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THE PERCEPTION OF NATURAL HAZARDS IN RESOURCE MANAGEMENT

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"What region of the earth is not full of our calamities?" Virgil

To the Englishman on his island, earthquakes are disasters that happen to others. It is recognized that "while the ground is liable to open up at any moment beneath the feet of foreigners, the English are safe because 'it can't happen here.'"¹ Thus is described a not uncommon attitude to natural hazards in England; its parallels are universal.

Notwithstanding this human incapacity to imagine natural disasters in a familiar environment, considerable disruption is frequently caused by hazards. The management of affairs is not only affected by the impact of the calamities themselves, but also by the degree of awareness, or perception of the hazard, that is shared by those subject to its uncertain threat. Where disbelief in the possibility of an earthquake, a tornado, or a flood is strong, the resultant damages from the event are likely to be greater than where awareness of the danger leads to effective precautionary action.

In this article we attempt to set down our imperfect understanding of variations in the perception of natural hazard, and to suggest some ways in which it affects the management of resource use. In so doing we are extending the notion that resources are best regarded for management purposes as culturally defined variables, by consideration of the cultural appraisal of natural hazard.

It may be argued that the uncertainties of natural hazards in resource management are only a special case of the more general problem of risk in any economic activity. Certainly there are many similarities. But it is only when man seeks to wrest from nature that which he perceives as useful to him that he is strongly challenged by the vagaries of natural phenomena acting over and above the usual uncertainties of economic activity. In other words, the management of resource use brings men into a closer contact with nature (be it viewed as friendly, malevolent, or neutral) where the extreme variations of the environment exercise a much more profound effect than in other economic activities.

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1. Nidrie, *When the Earth Shook* 36 (1962).

I

THE DEFINITION OF NATURAL HAZARDS

For a working definition of "natural hazards" we propose the following: Natural hazards are those elements in the physical environment, harmful to man and caused by forces extraneous to him. According to Zimmerman's view, the physical environment or nature is "neutral stuff," but it is human culture which determines which elements are considered to be "resources" or "resistances."² Considerable cultural variation exists in the conception of natural hazards; change occurs both in time and space.

In time, our notion of specific hazards and their causal agents frequently change. Consider, for example, the insurance concept of an "act of God." To judge by the volume of litigation, this concept is under constant challenge and is constantly undergoing redefinition. The "acts of God" of today are often tomorrow's acts of criminal negligence. Such changes usually stem from a greater potential to control the environment, although the potential is frequently not made actual until after God has shown His hand.

In space a varied concept of hazard is that of drought. A recent report adequately describes the variation as follows:

There is a clue from prevailing usage that the term 'drought' reflects the relative insecurity of mankind in the face of a natural phenomenon that he does not understand thoroughly and for which, therefore, he has not devised adequate protective measures. A Westerner does not call a rainless month a 'drought,' and a Californian does not use the term even for an entire growing season that is devoid of rain, because these are usual occurrences and the developed water economy is well bolstered against them. Similarly, a dry period lasting several years, or even several decades, would not qualify as a drought if it caused no hardship among water users.³

This may be contrasted with the official British definition of an "absolute drought" which is "a period of at least 15 consecutive days to none of which is credited .01 inches of rain or more."⁴

Even such seemingly scientifically defined hazards as infective diseases seem to be subject to changes in interpretation, especially when applied to the assignment of the cause of death. Each decennial revision of the International Lists

2. Zimmermann, *World Resources and Industries* (1951); see also Zimmermann's diagram, *id.* at 13.

3. Thomas, *The Meteorological Phenomenon of Drought in the Southwest, 1942-1956*, at A8 (United States Geological Survey Prof. Paper No. 372-A, 1962).

4. Meteorological Office, United Kingdom Air Ministry, *British Rainfall, 1958*, at 10 (1963). This definition was introduced in British rainfall research in 1887.

of Causes of Death has brought important changes to some classes of natural hazards. Thus, the change from the fifth to the sixth revision found a decrease of approximately twenty-five per cent in deaths identified as caused by syphilis and its sequelae as a result of the new definition arising from ostensibly improved medical knowledge.⁵

The definability of hazard is a more sophisticated form of perceiving a hazard. It is more than mere awareness and often requires high scientific knowledge, *i.e.*, we must understand in order to define precisely. But regardless of whether we describe definitions of drought by western water users or the careful restatement of definitions by public health officials, all types of hazard are subject to wide variation in their definition—a function of the changing pace of man's knowledge and technology.

To complicate the problem further, the rise of urban-industrial societies has been coincident with a rapid increase in a type of hazard which may be described as quasi-natural. These hazards are created by man, but their harmful effects are transmitted through natural processes. Thus, man-made pollutants are carried downstream, radio-active fallout is borne by air currents, and pesticides are absorbed by plants, leaving residues in foods. The intricacies of the man-nature relationship are such that it is frequently not possible to ascribe a hazard exclusively to one class or the other (natural or quasi-natural). A case in point is the question of when fog (a natural hazard) becomes smog (quasi-natural).⁶ Presumably some more or less arbitrary standard of smoke content could be developed.

In the discussion that follows, we specifically exclude quasi-natural hazards while recognizing the difficulty of distinguishing them in all cases. Our guide for exclusion is the consideration of principal causal agent.

II

A CLASSIFICATION OF NATURAL HAZARDS

Table I is an attempt to classify common natural hazards by their principal causal agent. It is but one of many ways that natural hazards might be ordered, but it is convenient for our purposes. The variety of academic disciplines that study aspects of these hazards is only matched by the number of governmental basic data collection agencies which amass information on these hazards. The most cohesive group is the climatic and meteorological hazards. The most

5. DHEW, Public Health Service, I Vital Statistics of the United States, 1950, at 31 (*Interpretation of Cause-of-Death Statistics*), 169 (*Mortality by Cause of Death*) (1954).

6. Glossary of Meteorology 516 (Huschke ed. 1959), defines "smog" as follows: A natural fog contaminated by industrial pollutants; a mixture of smoke and fog. (This term coined in 1905 by Des Voeux, has experienced a recent rapid rise in acceptance but so far it has not been given precise definition.)

diverse is the floral group which includes the doctor's concern with a minor fungal infection, the botanist's concern with a variety of plant diseases, and the hydrologist's concern with the effect of phreatophytes on the flow of water in streams and irrigation channels.

TABLE I
COMMON NATURAL HAZARDS BY PRINCIPAL CAUSAL AGENT

<i>Geophysical</i>		<i>Biological</i>	
CLIMATIC AND METEOROLOGICAL	GEOLOGICAL AND GEOMORPHIC	FLORAL	FAUNAL
Blizzards & Snow	Avalanches	Fungal Diseases <i>For example:</i>	Bacterial & Viral Diseases <i>For example:</i>
Droughts	Earthquakes	Athlete's foot	Influenza
Floods	Erosion (including soil erosion & shore and beach erosion)	Dutch elm	Malaria
Fog		Wheat stem rust	Typhus
Frost	Landslides	Blister rust	Bubonic Plague
Hailstorms	Shifting Sand	Infestations <i>For example:</i>	Venereal Disease
Heat Waves	Tsunamis	Weeds	Rabies
Hurricanes	Volcanic Eruptions	Phreatophytes	Hoof & Mouth Disease
Lightning Strokes & Fires		Water hyacinth	Tobacco Mosaic
Tornadoes		Hay Fever	Infestations <i>For example:</i>
		Poison Ivy	Rabbits
			Termites
			Locusts
			Grasshoppers
			Venomous Animal Bites

In a fundamental way, we sense a distinction between the causal agents of geo-physical and biologic hazards. This distinction does not lie in their effects, for both hazards work directly and indirectly on man and are found in both large and small scales. Rather, our distinction lies in the notion of preventability, *i.e.*, the prevention of the occurrence of the natural phenomenon of hazardous potential as opposed to mere control of hazardous effects. A rough rule of thumb is that changes in nature are to be classed as prevention, but changes in man or his works are control.

Given this rule of thumb, it is clear that few hazards are completely preventable. Prevention has been most successful in the area of floral and faunal hazards. Some such hazards (*e.g.*, malaria) have been virtually eliminated in

the United States by preventive measures, but they are still common in other parts of the world.

At the present levels of technology, geophysical hazards cannot be prevented, while biological hazards can be prevented in most cases, subject only to economic and budgetary constraints.

We suggest that this is a basic distinction and directly related to the areal dimensions and the character and quantities of energy involved in these natural phenomena. While much encouraging work has been done, we still cannot prevent a hurricane, identify and destroy an incipient tornado, prevent the special concentration of precipitation that often induces floods, or even on a modest scale alter the pattern of winds that shift sand, or prevent the oversteepening and sub-soil saturation that induces landslides. We might again note the distinction between prevention and control: we can and do build landslide barriers to keep rock off highways, and we can and do attempt to stabilize shifting sand dunes.

Despite much loose discussion in popular journals, repeated surveys of progress in weather modification have not changed substantially from the verdict of the American Meteorological Society in 1957, which was that:

Present knowledge of atmospheric processes offers no real basis for the belief that the weather or climate of a large portion of the country can be significantly modified by cloud seeding. It is not intended to rule out the possibility of large-scale modifications of the weather at some future time, but it is believed that, if possible at all, this will require methods that alter the large-scale atmospheric circulations, possibly through changes in the radiation balance.⁷

The non-preventability of the class of geophysical hazards has existed throughout the history of man and will apparently continue to do so for some time to come. Our training, interest, and experience has been confined to this class of hazards. Moreover, as geographers we are more comfortable when operating in the field of geophysical phenomena than biological. However, we do not know whether the tentative generalizations we propose apply only to geophysical hazards or to the whole spectrum of natural hazards. A priori speculation might suggest the hypothesis that men react to the non-preventable hazard, the true "act of God," in a special way, distinct from preventable hazards. Our observations to date incline us toward the belief that there is an

7. Senate Select Comm. on Nat'l Water Resources, 86th Cong., 2d Sess., *Weather Modification 3* (Comm. Print No. 22, 1960); see also Baton & Kassander, *Randomized Seeding of Orographic Cumulus* (Univ. Chi. Meteorology Dep't Tech. Bull. No. 12, 1958); Greenfield, *A New Rational Approach to Weather-Control Research* (Rand Corp. Memo. No. RM-3205-NSF, 1962).

orderly or systematic difference in the perception of preventable and non-preventable natural hazards.

This arises from the hiatus between popular perception of hazard and the technical-scientific perception. To many flood-plain users, floods are preventable, *i.e.*, flood control can completely eliminate the hazard. Yet the technical expert knows that except for very small drainage areas no flood control works known can effectively prevent the flood-inducing concentration of precipitation, nor can they effectively control extremely large floods of very rare occurrence. On the other hand, in some parts of the world hoof and mouth disease is not considered preventable, although there is considerable evidence that it is preventable when there is a widespread willingness to suffer large economic losses by massive eradication of diseased cattle combined with vigorous control measures of vaccination.

The hiatus between the popular perception of hazard and the perception of the technician scientist is considered below in greater detail.

III

THE MAGNITUDE AND FREQUENCY OF HAZARDS

There is a considerable volume of scientific data on the magnitude and frequency of various hazards. The official publications of the agencies of the federal government contain much of it. Examples of frequency data are shown in Figures 1, 2, and 3. In general, these show spatial variations in the degree of hazard in terms of frequency occurrence. The measurement of magnitude is more difficult to portray in graphic form, but in general it is directly related to frequency. For example, areas with higher frequency of hailstorms are also likely to experience the most severe hailstorms. The magnitude of floods is more complex, and attempts to portray variations in magnitude of floods graphically have generally not been successful.⁸ We have attempted to show variation in magnitude of floods for New York (Figure 4).

It is our finding that the variations in attitude to natural hazard cannot be explained directly in terms of magnitude and frequency. Differences in perception mean that the same degree of hazard is viewed differently. Part of this variation is due, no doubt, to differences in damage experienced, or in damage potential. In Tables II and III we have attempted to set out some examples of damage caused by natural hazards. These tables give some idea of the order of magnitude of damages to life and property. The estimates are in most cases crude. The loss figures given in Table II amount to about \$12 billion. If we

8. See, *e.g.*, the maps prepared by M. Maurice Pardé in Comité National de Géographie, Atlas de France, Sheets 20, 22 (1934).

Figure 2

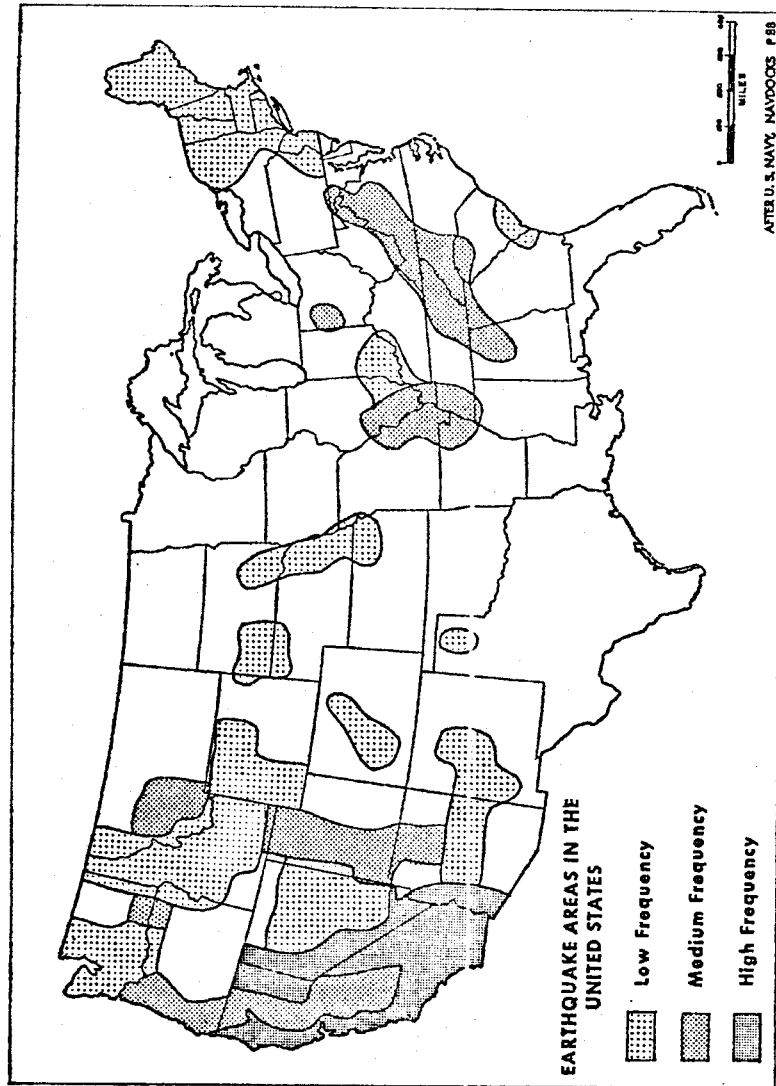


Figure 3

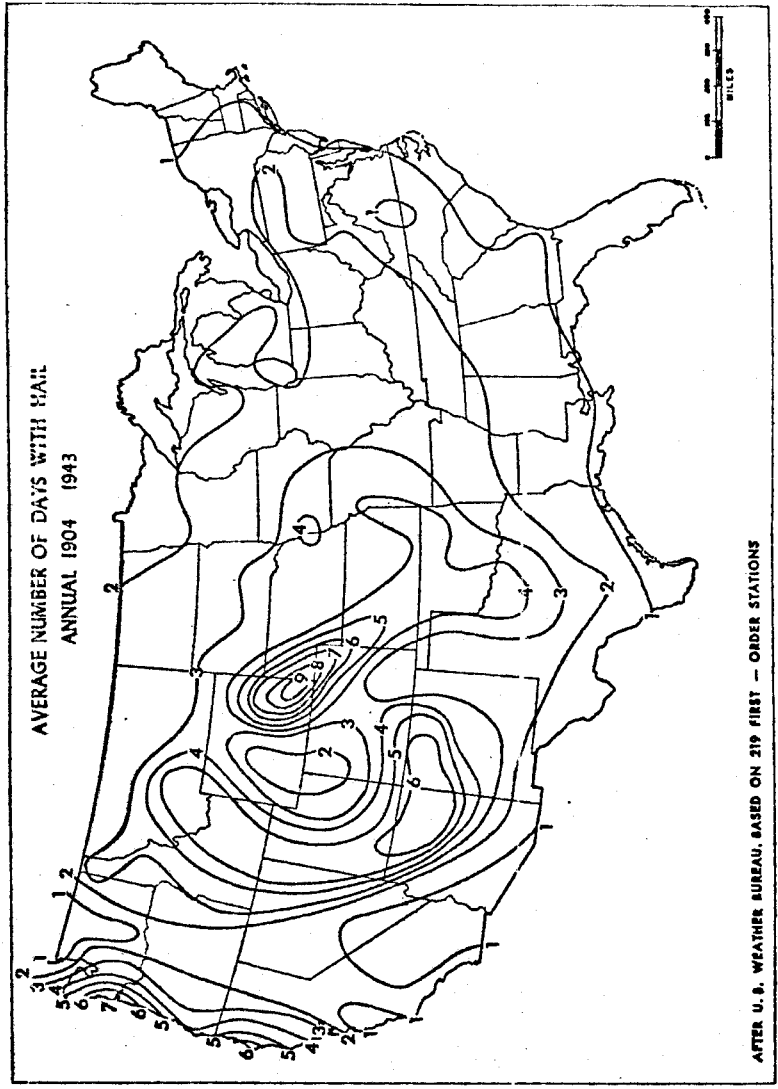
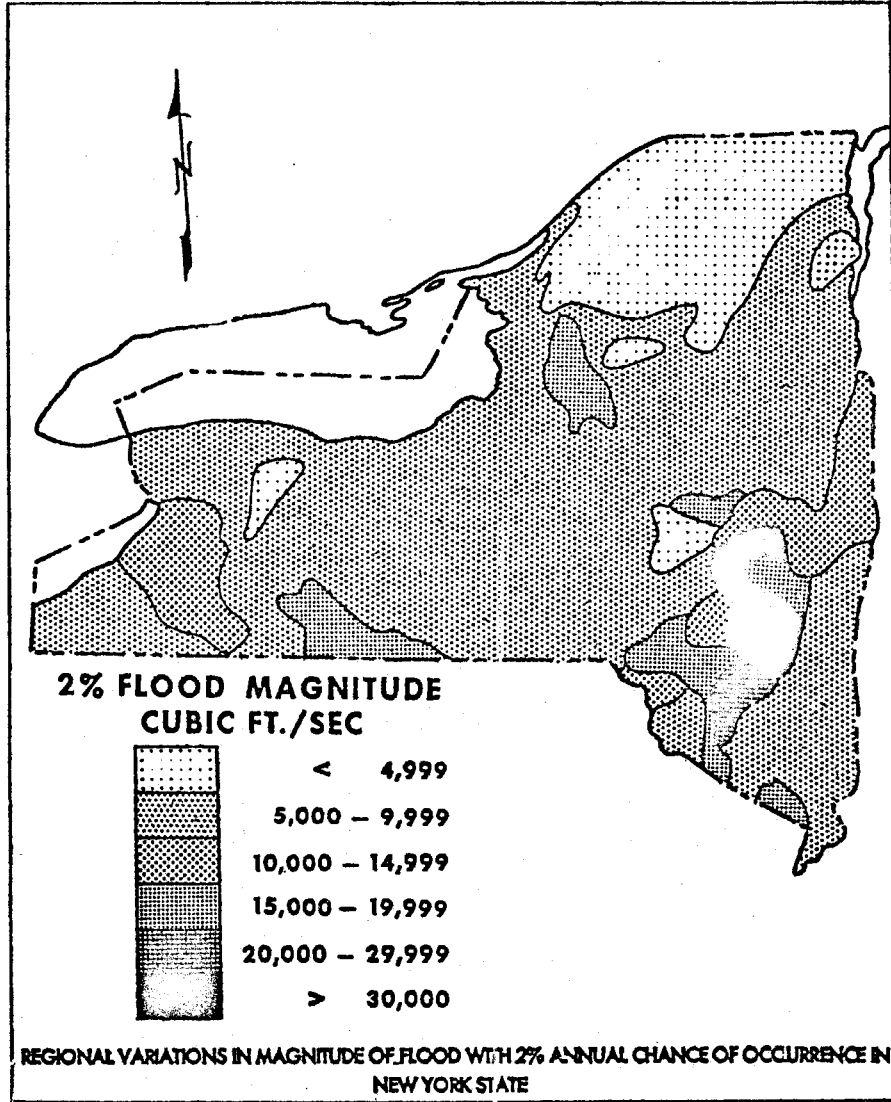


Figure 4



add to this the \$25 billion which are spent annually for health care,⁹ and the large amounts spent for control and prevention of other natural hazards, then

9. Mushkin, *Health as an Investment*, 70 *J. Political Economy* 129, 137 (1962); see also Merriam, *Social Welfare Expenditures, 1960-1961*, 25 *Social Security Bull.* 3 (No. 11, 1962).

TABLE II
AVERAGE ANNUAL LOSSES FROM SELECTED NATURAL HAZARDS

Floods	\$350 M (Million) to \$1 Billion ¹⁰
Hail	\$53 M ¹¹
Hurricanes	\$100 M ¹²
Insects	\$3,000 M ¹³
Lightning Strokes	\$100 M ¹⁴
Plant Disease	\$3,000 M ¹⁵
Rats and Rodents	\$1,000 M to \$2,000 M ¹⁶
Tornadoes	\$45 M ¹⁷
Weeds	\$4,000 M ¹⁸
TOTAL	\$11,648 M to \$13,268 M

TABLE III
LOSS OF LIFE FROM SELECTED NATURAL HAZARDS

Cold Waves	242 ¹⁹	(1959)
Floods	83.4 ²⁰	Average annual, 1950-1959
Hay Fever	30 ²¹	(1959)
Heat Waves	207 ²²	(1959)
Hurricanes	84.8 ²³	Average annual, 1950-1959
Influenza	2,845 ²⁴	(1959)
Lightning Strokes	600 ²⁵	Average annual, Years not specified
Malaria	7 ²⁶	(1959)
Plague	1 ²⁷	(1959)
Tornadoes	204.3 ²⁸	Average annual, 1950-1959
Tuberculosis	11,456 ²⁹	(1959)
Venomous Bites & Stings	62 ³⁰	(1959)
Venereal Disease	3,069 ³¹	(1959)

10. See notes 32-34 *infra*.

11. Flora, Hailstorms of the United States 3 (1956).

12. Our estimate.

13. Byerly, *Why We Need Loss Data*, Nat'l Academy of Science, Nat'l Research Council, *Losses Due to Agricultural Pests* 3 (Summary of Conference of the Agricultural Bd. Comm. on Agriculture Pests, Nov. 4-5, 1959).

14. Bureau of Yards & Docks, United States Navy, *Natural Disasters* 24 (Navdocks P-88, 1961).

15. Byerly, *op. cit. supra* note 13.

16. *Ibid.*

17. Flora, *op. cit. supra* note 11.

18. Byerly, *op. cit. supra* note 13.

19. DHEW, Public Health Service, II Vital Statistics of the United States 18-36 (1959).

20. Metropolitan Life Ins. Co., Statistical Bulletin, vol. 41, at 9 (April, 1960).

21. DHEW, Public Health Service, *op. cit. supra* note 19.

22. *Ibid.*

23. Metropolitan Life Ins. Co., *op. cit. supra* note 20.

it is clear that our struggle against natural hazards is of the same order of magnitude as the defense budget!

That these estimates are not highly reliable is demonstrated in the wide variation of some of them. Flood damages, for example, are placed at \$350 million by the United States Weather Bureau,³² over \$900 million by the United States Army Corps of Engineers,³³ and \$1,200 million by the United States Department of Agriculture.³⁴

There are partial explanations for the wide discrepancies in these and other similar data. These usually include such questions as definitions used, time period employed, methods of computation, accuracy and completeness of reporting, changing dollar values, and so on. However, even when all these differences are taken into account the perception of natural hazards still varies greatly. There is variation in the resource manager's perception of hazard. Managers as a group differ in their view as opposed to scientific and technical personnel, and the experts, in turn, differ among themselves. These differences persist even when all the scientific evidence upon which conclusions are based is identical. It is to this complex problem of differing perceptions that we now turn.

IV

VARIATIONS IN PERCEPTION

It is well established that men view differently the challenges and hazards of their natural environment. In this section we will consider some of the variations in view or perception of natural hazard. In so doing we will raise more questions than we shall answer; this is a reflection of the immaturity and youth of this line of research.

Our scheme will be to consider the *within group* and *between group* variation in perception of two well-defined groups: resource users, who are the managers of natural resources directly affected by natural hazards (including of course

24. DHEW, Public Health Service, *op. cit. supra* note 19.

25. Bureau of Yards & Docks, *op. cit. supra* note 14.

26. DHEW, Public Health Service, *op. cit. supra* note 19.

27. *Ibid.*

28. Metropolitan Life Ins. Co., *op. cit. supra* note 20.

29. DHEW, Public Health Service, *op. cit. supra* note 19.

30. *Ibid.*

31. *Ibid.*

32. Weather Bureau, Dep't of Commerce, Climatological Data, National Summary, Annual 1961, at 85 (1962).

33. Senate Select Comm. on Nat'l Water Resources, 86th Cong., 2d Sess., *Floods and Flood Control* 5-7 (Comm. Print No. 15, 1960).

34. Senate Comm. on Banking and Currency, *Federal Disaster Insurance*, S. Rep. No. 1313, 84th Cong., 2d Sess., 69-71 (1956).

their own persons),³⁵ and technical and scientific personnel—individuals with specialized training and directly charged with study or control of natural hazards.

A. Variation in the Perception of Natural Hazard Among Scientific Personnel

The specialized literature is replete with examples of differences in hazard perception among experts. They fail to perceive the actual nature of the hazard, its magnitude, and its location in time and space. Technical personnel differ among each other, and the use of reputable methods often provides estimates of hazards of great variance from one another.

Such variation is due in small part to differences in experience and training, vested organizational interest, and even personality. But in a profound and fundamental way, such variation is a product of human ignorance.

The Epistemology of Natural Hazard

We have emphasized the nature of natural hazard as phenomena of nature with varying effects on man, ranging from harmless to catastrophic. To know and to fully understand these natural phenomena is to give to man the opportunity of avoiding or circumventing the hazard. To know fully, in this sense, is to be able to predict the location in time and space and the size or duration of the natural phenomenon potentially harmful to man. Despite the sophistication of modern science or our ability to state the requirements for such a knowledge system, there seems little hope that basic geophysical phenomena will ever be fully predictable. No foreseeable system of data gathering and sensing equipment seems likely to pinpoint the discharge of a lightning bolt or the precise path of a tornado.

Given this inherent limitation, almost all estimation of hazard is probabilistic in content, and these probabilities may be computed either by counting (relative frequency) or by believing in some underlying descriptive frequency distribution. The probability of most hazardous events is determined by counting the observed occurrence of similar events. In so doing we are manipulating three variables: the magnitude of the event, its occurrence in time, and its occurrence in space.

For some hazards the spatial variable might fortunately be fixed. Volcanic eruptions often take place at a fixed point, and rivers in humid areas follow well-defined stream courses. For other hazards there may be broadly defined belts such as storm paths or earthquake regions (see Figure 2). There are no geophysical hazards that are apparently evenly or randomly distributed over

35. A definition of "resource manager," as we use the term, is found in White, *The Choice of Use in Resource Management*, 1 *Natural Resources J.* 23, 24 (1961).

the earth's surface, but some, such as lightning, approach being ubiquitous over large regions.

The size or magnitude of the hazard varies, and, given the long-term human adjustment to many hazards, this can be quite important. Blizzards are common on the Great Plains, but a protracted blizzard can bring disaster to a large region.³⁶ On great alluvial flood plains small hummocks provide dry sites for settlement, but such hummocks are overwhelmed by a flood event of great magnitude.

Magnitude can be thought of as a function of time based on the apparent truism of extreme events: if one waits long enough, there will always be an event larger than that previously experienced. In the case of geophysical events, waiting may involve several thousand years. Graphically, this is presented for fifty years in Figure 5 for two common hazards.

Most harmful natural phenomena are rare events; if they were not, we humans would probably have been decimated before we became entrenched on this planet. Since the counting of events is the major method of determining probabilities, rare events by their nature are not easily counted. Equally disturbing is the possibility that by climatic change, or improved scientific knowledge, or human interference, the class of natural events may change and create further uncertainties in the process of observing and recording.

Faced with a high degree of uncertainty, but pressed by the requirements of a technical society for judgments and decisions, scientific and technical personnel make daily estimates of hazard with varying degrees of success.

An example of unsuccessful estimating is seen in the case of the San Carlos Reservoir on the Gila River in Arizona. Completed in 1928, this reservoir has never been filled to more than sixty-eight per cent of its capacity and has been empty on several occasions.³⁷ The length of stream flow record on which the design of the dam was based was short (approximately thirty years), but it was not necessarily too short. The considerable overbuilding of this dam, according to Langbein and Hoyt, was due in part to the failure to take into account the increasing variability of annual flows as indicated in the coefficient of variation. In their view, the San Carlos Reservoir is "a victim of a deficiency in research to develop the underlying patterns of fluctuations in river flow."³⁸ To our knowledge, this deficiency still exists, and we have doubts as to whether such patterns can actually be determined.

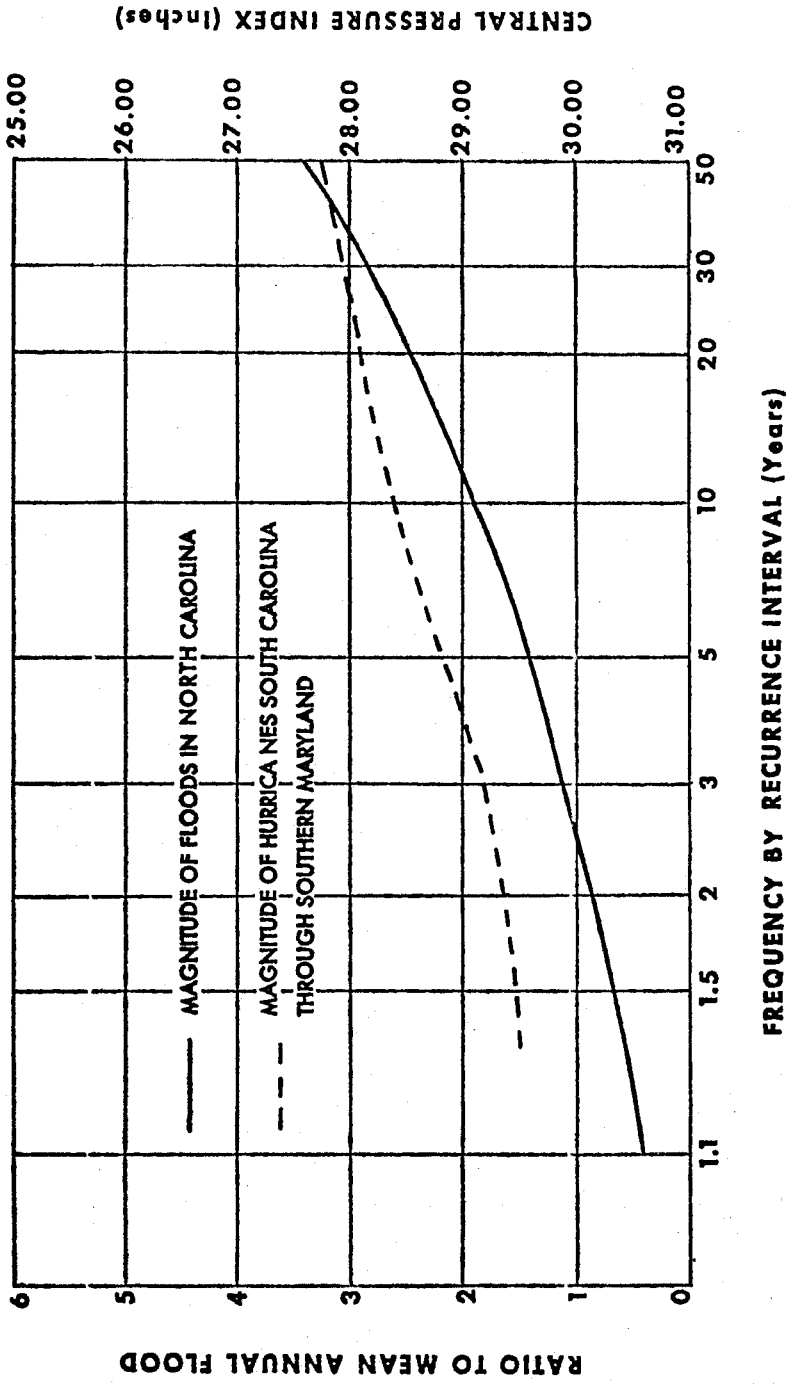
Until recent years, that highly reputable practitioner of actuarial precision,

36. Calef, *The Winter of 1948-49 in the Great Plains*, 40 *Ass'n Am. Geographers, Annals* 267 (1950).

37. Langbein & Hoyt, *Water Facts for the Nation's Future* 229 (1959).

38. *Id.* at 230.

Figure 5



SOURCE: NATIONAL HURRICANE RESEARCH PROJECT REPORT NO. 33; FLOODS IN NORTH CAROLINA; MAGNITUDE AND FREQUENCY

the insurance industry, charged rates for hail insurance that were largely a matter of guesswork.³⁹ Flora notes that

often in widely level areas, where we now know that the hail risk varies but little over a distance of a hundred miles or more, one county might have several damaging hailstorms while adjacent counties might escape entirely. In such instances, the county which had suffered severe damage would be given a much higher insurance rate than others.⁴⁰

With regard to flood insurance, the industry has long apologized for its unwillingness to even enter the fray, using words similar to these:

[The insurance company underwriters believe that] specific flood insurance covering fixed location properties in areas subject to recurrent floods cannot feasibly be written because of the virtual certainty of loss, its catastrophic nature and the reluctance or inability of the public to pay the premium charge required to make the insurance self sustaining.⁴¹

Some hazards have been only belatedly recognized. Langbein and Hoyt cite the fact that in the *American Civil Engineers Handbook*, published in 1930, there are no instructions about reservoir sedimentation.⁴²

Public agencies charged with flood control responsibilities have had to make estimates of the long run recurrence of these phenomena. Despite a great deal of work and ingenuity, results are not overly impressive. Three highly respected methods of flood frequency analysis place the long run average return period of the largest flood of record in the Lehigh Valley as either twenty-seven, forty-five, or seventy-five years.⁴³

The disparate views and perceptions of technical and scientific personnel are a reflection of our ignorance of the chance occurrence of events, and more fundamentally of our lack of understanding of the physical forces themselves. There is little hope of eliminating this uncertainty, and the technical-scientific community follows the course of recognizing it, defining it, and finally learning to live with it.

39. Flora, *Hailstorms of the United States* 56 (1956).

40. *Ibid.*

41. American Ins. Ass'n, *Studies of Floods and Flood Damage* 3 (1956).

42. Langbein & Hoyt, *op. cit. supra* note 37, at 232.

43. *Delaware River Basin, New York, New Jersey, Pennsylvania, and Delaware*, H.R. Doc. No. 522, 87th Cong., 2d Sess., VI, Plate 42 (1962).

B. Variations in the Perception of Natural Hazard Among Resource Managers

Resource users or managers do not display uniformity in their perception of natural hazard any more than do scientific and technical personnel. Not being experts, they have less knowledge or understanding of the various possible interpretations of data and are often amazed at the lack of agreement among the professionals. Their views may be expected to coincide insofar as the lay managers subscribe to the various popular myths of hazard perception (whether "it can't happen here," or "after great droughts come great rains," or "a little rain stills a great wind"). But in this age of enlightenment, perception is not easily limited to such aphorisms. Differences in perception arise both among users of the same resource and between users of different resources.

1. Perception Among Users of the Same Resource

Urban and rural flood-plain users display differences in the perception of flood hazard. Our own studies of urban⁴⁴ and agricultural⁴⁵ flood-plain users suggest a greater hazard sensitivity in terms of awareness on the part of agricultural land users. However, the frequency of hazard that encourages certain responses on the part of resource users is approximately equal for both urban and agricultural land users.⁴⁶

The limited work on flood plains in variation of perception between users suggests three explanatory factors: (1) the relation of the hazard to the dominant resource use, including in agriculture the ratio between area subject to flooding and the total size of the management unit, (2) the frequency of occurrence of floods, and (3) variations in degree of personal experience. Interestingly, there seems to be little or no significant effect in hazard perception by the few generalized indicators of level of social class or education that have been tested against hazard perception.

The first factor is essentially a reflection of an ends-means scheme of resource use. We would expect to find a heightened hazard perception in those cases, such as drought in an agricultural region or beach erosion on a waterfront cottage, where the hazard is directly related to the resource use. Where it is incidental, such as lightning or tornadoes, the perception of hazard is variant, vague, and often whimsical.

The second factor suggests that the frequency of natural events is related

44. Kates, *Hazard and Choice Perception in Flood Plain Management* (Univ. Chi. Dep't of Geography Research Paper No. 78, 1962).

45. Burton, *Types of Agricultural Occupance of Flood Plains in the United States* (Univ. Chi. Dep't of Geography Research Paper No. 75, 1962).

46. Kates, *Perceptual Regions and Regional Perception in Flood Plain Management*, Papers of the Regional Science Ass'n (1963). [Ed. note: A volume number has not been assigned to this set of papers.]

to the perception of hazard. Where the events in question are frequent, there is little variation among users in their perception. The same holds true where the event is infrequent, for here the failure to perceive a significant hazard is widely shared. It is in the situation of moderate frequency that one expects to find (and does find) considerable variation among resource users.

The third factor is also related to frequency. One would expect that when personally experienced a natural event would be more meaningful and lead to heightened perception. The limited evidence to date does not clearly bear this out. There is a pronounced ability to share in the common experience, and newcomers often take on the shared or dominant perception of the community. Also given a unique or cyclical interpretation of natural events, the experience of an event often tends to allay future anxiety; this is in keeping with the old adage about lightning not striking in the same place twice. Thus the effect of experience as a determinant of hazard perception is considerably blurred.

2. Perception Between Different Resource Users

Differences in perception are found between coastal and flood-plain land resource users in areas subject to storm damage or erosion. Unfortunately, we cannot say more about hazard perception differences between resource users. To our knowledge, they have never been carefully explored, although such study would undoubtedly throw much light on the problem of comparing the resource management policies of different groups and nations.⁴⁷ Some historical comment provides suggestions for the direction that such differences might take.

In a recent article, David Lowenthal notes the changes in our attitude towards wilderness. Once viewed as awesome and tyrannical, nature in the wild is now wonderful and brings us close to the spirit of the Creator. "Our forefathers mastered a continent; today we celebrate the virtues of the vanquished foe."⁴⁸ Nature itself has become synonymous with virtue.⁴⁹ This subject has been examined in some detail by Hans Huth in his study of the attitudes that led to the establishment of the conservation movement.⁵⁰

The rapid expansion of agriculture in the Great Plains during a relatively humid period by settlers from areas with different environmental experience and background is well known. Unprepared for the climatic hazards they encountered, many settlers "were predisposed to believe that the climate was be-

47. For one such attempt see *Comparisons in Resources Management* (Jarrett ed. 1961).

48. Lowenthal, *Not Every Prospect Pleases—What Is Our Criterion for Scenic Beauty?*, 12 *Landscape* 19 (Winter, 1962-1963).

49. Lowenthal, *Nature and the American Creed of Virtue*, 9 *Landscape* 24 (Winter, 1959-1960).

50. Huth, *Nature and the American* (1957).

coming permanently more humid. In fact, many thought that it was the spread of cultivation that brought about an increase in rainfall."⁵¹

Study of other hazards suggests that there is considerable difference in the social acceptance of personal injury depending on the kind of hazard that was the causal agent. Edward Suchman notes that "a report of a few cases of polio will empty the beaches, but reports of many more deaths by automobile accidents on the roads to the beaches will have little effect." He suggests that one explanation may lie "in the greater popular acceptance of accidents as inevitable and uncontrollable."⁵²

A contrast in awareness of natural hazards is exemplified by a warning sign observed in a coastal location on the island of Hawaii. Affixed to a palm tree in an area subject to *tsunamis* at the front door and the hazard of volcanic eruptions and lava flows at the back door (Mauna Loa volcano), this sign merely advises the reader: "Beware of falling coconuts!"

C. Variation in Natural Hazard Perception Between Technical-Scientific Personnel and Resource Users

It is our impression that there is considerable divergence between the perception of natural hazard of technical-scientific personnel and resource users. In the case of floods such divergence is widespread.

Although we have emphasized in the previous section the variation in probability that technical people might assign to a given flood event, these are essentially differences in estimation. Over the past several years we have interviewed or spoken with well over one-hundred technical people concerned with floods, and we have never met one who discounted the possibility of a flood occurring again in a valley that had been previously flooded. By contrast, out of 216 flood-plain dwellers interviewed in a variety of small urban places between 1960 and 1962, all of whom had a measurable flood hazard, some 84 categorically did not expect to be flooded in the future.⁵³

Another example of the disparity between the technical and resource user perception is found in the occasional experience of the rejection of plans for protective works by at least part of the resource users, even when the cost of such works directly to the users in monetary terms was nominal or non-existent. In Fairfield, Connecticut some users of waterfront property opposed the construction of a protective dike along the shore, principally on the contention that such protection "would seriously interfere with their view and result in loss

51. Thornthwaite, *Climate and Settlement in the Great Plains, Climate and Man*, USDA Yearbook 177, 184 (1941).

52. Suchman, *A Conceptual Analysis of the Accident Phenomenon*, Ass'n for Aid of Crippled Children, Behavioral Approaches to Accident Research 40 (1961).

53. Kates, *op. cit.* *supra* note 46.

of breeze."⁵⁴ Similarly, dune-levelling which is universally condemned by technical personnel as destructive of nature's main protection against the ravages of the sea, is widely practiced (as at West Dennis, Massachusetts) to improve the scenic view or to make room for more buildings.

Is such behavior adopted out of ignorance of the hazard; is it symptomatic of the irrationality of resource users in hazard situations; or is there some other explanation? While there are resource users who act in total ignorance of natural hazards, their number is relatively small. Nor can the difference simply be explained away in terms of irrationality. In our view, the difference arises primarily out of the evaluation of the hazard. We offer the following explanation for divergence in hazard evaluation:

1. For some resource users, the differences in perceiving a natural hazard may be a reflection of those existing among scientific and technical personnel themselves. Given the great uncertainty that surrounds the formulation of an "objective" estimate of hazard, the estimate made by a resource user may be no more divergent than that supplied by the use of a different formula or the addition of more data.

2. For some resource users we suspect the divergence in hazard perception may be as fundamental as basic attitudes towards nature. Technical-scientific estimates of hazard assume the neutrality of nature. There are resource users who perceive otherwise, conceiving of nature as malevolent or benevolent. Our language is full of metaphors and descriptions of "Mother nature," "bountiful nature," or, conversely, of "angry storms." Besides attributing motivation to nature, there is also the distinction of man's relation to nature. One recent anthropological study, using a cross-cultural approach, developed a man-nature classification comprising man over nature, man with nature, and man under nature.⁵⁵ Each of these three divergent points of view is represented by the following statement:

Man Subject to Nature. 'My people have never controlled the rain, wind, and other natural conditions, and probably never will. There have always been good years and bad years. That is the way it is, and if you are wise you will take it as it comes and do the best you can.'

Man With Nature. 'My people help conditions and keep things going by working to keep in close touch with all the forces which make the rain, the snow, and other conditions. It is when we do the

54. *An Interim Hurricane Survey of Fairfield, Connecticut*, H.R. Doc. No. 600, 87th Cong., 2d Sess., 14 (1962).

55. Kluckholm & Strodtbeck, *Variations in Value Orientations* (1961).

right things—live in the proper way—and keep all that we have—the land, the stock and the water—in good condition, that all goes along well.'

Man Over Nature. 'My people believe that it is man's job to find ways to overcome weather and other conditions just as they have overcome so many things. They believe they will one day succeed in doing this and may even overcome droughts and floods.'⁵⁶

Samples of respondents were selected from five different cultural groups in an area of western New Mexico, and their responses were distributed as shown in Table IV.

TABLE IV
VIEWS OF MAN AND NATURE BY CULTURAL GROUPS (in percentages)

View of Cultural Group	Nature	Man Subject to Nature	Man with Nature	Man over Nature	Number Interviewed
Spanish-Americans		71.7	10.9	17.4	23
Texans		30.0	22.5	47.5	20
Mormons		25.0	55.0	20.0	20
Zuni Indians		19.0	62.0	19.0	21
Rimrock Navaho Indians		18.2	68.2	13.6	22

Source: Variations in Value Orientations, Appendix 4.

The wide divergence of human views of nature, as illustrated in Table IV, is strong testimony to support our contention that variations in perception are significant and are likely to affect management policies. A society in which belief in the dominance of nature is strong, such as among the Spanish-Americans, is less likely to be conscious of the possibilities of environment control than one in which belief in the dominance of man over nature is more pronounced, as among the Texans.

The belief in technical engineering solutions to problems of hazard is widespread in American society. This belief in the efficacy of man's control over nature is frequently encountered in studies of hazard perception. Thus, it is no longer surprising to find protective powers ascribed to flood control works far beyond their designed capacity. Notable examples are seen in those persons who consider themselves protected by dams downstream from their flood-plain location, or who are satisfied that floods will not occur in the future because a government agency has been established to study the problem.⁵⁷

56. *Id.* at 86-87.

57. Such a response was given to Burton during recent field work in Belleville, Ontario. There, two respondents considered that the establishment of the Moira Valley Conservation Authority meant that no more floods would occur. Such is, in fact, far from the case. The Authority has not been successful in its attempts to have protective works constructed.

3. How much of the divergence in hazard perception can be ascribed to fundamental views of nature is speculative. Much more of the divergence is explicable in terms of basic attitudes towards uncertainty.

We are convinced that there is a fundamental difference between the attitudes or values of technical-scientific personnel and resource users towards uncertainty. Increasingly the orientation and formal training of scientific personnel emphasizes an indeterminate and probabilistic view of the world. Common research techniques involve the use of estimates that reflect imperfect knowledge, and stress is placed on extracting the full value of partial knowledge.

We have considerable social science and psychological theory and some evidence that resource users are unwilling or unable to adopt this probabilistic view of the world and are not able to live with uncertainty in such a manner as to extract full value from partial knowledge.

Malinowsky held that every human culture possesses both sound scientific knowledge for coping with the natural environment and a set of magical practices for coping with problems that are beyond rational-empirical control.⁵⁸ Festinger describes the role of the concept of "cognitive dissonance" as a motivating force, which may lead to actions or beliefs concerning the state of nature that do not accord with rational or logical expectations.⁵⁹ For example, he cites the case of a severe earthquake in India in 1934, in which some people experienced the earthquake but saw no evidence of damage which was quite localized. This situation apparently led to the circulation of rumors which helped to reduce the dissonance created by the fear generated by the earthquake and the absence of signs of damage. People were left in a state of fear but no longer saw reason to be afraid. The rumors that circulated in such a situation have been described by Prasad⁶⁰ and include the following:

There will be a severe cyclone at Patna between January 18th and January 19th. [The earthquake occurred on January 15th.]

* * * *

There will be a severe earthquake on the lunar eclipse day.

* * * *

January 23rd will be a fatal day. Unforeseeable calamities will arise.

58. Malinowsky, *Magic, Science, and Religion in Science, Religion, and Reality* (Needham ed. 1925).

59. Festinger, *The Motivating Effect of Cognitive Dissonance in Assessment of Human Motives* (Lindzey ed. 1960); Festinger, *A Theory of Cognitive Dissonance* (1947).

60. Prasad, *A Comparative Study of Rumors and Reports in Earthquakes*, 41 *British J. Psychology* 129 (1950).

In our experience resource users appear to behave in ways that suggest an individual effort to dispel uncertainty. Among flood-plain users and in coastal areas, the most common variant is to view floods and storms as a repetitive or even cyclical phenomenon. Thus the essential randomness that characterizes the uncertain pattern of the hazard is replaced by a determinate order in which history is seen as repeating itself at regular intervals. Some experiments in the perception of independent events and probability distributions have been conducted by psychologists. The results of such rigorous tests are interesting but are not yet at the level that affords useful generalizations about the real world.⁶¹ Where the hazard is made repetitive, the past becomes a guide to the approximate timing and magnitude of future hazardous events. An historical example of this is documented by Niddrie.⁶² A mild earthquake was recorded in London on February 8, 1750. A somewhat more severe earthquake occurred exactly one lunar month (twenty-eight days) later on March 8th. Predictions were made that a third and more terrible earthquake would occur on April 5th. Niddrie describes the events which followed:

A contagious panic spreading through every district of the town required only the slightest indication that those who could afford to leave the town unobtrusively were doing so, for a wholesale evacuation to begin. The gullible who could not leave bought pills 'which were very good against the earthquake.' As Doomsday came nearer whole families moved to places of safety By April 3rd it was impossible to obtain lodgings in any neighboring town or village.⁶³

When no earthquake occurred on April 5th the prophesies changed to April 8th as though the number eight had some special connotations for earthquakes. Niddrie reports that in fact few of the gentry and well-to-do returned to London until April 9th.

Another view, which is less common, is the act of "wishing it away" by denigrating the quality of the rare natural event to the level of the commonplace, or conversely of elevating it to a unique position and ascribing its occurrence to a freak combination of circumstances incapable of repetition. Either variant has the advantage of eliminating the uncertainty which surrounds hazardous natural phenomenon.

The last alternative view that we can suggest is the completely indeterminate

61. Hake & Hyman, *Perception of the Statistical Structure of a Random Series of Binary Symbols*, 45 *J. Experimental Psychology* 64 (1953); Cohen & Hansel, *The Idea of a Distribution*, 46 *British J. Psychology* 111 (1955); Cohen & Hansel, *The Idea of Independence*, 46 *British J. Psychology* 178 (1955); Hyman & Jensen, *Involvement and Set as Determinants of Behavioral Stereotype*, 2 *Psychological Rep.* 131 (1956).

62. Niddrie, *When the Earth Shook* 20-34 (1962).

63. *Id.* at 29-30.

position that denies completely the knowability of natural phenomena. For this group, all is in the hands of God or the gods. Convinced of the utter inscrutability of Divine Providence, the resource users have no need to trouble themselves about the vagaries of an uncertain nature, for it can serve no useful purpose to do so.

These viewpoints are summarized in Table V.

TABLE V
COMMON RESPONSES TO THE UNCERTAINTY OF NATURAL HAZARDS

<i>Eliminate the Hazard</i>		<i>Eliminate the Uncertainty</i>	
DENY OR DENIGRATE ITS EXISTENCE	DENY OR DENIGRATE ITS RE-CURRENCE	MAKING IT DE-TERMINATE AND KNOWABLE	TRANSFER UN-CERTAINTY 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."

I. Divergence of Values

Natural hazards are not perceived in a vacuum. They are seen as having certain effects or consequences, and it is rather the consequences that are feared than the hazard phenomenon per se. Another source of divergence in the perception of natural hazard between technical-scientific personnel and resource users is related to the perceived consequences of the hazard. For very good and sound reasons the set of probabilities related to the occurrence of a natural phenomenon at a given place is not the same as the set of probabilities of hazard for an individual. Given the high level of mobility in our society, the nature of the personal hazard is constantly changing, while the probabilities for a given place remain fixed (although not precisely known).

Thus, the soil erosion that concerns the technicians in Western Iowa, reported in a recent study,⁶⁴ is an ongoing continuous long-term hazard. The carefully calculated long-term rates of erosion, however, do not have the same meaning for farmers who averaged only nine years as individual farm managers, or where ownership itself changes hands every fourteen years on the average. Soil losses arise from a series of discrete physical events with intensive rains and high winds acting as the major erosional force. The long-term

64. Held, Blase & Timmons, *Soil Erosion and Some Means for Its Control* (Iowa State Univ. Agri. and Home Econ. Experiment Sta. Special Rep. No. 29, 1962).

average of these erosional events may have meaning for the continued occupancy of the agriculture of this area. Hence, the technician's concern for the cumulative soil loss. But given the short average managerial period, the cumulative soil loss seems hardly worth the cost and effort involved in its control for the individual manager.

2. The Case of the Modern Homesteaders

Evan Vogt's study of the "Modern Homesteader"⁶⁵ provides a case study that exemplifies the types of divergence that we have been describing.

Homestead, the site of Vogt's studies during 1951-1952, is in his own words "a small dry-land, bean-farming community" of 200 people in western New Mexico.⁶⁶ It was founded in the early 1930's by families from the South Plains Region of western Texas and Oklahoma, but prior to the deep drought of 1934-1936. While spurred by low agricultural prices, Vogt felt they migrated for primarily what they perceived as a good farming opportunity, a chance to receive 640 acres for sixty-eight dollars in fees and residential and improvement investments.⁶⁷

By 1932 eighty-one families had obtained sections under what was objectively governmental encouragement to agricultural settlement in an area with an average rainfall of about twelve inches. By 1935 the official perception of the suitability of the natural environment for agriculture had changed drastically. Under the Taylor Grazing Act,⁶⁸ all the land in the area which was still in the public domain was classified for grazing and no additional homestead applications were accepted. The official estimate had changed, but that of the local citizens had not. To this day they perceive of their submarginal farming area as one quite suitable for dry land farming. In so doing, their perception is at considerable variance with that of the governmental technicians in a variety of ways.

As we suggested before, total ignorance of natural hazards is uncommon. While drought and frost are perennial hazards (two decades have provided seven good years, seven average years, and six crop failures), these were not ignorant city folk lured to the Plains by free land. They came from agricultural families in an area of less than twenty inches average rainfall. They do, however, perceive the marginality of the area in their own fashion. So marked is the divergence of this perception that Vogt reports the following:

But through the critical days of 'battle' with the government, which had defined their community as 'submarginal' and unsuitable for

65. Vogt, *Modern Homesteaders* (1955).

66. *Id.* at 1.

67. *Id.* at 17-18.

68. 48 Stat. 1269 (1934), as amended, 43 U.S.C. §§ 315-315r (1958).

agriculture, there emerged in the Homesteaders a sense of mission in life: To demonstrate to the experts in the Departments of Agriculture and Interior that the Homestead area is farming country and that they can 'make a go of it' in this semi-arid land. They point to the fact that Pueblo Indians made a living by farming in the area long before the white man arrived. There is a general feeling that somehow the surveys and investigations made by the experts must be wrong. They insist that the Weather Bureau has falsified the rainfall figures that were submitted by the Homestead Weather station in the 1930's, and indeed they stopped maintaining a weather station because they felt that 'the figures were being used against us.'⁶⁹

Vogt mentions in passing another divergence in hazard perception. Homesteaders appear alert to the high westerly wind hazard that erodes the top soil, and they strip crop and plow across the line of this prevailing wind. In so doing, they look askance at the elaborate terraces constructed by the Soil Conservation Service in the 1930's because these terraces are on the contour, and contour plowing itself inevitably results in some of the rows lying in the direct path of the westerly winds.⁷⁰

Faced with continued drought, sandstorms, and killing frosts, the "Homesteaders" exemplify much of what has been discussed in this paper. Vogt finds the predominant attitude as that of nature being something to be mastered and, arising from this, a heady optimism in the face of continued vicissitudes. He finds the strong need to eliminate uncertainty to the point of not collecting weather data as reported above, or through the widespread resort to agricultural magic, involving signs of the zodiac, planting by the moon, and water witching. It is in this last act, the use of water witching, that we find direct parallels with the behavior of flood-plain users. The geology of the Homestead area as it relates to ground water supply is one of considerable uncertainty. The geological structure generates an uncertainty as to the depth and amount of water available at a particular point. Faced with such uncertainty, there was a strong-felt need to hire the local water witch to dowse the wells. While the performance ratio of successful wells to dry holes appeared equal whether they were witched or not, Vogt gives a convincing explanation that witching provides a determinate response to uncertainty where the best that the local soil conservation geologists could provide was a generalized description of the ground water situation. Whether, as in Vogt's terms, the motive is to reduce anxiety, or in Festinger's, to reduce cognitive dissonance, or as we would put it, to eliminate uncertainty, there is the apparently strong drive to make the indeterminate determinate.

69. Vogt, *op. cit.* *supra* note 65, at 68.

70. *Id.* at 70.

In conclusion, Vogt emphasizes

that despite more secure economic alternatives elsewhere, most 'Homesteaders' choose to remain in the community and assume the climatic risks rather than abandon the independence of action they cherish and the leisure they enjoy for the more routinized and subordinate roles they would occupy elsewhere.⁷¹

3. Levels of Significance in Hazard Perception

There are men who plow up semi-arid steppes, who build villages on the flanks of volcanoes, and who lose one crop in three to floods. Are they irrational? Or, to put it another way, having looked at the variation in hazard perception and speculated on the causes of variation, what can be concluded about the rationality of hazard perception? In general, we find absent from almost every natural phenomena a standard for the objective (*i.e.*, true) probability of an event's occurrence. Even if such existed, we are not sure that man can assimilate such probabilities sufficiently to be motivated to act upon them. If decisions are made in a probabilistic framework, what level of probability is sufficient for action? In the terms of statistics, what level of significance is appropriate? What amount of hazard or error is tolerable? Science is of little help here, since levels of statistical significance are chosen at ninety-five per cent or ninety-nine per cent primarily by convention.

Despite the impressive growth of game theory, the growing literature of decision-strategies, and some psychological experimentation with perceived probabilities, the artificiality of the game or laboratory seems to provide at best only limited insights into this complex phenomenon. On the other hand, the derivation of empirical observations, *i.e.*, estimates of the perceived frequency of events or perceived probabilities at which decisions are actually made, provides almost insuperable research difficulties.

In the last analysis, we seem destined to judge the rationality of man's actions vis-à-vis natural hazard out of a mixture of hindsight and prejudice. For the successful gambler in the game against nature there are but a few lonely voices crying that the odds will overtake him. The unsuccessful is clearly judged as foolhardy, ignorant, or irrational. Our prejudice expresses itself in our attitudes towards uncertainty, our preferences for certain types of risk, and how we feel about the objects of resource management.

CONCLUSION

There is a wide variation in the day-to-day management practices of resource users, even within culturally homogeneous groups. We believe that the varia-

71. *Id.* at 176.

tions in hazard perception reported in this article are an important explanatory variable. Unfortunately, careful studies of variation in resource management practices are few and far between. Some of the recent studies of innovation⁷² and the study of farm practices in western Iowa, already cited,⁷³ approach what we have in mind. To our knowledge there have been no studies which adequately describe variations in management practice and rigorously attempt to assess the role of differing perception.

We can say that there is good reason to believe that variations in perception of hazard among resource managers tends to diminish over time. Those who are unwilling or unable to make the necessary adjustments in a hazardous situation are eliminated, either because disaster overtakes them or because they voluntarily depart. Those who remain tend to share in a uniformity of outlook.

Long-term occupancy of high hazard areas is never really stable, even where it has persisted over time. A catastrophe, a long run of bad years, a rising level of aspiration marked by the unwillingness to pay the high costs of survival—each provides stimulants to change. The "Modern Homesteaders," while determined to stay put and exhibiting a high degree of uniformity in their assessment of the environment and its hazards, may yet yield to a combination of an extended run of drought and frost and the lure of a more affluent society. Long-term occupancy, while potentially unstable, is still marked by a tenacity to persist, reinforced, we think, by the uniformity of hazard perception that develops over time. Thus all of the homesteaders who took jobs elsewhere in the bad drought of 1950 returned to the community. More dramatic is the return of the residents of Tristan da Cunha to their volcanic island home.

We have no evidence of a similar growth in accord between resource users and scientific-technical personnel. Clearly, variations in perception may profoundly affect the chances of success of a new management proposal developed by the experts. Such new programs are constantly being devised, but assessments of past programs are seldom found. George Macinko's review of the Columbia Basin project is a recent welcome exception.⁷⁴ Rarely do such studies review programs in terms of divergence of perception. L. Schuyler Fonaroff's article on differences in view between the Navajo and the Indian Service is another exception which proves the rule.⁷⁵

While lacking many detailed statements of this divergence, we can nevertheless state the implication of our findings to date. The divergence in perception

72. See the bibliography in Lionberger, *Adoption of New Ideas and Practices* (1960).

73. Held, Blase & Timmons, *op. cit. supra* note 64.

74. Macinko, *The Columbia Basin Project, Expectations, Realizations, Implications*, 53 *Geography Rev.* 185 (1963).

75. Fonaroff, *Conservation and Stock Reduction on the Navajo Tribal Range*, 53 *Geography Rev.* 200 (1963).

implies limits on the ability of resource managers to absorb certain types of technical advice regardless of how well written or explained. Thus, to expect farmers to maintain conservation practices for long periods of time may be wishful thinking if such practices do not accord with the farmer's view of his resource and the hazards to which it is exposed. Similarly, to expect radical changes in the pattern of human adjustments to floods simply by providing detailed and precise flood hazard information is unduly optimistic. Yet another example is seen in the upper Trinity River area in Texas.⁷⁶ To expect farmers to convert flood-plain land from pasture to cotton or other high value cash crops simply because flood frequency is reduced is to assume that he shares the perception of the Soil Conservation Service. Nor is it a strong argument to claim that such changes in land use were indicated as possible by the farmers themselves, if the question was put to them in terms of the technologist's evaluation of the problem. Good predictions of the future choices of resource managers are likely to be based on an understanding of their perception and the ways in which it differs from that of the technologists.

It seems likely that the hiatus between technical and managerial perception is nowhere greater than in the underdeveloped countries.⁷⁷ There is good reason, therefore, for further research into this topic and for attempts to harmonize the discrepancies in technical programs wherever possible.

While the study of natural hazard perception provides clues to the ways in which men manage uncertain natural environments, it also helps to provide a background to understanding our national resource policy. Despite the self-image of the conservation movement as a conscious and rational attempt to develop policies to meet long term needs, more of the major commitments of public policy in the field of resource management have arisen out of crises generated by catastrophic natural hazards (albeit at times aided and abetted by human improvidence) than out of a need to curb man's misuse and abuse of his natural environment. Some years ago this was recognized by White: "National catastrophes have led to insistent demands for national action, and the timing of the legislative process has been set by the tempo of destructive floods."⁷⁸ It has also been documented in some detail by Henry Hart.⁷⁹ The Soil Erosion Service of the Department of Agriculture was established as an emergency agency in 1933 following the severe drought and subsequent dust

76. Burton, *op. cit. supra* note 45, at 59-73.

77. The results of a recent effort to improve communication between technical experts and resource managers are reported in Central Treaty Organization, *Traveling Seminar for Increased Agricultural Production, Region Tour* (1962).

78. White, *Human Adjustments to Floods* 24 (Univ. Chi. Dep't of Geography Research Paper No. 29, 1945).

79. Hart, *Crises, Community, and Consent in Water Politics*, 22 *Law & Contemp. Prob.* 510 (1957).

bowl early in the decade. The Service became a permanent agency called the Soil Conservation Service in 1935.⁸⁰

Just as flood control legislation has followed hard upon the heels of major flood disasters, so the present high degree of interest in coastal protection, development, and preservation has been in part stimulated by recent severe storms on the east coast.⁸¹ Such a fundamental public policy as the provision of water supply for urban areas was created partly in response to needs for controlling such natural hazards as typhus and cholera and the danger of fire, as well as for meeting urban water demands.⁸² Agricultural and forestry research programs were fostered as much by insect infestations and plant diseases as by the long-range goals of increased production.

Unusual events in nature have long been associated with a state of crisis in human affairs. The decline of such superstitions and the continued growth of the control over nature will not necessarily be accompanied by a reduction of the role of crisis in resource policy. Natural hazards are likely to continue to play a significant role, although their occurrence as well as their effects may be increasingly difficult to separate from man-induced hazards of the quasi-natural variety. The smog of Donora may replace the Johnstown flood in our lexicon of major hazards, and *The Grapes of Wrath* may yield pride of place to *The Silent Spring* in the literature of the effects of environmental hazard, but there will continue to be a pattern of response to crisis in human relations to an uncertain environment. Under these circumstances, understandings of the variations of perception such as we have attempted here are likely to remain significant.

⁸⁰ Buie, *Ill Fared the Land*, USDA Yearbook 155 (1962).

⁸¹ Burton & Kates, *The Flood Plain and the Sea Shore: A Comparative Analysis of Hazard Zone Occupance* (Unpublished manuscript, 1963), scheduled for publication in July, 1964 issue of *Geographical Review*.

⁸² Blake, *Water for the Cities* (1956).