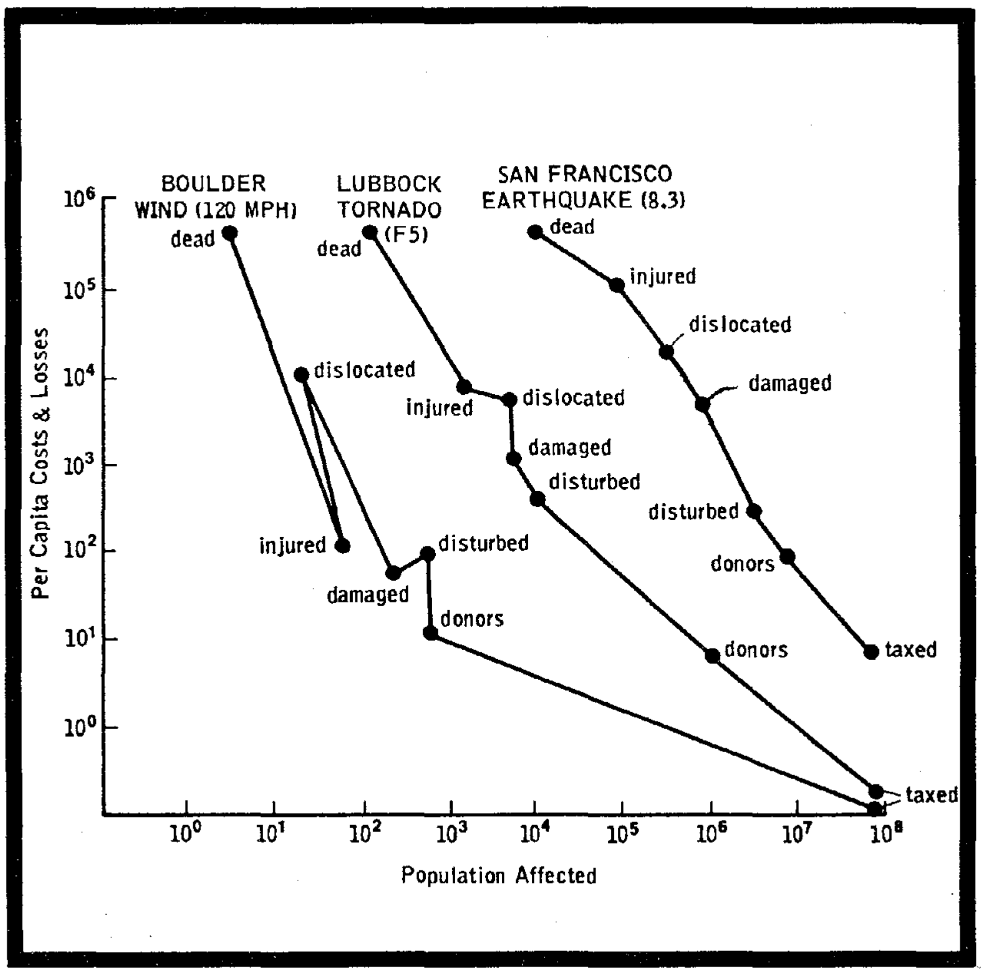
NATURAL HAZARDS AND THEIR DISTRIBUTIVE EFFECTS

Harold C. Cochrane



NSF-RA-E-75-003

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A Reseach Assessment

Harold C. Cochrane

Colorado State University

Program on Technology, Environment and Man

Monograph #NSF-RA-E-75-003

Institute of Behavioral Science

The University of Colorado

1975

Prepared with the Support of the
National Science Foundation
Research Applied to National Needs
Washington, D. C. 20550

NSF Grant Number GI-32942

Library of Congress
Catalog Card No.
75-620047

Together, the entire staff of Assessment of Research on Natural Hazards (J. Eugene Haas and Gilbert F. White, Co-Principal Investigators) developed the objectives, approaches, methods and procedures, and gave assistance which contributed to the production of this volume.

Assessment of Research on Natural Hazards Staff

Robert S. Ayre	Neil J. Ericksen	Dennis S. Mileti
Earl J. Baker	J. Eugene Haas	Allan H. Murphy
Elwood M. Beck	Paul C. Huszar	Sarah K. Nathe
Mitchel J. Beville	Janice R. Hutton	Deanna J. Nervig
Karen K. Bird	Lee E. Kapaloski	Madalyn M. Parsons
Waltraud A. R. Brinkmann	Doris Knapp	John H. Sorensen
Anita Cochran	Brian A. Knowles	Patricia B. Trainer
Harold C. Cochrane	Sigmund Krane	Hazel Visvader
Frederick W. Dauer	Michael K. Lindell	Richard A. Warrick
Barbara S. Dunn	Gordon McPhee	Gilbert F. White

Ian Burton, Don G. Friedman, and Robert W. Kates served as regular consultants to the staff; Richard R. Nervig executed the original illustrations in this volume.

Acknowledgments

There are a number of people who through guidance and inspiration helped me in the process of completing this publication. Special thanks are due to Charles W. Howe for a careful and thoughtful review of the approaches and methods employed. I am equally thankful to Gilbert F. White, who provided a creative environment in which an imagination could be fully exercised. Thanks also to George Zinke and Kenneth Boulding who, through their own works, helped me to grasp the moral and evolutionary aspects of the distribution problem.

As insightful and penetrating as my senior advisors were, much of what I learned in the process of writing this piece came through conversations with graduate students. Discussions with Neil Ericksen, Peter Lichtenstein, and Richard Warrick produced basic changes in the course of my work. Waltraud Brinkmann contributed greatly to the climatological analyses.

A variety of ideas which eventually were woven into the manuscript resulted from conversations with a number of gifted people, particularly Howard Kunreuther, Duane Baumann, Roy Popkin, Robert Kates, and Paul Huszar. To each of them I am deeply thankful.

Sarah Nathe, for a herculean effort of editing such a manuscript, and Janice Hutton, for providing the necessary resources, both deserve special thanks.

Finally, a special acknowledgment to my family, Susan and Joshua, who somewhat cheerfully endured the period of time I devoted to the completion of this publication.

ASSESSMENT OF RESEARCH ON NATURAL HAZARDS
AIMS AND METHODS

The Assessment of Research on Natural Hazards is intended to serve two purposes: (1) it provides a more nearly balanced and comprehensive basis for judging the probable social utility of allocation of funds and personnel of various types of research on natural hazards; (2) it stimulates, in the process, a more systematic appraisal of research needs by scientific investigators in cooperation with the users of their findings.

The basic mode of analysis is to examine the complex set of interactions between social systems and natural systems which create hazards from the extreme geophysical events. The chief hazards investigated relate to: coastal erosion, drought, earthquake, tornado, tsunami, urban snow, volcano, and windstorms. For each of those hazards the physical characteristics of the extreme events in the natural system are examined. The present use of hazardous areas and the variety of adjustments which people have made to extreme events are reviewed. The range of adjustments includes measures to modify the event, as by seeding a hurricane; modifying the hazard, as by adjusting building or land use to take account of the impact of the extreme event; and distributing the losses, as by insurance or relief. Taking all of the adjustments into account, the impact of the hazard upon society is estimated in terms of property losses, fatalities and injuries, and systemic disruption. An effort is made to identify the directions of change in the mix of adjustments and in their social impact. As a part of this review, those forces in the national society which shape the decisions about adjustments are appraised.

Authorities in the field are consulted through literature review, workshops on specific hazards, a national conference which was held in October, 1973, and individual reviews. Where appropriate and practicable, simulations of the extreme events and of their social impacts are carried out. In selected areas scenarios of past and possible future events and their consequences are constructed.

In the light of this analysis the possible contributions of research to amelioration of the national condition with respect to each hazard are assessed. Each set of adjustments is reviewed in terms of its potential effects upon national economic efficiency, enhancement of human health, the avoidance of crisis surprise, the equitable distribution of costs, and the preservation of environmental options. Evaluation of particular research activities includes (1) the average sum of social costs and social benefits from application of a given adjustment in changing property use, and (2) reduction in average fatalities and casualties. In addition to the direct impacts of extreme events upon society, account is taken of the costs and benefits which society reaps in seeking to cope with the hazards, as in the case of costs of insurance or of control works.

In addition to calculating the average effects of hazard adjustments, an effort is made to estimate the degree to which the occurrence of a very rare event which has dramatic destructive potentialities, such as an 8.0 earthquake or a 200-year flood, would disrupt society.

Estimates also are made of the extent to which the adoption of an adjustment reduces the options of maintenance of environmental values, and the degree to which the pattern of distribution of income among various groups in society may be changed.

Research proposals are appraised in the light of the likelihood that the research undertaken could yield significant findings, and the likelihood that once the research is completed satisfactorily, the findings may be adopted and practiced by the individuals or public agencies in a position to benefit.

The United States as a whole is doing a competent job of dealing with some aspects of its natural hazards and a very ragged job of handling other aspects. The overall picture is one of rising annual property damage, decreasing loss of life and casualties, coupled with a marked growth in the potentiality for catastrophic events. On the whole, the public costs of adjustments are increasing.

The assessment reveals that very little is known about the dynamic relationships among many of the adjustments. It is difficult to predict with any confidence what the consequence of new Federal investments or initiatives will be in particular adjustments.

For each hazard a set of research opportunities deserving special consideration for early adoption is presented. In addition, three types of research which cut across the various hazards are assessed: warning systems, land management, and relief and rehabilitation.

Among the research basic to other aspects of natural hazards activity are: carefully planned post-audits of certain disasters by interdisciplinary teams; community observations over time of critical points (recovery policies and administration, health, mental health, and preventive measures) of change and of the effects of Federal-state-community interaction; and a clearinghouse service.

In most research fields it is noted that certain types of research which have claimed substantial amounts of public support offer little prospect of effecting a basic change in the character of the national hazard situation. In those instances there are new lines of emphasis which promise larger returns. Many of these involve more explicit collaboration of social scientists and natural scientists than has been customary in the past. Wherever appropriate, the research recommendations include explicit provision for the translation of research findings into action by individuals or public groups.

To initiate effectively the desirable new lines of research will in some instances require a readjustment in legislative authority. In other cases it will require an increase in or reallocation of public funds for research. Much of it will involve changes in administrative procedures and policies of the responsible funding agencies. In many instances the effectiveness of the research will be linked strongly with the resolution of issues of public policy. These issues revolve around national land use management, financial assistance to suffers from disasters, and the sharing of responsibility among local, state, and Federal agencies in designing and maintaining community preparedness.

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CHAPTER I

INTRODUCTION

Geologic phenomena in the United States cause damage to property in excess of $5 billion per year. These losses range from cracked foundations due to expansive soils to the total disintegration of dwellings in severe tornadoes and earthquakes. These data have been recorded since the turn of the century. With this preoccupation for an accounting of yearly losses, the bearers of the losses have gone almost forgotten. Little is known about who is shouldering these losses--the disaster victim or the state and Federal governments. Furthermore, the social and economic status of disaster victims is as yet imprecisely understood.

The purpose of this publication is to highlight the identity of those individuals bearing the burden of disasters, and those paying for rebuilding as well as pre-disaster damage-mitigating measures. The material displayed in the following chapters is taxonomic in nature, that is, it is an assemblage of current knowledge concerning the distributional impacts of pre- and post-disaster measures. We have, in most cases, avoided judging the merits of different distributional patterns, but have concentrated on a simple presentation of the findings which may be readily used by policy makers and those interested in pursuing research in the field of natural hazards.

The problem of equity vs. efficiency has also been avoided. We proceed under the assumption that knowledge of distributional impacts is desirable in and of itself without reference to the efficiency of alternative hazard adjustments. Consequently, the study may disappoint those who expect to find a sequence of benefit-cost ratios accompanying a discussion of each natural hazard adjustment. This study is intended to help counterbalance the numerous studies purporting to measure the economic efficiency of ways to stem losses from natural phenomena.

A study of *who loses, how much,* and *who pays* begins with the losses: what they are, how severe they are. As shown in our description of the natural event, losses vary drastically with the type of phenomena. Geophysical events, such as large-scale earthquakes, can affect in total more than 50,000 square miles, inflicting widespread damage, loss of life, and economic disruption over much of the area. In contrast, windstorms, lightning, and similar meteorological phenomena are much "softer" in their impact, leaving less severe destruction and massive loss of life.

To illustrate and quantify these differences further, the patterns of damage due to a number of events, both simulated and actual, are described in Chapter II. These patterns serve as basic building blocks from which both direct and indirect effects cascade. Damage and destruction lead directly to injury and life loss as buildings twist, debris flies, dams break, and structures collapse. The effects of destruction are shown to radiate from the point of impact, undermining and disrupting neighboring regions as dislocations are magnified and transmitted through social and economic linkages (Chapter III).

As these impacts run their course, and reconstruction finally begins, the costs of rebuilding are absorbed in part by the entire nation (Chapter IV). Expenditures made by Federal agencies such as the Small Business Administration (SBA) and the Federal Disaster Assistance Administration serve to ease the burden of disaster victims by shifting the load to the general public. In an era of a balanced Federal budget, increased and unplanned reconstruction expenditures will most likely result in curtailment of other less urgent public programs, or in a general tax hike. In either situation, a substantial burden will be borne by those outside the area directly affected.

Although the direct involvement of the Federal government in disaster relief and hazard insurance is well-documented (see Kunreuther, 1973; Dacy and Kunreuther, 1969), there are several institutional arrangements such as the casualty loss deduction, personal bankruptcy, and urban renewal programs which also influence the ultimate distribution of natural hazard losses. These are briefly discussed, and their effects are analyzed in Chapter IV.

As important as these after-the-fact adjustments are to the disaster victim, before-the-fact adjustments (warnings, land use, modification of the event system, and control and protection) are at least as important to the *potential* victim of disaster. The question of who pays for such adjustments has not received a thorough investigation by social scientists. What has been done, along with other information identifying the benefactors and beneficiaries of these predisaster measures, is assembled in Chapter V.

Chapter VI pulls together the findings growing out of the above analyses and suggests a number of research topics.

CHAPTER II

CHARACTERIZING NATURAL EVENTS

The methods employed to assess the current potential for loss are two, simulation and records of historical disasters. The number of events analyzed was kept to a minimum, highlighting the most dramatic of the hazards--earthquakes, floods, hurricanes and tornadoes. Particular locations were selected for analysis because of their recent experiences, as with Rapid City, South Dakota, and Xenia, Ohio, or because of the likelihood of a future catastrophe, as with San Francisco and Dade County, Florida. Such a strategy reduces the generality of the findings, but restricting this chapter to manageable proportions required that such a cut be made.

Natural hazards result from the interaction of the natural and human-use systems. A natural event, be it the rumbling of the earth, a torrent of water, or the explosive forces of wind, exerts an influence on both man and his works. Energy from these events may be released suddenly and without significant natural warning, as in the case of an abrupt slippage along a fault in the earth's crust, or move slowly and evenly, as in the case of soil subsidence.

In a simplistic way, dramatic-destructive events can be viewed as processes whereby energy is transferred rapidly from the environment--wind, water, and ground--to the works of man, inflicting damage to both life and property.[1] It is *not* the *total* amount of energy released in any one of nature's upheavals that creates what is commonly considered a natural disaster, but energy concentrated and delivered over short time intervals. Natural processes such as oxidation, air mass movements, and

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[1]This definition is derived from Haddon, 1970. The transfer of energy is not unique to natural hazards. Structures both physical and biological are continuously subjected to energy from the environment as they follow the natural process of decay.

rainfall, so common to our everyday experience, are seldom considered in the category of natural hazards even though the total energy transfer for many of these ordinary phenomena may exceed that of even the largest conceivable earthquake.

As we shall see later in this chapter, it is this difference in the rate and magnitude of energy transfer that influences and characterizes each of the dramatic-destructive events. Each of these events inflicts a characteristic pattern of damage which differs markedly between and within hazard types. Although the energy/duration classification provides a crude means of sizing the disaster potential for each of the hazards, such a scheme is complicated by variations in the nature of construction to which the energy is being transferred; diferent techniques and quality of construction vary in their ability to withstand the forces of land, wind, and water.[2] The devastating earthquake that struck Managua, Nicaragua, on December 23, 1973, killed at least 20,000 people, due only in part to the fact that its epicenter was directly beneath city center (Richter 5.6). The pattern of heavy damage reflected the construction prevalent in Managua; poorly constructed masonry and adobe buildings respond poorly to ground motion induced by the earthquake. It is highly likely that the death toll would have been substantially reduced had Managua's buildings conformed to construction practices similar to those incorporated into California's post-1933 buildings.[3]

One way of illustrating the destructive forces of different geophysical phenomena is to plot their duration and energy released on a single diagram, as exhibited in Figure II-1. This diagram illustrates those events which are capable of causing extensive areas of heavy damage

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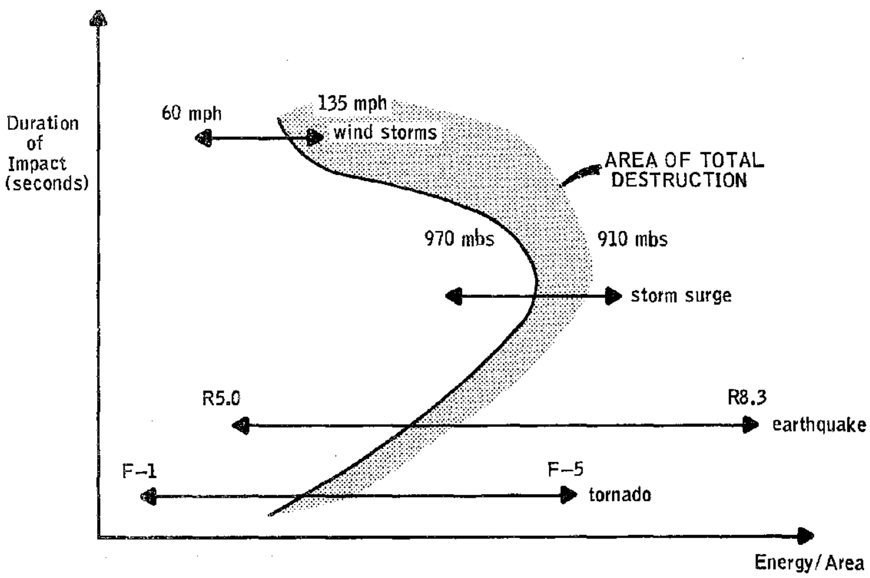
[2]It is almost as if energy in the form of mental and material resources is applied with varying degrees of success to counteract the natural and ongoing transfers originating in the environment. Although the energy transfer scheme is useful for illustrative purposes, it is subject to the criticism that different events spawn forces of different natures; the mode of structure failure induced through earthquake-generated vibrations will be quite unlike the structure failure resulting from extreme wind load.

[3]1933 marked the passage of the Field Act in the wake of the Long Beach earthquake, which instigated a systematic program of evaluating old, and strengthening new construction, particularly that of schools and hospitals.

FIGURE II-1

ENERGY, IMPACT DURATION, AND DESTRUCTIVENESS



Where

F – is a scale developed by T. Fujita (1972) to measure the magnitude of the tornado. An F –1 tornado possesses winds of less than 60 mph while the F–5 storm can have wind speeds of over 300 mph.

R – is Richter magnitude. The San Francisco Earthquake (1906) was estimated to be 8.3 on the Richter scale.

mbs – millibars. The severity of a hurricane is normally measured in central pressure; the lower the central pressure, the more intense the storm.

and destruction. The arrows indicate the range of events within any one hazard. As the duration of impact increases from the fraction of a second experienced with tornadoes to as much as a day with windstorms, the area of destruction increases somewhat and then tends to diminish. The most destructive events are shown in Figure II-1 to be the large earthquake, and storm surge resulting from the extreme hurricane.

These remarks emphasize the destructive forces of different natural phenomena. One could argue that a number of less dramatic events, soil subsidence and expansive soils in particular, are more destructive over the long run (that is, on an expected annual loss basis) than most of the more sudden and spectacular events such as earthquakes. However, as will be demonstrated throughout this publication we are interested in a much broader range of disaster effects than just loss of property. The sudden and total collapse of structures will be shown to lead to death, injury, and temporary economic and social dislocations, the combined effects of which will, in most instances, exceed that of lost real property.

The magnitude of these human costs is related to the destructiveness of the event. This is partly the reason why those who have studied natural hazards have found some difficulty in relating death, injury and disruption to the *total* loss experienced for any given event. Since estimates of total loss ignore differences in the distribution of damage as well as the real extent of the disaster, it is not surprising that events such as hurricane winds are likely to cause a great deal of damage yet little loss of life. In contrast, the long-track tornado which demolishes every third structure touched by the storm, fatally injures nearly ten persons for every 100 houses destroyed.

To illustrate how the differences among the hazards affect the types and distribution of losses borne by society, a set of four hazards of the dramatic-destructive variety have been selected for detailed analysis. The hazards chosen were earthquake, flood, hurricane and tornado. The following descriptions are based partly on the results of simulation and partly on damages recorded as a result of actual disasters. To provide a broad but manageable spectrum of events, particular sites were selected for analysis. Where simulation of a natural phenomenon was required, a brief description of the methods used is provided. An extended discussion of simulation was avoided since this topic was addressed in some detail in Friedman (1975).

The Coming San Francisco Earthquake

San Francisco is a city of almost 300,000 residences, and also one of nine Bay Area counties which would be significantly affected by an earthquake. The entire region employs approximately two million workers, half of which are involved in manufacturing, the other half in local service employment (wholesale trade, retail trade, and other forms of service). There are two major active faults in the area: the San Andreas Fault, which runs north through the southwest corner of San Francisco County; and the Hayward Fault, which runs north-south along the Oakland-Berkeley side of the bay.

The Bay Area economy has undergone significant changes since World War II. In 1939, fewer than a dozen cities had more than 10,000 population; this number increased to 33 by 1958 (Bay Area Simulation Study, 1967, p. 134). Since World War II, the economy has been shifting to a more spatially decentralized and economically diversified region, with no one city exerting a controlling force. The prime tendency which has been at work over the past seventy years is a movement of population and employment away from San Francisco and Oakland to the outlying areas where less congestion and cheaper land are available (Bay Area Simulation Study, 1967, p. 135).

The current distribution of activities is economically diverse. This diversity, although true for the region as a whole, is not true for sub-regions, which are somewhat specialized. The North Bay counties (Solano, Napa, Sonoma, and Marin) are relatively underdeveloped in terms of heavy industry except for Benicia Industrial Park and the Mare Island Shipyard. San Francisco City and County is the former manufacturing center of the area; however, book publishing and shipbuilding are still carried on to a significant degree. By far, San Francisco City's most important economic activity is the service sector--finance, real estate and administrative regional offices. A number of national corporations have their regional offices located there, as do many government agencies, the Federal Reserve Bank, Department of Transportation, Federal Trade Commission, Interstate Commerce Commission, Federal Deposit Insurance Corporation, and Small Business Administration.

South in San Mateo County a combination of heavy industry, steel, and light manufacturing is carried on. Santa Clara County is the center of aerospace contracting and the manufacture of electronics. Some automobile assembly is also carried on, as is the case with Alameda County. Finally, Contra Costa County is the center for steel and petrochemical processing in the region (Bay Area Simulation Study, 1967, p. 167).

Determining the likely impact on San Francisco of the coming earthquake requires a description of the types of shaking which different areas of the Bay region may sustain. A number of simulation models have been developed as aids (Friedman and Roy, 1969; Algermissen, *et al.*, 1969; Evernden, *et al.*, 1972). These simulations permit a more complete understanding of the seismic risk of an area, particularly in those locations for which the record of past events is relatively sparse. For the most part, the simulations are similar; they each begin with an idealized isoseismal pattern representing the areal extent of different earthquake intensities. The units of intensity are usually measured in the Modified Mercalli scale, which describes, qualitatively, the observed effects of the earthquake (see Table II-1).

The isoseismal patterns observed after an earthquake appear to conform to certain regularities. Large earthquakes produce roughly elliptical isoseismal contours, while smaller earthquakes are approximately circular. This seemingly regular behavior of earthquake damage patterns arises from the fact that large earthquakes are normally a product of extended slippage along a major fault. Housner (1970) has observed that, in fact, fault movement and earthquake magnitude are related. A large earthquake on the order of Richter 8.5 will produce a fault movement of nearly 500 miles, while a smaller shock (Richter 6.5) will create faulting which seldom exceeds ten miles. Since energy released from the earth's movement dampens with distance from the fault, one would expect that an approximate earthquake damage pattern would be one based upon an ellipse, the focal distance of which is determined by fault length. This procedure is the basis for simplified predictions of earthquake damages (see Figure II-2).

In order to complete the development of this simplified revision of the simulation, the attenuation of energy from the earthquake's epicenter must be determined. This has been done by estimating the actual damage patterns from historical earthquakes and supplementing them with observations of ground motion as a result of underground nuclear detonations. A description of alternative methods of incorporating this information into an idealized isoseismal pattern is provided in Schnabel and Seed (1972) and Algermissen, *et al.* (1969).

Although they approach an elliptical shape, actual isoseismal contours tend to be somewhat irregular. Friedman and Roy (1969) and Evernden, *et al.* (1972) show[4] that the irregularities can be explained

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[4]Based upon the works of Richter (1958) and Medvedev (1962).

TABLE II-1

MODIFIED MERCALLI INTENSITY VALUES

VI. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken (visibly, or heard to rustle).

VII. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.

VIII. Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.

IX. General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations.) Frame structures, if not bolted, shifted off foundations. Frames cracked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake fountains, sand craters.

X. Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.

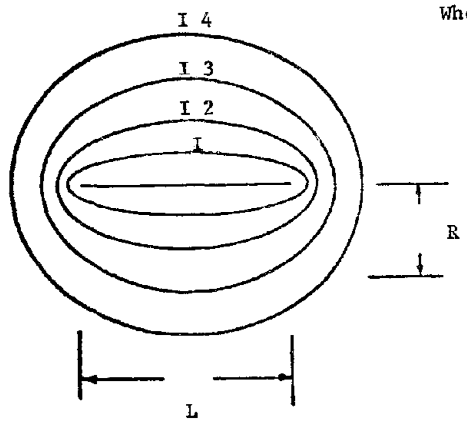
XI. Rails bent greatly. Underground pipelines completely out of service.

XII. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

(Richter, 1958)

FIGURE II-2

AN IDEALIZED ISOSEISMAL PATTERN



Where: L is the fault length for an earthquake with magnitude.
I, I_2, I_3, and I_4 are isoseismals indicating equal intensity levels.
R = distance from the fault.

by variation in local geologic conditions. Table II-2 shows the level of adjustment to intensity (Modified Mercalli) required for various soil types. The difference between the intensity on relatively soft alluvium and that on hard granite is almost 2.5 intensity units (Modified Mercalli): enough to alter considerably the type of damage experienced in a location.

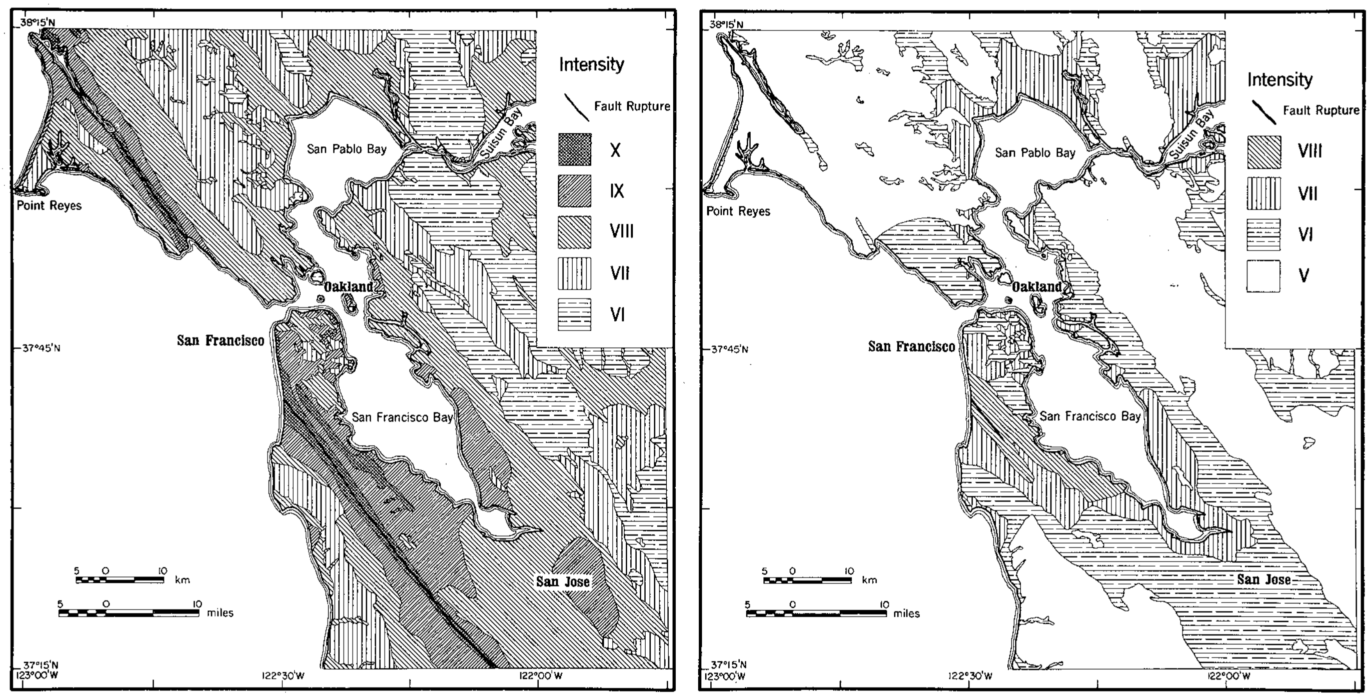
Adjusting isoseismals according to soil characteristics has been tested and has been found to provide a fairly accurate representation of historical events, the 1906 San Francisco earthquake in particular (Friedman and Roy, 1969). Utilizing the approach just outlined, the National Oceanic and Atmospheric Administration, through the U. S. Geological Survey, has simulated a set of earthquakes in the San Francisco Bay region. Figure II-3 shows the damage patterns for a large (8.3R) and a moderate (6.0R) earthquake, the epicenter of each located on the San Andreas Fault. These two patterns provide the foundation for assessing the distributional implications of the earthquake event in the following chapters.

Algermissen, *et al.* (1969) estimated the annual frequency of

FIGURE II-3

THE COMING SAN FRANCISCO EARTHQUAKE

SAN ANDREAS 8.3 | SAN ANDREAS 6.0



(Adapted from NOAA, 1972)

TABLE II-2

EFFECTS OF LOCAL SOIL CONDITIONS ON INTENSITY

California - Statewide (Friedman, modified)	Change in intensity (Modified Mercalli)
A - Granite and other hard rocks	-2 1/2
B - Coast ranges, etc.	-1 3/4
C - Coastal marine sedimentary rocks	- .8
D - Alluvium	- 1/2 to 0
No provision for poorer ground	--------

(Adapted from Evernden, *et al.*, 1972, p. 372)

earthquakes of varying intensity for the state of California. By analyzing the historical pattern of earthquake magnitudes, it was possible to show that the 3,128 earthquakes recorded between 1800 and 1967 under-represented the number actually occurring.[5] Correcting for this bias, the total number of earthquakes was estimated to be 12,000 for the same period. The bias was corrected by employing a generalized seismicity relationship for the region. The relationship, relating the log of the number of earthquakes to intensity, was first derived for a shorter but more complete period and then applied to the longer time span, 1867 to 1967 (Algermissen, *et al.*, 1969). The annual frequencies of the differing intensity earthquakes were derived, and are shown in Table II-3.

[5] This downward bias reflected the sparse population and the lack of trained observers in the early days of the state.

TABLE II-3

FREQUENCY OF EARTHQUAKE OCCURRENCE IN CALIFORNIA

Magnitude	Intensity	Annual frequency (estimated)
	IV	76.137
	V	17.75
	VI	4.145
	VII	0.966
6.0	VIII	0.225
	IX	0.0526
	X	0.0123
8.3	XI	0.00286

(Adapted from Algermissen, *et al.*, 1969, p. 30)

The annual frequency of a large earthquake (8.3R) occurring anywhere in California is roughly three in 1000 years; the frequency of a 6.0R earthquake is about two in ten years.

April 3, 1974, Tornadoes

On the evening of April 2, 1974, a tornado watch was issued by the National Weather Service Severe Storms Forecast Center for a nine-state region stretching from Michigan to Alabama. The warning was prompted by an unusually intense spring storm accompanied by a strong cold front. The following day the front clashed with a mass of warm air moving up from the Gulf of Mexico. This resulted in an outbreak of almost 100 tornadoes, which struck an eleven-state region, inflicting the greatest damage in the states of Ohio, Alabama, Kentucky, Indiana and Tennessee. The damage was at least $1 billion, and the life loss exceeded 300.

In contrast to earthquakes, scientific knowledge about tornadoes is meager--probably because of the event's small size and short duration. The physical characteristics that are known are based primarily upon visual sightings, photographs, and upon analysis of the damage path.[6] The physical

[6]One exception to this approach of analyzing the hazard's effects

characteristics of the event vary with the magnitude of the storm. Winds may be from as little as 50 mph to as much as 175-250 mph, although these speeds have never been accurately measured. Wind speed is not the most destructive force of the tornado. Inside the tornado pressure may drop, in extreme cases, to as little as 10% of the atmospheric pressure, causing structures to explode. Unlike earthquakes, tornadoes are a composite of physical forces, wind and pressure drop, each influencing the distribution of damage to a different degree. The track of a tornado also varies considerably--the longest recorded in 1971 was 198 miles long and .6 mile wide; the smallest one confirmed was ten yards long and one yard wide (Fujita, 1972, p. 2).

Since 1971, an attempt has been made to classify tornadoes crudely according to some measure of magnitude. Fujita (1971; 1972) developed a scale (F and FPP), which characterizes tornadoes according to their damage area, damage intensity, and path length and width. Using the F-Scale descriptions, climatologists have begun classifying all tornadoes; the results show that for total United States, of the 872 tornadoes recorded in 1971 only 97, or 11%, were of sufficient magnitude to create wide destruction (see Table II-4). It will be convenient to refer to

TABLE II-4

FREQUENCY OF OCCURRENCE OF DIFFERENT MAGNITUDE TORNADOES
1971

F Classification	Number Recorded	Relative Percent	Wind Speeds mph
F0	152	18	40–72
F1	367	42	73–112
F2	256	29	113–157
F3	72	8	158–206
F4	23	3	207–260
F5	2	.2	261–318
TOTAL	872	100	

(Fujita, 1972, p. 6)

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is the work done by T. Fujita (1972) at the University of Chicago, in which simplified physical models of the tornado event have been constructed.

tornadoes as belonging to one of two categories: *severe* and *moderate*. Severe encompasses those events which are classified as F-3 or greater, moderate includes all others.

The Coming Dade County Hurricane

Dade County is located at the southern tip of Florida, where the land elevation is seldom greater than ten feet above sea level. Recently, much of the area has been developed, and the number of single residential units in the county is approaching 450,000. Much like San Francisco, the Dade County area, including Miami, employs a large number of people in services. Wholesale trade, retail trade, finance, insurance, and real estate account for about 50% of the region's $2.2 billion gross product. Most of the remaining economic output is construction and government activity.

The coming Dade County hurricane will bring two distinct sets of damaging forces--storm surge and wind. Storm surge produces damage similar to, but more severe than that of normal riverine flooding, since the action of the surf tends to inflict greater stresses on structures. Unlike most flood-induced damage, which is related to the height of water, storm surge is best represented by height *plus* a second component, velocity, producing a damage relationship similar to that of flash floods.

The height of the storm surge is related to several factors: the wind speed, the length of the open water over which the wind is blowing, and the shape of and depth of water on the continental shelf. The height of the surge, although primarily determined by these factors, is modified by the shape of the coastline, the presence of estuaries which can double the surge height through a funneling effect, and the coincidence of the hurricane with astronomical tides.[7]

A number of hurricane simulations appropriate for assessing the damage patterns for the coming Dade County hurricane have been developed

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[7] A more precise discussion of the storm surge and wind phenomena can be found in Brinkmann, *et al.* (1975) which was the source upon which this discussion is based.

(Friedman, 1973; Jelesnianski, 1972). Although the dynamics of hurricanes are imprecisely understood, Jelesnianski has made use of empirical relationships derived from records of historical storms to estimate the peak storm surge. Nearly 30% of the variance in storm surge height can be accounted for by hurricane intensity, that is, its central pressure (Jelesnianski, 1972, p. 5).[8] To account for much of the remaining variance Jelesnianski incorporated factors into the model which reflect the effects of storm size (radius), local bottom topography, and storm motion; their inclusion boosts the variance accounted for to 70% (Jelesnianski, 1972, p. 26).

Figure II-4 shows the potential inundation due to storm surge resulting from an extreme and moderate hurricane, a "Camille" type (910 mbs) and a "Betsy" type (950 mbs) respectively. The contours show coastal flooding in feet above the terrain.[9] The major difference between the events is the magnitude of severe flooding, "Camille" generating almost 500 square miles of twelve-foot storm surge, compared to "Betsy's" 30 square miles.

Simulation of hurricane winds has been carried out by Friedman (1973). Keying on variables similar to those used by Jelesnianski, storm path, size, speed and intensity, a pattern of winds of differing velocities was obtained for a storm moving inland. Figure II-5 shows the effect of distance inland on wind speed. The diagram indicates that wind velocity drops rapidly as the hurricane moves inland; for the extreme hurricane (914 millibars central pressure), the maximum wind velocities reach 170 mph, but drop to 130 mph fifty miles from the coast. The relationship between wind velocities and dwelling damage (also shown in Figure II-5) suggests that wind damages from all but the "extreme" hurricane will result in an average loss of *less* than 10% of structure value.

Simulation results (Friedman, 1974) of wind patterns based on the relationship are shown in Figure II-6. The simulation presented on

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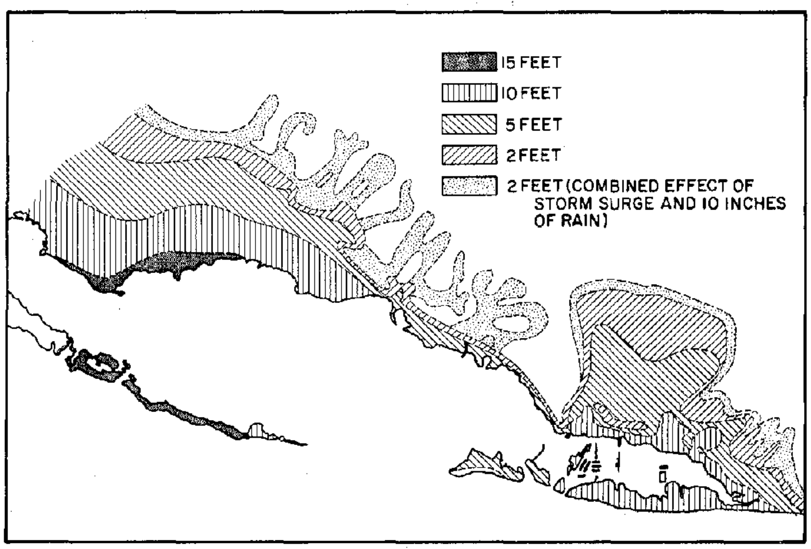
[8]The results shown by Jelesnianski indicate a linear relationship between peak storm surge height and change in atmospheric pressure (AP): two feet in peak surge for every ten millibars drop in pressure (p. 6).

[9]The contours shown exaggerate the magnitude of damage somewhat since they represent an envelop of peak storm surges associated with landfalls at four-mile increments. Not all the inundation shown would be expected from a single hurricane.

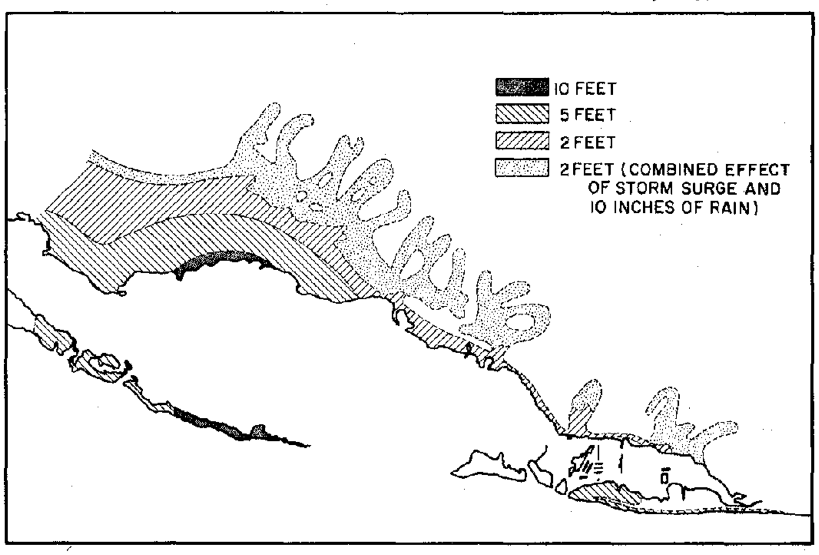
FIGURE II-4

THE COMING DADE COUNTY HURRICANE:
PATTERN OF STORM SURGE

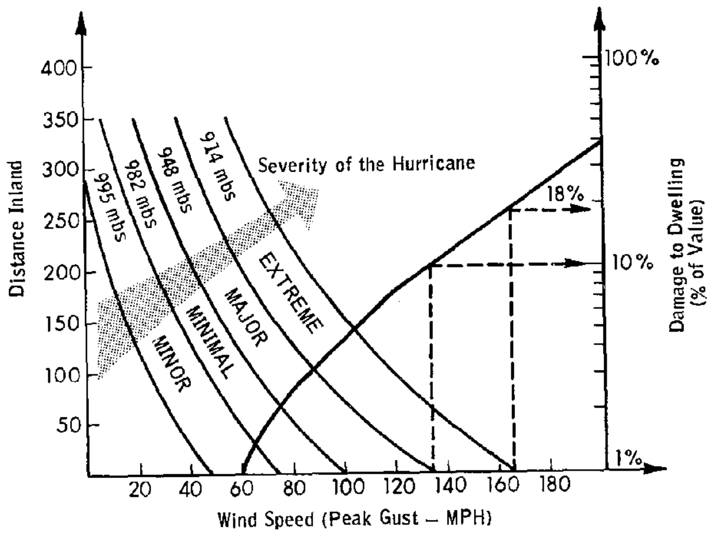
"Camille" Type (910 mbs)



"Betsy" Type (950 mbs)



(The Miami Federal Executive Board, 1973, p. 40 and 41)



(adapted from Friedman, 1963 and 1971)

FIGURE II-5

DISSIPATION OF HURRICANE WINDS AS STORM MOVES INLAND

the left of Figure II-6 represents an extreme hurricane (910 mbs, a "Camille" type) carrying wind velocities of up to 170 mph. The simulation on the right is of a more moderate revision (950 mbs), based upon an identical landfall. The likelihood of either hurricane occurring in Dade County is difficult to determine, both because the number of recorded hurricanes is relatively small and because the occurrence of hurricanes is not randomly distributed along the coast.[10] The National Oceanic and Atmospheric Administration has performed studies of the Gulf and East coasts for the Federal Insurance Administration (HUD) to determine the

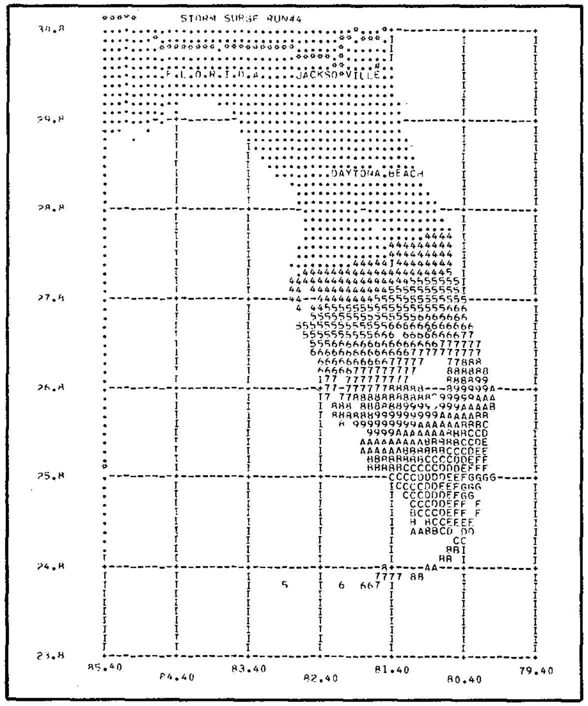
[10]It is theorized that certain tracks are more probable than others, with specific hurricane tracks being related to the storm's origin.

FIGURE II-6

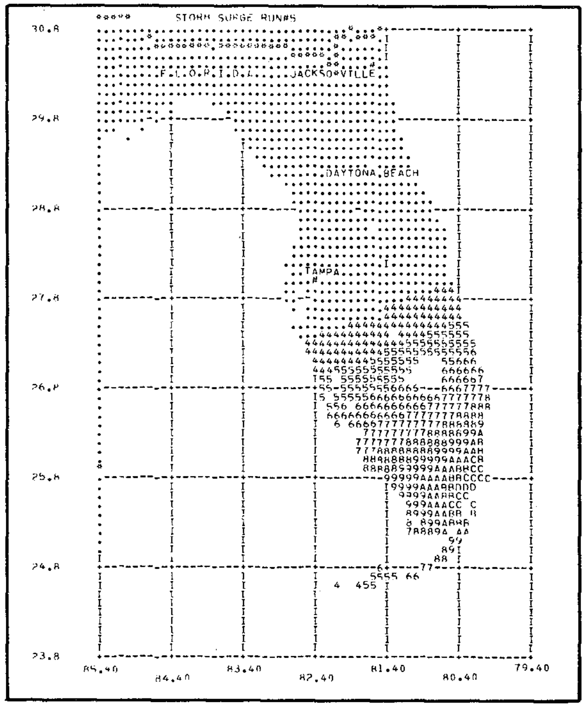
THE COMING DADE COUNTY HURRICANE: WIND VELOCITIES

Key: Digits indicate wind velocity (mph) from 10 to 90.
Alpha characters indicate wind velocity, greater than 90 mph.

"Camille" Type (910 mbs)



"Betsy" Type (950 mbs)



(Simulation performed by Friedman, 1974) return interval of varying magnitude events. Results of their analysis for the Dade County area reveal that the "Betsy" type storm has a return interval of 25 to 75 years, while a "Camille" type hurricane is likely to occur less than once every 200 years (derived from National Oceanic and Atmospheric Administration, 1972, p. 7).

Rapid City Flood

Rapid City, a relatively large town (44,000) in South Dakota, has had fourteen floods over its 100-year history. Rapid Creek waters drop 4,000 feet over a 34-mile stretch from their origin in the Black Hills to Rapid City. After some delay and after the damaging floods of 1942, 1949, and 1952, Pactola Dam was constructed sixteen miles west of town, the estimated effect of which was to control 76% of Rapid Creek's watershed runoff above the town. Aside from this structure and the recreational reservoir within the city limits, Canyon Lake Dam, the town's 2,000 residences in the 100-year flood plain were relatively unprotected from the hazard of flooding.

The nature of damage to which these residences were (prior to the 1972 flood) susceptible depends upon several factors: the velocity of the flood waters, the sediment and debris carried by the creek, and the depth and duration of flooding. The greater each of these factors, the greater the damage. Since the absence of any one factor may be compensated for by the increase of another, it is difficult to rely on any one factor to obtain an accurate estimate of a particular event's potential destruction. The flash flood of June 9, 1972, because of high velocity and debris, was more destructive than a slow flood, as is often the experience along the Mississippi River, even for comparable depths.

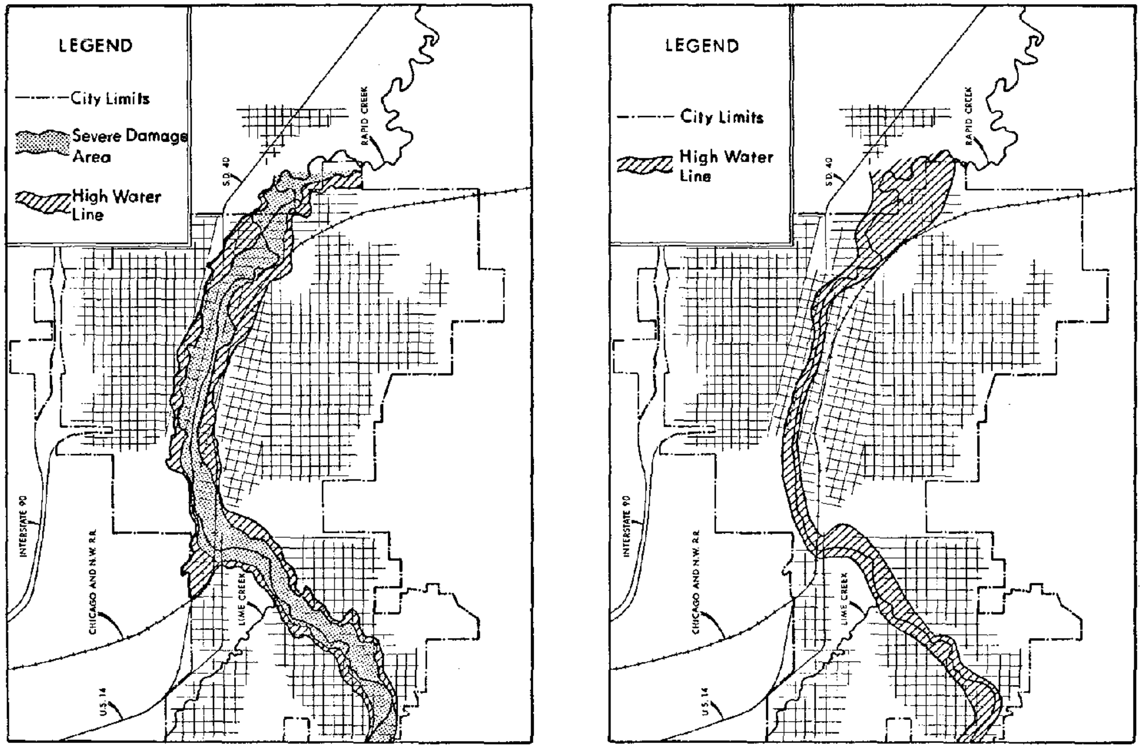
Variation in the inundation area for two historical events, the 1920 slow flood and the 1972 flash flood, are shown in Figure II-7. The most significant point of contrast between these events is the presence of a severe damage area in the 1972 disaster, absent in the 1920 flood. This zone reflects the effect of the wall of water which came cascading down the canyon at extremely high velocity, and created a swath of nearly total destruction.

FIGURE II-7

THE RAPID CITY FLOODS:
1920 & 1972

Flash Flood (1972)

Slow Flood 1920)



CHAPTER III

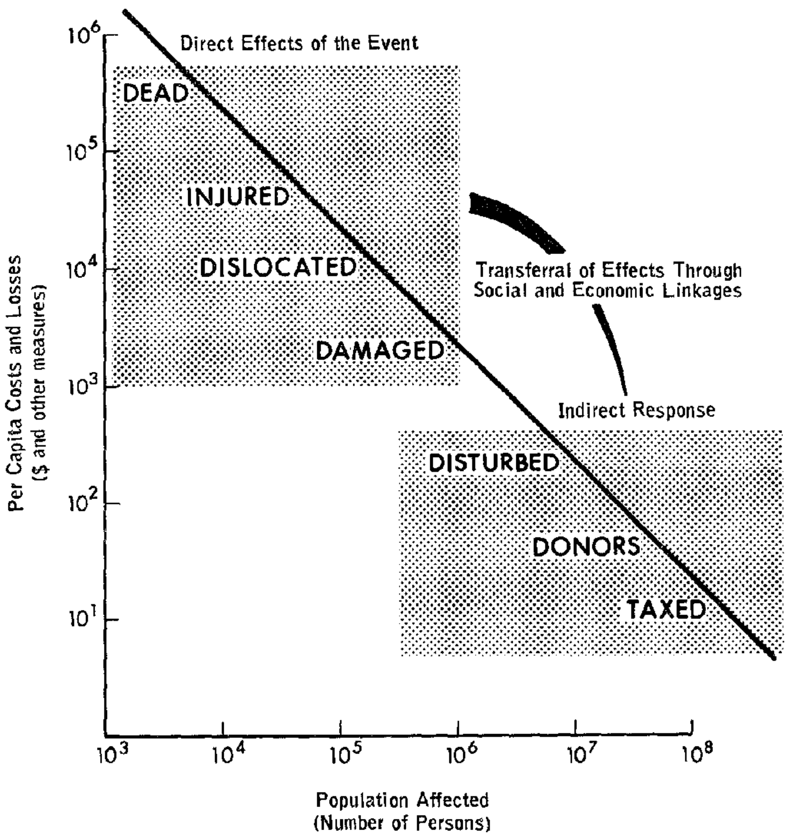
THE CASCADE OF DISASTER EFFECTS

> The costs of disaster, the pain of the dying and injured, the disruption of the lives of the living, the losses of real and symbolic wealth are not clearly assessed, counted or scaled. The costs of disaster are clearly inequitable, falling heaviest on a few, but the population affected, if only in some small measure is large in an interdependent industrial society (Bowden and Kates, 1974).

This statement summarizes the nature of the investigation on which we are about to embark. Following Bowden and Kates (see Figure III-1), a continuum or cascade of disaster effects will be constructed for each of the events discussed above. The continuum ranges from those killed and injured to those who pay for reconstruction through donations and taxes. Somewhere in between lie the dislocated, those experiencing loss of home, neighborhood and treasured possessions; the damaged, those whose loss is redeemable and who may be compensated through disaster relief and/or insurance; and the disturbed, those for whom the disaster creates some economic hardship, the temporary loss of employment or the inconvenience of disrupted economic and social activities.

Although the continuum shown in Figure III-1 indicates in a generalized way the types of suffering that follow disaster, the nature of the event, its onset time, location, and areal extent have much to do with the numbers of individuals that are destined to fall somewhere along the continuum. Hence, extrapolations from the *particular* events we have chosen to analyze should be made with the utmost caution. However, this is not to suggest that these sites were selected at random; on the contrary, their selection coincided with concern on the part of those who study natural hazards about specifics of disasters.

Unlike the effects of the San Francisco earthquake shown in Figure II-3, the effects of a large drought equivalent to that of the 1930's



(adapted from Cochrane, *et al.*, 1974)

FIGURE III-1
IMPACT OF DISASTER: A CONTINUUM OF EFFECTS

will be an order of magnitude more than the 5,000 to 10,000 estimated to die in the San Francisco earthquake. Although deaths will not be as direct and dramatic as the falling buildings and trapped victims, malnutrition accompanying the drought will, for either this country or for many of the grain-importing nations, affect the well-being of large populations. Similarly, the numbers of dislocated will be swelled both by nature's destructive capacity, and by social and cultural arrangements which may be equally effective in separating people from their property. It may have made little difference to those who lost their farms in the drought of the 1930's whether the causal mechanism was natural or social--the result was the same.

The following analyses draw upon the events discussed earlier. Their purpose is to provide an estimate of the degree to which the cascade shown in Figure III-1 is altered by particular hazards. Wherever possible, the characteristics of the population bearing a large share of the load are provided. Because each element in the continuum is linked, as will be shown, to other elements, the total magnitude of loss is *not* the simple summation of the components. The effects shown are gross losses before the effects of relief and insurance have been incorporated, the effects of redistribution being treated separately in a later chapter.

Dislocated and Damaged

The cascade of disaster effects illustrated in Figure III-1 pivots on the estimated number of families left homeless (dislocated) and the number whose homes sustained some form of damage less than that of total destruction. The importance of dislocation and damage in the scheme stems from the fact that death and injury are most often the product of twisted, collapsed and disintegrated dwellings. Similarly, the economic ripples that radiate from the point of disaster, the employment dislocations, are hinged closely to the destruction and damage brought upon the economic base of the region. Widespread but minimal damage which leaves an area's production processes relatively unaffected, is unlikely to perpetuate very strong secondary forces--any that may be set in motion are likely to dampen quickly. In contrast, the destruction of a large number of critical industries will send strong impulses throughout the region resulting in probable persistant economic dislocations and unemployment.

Figures II-3 through II-7 provide the basis for assessing the number of families that would have or had experienced dislocation and damage as a result of these particular natural disasters. Each map shows the degree to which the different forces characteristic of each event were/would be present--ground shaking, hurricane wind velocities, hurricane storm surge heights and riverine flood depths, indicated in Figures II-3 through II-7 respectively. The degree of damage sustained by the affected populations was derived by overlaying census track maps on these events and applying the appropriate intensity damage relationship found in Figure III-2.[1] These relationships simply indicate the percentage of a dwelling's value destroyed as the severity of the event's force increases. Ground shaking resulting in a Modified Mercalli measurement of X would damage *on the average* 24% of a wood frame dwelling's value. If the average dwelling in the affected region was valued at $20 thousand, damage to structure would total $4,800.[2] An eight-foot storm surge would totally destroy a single family dwelling (100% of value), an eight-foot slow flood would result in 22% loss in the dwelling's value, and so on.

The resultant distribution of damages for each event is displayed in Table III-1 (detailed breakdown may be obtained from Appendix I, The shape of the distribution, the relative number of structures destroyed and damaged, is derived from the interaction of the event forces, the areal extent of these forces, the number of persons dwelling in the affected areas, and a relationship which converts these natural forces into estimates of property destruction. Reviewing the results in Table III-1, one is struck by the wide variation in damages. For example, if the 1920 slow flood had occurred in Rapid City instead of the June 9 disaster, no more than 300 of the city's families would have been affected, most experiencing only minor inconvenience. In contrast, the flash flood

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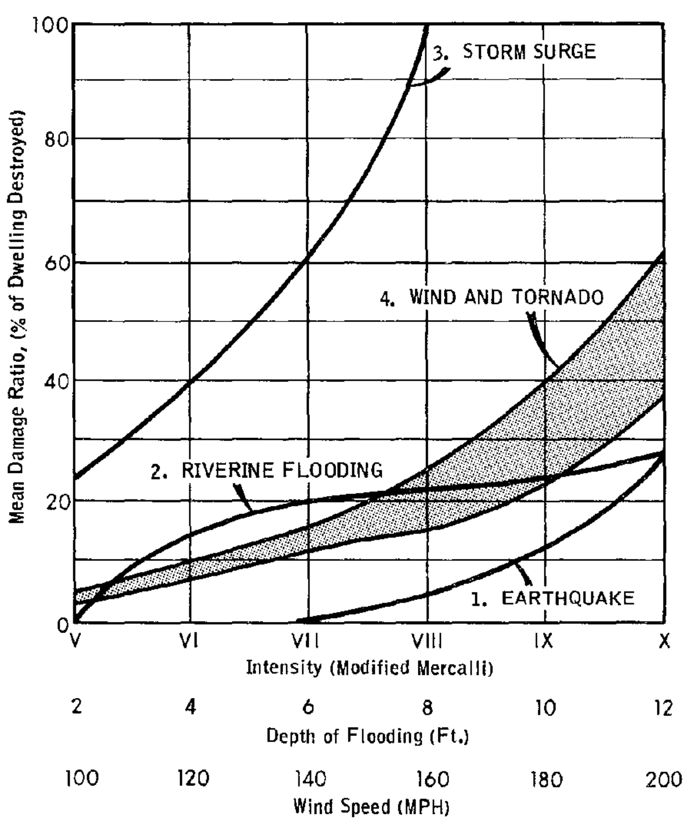
[1]For a detailed explanation of the procedure used, see Appendix II (not printed). A similar but not identical approach was used to obtain a distribution of hurricane wind damage. It was unnecessary to use census data for this hazard since the damage patterns were simulated and automatically calculated by a computer program (see Friedman, 1974).

[2]It is emphasized that 24% represents an average for M. M. intensity X. Some dwellings, depending upon type of construction, will collapse totally when subjected to such shaking, others of different construction will fare extremely well under identical circumstances. In order to capture the variability around the mean damage ratio at each intensity level, the variance in damages experienced as a result of the San Fernando earthquake was calculated for regions of equal intensity.

Intensity Damage Relations



Event Intensity

NOTES

The mean damage ratio is an average damage to structures subjected to the intensities shown. These ratios were supplemented with data on the variance around the mean ratio to obtain the distributions of damages shown in Table 3

SOURCES

EARTHQUAKE: Friedman (1966)
RIVERINE FLOODING: Friedman (1966)
STORM SURGE: Friedman (1966)
WIND AND STORM SURGE: Friedman (1971)

FIGURE III-2

EVENT INTENSITY AND DAMAGE

TABLE III-1

POPULATIONS AFFECTED FOR DIFFERENT HAZARD EVENTS

		HURRICANE DADE COUNTY a. Storm surge b. Wind (Southern Fla.)		EARTHQUAKE SAN FRANCISCO		RAPID CITY FLOOD		APRIL 3 TORNADOES[1]	
	Event Magnitude	"Camille" 910 mbs	"Betsy" 950mbs	Richter 8.3 San Andreas	Richter 6.0 San Andreas	1972 Flash Flood	1952 Slow Flood	F-1&2	F-3, 4 & 5
Number of Residences Affected (% of value)	Less Than 50%	a. 184,000 b. 569,000	a. 146,000 b. 214,000	285,850	33,200	1200	300	77	2774
	More Than 50%	a. 85,000 b. 0	a. 200 0	12,000	less than 200	800	0	13	1480
Number of Residences Exposed		a. 450,000 b. 1,074,000							

[1] Includes the states of Kentucky, Indiana, and Alabama

which did occur affected almost 2,000 families, over 40% of which lost home and possessions, and 237 of the least fortunate lost their lives.

A comparison between hazards shows a similar disparity with regard to destructive capacity. A "Camille" type hurricane (910 mbs) striking Dade County is likely to sweep away over *85,000* dwellings, and will create far more destruction than even an 8.3R San Francisco earthquake, in which *12,000* dwellings are likely to be shaken beyond repair. One way to compare these events is to plot their felt areas and the areas of total destruction on a single diagram, as is done in Figure III-3. The closer an event lies to the shaded area of the diagram, the higher the proportion of catastrophic loss to total loss. As shown, a 6.0R earthquake centered around San Francisco would result in over 1,000 square miles of felt area, yet only those within a total area of one square mile would experience severe damage. In the case of the 1920 Rapid City flood, the total area affected is drastically less, a little over ten square miles, with almost no severe damage.

In terms of the cascade of disaster effects, the zone of potential large-scale catastrophe is one in which both the felt areas and regions of complete destruction are great. It is in this zone that the potential for serious disruption and large-scale life loss is present.

Dead and Injured

1. Numbers of Dead or Injured

It was stated above there there is a strong likelihood that events which bring widespread destruction (as opposed to damage) to an area, will also bring a proportionately large level of casualties. As a test of this linkage, a ratio of deaths to total dwellings *destroyed* was calculated for 23 disasters (see Table III-2). A review of these ratios shows a fairly consistent relationship--for every 100 houses destroyed one would expect an average of eleven deaths to result. This simple procedure is subject to some criticism on at least three counts. First, the degree of natural warning (how quickly the event strikes) should influence the ratio. Slow floods may at times be very destructive but usually occur over a protracted period of time, normally several days, allowing most occupants to be evacuated from their homes. Flash floods, tornadoes, earthquakes and other dramatic events normally strike with little or no natural warning,

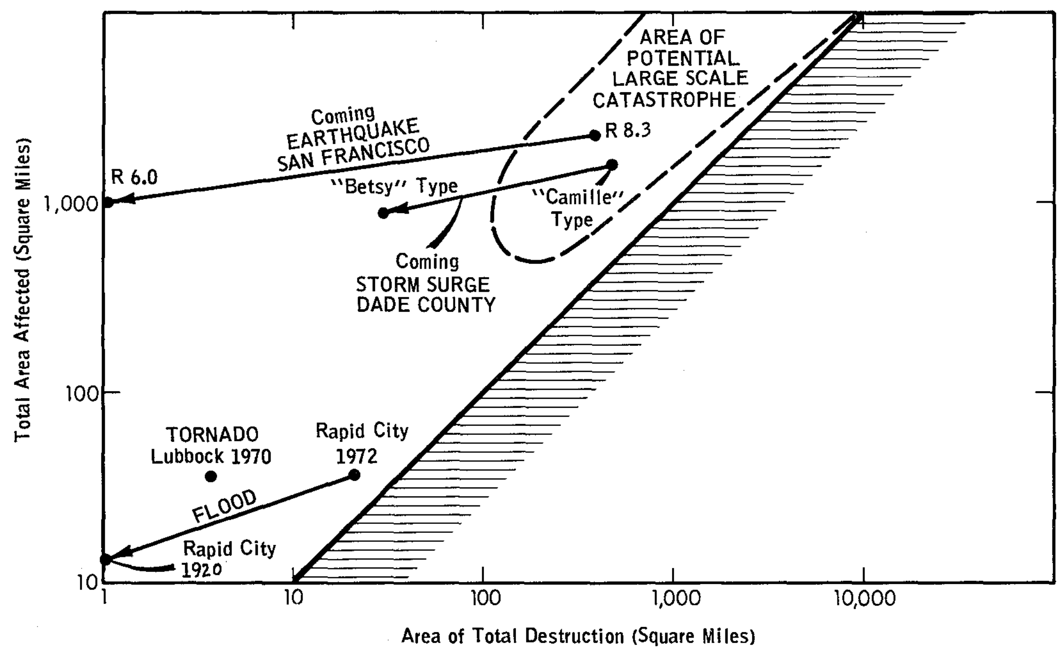


FIGURE III-3

DESTRUCTIVE AREA OF DIFFERENT HAZARD EVENTS

TABLE III-2

RATIO OF DEATH TO TOTAL DESTRUCTION IN PAST DISASTERS

Hazard	American Red Cross Disaster Report[1]		Ratio of deaths to structures totally destroyed
TORNADOES	Michigan	4-11-65	.080
	Illinois/Wisconsin	4-11-65	.061
	Faulkner County, Arkansas	4-10-65	.054
	Eastern Area -	4-11-65	
	Ohio		.093
	Indiana		.192
	Hail County, Texas	6-5-65	.071
	Mississippi/ Alabama	3-3-66	.397
	Greenwood County, Arkansas	4-19-68	.118
	Creighton County, Arkansas	5-15-68	.204
	April 3 Tornadoes	4-3-74	
	Ohio		.012
	Indiana		.034
	Kentucky		.050
	Tennessee		.110
	Georgia		.254
	North Carolina		.155
	Alabama		.080
		Average	.114
FLASH FLOODS	Sanderson, Texas	6-11-65	.460
	Rapid City, S. D.	6-9-72	.324
		Average	.334
HURRICANES	Hilda	10-3-64	.023
	Dora	9-14-64	.020
	Audrey	6-25-57	.255
	Betsy	8-27-65	.020
	Camille	8-5-69	.389
		Average	.110
EARTHQUAKES	San Fernando	2-9-71	.077

(American National Red Cross Disaster Summaries) [1] The variation in level of aggregation for the disasters reviewed is due to variation in Red Cross reporting procedure.

diminishing the usefulness of evacuation as a lifesaving practice. Second, this ratio ignores any improvements in the detection of phenomena and dissemination of warning messages. One may expect, as both detection and dissemination improve, that the ratio would decline. Third, the mode of structure failure would affect the probability of being killed. Total destruction from an earthquake may not result from the complete collapse of a dwelling, whereas the total destruction due to a tornado, more often than not, indicates a total disintegration of the structure (in Table II-2, the ratio for San Fernando [.077] is less than that for either flash floods [.334] or tornadoes [.114]).

Although these points seem to weaken our argument, it is surprising how closely most of the events cluster around the 11% average (except for flash floods). Because of this, and the fact that most of the disasters are recent, we will apply this average to all events, recognizing that this procedure will produce an upward bias for some events and a downward bias for others. For the crude nature of cascade we seek to develop, such errors will have little impact.

The total number of seriously injured was also found to be related to the number of structures totally destroyed. Using the same data from which Table III-2 was developed, it was discovered that in tornado disasters an almost one-to-one relationship exists between a house being destroyed and the occurrence of an injury of any type. Of the total injuries occurring, nearly 20% required hospitalization (see Figure III-4). It is assumed that this ratio also applies to other "hard" disasters such as earthquakes. For water-related disasters, hurricanes and floods, the ratio appears to be one injury for every two houses destroyed, with, again, a 20% ratio of serious to total injury.

2. The Costs of Death and Injury

Assessing the cost of injury and death is a difficult undertaking. However, it is something that is done, at least implicitly, everyday. Society appears to have limited the resources devoted to saving lives; dialysis, for example, is a costly means of preserving life, and few can either afford or receive sufficient outside aid in order to undergo such treatment for extended periods. The court system, in awarding damages in

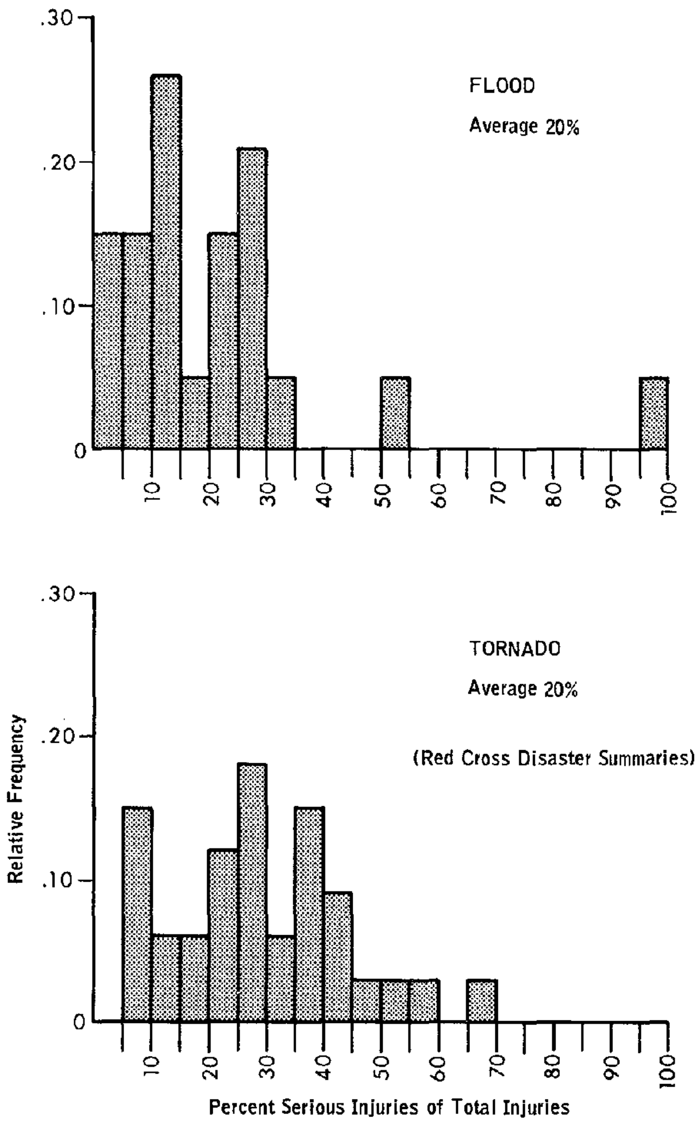


FIGURE III-4

RATIO OF HOSPITALIZATIONS TO TOTAL INJURY wrongful death or injury cases, provides a dollar estimate of pain and suffering (as well as foregone earnings) endured by those injured and the family of the deceased. The purpose here is not to detail casualty costs, but to provide a crude breakdown which is somewhat sensitive to the nature of the disaster, and one which would enable us to complete the cascade of disaster effects.

In order to determine the cost of serious injury for any event, we first sought to determine the distribution of costs experienced after a representative "hard" disaster. Figure III-5 shows the distribution of medical costs (A) and length of recuperation (B) for a sample of 102 injuries suffered in the Creighton County, Arkansas, tornado (1968). The average cost of hospitalization was estimated to be approximately $2,000, exclusive of follow-up costs, such as the fitting of artifical limbs or physical therapy. Almost 10% of the cases shown incurred health care costs in the range of $5 to $10 thousand (1973 dollars). Compounding the

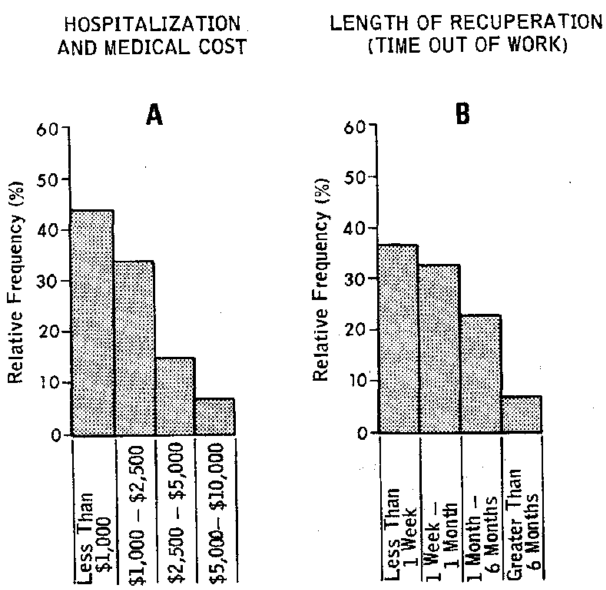


FIGURE III-5
DISTRIBUTION OF MEDICAL COSTS:
CREIGHTON COUNTY TORNADO

direct financial burden of this medical care is the lost wage due to long periods of recovery, which was estimated to last more than one month for almost 30% of those in our sample.

The costs of care and foregone wages are the real costs of injury and do not reflect the human costs of pain, suffering and incapacitation. One way of capturing these nonpecuniary aspects of injury is to review court awards. Table III-3 provides a breakdown of the magnitude of award

TABLE III-3

A REVIEW OF COURT AWARDS FOR PERSONAL INJURY

TYPE OF INJURY	AVERAGE AWARD (1960)
Permanent brain damage	$64,000
Head injury without permanent brain damage	12,000
Disfigurement (emphasized)	10,000
Disfigurement (unemphasized)	1,100
Fracture or dislocated vertebra	32,000
Disc injury	55,000
Spinal cord injury	111,250

(Estimates derived from Kelly, *et al.*, 1961)

by type of injury. Although it was impossible to overlay these awards on the real medical costs shown in Figure III-5, the magnitude of the awards indicates that a factor of two or three should apply, that is, the $2,000 average health care cost should be adjusted upwards to between $4,000 and $6,000, all factors considered.

It may be dangerous to extrapolate these findings to other disasters, particularly of the "soft" variety (slow floods, for example). For water-related disasters the probability of sustaining injury comparable to that shown in Figure III-5 is small. On the other hand, tornadoes and earthquakes, because of the forces involved--the collapse of buildings, and flying debris--increase considerably both the odds of sustaining injury and the costs of hospitalization.

Court awards in wrongful death suits were estimated by Melvin Belli in 1954 to average $167,000 (Buehler, 1972, p. 39). If the escalation in injury settlements observed over the past two decades is applied to death suits, the current figure most probably will lie in the $300,000-$350,000 range.

3. Who Are They?

Little is currently known about differences in death and injury rates among regions, income groups, or age groups. The few studies that have been done point to a discrepancy between casualty rates in the North and the South (Sims and Baumann, 1972), and between the old and the young (Trainer and Hutton, 1972). Because of the dilapidated condition of low-income housing (see Table III-4), one would expect a similar discrepancy

TABLE III-4

HOUSING CONDITION BY INCOME CLASS

Dollar bracket	Portion of all households in bracket	Housing condition (percent)		
		Sound	Deteriorating	Dilapidated
Annual income				
Under 1,000	5.9	67.4	19.9	12.7
1,001-2,000	9.4	70.5	20.3	9.2
2,001-3,000	8.5	76.2	16.4	7.4
3,001-4,000	7.9	79.9	14.3	5.9
4,001-5,000	7.8	82.8	13.5	3.7
5,001-6,000	8.9	86.0	10.9	3.1
6,001-7,500	13.5	90.1	8.5	1.4
7,501-10,000	16.3	93.5	5.9	0.6
10,001-15,000	15.3	96.4	3.3	0.3
15,001-25,000	5.4	98.4	1.4	0.1
Over 25,000	1.0	100.0	0.0	0.0

between the rich and the poor, although studies to substantiate this hypothesis have yet to be conducted.

Further support of the results obtained by Sims and Baumann and Trainer and Hutton was gleaned from American Red Cross summaries of the April 3 tornado disaster (1974). In reviewing the ratios shown in Table III-4, it is apparent that the greatest rates of death were found in the South and the least in the North. This discrepancy is particularly surprising since the most publicized disaster, that in Xenia, Ohio, had the lowest ratio, .012. There may be reasons for this difference, aside from a regional factor, e. g., differences in construction practices and time of the event. But as yet these results remain a puzzle.

The Red Cross summaries showed that the elderly were affected to a disproportionate degree. Table III-5 shows a comparison between our results and those obtained by Trainer and Hutton (1972) for the Rapid City

TABLE III-5

AGE DISTRIBUTION OF DISASTER FATALITIES

EVENT	AGE	AGE DISTRIBUTION OF POPULATION AFFECTED %	DISTRIBUTION OF DEATHS %	DIFFERENCE %
	Under 18	34.7	26.6	-8.1
TORNADOES	18 to 64	55.5	56.1	+ .6
April 3,	Over 64	9.8	17.3	+7.5
1974	TOTAL	100.0	100.0	0.0
(American National Red Cross Disaster Summaries)				
RAPID CITY	Under 18	34.8	21.9	-12.9
FLOOD	18 To 64	57.0	45.2	-11.8
June 9,	Over 64	8.2	32.9	+24.7
1972	TOTAL	100.0	100.0	0.0

(Trainer and Hutton, 1972)

disaster (1972). In both instances those over 64 years of age suffered a proportionately greater level of fatalities. This, of course, would be somewhat expected since the old are less apt to recover from serious injury; however, these results also point to an opportunity of reducing fatalities by selective programs to warn and provide adequate protection for the elderly.

The Disturbed

The effects of disaster may have impacts which reach far beyond the areas which are visibly damaged.[3] Economic dislocations of varying severity are likely to arise, not just due to direct damage to productive activity and lifeline services,[4] but also as a result of critical shortages and reduced demand, the secondary effects of damage to a region's economic base. The nature of these dislocations is similar to that caused by both reductions in automobile production and curtailments in the supply of energy in the form of coal and oil. Reduced activity at final assembly plants both idles workers, reducing their demand for goods and service produced and sold within the region, and reduces the car manufacturer's demand for materials and components from which cars are assembled, in turn idleing workers in other regions. On the supply side, recent experiences with an embargo on oil imports and a strike of soft coal miners has served to illustrate the impact of these critical shortages on both prices and employment. Although less dramatic and of a diminished magnitude, the temporary curtailment of production in a disaster-stricken community could create disruptions of a similar nature.

The word "disturbed" is used here to describe the disruptive influence disaster has on the "normal" *economic* functioning of the community. Although the emphasis here is on the economic, "disturbance" also has its psychological and social dimensions.

> The chaotic living conditions and distressing personal experiences often accompanying severe major disasters may cause unusual mental stress and lead to psychological disturbance.... Expert observers have noted a definite increase in mental health problems attributable to several recent catastrophes, such as

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[3]A few studies have been done to assess the secondary impact of disaster (see Dacy and Kunreuther, 1969; Minor, *et al.*, 1972; Harbridge House, 1972; and Cochrane, Haas, Bowden and Kates, 1974).

[4]Lifeline services refer to the services of utilities and government--electric power, natural gas, sewer, protection, roads, and transportation.

the San Fernando earthquake and the devastating floods of Rapid City, Wilkes Barre, Corning, and Elmira. Under these circumstances it is not uncommon to find increased anxiety, a great fear of subsequent disasters, intense feelings of depression, helplessness, irritation, anger, grief, despondency or even built...a marked rise in accidents,...and stress-induced physical illness (U. S. Senate, 1974, p. 2230).

1. Earthquake

A recurrence of an earthquake of the magnitude of that in 1906 in San Francisco, is likely to set in motion a dynamic set of adjustments, driven and governed by the economic and social linkages in the Bay area. As economic linkages tighten in response to the destruction, it is expected that unemployment will ensue, and will be translated into reduced demand for goods and services still produced in the region. Property and sales tax revenues would fall at a point in time when the need for expenditures is the greatest--when reconstruction of public facilities, roads, and utilities is vital to the recovery of the economic structure. Direct damage to productive capacity would retard the production of intermediate goods in the area. To the extent that serious shortages of critical goods develop, and inventory levels are insufficient to absorb the effects of supply disruption before alternate supplies can be found, a further decline in regional output would be expected. It is this complex interaction of supply, demand, and damage which forms the basis of the analysis to follow.[5]

Before these indirect effects just sketched can be estimated, the direct reduction of the region's productive capacity must first be determined. This was done by overlaying the isoseismal pattern shown in Figure II-3 (San Andreas 8.3), on a map of planning districts,[6] each district indicating the relative concentrations of residences, the number of persons employed in basic industry, and the number employed in local service industry. By so doing, earthquake intensity levels could be allocated to each district, and the direct effects of the disaster on regional economic activity could be determined. Table III-6 shows the number of

[5]A more rigorous explanation of the methods employed in deriving the results shown here is provided in Appendix II (not printed).

[6]The planning districts used in this study were formulated by the Association of Bay Area Governments (1973); see Appendix II (not printed).

workers affected by earthquake intensity level.

TABLE III-6

EMPLOYMENT AFFECTED BY INTENSITY LEVEL

Type of Activity or Structure	Intensity--Modified Mercalli X	IX	VIII	VII	VI	Total Employment Affected	Total Employment In Region
Basic Industry Employment (Thousand)	83	253	421	78	44	879	965
Basic Service Industry Employment (Thousand)	84	220	479	72	54	909	1,011

The intensity damage relationship used in this study (Appendix II, not printed) suggests that a great proportion of the economic activity carried on in the intensity X area would come to a halt as a direct consequence of the earthquake. This zone of damage is shown in Table III-6 to encompass nearly 170 thousand workers. In addition it is expected that certain activities located in intensity zones IX and VIII will experience termination of output and service. In total, nearly 210 thousand employees would find their places of work at least temporarily unable to continue operation because of damage to both structure and contents.

The projection of 210 thousand unemployed San Francisco Bay workers underestimates the total impact of the disaster because it ignores secondary effects alluded to above. Most of the basic employment effects are estimated to occur in the cities of San Francisco and San Jose. Similarly, local service employment reductions are likely to concentrate in San Francisco proper. Those industries and services which are most concentrated in these areas are food products; paper products; finance, insurance and real estate; government services; and other types of light manufacturing. In order to estimate the secondary effects of such reductions in employment, it is necessary first to determine how the Bay Area economy is likely to restabilize. The problem is not so simple as a uniform expansion and contraction of the gross regional product, because not all activities are affected to the same degree. A simple interindustry approach provides little in the way of guidance.

The economic adjustment would probably follow a pattern which begins with a direct and immediate curtailment of certain activities. Reductions in output of key industries and services would create bottlenecks and shortages to exacerbate economic contraction and the problems of unemployment. As the ranks of the unemployed grew, demand for goods produced and distributed in the region would contract and add additional impetus to the collapse. At the same time, revenues obtained from sales and property taxes would diminish; in the absence of external sources of aid, local governments would be forced to reduce services at a time when demand for their restoration will have peaked. The linkages between direct damage, employment, final demand, taxation, and government services will tend to feed back and forth until the Bay Area economy stabilizes at some reduced level of gross product. It is unlikely that this process will be allowed to run its full course; Federal agencies will at some point step in to prop up local government, provide assistance to the unemployed, and facilitate the easing of shortages and bottlenecks.

Ideally this adjustment process could be analyzed with a dynamic input-output model which would contain a provision for relative price changes, the price changes reflecting excess demand for certain products in short supply.[7] It is difficult to forecast the potential for other types of substitutions, but a dynamic interindustry analysis would be an adequate approximation to the types of adjustments occurring in the post-disaster situation.

Because of the exploratory nature of this study, a somewhat simpler approach to this problem was undertaken. Analysis of the economic contraction was limited to the first year following the disaster. This

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[7]Considerable effort has been expended in recent years on a similar problem, that of assessing the economic impact of a nuclear attack. The models thus far developed, although complex, could readily be converted and applied to the problem of natural hazards. For an example, see Pitcher (1971) for a discussion of the General Economic Model used by the Office of Civil Defense. The Army Corps of Engineers has also considered the use of the imput-output technique to estimate development benefits of water resource investments. The Corps has restricted their assessment to the economic stimulation of a region as a direct result of the project, and has omitted reference to the secondary impact due to disaster.

eliminated problems of capital accumulation during the recovery phase, as well as relative price changes. With these factors omitted, the problem could be formulated within a linear programming framework, one in which the regional product is maximized subject to the constraints of the remaining resources, and to the pre-earthquake technical coefficients of production.[8]

There are certain advantages to what at first may appear to be an overly abstract and normative mode of analysis. First, production patterns are not likely to shift quickly, and since the period of investigation is limited here to one year after the impact, the assumption of fixed coefficients may not be all that unrealistic. Second, the results obtained through linear programming are likely to be conservative, the losses actually materializing tending to be higher. Lastly, the analysis is conducted in real terms so price changes due to local bottlenecks (or to any other institutional considerations such as bankruptcy) are ignored. This would tend to underestimate the disruption the Bay Area may actually experience. Application of this approach yielded the secondary reductions in regional product and value shown below in Table III-7 (see Appendix II, not printed, for a more detailed presentation of results).

TABLE III-7

INTERINDUSTRY EFFECTS OF DAMAGE TO SAN FRANCISCO'S PRODUCTIVE SECTOR

	Levels of Economic Activity		
Economic Indicator	Pre-Earthquake ($ Billion)	Post-Earthquake Direct Damage Only ($ Billion)	Post-Earthquake Direct Damage Plus Indirect Effects ($ Billion)
Gross Regional Product	53	43	39
Value Added	22	19	16

[8]See Appendix II (not printed) for a more detailed discussion of the method employed.

There are two indicators shown in Table III-7: Gross Regional Product, which shows a decline of $14 billion; and Value Added, which is reduced by $6 billion. Although the term gross product is the most familiar in discussing economic performance, it is a misleading indicator to employ in deriving the implications of a regional economic downturn. It includes not only the value of economic activity of the region, but also the value of goods and intermediate products made elsewhere; therefore, the Value Added category, reflecting incomes to labor, capital, and other factors of production based solely within the region, is used to indicate the degree of economic collapse the earthquake would induce--about $6 billion in the first year.

On a household basis, this loss would amount to $4,000.[9] However, not all families would be affected evenly. Unemployment in some industries may be short-lived, but others with higher capital intensity and with greater dependence upon regional economic activity could require more than the year estimated in Table III-6. Not all of the $6 billion in lost income would be borne entirely by the Bay Area residents, since the reduction in value added would be reflected in profits, rents and wages. Much of the decline in profits would be transmitted outside the region via diminished dividend payments.[10] The $4,000 average loss per family should be adjusted to account for differences in income source and the degree to which individuals may be affected. Including these considerations, the per-family loss is adjusted to $8,000 for the 250,000 families most significantly affected.[11]

One factor purposefully excluded from the interindustry analysis, the effect of price changes, needs special attention both because of its

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[9]This estimate was derived by dividing the $6 billion reduction in value added by the approximate 1.8 million affected by the disaster.

[10]Stockholders of affected corporations may also incur losses because of stock price fluctuations. These and related affects are neglected.

[11]Most significantly affected are those whose place of employment was located in areas of intensity X and IX.

potential for prolonging the period of recovery of the area, and because of the implications for equity. Evidence concerning local inflation following a large disaster is inconclusive. Dacy and Kunreuther (1969) found that price changes following the Alaskan earthquake were rather insignificant. However, this could be explained on two grounds. First, the disaster was relatively minor in terms of total damage, around $300 million. Second, Federal government employment in the state totaled, in 1963, 58% of the work force (Rogers, 1970). This large exogenous source of funds as well as goods would be sufficient to stabilize the economy given the magnitude of shock it experienced. It appears for these and other reasons that the problems of Alaska and San Francisco may not be comparable. New evidence available from Rapid City appears to indicate that a considerable rise in building costs and housing values followed the flood in 1972. Verification of this possibility deserves careful attention, since the prevailing belief is that acts of benevolence following a disaster serve to keep the price of essentials such as housing from escalating. A restrained set of prices may not be the case for a large, concentrated disaster, such as that considered here.

Rapid price changes in the stricken community have two effects. First, they tend to retard recovery since they introduce another element of uncertainty which would only serve to compound the problems of reestablishing stabilization in employment and output. They may also put the regional industry in an unfavorable cost position at a point when its productive position is already weak. Second, rapid price changes would lead to a transfer of resources from the disaster victims to real estate and construction interests, many of which may be based outside the region or even the state.

Aside from price changes, disruption to the San Francisco area economy is likely to result in a broader but less significant disruption to the State of California and the Western Region in general.[12] There is some evidence to suggest that southern California is economically insulated from the North fairly well. Martin and Carter (1962) found, in an inter-

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[12]Although this study did not specifically address the problem of multiregional input-output effects, it would be a logical extension from the basic approach applied here.

industry analysis of the state, that the effects of final demand for northern products are concentrated within northern California, rather than being distributed over the entire state (p. 63). The Los Angeles area is likely to be affected by the disruption in the North, but not to any significant extent.

2. Flood

Harbridge House (1972), inquiring into the long-term economic impact of Tropical Storm Agnes, concluded that similar disruptions to those depicted above for earthquakes occurred in the Agnes-induced floods. Figure III-6 shows the affects of flood damages on employment for durable and nondurable manufacturing. The trends show that employment in the production of nondurables (the economic sector hardest hit by the disaster) had not recovered its pre-disaster level even after fourteen months. Fortunately for the region, the stimulation of durable goods production resulting from the massive inflow of Federal aid (under Public Law 92-385) was sufficient to absorb most of the unemployed workers.

There are several reasons why the impact on employment for the Agnes disaster was not greater. First, as in most flood plains,[13] a relatively small proportion of a town's productive capacity is exposed to damages. Although the number of nondurable industries affected was large, durable manufacturing, because of location in new industrial parks off the flood plain, was relatively untouched by the flood waters. Second, if a structure was affected, the probability of damages inhibiting production for an extended period of time was small. These ingredients for a relatively rapid recovery do not necessarily apply to the magnitude of disaster such as that depicted above for earthquakes.[14]

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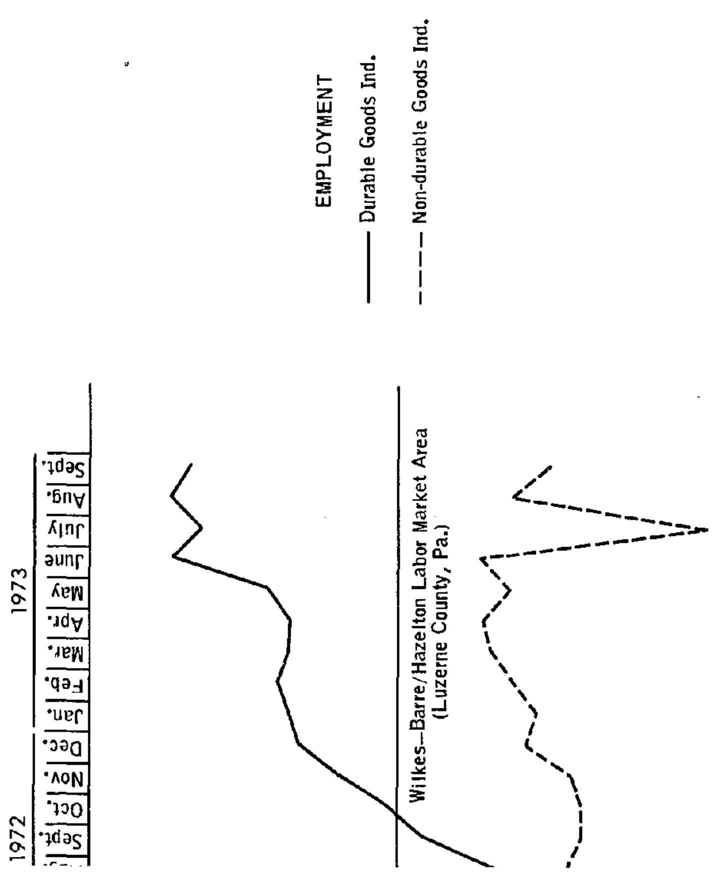
[13]A study of 25 communities of varying size and regional location showed that the average percentage of developed land in the flood plain was 10%. There were a few communities for which the percentage exceeded the average--Charleston, South Carolina, 20%. However, it is not uncommon to find in the Northeast old established towns whose industry is concentrated in the flood plain (Goddard, 1973).

[14]The large earthquake (Richter magnitude 8 and greater) will inflict extensive damage over a much wider area, affecting nearly nine counties in the San Francisco Bay region.



ed from Harbridge House 1972, p. IV–6)

FIGURE III-6
EMPLOYMENT EFFECTS DUE TO THE AGNES FLOODS

One lesson from Lubbock that may apply to a larger disaster is the willingness of employees to help clean up after the disaster and the willingness of companies to employ them to do so. Minor, *et al.* (1972) point to this in their analysis of the machinery sector of the Lubbock economy:

> A significant factor which was common to many of these firms was the maintenance of a full payroll as long as there was work to be done (clean-up, reconstruction work) (p. 31).

However, upon completion of these tasks the employees were usually temporarily unemployed.

> When this had been accomplished, only the labor forces required to support limited production were retained. Thus, most of these firms retained a full labor force in the immediate post-disaster period (1-4 weeks) but cut back on employment during later time periods (1-6 months). Many

coastal counties of Texas and Louisiana.[16] Although the population concentration and potential for loss of life is less in these areas than in Dade County, the potential for protracted employment effects is much greater. The degree of risk to which these refineries are exposed and the potential for disruptive effects is as yet incompletely investigated.[17]

Putting the Effects Together

In summary, the number of those disturbed depends upon the magnitude of the disaster and the affected region's linkages with neighboring areas. From the limited number of studies that have been done so far to estimate the potential of economic disturbance following disaster, it appears that earthquakes and hurricanes are capable of generating the greatest effects. Floods and tornadoes, because of their limited areas of severe damage, do not seriously threaten generation of employment effects which radiate much beyond the community level. Table III-8 provides crude estimates of disturbances based upon the studies just cited.

These figures represent the general nature of disturbance for a particular set of disasters; variations in industrial concentration and types of activities affected could shift the numbers disturbed and the per capita costs for other disaster locations.

Figure III-1 showed in an illustrative fashion how the impact of disaster may cascade from the dead to the taxed. In this section we will assemble the estimates made above to compare and contrast the disaster potential of the four dramatic destructive events. Estimates for the categories "donors" and "taxed" are temporarily omitted in the material that follows, since the distributional impact of reconstruction under a variety of public programs is treated separately in a section to follow.

Although this study is limited to the events previously discussed, it may turn out that these are not the most catastrophic of disasters. An

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[16]This estimate was derived from "domain" input-output data provided by Neal FitzSimons of the Defense Civil Preparedness Agency. The area for which the 22% applies is comprised of the following counties: Jefferson, Harris, Galveston, Nueces, Brazona, all in Texas; and St. Bernard Parish in Louisiana.

[17]A study of the Galveston area has revealed that the coastal areas on which substantial refining capacity is based have been sinking at the average rate of six inches a year (Warren, 1974).

TABLE III-8

A REVIEW OF SYSTEMIC EFFECTS OF SELECTED DISASTERS

DISASTER	NUMBER OF FAMILIES AFFECTED	PER FAMILY COST ($)[2]
Coming San Francisco Earthquake		
Richter 6.0	Less than 1,000	1,000
Richter 8.3	250,000	8,000
April 3 Tornadoes		
F - 1 and 2	none	none[1]
F - 3, 4, and 5	Less than 500[1]	3,000[1]
Coming Dade County Hurricane		
"Betsy" Type (950 mbs)	none	none
"Camille" Type (910 mbs)	10,000	1,500
Rapid City Floods		
1920 Slow Flood	none	none
1972 Flash Flood	Less than 200	1,000

[1]Based upon information available on the Lubbock Tornado

[2]Of those affected

extension of the methods employed in this chapter to a large midwestern drought comparable to that of the dust bowl period of the 1930's, may show a continuum of disaster effects far surpassing that of even the large San Francisco earthquake. The purpose of including an agricultural hazard in the study of catastrophe is that it is much unlike the dramatic-destructive events thus far discussed. The focal point is *not* destruction of property in the form of dwellings and industrial and commercial buildings. The influence of drought on how the disaster effects cascade, is through disruption and damage to agricultural activity, the disruption spreading to other sectors of the economy in a manner similar to that discussed for earthquakes. As the effects spread, health and life are threatened and people are separated from their homes, not by the immediate violence of nature, but by social forces such as bank foreclosure set in motion by climbing unemployment levels. Hence, drought is unique among the hazards in its influence and its impact is possibly the most pervasive.

Figure III-7 shows the catastrophic nature of the 8.3R San Francisco earthquake in isolation. The range A to C provides alternative estimates (to ours) of the number of dead and injured that may result from an earthquake of this magnitude. *A* relates the number of dead to the number of houses destroyed (as was described above); *B* is the death toll estimated by the National Oceanic and Atmospheric Administration (NOAA, 1972b) excluding the potential of damn failure; and *C* is the casualty estimate if dam failure occurs (NOAA, 1972b). The dashed line illustrates the type of variation that may be expected at any point along the continuum, although the variation shown is for injury only. At least for the category *injured*, a broad range is to be expected,[18] but, by far, the predominant injury is likely to be minor.

As shown for this event, the *number* of disturbed (unemployed) equals that of the *damaged*; more surprising, the average loss due to economic dislocation exceeds that borne by those who suffer structural damage to their homes. This is because of the areal extent of the disaster; by far, most of the damaged (see Appendix I) dwellings are located in the low intensity areas. The *average damage* tends to be low, even though some homeowners are likely to experience severe losses.[19] In contrast, the number of unemployed and the magnitude of their loss resulting from the small earthquakes (6.0R) is shown in Figure III-8 to be much less severe than those who sustain damage. The implication is that the relative importance of disaster effects, the shape of the continuum, is as variable within a hazard as it is between hazards. This is illustrated by the contrasting effects of a tornado (dashed line in Figure III-8), earthquake, storm surge and wind (Figure III-9).

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[18]Following the results shown in Figure III-7, the average serious injury is estimated to be $8 thousand while the average minor is $5 hundred. However, these are averages. Some injuries will cost (both in real resources and psychic costs) $200 to $300 thousand. However, they represent (as is shown by the distribution of costs in Figure III-7) a small percentage of the total number of injuries sustained in disasters.

[19]Most of the severe losses are included in the category *dislocated*. The part of the continuum connecting *dislocated* and *damaged* illustrates variability in damage much the same way as the dashed line does for the *injured*. However, within the category *damaged* there is also variability, some homes experiencing only cracked plaster, while others have severe structural damage.

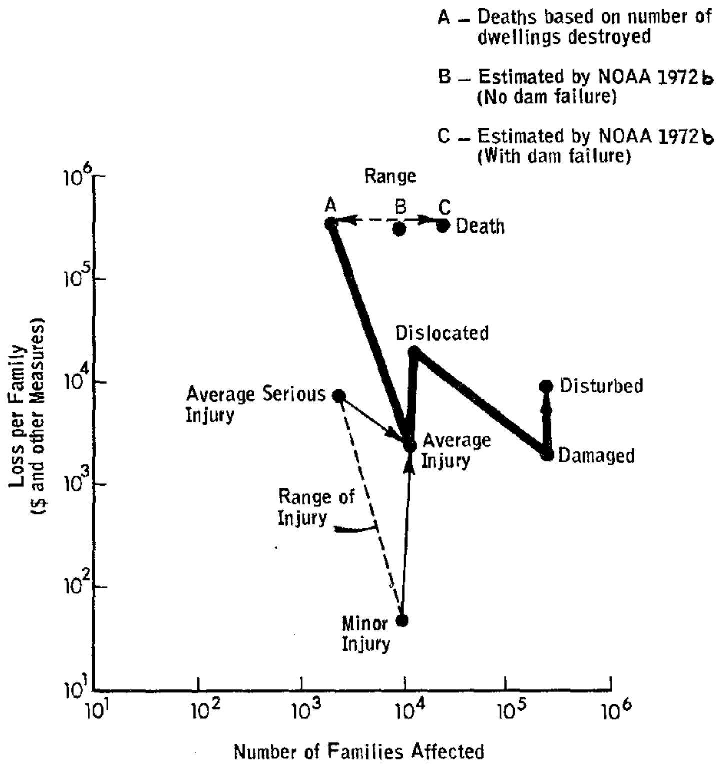
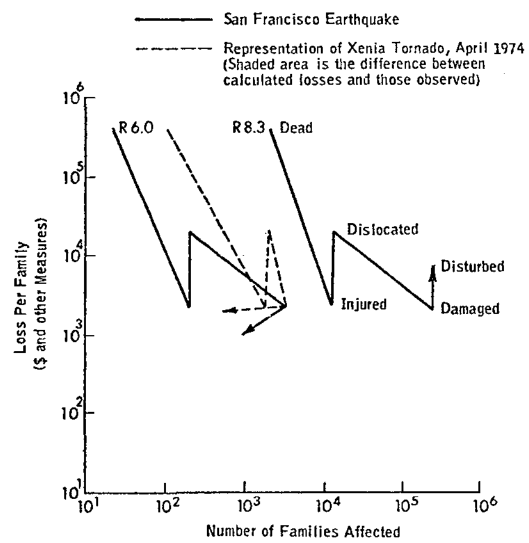


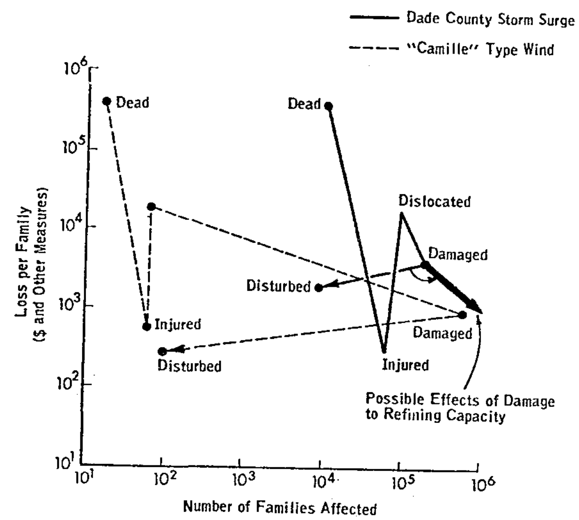
FIGURE III-7

CASCADE OF EFFECTS:
COMING SAN FRANCISCO EARTHQUAKE
RICHTER 8.3



EFFECTS CONTRASTED:
EARTHQUAKES AND TORNADO

FIGURE III-8



EFFECTS CONTRASTED:
HURRICANE STORM SURGE AND WIND

FIGURE III-9

These results show what was already expected: the larger the event, the more far reaching the impact and the further the continuum shifts to the right. The number of unemployed is related to the severity of damage and the types of economic activity carried on in the affected region. The magnitude of burden sustained by the *disturbed* can be described by a rotation around the point representing the *damaged*. For the coming San Francisco earthquake the direction is vertical, implying a relatively large burden sustained by the unemployed. As the damaging force of the events weakens, as it does for the 6.0R earthquake, the burden shifts or rotates to a point where the unemployed bear little of the total loss resulting from the disaster. Similarly, the nature of economic activity will force a rotation which will influence the shape of the loss continuum. As shown in Figure III-9, the Dade County Hurricane, if it were to strike a vital oil refining installation, would result in a much larger secondary impact than that for the landfall we analyzed.

CHAPTER IV

THE BURDEN OF RECONSTRUCTION

Since there is no such thing as certain protection, adjustments to hazards, whether in the form of proofing techniques, control and protection works, or modifying the event itself, are likely at some point in time to succumb to the forces of water, wind and/or earth. The breeching of levees and seawalls, the weather modification that failed to divert the hurricane or suppress the hail, and the irrigation system that was rendered useless in the 100-year drought are a few of the more striking failures that natural events are capable of inducing in man's engineering works. The annual loss from all hazards has been estimated to lie somewhere between $5 and $10 billion per year, or roughly one-half of one percent of the nation's gross national product. But who bears these losses? What percent of the total loss is absorbed by the Federal government through relief and reconstruction efforts? Are there any particular income groups that experience excessive hardship? These are a few questions on which the following analyses attempt to shed light.

Disaster Relief: The Government's Share

Although the Federal government had provided aid in specific instances to disaster-stricken communities prior to 1950, it was not until Public Law 81-875 in 1950 that the first permanent program of disaster assistance to state and local governments was enacted. Public Law 81-875 was followed by a long string of legislation which provided the Federal government with increasing responsibilities in the post-disaster reconstruction period.[1] The pace of Federal involvement was quickened with the occurrence of the 1964 Alaskan earthquake and the subsequent passage of

[1] A much amplified history of the Federal involvement in disaster relief and reconstruction can be found in the Relief and Rehabilitation Report (Mileti, 1975).

Public Law 88-451. The most significant provision of the law was that it permitted for the first time a massive disaster loan program administered by the Small Business Administration (SBA).

In 1965, with Hurricane Betsy, came the passage of the Southeast Hurricane Disaster Relief Act (Public Law 89-339). The act provided a precedent which was to signal what thereafter was an ever-escalating liberalization of the Small Business Administration loan provisions. A forgiveness was introduced which cancelled $1,800 after the first $500 of the loan was repaid.

Following this act a rapid succession of legislative acts increased the forgiveness and decreased the interest rate at which the loans had to be repaid. Public Law 91-606, The Disaster Relief Act of 1970, increased the forgiveness to $2,500. Public Law 92-385, enacted August 16, 1972, increased forgiveness to $5,000 and lowered the interest rate from 3% to 1%. These acts provided more than loans. For example, the Disaster Relief Act of 1969 provided (1) temporary housing; (2) disaster unemployment insurance; (3) grants for debris removal; and (4) food coupons for the low-income victims of disaster.

A complete reversal of the trend occurred in 1973; the passage of Public Law 93-24 rescinded forgiveness for all disaster loans and increased the interest rate to 5%. The recent passage of PL 93-288 signals yet another twist in the role the Federal government is prepared to play in disaster situations. As a substitute for the liberalized Small Business Administration loan program, a grant in aid to the "needy" was established in which up to $5,000 could be made available.

The past ten years have presented a bewildering array of legislative initiatives to deal with the problem of post-disaster relief and reconstruction. Each time a benefit was introduced, it was assimilated and became the floor upon which further benefits were provided. Each time a disaster struck--the Alaskan Earthquake, Hurricane Betsy, the Rapid City Flood, and then Hurricane Agnes--the clamor for liberalized relief was escalated and added momentum to Federal involvement. Not only did this momentum have a forward dynamic, but it also reached back in time--on most occasions the new provisions were made retroactive to some previous disaster, further complicating the process of recovery. The relief provisions for Betsy were made retroactive for Alaska; the benefits made available to the victims of Agnes also applied to Rapid City. Although Public Law 93-288 appears to have halted the momentum, it has yet to be subjected to the test of crisis conditions following a major disaster. Nor is it certain how the provisions of the act will be interpreted under the inevitable political pressure to expedite the recovery process.[2] For the most part the general trend has been to decrease interest rates, increase forgiveness, and provide more liberal criteria for the refinancing of existing mortgages. The result has been that the disaster victim has been responsible for a progressively shrinking proportion of damages, the Federal government assuming an increasing share of the loss.[3]

In spite of this, it is surprising to note that the magnitude of Federal relief expenditures has never been fully determined. The total direct expenditures between 1953 and 1973 have been estimated to be $4 billion (see Table IV-1). But these figures do not include (1) the grants implicit in low interest Small Business Administration loans;[4] (2) the

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[2]This pressure was one cause of the widespread dissatisfaction with the distribution of aid following the San Fernando earthquake (1971). Initially, the processing of loan applications was painstakingly undertaken. However, political pressures to expedite the processing were brought to bear on the Small Business Administration, with the result that requests for aid were reviewed more casually. If this is the situation for such a moderate event, what will result from the extreme situations depicted by the coming San Francisco earthquake and Dade County hurricane?

[3]The widening gap between benefactor and beneficiary is of itself insufficient evidence to proclaim a significant malfunctioning of the relief process. It may simply reflect a general trend in public expenditures--taxing one income group or region for the construction of public projects which benefit others. Grants of different sorts, both private and public, have been estimated to comprise 40% of all transactions in this country (Boulding, 1973a). In fact, it would be difficult to conceive of a grantless society, and it would be short-lived if one were constructed, particularly if children were made to engage in exchange from birth onward. So, it is not unusual and may be culturally inescapable that grants should form a significant component of the hazard system. Partly based on this reasoning it has been argued that, if anything, too little relief is provided for disaster victims. Accordingly, it has been suggested that it is a citizen's *right* as a member of an affluent society, to be made whole after a disaster--mentally, physically and materially.

[4]Forgiveness *is* included in the total, but the grant associated with the reduced interest rate is not.

TABLE IV-1

DIRECT FEDERAL EXPENDITURES FOR

DISASTER ASSISTANCE, 1953-73

	AGENCY	AMOUNT
1.	Federal Disaster Assistance Administration (FDAA), formerly Office of Emergency Planning and Office of Emergency Preparedness (OEP)	$1,844,827,290
2.	Small Business Administration	809,254,922
3.	Farmers Home Administration	448,180,766
4.	Department of Agriculture	18,415,159
5.	Federal Highway Administration, formerly Bureau of Public Roads	484,637,000
6.	U. S. Army Corps of Engineers	299,341,940
7.	Veterans' Administration	2,000,000
8.	Office of Education	102,330,691
9.	Federal Insurance Administration	46,774,000
	Total	$4,051,761,768

(U. S. Senate, 1974, p. S2221)

tax refunds that individuals obtain from the application of the casualty loss deduction to their Federal income taxes; and (3) the selective use of other government programs (Urban Renewal, for example) to help offset disaster-related losses. The following three sections are devoted to filling these gaps.

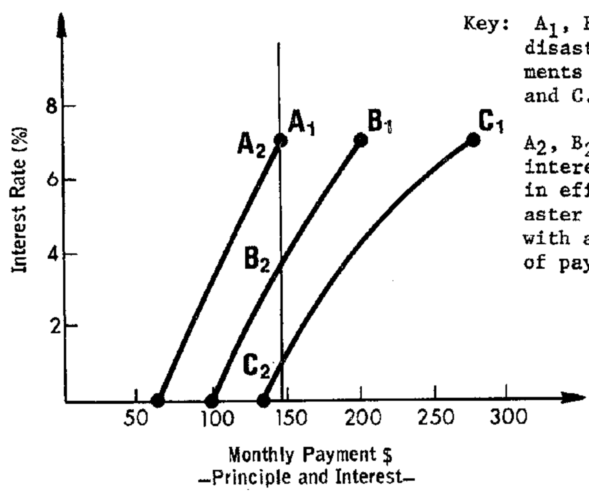
1. Disaster Loan Programs: More Detail[5]

Property losses absorbed by the disaster victim are dependent upon the provision of forgiveness and refinancing, and the interest rate governing the repayment of a disaster loan. In addition, the burden is dependent upon the type of disaster, the magnitude of loss incurred, the income position of the individual, and the equity in real property destroyed. For example, if a person living on retirement income, maintaining the bulk of his wealth in real property (dwelling and contents) with little or no mortgage attached to it, were to lose everything in a disaster, he would not receive the benefits of refinancing the outstanding mortgage at reduced interest rates, nor would the benefits of tax relief be forthcoming. At the other extreme, an individual with real property heavily mortgaged and at the peak of his earning potential would reap substantial benefits from both reduced interest rates and the casualty loss deduction.

To illustrate the effects of refinancing on both the burden of repayment and the magnitude of Federal grant accompanying reduced interest rates, the following set of simple calculations is presented. Assume a situation in which three houses of modest value, each priced at $20,000, are totally destroyed. The first house, A, was owned outright, the last payment being made just prior to the disaster; the second house, B, had one-half of the mortgage still to be paid; and the third house, C, had just been purchased (100% mortgage), and the owner had yet to make the first payment. Now, assuming further that all three owners possessed identical home mortgages carrying an interest rate of 7%, the pre-disaster

[5]The analysis of Federal burden in this section is limited to that borne by SBA with its disaster loan program. The relationships to follow do not reflect any Federal aid in the form of food aid to the state or community to help rebuild public facilities.

payments, including principal and interest, for all three homes would have been $143 per month.[6] In the wake of the disaster their debt positions would be altered to include both whatever mortgage still exists and any additional loans necessary to repair damaged property. Assuming that conventional sources of funds are available and that the banking community is willing to refinance old and new debt at the same interest rate (7%) for an additional 25 years, the new monthly payments for A,B, and C (A_1, B_1 and C_1 in Figure IV-1) would be $143, $215, and $286, respectively.[7] Now, if the SBA is willing to step in and offer a reduced interest rate, these payments may be decreased enough, under certain circumstances, to leave the individual with an unchanged (from that of the pre-disaster level) schedule of payments. Such a situation is depicted in Figure IV-1; A_2, B_2 and C_2 show those levels of interest that leave each disaster victim with a mortgage payment unaltered from that of the pre-disaster level ($143/month).



Key: A_1, B_1 and C_1 are the post-disaster schedule of payments for homeowners A, B, and C.

A_2, B_2 and C_2 are those interest rates which, if in effect, would leave disaster victims A, B, and C with an unaltered schedule of payments.

FIGURE IV-1

REFINANCING GRANT:
100% DAMAGE $20,000 RESIDENCE
25 YEAR REFINANCING

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[6]In each case a 25-year mortgage is assumed.

[7]These simple calculations abstract from the fact that normally interest payments are greater during the early years of the mortgage.

Table IV-2 shows in more detail how A, B, and C are affected by changes in the interest rate--the reduction in monthly payments and the present value of Small Business Administration benefits (reduced payments). The results in the table indicate that benefits increase with pre-disaster indebtedness. Even a 4% interest rate charged by the Small Business Administration, when the market rate is 7%, is sufficient to generate benefits which exceed the most liberal forgiveness clause ever provided--$5,000

TABLE IV-2

EFFECT OF INTEREST RATE CHANGES ON PUBLIC AND PRIVATE BURDEN

Individual	Interest Rate Charged by SBA (%)	Reduction in Monthly Payments Due to Refinancing ($ per month)	Present Value of Benefits[1] ($)	% of $20,000 Loss Absorbed by the SBA
A	7	0	0	0
No mortgage	4	37	5,174	26
	.6	72	10,068	50
B	7	0	0	0
50% mortgage	4	55	7,691	38
	.6	108	15,102	76
C	7	0	0	0
100% mortgage	4	74	10,348	51
	.6	144	20,136	101

[1]Derived by determining the present value of the annuity (reduced monthly payments), assuming a market rate of interest of 7% over 25 years.

in Public Law 92-385. With the lowest interest rate shown, .6%, individual C receives benefits which exceed his losses (101% of the loss). Table IV-2 also highlights the importance of pre-disaster debt position in determining the magnitude of loss borne by the Federal government. In moving down the table from A to C the percentage of the loss absorbed by the SBA increases (except for 7%) regardless of the interest rate charged. This is due simply to the fact that the greater the loan the greater the benefits, and the greater the pre-disaster mortgage the greater the SBA loan.

If the disaster event had been less catastrophic, damaging only 30% of the dwellings' value, the percentage of burden borne by the Federal government would have been even larger than that shown in Table IV-2 (column 5).[8] Comparing the situation depicted for individual C with the same individual in Figure IV-2, given 30% damage, the interest rate which

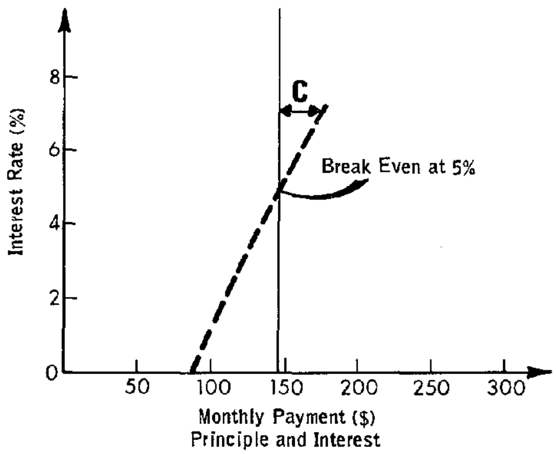

FIGURE IV-2
REFINANCING GRANT:
30% DAMAGE $20,000 RESIDENCE
25 YEAR REFINANCING

leaves the individual with the same monthly payment shifts upward from .6% to 5%. In other words, damage, aside from total destruction, which permits refinancing, will result in the individual assuming little of the reconstruction costs, particularly for those individuals that possess large mortgages.

The preceding discussion has emphasized in a hypothetical fashion a distributional aspect of government disaster loan programs: the government's share of the loss. However, what has been the experience; how do these same programs affect the long-term debt position of individuals, the

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[8]The limit of 30% has been used by the SBA as a rule of thumb to distinguish between minimal and "severe" damage. This distinction was necessitated by disaster legislation which enabled the SBA to make mortgage money available (refinancing of existing mortgages) to those disaster victims experiencing "severe" damage. Thirty percent was the SBA interpretation of the concept "severe."

victims of actual disasters? Figure IV-3 shows how debt payments, as a percentage of income, change after a disaster.[9] The distribution shown in Inset A illustrates pre-disaster mortgage payments. Only 8% of the families in this category had payments which exceeded 25% of their monthly incomes. By including all pre-disaster long-term debt (Inset B) the percentage of families with debt exceeding one-quarter of their income jumps to 30%. The added debt caused by disaster shifts the distribution further to the right (Inset C). The result is that 38% of those homeowners affected by this particular set of disasters are compelled to make monthly payments which exceed one-quarter of their monthly income. By including those affected severely enough to qualify for refinancing, the percentage jumps again, this time to 45% (Inset D).

One conclusion and one observation can be drawn from the results shown in Figure IV-3. It appears that the SBA is at least adhering partially to the requirement that loans be made on a non-discriminatory (with regard to income) basis. Most conventional lending institutions limit their loans to applicants on the basis of income--the rule of thumb most often employed is monthly payments are not to exceed one-fourth of the monthly income less any additional long-term debt obligations. Inset D indicates that at least 45% of the disaster victims who were forced to refinance existing mortgages, assumed payments in excess of this lending guide. The one observation that follows from Figure IV-3 is that a large number of individuals caught in disasters are being placed in an extremely unfavorable debt position. The lending guide established by savings and loan banks is partly for the protection of the bank, but it also indicates the level of debt an individual can safely carry without excessive strain on his budget.[10]

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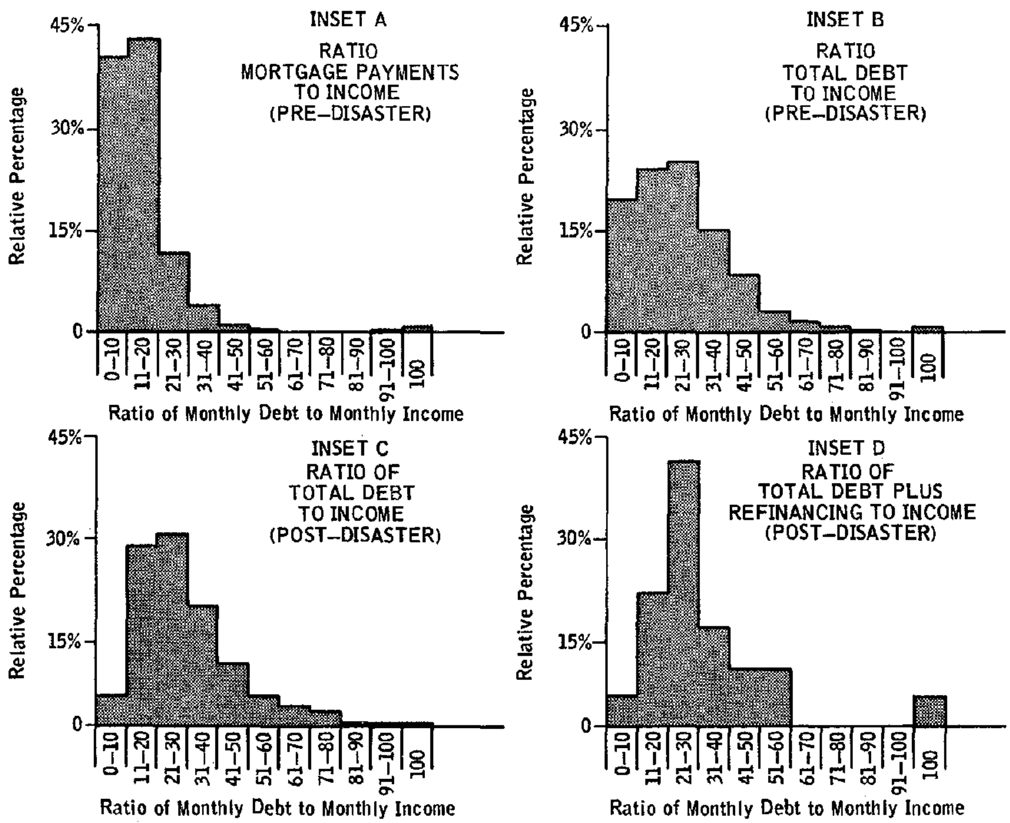
[9]The loan data used to obtain the distribution shown in Figure IV-3 include Betsy (1965), Camille (1969), Celia (1970), and Doria (1971); the Rapid City (1972); the Agnes (1972); the Lubbock tornado; and the San Fernando earthquake (1971).

[10]One method of making these loans even when income appears to be insufficient for their repayment is by resorting to a "hardship" declaration. In this case, payments on principal, interest, or both, may be deferred during the first three years of the term of the loan. The maturity of the loan would be geared to the borrower's ability to repay.



SHIFT IN HOMEOWNERS DEBT POSITION AFTER DISASTER

FIGURE IV-3

Our simple example of the three homeowners served in part to illustrate the effect of disaster intensity on the Federal burden. It was also shown above that the likelihood of sustaining extensive damage varied considerably among geophysical events; a moderate earthquake, Richter magnitude 6.0, was shown to generate a damage pattern much unlike that of a severe hurricane, 910 mbs. The frequency of heavy damage ranged from less than a few hundred dwelling structures to more than 50,000 for the respective events.

Utilizing the distribution of damage recorded both in Table III-1 and Appendix I, the Federal burden was calculated for a range of relief programs. Various combinations of interest and forgiveness were used to reflect the actual development of relief policy described earlier. Combinations other than that corresponding to relief provisions inherent in disaster legislation have also been provided in order to suggest the sensitivity of public burden to either of these grant provisions. Table IV-3 shows the percentage of burden borne by the Federal government for four disasters--the coming San Francisco earthquake (8.3R and 6.0R) and the coming Dade County hurricane (910 mbs and 950 mbs).[11] As shown, the range of a Federal burden varies considerably, from 97% to 0%, depending both upon the event and on the allowances for repayment.[12]

By contrasting the results provided in Table IV-3, we see that the average homeowner absorbs less of the total loss in the case of the San Francisco earthquake. This difference is due, once again, to the distribution of damages caused by each event, the Dade County hurricane being the more destructive of the two. As destructiveness increases, the forgiveness portion of the SBA loan program is shown to cover less, on a

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In extreme cases--retirement, disability or other similar circumstances--SBA may consent to the suspension of payments of principal during the lifetime of the individual and his spouse (Rules and Regulations, Small Business Administration Disaster Loans, 1973, p. 18212). In the end, the disaster victim is posed the difficult choice: whether to apply for a "hardship" declaration, or to accept the debt and make the burdensome payments to the SBA.

[11]The percentages shown reflect the influence of storm surge only. The effects of wind damage are analyzed separately.

[12]The effect of applying the casualty loss deduction is not included in Table IV-3.

TABLE IV-3

FEDERAL BURDEN FOR DIFFERENT HAZARD EVENTS
AND RELIEF PROVISIONS

Coming San Francisco Earthquake

		R 8.3					R 6.0			
		Forgiveness ($)					Forgiveness ($)			
		5000	2500	1800	0		5000	2500	1800	0
Interest Rates (%)	1	93	76	68	48	1	97	83	75	48
	3	87	69	56	37	3	93	78	68	37
	5	81	60	49	22	5	88	71	58	22
	7	73	51	40	0	7	83	59	47	0

Coming Dade County Hurricane

		"Camille" Type					"Betsy" Type			
		5000	2500	1800	0		5000	2500	1800	0
Interest Rates (%)	1	79	69	54	48	1	97	84	75	48
	3	68	56	52	37	3	89	75	64	37
	5	54	39	34	22	5	80	62	52	22
	7	41	33	19	0	7	71	51	42	0

percentage basis, of the homeowner's total loss. Consequently, he is forced in this circumstance to take advantage of other SBA provisions, such as reduced interest or refinancing. The 6.0R earthquake, in contrast, inflicts damage which seldom exceeds $5,000; with a $5,000 forgiveness in effect and a 7% interest rate, the Small Business Administration disaster loan program would cancel 83% of the average loan's value.[13]

The effect of the damage pattern on the Federal can be seen more easily by decomposing the grant provisions (interest and forgiveness), as is done in Figure IV-4. The cross-hatched area represents the grant associated with forgiveness, and, as expected, it is insensitive to the interest rate. The shaded area designates the impact of reduced interest rates. The upper bound incorporates the effect of both financing of losses and refinancing of mortgages; the lower bound excludes refinancing. The significance of these results (Dade County Hurricane) is--the grant emanating from the lowest rate (1% without refinancing) charged by the SBA nearly exceeds the aggregate benefit derived from forgiveness. The addition of refinancing boosts the government's share of the losses from 55% to 83%, an increase which is again equivalent to the forgiveness grant. A similar analysis of the grants appearing in the wake of the 6.0R San Francisco earthquake (B) suggests just the opposite conclusion. Here, refinancing adds little to the Federal share of the loss (less than 10%).

A recurrent theme throughout our study has been the impact of destructiveness on death, injury, and dislocation; Table IV-3 and Figure IV-4 also suggest the importance of this factor in determining in whose hands the ultimate burden of rebuilding lies. The sensitivity of this burden to destructiveness is more explicitly layed out in Figure IV-5. Here the percentage of the total loss absorbed by the SBA is related to the

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[13]This situation is similar to that encountered after the San Fernando earthquake in 1971. Approximately 60% of the loans made in the wake of this event were for less than $2,500, while only 2.5% of the loans were for more than $5,000 (Mileti, 1975). Using this distribution of loans in a manner similar to that used to obtain the results shown in Figure IV-1, the resultant Federal burden for the San Fernando earthquake was calculated to be approximately 77% of the total loss. This estimate compares favorably with our estimate for San Francisco's 6.0R earthquake, where the Federal burden was estimated to be 71% for an equivalent loan program ($2,500 forgiven and a 5% interest rate).

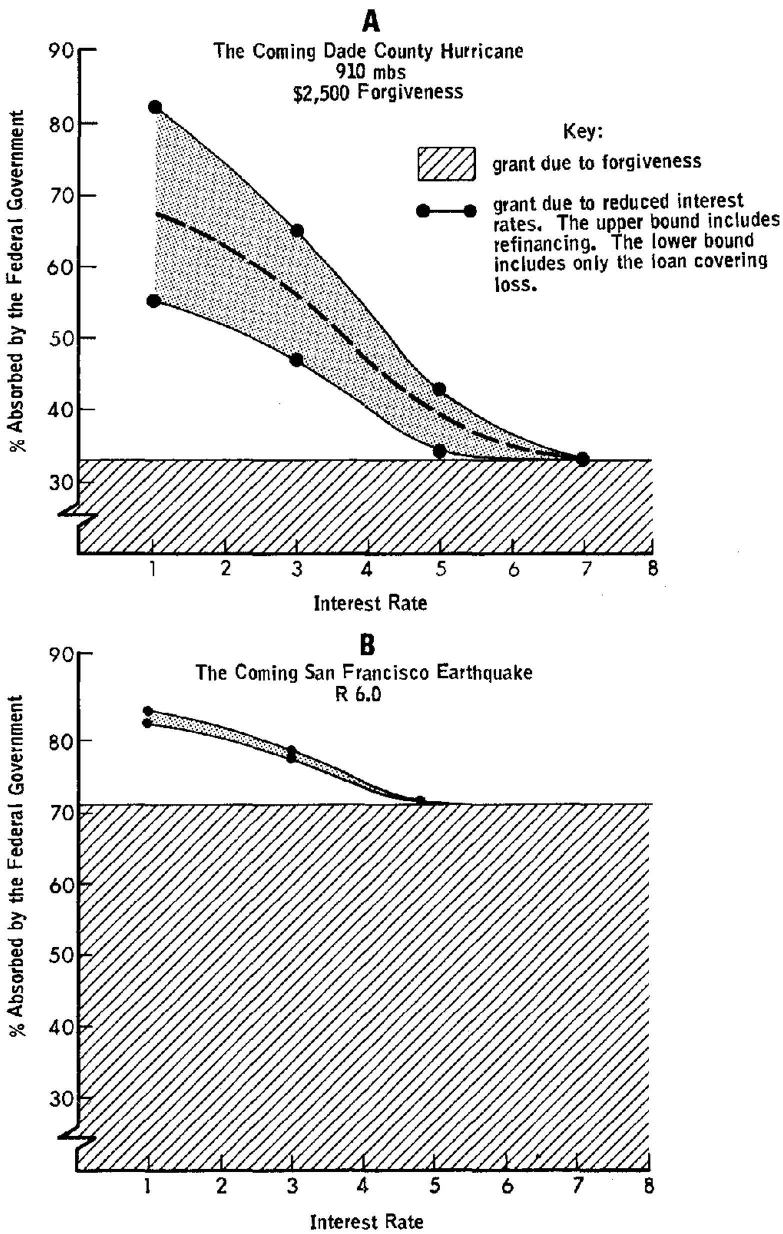

FIGURE IV-4
EFFECTS OF INTEREST AND FORGIVENESS
ON FEDERAL BURDEN

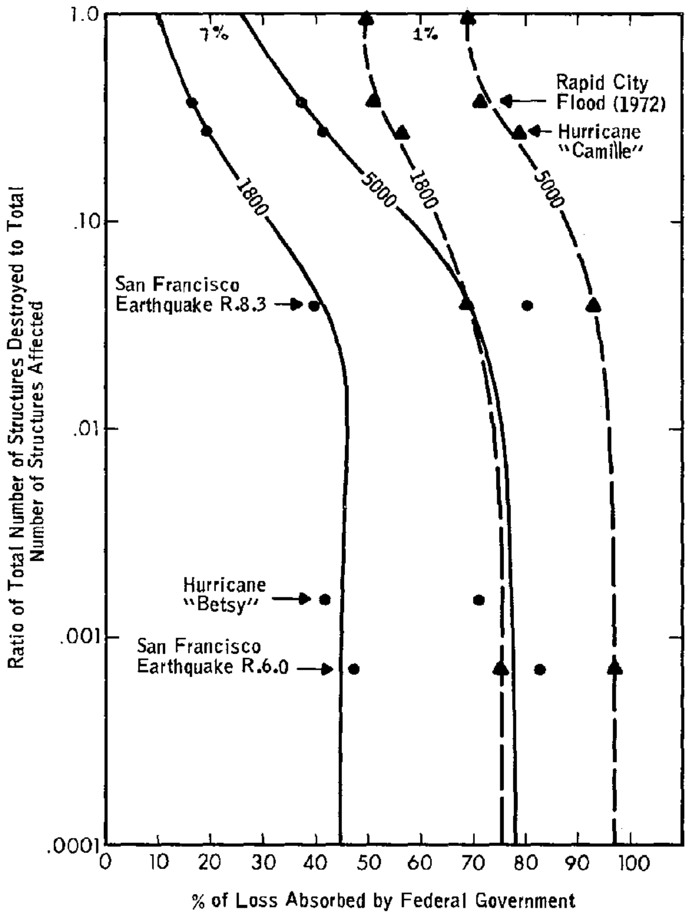

FIGURE IV-5

FEDERAL BURDEN AND EVENT DESTRUCTIVENESS damage patterns developed earlier, represented simply by an index of destructiveness (total houses destroyed over total number affected). The two bands shown represent an extreme range of interest, 7% to 1%; the border of each band indicates the effect of government burden of two levels of forgiveness, $1,800 and $5,000. The diagram suggests a relatively uniform relationship--the more extreme the event, the greater the hardship on the disaster victim. This conclusion by itself is not unexpected. Even so, it is surprising how sensitive the Federal burden is to both type and magnitude of disaster.

Because we have, for the last few pages, dwelt upon a broad range of alternative SBA aid programs, it may be an appropriate point to refocus our attention on current disaster legislation (Public Law 93-288) by asking how it is likely to fare with respect to the distributional question.

At least implicitly, the formulators of the Disaster Relief Act Amendments of 1974, Public Law 93-288, recognized the necessity of distinguishing between "emergencies" and "major disasters."[14] Hence, there is at least the potential that some of the problems illustrated in Figures IV-4 and IV-5 may be alleviated. On the negative side, the Act falls short of indicating criteria according to which events may be classified; recall that the results shown in Table IV-3 suggest that it is not necessarily the most dramatic events, those capturing the headlines, which inflict the greatest hardship. It seems that one major yet unaddressed task left the lawmakers is to provide operational criteria for the categories, "emergency" and "major disaster."

What are the current provisions for aid? Public Law 93-288 provides an individual and family grant program (Sec. 408) which is an appro-

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[14]In the act an emergency is defined as "any hurricane, tornado, storm...or other catastrophe in any part of the United States which requires Federal emergency assistance to supplement state and local efforts to save lives and protect property, public health and safety or to avert or lessen the threat of disaster....Major disaster means any hurricane, tornado, storm...or other catastrophe in any part of the United States which, in the determination of the President, causes damage of sufficient severity and magnitude to warrant major disaster assistance under this act, above and beyond emergency services by the Federal government...." (Congressional Record-Senate, 1974, p. S7644).

priation to the state, the purpose of which is to help individuals meet disaster-related expenses or serious needs. But the grants are to be made "only in those cases where such individuals or families are unable to meet such expenses or needs through assistance under other provisions of this act, or from other means" (Congressional Record-Senate, 1974, p. S7647). In addition:

> The Federal share of a grant to an individual or a family under this section shall be equal to 75 per centum of the actual cost of meeting such an expense or need....*No individual and no family shall receive any grant or grants under this section aggregating more than $5,000 with respect to any one major disaster.* (Author's emphasis.)

Although there may be some reluctance in identifying the individual or family grant as forgiveness, it may serve a similar function. Referring once again to Figure IV-5, a $5,000 grant with no provisions for reduced interest rates will result in a considerable range in Federal burden ranging from 80% to 38% depending upon the destructiveness of the event. This disparity will be accentuated by the addition of grants to make temporary repairs (Sec 404):

> In lieu of providing other types of temporary housing after a major disaster, the President is authorized to make expenditures for the purpose of repairing or restoring to a habitable condition owner-occupied private residential structures.... *No assistance provided under this section may be used for major reconstruction or rehabilitation of damaged property.* (Author's emphasis.) (Congressional Record-Senate, 1974, p. S7647).

Since disaster areas with a low ratio of total destruction to total structures affected include many dwellings with minimal damage, the temporary repair grant may shift the burden even further toward the Federal government. In contrast, victims of highly destructive events (at the uppermost extreme of the destructiveness scale: flash floods, tornadoes and extreme hurricanes) will not receive much in the form of aid as a result of this provision.

One final point--although it is apparent that perceived abuses of Federal relief have tended to push legislation along a more conservative path (PL 92-288), it may be that a major source of the problem highlighted throughout this section, is not intentional abuse of rules by the victims of disaster, but a too liberal interpretation of the disaster area by

Federal agencies. It is common for a number of counties to be included in a disaster declaration even though severe damage is restricted to a portion of a community. This procedure of "over-declaration" is probably as, or more responsible than any other factor for discontent with Federally administered relief programs.[15]

2. The Role of the Internal Revenue Service in Disaster Relief[16]

Regardless of the disaster loan legislation in effect for any particular disaster, an immediate source of funds for the disaster victim is the income tax refund. The casualty loss can be moved to the previous year's return if the disaster occurred after the end of the previous tax year and before the due date for filing that year's return. The loss is determined from the original cost (or "basis") of an item damaged and its fair market value just prior to the disaster. Deductions are limited to the minimum of basis and fair market value.

The casualty loss enables the taxpayer to recoup a portion of his loss equal to taxes paid on income offset by the damage. The income may either be in the form of ordinary income--wages, interests and profits--or against capital gains. The size of this relief grant is determined solely by the individual's income and deductions claimed in the preceding and current year.[17] Some individuals, for reasons of sickness, age (fixed retirement income), unemployment, or a low paying occupation, would have relatively little income against which those losses could be applied. Similarly, businesses which had experienced a temporary decline in earnings may not have the profits against which to apply such losses.

Because of the nature of the income tax laws, chance plays a major role in the amount of aid one receives. If the disaster victims are

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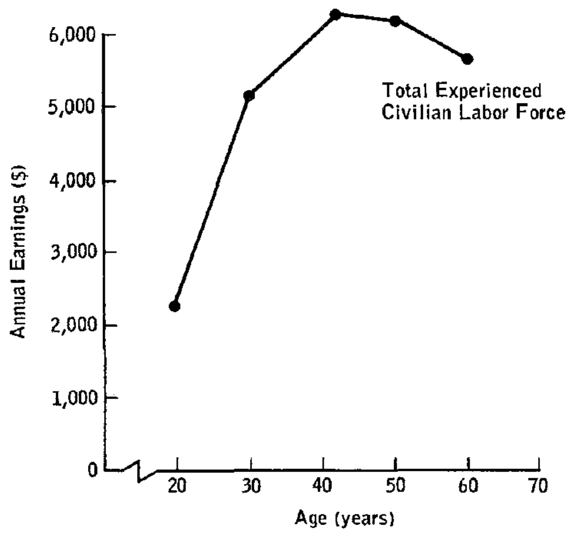
[15] The San Fernando earthquake serves as an excellent example of the discontent to which we refer.

[16] This discussion is based in part on a personal communication from Stromme (1974).

[17] Two years is usually sufficient time to write off all losses. Residual losses may be carried back three years and carried forward to the succeeding five years.

to be treated more evenly, it may be necessary to make special provisions in the income tax laws for natural disasters. One way of doing so is to institute an income averaging method whereby an average of the last ten years of income and deductions are used to determine the tax rebate.[18] These effects may not be trivial. As shown in Figure IV-6, the profile of earnings over time varies by more than 370% from the point one enters the labor force to retirement.



(U.S. Department of Commerce, 1967, p. 7)

FIGURE IV-6

ANNUAL INCOME AT PRESENT AGE (1959)

3. Urban Renewal

Ongoing Federal programs such as urban renewal provide a means of linking the short-term needs of relief with the longer-term goals of

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[18]The procedure could be reversed for the young; earnings can be extrapolated into the future ten-year period.

reconstruction. Such was the case at Rapid City, South Dakota. The flood of June 9, resulted in a planning grant from the U. S. Department of Housing and Urban Development of $300,000, followed shortly thereafter by an Urban Renewal grant of $48 million to establish a floodway through the community. Aside from administrative costs, the two most significant categories of expenditure under the Rapid City Urban Renewal program were payment for relocation ($15 million) and real estate purchases ($24 million) (Rapid City Urban Renewal Department, 1973).

The industrial park and area for recreational facilities which are scheduled to occupy much of the floodway of Rapid Creek were acquired through the purchase of the structures remaining after the disaster. Although it is difficult to consider urban renewal and other similar government programs as financing any particular adjustment, it was applied in Rapid City in such a way that the losses were shared with the Federal government.[19]

Because urban renewal is primarily for cities, the distribution of resources is bound to be viewed by certain disaster victims as unjust. Although a substantial proportion of the damages in the Rapid City flood was concentrated in the city proper, the surrounding rural areas--Sturgis and Pennington--were substantially affected by the disaster. However, because they were not part of the urban renewal plan, they were not eligible for relief such as that provided Rapid City.

Since many of the communities subject to damages from flooding are small and rural (it was estimated by the Assessment of Research on Natural Hazards Project that of 6,000 communities subject to flooding, nearly 4,500 have populations of less than 10,000), the benefits of applying urban renewal to effect land use and to aid disaster victims will be concentrated in the urban centers. To our knowledge there is no counterpart to the Urban Renewal Program for rural communities. The implication is not that urban renewal, open space, and other government programs should be restricted from providing aid to urban areas struck by disaster; it raises the question of inequitable treatment for those in the same eco-

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[19]One could also rightfully argue that the urban renewal purchases represent a special form of land use control.

nomic circumstances, each being subjected to the same emotional trials of disaster, being treated differently by the Federal government.

4. Personal Bankruptcy

Personal bankruptcy is not commonly practiced, although it is a viable option of spreading the losses from disaster. Even in the Rapid City flood, where more than 40% of the dwellings were totally destroyed, fewer than ten bankruptcies were filed. One explanation for this behavior is that the combination of government grants discussed above made such actions unnecessary. However, in the absence of those grants, the banking community may have been forced to absorb a much larger share of the loss.

The average housing debt outstanding is shown in Figure IV-7 to amount to more than 60% of the property's value. If a large number of bankruptcies *were* to materialize, a substantial amount of the loss would be shifted to the financial institutions which would then reflect it in their profit and loss statements. The impact of such an eventuality on a bank's survival would depend upon the magnitude of the disaster, the diversification of the bank's holdings, and on the reaction of appropriate regulatory agencies. One could speculate that the burden eventually would be shifted back to the Federal government in the form of either reduced taxes collected from the banking corporation, possible emergency loans at reduced interest rates, or reduced taxes collected from stockholders.

This potential distribution of burdens is compounded by the fact that bankruptcy, even if necessary, may not be equally open to all. Figure IV-7 shows that the old own a much higher percentage of their homes, 80%, than any other age group. Bankruptcy in this situation is not a viable option, and can only bring added burden.

How Different Income Classes Fare Under Alternative Loan Programs

In this section the analysis is extended to the distributional impacts that follow from socioeconomic differences in the recipients of Federal aid. The question of what share of the burden is borne by the Federal government is discarded, and we concentrate on measuring the flow of funds, aid, or benefits to homeowners in various income brackets. We begin in a manner similar to that utilized above. By pulling together the eight disaster events and a number of alternative aid programs, we

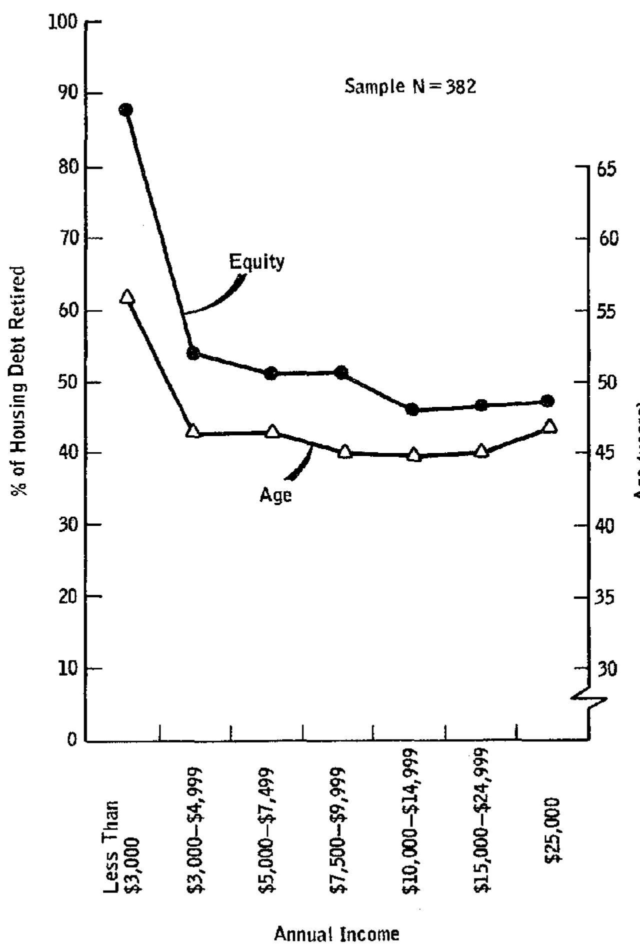

FIGURE IV-7

DEBT RETIREMENT RELATED TO INCOME

are able to determine how much aid goes to different income groups. With this knowledge it becomes possible to calculate the *degree of inequality* with which Federal monies are disbursed. However, it is seldom that equity and strict equality are equated, for, although the distribution of Federal resources may (will) turn out to be very unequal, such a result, particularly in the context of human suffering, may also be viewed as a *legitimate inequality* and therefore equitable. Our purpose is not so much to pronounce judgment on the fairness of these aid programs, but to provide the information upon which such a judgment can eventually be made (in the political arena).

It is expected (see Appendix III, not printed) that the greater a homeowner's income, the greater the wealth subject to destruction by natural phenomena. The losses borne by these middle and upper income groups tend, *on a percentage basis*, to be greater than that for lower income groups. This result, shown in Figure IV-8, is due to the fact that

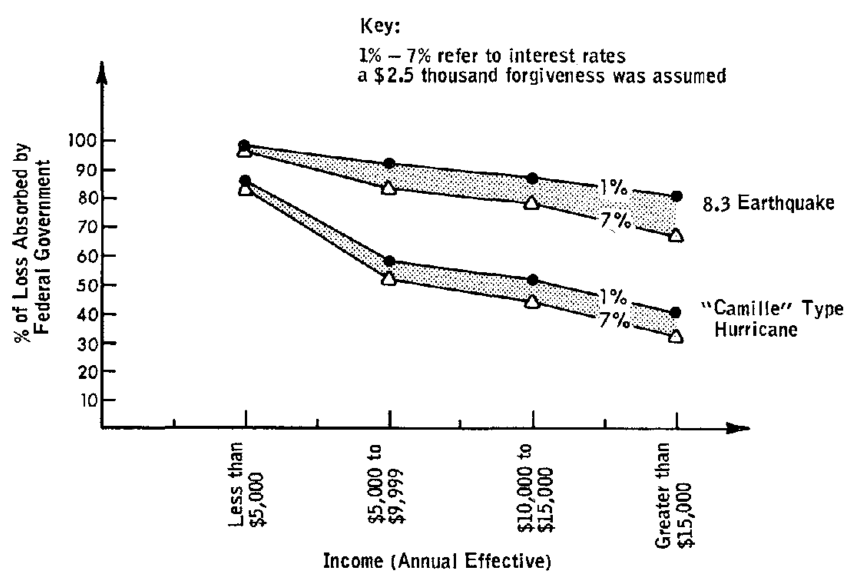

FIGURE IV-8

PERCENT OF LOSS COVERED BY INCOME GROUP

forgiveness is likely to cover a major proportion of damages sustained to a moderate to low valued dwelling. For example, a $10 thousand house (mobile home) can sustain 50% damage without taxing the resources of the homeowner, providing a $5 thousand forgiveness is in effect. In contrast, a similar damage ratio applied to a $100 thousand dwelling will result in 90% of the loss being borne by the homeowner.[20]

As was shown above in the analysis of government share of the burden, event intensity is also at work here to influence the ultimate distribution of burdens among income groups. The coming San Francisco earthquake is shown in Figure IV-8 to exert less of an impact on all income groups than that of a Camille-type hurricane.

Although this is one way of looking at the distribution of aid, another viewpoint is equally instructive. Although the upper income groups appear to be bearing a greater proportion of their losses, they are at the same time receiving a larger proportion of aid flowing to the disaster area. With the use of a Lorenz curve, it was possible to calculate the degree of inequality with which aid is disbursed under a variety of circumstances.[21] The level of inequality can be compared to inequalities inherent in the existing distribution of income. By so doing, a benchmark is provided against which alternative aid programs may be contrasted. It is not suggested that an equal distribution of aid is desirable or equitable; the sole purpose of this exercise is to provide the information from which judgments concerning their merits may be made.

Figure IV-9 shows those aid programs (combinations of interest and forgiveness) which provide a distribution of benefits which at least match the existing distribution of income. Each curve represents a different event of the eight under investigation; for simplicity in reading the graphs, high intensity and low intensity events have been grouped together (Insets A and B respectively). Combinations of interest and forgiveness which lie to the *left* of the curves will provide a more *unequal* distribution of aid; those that are to the *right* are *more equal*.

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[20]Excluding the effects of reduced interest rates and casualty loss deductions.

[21]A fuller explanation of the procedure used can be found in Appendix III (not printed).

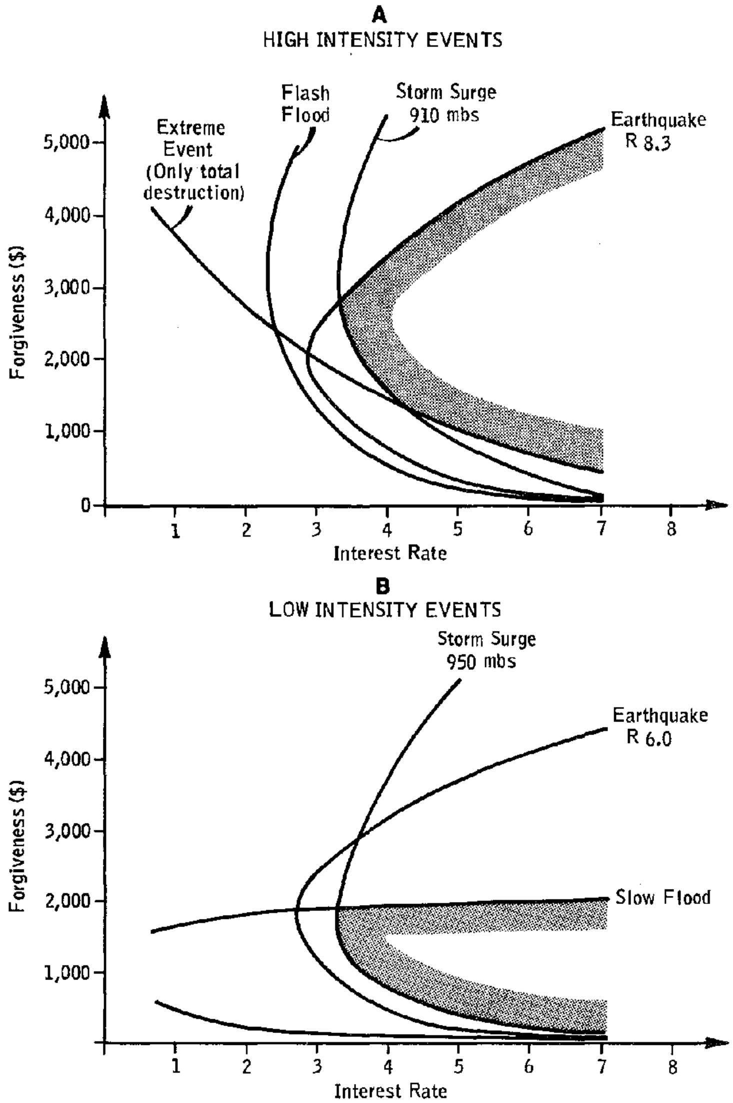

FIGURE IV-9

DISTRIBUTIONAL IMPACT OF ALTERNATE GRANT PROGRAMS
EVALUATED FOR DIFFERENT EVENTS

Once again, the nature of the event influences the equality with which aid is disbursed, the high intensity events tend to be less sensitive to forgiveness than the low intensity events. The reason for this lies in the general shape of the curves. Taking a section at a fixed interest rate (4% for example), the introduction of forgiveness in increasing amounts at first tends to promote equality, but application of succeeding increments eventually leads to greater inequality. This is because there exists a limit to which forgiveness is a benefit to lower-income homeowners. If the damage ratio is low, as it is in slow floods, a minimal forgiveness is normally enough to cover most of the damage. As forgiveness escalates, the lower-income homeowner, at some point, will be unable to take advantage of these added benefits since his damages will have already been fully paid at some former forgiveness level. The middle and upper income homeowner, however, because of his higher losses, will continue to be able to absorb these benefits. Similarly, the addition of benefits through reduction in interest will, given a fixed level of forgiveness, aid the wealthy more than the poor since they have more to finance and refinance.[22]

The shapes of the contours shown in Figure IV-9 are a product of the above factors, compounded by the severity of the event. As the damage ratio increases the ability of all homeowners to absorb these benefits also increases. This is why the relationships shown in Figure IV-9 tend to shift upward from that shown in B to that in A.

In summary, the contours in Figure IV-9 indicate that reducing either the interest rate or increasing the level of forgiveness (beyond $3,000) will tend to promote greater inequality in the distribution of relief benefits in all disaster situations. From the standpoint of income

[22]In equation form,

$$\left.\frac{\partial G}{\partial FRG}\right|_{i}$$

has a minimum. Similarly,

$$\left.\frac{\partial G}{\partial i}\right|_{FRG}$$

has a minimum. G is the gini coefficient (see Appendix III, not printed, for an explanation), FRG is forgiveness, and i is interest.

distribution it appears that those combinations of interest and forgiveness located in the shaded area would provide suitable results. However, a disaster *may* be an inappropriate situation for concern with income distribution. A highly unequal distribution of aid governed by the magnitude of one's loss (regardless of his initial wealth position) may be deemed *legitimate* and therefore socially desirable. This is a political question and will not be pursued here. We turn attention to other factors which have tended to promote inequality, possibly illegitimately.

It was shown earlier that indebtedness, under certain circumstances, was to the advantage of disaster victims. From a sample of Small Business Administration disaster loans,[23] it appears that housing debt is related to income and age. Figure IV-7 shows average equity by income group. Those in the group of *less* than $3,000 annual income had invested nearly 90% of the home's value. The average age of this group, approaching 62 years, indicates that this group is composed mostly of those living on retirement income. Disaster assistance provided in Public Law 93-288 would not meet the needs of this income and age group even though the law is careful to state that there will be no discrimination (Sec. 31). Public Law 93-288 states that provision shall be made for

> insuring that the distribution of supplies, the processing of applications, and other relief and assistance activities shall be accomplished in an equitable and impartial manner, without discrimination on the grounds of sex, age, or economic status (U. S. Senate, 1974c, p. S7645).

Re-emphasis of an equitable distribution of aid grew out of testimony read at public hearings to investigate the adequacy of Federal disaster relief. Common complaints relating to the issue of equity are given below (U. S. Senate, 1973; 1973a; 1973b):

> (1) Many of the elderly in filling out Small Business Administration applications were not advised of the law's provisions for the suspension of loan principal payments (p. 865). This concern was echoed by the American Friends Service Committee in a study conducted to investigate the distribution of aid to disaster victims. 'During our interviews we became concerned

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[23]The sample spanned a seven-year period and included loans from hurricanes Betsy (1965), Camille (1969), Celia (1970) and Doria (1971); the Rapid City flood (1972); the Agnes floods (1972); the Lubbock tornado (1970); and the San Fernando earthquake (1971).

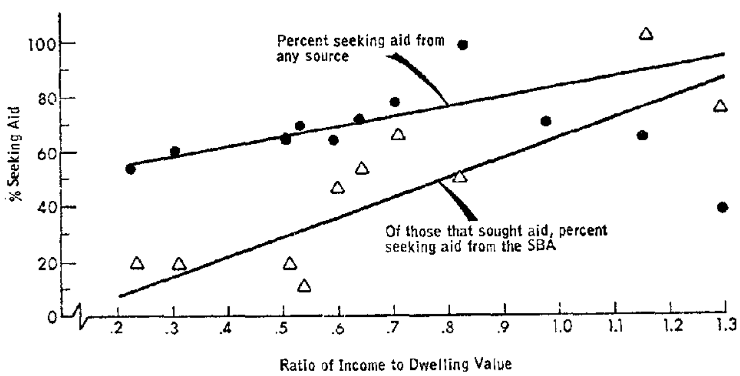
over the loan policy for the elderly....We felt that while older people were not actually being denied loans, some were being given terms they could not afford...we talked to one man in his sixties who had lost a home on which he had completed all mortgage payments. He was offered a 15-year loan which made his payments $300 per month....On the whole, experience with other similar Federal agencies demonstrates that in order to get the full benefit of the program, one must know more than the bureaucrat' (pp. 1679-1680).

(2) The Small Business Administration was accused of excessive zeal in protecting public funds. There were several cases of loans being turned down either because of age or because the applicant had no visible means of repayment (p. 881).

(3) The web of paper work involved in loan applications was frequently criticized: 'in many instances, through no fault of his own, the senior citizen can not make the necessary decisions or applications to benefit from many (much) of the recovery effort' (p. 1359).

(4) Housing shortages affected the elderly. People living on fixed incomes are not able to afford apartments that are being rehabilitated by landlords and put on the open market (p. 1195).

Bolstering the point made in (3), an interview of Rapid City disaster victims (Mileti, 1974) showed a marked relationship between the income of the victims and the indication that they had or would seek aid (Figure IV-10). Of the 187 individual heads of households interviewed,



RELATIONSHIP BETWEEN PROPENSITY TO SEEK AID AND INCOME
RAPID CITY FLOOD, 1972

FIGURE IV-10

the lower income groups were more reluctant to seek aid (or were prevented from seeking aid) from a Federal source, the Small Business Administration in particular, than the upper income groups.

Insurance: The Victim's Share

Insurance is often cited by economists as the key to the adoption of damage-mitigating adjustments and the efficient use of hazardous areas (Krutilla, 1966; Lind, 1966):

> Insurance premiums proportional to risk and equal to both the private and social cost of flood plain occupance will serve as a rationing device, eliminating economically unwarranted uses of flood plain lands on the one hand, while not prohibiting uses for which a flood plain location has merit on the other hand. In addition, reduction of flood loss insurance premiums can serve as a standard to measure the economic justification of alternative flood control measures...or other non-structural flood control measures (Krutilla, 1966, p. 183).

This line of reasoning underlies the Report by the Task Force on Federal Flood Control Policy (1966) which recommends the shifting of costs of flood plain occupance to the occupants themselves through an indemnity fund.[24]

> The primary gain would be to discourage flood plain development that detracts from the total social income and to encourage only investment that clearly is warranted by the net benefits gained (HD465, p. 16).

As Table IV-4 points out, insurance is available for most hazards and, in fact, the occupants do pay premiums reflecting the risk they face (albeit imperfectly) for all hazards but one, flooding. Table IV-4 also shows that the only widely purchased insurance is Homeowners Comprehensive,

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[24]Although convincing from the vantage point of traditional economic thinking, there is a flaw in the argument: what if the price differential, for whatever reason, erodes over time? One strong reason for the recommended implementation of actuarial insurance was the information price differences would provide individuals who may be ignorant of the hazardousness of alternative locations. If these same individuals are ignorant of the event system, what will restrain prices from equalizing over time? It is possible that either of two situations may arise: (1) property owners outside the flood plain will reap windfall profits as their land values increase relative to that of the land values inside the flood plain; or (2) the land-holders inside the flood plain will realize a capital loss. In the event of either situation (or some combination of the two), the tendency may exist for the effect of insurance on decision-making to erode, as land price differentials diminish.

TABLE IV-4

SUMMARY OF INSURANCE PROGRAMS

Natural Hazard	Available Coverage	Marketing Agents	Premiums	Amount of Deductibles	Approximate Percent Of Population At Risk Covered
Tornado and windstorms Hail (Property) Hurricane wind	Property	Private Ins. Companies	Based on risk (Part of homeowners comprehensive)	Normally $100 except in high-risk areas where it is higher	80-90
Earthquake	Property	Private Ins. Companies	Based on risk (Type of structure)	5% of cash value of policy	Less than 5
Flood Storm surge Mudslide Riverine Flooding	Property	Private Ins. Companies	Existing property-federally subsidized New property-Based on risk	Maximum of $200 or 2 per cent of value of loss	Less than 5
Hail (Agriculture)	Crops	Private companies (CHIAA) Federal Crop Insurance Corp.	Based on risk	Payments to farmers which bring actual yield up to guaranteed yield	10-15
Drought	Crops	Federal Crop Insurance Corp.	Based on risk	Payments to farmers which bring actual yield up to guaranteed yield	10-15
Volcanoes	None	-	-	-	-

which protects against wind, hail and tornado. It is not surprising that the adoption rate for this form of insurance is as great as it is since it is a requirement of most lending institutions. The adoption rates for flood and earthquake policies lag far behind, with less than 10% of the population-at-risk participating.

The following sections provide some insight into the distributional impact of different insurance programs. Wherever possible, the socioeconomic characteristics of purchasers is highlighted, but for the most part the objective is to determine the share of loss borne by the disaster victim, the insurance company, and the Federal government.

1. Flood

The largest publicly sponsored program in the area of hazard insurance was set in motion by the Flood Insurance Act of 1968 (amended by Public Law 91-152, 1969), insuring residential and business property against flood losses. The flood insurance program differs from other hazard insurance programs in a number of critical areas: the amount of government subsidy offsetting actuarial rates; the criteria for eligibility; and the linkages to loss-mitigating adjustments.

The Flood Insurance Act distinguishes between communities; any community willing to enact land use control measures is eligible for flood insurance coverage at rates which reflect a small proportion of the actuarial risk.[25] The Federal government's role is to estimate rates, provide a grant which accounts for the difference between actuarial and subsidized levels, and provide reinsurance against catastrophic loss to private insurors who do the marketing. The community is responsible, if it wishes to continue participation in the program, for a detailed hydrologic study of the area-at-risk, and for some form of self-protective action. Communities are usually admitted to the program under an emergency status, but only if they indicate an intent to comply with the procedure just outlined.

If after a reasonable period they have not complied, they are dropped from the list of those communities eligible and insurance at the

[25]The subsidized insurance rate, 10% of the actuarial risk, applies to the property already in the floodway. Any new construction is obligated to pay a rate reflecting the full actuarial value.

subsidized rate becomes unavailable.[26] However, if these rate-making studies are complete, and self-protective actions are undertaken, the community is included under the *regular* insurance program. The regular program entitles the community to continue to purchase flood insurance at subsidized rates.

As of January, 1974, there were a total of 2,940 communities participating in the program, but only 590 had regular status. With approximately 10,000 areas estimated by U. S. Department of Housing and Urban Development to have flood problems (both inland and coastal), it appears that more than 66% of the communities at risk have yet to take even the most minimal steps to participate in the insurance program. Of those that have chosen to enter, purchases of flood insurance have not been numerous; by October of 1973, a little over 300,000 policies had been sold, covering about $5 billion in property. Although it is difficult to assess the total market value for any line of insurance, a conservative estimate of the number of residential structures-at-risk would be 2.8 million.[27] Under this assumption, the policies that have been sold represent less than 11% of the potential market.

The fact that flood insurance rates are subsidized as heavily as they are makes the answer to the question, "who buys insurance?" essential to understanding who ultimately bears the losses from disaster. For example, if flood insurance is bought by the middle and upper income groups, 90% of their flood losses will be paid by the Federal government, whereas the lower income groups will have to rely on other means of recouping damages such as public or private relief. Data on life insurance sales tend to confirm this possibility. Figure IV-11 shows the distri-

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[26]After December 31, 1973, no properties can be newly insured or have policies renewed except those in communities for which actuarial rates are available.

[27]Original estimates by Friedman and Roy (1966) based on White, *et al.*(1958) set the number of residential structures subject to flood (inland) damage at 1.2 million. This was based upon 1,000 communities thought at that time to have flood problems. Since then the number has grown to 6,000 with the addition of small rural areas, escalating the original estimate to approximately 1.6 million structures. With the addition of residences at risk along the coastline (6 million individuals or approximately 1.2 million homes; see Brinkmann, *et al.* [1975]) brings an estimate of the total market for insurance to 2.8 million potential policies.

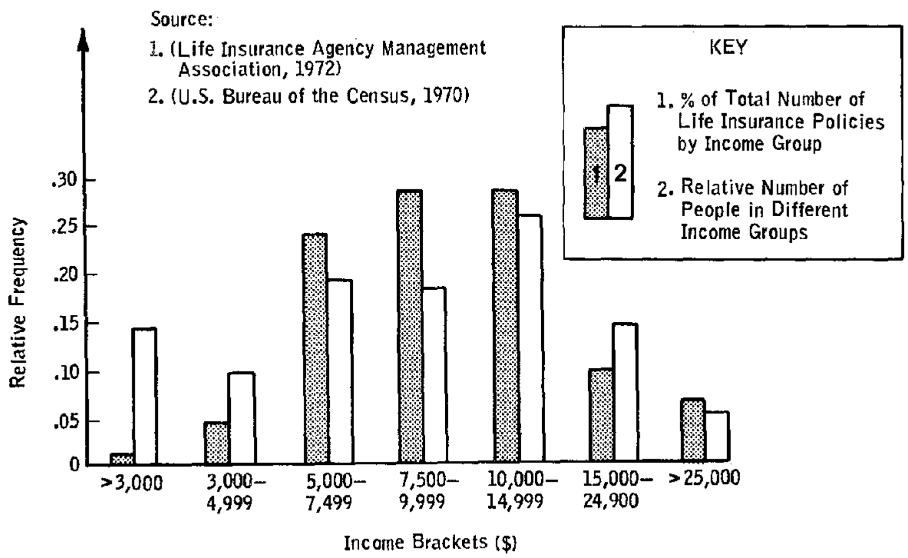

FIGURE IV-11
DISTRIBUTION OF LIFE INSURANCE POLICIES BY INCOME GROUP

bution of life insurance policies to male adults. When compared with the national distribution of income, it becomes evident that those with incomes under $5,000 per year purchase disproportionately fewer insurance policies than their numbers would suggest. The income group $3,000 to $4,999 contains 14% of the total population, yet this same group purchased less than 5% of the total number of insurance policies in force.

2. Earthquake

Earthquake insurance is privately marketed, with premiums reflecting construction type. However, the demand for insurance, even in the high-risk areas of California, has been minimal. It is estimated that the $5-$8 million in insurance premiums collected each year in the United States would cover only $3 billion worth of property, or less than 3%[28]

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[28]Assuming $1 trillion of property is exposed to earthquake damage (U. S. Department of Housing and Urban Development, 1971, p. 53).

of the total property-at-risk (U. S. Department of Housing and Urban Development, 1971, p. 53).

This minimal interest in coverage continues despite the insurance availability (although not vigorously marketed), and relatively low cost--20¢ per $100 coverage for a wood frame house in California.[29] One possible explanation for this apparent lack of interest is the 5% deductible clause; owners absorb all damages up to 5% of the cash value of the policy. Given the shapes of the damage distributions developed earlier, it can be shown that much of the damage accompanying an earthquake would be absorbed out-of-pocket by the individual homeowner. Figure IV-12 indicates the frequency distribution of dwelling damage for San Francisco earthquakes of Richter magnitudes 8.3 and 6.0. Superimposed on these damage distributions is a curve showing the relationship between deductible (as a percentage of dwelling value) and the percentage of the total loss absorbed by individuals. For these relatively infrequent earthquakes, the 5% deductible is estimated to cover 85% and 73% of the respective losses. For the less damaging but more frequent earth shocks, one would expect insurance to cover less of the repair costs, as is suggested by Figure IV-12B.[30]

Table IV-5 extends this comparison to other events, specifically the Rapid City floods and the Dade County hurricanes. The results show that the more intense the event, the less, on a percentage basis, the homeowner will bear of the total burden of reconstruction. The relatively minimal events such as the 1920 flood and the Betsy-type hurricane are shown in Table IV-5 to require 40% and 21% of the respective total losses to be paid out-of-pocket by the disaster victim.

3. Hail, Wind, and Tornado

Homeowners have at least partial protection from hail, wind, and tornado damage since Homeowners Comprehensive insurance is required by

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[29]This rate is lower than the extended coverage rate in many states.

[30]Only damage patterns for 8.3R, 7.0R and 6.0R were available, hence a crude estimate of lower magnitude events on individual burden is provided as a dashed line.

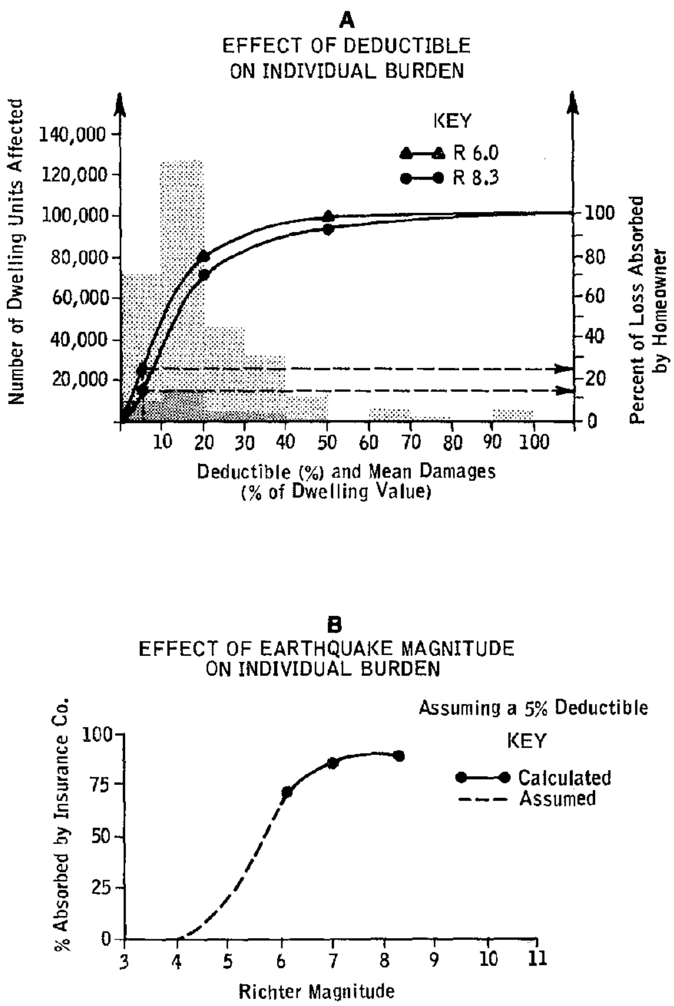
A
EFFECT OF DEDUCTIBLE
ON INDIVIDUAL BURDEN
KEY
R 6.0
R 8.3
Number of Dwelling Units Affected
140,000
120,000
100,000
80,000
60,000
40,000
20,000
Percent of Loss Absorbed by Homeowner
100
80
60
40
20
0
10 20 30 40 50 60 70 80 90 100
Deductible (%) and Mean Damages
(% of Dwelling Value)
B
EFFECT OF EARTHQUAKE MAGNITUDE
ON INDIVIDUAL BURDEN
Assuming a 5% Deductible
KEY
Calculated
Assumed
% Absorbed by Insurance Co.
100
75
50
25
0
3 4 5 6 7 8 9 10 11
Richter Magnitude

FIGURE IV-12

TABLE IV-5

PERCENT OF LOSS ABSORBED BY HOMEOWNER BY DEDUCTIBLE[1]

	San Francisco Earthquake San Andreas		Dade County Hurricane Storm Surge		Rapid City Flood	
Deductible	R8.3	R6.0	Camille Type (910mbs)	Betsy Type (950 mbs)	Slow Flood 1920	Flash Flood 1972
2%	7	14	6	21	20	4
5%	15	27	14	36	50	10
20%	70	80	64	65	99	31

[1]The percentages shown were derived from the distribution of damages shown in Appendix I and the assumption that every homeowner affected had insurance (equal to the value of the home). The losses shown for both hurricane and flood do not include the effect of subsidized rates which is discussed in more detail in a later section.

many lending institutions as a prerequisite for a mortgage on property. According to Kunreuther (1973a), insurance companies have been willing to include these hazards as part of Homeowners Comprehensive because damage from a particular disaster is normally limited to a sufficiently small area and will not greatly affect the company's reserves. Not all lending institutions require the coverage, and, furthermore, there has been a tendency for insurance companies to restrict coverage in areas in which civil strife is a potential.

As if 1971, industry-wide premiums collected from homeowners' policies were $3 billion (*Bests Review*, 1972). This represents a substantial proportion, greater than 60%, of the property-at-risk, but the coverage is spotty. Only 50% of the homes damaged in the Lubbock tornado (1970) were estimated to be covered by insurance, and the average coverage was 40% of the home's value (Kunreuther, 1973a).

The Eastern Area tornadoes (April, 1974) showed a similar pattern of coverage. The American Red Cross estimated that the average number of homes covered in the six states affected was 80%.[31] However,

[31]The source for this estimate was the American National Red Cross Disaster Summaries, April 3 and 4 Tornadoes (1974).

there were some areas which had relatively little insurance (Figure IV-13). Those counties in which little insurance was in force were, in fact, the low income counties in the region. Figure IV-14 shows the relationship between median income and percentage of those insured (curve A). A similar relationship appears to hold for income and percentage of house value covered (curve B). The lowest income group shown was discovered to have approximately 53% of their homes insured at an average coverage of 54% of the house value. In contrast, 85% of the highest income group was insured for 84% of the structure's value.

4. All-Hazard Insurance

From time to time, interest in all-hazard insurance, covering each property owner regardless of his exposure to hazards, has surfaced. In the wake of the Agnes floods (1972), it was suggested that such a program be implemented retroactively to replace relief provisions of Public Law 385. More recently, a bill calling for the development of such an all-hazard insurance program was introduced by Rep. Flood (H. R. 4772). The "National Catastrophic Disaster Insurance Act of 1973" would establish a program of Federal insurance covering catastrophic natural and other disasters: floods, high waters, windstorms, hurricanes, tornadoes, tidal waves, snow storms, blizzards, earthquakes, and atomic accidents. The program would be financed through a fund in the Treasury Department which would be credited with all premium surcharges imposed and collected by private insurors. The amount of surcharge was restricted to 5% or less, but was to be varied according to the region to reflect variation in risk and the presence of control measures. The surcharge applied to private homeowner insurance already in force, with the amount of such insurance governing the coverage in advent of natural disaster.

Aside from the potential conflict such a program may create with private insurors, the bill raises several questions which have yet to be satisfactorily answered by natural hazards research. For example, except for extremely hazardous locations, does the nation's population face a uniform risk from the full range of natural hazards? Do the snow and flood hazards in the Northeast generate damages comparable to the tornado threat in the Southeast sections of the country? In terms of equity, the

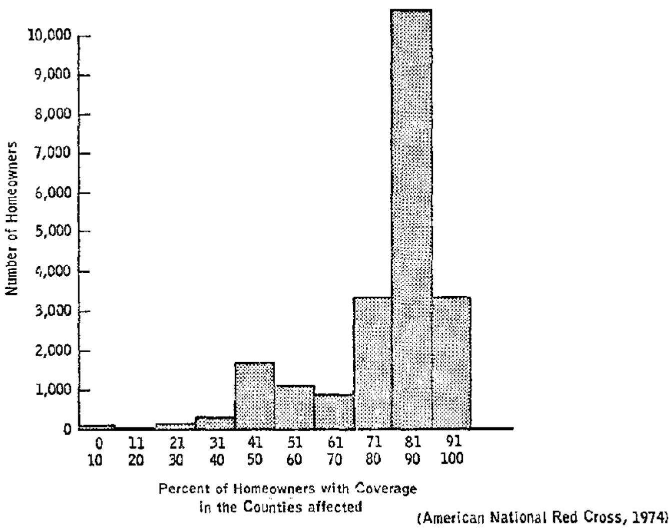

FIGURE IV-13
EASTERN AREA TORNADOES:
PERCENT INSURED BY COUNTY

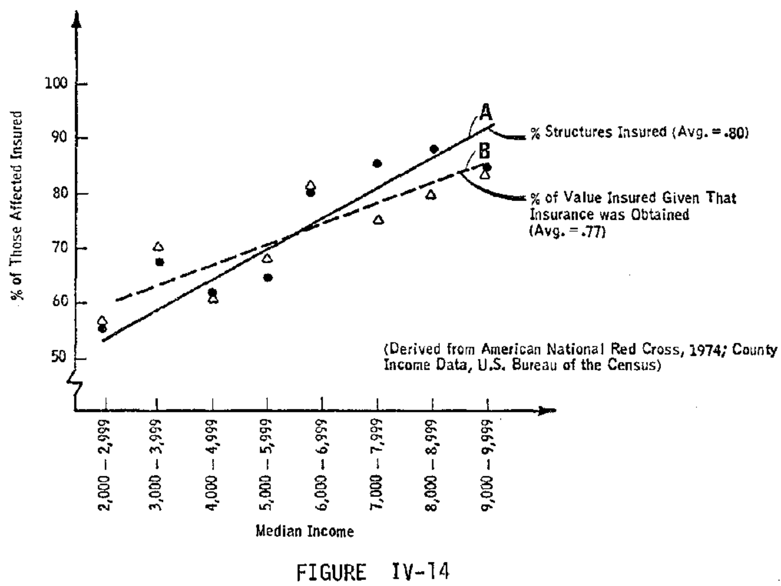

FIGURE IV-14
RELATIONSHIP BETWEEN INCOME AND INSURANCE COVERAGE

bill can be criticized on several points. First, as shown above, the lowest income groups may not buy insurance--there is no provision for this group in the act. There is little incentive in the program, as it is described, for self-responsible action, nor is there much incentive for individuals and communities to undertake damage-mitigating measures aside from that of control and protection. Other adjustments such as land use, flood-proofing, and building codes may be de-emphasized. There is no incentive to expand our knowledge of the hazard agent, nor is there any inducement to strengthen programs of hazard mapping.

1. Comparing Insurance to Disaster Relief

Table IV-5 showed that the burden of spending losses through insurance falls most heavily upon those whose property is exposed to the perils of natural phenomena, in all cases except that of inland and coastal flooding. For these few hazards, the burden is shouldered primarily by the Federal government.[32] Although not the preferred situation from the standpoint of equity, this still may be more desirable than the various relief programs that have punctuated recent history. There are several reasons for this. First, even considering the level of grants associated with the Flood Insurance program, the costs may be less than relief programs of comparable magnitudes:

> Analysis of three major disasters--Tropical Storm Agnes, the Rapid City flood, and the San Frenando earthquake--leads to the conclusion that both the property owners and the Federal government would have been better off under an insurance program than they were under the Small Business Administration disaster loan program (Kunreuther, 1973, p. 46).

With reference to Table IV-5, Kunreuther's conclusions can be checked by calculating the government burden for the Rapid City and Dade County disasters, assuming full coverage on the part of the populations affected, and comparing it to results developed earlier for alternative relief programs. Since 90% of the actuarial rates are covered by the Federal government, the government share for these disasters is shown to

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[32]This is true at least in the initial phases of the Flood Insurance program where premiums charged the homeowner reflect only 10% of the actuarial rate.

be a simple ratio of the results provided in Table IV-5 (see Table IV-6).

TABLE IV-6
LOSSES BORNE (%) BY
THE FEDERAL GOVERNMENT: INSURANCE

	Dade County Hurricane Storm Surge		Rapid City Flood	
Deductible	Camille Type (910 mbs)	Betsy Type (950 mbs)	Slow Flood 1920	Flash Flood 1972
2	84	71	54	86
5	77	58	22	81
20	58	31	10	62

A comparison of the results in Table IV-6 with those of Figure IV-5 for similar events provides two interesting observations. First, Kunreuther's conclusions do not hold for all events--a Federal burden of 71% (Table IV-6) for the Betsy-type hurricane falls within the bands of Figure IV-5, while the burden for Hurricane Camille (84%) does not. Because of this, it may be dangerous to generalize about which method of spreading the loss is most preferable. The Federal government may not be better off under an insurance program. Much depends upon the nature of the damage distribution for a particular event, and how often different events are likely to occur.[33] Second, the insurance program appears to be desirable on entirely different grounds than those mentioned heretofore. The percentage of burden borne by the Federal government increases with the severity (as measured by the intensity ratio) of the event; this tendency is just opposite that of relief, where it may be recalled (Figure IV-5) that the government's share (on a percentage basis) reduced as the

[33]This conclusion should be qualified by the fact that we used a 90% subsidy of actuarial rates. As time passes and new construction continues, this percentage should decline since new policies will reflect rates more closely aligned with the risk the policy holder faces.

severity of the event increased.

A final verdict on the merit of these two means of spreading losses must await a more thorough study which extends the number of events and incorporates their likelihood of occurrence. Although it is as yet difficult to decide between these two measures, insurance is superior to relief in at least one respect. The receipt of insurance payments is automatic and conforms more closely with the cultural norms of exchange--premiums are paid in return for coverage. Relief, on the other hand, may bear the stigma of a gift or welfare.

2. Other Forms of Insurance

In our discussion of property insurance it was pointed out (see Figure IV-11) that lower-income groups purchase disproportionately few life insurance policies. Because of this it is likely that the period of transition following a disaster-related death will be most difficult and disruptive to the poor.

Earlier, we reviewed the likely medical costs due to disaster-related injuries and estimated the number of casualties for a variety of disasters. For most events, the average cost of injury, even including a factor reflecting psychic costs (pain and suffering), is less than one-third the cost of dislocation. Even so, the burden imposed on the disaster victim is far from negligible--the costs of hospitalization are projected to run close to $50 million for the 8.3R earthquake. Who pays for this? How will a national health insurance scheme change the health cost burden borne by disaster victims?

The answer to who pays the medical bills lies in the nature of medical coverage in force at the time of disaster. Most private insurance plans fail to cover catastrophic medical expenses, liabilities often being restricted to less than $5,000. Recalling that the average medical expense in a disaster is $2,000, a review of Figure III-5 shows that almost 10% of tornado casualties experience direct medical bills in the range of $5,000 to $10,000. These direct expenses represent hospitalization and surgery only; if other follow-up expenses such as home nursing, artificial limbs and physical therapy are included, the range shown could easily double. In light of these costs, it is not surprising that a large number of the approximately 100,000 personal bankruptcies filed each year are due to overly burdensome medical expenses.

Over 20% of the population under the age of 65 has no private health insurance. According to Davis (1974, p. 208):

> A disproportionate number of the working poor, of blacks, and of people living in the south are among those uninsured.... Forty percent of all black people and 60 percent of the poor do not have health insurance coverage. Of persons under age sixty-five, 82 percent have insurance in the Northeast compared with only 72 percent in the South.

A more detailed breakdown of insurance coverage by income group is provided in Table IV-7. These percentages suggest the severity of burden the poor, the unemployed, the disabled, and the part-time employed

TABLE IV-7
PRIVATE HEALTH INSURANCE ENROLLMENT RATES (%)
BY INCOME CLASS AND LABOR FORCE STATUS

	Annual income class				
Labor force status of family head	All incomes	Poor (under $3,000)	Near poor ($3,000-5,000)	Middle income ($7,000-10,000)	High income (over $15,000)
Full-time employed	88	41	73	89	98
Part-time employed	44	35	52	62	-
Disabled [1]	38	20	40	-	-
Unemployed	27	4	20	-	-
All statuses	76	38	65	92	95

[1]Many disabled counted in these statistics are now covered by Medicare.

(Davis, 1974, p. 209)

shoulder. It is currently unknown how many in each group are reached by sources of aid other than that provided by the Red Cross.

With a national health care program on the horizon, there exists a strong likelihood that the health care provided the poor after disaster will improve. Over a dozen bills have been introduced in Congress attempting, in one form or another, to revamp Medicare and Medicaid. As of 1974, the four major competing health insurance bills were: Long-Ribicoff; Kennedy-Griffiths; Kennedy-Mills; and the administration bill. The Kennedy-Mills bill ties together many provisions of the other three; in essence it seeks to focus resources on those with the greatest need for financial assistance--the poor and those with large medical bills. A medical insurance program encompassing these concerns will go far toward reversing the distributional impacts of the current private insurance programs, and may tend to diminish the adverse distributional impacts indicated above.

CHAPTER V

HOW MIGHT LOSSES BE REDUCED: WHO PAYS THE BILL?

The losses described in some detail earlier were estimated given the assumption that the current mix of adjustment at each site would continue unaltered. Although the estimates provided are representative of current loss-mitigating measures practiced at each location, it is unlikely that the potential for loss will remain stationary. There are a number of options by which either the frequency of events may be reduced (modify the cause), the forces of the event channeled (modify the hazard), or the potential for losses reduced given that an event occurs (modify loss potential). There is a scarcity of data concerning both the costs of these measures and who the ultimate benefactors and beneficiaries are. The following sections assemble whatever data were available and provide a simple description of each adjustment.

Finally, we have avoided a discussion of optimal pricing policies; there is ample literature addressing this problem (see Hanke and Davis, 1973). Our main focus is cost-sharing arrangements which have been, or are currently in effect.

Modify the Cause

Modification of severe storms--both tornadoes and hurricanes--modification of precipitation patterns, alleviation of stresses in the earth's crust, and suppression of hail are all examples of attempts to mitigate loss through a reduction of nature's forces. Most of these activities are still in the experimental phase of their development, and subsequently are heavily subsidized by the scientific establishment--Federal agencies, the National Science Foundation, and non-profit research foundations.

Hail suppression and modification of precipitation patterns are operational to a limited degree, the level of non-government funds devoted to such activity being around \$8.5 million (Changnon, 1973, p. 643).[1] Private interest in such programs, although still relatively small, stems from three factors: (1) the adjustment is relatively inexpensive; (2) the beneficiary is readily identifiable; and (3) the external effects--damages inflicted upon neighboring counties--are not very noticeable or easily provable in court, which is not to suggest they are small.

These three factors do not operate under other event modification activities, notably tornadoes, earthquakes, and hurricanes. Modification of the hurricane hazard, for example, may be inexpensive, but the beneficiary is not easily identified, nor are the damages inflicted on other parties negligible or invisible. To be effective, hurricane seeding must be undertaken at some distance from the coast, at a point in time when the landfall is uncertain. With much of the coast susceptible to the forces of the event, no one county or state could be established as the beneficiary of the modification process. It is not yet certain how modification will affect other geographical regions. If hurricanes are successfully diverted from populated areas, the rains upon which Southeastern agriculture depends may not be forthcoming.[2] Moreover, the opposite effect of a possible reduction in wind velocities at the expense of increasing rainfall may reduce damage to coastal residences, while increasing damage to those living in flood plains inland.

Similar problems accompany modification of the other events of catastrophic nature. If modification of hurricanes, tornadoes and earthquakes were to become operational, it should not be expected that they would be privately financed. The financing would most likely come from the state, and in all probability the Federal government would assume a predominance of the financial and managerial burden.

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[1] This may be compared to Federal expenditures on research which are approximately \$25 million (Changnon, 1973).

[2] The magnitude of agricultural losses resulting from hurricane modification has been debated. Some (Hartman, *et al.*, 1969; Taylor, 1970) have concluded that the effects are not significant because the hurricane season does not occur at a point in the growing season which significantly affects yields.

Modify the Hazard

Modifying the hazard mitigates losses by channeling the forces of nature without attempting a reduction in the forces. Dams and channels restrict the flow of rivers, storm surge barriers diminish the effects of coastal flooding, and snow-fighting facilitates the normal flow of urban activity. There is a striking variety of ways to cover the cost of these measures (see Table V-1). Modifying the snow hazard via snow removal operations is supported almost 100% at the community level, much of the revenue for such activity being generated from gasoline taxes. In contrast, modifying the flood hazard by control and protection--dams, levees, and channels--is supported largely through Federal funds.[3]

The precedent for cost-sharing in the field of flood control dates back to June 5, 1920, when the Chief of Engineers was directed by Congress to include in his survey reports recommendations for special local cooperation when any special benefit accrued from projects. Federal involvement in flood control solidified with the passage of the Flood Control Act of June 22, 1936, in which destructive floods were held to be a menace to national welfare. Accordingly, the government was able to provide protection so long as the benefits "to whomsoever they may accrue are in excess of estimated costs". The interests of the Corps of Engineers broadened after the hurricanes that struck the Northeast in 1955. With the passage of the Flood Control Act of 1958 (Public Law 500, 85th Congress), cost-sharing was extended to works to protect areas subject to inundation through hurricane, high winds, or unusual tides.

Aside from the influence of Federal legislation on cost-sharing formulas, economists have argued that normally the total costs of providing control and protection exceed the value of the net fiscal benefits the community stands to realize from the project. The reason cited (see

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[3]A heavy involvement on the part of the Federal government is not unique to the modification of natural hazards. The Department of Urban Development provides up to 66 2/3% of program costs for development of mass transit systems and up to 80% for municipal development of libraries, hospitals, and other civic projects. A more striking example of Federal involvement is in the area of road construction where only 10% of local funding is required to finance interstate highways.

TABLE V-1

REVIEW OF COST-SHARING

ARRANGEMENTS TO MODIFY THE HAZARD

Hazard	Capital Costs Burden (%) Local	Federal
Flood		
Corps of Engineers		
Large Reservoirs	0[1]	100
Local Protection	20[1]	80
Soil Conservation Service		
Land Treatment Reservoirs	50[2]	50
Bureau of Reclamation		
Major Flood Control	0	100
Hurricane		
Corps of Engineers	30[3]	70
Coastal Erosion	50[4]	50
Drought	-[5]	-
Snow	100	0

[1] (Loughlin, 1974)

[2] Beneficiaries of reservoir programs must provide only lands, easements, rights-of-way, and relocations and operation and maintenance costs. (Loughlin, 1974)

[3] (Dacy and Kunreuther, 1969)

[4] (Hanke and Davis, 1973)

[5] Repayment of project costs, due to the Reclamation Act of 1939, has been limited by the ability of irrigators to pay for water. Repayment is based upon farm productivity, but is limited to 75% of the irrigator's ability to pay. It is difficult to establish a local share since a variety of devices (no payment of interest and transfer of funds from project to project) have reduced payments considerably below the 75% level. (Hanke and Davis, 1973)

Institute for Water Resources, 1971, p. 54) for the inability of the community to pay the full cost of protection projects is that the community cannot extract a large enough proportion of the resulting benefits. If land and property value increase because of protection, the real property tax is insufficient to capture the gains. Most of the benefits are capitalized and retained by the homeowner.

This argument is predicated upon the assumption that the reduction in losses resulting from protection is observed and is reflected in the selling price of flood-prone property. The evidence supporting this assumption is inconclusive. In an analysis of land values and flood risk in the Wabash river basin, Baxley (Institute for Water Resources, 1969) concluded that the relationship between risk and value was strong for certain areas (Lower Wabash), and weak for others (Upper Wabash).[4] If the benefits of flood reduction, as suggested by the results from the Upper Wabash, are not capitalized, there may be little chance that the local government can ever capture, via conventional means, the resources necessary to undertake a flood control project.[5]

Modify the Loss Potential

1. Land Use Management[6]

Most broadly defined, land use management is the process whereby the natural resource, land, is put to its "best" use. Two problems immediately become apparent: according to what criteria is "best" to be determined; and what the appropriate social mechanisms or processes are which will bring about the "best" uses. Chapter I was devoted, in a small part, to describing criteria by which preferable public policies could be

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[4]However, even for the strongest relationships, the confidence limits that could be attached to land value estimates are relatively wide, stemming mostly from variance in all factors that determine land values (Institute for Water Resources, 1969, pp. 154, 155).

[5]Under the category *conventional means* we are including property taxes only. Innovative programs such as establishment of a public utility are excluded.

[6]Much of the descriptive material for this section was obtained from Baker and McPhee, 1975.

identified: National and regional economic efficiency, environmental quality, and income redistribution. These are also the criteria according to which a "better" land use plan may be identified.

The economic aspects of locational decisions have had much to do with the pattern of land development in the past. The flat lands of river valleys have been less expensive for contractors to develop than the slopes of the surrounding hillsides. The benefits of soil fertility and climate have been capitalized into the selling price of farms. However, because of inherent limitations in the ability to process information about random events (Slovic, Kunreuther and White, 1974), the price of land may not truly reflect the hazardousness of alternative locational sites. In addition, the private calculus of decision-making may not capture the full social cost of a location. The selling price of a piece of land may well mirror the real estate demand and supply picture, but most likely does not accurately reflect the external costs the decision inflicts on others. For example, the decision to locate a factory in a hazardous area may be made without due regard for the effects the plant's potential cessation of operation would have on the earnings of its employees, the tax base of the town, or upon other industries to which it may be tied.

For reasons such as these, the public sector (local, state and Federal governments) has attempted to modify land use patterns. Land has been acquired through purchase or lease. Programs of acquisition, greenbelts and the like, are numerous and diversified at the local and state levels. Federal programs geared to the acquisition of open space are: (1) U. S. Department of Housing and Urban Development Open Space Program; (2) U. S. Department of Urban Renewal (discussed earlier in Chapter II); (3) Land and Water Conservation Act; and (4) Historical Preservation Act.

The use of land has been regulated. Regulation has been accomplished at the state level through the application of comprehensive land use controls which establish guidelines for land use. One example of such a practice is the State Land Conservation and Development Commission in the State of Oregon. Similar activities have been undertaken in Florida (Coastal Coordinating Council) and California (Urban Geology Master Plan). The state can also pass enabling legislations for local governments' zoning and building regulations. The Federal government, because of interstate complications, can assist in land use regulation. Legislative acts growing out of concern for land use are the Land Use Policy and Assistance Act (1973), Coastal Zone Management Act of 1972 (Public Law 92-583), and the National Flood Insurance Act of 1968 (Public Law 92-213). In addition, the Federal government can control the lands it owns (33% of the total land area).

The use of land has been modified through economic incentives and disincentives. A few states (Connecticut, for example) provide property tax relief to encourage preservation of open space. Local governments have also adopted economic incentives in the form of tax relief by substituting a tax based upon use value rather than market value.

Although regulation comprises the most prevalent measure of government management of hazardous areas, it has not gone unchallenged in the courts. Zoning ordinances are not always within the legislative authority of the local community. In addition, the landowner may challenge a zoning regulation as it applies to himself:

> In order to satisfy the substantive due process, there must be a rational connection (nexus) between the regulation in question and the promotion of the public health, safety, and welfare....The court will generally look for two things. First, does the regulation's purpose clause bear a reasonably close relationship to the goals to be achieved by the regulation....Second, does the ordinance have a 'safety valve' that will prevent individual instance of injustice (Baker and McPhee, 1975).

In either case, the community runs the risk of having its regulatory scheme overturned by the judicial process.

It is difficult to identify the benefits of land use, and equally difficult to identify the beneficiaries. If what is meant by "better" land use is a contribution to the welfare of the community and nation through the attainment of the multiple objectives of efficiency, equity, and environmental preservation, then the degree to which these goals are attained is a measure of the benefits. The beneficiaries of land use management are those who were saved the unsought and unexpected expense and human suffering that accompany the occupancy of hazardous areas.

The costs of land use management are (1) the resources spent for acquisition, (2) the restrictions on locational decisions along with foregone economic opportunities accompanying zoning, and (3) the resources devoted to tax relief in the maintenance of open space areas. The benefactors for those acquisition programs that are supported through local initiatives, and for which the sales tax is the prime source of funds, tend to be the poor and middle income groups. Federally supported programs shift the burden to the general public, and because of the relatively progressive nature of the Federal tax system, the middle and upper middle income groups shoulder more of the costs of these programs. Accurate estimates of the magnitude of both benefits and costs, as well as how they are distributed, have yet to be assembled.

2. Warnings

The process of warning (Mileti, 1975a) consists of three elements--evaluation, dissemination, and response. Evaluation is concerned with the detection and measurement of changes in the geophysical/meteorological system. Detection, to be of use, must be disseminated; dissemination is comprised of the decision to warn, the formation of the content of the warning message, and the transmission of such messages. The third element, response, is the adoption of protective action on the part of the threatened community.

The responsibility for each of the elements varies consistently among the hazards, as shown in Table V-2. Evaluation, with the emphasis on technical apparatus and highly trained personnel, is primarily the domain of Federal agencies such as the National Weather Service. Dissemination, relying more heavily upon the communications media, is accomplished by local radio and television operations in conjunction with local authorities, usually the police and/or civil defense. Response is normally up to the individual, although some local government assistance is given in forced evacuations.

Total Federal expenditures on the warning system are $139 million annually, almost 70% of which is devoted to evaluation; the remainder of the warning budget is split almost evenly between dissemination and response.[7]

[7] A large part of the Federal funds devoted to "response" is for the purpose of community preparedness.

TABLE V-2

REVIEW OF WARNING-RELATED EXPENDITURES

KEY: E = Evaluation; D = Dissemination; R = Response

	GOVERNMENTAL AGENCIES AND OTHERS	AVALANCHE	COASTAL EROSION	DROUGHT	EARTHQUAKE	FLOOD	FROST	HAIL	HURRICANE	LANDSLIDES	LIGHTNING	TORNADO	TSUNAMI	URBAN SNOW	VOLCANO	WIND	Yearly Cost of Operation (Million $)
FEDERAL	NOAA																
	National Weather Service	E	E	E		E	E	E	E		E	E	E	E		E	
	National Meteorological Center											E		E			
	National Severe Storms Forecast Center										E	E					
	Agricultural Weather Service						E					D					
	Radar Report + Warning Coordination Circuit								E		E	E					
	River District Offices & Forecast Centers					E											E 68.1
	GOES – Satellite System								E			E	E				D 14.2
	Environmental Data Drought Index			E													R 0.0
	National Hurricane Center								E								
	Hurricane Warning Offices								D								
	Weather Service Forecast Offices			E		E	E					E		E		E	
	NOAA Weather Wire Service		D			D		D	D			D				D	
	Joint Effort w/Univ. of Hawaii												E				
	Flash Flood Warning + Alarm System					E											
	U.S. Department of Interior					E											E 6.3
	U.S. Geological Survey			E	E	E				E			E		E		D 0.1
	Hawaii Volcano Observatory														E		R 0.0
	National Tsunami Warning Center												D				
	U.S. Department of Defense																E 21.6
	Army Corps of Engineers					R							E				D 8.4
	Defense Civil Preparedness Agency																R 19.6
	Nat'l Warning Centers & State Warning Points																

(Continued on next page)

TABLE V-2

(Continued)

KEY: Evaluation (E) · Dissemination (D) · Response (R)

	GOVERNMENTAL AGENCIES AND OTHERS	AVALANCHE	COASTAL EROSION	DROUGHT	EARTHQUAKE	FLOOD	FROST	HAIL	HURRICANE	LANDSLIDES	LIGHTNING	TORNADO	TSUNAMI	URBAN SNOW	VOLCANO	WIND	Yearly Cost of Operation (Million $)
FEDERAL	U.S. Department of Agriculture	E				E											
	U.S. Forest Service	E								E	E						E 0.7
	Fire Control Offices										E						D 0.0
	Soil Conservation Service					E											R 0.0
	NASA	E							E	E					E		?
	Department of Transportation																?
	Federal Highways Administration	E								E							
	Federal Disaster Assistance Administration																
STATE	State of Calif. Div. of Mines & Geology												E				
	Alaska Tsunami Regional Warning System												E				?
	State Highway Departments	E															
	State Police		E														
	State Geological Div. + other State Agencies									E							
LOCAL	Local Govt. Employers, Police etc.		D			D			D	D		D	D	D, R	D		
	Local T.V. + Radio		D	D		D	D		D	D		D	D	D	D	D	?
	Local Geological Div. & other State Divisions									E							
INDIVIDUAL	Private Weather Forecast			E, D			E, D							E, D			
	Private Sector	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	?

(Derived from National Oceanic and Atmospheric Administration, 1973)

The total costs of state and local involvement are difficult to estimate since the agencies responsible for implementing a disaster warning, e.g., police and fire departments, are organized around other purposes. Urban snow provides an exception since some communities contract the services of consulting meteorologists to help plan snow-fighting strategies.

The cost of responding to warnings is equally difficult to assess. In general, it requires an estimate of forecast accuracy: how many times forecasts dictated actions which turned out to be unnecessary; how many times forecasts suggested no action when, in fact, action would have reduced losses; and the cost of responding to a forecast which turned out to be correct. The second category, although it can be attributed to the warning adjustment, was discussed as a residual loss in Chapter III.

Currently the accuracy of forecasts for many of the natural hazards is low. It was shown in the Urban Snow Report (Cochrane and Knowles, 1975) that if a municipality were blindly to follow predictions of heavy snow, the cost of errors, of renting additional snow-fighting equipment in preparation for the large storm when it was not needed, or of not preparing for a storm when it materialized would cost the community about 50% of the total hazard cost,[8] or about $1.60 per person annually.[9] Applying this estimate to the number of individuals residing in urban areas most susceptible to snow, it is estimated that the annual cost of decision errors would exceed $100 million per year. Inclusion of "correct" responses to snow warnings would increase the cost of implementing warnings by at least 50%.

It appears that response to the snow hazard by itself is more costly than evaluation and dissemination totalled for all hazards. Although it is difficult to estimate further the resources devoted to warnings for either individuals or communities, it is apparent that in spite of large Federal input to evaluation and dissemination, the bulk of

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[8]The hazard cost includes both expenditures on adjustments and residual damages.

[9]This estimate is based upon the cost of forecast error shown in the Urban Snow Report (Cochrane and Knowles, 1975).

the burden lies with the individual and community.

Over the past 25 years, the tendency has been for an increasing Federal involvement in all three phases of the warning process. Budgets for detection have increased, and federally developed technology has crept into the dissemination of warnings. The National Oceanic and Atmospheric Administration and the National Aeronautics and Space Administration have conducted studies to determine the feasibility of applying satellites to the task of detection and warning dissemination. The Defense Civil Preparedness Agency is involved with the development of a Decision Information Distribution System (DIDS) which would be capable of issuing warning of threats from natural phenomena *automatically* through a device attached to an individual's radio or television receiver.

This increasing reliance on an escalating Federal involvement and on the technology of the warning process signals some concern about their effects on the ability of populations to respond to warning messages. These trends have been accompanied by a decline in participation of voluntary organizations such as amateur river observers. One cannot help but wonder whether the introduction of technological devices from the Federal level has given the warning process a greater efficiency in detection at the expense of a deterioration in dissemination and response.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Review of Findings

Chapters II through V have covered a broad matrix of fact and speculation concerning the dsitributional impact of different natural hazard adjustments. Several themes emerge from the foregoing analyses.

Hazards vary widely in their destructiveness and in their impact on different income groups. It appears, however, that the lower income groups consistently bear a disproportionate share of the losses: they receive, in most instances, the smallest proportion of disaster relief; they are the least likely to be insured (for either health, life or property); and they live in dwellings which are of the poorest construction and most subject to damage.

Average annual loss is an inappropriate index for the analysis of the distribution question. It aggregates the severity and frequency of disaster, thereby veiling the effects of hazard adjustments on losses and their distribution.

It appears that Federal involvement is greatest for the adjustments which involve more than one political jurisdiction.[1] Dam construction, warning (detection and evaluation, hurricane seeding, and earthquake modification are all examples of adjustments which conform to this hypothesis. Relief and insurance (floods and storm surge) are questionable in this regard, although the argument can be made that the systemic effects of disaster cut across political boundaries.

The Federal government, under a wide variety of *relief programs,*

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[1]It has been argued that multiple jurisdictional involvement is the *only* real reason for the evolution of Federal cost sharing formulae. If it weren't for the fact that most hazard adjustments of the control and protection variety cross numerous political jurisdictions thereby making cooperation difficult, Federal involvement would be much diminished.

seems to bear a substantial proportion of the loss to property.[2] However, this percentage tends to decline as the severity of the event, measured by an index of destruction, increases. The greatest hardship appears to be borne by those caught in catastrophic events, and the hardship is least for those affected by relatively mild natural phenomena. Just the reverse of this tends to hold for federally subsidized insurance (inland and coastal flooding). Because of a 2% deductible and the substantial grants offsetting actuarial rates, losses borne by the victim of disaster tend to decrease as the event's destructiveness increases (see Figure VI-1 for a comparison of relief and insurance).

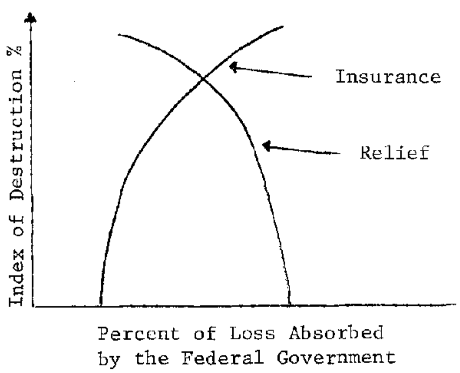

Figure VI-1: Insurance and Relief Grants Contrasted

Deductibles also influence the distribution of loss between the insurance company and policy holder in nonsubsidized insurance situations (earthquake, hail, wind and tornado). For example, a 5% deductible policy will cover less than 50% of the total loss resulting from the relatively frequent, but rather small 5.0R earthquake. For the less frequent and larger disaster (an 8.3R earthquake), the percentage covered jumps to 85%.

A smaller percentage of lower income individuals seek aid from the Federal government than middle and upper income groups. This may be due in part to the fact that they often do not qualify for government loans. By not being able to demonstrate an ability to repay, they are foreclosed

[2]This statement applies to most hazards aside from wind, hail and tornado which are covered to substantial degree by homeowner insurance.

from the forgiveness feature of SBA disaster loans. Public hearings investigating the adequacy of Federal relief in the post-Agnes period reaffirmed this point.

Liberalized relief policies *do not* always lessen inequalities among individuals. For the most part, generous interest and forgiveness grants benefit those who have the greatest wealth at risk, the upper and middle class homeowners. Even though these groups tend to reap the greatest proportion of total SBA benefits, they are also absorbing (as a percentage of their individual losses) the greatest proportion of the damage. Those earning incomes over $15 thousand per year must absorb over 50% of their losses, whereas the below-$5,000 yearly income group need pay only 15%.[3] Current disaster loan provisions will tend to change the burden borne by lower income groups, but the direction of this change depends upon how the grant to the needy is administered.

The secondary impacts (for instance, economic disruptions) which are likely to follow a large-scale disaster such as a recurrence of the 1906 San Francisco earthquake, may at least match in value the physical damage to commercial and residential structures. Along with these economic and social dislocations, a separate set of distributional problems will grow which are yet very imprecisely understood. For example, little is currently known about the distributional impacts a local inflation in the construction trades will have on the affected region. Similarly, the potential for land revaluation and bank foreclosures could bring a set of distributional impacts with which public agencies are currently unprepared to cope.

Injury and death are apparently linked to the destructiveness of the geophysical event. On the average, eleven individuals may be expected to die for every 100 dwellings that are totally destroyed. This estimate, of course, is subject to the qualification that events differ with respect to onset time and mode of structure failure, but there appears to be some consistency about this average. Of those dying, individuals of 64 and over tend to bear a disproportionate share of the burden.

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[3]These estimates are derived from Figure IV-8, given a 1% interest rate, a $2,500 forgiveness, and a Camille-type disaster in Dade County.

Lastly, the heaviest non-local involvement in the warning system occurs in the areas of detection and evaluation. However, if the warning system is defined to include appropriate response, it appears that by far the greatest burden of loss falls on the individual and the local community. The brief analysis of the warning system applied to the urban snow problem shows that the cost of response to this hazard exceeds the cost of evaluation and dissemination of all other hazards combined.

Research Opportunities

This study has concentrated on a series of events occurring at particular sites. It would be important to expand these analyses to include other sites, both actual and simulated, and to observe how the cascade of disaster effects would be altered from that presented here.

Most of the distributional impacts shown in Chapter IV assumed that an SBA grant would be recognized immediately by the disaster victim. This does not always seem to be borne out by experience, as evidenced by the case cited in Chapter IV, in which it appeared that elimination of forgiveness tended to reduce SBA loan requests even though a substantial grant in the form of reduced interest was still available. Verification of this possibility deserves careful attention.

The distributional impacts resulting from other than property damage require additional research; these may encompass the most subtle yet pervasive re-distributions of wealth occurring after disaster. Included in such an investigation should be an analysis of the distributional impacts of any local inflation which is likely to accompany a large-scale catastrophe. This study should delve into different approaches to reducing undesirable redistribution of wealth which may result from such an inflation.

Although a method for assessing the income distribution changes from different relief programs under a variety of disaster situations has been developed, it would seem necessary to follow this study by questioning the victims in order to obtain some indication of what an *equitable* distribution of burdens appears to be from the vantage point of the disaster victim. For example, it was shown above that certain loan programs tended to skew the current distribution of income more than it would be otherwise. However, these same loan programs also left the middle and upper income homeowner bearing a greater percentage of individual losses. A structured interview should help to put the results of these findings in perspective with regard to the question of "fairness" from the victim's viewpoint.

One final research opportunity grows from all the proceding analyses: a concern for knowing the dynamics, or the *laws*, of distribution. What we have covered thus far is a snapshot of distributional patterns as they appear today, and we have attempted at points to expand the analysis to incorporate a range of programs (particularly in the arena of disaster relief). However, the analysis has been one of classification, sorting the beneficiaries and benefactors of different hazard adjustments; we may have missed critical linkages between adjustments--the kinds of linkages which lead to distributional patterns quite unanticipated by the method of analysis used here.

Most of what has been shown in these chapters could be called the "distributional *rules*" of the hazard system: cost-sharing arrangements; provisions for SBA loan repayment; and grants for the adoption of insurance. The distinction between distributive laws and distributive rules is a very difficult one to maintain, partly because the terms *laws* and *rules* are often used interchangeably. Yet for our purposes, they are entirely different. Central to the issue is whether these impacts can be administratively changed through redistribution, or whether they are a product of a pervasive undercurrent that is subtly guiding the hazard system.[4]

The analysis carried out in Chapter II was designed to show how different government policies on cost-sharing, insurance, and relief and rehabilitation would lead to different patterns of benefits and costs. These patterns are administratively changeable. If a 7%, no forgiveness relief policy produces an unsatisfactory distribution of burdens, a legislative amendment can be passed to rectify the problem. For that matter, most of the adverse impacts illustrated in Chapter II can be reversed through administrative action, i.e., through an appropriate mix of grants and taxes. But these administrative solutions are not grounded in any

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[4]Due to the absence of any concerted effort in conducting post audit studies of specific disasters, little is known about the distributional effects of the burden.

understanding of the hazard system's underlying forces; they are reactions to what is visible: the losses, the suffering, and the opportunities to protect.

Not all such impacts are easily recognized or subject to change by administrative action; the ultimate *distribution* of burdens and benefits, through time, is a product of a much deeper set of factors--the interaction of the cultural, social, cognitive and natural systems. It is seldom that public action has the sole effect of adding to, or subtracting from an individual's wealth. Such action normally is accompanied by a qualitative residual, which, in the case of natural hazards, is an alteration of the likelihood that different hazard adjustments will be chosen. It is this concern for the effect of public action on ongoing individual motivation and subsequent decision-making that has been omitted from the analysis carried out above.

Aside from distributing wealth and protection, the actions of the Federal Insurance Administration, the Federal Disaster Assistance Administration, the Army Corps of Engineers, and the National Oceanic and Atmospheric Administration have the potential to shift and distort knowledge about the hazards individuals face. The construction of control and protection works by the Corps of Engineers, for example, protects individuals from the ravage of floods but, at the same time, changes the natural frequency of stream flow. To the extent that experience gained from this variation previously provides *information* useful to the population-at-risk, such measures reduce the flow of information to the decision maker. This type of underlying relationship is what we seek to discover--factors relating to distribution that are not subject to change by an administration's edict, but which are grounded in cognitive and social environments.

If knowledge about one's natural environment is, in fact, an important ingredient in the dynamic process of determining distribution, then impacts on knowledge need to be considered in the policy-making process, along with wealth. It is shown in Appendix IV (not printed) that it is insufficient to ask how adjustments change the present distribution of wealth in society; the companion question must also be asked--how does an adjustment alter the flow of information to those at risk from natural phenomena?

It should be apparent by now that by introducing information into the problem setting, we have discarded the traditional economic assumption that individuals make decisions on the basis of *full knowledge* about their environment. Uncertainty plays a critical part in the decision-making process; Appendix IV (not printed) presents a simplified discussion of behavior of individuals under uncertain situations to set a direction for future research. Building on this base, a model which captures the interaction of public and private decision-makers is then constructed, with the hope that the framework provided establishes a new and more basic direction for the analysis of distribution.

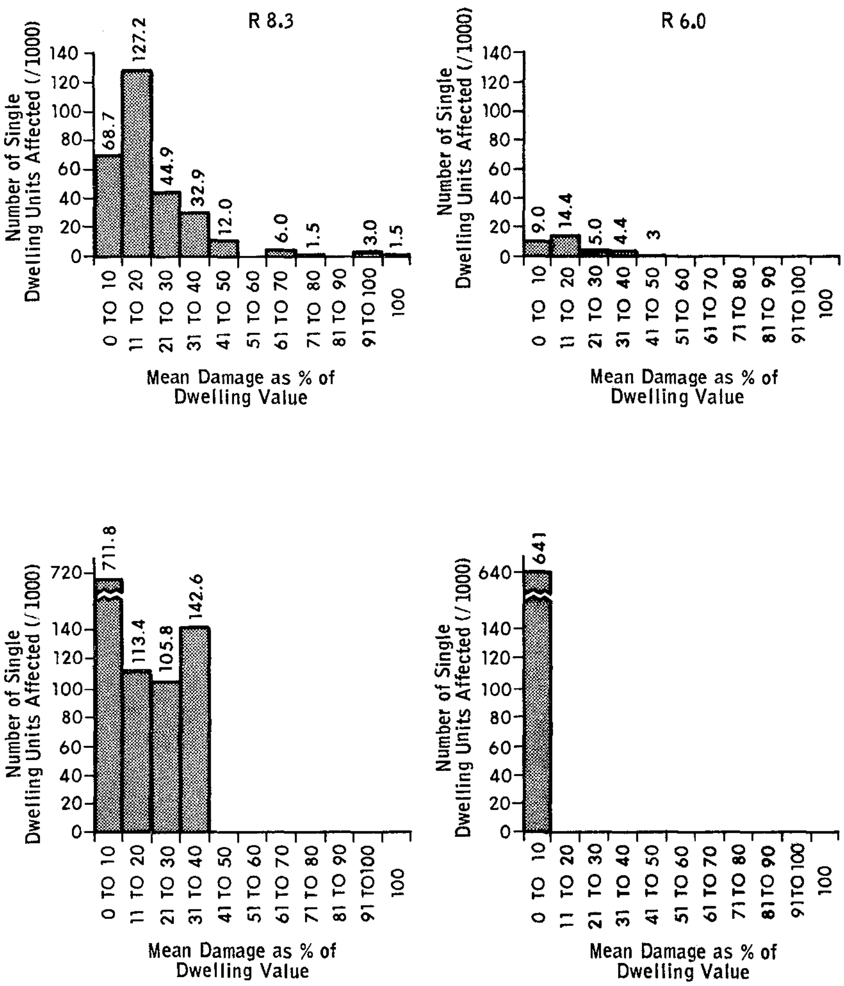
Appendix I

Damage Distributions

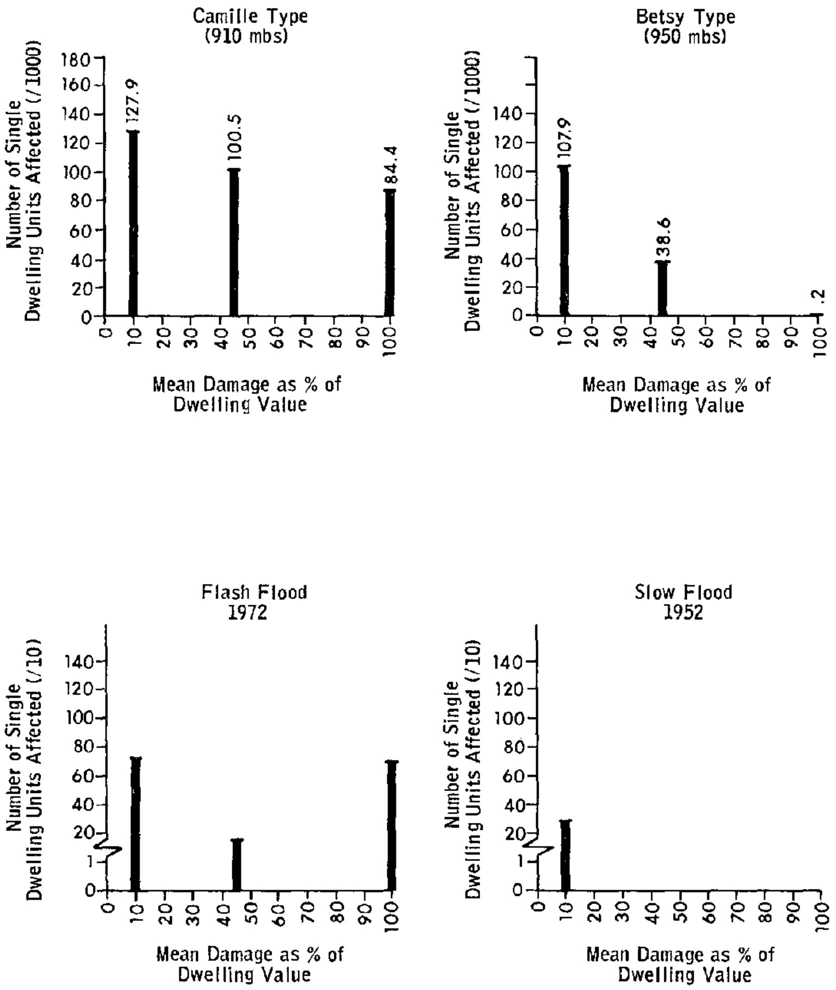
For

Selected Events

SAN FRANCISCO
EARTHQUAKE



DADE COUNTY HURRICANE
STORM SURGE



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