee for Development Planning in Alaska, coordinating all federal activities in that state, was established by executive order.

Here, in all these program approaches, comes an initial need for Professor Kates' specialized generalist, whether he be the geographer, political scientist, or broadened biological or physical scientist. The expressed need of the specialized generalist is for an initial articulation or a speaking out of the concepts or strategic approaches to the problems of people in a relatively homogenous regional environment. This environment encompasses broad economic and social systems. Here are expressed relationships between national and regional goals.

Following such strategic articulation, however, there is need for investigation of priority problems and analysis of values and needs for the direct pragmatic enhancement of the socio-economic and technological life of people within that environment. Terms of cross-disciplined specialists concerned with priority functional problems of a particular region now come to the fore. There are many examples of this, such as the relationship of the highway and its tremendous impact on the structure of our society for many, many years ahead. This can be translated and correlated with the needs of education, the tying together of urban growth-center potentials, water resource development, etc.

Dr. Kates discussed Alaska in his example of responses to human behavioral patterns. I'd like to use the Arctic environment for some additional examples of the necessity to synthesize social and physical science response to human need. First let's look at the native problem in Alaska, which is particularly acute. The Eskimo is experiencing great unrest these days. He is an emerging local power in a minority sense. He is influencing thought on the social and educational problems of the Arctic people, the use of natural resources, state selection of land under the Statehood Act, etc., and he is speaking out more and more in his concern that his environment not be poorly used by the white man.

The Arctic is a fragile environment. Of all the representatives of the species man, for thousands of years perhaps the Eskimo has been most in balance with his environment. The advent of the white man in the Arctic has upset this balance by substituting a partial welfare economy. The relief check and other social problems have imposed cultural and political situations foreign to the Eskimo without attacking basic problems. The result is the highest birth rate in the world, people out of balance with their environment, and without a resource base for their expanding population.

In the cities of Anchorage and Fairbanks, where Eskimo ghettos are developing; and in the rural Arctic conditions are appalling. Frequently, poverty problems exist that make similar circumstances in the lower 48 states pale in significance. The Federal Field Committee for Development Planning in Alaska is tackling many of the problems of northwestern Alaska with the task force cross-disciplinary approach in order to try to offer solutions to native problems in the Arctic. From the Field Committee approach, that is utilizing people from several federal and

state agencies and from universities in the Arctic, should emerge agency missions and programs based upon priority need and value.

Next, let us consider Alaska's continuing dependence on marine environment. Alaska has half of the U.S. continental shelf, fisheries are its greatest economic asset, marine transportation is vital, and minerals from the sea hold future promise. Here is a good place to focus Dr. White's concern for combining social and economic forces to help delineate programs for the Environmental Science Services Administration. Correlation of a resource base for the Eskimo's livelihood involves the biological and physical sciences and new technology adaptable to the Arctic.

At present, little is known of Arctic marine resources—in either biological or physical description. As native populations shift to better land sites, where their littoral environment is improved, they must also possess a viable economic resource base. One can notice along the coast of the Chukchi Sea that the native problem is reflected not only by an adequate village site with adequate environmental parameters on the land but also by the determination and development of an existing resource base acceptable to the Eskimo culture. Essentially, this means fisheries and marine mammals.

Here is a specific place where benefits to a small segment of people are possible through coordinated, interdisciplinary, and interagency government programs. Socially and economically determined work priorities for the Bureau of Commercial Fisheries in the evaluation of fishery stocks and for ESSA's prerequisite bathymetry and meteorological programs will have to proceed hand in hand for the advancement of these people. This is a fundamental challenge for government.

Now, in closing, I'd like to give you a last example of the kinds of things which occur and which have pragmatic, interdisciplinary meanings and which are evident in the everyday life of the Eskimo. A few weeks ago, I was asked to pass on an agency technical assistance project to teach Eskimos how to better retrieve walrus. As well meaning as this project was, I just about exploded, because in the whole northern Arctic there are not a dozen white men who could even keep up with Eskimos hunting walrus, let alone teach them how better to retrieve their catch. But, nevertheless, the problem is a serious one and needs to be looked at from the other side of the coin. Essentially, the problem is that, in many parts of the Arctic, 50 to 95 percent of the Eskimo meat supply spoils. Food is an economic problem. Technology is required that will bring these people a way to preserve food that improves on the "stink hole" method they now employ in the permafrost or in the drying of split muktuk. During the summer months, their meat spoils at a rapid rate. The result is food that is unmarketable and barely edible to any but a few Eskimos on the verge of starvation and their dogs.

In this situation is a conservation problem. On one hand, a lowering of the number of walrus killed is believed to be necessary by conservationists concerned with maintaining a walrus population. On the other hand, it is a social-welfare problem that the natives don't have healthy food and it is an economic problem to beat the high cost for normal refrigeration fuel sources. I'd like to suggest here again that interdisciplinary imagination concerned with a specific problem may become a concerted force for positive action, a force to bring new and old technologies together within an atmosphere of cultural and economic harmony in order to preserve food supplies in remote areas. In such projects and for such practical problems the interdisciplinary marriage can be most effective. Let us hope it goes to work.

Public Policy Implications of Environmental Control

LYNTON KEITH CALDWELL

Prediction regarding the future of man's control over his physical environment has scarcely passed beyond reasoned speculation. Advances in predictability derive largely from greater understanding of the physical sciences. The handicaps of predictability lie in the contradictory nature of human behavior.

Assuming that man will attempt to extend control over his environment to the uttermost limits of physical possibility, the major public question is: What kind of environment will this control create? There is, of course, an indeterminate number of scientific and technical problems requiring solution before environmental control can be extended in whatever direction man chooses within the parameters laid down for him by nature. Environmental scientists and engineers will not find their work exhausted in any future that we can now foresee, but the problems they will attack and the emphasis they will give to alternative aspects of research will surely be conditioned, if not determined, by social policies expressed largely through the actions of government.

Questions of environmental policy and control are always reducible to questions of social choice. There is no apparent scientific imperative that impels environmental research or policy in one direction rather than another. But there are social and perhaps even biological compulsions that cause men and their societies to behave in particular ways toward their environment. These compulsions are as yet poorly understood and may, or may not, be amenable to premeditated change. Yet, whatever their bases, these compulsions are projected upon the environment in the form of social choices expressed through political acts. More precisely, public environmental policy is woven into the complex matrix of the political process through which the cybernetic interactions of social decision and control take place. Efforts to understand the political bases of public environmental control lead ultimately to a study of the inter-