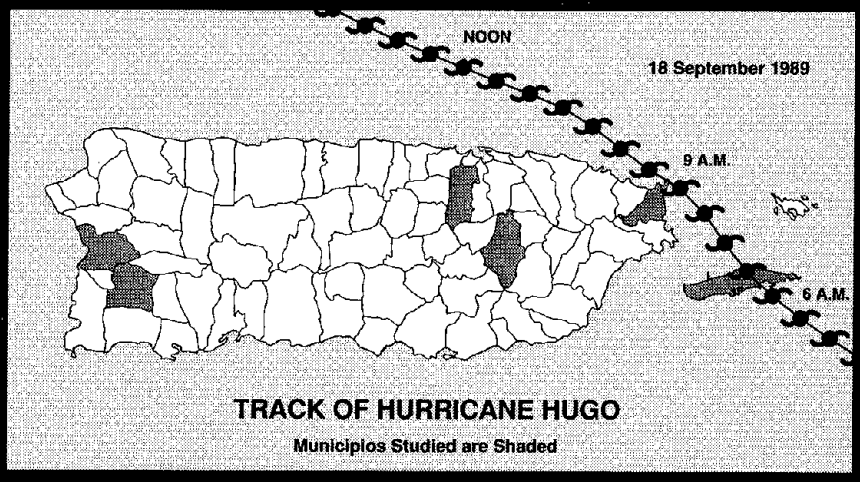
Attitudes, Experience, and Behavior of Homeowners



NATURAL HAZARDS IN PUERTO RICO
Attitudes, Experience, and Behavior of Homeowners

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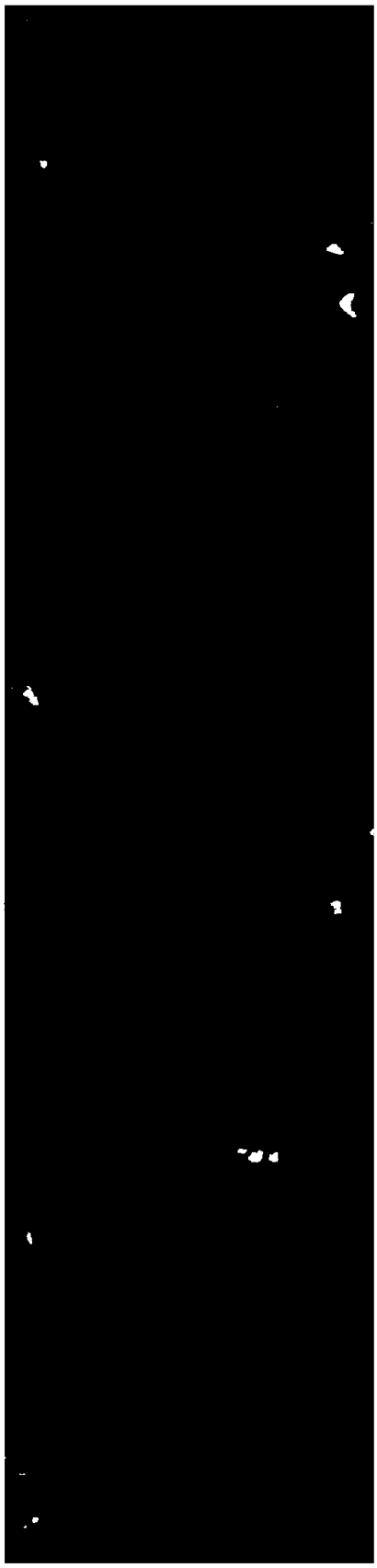

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Preface

This book reports the findings of a 1990 sample survey of Puerto Rican homeowners. The purposes of the survey were threefold: first, to document perceptions and response to a variety of natural hazards confronting Puerto Rican residents; second, to assess the effects of different intensities of experience with a hurricane on risk perception and insurance purchase; and third, to compare attitudes and response to natural hazards in two different environmental, cultural and political settings — Puerto Rico and California. The first chapter reviews the goals of the study as well as its theoretical underpinnings, and presents previous related research, including a summary of the California studies completed by the authors which shaped the nature of the study questions posed in Puerto Rico. The second chapter provides an overview of the Puerto Rico study site, including a discussion of its history and economy, the various natural hazards that threaten life and property in Puerto Rico, and a discussion of the contrasts between Puerto Rico and California. The third chapter reviews the study design — the selection of study areas, the selection of the survey sample, the survey design, and the development of the geographical data base. The next four chapters report the findings of the survey and the associated geographical analyses. Chapter 4 focuses on the adoption of mitigation measures, the variability of this adoption by location and experience with the hurricane, and a discussion of the nature of insurance as a mitigation measure. Chapter 5 summarizes survey findings concerning the homeowners' perception of hazards in their immediate environment as well as the images they have about hazards in other parts of Puerto Rico. It presents findings about the relative level of concern with hurricanes and earthquakes, as well as some comparisons with the attitudes of California residents. Chapter 6 includes a discussion of the voluntary adoption of earthquake insurance in Puerto Rico, focusing on those homeowners with no home mortgage, along with a brief discussion of the co-insurance gap. Chapter 7 reviews studies relating experience with a hazard and subsequent perception and behavior, and presents empirical findings on the impacts of experience with Hurricane Hugo on both voluntary insurance adoption as well as the adoption of other mitigation measures in Puerto Rico. Chapter 8 draws the empirical findings together and suggests several policy implications of this research.

The research reported here is based on work supported by a grant from the National Science Foundation — Grant No. BCS-9017369. We are grateful to Dr. William Anderson of the National Science Foundation for his enthusiasm about this project and his continuing advice and support. Our faculty colleagues

in Puerto Rico — Professors José Molinelli and Nancy Villanueva — provided advice on the design of the research, translated the questionnaire and final reports into Spanish, organized advisory committee membership, and facilitated this work in ways that were indispensable. Professor José Molinelli was the coordinator of the project in Puerto Rico, and it was to him that questionnaires were returned. He also read and edited this manuscript. Professor Nancy Villanueva spent a great deal of time with the authors in the field, and provided immense support in the design and implementation of this project.

We were assisted by several able and enthusiastic graduate and undergraduate research assistants. Denise Blanchard was the senior research assistant in this project — helping to coordinate the advisory committee meetings and the mailings. James Zack managed the bulk of data entry, statistical analyses, geographic information analyses, and produced many of the cartographics in this manuscript. John Carroll also did statistical analysis and the production of graphics. Augusto F. Gandia-Ojeda collected data for the floodplain mapping segment of the project.

Staff assistance was provided by Debbie Rauch of the University of Oregon, Regina Hanson of the University of Colorado and Gisela Porras of the University of Puerto Rico. We also with to express our gratitude to David Butler of the University of Colorado for his carefult editing and comments.

We are grateful to our advisory committee for their help in the design of the survey questionnaire and their very useful advice in the interpretation of our findings. This committee included: Sam Arana, Eunice Betancourt, Walter Bothwell, Carlos Bruno, Victor Carreras, Rafael Corrada, Ana Luisa Davila, Felipe Franco, Juan Antonio García, Marie González, Dennis Hanspwurcel, Colleen Heilig, Gustavo Martínez, Eric McDonald, Alberto Ortiz, Angelita Rieckehoff, Manuel San Juan, María Sarmentero, Maribel Torres and José Velez.

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Introduction

Television advertisements promoting tourism portray Puerto Rico as an American paradise: a vacation destination where tourists bathe in warm gentle sea waters, explore the only U.S. national park containing a tropical rain forest, windsurf, and enjoy the nightclub and casino night life of a major city. Music of salsa and merengue fills the air as tourists swarm around the docks waiting to embark on luxury cruises throughout the Caribbean islands. Contrasting images of Puerto Rico depict the struggles of an impoverished rural people attempting to escape to a better life by moving to the big city or to mainland destinations such as New York, Chicago or Boston, or images of drug trade and its accompanying violence. Still other images present Puerto Rico as a land of economic opportunity for American corporations — a site where light manufacturing of electronics or pharmaceuticals is encouraged with generous forgiveness of federal corporate taxes.

The hurricane, the devastating landslide, the riverine flood, or the earthquake with accompanying tsunami interrupts all these images. And yet this setting, this vulnerability to natural hazards, is an important part of the reality of Puerto Rico.

This book summarizes an investigation of the attitudes of Puerto Rican homeowners toward the natural hazards in their environment and the mitigation measures these residents adopt to protect their lives and property. It provides baseline information about attitudes and behavior of Puerto Rican residents assessed after a major hurricane — Hurricane Hugo in 1989 — but before the devastation that would accompany a major earthquake that could cause billions of dollars of damage and thousands of deaths and injuries.

Goals of the Study

This study was undertaken with three general goals in mind. The first goal was to document the attitudes and behavior of homeowners in Puerto Rico toward natural hazards. No previous studies had attempted to assess such factors. This goal was examined for the overall Puerto Rico population and also

examined for the population stratified by geographic location and mortgage status.

The second goal is to assess the effects of different intensities of experience with a hurricane on risk perception and insurance purchase. Since much theoretical work links experience with attitude shift and also with behavior change, we expected to explore the direct and indirect effects of Hurricane Hugo on attitudes toward hurricane and other hazards as well as the adoption of mitigation measures.

Third, this study also provided an opportunity to compare directly the attitudes and responses in two different environmental, cultural and political settings — California and Puerto Rico. The triggering events were major natural disasters affecting these two regions within a one-month period in 1989. Since the authors had conducted intensive surveys in California on earthquake hazard perception and response, one of the goals was to explore the commonalties and differences in the two regions. We expected several similarities: homeowners in both areas had different levels of experience with the event itself, which should independently affect attitudes and the adoption of mitigation measures. In addition, both groups had a common experience in dealing with state and federal agencies such as the Federal Emergency Management Agency in the recovery phase.

We also expected several contrasts. First, the hazard event in California was an earthquake, in Puerto Rico, a hurricane; thus the responses to the events should differ because of the varying characteristics of each event, such as prediction, recurrence, exposure, temporal variability, and intensity. Second, the political economies of the two areas — although united through association with the U.S. federal government — are very different. Unemployment is much higher in Puerto Rico, as is the sense of cultural identity. These factors should affect the propensity to depend on federal aid, and therefore to adopt local or household mitigation measures. Third, the extent of personal and family linkages across the entire island of Puerto Rico makes family/friendship ties a kind of mitigation in themselves (Bolin and Bolton, 1986). These ties are very different from the types of family dependence possible within the Hispanic population in Santa Clara County, California, where relatives are frequently located at long distances, or for the Anglo population, which tends toward more nuclear family ties. We believed that our focus on Puerto Rico would also illuminate our findings in California, and we attempted to develop direct comparisons between the two areas.

These three general goals were translated into five specific research hypotheses that concern the impacts of experience on beliefs and action, comparisons between predictor variables in the two regions, and the impacts of the political economy on hazard response. Before discussing the specific hypotheses, it is useful to review the research on which this study was based. The development of the research design, as well as our expectations concerning empirical findings, is informed and influenced by previous studies — both

theoretical and empirical — concerning attitude formation and the linkage between attitude and behavior.

Theoretical Underpinnings of the Puerto Rico Survey

Why do individuals adopt or resist mitigation measures? This topic — the development of attitudes toward natural disasters, factors that cause attitude changes, and the linkages between attitude change and behavior change — has been the subject of an immense amount of research (Weinstein, 1989a; Kasperson and Stallen, 1991; Sorensen and Mileti, 1991; Palm and Hodgson, 1992a).

Differences in individual response result in part because, in general, behavior is highly constrained by factors other than attitude and opportunity. In a 1990 book, Palm argued that individual behavior is best understood within the context of the constraints and enablements set by the household, community, and society, including those arising from the political-economic system, cultural context, and media biases. For example, an individual may be highly aware of a hazard and the mitigation measures that would best address that hazard, but still be constrained from action by (1) powerlessness within the household; (2) lack of household resources to adopt the measures; (3) community or society values discouraging adoption; (4) legal or bureaucratic impediments; or a host of other factors. Thus, we do not expect to see a direct and perfect relationship between attitude and behavior in the empirical world. Further, the greater the constraints set by the political-economic system, the weaker will be the relationship between personality characteristics, such as individual beliefs and personalization of the risk, and measurable response.

Constraints on the household/individual are set by the political-economic and cultural context, resources, managers and cultural assumptions. Given these constraints, how does the individual or household respond to hazards in the environment? The political economy and cultural values provide information to the individual and set constraints within which the individual can translate knowledge into effective action. The variability of responses arises from the translation of scientific knowledge about environmental risk into individual action. This process usually involves the individual's experience with the hazard and integration of the hazard as a factor of life to be managed actively.

Awareness of the Hazard

Individuals vary in their awareness of the existence of local hazards. This awareness is in part a function of how long they have resided in the area and their personal experience with the local hazard condition. The seriousness of previous hazard events — the extent of loss of life and property damage — the recency of

the event, and the extent of personal loss to the individual all have an impact on individual awareness.

How does awareness translate into behavior change? Weinstein (1989a) reviewed the impacts of personal experience on the adoption of self-protective behavior. Mechanisms in this linkage are: experience, cognitive limitations, fear, optimism and social factors. Very briefly, existing theory would suggest eight possible impacts: (1) personal experience may affect the likelihood of future victimization since accessibility from memory will influence probability judgments (Kahneman and Tversky, 1979; Perloff, 1983), unless the individual believes that risk is cyclical and therefore will be lower after victimization (Slovic, Kunreuther and White, 1974); (2) personal experience provides information about the possible severity of the harm and the existence of preventative measures; (3) experience adds to the concreteness of information (Borgida and Nisbett, 1977; Nisbett and Ross, 1980), and makes events more "available" to recall (Fazio, Zanna and Cooper, 1978), increasing the agreement between attitudes and behaviors (Fazio, et al., 1982); (4) experience reduces uncertainty about the event (Fazio and Zanna, 1978); (5) personal experience increases the salience of the threat and the motivation to avoid its harm (Janis, 1967; Averill, 1987); (6) experience demonstrates that individuals are not invulnerable (Janoff-Budman, 1985; Perloff, 1983; Weinstein, 1987); (7) society exerts an influence on individuals to adopt precautions to avoid further victimization, since individuals may expect blame rather than sympathy if they become victims a second time (Janoff-Budman, 1985); and (8) specific situations motivate people to attend to messages that may change attitudes (Petty and Cacioppo, 1986; Chaiken and Stangor, 1987). The research cited above suggests that direct experience increases attention to and avoidance of future disasters.

But not all research suggests a linkage between experience and behavior. Brehmer (1980) suggests that experience may not be a good teacher. He notes that because individuals tend to use confirmatory evidence, to make unwarranted assumptions about causality, and to disregard negative information, experience that, to the outside observer, should lead to behavior changes or learning actually may fail to affect individual judgments. This study suggests that expectations of clear associations between experience with the hazard and expected changes in mitigation behavior may not be warranted.

Individual awareness can be enhanced by the amount of public information encountered by the individual, both from government agencies and from the general knowledge pool. Government agencies have attempted to increase the level of hazard awareness through numerous measures, including public information campaigns (warnings on inside covers of telephone books, community meetings, brochures), legislation requiring disclosure of insurance purchase, and dissemination of materials in the public schools. Information about the hazard may also be part of the general lore of the local area.

The nature of the physical environment itself may affect the amount of individual information. For example, when natural disasters occur frequently and regularly, households learn ways to cope with the environmental variability.

Effectiveness of Risk Communication

The act of communicating risk to the general public — an issue of strategy and ethics — has been studied in great depth. Based on empirical and theoretical research on communication theory and its application to environmental hazards, prescriptive statements have been developed to improve the probability of accurate risk assessment (recent examples include: Handmer and Penning-Rowsell, 1990; Wilson, 1990; Sorensen and Mileti, 1991; Renn, 1991; Covello, 1991). Effectiveness in risk communication is related to general issues of persuasion. Research has found that communication is more likely to persuade if the information source is attractive (Lee 1986; McGuire 1985), if the receiver has empathy with the source (McGuire, 1985), if the source is credible (McGuire, 1985), if the source is trusted (Renn and Levine, 1991), if the source is perceived as having expertise (Lee, 1986). Thus, the likelihood of persuasion is affected by the source (its credibility, reputation and attractiveness), the nature of the message (its length, complexity and method of presentation), and the transmitter of the message (its credibility, past record, neutrality), as well as by the social context within which the message is transmitted (climate of trust, competition of the message with others, reputation of the media) (Renn and Levine, 1991). In addition, the receiver must be attentive to the message: the issue must be of central interest, and the receiver must accept the credibility of the argument with reference to personal experience, plausibility and congruence with the individual's value system (Chaiken and Stangor, 1987; Renn and Levine, 1991).

Has there been a consistent attempt to convey the risks of earthquakes, flooding and hurricane damage to the general public in Puerto Rico, and has this risk communication followed the principles outlined above? Although complex, the answer is probably "no." Various U.S. federal agencies have provided publications and offered workshops for local government and community leaders concerning earthquake hazards (Hays and Gori, 1984a, 1985a, and 1987). However, in spite of these efforts, much more needs to be done. For information about objective risk to be translated into actions and mitigation measures adopted, Puerto Rican leaders at the local and commonwealth levels need to do a great deal more. These leaders must become trusted, credible information sources, and they must convey a message to the audience that will move them to action. Without a recent history of such a communication effort in Puerto Rico, we would expect to find that people have relatively inaccurate levels of perceived risk and have done little to translate perceived vulnerability into mitigation efforts.

Translation of Knowledge into Action

An individual's response to a hazard cannot be predicted solely by drawing conclusions about the amount of knowledge or experience he or she has with the hazard. Individuals must be aware of the existence of the hazard. But, before

they will take action they must also translate this knowledge into a belief that their own lives and property are susceptible to danger.

Many factors account for individual variability in the translation of knowledge into action. For example, some researchers have investigated the role of ethnicity. Bolin and Bolton (1986) found that Hispanics, when compared with Anglos, were more likely to have trouble acquiring adequate aid and recovering from a disaster and had greater numbers of nonproductive dependents, poorer insurance coverage, and fewer personal resources. Such work suggests that a comparison between Puerto Ricans and the largely Anglo California homeowners surveyed in the earthquake project might point to reasons for any observed differences based on ethnicity, particularly if the effects of differing political economies, income levels, and resource limitations could be factored out.

Although survey researchers tend to ask questions about age, income, sex and educational levels of respondents, several studies have found that these demographic factors do not consistently affect either perception or response to hazards (Palm et al., 1990; Mileti, et al.,1990; Drabek, 1986).

However, five other factors do seem to be consistently related. We will review each of them and their status in Puerto Rico.

Available Resources. The individual or household must have the resources available to adopt effective mitigation measures. The household must have the intellectual skills, the monetary resources and the time to consider the hazard and possible mitigation measures, to select a set of measures, and to adopt them. Obviously such resources are unequally distributed in a population. Furthermore, when resources in a given society are generally scarce, as is Puerto Rico when compared with California, responses will be constrained.

Belief of Control of Own Destiny. Individuals vary in the degree to which they believe they control their own destiny or that it is controlled by others. Some researchers have suggested that this personality characteristic, known as "locus of control," is related to the adoption of mitigation measures (Simpson-Housley and Bradshaw, 1978). Several empirical studies are relevant. One study which preceded the availability of FEMA subsidized flood insurance in U.S. territories, focused on adjustment to hurricane hazards in the Virgin Islands (Bowden, 1974). In this survey of about 100 residents of Tortola, St. Croix and St. Thomas, the major factor associated with the likelihood of hurricane preparedness was activities on Supplication Day: those who prayed for protection against hurricanes were more likely to be aware of the hurricane hazard.

A study directly comparing Puerto Rican and mainland responses to natural hazards was conducted some twenty years ago (Sims and Baumann, 1972). Although this study's conceptualization, methodology and analysis were extremely weak, it provides an example of an earlier cross-cultural comparison between Puerto Rican and U.S. mainland residents. Questions concerning hurricane warning, response during and immediately after a hurricane, and

assessment of internal vs. external locus of control were administered to 120 residents of Tallahassee, Florida, Pass Christian, Mississippi, and Galveston,Texas, as well as to 147 residents of Puerto Rico. The authors concluded that Puerto Ricans experience more "fear" as opposed to "anxiety" prior to the hurricane but after a prediction, and experience more "fear" and "concern for consequences" during the hurricane. Americans are more likely to "begin restoration" when the hurricane is over, giving evidence for "the model of a more grief-stricken, passive Puerto Rican in the wake of a hurricane" (p. 6). Finally, Puerto Ricans tend to believe more in random luck: "the Puerto Rican, who believes God to be powerful and important, is less likely to feel that he can reduce damage when confronted with the awesome power of the hurricane" (p. 9). Too much credence cannot be given to this research. Among the many problems are: (1) the size and representativeness of the samples and methodology involved in the analysis; (2) the lack of description of sampling frame and selection process; and (3) the absence of a report of statistical tests indicating the significance of observed differences. Further, it is not clear that "fear" and "anxiety" are concepts easily translated and compared across cultures. This study raises many questions concerning attitudes toward the hazards and predilections to take action. The 1991 Puerto Rico survey discussed in this monograph and its comparison with the 1989 and 1990 surveys in California attempt to deal with some of these questions.

A related finding is that the pursuit of information itself and the adoption of some mitigation measure are likely to increase further self-protective behavior (Mileti, 1990; Sorensen and Mileti, 1991). One might expect that those who believe they can affect their own circumstances are more likely to seek out information, and that in that process, the problem and its solutions become more concrete to the individual. Mileti and his colleagues have termed this process "coming to 'own' the risk information" and argues that this is a primary factor mediating between information provision and taking action as a result of this information (1990, p. 1062).

Individual Probability Calculation. Individuals personally calculate the probabilities that a given hazard will affect them, using all the decision-making heuristic errors suggested by psychologists. Their calculations may result in a very different perception of the likelihood of occurrence than that predicted by scientists studying the same phenomenon, with concomitant differences in behavior than might be predicted by strictly applying a utility model.

A study related to this issue focused on the propensity to purchase hazards insurance. Burby et al. (1988) studied the responses of homeowners to flood hazards in Arvada, Cape Girardeau, Fargo, Omaha, Palatine, Savannah, Scottsdale, Toledo, Tulsa, and Wayne. At the time of this survey (1987), only about 26 percent of the respondents had flood insurance; another 21 percent had carried it in the past but had dropped it. The major reason given for not having insurance was that it was "not worth it; the flood risk was too low" (Burby et

al., 1988, p. 144). Thus, respondents did not purchase or maintain flood insurance because of a lack of perceived seriousness of the flood problem.

Time-Frame. The time-frame used in decision making affects individual response (Svenson, 1991). For example, an individual who feels committed to the area for a long period may be more likely to take into account hazards with low immediate probabilities but fairly high cumulative probabilities over time. In contrast, an individual who expects to live in the area for three years or less is very likely to ignore a low-probability, high potential damage risk. Time-frame may also affect changes in the nature of response: while new homeowners or newcomers to the area may take more active measures to protect the value of their property, longer-term residents may become complacent or neglectful. Thus, sheer length of residence in a region may affect response to the natural hazard. In Puerto Rico, we expect length of residence at a particular site to affect the probability of adopting a given mitigation measure.

Salience of Hazard. A major factor affecting individual response to hazard is the salience of the hazard in comparison with other concerns in the individual's daily life. The individual deals with natural hazards only when they have a high degree of salience — when they seem more important than the other problems the individual confronts in daily life. The extent to which hurricanes or earthquakes are as significant to Puerto Ricans as other hazards of life, such as unemployment, health care or crime, has not been documented, but we would expect that the environmental hazards would have only transient salience to Puerto Ricans — rising in significance during and immediately after a particular disaster and then falling to a relatively low level of salience.

The web that constrains and enables response is thus complex, but certain conditions are likely to precede individual response to hazard. The individual must be aware of the hazard, understand his/her capacity to mitigate its effects, have the economic and physical resources to enact the mitigation, and be motivated to respond. Motivation may result from an event that triggers fear of an impending disaster, or a new awareness of the necessity to adopt the mitigation strategy, or the influence by friends and family to enact this or some other means.

Previous Empirical Studies: California

Previous research by the authors and others has linked attitudes toward natural hazards with the adoption of mitigation measures. Many surveys indicate that the majority of California households do not prepare for earthquakes. A 1977 survey of 1,450 Los Angeles residents (Turner et al., 1979) showed that a large percentage of people living in an earthquake-prone area believe they *cannot* prepare for an earthquake — whether by adopting insurance or other measures. In response to the survey statement, "The way I look at it,

nothing is going to help if there were an earthquake," 32 percent of the respondents agreed (Turner et al., 1980, p. 67). An even larger percentage — 41 percent — agreed with a less strongly worded yet still fatalistic statement: "There is nothing I can do about earthquakes, so I don't try to prepare for that kind of emergency."

The same survey asked whether households or respondents had taken any measures to prepare for an earthquake and its immediate consequences. Possible measures ranged from having on hand a working flashlight, a working battery radio, a first-aid kit, stored food, and stored water or rearranging cupboard contents to inquiring about earthquake insurance or structurally reinforcing their homes. The authors concluded from the survey responses that "most households are unprepared for an earthquake and that the prospect of an earthquake has stimulated relatively little preparatory action" (Turner et al., 1980, p. 101).

In 1979, Palm undertook a smaller survey of residents of Special Studies Zones (surface fault rupture zones) in Berkeley and Contra Costa County. The author sought to determine whether those who both received and recalled a disclosure that their property is within a Special Studies Zone would be more likely to adopt a set of mitigation measures than the general population of Los Angeles (Palm, 1981). The study population consisted of recent home buyers who understood the meaning of a Special Studies Zone and had higher average income and education than the general population. Although these residents were more likely to have inquired about earthquake insurance (41 percent), bought earthquake insurance (24 percent), and invested in structural reinforcements for their homes (9 percent), they were generally less likely than the Angelenos to adopt such mitigation measures as instructing children what to do in an earthquake or establishing emergency procedures at the residence. Thus, studies completed in the late-1970s showed an astounding lack of individual or household preparedness.

More recent surveys in California show little change in this behavior. In a survey by Palm, et al. in 1989, less than 10 percent of the respondents answered affirmatively to the question: "Have you done anything to minimize the amount of damage an earthquake might cause to your home?" Furthermore, even among the 10 percent who had undertaken mitigation measures, fewer than 50 percent had spent more than $50 for such measures (Palm et al., 1990).

A last example is telling. Mileti and colleagues (1990) conducted a survey on Coalinga, Paso Robles, and Taft, California. These towns are within 75 miles of the predicted epicenter of a Parkfield earthquake forecast of magnitude 5 to 6 with a 90 percent probability between 1985 and 1993. If any individuals in any setting would be expected to undertake mitigation measures it would surely be these, since the U. S. Geological Survey has predicted an earthquake as almost a certainty in the near future. In this study area, individuals were asked to indicate the preparedness actions they had taken since hearing the prediction of a Parkfield earthquake.

Total percentage responses concerning preparedness are underestimated here since some actions were already performed prior to the prediction. Yet in none

of the communities surveyed and for none of the 27 possible mitigation measures in the questionnaire did more than 31 percent of the respondents say that they had adopted that measure. The most frequently adopted preparedness action in all three communities was to find out what to do during an earthquake (25-31 percent) or stockpile emergency supplies (19-28 percent). Fewer respondents took more expensive and time-consuming measures such as purchasing earthquake insurance (10-20 percent) or making the house more earthquake resistant (6-17 percent).

This lack of preparation in California against a future earthquake that has received an immense amount of public press is strong evidence that homeowners tend to ignore the natural hazard and refrain from taking even the simplest measures to mitigate against its preventable impacts. These very consistent survey findings set up an expectation that we would find a similar lack of concern with mitigation measures in Puerto Rico.

The California Insurance Studies

We have noted that the research in Puerto Rico stems from earlier surveys in California linking hazards awareness, attitudes toward risk, legal settings, and the practices of the insurance, real estate and financial institutions with the adoption of mitigation measures including earthquake insurance. Furthermore, the methodology used in the Puerto Rico survey was patterned on that used in the authors' California studies. Therefore, to set the Puerto Rico survey in context, it is useful to review the findings of the California studies (Palm et al., 1990; Palm and Hodgson, 1992a, 1992b).

Both California surveys were influenced by the classic Kunreuther et al., (1978) study of flood insurance and earthquake insurance purchase in California. At the time of the Kunreuther survey, less than 5 percent of California residents had earthquake insurance.

Since 1978, several events have had important implications for the likely purchase of earthquake insurance. First, the legal context has shifted, making knowledge of the availability of earthquake insurance more prevalent. California state legislation dating from January 1985 requires insurance companies to offer earthquake insurance in order to do business in the State of California (§1081, Section 2 of Stats. 1984, c. 916. California Insurance Code). This legislation ensures that homeowners are informed of the availability of earthquake insurance and offered an opportunity to purchase it as an addendum to their standard homeowner's coverage.

A second change is an increased concern by the insurance industry about its susceptibility to major insured losses in the event of a major damaging earthquake. The insurance industry has concluded that earthquakes are an "uninsurable hazard" (Hall, 1987). The industry argues that it cannot prepare for a catastrophic event, such as a major damaging earthquake in a metropolitan area, that takes place only once every hundred or more years. It bases this argument on three reasons: (1) difficulties in earthquake prediction; (2) adverse selection - the tendency for only those at greatest risk to purchase the insurance; and (3) the

capacity problem — the inability of insurance companies under current tax laws to accumulate a sufficiently large reserve to respond to a very large earthquake.

As a result of these serious fears, insurance companies have united to propose a cooperative arrangement with the federal government that would reduce their risk yet enable them to continue to provide earthquake insurance. The American Insurance Association, the Alliance of American Insurers, the American International Group, State Farm Insurance and the National Association of Independent Insurers have formed a coalition to participate in the Earthquake Project. The goal of this coalition is to pass federal legislation that would set up a federal earthquake insurance program patterned after the National Flood Insurance Program. Under the proposed program, the federal government would form a partnership with the insurance industry through the creation of a Federal Earthquake Insurance and Reinsurance Corporation (FEIRC) to administer a two-tiered earthquake insurance program. The program would require all homeowners with mortgages backed by federal agencies or issued by a federally insured institution (such as a savings and loan or commercial bank) to purchase earthquake insurance, regardless of place of residence. This program would spread the risk, a major concern of the insurance industry. Various forms of this legislation, originally promoted by the industry (Earthquake Project, 1989), have been introduced into Congress. Publicity from the insurance industry in support of this legislation may have increased public awareness of risk and therefore induced more insurance purchase.

In addition to these legal changes and the attempts by the insurance industry to increase awareness of earthquake hazards throughout the nation, local and state governments and consortia of business and governments have tried to increase hazards awareness in California. Part of this campaign to increase public awareness, particularly after the 1989 Loma Prieta earthquake, was the inclusion of a 16-page color insert in the Sunday newspapers in the San Francisco Bay area in September 1990 that described the earthquake hazard and illustrated detailed methods of mitigating against damage. These efforts undoubtedly impacted public awareness of the earthquake hazard and may also have affected the propensity to purchase insurance.

Given these changes, we revisited the issue of earthquake insurance to probe the adoption of other mitigation measures. The empirical work was based around an initial survey of 3,421 owner-occupiers in Contra Costa, Santa Clara, Los Angeles and San Bernardino counties in the spring of 1989. The random samples of the counties came from the list of owner-occupiers in the county tax assessor's roles.

The general structure of the survey methodology was patterned on the classic study of mail and telephone surveys developed by Don A. Dillman — the "total design method" (TDM). The key portion of the total design method is the sequence of mailings and follow-ups designed to increase response rate. Response rates for the full survey varied from a high of 70 percent in Santa Clara to a low of 62 percent in Los Angeles County. Geographical characteristics of the surveyed homeowners were derived through the use of a

geographic information system (GIS). Other locational characteristics (such as distance from a special studies zone) were measured with GIS analytical capabilities.

Survey Results: Pre-Loma Prieta Earthquake

1. How many homeowners buy insurance? One measure of purchase increase is the dollar volume of insurance premiums. This index has increased markedly since 1950. Using a constant dollar calculation, the total premium receipt was approximately $11 million in 1973-74. By 1984 the dollar volume of premiums increased to $79 million, and by 1988 it was over $250 million in 1988.

The percentage of households covered by earthquake insurance also increased. In each of the four counties surveyed, more than one out of five, and as many as two out of five homeowners have earthquake insurance. The largest percentage was recorded for Santa Clara County (40 percent), while the smallest percentage (22.4 percent) was recorded for Contra Costa County.

2. Who are the insured? In this portion of the research, we looked for differences in the demographic or socioeconomic composition of the insured as opposed to the uninsured population. Specifically, we wanted to discover if the insured tended to be wealthier, have more of their net worth tied up in their home, and/or be older — or alternatively if they were similar to the rest of the population.

Previous research suggested a positive relationship between equity and purchase of insurance, as well as between age of the homeowner and purchase of insurance (Anderson and Weinrobe, 1981; Willinger, 1989; Schiff, 1977; Arrow, 1970; Turner et al., 1979; Hodge et al., 1979; Drabek, 1986). Percentage of equity was defined as the market value divided by the total claims against the property (e.g., total outstanding mortgages). The percentage of total net worth of the household represented by this net equity was also examined. Net equity was the major component of total net worth for most respondents, constituting at least 50 percent of net worth in all study counties for both insured and uninsured populations. However, statistical tests indicated that percentage of equity in the house and percentage net worth made up by home equity were generally unrelated to insurance purchase. Therefore, the home equity position generally did not differentiate between insured and uninsured households.

On the average, heads of households in the survey were in their late forties to mid-fifties with the older homeowners in Los Angeles County (55 years for insured and 54 for uninsured) and younger homeowners in San Bernardino County (48 for the insured and 49 for the uninsured). Age of head of household did not distinguish between insured and uninsured except in Contra Costa County, where older homeowners were more likely to purchase insurance. In general, however, in the four study counties, the age of head of household cannot be regarded as a predictor of insurance purchase.

Other socioeconomic and demographic variables — including length of tenure in California, length of tenure in the home, age of the house, years of school completed, presence of children under age 18 in the household, presence of persons over age 65 in the household, family income, and estimated home value— were also tested for differences between insured and uninsured. Scattered relationships were evident between insurance purchase and these variables. For example, insured households were less likely to include children under age 18 in Contra Costa County, and persons with more years of school completed were more likely to have insurance in Los Angeles and San Bernardino counties. In addition, family income was related to insurance purchase in Santa Clara and San Bernardino counties. However, no consistent relationships were evident across the four counties between these socioeconomic and demographic variables and insurance purchase.

Second-order relationships between insurance status and key independent variables, such as age of head of household, percentage of equity, family income and net equity as a percentage of total net worth were investigated. Relationships were not consistent, however. Only in Contra Costa County did the relationship between age and insurance purchase, which was significant as a first-order relationship, hold up when controlling for income, equity and net worth. In the other three study counties, no statistically significant relationship was found between age and the tendency to purchase insurance when controlling for the economic characteristics of the household. Similarly, percentage of home equity did not generally discriminate purchasers from nonpurchasers when controlling for age, income or net worth. In sum, insurance status was not linked to key socioeconomic and demographic variables. Even when modified for a second-order relationship, no consistent pattern was seen between demographic or economic characteristics and insurance purchase behavior.

Linear combinations of the same variables were similarly unrelated to insurance status. Discriminant analysis using information on age, income and residential history showed relatively poor explanatory power. The best function (in correctly classifying households as insured or uninsured) was that for Contra Costa County based on age of head of household, whether born in California, presence of persons over age 65, presence of children in the household, and length of residence in California. Other functions were less effective in correctly classifying household insurance status and had small eigenvalues and poor canonical correlations between the discriminant score and the group value.

Thus, whether using univariate or multivariate analysis, we found no significant difference between insured and uninsured with respect to these variables, or any other demographic variables we measured (ethnicity, years of school completed, family income, years of residence in California, etc.). This finding indicates that, contrary to expectation, insured homeowners do not differ from uninsured homeowners with respect to income, net worth, equity, age, place of birth, or any other demographic indicator.

3. Where are the insured located with respect to geophysical risk? Earthquakes are sometimes dubbed an "uninsurable hazard" because susceptibility to damage is not spread randomly among the insured population and those who are most at risk also tend to adopt insurance. While conceding that this locational principle works on a national scale, we tested for "adverse selection" on a metropolitan scale, to see if those people living closer to the fault, or in areas particularly susceptible to intense ground shaking or liquefaction, were more likely to adopt insurance than those at relatively less risk.

We used several measures of seismic risk. Probably the most accurate indicator of seismic risk examined was the map of composite intensities developed by Evernden and Thomson (1985) for the Los Angeles region. The map provides Modified Mercalli intensities for one square kilometer grids for a composite of 87 earthquakes. Using the Evernden and Thomson predicted MMI zones, households in Los Angeles and San Bernardino counties were assigned a risk intensity category. Simple correlation coefficients were calculated between the risk category and the presence/absence of earthquake insurance. The simple correlation in Los Angeles was -.04 and in San Bernardino was -.003, indicating a virtually random relationship between the purchase of earthquake insurance and objective seismic risk.

Other less sensitive indicators of seismic risk showed the same patterns. Simple correlations were calculated for distance from an active surface fault zone (Special Studies Zone) and the purchase of earthquake insurance for all four sample counties. These correlations ranged from a high of .10 in San Bernardino County to a low of .002 in Santa Clara County.

Thus, no matter how it was measured, geophysical risk was found to be unrelated to the insurance purchase decision at the metropolitan scale. This finding supports earlier survey research that shows that disclosure of the special studies zone does not affect the decision to purchase a given house (Palm, 1976) and recent econometric research indicating that house prices are not adversely affected by special studies zone locations (Cochrane, 1992).

4. How do perceived and actual risk compare? The heart of this research was the probing of the nature of perceived risk, and the relationship between risk perception and the adoption of insurance or other mitigation measures. Although geophysical risk does not predict insurance purchase, previous research has suggested that perceived risk may be an important factor in the purchase decision (White and Haas, 1975; Drabek, 1986; Turner et al., 1979). Palm et al., (1990) tested for relationships between risk perception with actual geophysical risk and risk perception with insurance purchase. To measure perceived risk, the survey included four questions. The first question asked for an estimate of the probability that a major (1906 San Francisco-type) earthquake would occur in the next 10 years in the respondent's community. The second requested an estimate of the likelihood that the respondent's own home would be seriously damaged by such an earthquake. The third question elicited an estimate of the probability of an earthquake causing more than 10 percent damage to the

home. And the fourth asked for an estimate of the dollar value of probable damage to the home and contents following a major, damaging earthquake. Kunreuther et al. (1978) posed three of these questions in an earlier survey of hazards insurance purchase.

Empirical analysis showed that homeowner estimates of earthquake risk were correlated with the insurance purchase decision. Homeowners who believe that a major damaging earthquake is likely in the next ten years are also more likely to have earthquake insurance. This relationship between perceived risk and insurance purchase was strong, both when measured as an individual variable and when perceived variables were included in multivariate analyses.

Conclusions of 1989 California Study. In sum, we found that while demographic characteristics and location with respect to objective risk did not predict insurance, perception of risk was a good predictor. But the survey left a very important question unanswered: how would experience with an earthquake affect both risk perception and the adoption of mitigation measures against future earthquakes?

Post-Loma Prieta Study

We completed the surveys in summer 1989. A few weeks later, on October 17, 1989, the Loma Prieta earthquake struck in the San Francisco Bay region of California. This earthquake provided us with an unprecedented opportunity to obtain pre- and post- earthquake surveys of the same individuals — a unique opportunity in earthquake hazards research.

Our selection of four counties provided a natural laboratory to measure the impacts of experience. Santa Clara County had experienced the earthquake directly, and, although all our respondents might not have experienced damage to their property, they had seen damage in their neighborhoods and communities. Contra Costa County respondents had experienced the earthquake less directly; although they had little damage to their homes, they were subjected to a barrage of news stories on the impacts of the earthquake, as well as being inconvenienced by closure of the Bay Bridge.

The residents of the southern communities (Los Angeles and San Bernardino) did not experience the earthquake directly but encountered a large number of news stories warning them of the impacts of a similar possible earthquake in their area. We looked at how these different levels of experience would affect attitude and behavior shifts.

Survey Method. From June to September 1990, we resurveyed all owner-occupiers who had responded to the 1989 survey. We used the same survey methodology (up to 4 mailings or 3 mailings and a telephone call). Most of the questions in the 1990 survey were repeated except for the detailed demographic questions (income, mortgage balance, other loans outstanding, race, etc.) already asked of these respondents. We attempted to assess changes in

attitude and behavior and link them to relative degrees of experience with the Loma Prieta earthquake.

Research Findings. The post-Loma Prieta study examined the impacts of experience on insurance purchase and perceived vulnerability. This survey yielded three major findings.

The first finding dealt with the increase in perceived risk after the earthquake. We found that homeowners in all counties were, on average, more concerned with future earthquake risk after the Loma Prieta earthquake than they had been the year before. This effect, as expected, was slightly greater in the northern counties than in the southern counties. For example, respondents in all counties were more likely to believe that there was at least a 1 in 10 chance of a strong earthquake of the size that struck San Francisco in 1906 occurring in their community in the next ten years. Similarly, there was a consistent increase in the percentage of respondents who believed that such an earthquake would cause at least 10 percent damage to their own home in the next ten years. For example, in Los Angeles County, 74.7 percent of the respondents in 1990 believed that their own homes would suffer such damage, up from 63.6 percent a year before.

The second finding focused on earthquake insurance purchase. Although homeowners expressed more concern about a future earthquake, the purchase of earthquake insurance coverage increased only slightly in all four counties after the Loma Prieta earthquake. Of the 996 survey respondents uninsured in 1989, only 64 homeowners (about 6 percent of the sample) bought insurance after the earthquake. These additional purchasers brought the percentage of homeowners with earthquake insurance to a high of 52 percent in Santa Clara County and a low of 30 percent in Contra Costa County. Homeowners' main reasons for not purchasing insurance in 1990 were that they felt it was too expensive and that the deductibles were too high.

The fact that increased concern does not translate into increased insurance purchase suggests that the general population may be resistant to voluntary earthquake insurance under current conditions. We concluded that without changes in the way insurance is sold or the cost of insurance to the household, large percentages of California residents will continue not to purchase catastrophic insurance.

The third finding was that experience with the earthquake — as measured by both distance from the San Andreas Fault and damage to one's own home — affected perception of risk from future earthquakes. Those who suffered damage were more likely than others to believe that a major earthquake would affect their community in the next 10 years, that their own homes would suffer at least 10 percent damage from such an earthquake, and that such an event was likely or very likely. We concluded that experience with the Loma Prieta earthquake increased the salience and concreteness of the damage associated with an earthquake.

Implications of Previous Research for Study Design

The research just reviewed suggested several hypotheses that were investigated in the current study in Puerto Rico. First, given the low propensity to adopt mitigation measures in California even after lengthy and expensive public information campaigns, it is unlikely that a large number of respondents will adopt voluntary mitigation measures. This hypothesis will be tested with simple information on the volume of adoption of voluntary mitigation measures. This hypothesis will be discussed in chapter 4.

Second, the political economic structure and the organization of the insurance/lending industry in Puerto Rico should have a major impact on the propensity to adopt earthquake insurance as well as on the awareness of the size and nature of coverage. To test this hypothesis, homeowners with mortgages will be compared to those without mortgages. Given the practices of the lending industry, we would expect to see an association between mortgage status and insurance in Puerto Rico; such a relationship should not exist in California. The discussion of these findings is in chapter 4.

Third, because major hurricanes occur more frequently than major earthquakes in Puerto Rico, there will be more "concern" with hurricane hazards in Puerto Rico. To test this hypothesis, common questions about "concern" with various natural hazards will be compared and the spatial patterns in these responses analyzed. This portion of the analysis will be presented in chapter 5.

Fourth, given the California findings about the impacts of hazard perception on behavior and the lack of relationship between demographic characteristics and either hazard perceptions or behavior, we expected that those in Puerto Rico who were more concerned with future natural disasters would also be more likely to adopt mitigation measures. We expected little relationship between the adoption of mitigation measures and demographic or socioeconomic characteristics, both because these factors were not important in California and because the Puerto Rican population is relatively homogeneous ethnically and economically. To examine this hypothesis, various tests of association with voluntary insurance and indicators of attitude or demographic/economic status was done. This analysis will be presented in chapter 6.

Fifth, given previous research on the impact of experience on salience of hazards and on response to them, we expected that residents of municipios that had suffered more damage from Hurricane Hugo would have greater awareness of the risk, greater fears about future hurricanes, and greater tendencies to adopt mitigation measures including voluntary insurance. To test this hypothesis, individuals will be stratified on the basis of (1) general damage level of their community, (2) personal experience with damage, and (3) whether or not they had a mortgage. Dependent variables will be indicators of concern about future hurricanes as well as actions taken including expenditures on mitigation measures such as voluntary insurance. This portion of the analysis will be presented in chapter 7.

These hypotheses, along with others that evolved from the specific nature of the insurance/housing market in Puerto Rico, guided the design of the questionnaire and the organization of the study.

Conclusion

Hurricane Hugo in September 1989 provided an opportunity to gather baseline information about the attitudes of Puerto Ricans not only to hurricane hazards but also to other natural hazards of their environment. Previous research by the authors and others suggested a set of five hypotheses around which the work was organized. Before reviewing the results of the empirical analysis, it is important to outline a few of the characteristics of the study site that affect this analysis. In the next chapter, the political, economic and geophysical characteristics of Puerto Rico are described, along with their implications for the empirical study of risk perception and behavior.

2

The Study Site: Puerto Rico

The Commonwealth of Puerto Rico is the eastern-most and smallest island in the Greater Antilles (Figure 2.1). The island's population is more than 3.2 million, about one-third of whom live in the San Juan-Bayamon-Carolina metropolitan area. The main island of Puerto Rico is approximately 110 miles long by 35 miles. The commonwealth also includes several smaller islands, notably Mona Island, Culebra, and Vieques.

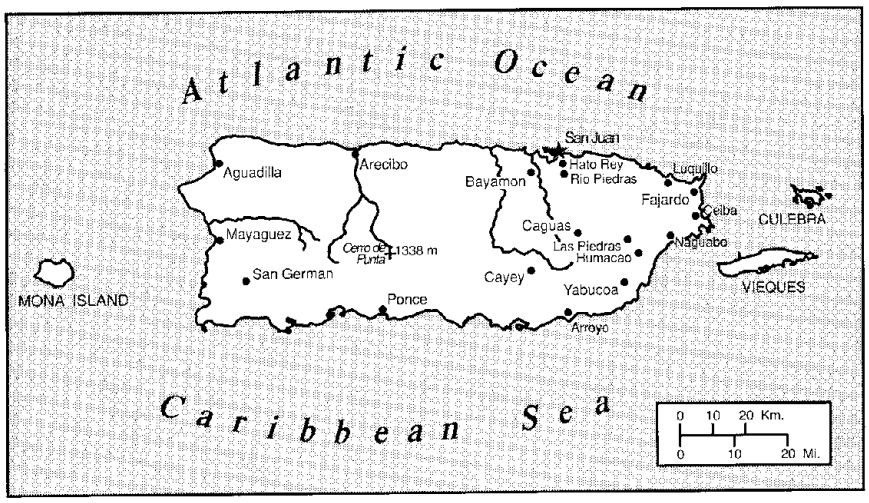


Figure 2.1 Puerto Rico

Puerto Rico was inhabited by Awarak and Carib Indians at the time of first Spanish contact: "When the white man arrived on Puerto Rico, he found the Carib and Arawak in mortal combat, the former straining to invade the other Antilles and the latter resisting this invasion" (Picó, 1974, p. 9). The island

was visited by Columbus in 1493, and Juan Ponce de León began colonization there in 1508. European settlement was initially undertaken by Spaniards who gave up a doomed search for gold and began farming and raising livestock. By 1800, the island's population was approximately 150,000; during the next century, it increased sixfold. African slaves, imported by the Spanish, made up a significant population segment; in 1834 (Picó, 1974, p. 229) a total of 41,818 slaves were present in a population of 358,157. The agricultural economy was based on cattle, sugar cane, tobacco and coffee, with sugar cane gaining ascendance after 1815.

The Spanish ceded the island of Puerto Rico to the United States in 1898 after the Spanish-American war. At that time, the agricultural economy had severe problems: dependence on the export of cash crops, reduced soil productivity, and an inequitable distribution of lands — 50 percent of the land was owned by only 5 percent of the farmers (Wallach, 1989).

Puerto Ricans became U.S. citizens in 1917. The government evolved from colonial to its present "commonwealth" status in 1952. It has powers of local self-government resembling, but yet different from, those of states of the Union. Although subject to laws enacted by Congress, Puerto Rico has several economic and fiscal advantages, including exemption from federal individual income taxes. The changes in the economy that have set the course for modern Puerto Rico date from the post World War II period. In 1950, 40 percent of the labor force worked on farms; at present this figure is only 3 percent.

Two of the people credited with Puerto Rico's transformation from an agrarian economy are Rexford Guy Tugwell and Luis Muñoz Marín. Tugwell, the governor in 1940, instituted planning reform affecting the sugar industry, the water system and the transportation and communication system. Muñoz, who succeeded him as governor in 1948, carried out further reforms in the sugar industry, in housing, and in medical systems; he also began a rural electrification program, improved highways, and transformed in the political status of Puerto Rico (Hauberg, 1974). During his tenure, there were dramatic changes in demographic indicators: between 1940 and 1978 the crude birth rate fell from 39 to 22.4 per 1000 and life expectancy rose from 46 to more than 70 years. Under Muñoz's guidance the Industrial Incentives Act of 1947 was passed exempting from federal taxes the profits from goods manufactured in Puerto Rico and sold on the mainland. Although the impact of this legislation became clearer in the 1970s, it had an immediate effect: 9 companies established plants in Puerto Rico in 1947 and 16 more in 1948, and the commonwealth's gross domestic product doubled within a decade (Wallach, 1989).

With minimum wage laws and a decrease in the price of sugar cane, the labor force changed dramatically. Hundreds of thousands of peasants left their agricultural homes and moved to San Juan, or New York City and beyond. From a flow of about 11,000 in 1944, the annual net migration from Puerto Rico to the United States rose to almost 70,000 in 1954. By 1960 almost a half a million persons born in Puerto Rico lived in New York state, with smaller

numbers in New Jersey (about 40,000) and Illinois (about 26,000) (Hauberg, 1974).

In the wake of new legislation, migration and federal programs, the economy of Puerto Rico underwent a major transformation. At present, Puerto Rico's exports are not the traditional, pre-World War II staples of sugar, tobacco and coffee. Instead, they are pharmaceuticals, electronics and other consumer goods. The current industrial economy in Puerto Rico is clearly driven by a U.S. federal tax law provision that stimulated the siting of branch plants of U.S. corporations in Puerto Rico. Under section 936 of the Internal Revenue Code, a successor to the 1947 act, U.S. companies operating in Puerto Rico receive full credit on their federal taxes for income received from local sources in Puerto Rico as well as full deductions on profits repatriated from their subsidiaries in Puerto Rico. In other words, a company that produces products that are relatively cheap to ship and that are made with raw materials inexpensive to assemble (a "footloose" industry in traditional economic geography) can greatly benefit from operating a subsidiary in Puerto Rico. According to a ranking by Caribbean Business, the largest employers in Puerto Rico include W. J. Heinz Company (food processing), Baxter International (medical devices), Westinghouse (electronics), General Electric (electronics), Sara Lee Corporation (apparel manufacturing), Johnson and Johnson (pharmaceutical), Playtex Apparel (apparel manufacturing), Digital Equipment (electronics), Abbott Laboratories (Pharmaceutical), Motorola (electronics), and Lederle (Pharmaceuticals). These corporations and others operating under this IRS section deposit their money in Puerto Rican banks, deposits totaling about $5 billion, which account for about 40 percent of the bank deposits in Puerto Rico.

Another major linkage between the mainland and Puerto Rico is the burgeoning tourist industry. With the virtual elimination of Cuba as a U.S. tourist destination, Puerto Rico has become an important tropical vacation site, particularly for winter travelers from the east coast or those embarking on Caribbean cruises. Picó (1974) notes that although the total number of tourist hotel rooms numbered only about 600 at the end of the 1940s, this number had increased to 8500 in the early 1970s.

At present, Puerto Rico is neither totally American nor totally Caribbean (Rodman, 1989). Puerto Ricans are American citizens: they carry American passports, move freely within the United States, and serve in the armed forces. Yet they are not full citizens in that Puerto Rican residents do not vote in U.S. national elections. Even those who consider themselves 100 percent American and favor statehood have a latent nationalism based on language and culture. Puerto Rico has its own flag and national history, and yet it is so tightly interwoven into the American economy that it receives 60 percent of its imports from the mainland and sells 85 percent of its exports to the mainland.

The transitional nature of Puerto Rican culture is reflected in a major political issue that divides Puerto Ricans: statehood. Puerto Ricans are almost equally divided on whether to endorse statehood or to keep some form of

commonwealth status: very few (less than 10 percent) want full independence. The major arguments against statehood are economic (the loss of special tax provisions) and cultural (threat to the Spanish language and the heritage of Puerto Rican culture). These are the primary arguments of the Popular Democratic Party, the party in control at the time of this survey. The major arguments for statehood are political equality and economic security — arguments promoted by the New Progressive Party.

Economically, Puerto Rico is transitional within the Caribbean. Although it is the wealthiest political entity in the region, it has a lower per capita income than any state in the union. Culturally, too, it is transitional; its people take great pride in their Spanish heritage and traditional culture, the island's economy is immensely influenced by U.S. corporations as well as U.S. retailing and service establishments (Burger King, McDonalds, K-Mart, Baskin-Robbins, J.C. Penney's, Ralph Lauren and Farrah factory outlets, and mainland cable television stations) and federal programs provide opportunities for Puerto Ricans as designated "minorities."

Natural Hazards in Puerto Rico

Puerto Rico is susceptible to several types of natural disasters, including earthquakes, tsunamis, hurricanes and coastal floods, riverine flooding, landslides, and subsidence. These hazards differ in intensity, frequency of recurrence and magnitude of impact. In this section, we will briefly review each of these hazards and the types of damage they have inflicted on the island in recent years in the island.

Earthquakes

Puerto Rico is situated near a high oblique subduction zone at the juncture of the North American and Caribbean plate (Figure 2.1). Hays and Gori noted that Puerto Rico "is located in one of the most earthquake-prone regions of the world" (1984b, p. 13). The historic record of Puerto Rican earthquakes is 400 years old with the first recorded damaging earthquake occurring in the 1520s and destroying the home of Ponce de Leon (McCann, 1984, p. 41). The largest earthquakes (over intensity M7) took place in 1717 when the San Felipe Church in Arecibo was completely ruined, in 1787 when the El Morro and San Cristobal forts in San Juan were severely damaged and many churches and buildings destroyed, in 1867 when an earthquake in the Anegada Passage caused damage in eastern Puerto Rico, and 1918 when an earthquake accompanied by a tsunami struck the west coast of Puerto Rico. Hays and Gori (1985) have estimated that large earthquakes (magnitude 7.5) "are expected to recur, on the average, about once every 80 years." Although the island population experiences frequent smaller shocks, the last earthquake disaster was the 1918 occurrence with an epicenter in the Mona Passage (Coffman et al., 1982). This estimated

magnitude 7.5 earthquake was accompanied by a tsunami that drowned many inhabitants and destroyed numerous dwellings on the west coast of Puerto Rico. About $4 million in property was destroyed, and 116 people died. Most damage to buildings took place in areas built on alluvium. In addition, some poorly constructed brick buildings and concrete walls and foundations failed, bridges were damaged, and chimneys destroyed.

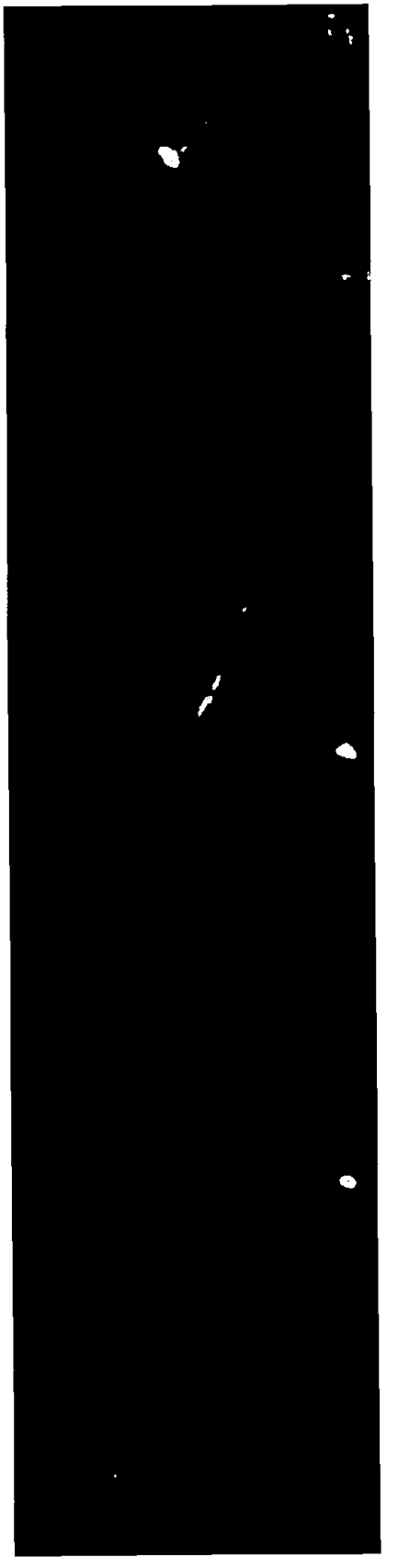
McCann (1984) concludes that there is high seismic potential for a major fault north of Puerto Rico and the Virgin Islands. He reasons that the studies of historic earthquakes and other seismological evidence suggest "a high level of hazard for the region," generating "great" earthquakes in excess of magnitude 7.5 to 8.0.

Molinelli (1987, p. 71) notes that "a significant portion of the residential, commercial, industrial and transportation infrastructure is located on geologic materials that are vulnerable to earthquake-induced geologic hazards. Thus, the potential damage created by future earthquake events is greater today than ever before." In a study of earthquake vulnerability of the San Juan region, Molinelli (1987) points out areas at risk of intense ground shaking along the floodplains of the Rio Bayamon, Rio Piedras and Rio Grande de Loiza, as well as development on sand, clay and sandy clay beds in Carolina, San Juan and Bayamon. A large number of high rise buildings and housing units as well as airport facilities, roads and water mains are located in areas susceptible to ground shaking amplification. In addition, about 17 percent of the area is susceptible to liquefaction, and other areas are susceptible to earthquake-induced landslides, particularly in the southern part of the metropolitan area.

In sum, although 75 years have passed since a major damaging earthquake affected Puerto Rico, a high degree of seismic hazard and serious vulnerability threaten the island because so many buildings and infrastructure are located within particularly hazardous zones. Although earthquakes are relatively rare, they have the potential to cause catastrophic damage and large numbers of deaths through a single event.

Tsunamis

Puerto Rico is susceptible to tsunamis or seismically induced sea waves. These waves — also incorrectly called "tidal waves" — are defined as "a water wave or a series of waves generated by an impulsive vertical displacement of the surface of the ocean or other body of water" (Lander and Lockridge, 1989, p. 1). Tsunamis are associated with earthquakes: they are generated when "a large mass of earth on the bottom of the ocean drops or rises, thereby displacing the column of water directly above it" (Lander and Lockridge, 1989, p. 1). Generally, tsunamis occur in large subduction zones, boundaries between tectonic plates. As noted above, Puerto Rico is located near such a zone, at the boundary of the North American and Caribbean plates. It is vulnerable not only to locally generated tsunamis but also to those produced along more remote fault zones.



One of the most dramatic tsunamis in the region occurred on November 18, 1867, associated with an earthquake in the Anegada trough between St. Croix and St. Thomas. The event had historical implications — causing a delay in the U.S. purchase of the Virgin Islands for 50 years (Paiewonsky, 1981 as cited in Lander and Lockridge, 1989) — and resulted in damage in the settlements in the Virgin Islands and in Vieques, Yabucoa and Fajardo in eastern Puerto Rico (Reid and Taber, 1920 as cited in Lander and Lockridge, 1989).

Another tsunami, at the opposite end of the island, occurred on October 11, 1918, associated with a M 7.5 earthquake off the northwest coast of Puerto Rico. Of the 116 people killed in this earthquake throughout western Puerto Rico, 40 died because of the tsunami. Reid and Taber (1919 as cited in Lander and Lockridge, 1989, p. 217) report the event as it affected the municipio of Aguadilla:

> At Aguadilla the height of the wave seems to have varied somewhat in different parts of the city, but at no place were the measurements less than 2.4 m above sea level, and near the head of the bay the crest of the wave must have been at least 3.4 m in height. In this town 32 people are said to have been drowned, and about 300 little huts built along the beach were destroyed.

In Puerto Rico, structures close to the shoreline are susceptible to this earthquake-related phenomenon.

Hurricanes and Coastal Flooding

Hurricanes, one of the most devastating natural hazards, occur frequently in the Caribbean region. The major impacts of a landfalling hurricane or one that parallels the coast are storm surge, winds, rainfall and tornadoes. Of these impacts, storm surge — the rapid rise of sea level — accounts for over 90 percent of the deaths associated with hurricanes (Pielke, 1990, p. 59).

Granger (1989) compiled statistics on the recurrence and intensity of hurricanes in the eastern Caribbean. He calculated that since 1880 a hurricane has occurred virtually every year, but since 1960 the frequency has decreased while intensity and magnitude of hurricanes have increased. Category 5 hurricanes (with maximum sustained winds in excess of 158 mph) are expected to occur once every 15 years. Examples of hurricanes which eventually became Category 5 in recent years are Donna (September 1960), which passed to the northwest of Puerto Rico, and Inez (September 1966) and David (August, 1979), both of which passed to the south of Puerto Rico (Pielke, 1990).

In the past 100 years, Puerto Rico has been affected by 13 landfalling hurricanes as well as 43 tropical storms and hurricanes passing within 75 miles of the capital city (Oxman, 1987, p. 7). The August 1899 San Ciriaco hurricane moved from Arroyo to Aguadilla, bringing with it 23 inches of rain within a 24-hour period and claiming 2,184 victims with $35 million in direct damage. This hurricane brought on both coastal and riverine flooding: in Arecibo, 500 to 1000

persons drowned from river flooding on the Arecibo river. The September 1928 San Felipe II hurricane followed a similar path to the San Ciriaco, with winds reaching 200 miles per hour and economic losses of $50 to $85 million. Although fewer lives were lost (about 300), property damage was enormous, leaving over 83,000 families homeless. The September 1932 San Ciprián hurricane struck the northeastern part of the island, killing 300 people and causing another $30-$50 million in property loss. More recent tropical storms have also caused great devastation. The September 1975 Tropical Storm Eloise, which passed to the north of Puerto Rico, claimed 34 lives with property damage in excess of $125 million.

Landfalling hurricanes are thus capable of causing major devastation and account for most of the damage losses associated with flooding in Puerto Rico. Although hurricanes cause more losses of property on an annualized basis than do earthquakes, they occur with greater frequency and are therefore seen as a familiar annoyance, a part of the island environment with which residents must annually cope.

Flooding

Riverine floods induced by heavy rains also cause damage in Puerto Rico. For example, the floods of October 1970 in the eastern two-thirds of Puerto Rico resulted in $68 million in damage and 18 deaths. Total rainfall at some stations for the six-day storm period exceeded 38 inches. In 1975, during a September flood period, flash floods and river floods caused 34 deaths, 120,000 refugees and property damage in excess of $125 million.

Smaller-scale flooding also occurs frequently in Puerto Rico, resulting from a combination of moderately heavy rainfall and insufficient draining or clogged drainage systems. Communities susceptible to such frequent flooding include beach settlements in Fajardo, portions of San Juan (Hato Rey and Rio Piedras), portions of Aguadilla, and Caguas (Puerto Rico Department of Natural Resources, 1980).

Like hurricanes, flooding recurs at regular intervals, usually from late summer through early winter at the same time that tropical storms threaten. Some portions of the island are flooded fairly regularly, and thus the hazard is familiar to its inhabitants.

Landslides

Jibson (1987) has described Puerto Rico as "one of the most landslide-prone areas in the United States" (p. 183) because of its mountainous terrain and tropical climate. Construction of roads and houses contributes to the hazardousness of slides when areas of otherwise moderate susceptibility become unstable. Such exacerbation of vulnerability is evident along the road cut and fill slopes in the Caguas-Cayey region (Molinelli, 1984). Most common landslides are debris flows and debris slides, which are particularly hazardous because they give advance warning and move very rapidly. One of the most

serious recent landslides took place in Mameyes in the municipio of Ponce where approximately 100 people were killed in a landslide associated with an October 1985 storm.

Landslides are a sudden and deadly phenomenon in Puerto Rico. However, since vulnerability is increased by poor land use, it can also be reduced by improved land use and construction practices.

Subsidence and Collapse

A final hazard affecting the Puerto Rican population is subsidence. Subsidence and surface collapse result from a combination of natural factors and human activity (Griggs and Gilchrist, 1983). The major causes of subsidence and collapse include withdrawal of large volumes of fluids such as petroleum or water, drainage of wetland areas (often to convert them into agricultural land or residential settlement), removal of subsurface materials (in underground mining), application of heavy loads on a subsurface that cannot bear these loads (in dense construction), creation of new land through artificial fill, and the settling of that land.

Entirely different causes of subsidence are such natural factors as tectonic activity and the formation of sinkholes. Serious damage to portions of northern Puerto Rico (Gomez-Gomez, 1984) results from the second type of subsidence, caused by the formation of sinkholes in the blanket sand deposits. In Puerto Rico, rainfall filters through the limestone formations creating cavities that eventually become underground rivers and caverns. When the cavern becomes sufficiently large, the roof collapses, causing a sinkhole. Problems occur when these sinkholes develop in settled areas, damaging buildings, roads and other infrastructure.

The hazards of subsidence and collapse can be reduced through more careful siting of activities and construction measures that take into account the impacts of soil settlement on the structure.

Contrasts Between California and Puerto Rico

Since some of our major findings deal with contrasts between the Puerto Rico perceptions/behavior patterns and those of California, it is useful to outline some similarities and differences between these two study areas. Both Puerto Rico and California share in the political organization of the United States. The economies of the two areas are surprisingly similar at first glance: each has an agricultural structure based on cash crops intended for export, overlain with an urban structure based on high tech industries — electronics and defense in California, pharmaceuticals and electronics in Puerto Rico. Both are relatively prosperous in comparison with other states/nations in their respective regions. Some of the insurance companies and financial institutions doing business in California are also present in Puerto Rico. The Commonwealth of Puerto Rico

shares with California access to federal assistance through the Federal Emergency Management Agency, and may be declared by the President of the United States a disaster region with attendant aid and recovery assistance.

Both regions also share a vulnerability to natural hazards. Puerto Rico is susceptible to riverine and coastal flooding, wind and water damage associated with hurricanes, ground failure caused by human-induced erosion and heavy rains, and ground shaking and tsunamis associated with seismic activity. California is subject to most of these hazards, as well as to drought.

Demographic and Economic Contrasts

Despite these similarities, California differs from Puerto Rico in several important ways. The total population of California was almost 30 million in 1990, while that of Puerto Rico is just over 3.5 million (Census of Population, 1990). The ethnic composition of California is far more diverse than that of Puerto Rico. California's population includes 7.7 million Hispanics (about 26 percent), 2.8 million Asian or Pacific Islanders (9.6 percent), 242,000 American Indians (almost 1 percent), 2.2 million African Americans (7.4 percent), and another 3.9 million of "other" non-white and non-Hispanic people. In Puerto Rico, race and ethnicity are not reported in the census, reflecting an assumed uniformity in ethnicity.

The economies of the two places are also very different in scale. California's gross state product in 1986 was $534 billion, whereas Puerto Rico's was $16 billion. When gross state product is converted into per capita terms, the ratio is approximately 4 to 1: the per capital gross state product for California was $19,772 while that for Puerto Rico was $4,896.

According to the 1990 Census of Population, the mean after-tax family income in California is $41,586; in Puerto Rico, $22,611. Indeed, Puerto Rico has a lower median family income's than West Virginia or Mississippi, the states with the lowest median income in the continental United States. Although income levels are lower in Puerto Rico, its income distribution across the population is more homogeneous. Similarly, Puerto Rico shows more linguistic unity. Although Spanish in the dominant language in Puerto Rico and English in California, California has far more linguistic diversity, with large numbers of Spanish, Korean, Chinese, and Filipino speakers. The common language and associated ethnic identification in Puerto Rico contribute to a national identity lacking in California or in any U.S. state.

Insurance/Banking Industry Policies

Among the mitigation measures studied in both California and Puerto Rico was the decision to purchase hazards (earthquake) insurance. The banking/insurance structure in these two areas is markedly different. In California, the individual alone makes the decision to purchase catastrophic earthquake insurance. Insurance companies offering homeowner's coverage within California are required not only to make earthquake insurance available

but also to disclose its availability to their policy holders. The purpose of this disclosure requirement is explicitly stated in the 1984 California legislation: "it is the intent of the Legislature in enacting this act to promote awareness of earthquake insurance by residential property owners and tenants by requiring insurers to offer that coverage" (§1081, Section 2 of Stats. 1984, c. 916. California Insurance Code).

In California, lending institutions generally do not require earthquake insurance as a condition for getting a loan, even in areas susceptible to surface faults, ground shaking or liquefaction (Palm et al., 1983). Although the lender may escrow monthly payments toward the annual payment of property taxes and homeowner's insurance, this practice is not universal.

The secondary mortgage market with which California lenders interact also does not require earthquake insurance in mortgage packages originated in California. For example, the regulations of the Federal Home Loan Mortgage Corporation (Freddie Mac) require flood insurance if the property is located in a FEMA-designated floodplain and also "hazard insurance" (protection against "loss or damage from fire and other perils covered within the scope of standard extended coverage"), but not an earthquake insurance addendum.

In Puerto Rico, the insurance decision is different. The standard insurance policy required by lenders is similar to that offered by companies insuring homes in California and other mainland states: that is, the basic policy insures against fire, lightning, internal explosion, windstorm or hail. This standard policy excludes earth movement, water damage, power interruption, neglect, war and nuclear hazard. Earthquake and volcanic eruption damage is insured by the addition of an addendum (DP00-69 (Ed. 7-85), Insurance Services Office, Inc., 1981, 1985). This addendum requires payment of an additional premium and provides reimbursement beyond a fixed deductible, although no less than $250. Excluded from coverage is damage directly or indirectly resulting from flood or tidal wave even if aggravated by the earthquake or volcano; also excluded is damage to exterior masonry veneer.

In Puerto Rico a standard earthquake or volcanic eruption insurance endorsement is *required by the lenders as a condition of the mortgage loan* (personal communication, Jose Velez, Assistant Vice President, Royal Insurance Company of Puerto Rico; Carlos Bruno, American International Insurance Company; Eunice Betancourt, Vice President, Puerto Rico American Insurance Company; Juan Antonio García, Executive Director, Association of Insurance Companies of Puerto Rico, November 15, 1991). Lenders in Puerto Rico require such coverage because of secondary mortgage market regulations requiring earthquake insurance on loans originating in Puerto Rico.

The largest of the secondary market participants in the Federal National Mortgage Association (FNMA) or Fannie Mae. Although FMNA does not require earthquake insurance addenda on packages of loans originating in California or any other state, it does require an earthquake insurance endorsement for loan packages originating in Puerto Rico and Guam. Its specific guidelines

for mortgage documents concerning both the selling of mortgages (Section 106.05) and the servicing of second mortgages for PUDs (Section 203.06) state that, "we require earthquake insurance for all buildings in Puerto Rico. In Guam, we require earthquake insurance for buildings of masonry construction only. We also require a typhoon endorsement in Guam. The amount of required coverage and the deductible limitations are the same for these policies as they are for policies for fire and extended coverage." The FNMA does not designate a particular carrier or insurance company nor does it prescribe the method of payment, whether through escrow or annual or semi-annual payment by the homeowner. Although the second major player in the secondary market, the Federal Home Loan Mortgage Corporation, does not require an earthquake insurance endorsement in Puerto Rico, FNMA's influence is great enough to cause the universal implementation of mandatory earthquake insurance coverage.

Further, unlike many California residents, Puerto Rican homeowners do not make the insurance payment separately from the mortgage payment: the insurance premium is universally escrowed as a matter of practice. As a result, some Puerto Rican homeowners are not aware that they pay for earthquake insurance as part of their mortgage payment.

These differences in lending/insurance practice in the two areas create major differences in the decision environment for the individual homeowner. In Puerto Rico, all homeowners are required to purchase earthquake insurance as a condition of getting a loan, although they may not be aware of payment for such coverage. Therefore, only those who own their homes with no mortgage lien make a free choice when they purchase insurance. In California, no such coverage is required so all purchases of earthquake insurance are free decisions by the homeowner.

Conclusion

The geophysical setting of Puerto Rico and the political economic structure of the commonwealth provide important conditions and constraints to hazards perception and response. Although hurricanes are a fairly common experience in the sense that at least one major landfalling hurricane occurs every generation, most Puerto Ricans probably have not experienced a major, devastating earthquake. Similarly, while flooding is widespread and fairly commonplace, tsunamis are highly unusual events. We would expect that when asked to rank various natural hazards for degree of "concern," the very destructive and unusual events such as earthquakes and tsunamis would loom larger in the minds of island residents than the more frequent though equally devastating flooding and wind storms.

The political economic structure also contributes to the structure of response and the adoption of mitigation measures. Puerto Rican homeowners with a mortgage do not have the option to buy earthquake hazards insurance: they are required to do so by lenders. Furthermore, lending practice requires escrowed

insurance payments so that individual homeowners may not be aware of their insurance coverage. This structure results in different insurance response patterns for those who have a mortgage on their home as compared to those who own their homes free of a mortgage.

3

The Study Design

Hurricane Hugo struck Puerto Rico and the Virgin Islands on September 17-18, 1989 (Figure 3.1). The hurricane was classified as Category Four when it approached the U.S. Virgin Islands[1]. Large numbers of homeowners in St. Thomas and St. Croix lost their houses, and many left the islands (Christian, 1992).

Puerto Rico had not experienced a hurricane of this magnitude in over fifty years. The hurricane's west side eyewall moved over land in Puerto Rico crossing Ceiba, Fajardo and Luquillo, as well as the islands of Vieques and Culebra (Federal Emergency Management Agency (FEMA), 1989). Maximum sustained winds at San Juan reached 125 mph on Sunday, September 17. Unlike the damage patterns in South Carolina, damage in Puerto Rico primarily resulted from strong winds rather than from rainfall or flooding. Total damage was estimated at $1 billion (FEMA, 1989), with only one death attributed to the hurricane. Most severe damage was in the island/municipios of Vieques and Culebra, with heavy damage also in Naguabo, Ceiba, Fajardo, Loiza, Rio Grande, Humacao, Las Piedras, Carolina, and Luquillo, in the eastern and northern portions of the island.

The hurricane resulted in major losses of homes; FEMA estimated that "more than 4500 families in Puerto Rico had lost their homes" (FEMA, 1989, p. 14). This figure was later revised upward by the Commonwealth government to approximately 5000 homes totally destroyed in the hurricane. The FEMA team pointed out the vulnerability of large populations in areas with unregulated development: "The most widespread and serious examples of unregulated development were the many communities of squatters, which were observed in many high risk locations (e.g., hillsides, coastal areas, flood plains)" (FEMA, 1989, p. 14). The team also noted that although the Puerto Rico Building Code,

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[1] Hurricanes are classified on the basis of their intensity according to the Saffir/Simpson Damage-Potential Scale. A category 4 hurricane is defined as one with central pressure of 27.17-27.90 inches of central pressure with maximum sustained winds of 131-155 miles per hour. It is the second most intense category of hurricane.

as amended in 1987, includes earthquake and hurricane protection requirements, many houses were built without reference to code.

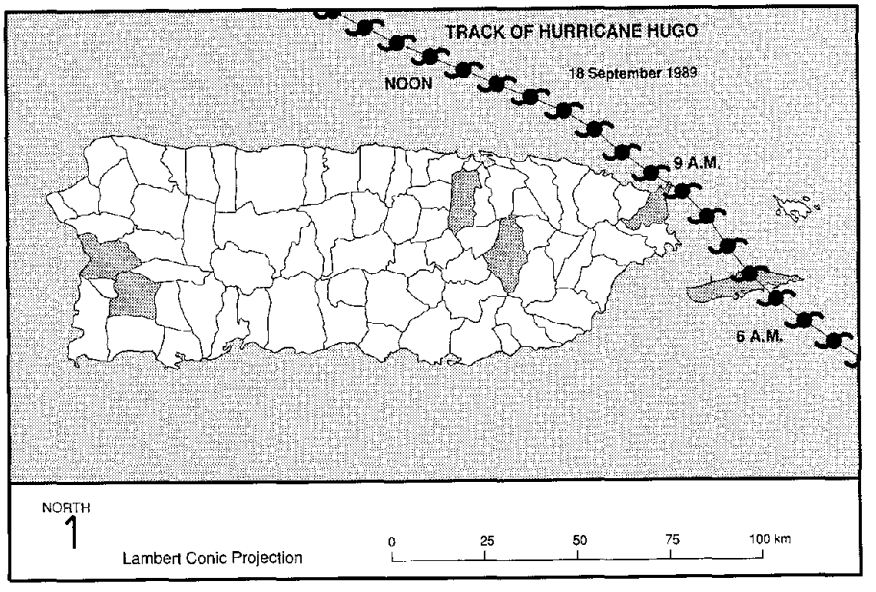


Figure 3.1 Track of Hurricane Hugo

The Selection of Study Areas

Puerto Rico homeowners experienced Hurricane Hugo in four levels of intensity. First, many residents of Vieques, Culebra, Naguabo, Humacao, Ceiba, Fajardo, and Luquillo, in the eastern and northern portions of the island, experienced the hurricane directly and intensely, with major structural damage to their dwellings and loss of belongings. Second, some residents of the same regions as well as areas further west including metropolitan San Juan, whose houses were built in more protected locations or with more hurricane-resistant construction, experienced less intense damage to their homes or contents. These people may have had damage to awnings or windows or to the exterior paint on their houses, but the losses were relatively minor. In addition, residents in these regions lost electricity and water for one to ten weeks after the hurricane. Some

of these residents, particularly in metropolitan San Juan, experienced the hurricane directly, but because of a loss of electricity, did not view the television accounts of the hurricane and therefore missed the dramatic portrayals on local news. Third, some residents in the southern and western portions of Puerto Rico who suffered no property damage or utilities outages may have had relatives in the affected regions and may thus have heard directly about the hurricane from close contacts. Finally, some Puerto Ricans escaped direct hurricane damage themselves and also had no family ties in the part of Puerto Rico damaged by the hurricane. Persons who experienced one of the first three of these levels of intensity provided a population to test for the impacts of direct, less intense, and indirect experience with a hurricane on attitude formation and subsequent mitigation adoption.

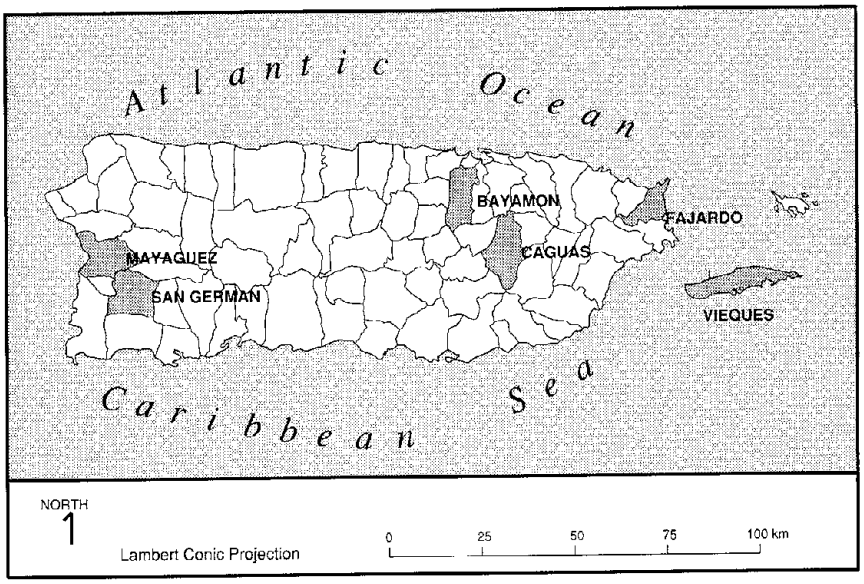


Figure 3.2 Study Municipios

Six municipios were selected for the sample survey (Figure 3.2). In the areas of highest damage, surveys were conducted in two municipios: Vieques and Fajardo. Although Vieques is an unusual setting in that two-thirds of the

island is occupied by the U.S. military and the civilian population is concentrated in the central one-third, it was one of the two offshore islands most heavily damaged by Hugo. Vieques had a 1980 population of 7662 and 1858 owner-occupied housing units. FEMA "cases" (houses that were totally destroyed) projected as of February 23, 1990, included 509 housing units. Fajardo, with a population of 32,097 and 7,669 owner-occupied units, was also severely damaged. This municipio contains both well-established residential areas and many second homes of San Juan residents. FEMA cases here totaled 339.

We selected two municipios within commuting range of the metropolitan area of San Juan, both of which experienced a moderate amount of damage or inconvenience. Although some damage to housing occurred in these areas, more residents only lost water and power temporarily, with minor damage to awnings, windows and trees. The two study areas selected were Bayamon and Caguas. Bayamon, an industrial suburb, had a 1980 population just under 200,000 with over 40,000 owner-occupied housing units. There were approximately 40 FEMA cases in Bayamon. Caguas had a 1980 population of 118,000, almost 24,000 owner-occupied units, and about 80 FEMA cases.

The western island suffered little or no impact from the hurricane (Figure 3.2). The two study municipios in this region were Mayaguez and San German. Mayaguez, the third largest city, had a 1980 population of 96,200 and 16,200 owner-occupied housing units. It has an international airport, and a major campus of the University of Puerto Rico specializing in agriculture and engineering, and it is an important industrial center. San German had about 33,000 inhabitants in 1980 with 6,900 owner-occupied housing units. It is the site of the InterAmerican University, a private institution.

Survey Sample

In the empirical portion of this study we undertook to survey owner-occupiers in six municipios of Puerto Rico. The purpose of the study was to assess the extent to which homeowners purchase earthquake and windstorm insurance, the extent to which they adopt other mitigation measures, the reasons for their insurance purchase or mitigation activity decisions, their awareness of and attitudes toward hurricane, earthquake, landslide and flood risk, and the economic and demographic characteristics of the homeowners that might correlate with the purchase decision.

The study was limited to owner-occupiers. Condominium dwellers were excluded from this sample because insurance decisions of a collectivity as large as a homeowners' association involve negotiations and group interactions beyond the scope of this study. Similarly, renters were not included in the sample because they do not make the insurance purchase decision. Finally, we restricted the survey to owners who actually lived at the site since we wanted to assess the perceptions of those living within a given geophysical setting. Our sample was

thus limited to those individuals who owned the property, lived at the site, and made the decisions to purchase or forego insurance or other mitigation measures at the individual or household level.

A statistically random sample was drawn from a complete list of single-family, detached, owner-occupied homes maintained by the Commonwealth tax assessor's office (i.e.,the Hacienda). This record contains names and addresses for all properties on the tax roll in each municipio; it is updated each year for property improvements, land use, and property transactions. A random sample was drawn from a list of the entire population of owner-occupiers in each study municipio. The random sample was also spatially random, reflecting the actual population density and distribution in the county.

An additional and separate sample of 100 residential insurance policy holders who had homeowners' insurance coverage from a single insurance company (American International) was also drawn. This separate sample was used to determine the accuracy of homeowners' awareness of insurance coverage for specific hazards. This separate sample was not used in other analyses.

Sample size was based on an estimate of the allowable error in the statistical tests, and types of analyses and expected response rates. Since the response rates from mail surveys are never 100 percent, the size of the mail survey was increased to compensate for the expected response rate. We assumed a conservative response rate of 40 percent using the Dillman survey method (Dillman, 1978). For an expected response frequency of 80 to 100 per municipio, we estimated a necessary sample size of about 1300, or 200-250 per municipio. The majority of statistical tests conducted were to determine the significance of differences in the distributions (chi-square), differences in means (t-test or analysis of variance), or multivariate linear (or sigmoid function) analyses (discriminant and logit analysis). The expected number of respondents per municipio of 80 to 100 was deemed sufficiently large to satisfy the assumptions of normality in the analyses.

We developed a 14-page questionnaire in English, based on questions used in the California research (Palm et al., 1990; Palm and Hodgson, 1992). The questions were translated into Spanish by the project collaborators at the University of Puerto Rico and then reviewed and revised by an advisory committee.

The advisory committee was convened to guide the research team in the design of the survey instrument and on policy issues affecting the research context. The committee served an important function in the Puerto Rico research since it provided us with supplementary information as well as advice on practices unique to Puerto Rico. The advisory committee was composed of a representative from the National Flood Insurance Program in Puerto Rico, the director of the Puerto Rico Insurance Institute, the vice president of Puerto Rico American Insurance Company, the vice president of Metmor Financial Services, the vice president of Banco Popular, the executive director of the Association of Insurance Companies of Puerto Rico, the natural hazards and technology officer of FEMA Region II — Caribbean Office, the president of General Accident

Insurance Company of Puerto Rico, a representative of Caribbean Underwriters Corporation, a representative of the Office of the Insurance Commissioner of Puerto Rico, a vice president for Mortgage Banking of Chase Manhattan Bank, the executive director of the Mortgage Bankers Association of Puerto Rico, a member of the Puerto Rico Seismic Safety Commission, the vice president of American International Insurance, and an assistant vice president of the Royal Insurance Company of Puerto Rico, as well as faculty members from the University of Puerto Rico with expertise in survey research and demography.

The Total Design Method

A large number of studies and meta-analyses have been conducted on the impacts of variations in survey method on response rate (Glass, et al., 1981; Fox, et al., 1988). Previous researchers concluded that response rates increase with university sponsorship, when the respondents are pre-notified by letter, when a postcard follow-up is used, when first-class postage is affixed to the outside envelope, when the questionnaires are green rather than white, and when stamps are used for the return postage rather than a business reply envelope. In addition, the inclusion of a small cash incentive with the questionnaire has a positive effect on response rate. Greater numbers of contacts with the respondent also increase response rate as does salience of the topic to the respondent and brevity of the questionnaire (Heberlein and Baumgartner, 1978; Goyder, 1982).

The survey method used in this study took advantage of the techniques previously tested to ensure a high response rate. This method was developed by Don A. Dillman (1978). Dillman labels his survey procedures and strategies the "total design method" (TDM).

The theory behind this method is the "social exchange theory." This theory suggests that people will be motivated to respond to a survey because of an understanding that they will receive some kind of a return for their actions. Social exchange theory says that people will weigh the reward that they hope to gain from their actions against the costs of taking that action, and when they perceive the gain to be greater, they will engage in the behavior. Therefore, to get the maximum survey response, according to Dillman, the researcher must (1) maximize the rewards, (2) minimize costs, and (3) establish trust. Each of these three steps must be integrated into the research design.

Maximize Rewards

One reward is showing personal regard to the respondent. This type of reward is incorporated into the cover letter sent with the survey, which indicates that the individual was carefully selected and that the response is needed for the study's success. Other positive ways of showing personal regard are using real signatures and individualized greetings (e.g., *Estimada Sra. Gomez* [Dear Mrs. Gomez]) on the cover letters, typing letters individually, personally addressing

envelopes rather than using address labels, and applying stamps rather than metering postage.

A second mode of reward is to use verbal appreciation, such as "thank you for participating in this survey." Personal regard is also shown by statements in the cover letter requesting the respondents' opinions; e.g., "It is not known what people like yourself think on these important issues, so we are attempting to find out."

Minimize Costs

Since time is a major cost, it is important to make the questionnaire as short and as simple to answer as possible. The questionnaire booklet must look inviting and easy to complete. Dillman even specifies a certain way to fold the materials and insert them into envelopes so that when the respondent opens the envelope, both time and effort are saved.

Personal questions imply a great cost — especially overly direct questions such as those about lifestyle or income. Thus, responses to certain questions (such as "What is your income?") are couched in terms of financial categories ($25,000 to $35,000 per year) so that the respondent does not need to answer with specificity the items they find too personal.

Finally, cost to the respondent is reduced by providing a stamped, self-addressed return envelope so that no money is required to return the completed survey.

Establish Trust

Dillman's final criterion for success is the establishment of trust. This can be accomplished by including a small monetary payment or offering to send the study results. Another way of establishing trust is to identify the study with a known organization that has legitimacy, such as a state university. For our survey, we sent a small token payment with the third round of surveys (the certified letter), we offered to send the study results, and we identified ourselves with the prestigious University of Puerto Rico at Rio Piedras. All mailings were done from the Department of Environmental Sciences at the University of Puerto Rico. Respondents were assured in each mailing that if they had questions they should contact the director of this program, José Molinelli, a professor of geography at the University of Puerto Rico.

The key portion of the TDM is the sequence of mailings and follow-ups designed to increase response rate. The mailings involve four steps: (1) the initial mailing of the cover letter and questionnaire; (2) seven days later, a postcard thanking respondents and reminding non respondents to return questionnaires; (3) 21 days after the initial mailing, a letter and replacement questionnaire to non respondents; and (4) 49 days after the initial mailing, a letter and replacement questionnaire sent to nonresidents by certified mail. Each step increases the response rate. In the five surveys that Dillman administered using this method, the first step resulted in response rates of 19 to 27 percent,

and the postcard reminder added another 15 to 25 percent. After the second questionnaire mailing, the average response rates rose to 59 percent, and after the final, certified mailing, response rates had increased to 72 percent.

Implementing the Survey

Pretest of Survey Instrument and Method

The pretest portion of the study consisted of a sample of 106 homeowners from Bayamon. The sample list was carefully developed to ensure correct postal addresses. Two forms of the questionnaire were sent, in which the form of several questions and the questionnaire color varied. The response rate in the pretest was 73 percent, with little impact of color or form on the likelihood of response. Based on written comments from some respondents and our own observations of confusion over some questions, we modified the questionnaire and prepared for the full mailing.

The Full Mail Survey

The full mail survey took place from June through August 1991. We attempted to terminate the study in mid-August to reduce the probability of a hurricane occurring in Puerto Rico while the survey was in process and contaminating responses. A 14-page questionnaire was mailed to selected households with cover letters signed by Professor Molinelli of the University of Puerto Rico at Rio Piedras. The respondents were asked to return their questionnaires to the Environmental Sciences Program at the University of Puerto Rico. There they were collected and mailed to Colorado for analysis. All materials — letters and questionnaires — were in Spanish, and we included a $1 bill with the third step of the survey.

Response Rates

The survey questionnaire was sent to approximately 1334 households in the random sample. Response rates for the full mail survey were even higher than those obtained in California: they varied from a high of 80.7 percent in Mayaguez to a low of 70.0 percent in Vieques (Table 3.1).

Locational Characteristics of Homeowners

The fundamental geographic characteristic of a residence is its spatial location with respect to other geographic phenomena. Earthquake hazard mapping has not been done at a microzonation scale for most of the municipios studied. However, the location of the structure with respect to the flood hazard was important in this study as a hypothesized influence on the decision of the

Table 3.1 Response Rates to the Full Mail Survey

	Bayamon	Caguas	Fajardo	Vieques	Mayaguez	San German	Total
Total Survey Mailed	248	236	208	204	200	230	1334
Returned to sender	42	72	39	14	55	54	275
Returned after first mail	79	66	67	65	67	89	433
Returned after second mail	36	31	29	31	21	26	174
Returned after certified mail	48	25	30	37	29	19	188
Total Surveys mailed back	163	122	126	133	117	134	795
Final Response Rate	76.2%	73.9%	74.6%	70.0%	80.7%	76.1%	75.1%

homeowner to adopt mitigation measures. Thus we needed an accurate and economical method of determining the geographic position of the home and measuring its location with respect to flood hazards.

In situ methods of determining position and measuring spatial relationships were far too costly. However, this information may be obtained with sufficient accuracy by using a geographical information system (GIS). A GIS was used in this study to determine the spatial location and relationships between flood and earthquake-related hazards.

The Geographic Database and Spatial Analyses

The geographic database developed in this study contained both spatial and aspatial data: locations of each respondent's home, demographic and attitude data, locations of the 100-year flood zones, municipio boundaries, and other transportation and hydrographic features. The geographic location of each homeowner surveyed was determined by consulting land parcel maps for each municipio. The demographic and attitude data were collected using the mail survey described above. Boundaries of the 100-year flood insurance rate zones were digitized from FEMA map sheets. Municipio boundaries were digitized from topographic map sheets. Other transportation and hydrographic features used as cartographic background information were collected from the USGS Digital Line Graph files.

These data were converted into digital form and entered into the Arc/Info geographical information system (GIS). This GIS was used to transform all locational information into a Lambert Conformal Conic map projection for the Puerto Rico island. A copy of the aspatial data collected from the mail survey was entered into a Statistical Package for the Social Sciences (SPSS) database. All geographical analyses and cartographics were produced using the GIS while statistical tests were performed using a statistical package.

Determination of Homeowner Locations

The geographic location of each respondent's residence (a process referred to as geocoding) could be determined by several means: GPS, address-matching with TIGER files, or manual interpolation using parcel maps. A handheld global positioning system (GPS) receiver with an automobile could be used to collect the locations of each residence. However, this approach would first require locating the residence street address on a map and navigating to the residence — a very time and labor intensive process for a large number of residences. Based on previous field work in Santa Clara County (California), we determined that an average of 30-45 minutes was required to locate, drive to, and collect a GPS fix for each surveyed home location. We concluded that this effort was prohibitive for the number of homeowners surveyed in Puerto Rico.

A common method for geocoding a home location in the United States is to match addresses of the homeowners with digital files representing the location of street segments. This very efficient method may be relatively inexpensive if digital street files are available. For U.S. metropolitan regions, the Dual

Independent Map Encoding (DIME) and Topologically Integrated Geographic Encoding and Referencing (TIGER) street address files have been developed to meet U.S. Census data collection needs (Trainor, 1990; Broome and Meixler, 1990). For the 1990 Census, the DIME data model was superseded by the TIGER model, a more comprehensive street address model.

TIGER files containing the street locations have been created for all counties of the United States and municipios of Puerto Rico. For the TIGER file in the United States, all metropolitan regions have address ranges associated with each street segment (i.e., a block face). This allows automated address matching for any metropolitan region in the United States. Such automated geocoding was used in the two previously discussed studies in California. Unfortunately, none of the TIGER files in Puerto Rico has address ranges associated with the street segments. Thus, automated geocoding of the homeowner's address was not possible for this study in Puerto Rico.

Geographic locations of each land parcel may also be measured on county zoning maps. After the address and parcel-identification are correlated and the correct plat map is found, location may be manually interpolated or digitized from these maps. In Puerto Rico, parcel maps are available for all municipios at a scale of 1:1,000. In this study, the home was assumed to be at the center of the land parcel. Thus, the geographic location for the residence was measured at that location.

100-year Flood Zones

Digital representations of the 100-year flood recurrence zones for the six municipios in this study were collected from the Flood Insurance Rate Maps (FIRM) distributed by FEMA. The flood insurance zones (100 and 500 year recurrence zones) in Puerto Rico are mapped at scales of either 1:10,000 or 1:20,000. The continuous large-scale topographic maps in Puerto Rico are at a scale of 1:20,000, whereas the continuous large scale maps in the U.S. are 1:24,000. The FEMA maps in Puerto Rico are at a scale commensurate with the large mapping effort of the USGS. The critical points representing each polygon (e.g., the 100-year flood zone taken from the FIRM) were digitized. These data were then reprojected in the Lambert Conformal Conic map projections using the Arc/Info software (Fig. 3.3). Location of an individual homeowner's residence inside or outside a 100-year flood zone was determined by digitally overlaying the maps of home sites and the 100-year flood zone boundaries (a point-in-polygon test).

Geographic Distribution of Responses

The attitudes and behavior of the homeowners were analyzed using cartographic and statistical methods. Univariate and multivariate statistical methods were used to investigate the relationship between attitudes, behavior, natural hazards, and experience. Spatial patterns of homeowner responses toward natural hazards may indicate underlying but elusive relationships between

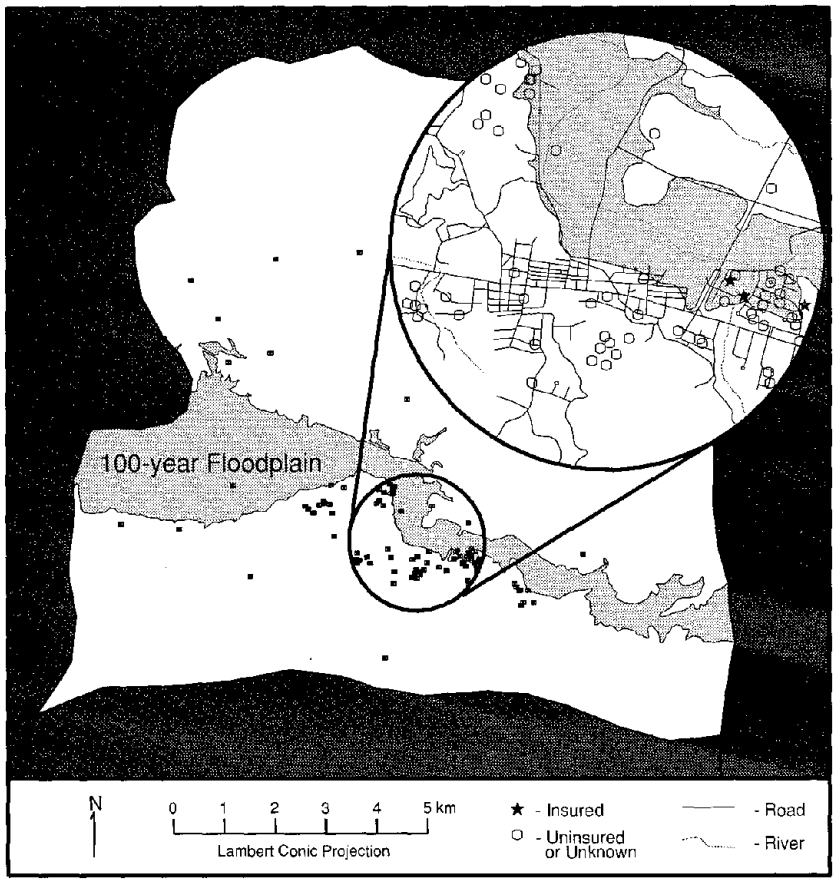


Figure 3.3 Homeowner locations with respect to the 100-year floodzones for a portion of San German municipio.

attitudes, behavior and such natural hazards (Palm and Hodgson, 1992; Hodgson and Palm, 1992). Thus, a number of maps were created to display and visually analyze such distributions to document the patterns and possibly detect such elusive relationships.

Experience with Hurricane Hugo. Much of the damage caused by Hurricane Hugo resulted from wind rather than the heavy rains associated with the

hurricane. Maximum wind speeds were 104 mph at Roosevelt Roads Naval Station, with gusting up to 120 mph. Wind velocities of 84 mph with gusts up to 92 mph were recorded at the Luis Muñoz Marin Airport near San Juan. The storm surge along the coast of eastern Puerto Rico was estimated at only 4 to 6 feet (Interagency Hazard Mitigation Team, 1989).

The lack of damage from flooding distinguishes Hurricane Hugo from very destructive hurricanes in the United States, such as Hurricane Agnes in 1972 (Dury, 1977). Because heavy rain or a large storm surge was not associated with Hugo, concrete or concrete block homes, did not suffer significant damage from Hugo.

A relatively large number of homeowners experienced damage from Hurricane Hugo, but their geographic locations varied. Of the 636 respondents to the survey, 40 percent claimed to have experienced some degree of damage to their home from the hurricane. As expected, the percentage of homeowners who experienced damage varied dramatically by municipio location (Figure 3.4). Almost 85 percent of homeowners on Vieques and 74 percent in Fajardo experienced damage to their home. Less than 4 percent of homes on the western side of the island incurred damage from the hurricane.

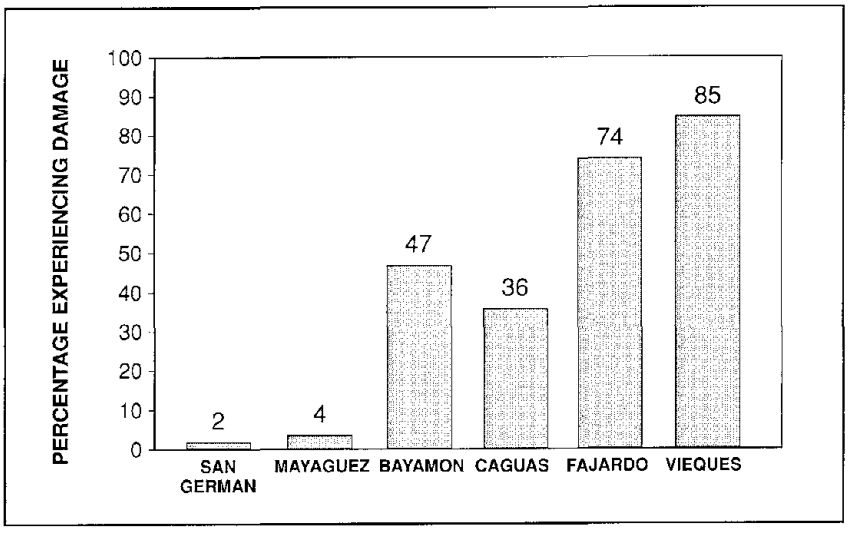


Figure 3.4 Percentage of homeowners that claimed home damage from Hurricane Hugo.

Insurance deductibles are often 5 percent of the home value. Thus, it is important to calculate not only the absolute value of the loss, but also the percentage of home value affected. An estimate of the dollar amount of damage

to the total home value was computed by dividing the reported dollar damage from Hugo by the home value. We found that less than 4 percent of the homes in the entire sample had damage greater than 20 percent of their value. Twenty-three percent received less than 5 percent damage.

Experience with Other Hazards. Not surprisingly, experience with previous natural hazards varied geographically by municipio. Overall, since a damaging earthquake has not occurred in Puerto Rico since 1918, only experience with previous floods or hurricanes was elicited in the survey form. Less than 8 percent of all homeowners in the study municipios had experienced damage from a previous flood or hurricane. However, more than 15 percent of homeowners in San German and 14 percent of those in Fajardo and Mayaguez had experienced home damage from previous floods or hurricanes. The single most devastating event experienced by the homeowners in Mayaguez and San German was flooding in 1975.

Conclusion

In this chapter, we have described the survey method, sampling design, and characteristics of the survey sites. We have also presented the methods used to geocode the individual responses and relate the variation in responses to the spatial variation in natural hazards. This survey followed the Total Design Method, adding a token payment in the third mailing. Response rates were high, and the sample seems to represent the total population of owner-occupiers in the six municipios. Damage associated with Hurricane Hugo varied widely according to geographic location. More than three-fourths of the respondents in the municipios of Vieques and Fajardo experienced some damage to their homes, whereas less than 5 percent on the western portion of the island experienced damage. Furthermore, most respondents had not experienced damage from a previous flood or hurricane, and virtually none of the respondents was a survivor of the 1918 earthquake, the most recent major earthquake in Puerto Rico.

4

Adoption of Mitigation Measures

Although purchasing insurance is the most direct and comprehensive method of minimizing the possible effects of a natural hazard, homeowners may choose many other mitigation measures. Some of these measures are considerably less expensive than carrying insurance coverage. For example, planning for evacuation of a home and subsequent reunion of the family members involves no monetary outlay. The purchase of emergency food or water storage requires a small monetary commitment. However, some activities, such as structural reinforcements, are very expensive.

The type of mitigation activity varies with the threatened hazard. For example, to protect against hurricane damage, the homeowner may reinforce windows, doors, or the roof. Walls may be constructed to guard against wind or the storm surge. Improvements in drainage may minimize flooding from heavy rains.

Home modification to control structural or contents movement is the primary method for protecting one's home against an earthquake. Bolting a wood frame home to the foundation is a common measure taken in California. However, in Puerto Rico, most of the homes are constructed of concrete or block. In the surveyed population for this study, 97 percent of the respondents indicated that their house was built from concrete or block. Stabilizing this type of structure requires expensive and extensive bracing of the walls. However, movable contents, such as the water heater and furniture, can be attached to the walls with relatively inexpensive straps.

Mitigating against flood damage is primarily through floodproof retrofitting. Floodproof retrofitting measures include reinforcing basement walls; permanently sealing exterior openings to basements; using masonry construction; erecting low floodwalls; sealing of the outside basement walls; installing sump pumps; and modifying the local topography and surrounding yard (Waananen et al., 1977; Laska, 1991). Floodproofing an existing structure is often expensive and should only be considered for floods of short duration and low stages and velocities.

Research Questions

In this study, several research questions were posed to determine the mitigation measures taken by homeowners. Since we expected that insurance purchase was the most common measure, the following information was sought:

(1) What types of mitigation activities were taken?
(2) How many homeowners voluntarily take mitigation activities?
(3) Does mitigation activity vary geographically by municipio?
(4) Are the mitigation measures taken comparable with California homeowners?
(5) What is the nature of insurance as a mitigation measure:
  (5a) Are homeowners aware of their insurance coverage?
  (5b) What is implied by lack of awareness of insurance?
  (5c) Does insurance subscription vary geographically by municipio?
  (5d) Is insurance subscription influenced by mortgage status?

Adoption of Noninsurance Mitigation Measures

Overall, 27 percent of the homeowners claimed to have taken some activity to mitigate against future damage from hurricanes. These activities were primarily reinforcements of windows, doors, and roofs, purchase of emergency supplies, and clearing of trees. Not surprisingly, the percentage of homeowners in each municipio that undertook mitigation measures was directly related to either the experience with Hurricane Hugo or knowledge about the risk from hurricanes (e.g., the paths of recent hurricanes). For instance, 44 percent of homeowners in Vieques took some measures while only 12 percent in Mayaguez did so. The relationship between experience with Hugo and the adoption of mitigation measures will be explored further in Chapter 6.

Only 2 percent of the survey sample indicated that they took measures to protect their homes against future earthquake hazards. Twenty-five percent of these undertook structural modifications to their home. The numbers of homeowners who adopted earthquake mitigation measures were too small to analyze any geographical variability in response.

Few homeowners undertook floodproof retrofitting activities, and those who did were clustered geographically. Only 5 percent of all homeowners in the sample reported mitigating against future floods. Of this small number, 42 percent had their residence in Fajardo.

The 73 percent of homeowners who did not undertake noninsurance mitigation measures against hurricanes, reasoned that the measures were too costly or unnecessary. Forty-three percent of these indicated that the reason was financial, 34 percent said that other mitigation measures were "not necessary" or they considered their home location as a "safe place."

As indicated above, 98 percent of the homeowners did not take mitigation measures to protect their home from earthquake damage other than the purchase of insurance. Most stated that the primary reason for not taking other mitigation measures was that they were too costly (34 percent). Eighteen percent said that they "did not need" other mitigation measures or that they were "not necessary."

Adoption of Insurance as a Mitigation Measure

Insurance purchase was the primary mitigation measure used to provide information about the homeowner's behavior toward natural hazards. Of the three types of hazard coverage in Puerto Rico, only flood insurance rates vary by geographic location. Earthquake insurance premiums in Puerto Rico vary by construction type, not by geographic location. The most expensive premiums are for masonry, concrete or block construction, and the least expensive premiums are for wood and metal construction. Rates for the masonry construction (as in Old San Juan) are about $5.50 per $1,000 coverage. For concrete construction the rates are about $2.00 per $1,000. Deductibles for earthquake insurance are typically about 5 percent. This premium structure is comparable to the rates for woodframe construction in California, although there the deductible may range up to 10 percent.

Like earthquake premiums, windstorm insurance does not vary by geographic location; however, the premiums do vary by construction type. The standard fire policy includes extended coverage for windstorm insurance. The least expensive windstorm coverage is for concrete construction (about $0.28 per $1,000), masonry construction is moderately expensive (about $0.60 per $1,000), whereas the most expensive coverage is for metal/wood construction (about $1.50 per $1,000). Deductibles for windstorm insurance are typically about $125.

Flood insurance varies by geographic location, construction type, and the date of construction. Three geographic zones for flood risk (A, B, and C) are depicted on flood insurance rate maps (FIRMs). Zone A depicts the area of the 100-year flood probability and consequently the highest insurance premiums. Zone B represents the geographic area between the 100-year and 500-year zone boundaries.

Homes with a basement located in the 100-year flood zone have the highest premiums. Homes are designated as "pre-FIRM" or "post-FIRM" depending on whether they were constructed before or after the publication of the rate maps. Homeowners may purchase subsidized flood insurance within the United States and Puerto Rico if their community participates in the National Flood Insurance Program. The entire Commonwealth of Puerto Rico is considered by FEMA as one community and does participate in the National Flood Insurance Program.

In previous research, the adoption of earthquake, windstorm, or flood insurance was used as an indicator of the behavior of a homeowners towards hazards (Burby et al., 1988; Palm et al., 1990; Palm and Hodgson, 1992). All

three vary by the construction type of the home. However, this measure can be used only if the homeowner is aware of his/her insurance status and can accurately respond to questions about the nature and size of insurance coverage.

To analyze responses with confidence, we conducted an independent check on the accuracy of homeowner awareness of insurance coverage. In California, using information from insurance companies to check against homeowner responses, Palm et al. (1990) found that from 90 to 100 percent correctly knew the status of their earthquake insurance coverage. However, because of the manner in which insurance is provided in Puerto Rico, we suspected that the percentage of homeowners that correctly knew their coverage status might be less than in California.

Awareness of Insurance Coverage

We used a separate sample drawn from an insurance company listing to determine the accuracy of homeowner recall of the status of their windstorm and earthquake insurance addenda. The American International Insurance Company provided us with a list of approximately 100 clients who had both windstorm and earthquake insurance as a part of their standard homeowner's package. This list was a random selection of homeowners covered by this company in the municipios of Bayamon and Fajardo. Questionnaires identical to those used in the full survey were sent to this subsample but without subsequent mailings to increase survey response rates. Forty-two of the 100 homeowners contacted responded to the survey.

Although all had coverage against windstorms and earthquakes, only 59 percent believed that they had coverage against windstorms (Figure 4.1). Seventy-three percent of these homeowners believed they had coverage against earthquakes. These percentages of accurate insurance status identification were considerably lower than we had expected based on the previous work in California. After discussing these findings with the advisory committee, we concluded that the homeowners were unaware of their actual insurance status because (1) the insurance premium is generally not itemized on the monthly mortgage statement so that individuals may be unaware that they are paying for insurance as well as principal and interest, and (2) the insurance contracts are generally signed without discussion about policy coverage at the time of house closing.

The homeowners' inaccurate knowledge of insurance coverage tempers our analytic use of insurance status as an indicator of behavior toward hazards, at least for those homeowners who include the insurance payment with the monthly mortgage payment. However, homeowners who pay premiums separately from the mortgage payment are more likely to be aware of the specific hazards covered. Certainly, homeowners who do not have a mortgage on their home are more likely to be aware that they are paying for insurance.

Overall Patterns

In the six study municipios, 32 percent of homeowners claimed to have windstorm insurance, and 34 percent claimed to have earthquake insurance. However, there were dramatic variations among the municipios (Figure 4.2). Forty-nine percent of the homeowners in Bayamon but only 9 percent of the homeowners in Vieques claimed to have earthquake insurance.

Most of the respondents who believed they had earthquake insurance also thought they had windstorm coverage. The percentage difference in earthquake versus windstorm coverage was less than 2 percent in all municipios except Bayamon where it was 5 percent.

The percentage of respondents that indicated they had earthquake insurance varied by county or municipio, a finding similar to that in the California studies (Palm et al., 1990; Palm and Hodgson, 1992). In Puerto Rico, however, unlike in California, all homeowners with a federally insured mortgage were required to have both earthquake and windstorm insurance. This requirement raises important issues: Why does the percentage of homeowners that claimed insurance coverage differ so dramatically? Could the differences be explained by stratifying the sample by mortgage status between those with and those without a home mortgage?

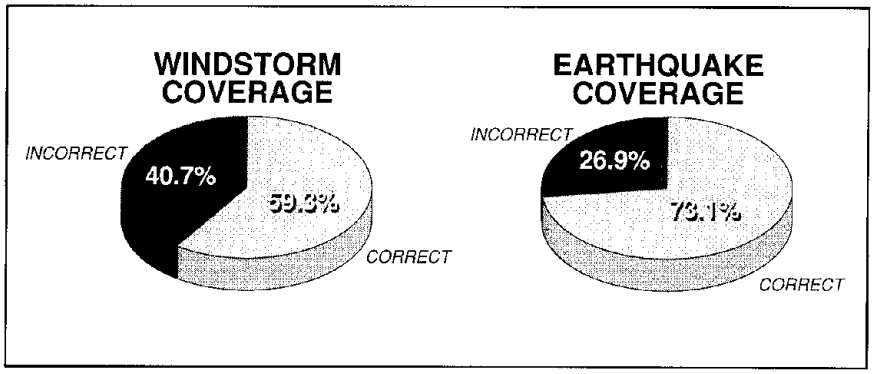


Figure 4.1 Percentage of homeowners in the subsample who correctly knew their insurance status. Note: All homeowners in this sample had earthquake and windstorm coverage.

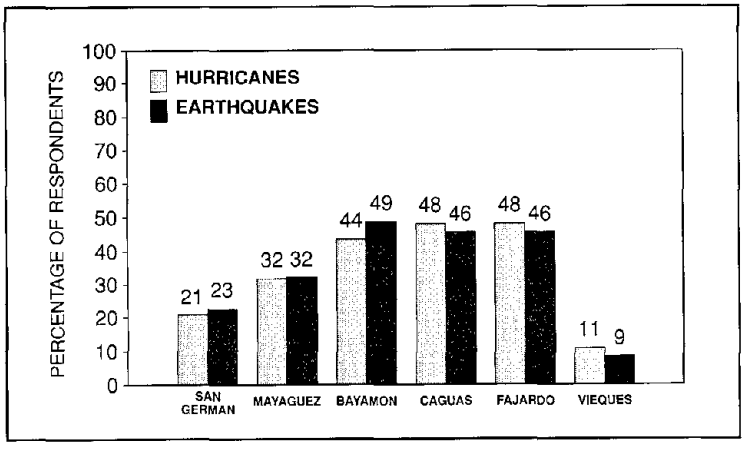


Figure 4.2 Percentage of the homeowners insured against windstorms and earthquakes by municipio.

Stratification by Mortgage Status

Of all the homeowners in the six municipios studied in Puerto Rico, 66 percent had a home mortgage. However, the percentage of those with and those without a mortgage varied dramatically by municipio. Over 89 percent of the homeowners in Bayamon compared to only 21 percent of the homeowners in Vieques had a home mortgage (Figure 4.3a). In fact, over 80 percent of the homeowners in Bayamon, Caguas, and Fajardo carried a home mortgage.

Comparison of the histograms in Figure 4.2 and 4.3b suggests a strong monotonic relationship between insurance status and mortgage status for homeowners in Puerto Rico. For example, those municipios with a low percentage of homeowners carrying a home mortgage (e.g., Vieques and San German) were also the municipios with the lowest percentage of insurance coverage. By stratifying the sample in each municipio by mortgage status, we further examined the relationship between insurance coverage and mortgage status. From 41 percent to 55 percent of the homeowners with a mortgage claimed to have coverage against earthquake perils. Since insurance coverage is required for all homeowners with a mortgage, 100 percent of these homeowners are actually covered by earthquake insurance. Thus between 59 percent and 45 percent in each municipio believe they are not covered by insurance against earthquake damage even though they actually have such coverage. For those without a mortgage, the percentage of homeowners claiming to have earthquake insurance varied from 0 percent in Vieques to 27 percent in Bayamon. We may

assume that those homeowners without a mortgage and who voluntarily decide on hazard insurance coverage are likely to correctly know their insurance status then the economic impact of a devastating earthquake on a population with such low insurance subscription rates would be substantial.

In all municipios, respondents stated that cost was the primary deterrent to adopting windstorm or earthquake insurance. Cost as an important factor in the insurance purchase decision has also been well documented within the United States (Kunreuther et al., 1978; Cross, 1985; Palm et al., 1990).

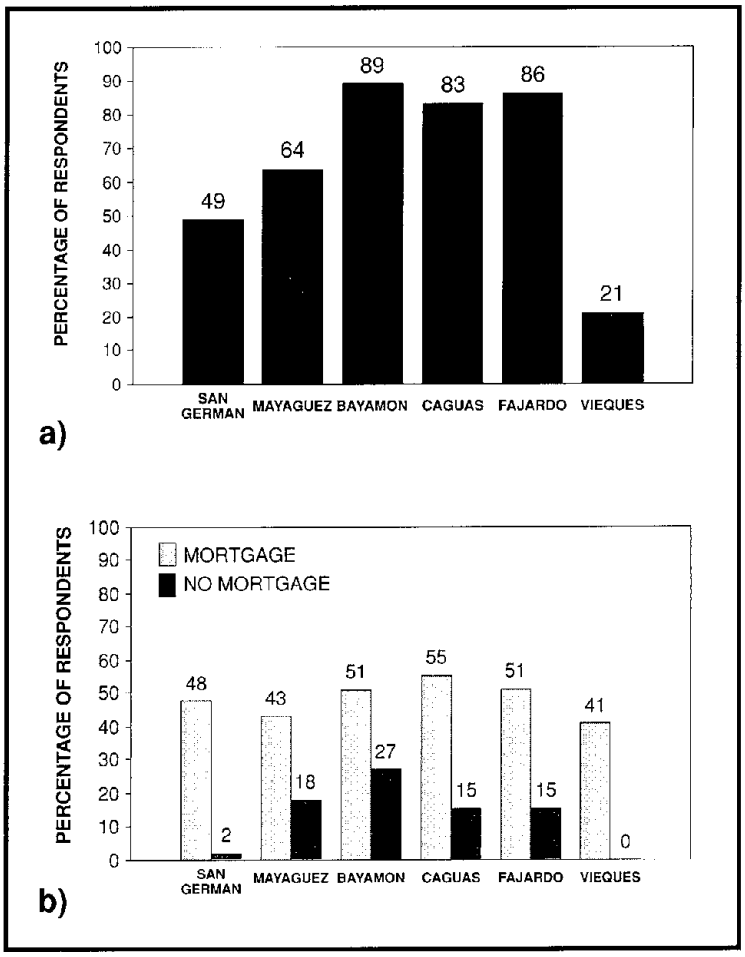


Figure 4.3 Percentage of homeowners with a mortgage in (a) and percentage of homeowners with earthquake insurance stratified by mortgage status in (b).

Correlation Between Hazards

The patterns of percentage of homeowners claiming windstorm coverage are very similar to those for earthquake insurance. The relationship between adoption of earthquake and windstorm insurance was strongly positive. If homeowners carried earthquake insurance, they were also likely to have windstorm insurance: 89 percent of those homeowners with earthquake insurance also had windstorm insurance. Similarly, 90 percent of those with windstorm insurance also had earthquake insurance.

Comparison with California Studies

In the California studies by the authors in 1989 (Palm et al., 1990), roughly 10 percent of the homeowners had undertaken mitigation activities other than insurance purchase. This percentage of homeowners undertaking mitigation activities was similar to the 12 percent found by Kunreuther et al. (1978) in 1973-4. However, only 2 percent of the homeowners in Puerto Rico indicated that they had taken other activities to mitigate against earthquakes. Two factors may account for this difference: experience with earthquakes and home construction.

First, fewer Puerto Ricans had direct experience with an earthquake. Puerto Rico has not had an earthquake since 1918, while California has had damaging earthquakes every few years. Thus many California homeowners have directly experienced a damaging earthquake. The impacts of such experience on the likelihood that homeowners would adopt noninsurance mitigation measures are illustrated by the geographic variation found in the California study conducted after Loma Prieta. Although 31 percent of the homeowners in Santa Clara County and 10 percent of the homeowners in Contra Costa County had invested in noninsurance mitigation, fewer than 6 percent in Los Angeles and San Bernardino counties undertook other mitigation measures (Palm and Hodgson, 1992). Thus, those homeowners with greater experience with the Loma Prieta earthquake were more likely to take mitigation activities.

Second, structural modifications in Puerto Rico are considerably more expensive than structural modifications in California. The most common home construction in California is wood frame, while that in Puerto Rico is concrete or block. Wood frame construction is considerably more resistant to earthquake shaking while concrete or block is one of the least resistant. A common and necessary modification to wood frame homes is to bolt the house to the foundation. Bracing concrete or block homes is considerably more expensive. Although 31 and 10 percent of the homeowners in Santa Clara and Contra Costa counties, respectively, had undertaken noninsurance mitigation activities, most of the activities were very inexpensive. Over half of those homeowners undertaking mitigation activities spent less than $15.00 (Palm and Hodgson, 1992).

Awareness of Insurance

In California, 97 percent of all homeowners correctly knew whether they had earthquake insurance (Palm et al., 1990). In Puerto Rico, 73 percent of homeowners who had earthquake insurance knew they were covered. This large difference in accuracy of knowledge concerning coverage probably results from voluntary versus mandatory insurance coverage in California and Puerto Rico, as well as the manner in which it is communicated to the home purchaser. Homeowners that must voluntarily choose or forego insurance and who pay for insurance separately are likely to be aware of this expenditure. In contrast, those who are required to carry earthquake insurance may forget coverage details of their policy. Also, because of the context in which the insurance policy is written and communicated to the buyer during closing and the escrowing of mortgage, taxes and insurance, it is not surprising that the Puerto Rican homeowners are unaware of their coverage.

Insurance Adoption

For the six municipios studied in Puerto Rico, 66 percent of the homeowners carried a mortgage on their home. In the four California counties studied, about 80 percent of all homeowners surveyed had a mortgage. In both study areas, the percentage of homeowners with a mortgage varied by county or municipio. The percentage with a mortgage in the four California counties varied from 15 percent to 31 percent, compared to a variation of 21 to 89 percent in Puerto Rico.

The primary reason for not adopting earthquake insurance in both Puerto Rico and California was because the premiums were too expensive. This concern for the cost of premiums was also found in other studies for flood hazards in the United States (Cross, 1985; Kunreuther et al., 1978).

Conclusions

Ironically, a large percentage of the homeowners in Puerto Rico are unknowingly protected against hurricanes and earthquakes through mandatory coverage against such natural hazards. Approximately half of the homeowners with a mortgage (and thus insured) are unaware that they are covered by windstorm or earthquake insurance. Ethical questions arise with respect to the mandatory peril coverage in Puerto Rico, since the objective risk here is far less than in parts of the fifty states where no such coverage is required. Nonetheless, the result of such a requirement is comprehensive coverage against natural hazards — at least for those with a mortgage. Without such mandatory coverage, homeowners are reluctant to adopt other mitigation measures or voluntary insurance. Given construction practices in Puerto Rico, the lack of insurance coverage and the absence of adoption of other mitigation measures

could result in damage of disastrous proportions, particularly with a moderate or major earthquake.

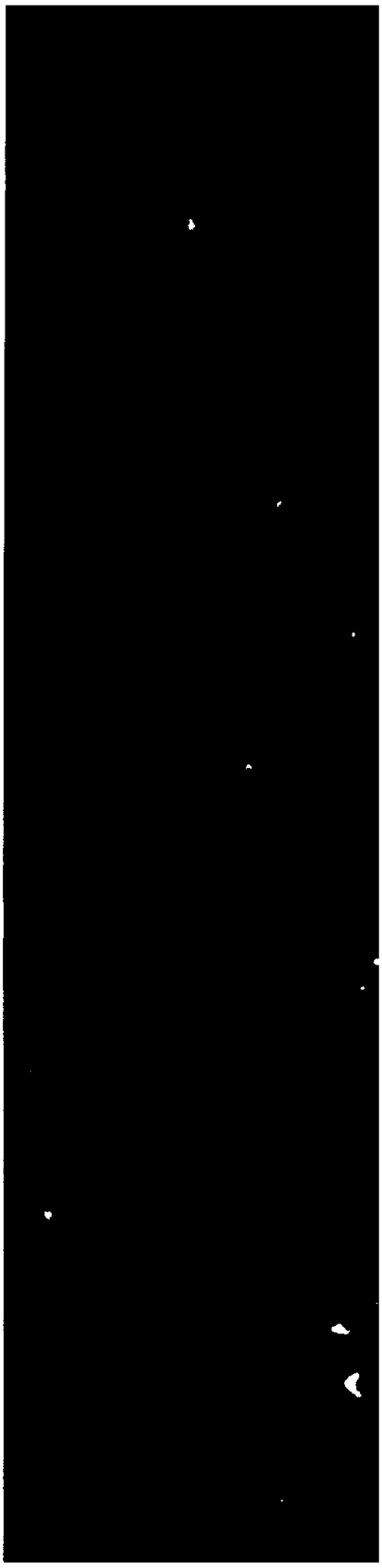
Despite the frequency of damaging hurricanes striking the Puerto Rican commonwealth, residential homeowners seldom adopt mitigation measures to protect their home. Fewer than 27 percent of all respondents in this survey had undertaken some form of mitigation to protect their homes against future hurricane damage. However, the majority of houses in Puerto Rico (97 percent in this survey) are constructed of concrete or concrete block and are thus very resistant to hurricane induced wind damage and flooding. The relative resistance of these homes to hurricane damage is implied in the reasons given by respondents for not undertaking other mitigation measures: thirty-four percent of the respondents said that such activities "were not necessary" or that their home was located in a "safe place." Because most of the homes in Puerto Rico are made of concrete or concrete block, few of the residents experienced significant damage from Hugo, and the standard insurance policy includes windstorm coverage, it was not surprising that few homeowners undertook noninsurance mitigation measures to protect their home from hurricane or flood damages.

The reluctance of homeowners to take noninsurance mitigation measures places the burden of responsibility on insurance companies to compensate homeowners after the damage is done. Since the deductible for windstorm damage is about $125, an insured homeowner has little incentive to adopt mitigation measures. Also, since all homeowners with a mortgage are required to have windstorm insurance, these homeowners are at little risk. However, a number of homeowners (28 percent) own their home and claim not to have windstorm insurance. Seventy percent of these homeowners who do not have a mortgage or windstorm insurance have not taken other mitigation measures. Although we could not corroborate their claim of not having windstorm insurance, we may assume that since their decision to purchase or forego insurance was voluntary, their knowledge of their insurance coverage was accurate.

Even fewer respondents adopted noninsurance mitigation measures to protect their homes against earthquake damage. As with windstorm insurance, 28 percent of the population do not have a mortgage and also claim not to have earthquake insurance. Ninety-nine percent of homeowners who do not have a mortgage and who indicated they do not carry earthquake insurance have also not taken other mitigation measures to protect against earthquakes. The lack of adoption of both earthquake insurance and earthquake-related mitigation measures presents a serious problem to the commonwealth.

The aggregate vulnerability to earthquake damage is geographically variable. In the municipios with a high percentage of homeowners with a mortgage (e.g., Bayamon, Fajardo, and Caguas), homeowners are protected by the mandatory earthquake insurance. In contrast, an earthquake impacting municipios with a low percentage of homes with a mortgage (and corresponding low rates of insurance coverage) such as Vieques or San German, would cause serious economic disruption to a large percentage of the population without catastrophic

insurance coverage. Because the construction of a large number of homes in Puerto Rico is not resistant to ground shaking or ground failure, a moderate size earthquake impacting these areas could easily result in a large number of homeless and economically unprotected families. Such a disaster would place an enormous responsibility on commonwealth or federal government programs.



5

Attitudes Toward Natural Hazards

Geographers have long been interested in environmental perception — the images of places and the ways in which people form these images. Such images both reflect values and influence behavior. In our study we are particularly interested in homeowners' perception of hazards in their immediate environment and the images they have of other regions of Puerto Rico. How concerned are Puerto Ricans about future natural disasters? What are their beliefs concerning future natural events that could affect their own homes? What do they believe are the most hazardous areas in Puerto Rico? Are Puerto Ricans more concerned about hurricanes or about earthquakes? How do the attitudes of Puerto Rican residents compare with those of the homeowners in California?

We hypothesized that Puerto Ricans would be more concerned about hurricane hazards than earthquake hazards. This hypothesis is based on the Puerto Ricans' recent experience with Hurricane Hugo and on the absence of experience with a major earthquake in Puerto Rico since 1918. Puerto Ricans brace for a potential hurricane each summer at the onset of the hurricane season. Not all hurricanes make landfall on the island, but nonetheless Puerto Ricans have considerable experience with the destructive potential of hurricanes. For similar reasons, we expected that Californians would be relatively more concerned about earthquake hazards.

Geographical Variation in Attitudes

One might also expect that the attitudes of homeowners in Puerto Rico would vary by municipio. Homeowners in Puerto Rico have different levels of historic experience with hurricanes, floods and landslides, depending on where the disaster occurred. As indicated in chapter 3, Hugo's damage was primarily to the eastern side of the island. Based on recent experience with Hurricane Hugo, we would expect more concern toward hurricane hazards in Fajardo and Vieques and less concern in Mayaguez and San German.

The expected attitudes of the Puerto Rican homeowners toward earthquakes were more difficult to assess. With so little experience with major earthquakes, the population must rely on information from the media. Yet the entire island is susceptible to shaking from an earthquake. With such scanty historic record of earthquakes and practically no experience, we anticipated that the concern toward earthquakes would be similar among all municipios.

Mental maps reflect the biases and values of individuals about some spatial phenomena. Cartographic techniques have been used to depict mental maps for a wide variety of phenomena, such as desirable regions of the United States and fear of crimes. For example, David Ley (1974) mapped individuals fears of different locations within a city. The resulting "environmental stress surface" depicted the overall places to avoid as well as those areas of greater safety.

This study sought to document the spatial variability in mental maps of hazard risk for Puerto Rico. We know of no other studies that have mapped such cognitive hazard risk. The following research question was examined: Are the cognitive maps of risk similar for different experiences or geographic locations? In other words, do those homeowners in Mayaguez and San German perceive similar levels of risk for geographic locations as the homeowners in Fajardo and Vieques?

Previous Research with Hurricane Hazards

Of particular relevance to this study was a survey in the lower Florida Keys on attitudes and behavior of homeowners to hurricane hazards (Cross, 1985). Sixty percent of the respondents believed that a damaging hurricane was "very likely" or "likely" to occur in the next 10 years. No relationship was found between concerns for possible future hurricanes and actual physical vulnerability of home. Long term residents were more likely than recent home buyers to say that they would remain in their homes during a future hurricane. Experience, obviously not too negative, may have had a contradictory effect on behavior. Cross found no relationship between perceived vulnerability and the likelihood of purchasing flood insurance coverage. Contrary to our previous findings with respect to earthquake hazards (Palm et al., 1990), Cross (1985) found no difference in perceived vulnerability between the insured and the uninsured. Similar to our findings, he found no difference in socioeconomic status between insured and uninsured.

Overall Concern Toward Hazards

To assess the overall concern toward hurricane and earthquake hazards, we included questions probing homeowner concern with future disasters. The first question was posed as, "How concerned are you that each of the following

disasters (hurricanes, floods, earthquakes, and landslides) may cause serious damage to your home?" Possible answers were ranked from "very little concerned" to "highly concerned."

The magnitude of anticipated damage was measured by the question, "Suppose that a devastating hurricane struck your community. How much damage do you estimate would be caused to your house as well as its contents?"

Perceived Vulnerability

Not surprisingly, 79 percent of all homeowners surveyed were concerned, very concerned, or highly concerned that a hurricane would cause serious damage to their home (Figure 5.1). However, contrary to expectations, the Puerto Ricans expressed greater concern for damaging earthquakes than hurricanes. Thirty-four percent of the homeowners were highly concerned that an earthquake would seriously damage their home. Only 18 percent expressed this level of concern for hurricanes. Based on the prevalent home construction on the island (concrete or block), this concern is well warranted. Perhaps this concern is a result of Commonwealth, academic, and the popular media attention to earthquake hazards.

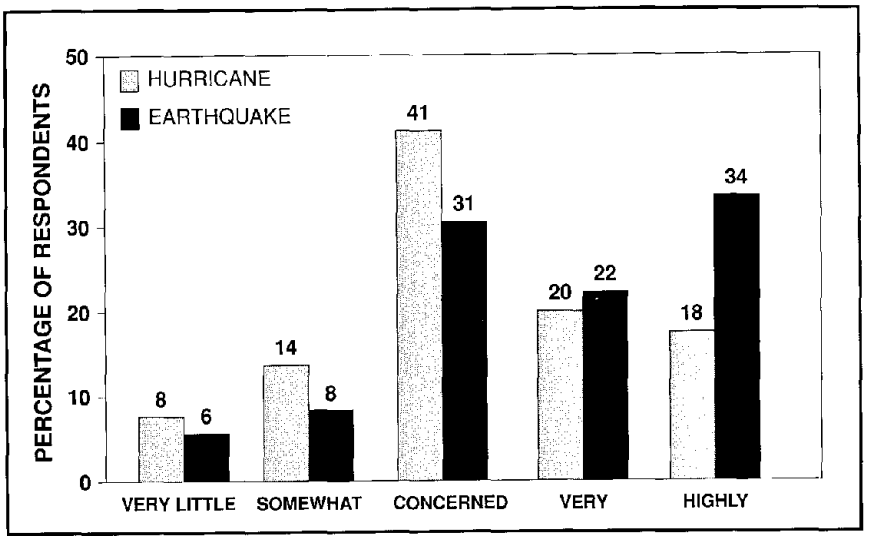


Figure 5.1 Concern of homeowners that a future hazard (earthquake or hurricane) would cause damage to their home.

Magnitude of Damage

Most respondents believed that a future earthquake would result in more damage to their own homes than a future hurricane (Figure 5.2). Forty-one percent of the respondents indicated that a devastating earthquake in their community would result in 75 percent or more damage to their home, but only 7 percent believed a hurricane would cause such a level of damage. The majority of respondents felt that a devastating hurricane in their community would result in 25 percent or less damage to their home.

To what do we attribute these different levels of concern? Are the homeowners aware that their hurricane resistant home construction is very unstable in earthquake shaking? Does the minor-to-moderate damage of historical hurricanes reinforce the belief that future hurricanes are to be feared less than future earthquakes? Does the ability to predict and quickly conduct some hurricane mitigation measures(e.g., boarding of windows, evacuation) lessen concern? Although our survey instrument does not enable us to answer these questions, they deserve attention in future work on perceived vulnerability to disasters in Puerto Rico.

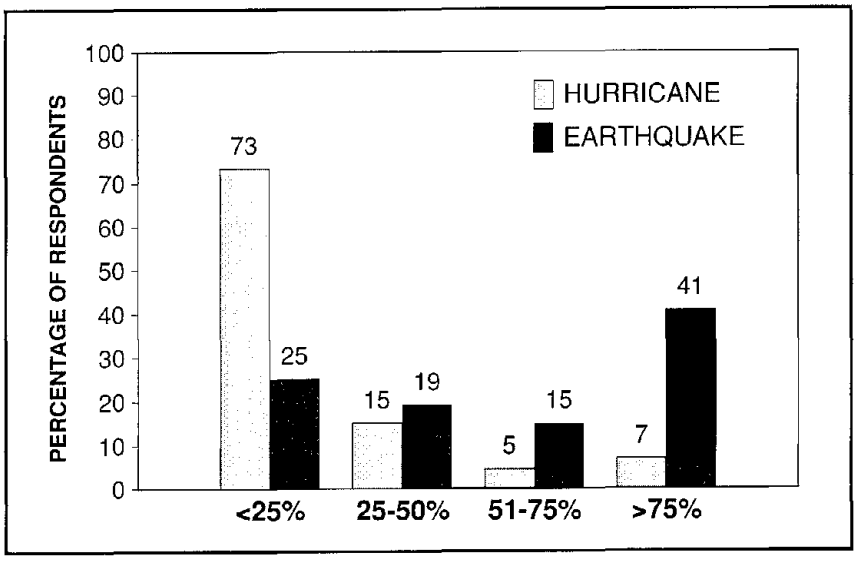


Figure 5.2 Percentage of homeowners that believe a future hazard (earthquake or hurricane) is likely to cause some level of dollar damage to their home. Damage amounts are expressed as a percentage of the total reported home value.

Variation in Concern by Municipio

Geographical variations in homeowners' attitudes were also analyzed. The percentage of homeowners circling either "very concerned" or "highly concerned" were compared for each municipio and for both hurricane and earthquake hazards (Figure 5.3). Again, not surprisingly, homeowners expressed the greatest concern for a hurricane causing serious damage to their home in municipios on the eastern end of the island, the areas most damaged by Hurricane Hugo. Only 25 percent of the respondents in Mayaguez expressed a similar concern for future hurricanes.

The concern of future damaging earthquakes was relatively similar across municipios, except for Vieques. From 48 to 58 percent of the homeowners in all other municipios studied were very or highly concerned that an earthquake in their community would seriously damage their own home. Although Vieques has not suffered damage from a recent earthquake, the level of perceived vulnerability there was higher: 64 percent of the homeowners in Vieques were very or highly concerned about future damaging earthquakes.

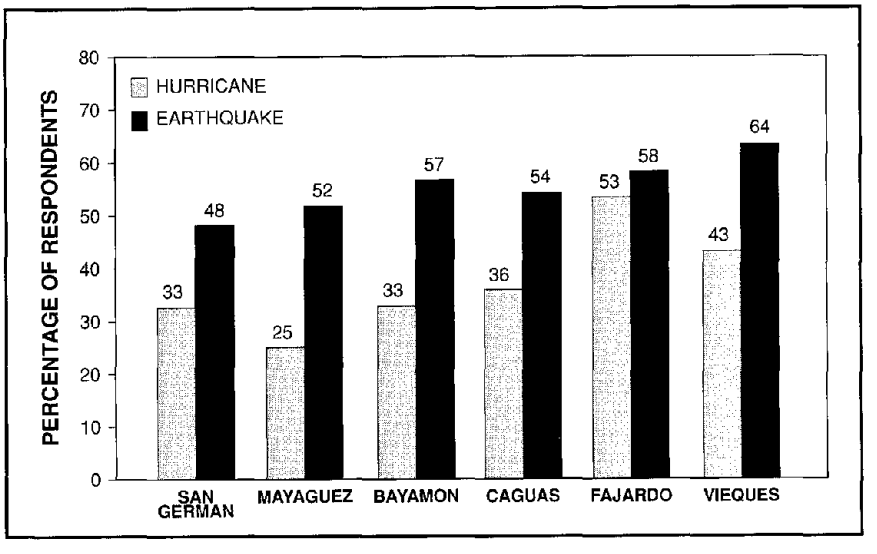


Figure 5.3 Percentage of homeowners who were very concerned or highly concerned that a future hazard (hurricane or earthquake) would cause damage to their home.

Paired Comparisons of Attitudes

Our next task was to assess general levels of perceived vulnerability in the Puerto Rican population. We questioned here whether homeowners who were only slightly concerned with earthquakes would have similar low levels of concern about hurricanes, and vice versa. We tested for a relationship using paired responses of the homeowners' answers to the question, "How concerned are you that each of the following disaster may cause serious damage to your home?" High frequencies in the diagonal of the resulting table created from paired responses would indicate that the concern for hurricane and earthquake hazards was the same at the individual level.

The gamma statistic was used to test for a significant ordinal relationship between such paired concern for future hurricanes and earthquakes (Table 5.1). Gamma was .519 and significant, indicating a strong ordinal relationship. What this means is that those who are little concerned with one hazard tend also to be unconcerned with the other, and vice versa. However, the comparatively large frequencies in the upper right portion of the table (as opposed to the lower left) depict the greater levels of overall perceived vulnerability to earthquakes as opposed to hurricanes. Thus, while individuals have a similar level of concern with both hurricanes and earthquakes, a number of individuals express more concern toward earthquakes.

Table 5.1
Paired Comparisons: Frequency of Concerns for Hurricanes and Earthquakes

		Concern for Earthquakes				
		Very Little	Somewhat	Concerned	Very	Highly
Concern for Hurricanes	Very little	20	6	1	1	9
	Somewhat	3	24	29	25	26
	Concerned	6	16	110	70	55
	Very	4	2	27	41	50
	Highly	2	3	13	12	79

Geographic Knowledge and Behavior

In his study of homeowners in the lower Florida Keys, Cross (1985) found that for those homeowners without a mortgage who had been informed about the hurricane hazard, over 79 percent had purchased flood insurance. Cross concluded that knowledge of their location with respect to flood hazards was related to their flood insurance coverage.

In Puerto Rico, as well as other municipalities participating in the National Flood Insurance Program, flood insurance is required of homeowners who live in a 100-year flood zone and who have a federally insured loan. Because flood insurance is an additional addendum, we expected that the awareness of location with respect to flood zones would be more accurate. We wanted to document whether homeowners were accurate with respect to their estimate of their location within a floodplain. Homeowners were asked if they lived within 100-year flood insurance zones. Using GIS methods, the actual location of the home with respect to the 100-year flood zone was determined. Their responses to the survey were crosstabulated with their actual location with respect to the flood zone.

Only 12 percent of the survey respondents were in a 100-year flood zone (Fig. 5.4). Of these, only 26 percent were aware that they were in a flood zone. Further, twelve percent of the respondents who actually located outside of a flood zone believed that they were living in a 100-year flood zone.

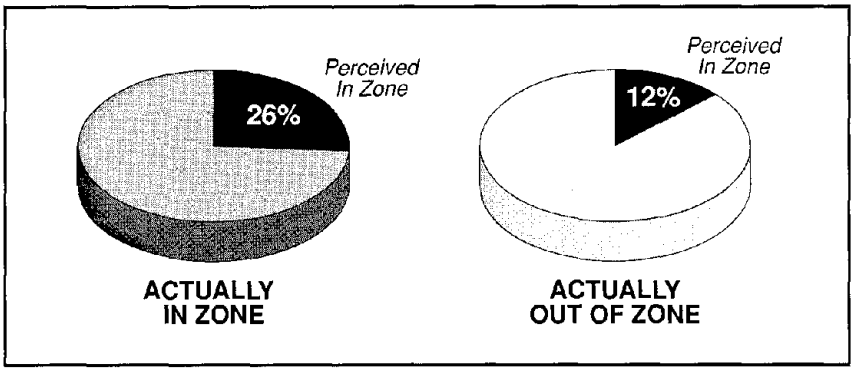


Figure 5.4 Accuracy of perceived home location with respect to the 100-year flood zone.

Not only were respondents unaware of their location, but the location played little or no role in predicting flood insurance coverage. Only 18 percent of the homeowners who believed they were living in a 100-year flood zone were insured, compared to 15 percent insured who believed they were outside a flood

zone (Figure 5.5). Surprisingly, of those who were in a 100-year flood zone and correctly knew that they were, none was insured! A chi-square test indicated no relationship between knowledge of home location with respect to flood zones and insurance subscription. In contrast with the work of Cross (1985), we concluded that neither perceived nor actual location within a flood zone was related to flood insurance purchase.

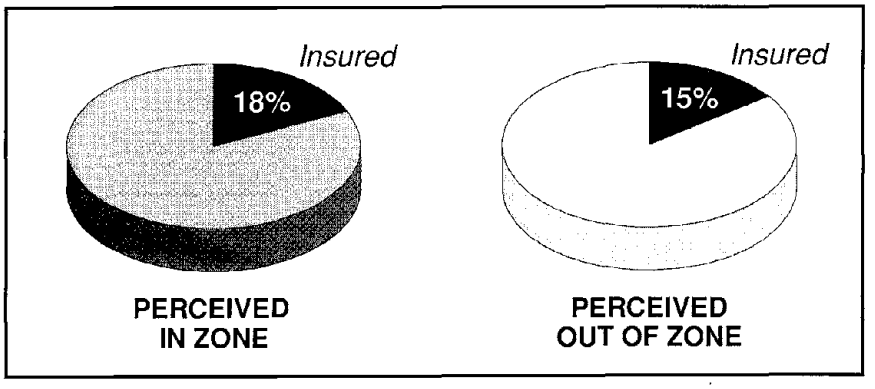


Figure 5.5 Percentage of the homeowners who purchase flood insurance stratified by perceived flood zone location.

We also examined the relationship between geographic knowledge of their home location with respect to a flood zone, insurance subscription and mortgage status. Since mortgage status has a significant effect on the windstorm or earthquake subscription of Puerto Ricans, we stratified the survey respondents based on mortgage status. Twenty-one percent of those homeowners with a mortgage and 3 percent of homeowners without a mortgage purchased flood insurance (Figure 5.6). For those homeowners who believed they were living in a flood zone and had a mortgage, only 28 percent were insured. Thus, while knowledge of flood zone location does not influence insurance purchase, the mortgage status of the homeowner influences the decision to purchase insurance.

Mental Maps of Hazardous Areas

This study also sought to document spatial variation in mental maps of perceived vulnerability to natural hazards in Puerto Rico. Such probing of mental maps would help answer questions as: Are the cognitive maps of risk similar for different experiences or geographic location? Do those homeowners in Mayaguez and San German perceive similar levels of risk for geographic

locations as the homeowners in Fajardo and Vieques? Based on historical occurrence, one might expect that Puerto Ricans would believe that the eastern end of the island is more susceptible to damage from hurricanes. Similarly, the absence of fault zones or recent earthquake history might lead one to expect that the cognitive map of earthquake hazards would not show geographic concentrations of risk. Further, we wished to ascertain whether home location affected the perceived safety or vulnerability of areas.

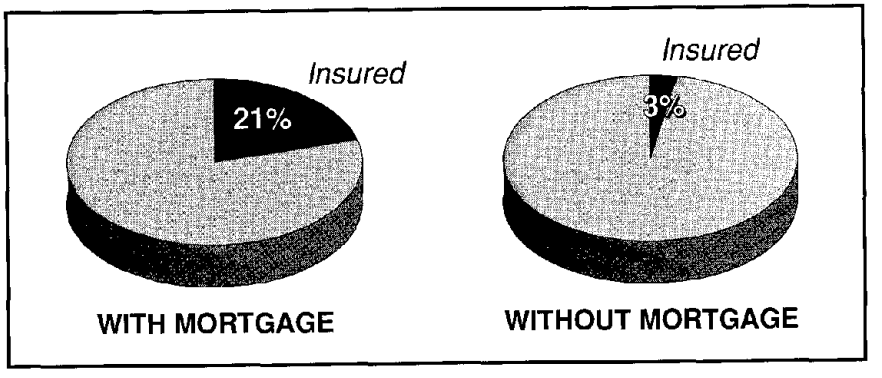


Figure 5.6 Percentage of the homeowners who purchase flood insurance stratified by mortgage status.

Previous empirical work in geography suggests two mutually exclusive sets of relationships between location and perceived vulnerability. The first is based on distance-decay of interaction, knowledge, and emotional involvement: individual's emotional involvement with places decreases logarithmically with increasing distance from their home (Dornic, 1967; Gould and White, 1986). This empirical regularity would predict that individuals are more attached to their home areas than to more distant areas and therefore exaggerate both the benefits and the hazards of home. Homeowners may exaggerate the vulnerability of their community and their own homes to natural hazards. We would thus expect the perceived vulnerability surface to reflect a combination of (1) actual, historical evidence of disasters in particular areas plus (2) a tendency to claim that their own community is more vulnerable because of their knowledge about home.

The second type of finding is that people tend to show a preference for their home area: they emphasize the benefits and minimize the faults of the home area. If this generalization is true, then homeowners would tend to suggest places other than their own as more susceptible to natural hazards. Responses

would be a combination of (1) actual, historical evidence and (2) a minimization of hazards in the home area.[1]

Methods

The beliefs of each homeowner about the most hazardous areas in Puerto Rico were measured by the question: "In your opinion, what town or city in Puerto Rico is most vulnerable to damage caused by earthquakes?" Similar questions were used for hurricanes, floods, and landslides. Each respondent was allowed to indicate more than one selection. Responses for specific communities were aggregated into the municipio in which the community was located. Cognitive maps of risk were created by depicting the frequency a municipio was referenced using graduated symbols.

Mental Maps of Earthquake Risk

The cognitive map of earthquake risk for all respondents is depicted in Figure 5.7a. The communities most frequently mentioned were the San Juan metropolitan area and Mayaguez, with lower frequencies in Aguadilla, San German, Ponce, and Fajardo. Earthquake risk maps for the respondents of separate regions — western (Mayaguez and San German), central (Bayamon and Caguas), and eastern (Fajardo and Vieques) — indicate obvious differences among these respondent groups (Figures 5.7b and d). The respondents from Mayaguez and San German most often mentioned their region and did not mention earthquake risk on the eastern side of the island. Conversely, the respondents from the eastern side of Puerto Rico often mentioned their own local region and to a lesser extent communities in the west. Both eastern and western groups frequently mentioned the San Juan metropolitan communities. The response map from Bayamon and Caguas was more similar to the aggregate earthquake risk map than the other two groups; however, the islands of Culebra and Vieques were not mentioned at all (Figure 5.7c).

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[1] Yi-Fu Tuan (personal communication, 1992), who has studied attachment to home as well as landscapes of fear, notes the ironies and ambiguities surrounding the relationship of home and safety: "Generally speaking, home to most people is haven; outside is danger . . . . On the other hand, the ultimate secure place (Eden or paradise) is never home but some place far away; and one of the secure things about Eden is that it has no weather — no natural hazard. In other words, home may be haven, but it is also the place where nearly all the disasters of life — human and natural — occur. . . . Home *seems* safe rather than *is* safe — a common theme of horror movies, based on unconfessed experience. It may be that in less affluent societies, this mechanism [of repressing the negatives about home] works less well: certainly inner-city people are only too aware of the violence at home and in the neighborhood; and it may be that they also feel more vulnerable to natural hazards--or quasi-natural hazards, such as fire.

Mental Maps of Hurricane Risk

The aggregate cognitive hurricane risk map depicts a very clustered pattern of communities on the eastern side of the island, the islands of Culebra and Vieques, and to a lesser extent the coastal region of the San Juan metropolitan area, Ponce, and Mayaguez (Figure 5.8a). As with the earthquake risk map, the responses from Bayamon and Caguas produced a risk map very similar to the aggregate map (Figure 5.8c). The "eastern" responses identify almost solely the municipios of Vieques, Culebra, Fajardo, Humacao, and other municipios damaged in Hurricane Hugo (Figure 5.8d). Virtually none of the other municipios (with the exception of a small number of responses for San Juan and Ponce) was identified as susceptible to hurricanes. The "western" responses also identify the susceptibility of Culebra, Vieques, Fajardo and Humacao, but almost equally identify Ponce and Mayaguez as well as, to a lesser extent, Cabo Rojo (Figure 5.8 b).

Mental Maps of Flood Risk

The flood risk map depicts a pattern similar to that of the hurricane risk map, with concentrations along the coastal areas, particularly the northern coast (Figure 5.9a). Comparing the "western" and "eastern" responses, we see that individuals tend to expect that their home area is most susceptible to the hazard, with a secondary concern for the metropolitan area (Figure 5.9b and d). The presence of the metropolitan area here probably reflects a combination of actual susceptibility (particularly in the frequently flooded areas around Carolina and Loíza) combined with an emphasis on local flooding by the television/newspaper coverage. Since the two major newspapers are published in San Juan, and local television broadcasting is based there, news concerning the major city is emphasized throughout the island, tending to exaggerate events that happen there while underreporting events elsewhere. The responses of the Bayamon and Caguas residents reflect both local emphasis on hazards and knowledge of the areas particularly damaged by Hugo (Figure 5.9 c). This result is particularly ironic since damage from Hugo was from high winds, not flooding.

Mental Maps of Landslide Risk

The analysis of areas susceptible to landslides again shows a combination of the identification of areas that recently experienced major events with an emphasis on the home area (Figure 5.10). However, San Juan does not tend to be named as an area prone to landslide hazard. The responses from Bayamon and Caguas tend to localize around Ponce — the site of the Mameyes landslide — the Caguas region itself, and other inland areas. The "western" responses emphasize Mameyes, with a secondary emphasis on San German region (Maricao and Las Marias as well as San German). These responses virtually ignore the possibility of landslides in Vieques or the northeastern municipios. The "eastern" responses, in contrast, focus on Mameyes but also emphasis eastern and central municipios including Vieques. Virtually no identification is

made of Maricao, Las Marias, San German or other western municipios as susceptible to landslides.

Risk Map Summary

This analysis of cognitive risk clearly demonstrates that two factors overwhelmingly influence the general perception of hazardous areas: (1) the location of recent disasters and (2) home location of the respondent. Recent disasters, particularly those resulting in deaths or those highly publicized, tend to become associated for a period of time with a particular region. Although little objective reason may support the belief that hurricanes pass to the northeast of the island (indeed, some historical hurricanes have wreaked damage across western municipios), respondents' memory of Hurricane Hugo had a major effect on their assessments in 1991.

The second factor affecting response is the myopic focus on the home municipio. Regardless of the hazard or the objective risk surface, people tend to focus on the hazards affecting their home territory. This readiness to believe the existence of natural hazards in the local municipio is an important finding — one with significant policy implications. It demonstrates that Puerto Rican respondents have a feeling of vulnerability that could be converted into action by homeowners to increase their security from natural disasters by adopting simple mitigation measures. We will return to this idea in the final chapter.

Conclusions

Puerto Ricans are indeed concerned about the vulnerability of their homes and belongings to future hurricanes and earthquakes. A large percentage have protected their homes by purchasing windstorm and earthquake insurance. However, they have taken relatively few noninsurance mitigation measures to safeguard their homes or property against either hazard. Even more disturbing is that homeowners without a mortgage, who are free to buy or avoid insurance, tend not to purchase hazard insurance.

The concern for damaging earthquakes is considerably greater than concern for hurricanes. Yet only a very small percentage of homeowners have chosen non-insurance mitigation activities, probably because of the expense.

The geographic distribution of concern for hurricanes suggests that experience with Hugo may have heightened awareness for the homeowners on the eastern portion of the island. As expected, there was little variation in concern for earthquakes by municipio.

The current knowledge of home locations with respect to flood hazard zones in Puerto Rico was very low. Apparently, little effort has been made to educate homeowners in flood zones about such risks, and those efforts undertaken have been largely unsuccessful. Unlike previous studies where knowledge of the home location with respect to flooding hazards was a predictor of insurance purchase, we found no such relationship in Puerto Rico.

The purchase of flood insurance was found to be related to mortgage status, suggesting that only mandatory measures were effective in inducing insurance purchase. The mandatory flood insurance requirement for homes located in 100-year flood zones, however, does not appear to be adequately enforced. Since the entire island is considered a participant in the FEMA sponsored program, all homes in the 100-year flood zones should be insured. The next chapter quantitatively evaluates the relationship between these attitudes toward natural hazards and subsequent mitigation behavior.

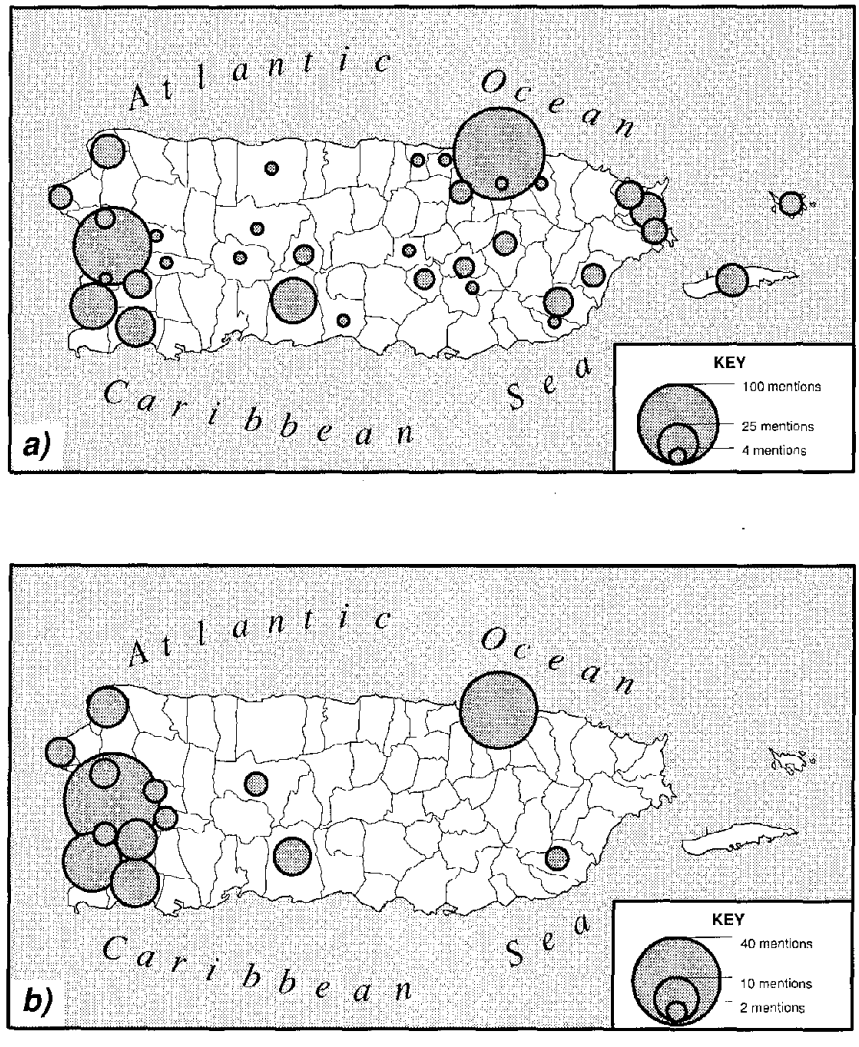
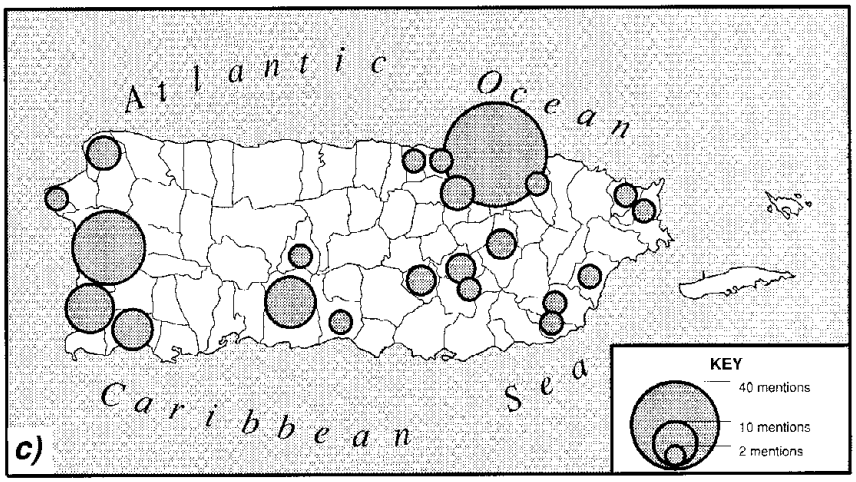


Figure 5.7 Cognitive maps of earthquake risk derived from community mentions of homeowners in the survey. The map in (a) depicts the aggregate concern of all respondents while risk maps for individual respondent groups are depicted for Mayaguez and San German in (b), Bayamon and Caguas in (c), and Fajardo and Vieques in (d).



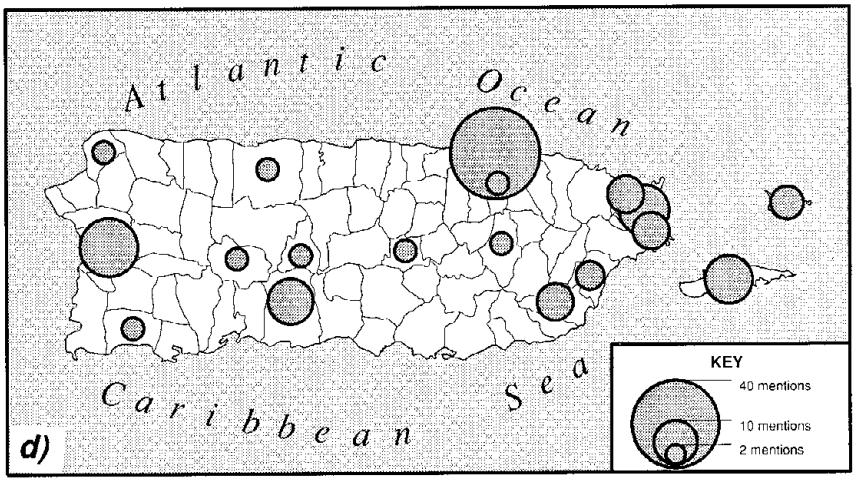


Figure 5.7 (cont.)

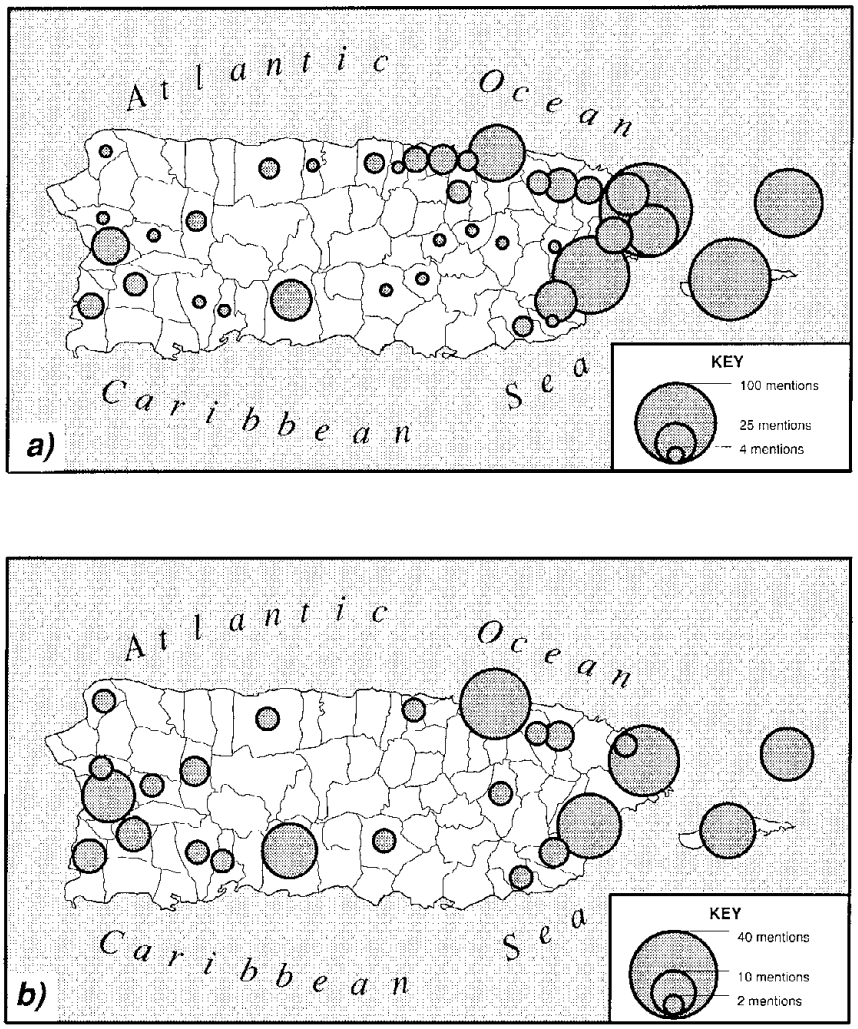


Figure 5.8 Cognitive maps of hurricane risk derived from community mentions of homeowners in the survey. The map in (a) depicts the aggregate concern of all respondents while risk maps for individual respondent groups are depicted for Mayaguez and San German in (b), Bayamon and Caguas in (c), and Fajardo and Vieques in (d).

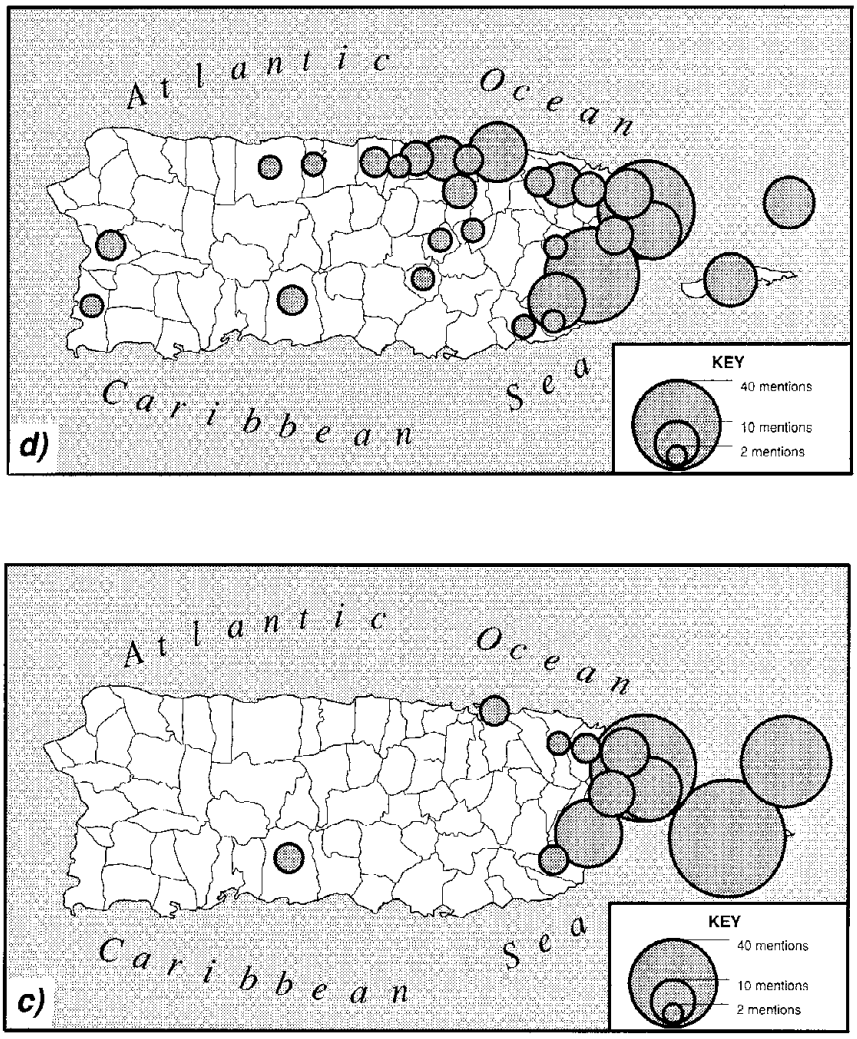


Figure 5.8 (cont.)

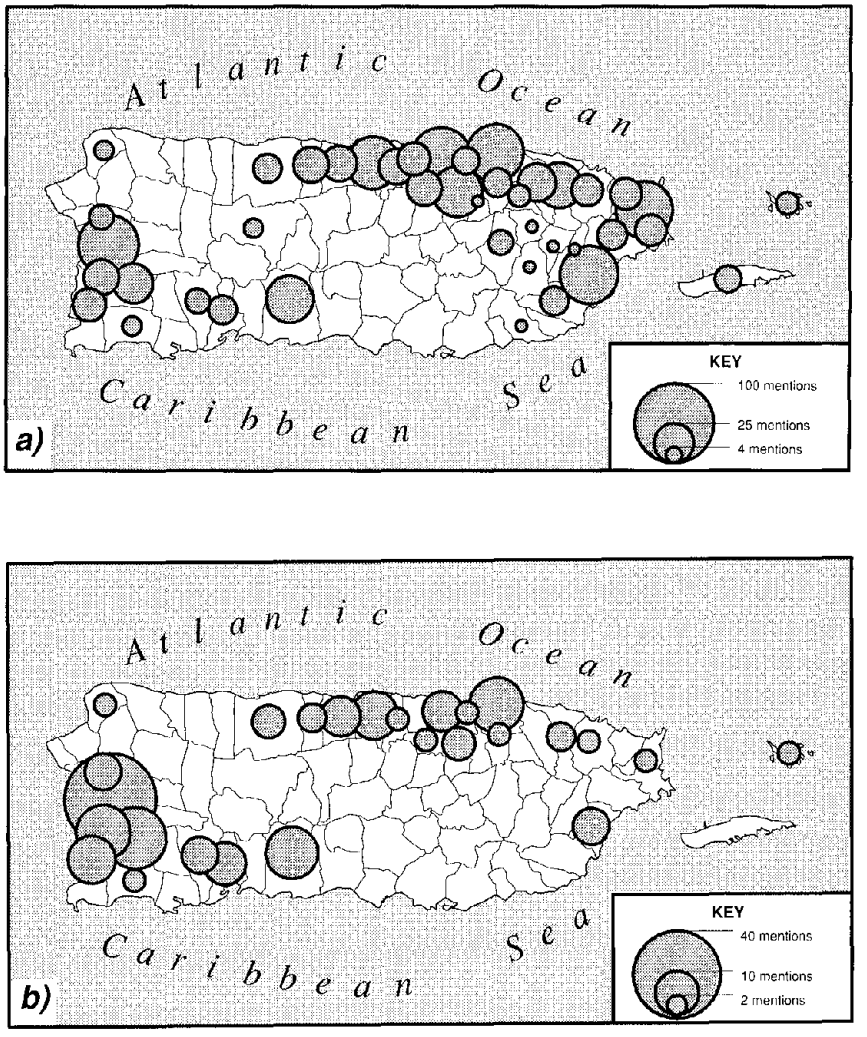


Figure 5.9 Cognitive maps of flood risk derived from community mentions of homeowners in the survey. The map in (a) depicts the aggregate concern of all respondents while risk maps for individual respondent groups are depicted for Mayaguez and San German in (b), Bayamon and Caguas in (c), and Fajardo and Vieques in (d).

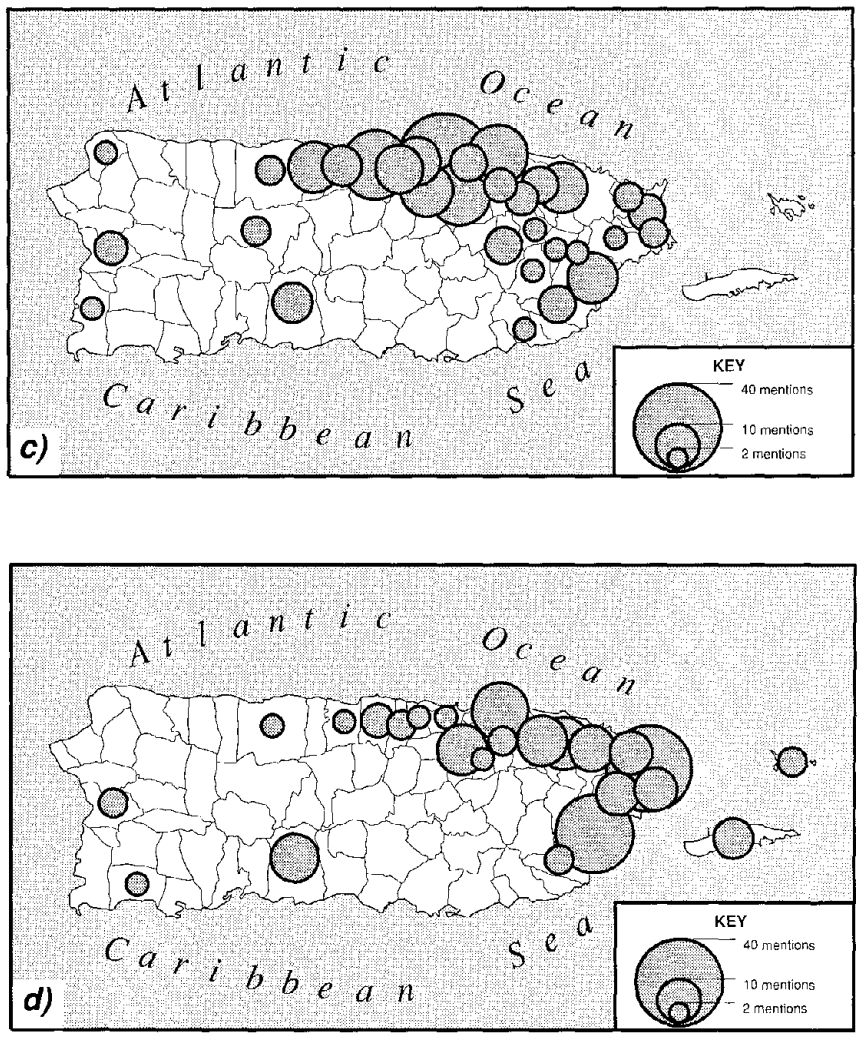


Figure 5.9 (cont.)

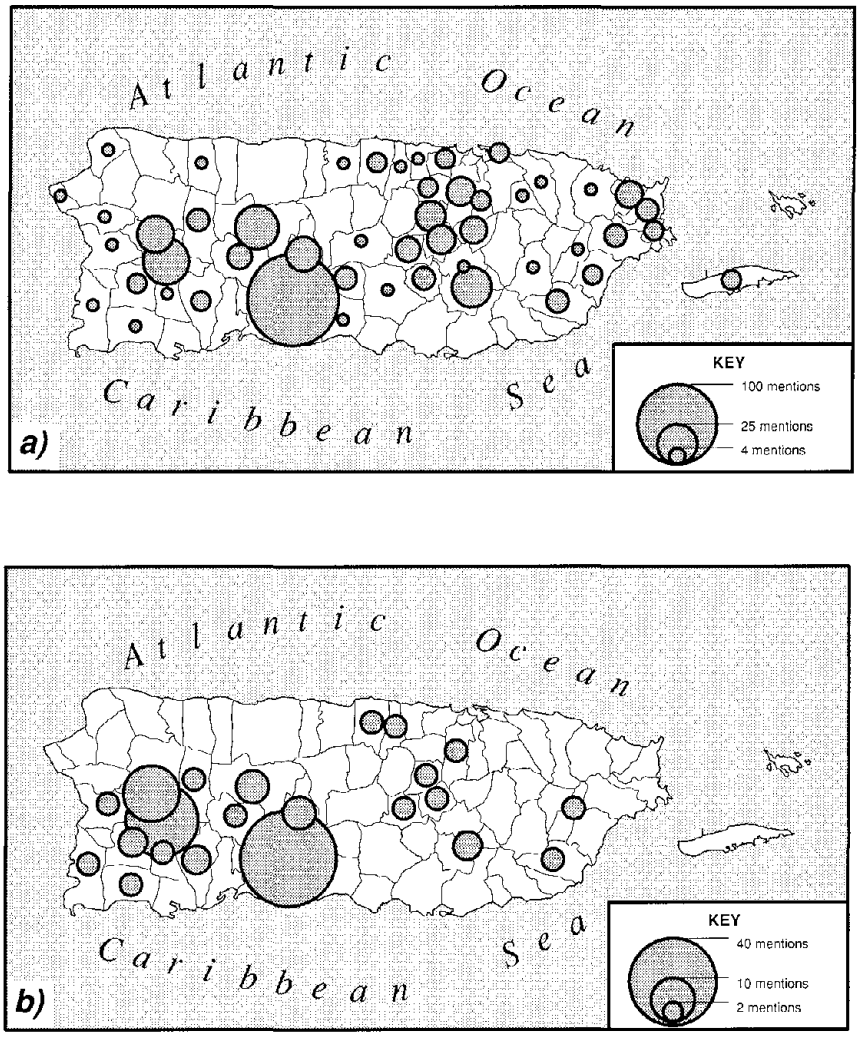


Figure 5.10 Cognitive maps of landslide risk derived from community mentions of homeowners in the survey. The map in (a) depicts the aggregate concern of all respondents while risk maps for individual respondent groups are depicted for Mayaguez and San German in (b), Bayamon and Caguas in (c), and Fajardo and Vieques in (d).

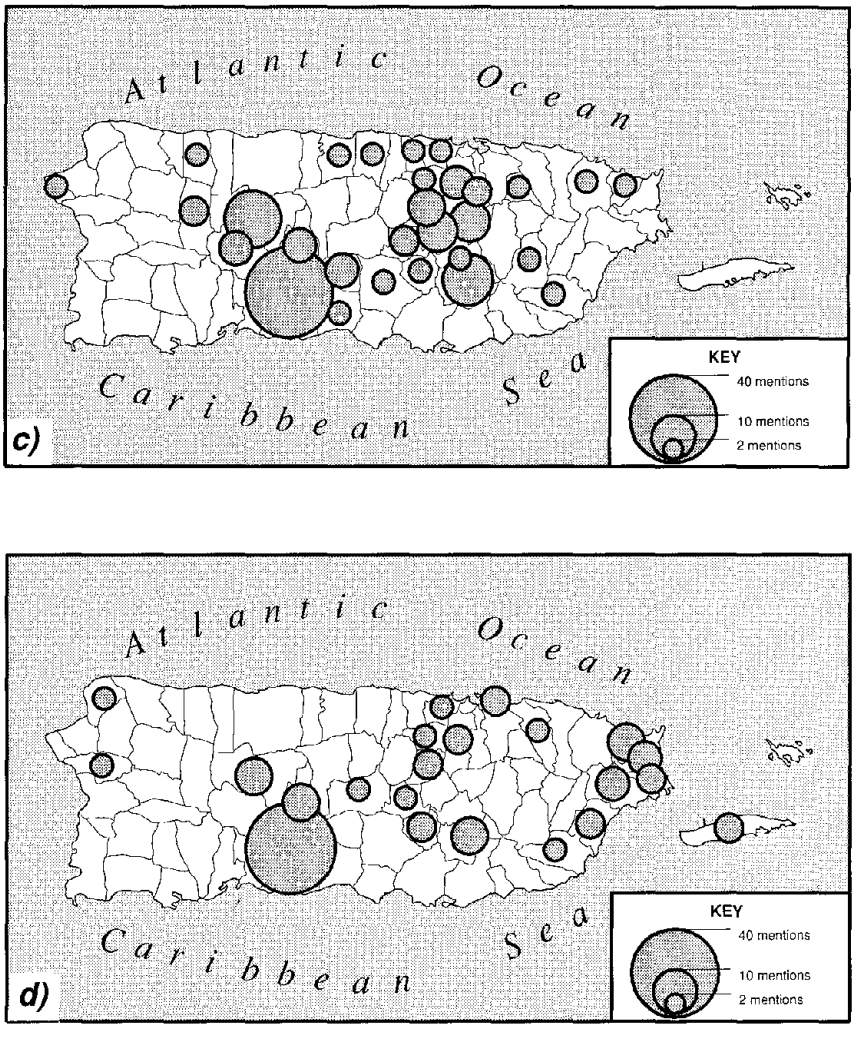


Figure 5.10 (cont.)

6

Voluntary Adoption of Earthquake Insurance in Puerto Rico

In this chapter, we will focus on earthquake rather than windstorm insurance subscription in Puerto Rico. We chose this focus because the two types of insurance are treated differently by the insurance industry. Windstorm or hurricane insurance is included in extended coverage, and is thus part of the ordinary homeowner's insurance policy. Virtually all home mortgage lenders, whether in the United States or in Puerto Rico, require this extended coverage. Therefore, if homeowners have a mortgage on their property, they are required to have fire and windstorm insurance. Furthermore, most homes — even those owned free and clear — are covered by fire insurance policies that include windstorm coverage as part of the extended coverage. Although homeowners may not be aware that they have purchased windstorm insurance, they probably have this type of coverage as part of their home insurance.

The situation is very different for earthquake insurance. Voluntary earthquake insurance purchase is limited in Puerto Rico to two populations. The first population is that set of homeowners who do not presently have a mortgage loan on their house. As we have already noted, lenders in Puerto Rico require earthquake insurance as a condition of granting a mortgage loan. Therefore, those homeowners whose properties are secured with mortgage financing do not have a choice with respect to earthquake insurance coverage. However, households that do not have mortgage financing have the option to choose earthquake insurance or remain uninsured. Since only these households make a choice to purchase insurance, we focused on this group to examine risk taking and risk aversion in Puerto Rico.

A second population involved in voluntary insurance purchase is those people for whom basic but not necessarily full insurance is required. All homeowners make an annual decision to update coverage; as a result the homeowner may voluntarily choose to increase coverage or to allow it to fall below the actual property value, creating a co-insurance gap. This chapter will explore the insurance decisions in both cases: the decision to purchase insurance

by those for whom insurance is not mandatory and the decision to carry full insurance coverage by those for whom only a small policy is mandatory.

The Insurance Purchase Decision Among Nonmortgagees

The first section of this chapter focuses on those Puerto Rican respondents who chose earthquake insurance coverage although they were not required to do so. In Puerto Rico, this population is restricted to those with no mortgage debt on their home. We compare this population to the Californians with no mortgage debt on their homes. It is important to note that in Puerto Rico, only 194 respondents had no mortgage on their home; even more significant, only 13 of these non-mortgagees had voluntarily purchased earthquake insurance. Thus the statistical analysis on the insured and uninsured should be interpreted with great care.

Mortgagees and Other Homeowners

Whether in Puerto Rico, California, or elsewhere, homeowners who do not have a mortgage on their home can be expected to differ from the general population in several respects. Those who own their homes free and clear either purchased their home for cash or paid off a mortgage loan. The latter tend to be older and to have lived in their homes for a longer period of time. They also are likely not to have "traded up" for a more expensive home, and therefore their home values tend to be lower, and their homes older. They probably have not experienced dramatic income or social class mobility during their lives; otherwise, they might have moved to a larger, newer, and more expensive house to reflect their new status. They are also likely to have relatively lower incomes and to have completed fewer levels of school than the rest of the owner-occupiers.

In Puerto Rico, 66 percent of the survey respondents had a mortgage on their home. This percentage compares with the 80 percent of California respondents who had mortgage financing on their home. Our first analysis established the general differences between the population with a mortgage and that without a mortgage in Puerto Rico. We found that households with a mortgage differed significantly from those with no mortgage in each of the economic and demographic variables studied (Table 6.1). Those homeowners who owned their house clear of a mortgage tended to be older and, less educated, earn lower incomes, live in older homes of lower resale value, and have occupied their homes longer than those with mortgages.

When we compared the populations with and without a mortgage in California, we found differences in demographic characteristics, except for home value: although those with a mortgage tended to own homes with higher value, the variability was too large for this difference to be statistically significant (Table 6.2). As in Puerto Rico, California households with no mortgage

financing tended to be older, have lower levels of education and income, have lived longer in the house, and live in older housing.

In summary, the Puerto Rico sample with no mortgage loan on their home differed in demographic characteristics from the sample with a mortgage loan. Given these differences, we looked at the impacts of various economic, demographic and risk awareness variables on the insurance purchase decision.

Table 6.1
Mean Values and t-Tests on Discriminating Between Mortgage Status: Puerto Rico

Variable	With a Mortgage	Without a Mortgage
age of respondent**	49.5	59.9
education**	8.3	4.9
income**	$22,493	$13,077
age of house**	17.5	21.0
# of years in house**	13.9	21.4
value of home**	$71,784	$62,902

* significant at .05
**difference significant at .01

Table 6.2
Mean Values and t-Tests on Discriminating Between Mortgage Status: California

Variable	With a Mortgage	Without a Mortgage
age of respondent**	47.3	67.3
education**	15.2	13.9
income**	$67,534	$46,925
age of house**	23.7	33.6
# of years in house**	10.8	21.6
value of home	$271,414	$250,246

* significant at .05
**difference significant at .01

Individual Variable Analysis: Demographic and Economic Variables

Background. Consistent patterns of economic and demographic correlates of earthquake insurance purchase may have policy implications. For example, if homeowners with low incomes or who are retired or unemployed purchase insurance in disproportionately low numbers, then this population is particularly susceptible to economic disruption when an earthquake destroys their homes.

Previous empirical research led us to inquire about individual variable relationships. For example, older homeowners may be more likely to purchase insurance than younger households. This argument is based on two principles. The first is the assumption of risk aversion (Arrow, 1970) by the elderly: retired heads of households with relatively high net equity tend to purchase earthquake insurance to protect the major repository of household wealth. The second part of the argument entails the adoption of adjustments to hazards among the elderly. For example, Myra Schiff (1977) concluded that there is a "high correlation between age and the tendency to adopt adjustments," which "suggests that the adoption of adjustments becomes habitual and is cumulative." Individuals learn about their environments as they live in an area over time, and once made, an adjustment — such as the purchase of insurance — becomes part of the individuals repertoire. The argument assumes that people learn from environmental cues and make proper adjustments over time.

Empirical studies also suggest that a wide range of demographic factors are correlated with hazard mitigation or insurance purchase. Previous research has noted the impact of such variables as ethnicity (Turner et al., 1979; Hodge et al., 1979), presence of dependent children in the household, and a general battery of other characteristics (see Drabek, 1986 for a review), (Tables 6.3 and 6.4). For this study, the demographic variables studied were length of time at present address, age of house, years of school completed, and estimated selling price of the home.

Univariate Analysis. In Puerto Rico, demographic variables did not tend to differentiate the insured from the uninsured among those without a mortgage, but socioeconomic variables did (Table 6.3). Although the insured tended to be slightly older and to live in somewhat older houses, these differences were not statistically significant.[1] The insured and the uninsured did differ with respect to socioeconomic variables, however. Those with more years of school completed

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[1] Again, the number of households that had no mortgage but purchased insurance was very small in Puerto Rico. In California, of the households with no mortgage, 91 had insurance and 175 did not. In Puerto Rico, of households with no mortgage, only 13 had insurance, and 181 did not. Because of this very small cell number of no mortgage-uninsured in Puerto Rico, all statistical comparisons presented in this chapter should be interpreted cautiously.

tended to purchase insurance more than those with fewer years of school completed, and insured households tended to live in more expensive homes than the uninsured.

These findings markedly contrasted with the differentiation between the insured and the uninsured among those with no mortgage in California. Here, age of head of household, number of years in the home, age of the house, and years of school completed distinguished the insured from the uninsured (Table 6.4). The insured population tended to be younger (contrary to the expectations of theory), to have lived in the home a shorter period of time, to be living in a newer house and to have completed more years of school. Estimated home value for the insured was somewhat higher, but this difference was not statistically significant.

Table 6.3
Means and Levels of Significance of t-Tests for Insurance Purchase for Puerto Ricans with No Mortgage

Variables	Insured	Uninsured
Age of head of household	62.2	59.4
How long lived in home	21.8	21.0
Age of house	24.8	20.6
Years of education*	8.0	5.7
Estimated home value**	$100,653	$60,116

* significant at the .05 level
** significant at the .01 level

Table 6.4
Means and Levels of Significance of t-Tests for Insurance Purchase for Californians with No Mortgage

Variables	Insured	Uninsured
Age of head of household**	64.3	68.9
How long lived in home**	24.8	29.1
Age of house*	30.8	34.9
Years of education**	14.7	13.5
Estimated home value	$253,537	$246,719

* significant at the .05 level
** significant at the .01 level

Multivariate Analyses

For Puerto Rico, the individual variable analyses suggested little association between demographic variables (age of respondent, age of house, how long lived in house) and the adoption of insurance. In contrast, virtually all socioeconomic and demographic variables were associated with insurance purchase for the 1990 California respondents without a mortgage.

To clarify the nature of these relationships between predictor variables and insurance status, and to compare predictor variables between Puerto Rico and California, a more comprehensive analysis was needed to test for differences simultaneously on groups of predictors. To test for relationships with multiple independent variables with a dichotomous dependent variable (i.e., insurance subscriptions), we used both discriminant analysis and logit analysis. Discriminant functions provide a general description of that linear function that separates those who purchased from those who did not purchase insurance, assuming multivariate normality. The logistic regression provides a better analysis of the parameters that predict membership in each of these categories if one or more of the variables is qualitative, since it demands fewer assumptions of normal distributions and equivalence of the covariance matrices (Press and Wilson, 1978).

Discriminant Analysis.

In discriminant analysis, linear combinations of the independent (or predictor) variables are formed and serve as the basis for classifying cases into each group. Thus, information contained in multiple independent variables serves as the basis for assigning cases to groups. Although the use of discriminant analysis assumes the use of multivariate normal independent variables, it has been noted that "in the case of dichotomous variables, most evidence suggests that the linear discriminant function often performs reasonably well" (Norusis/SPSS, 1989, p. 35; citing Gilbert, 1968).

The two major statistics for the individual variables are the standard canonical discriminant score and the Wilk's Lambda. The canonical discriminant score simply indicates the "importance" of the individual variable to the overall discriminant function. The greater the magnitude of the score the more important the variable is to the overall function. The other statistic is the Wilk's Lambda or U-Statistic. For individual variables, lambda is the ratio of the within-group sum-of-squares to the total sum-of-squares. A lambda of 1.0 occurs when within-group variability is small compared to the overall variability. Thus, large values of lambda indicate weak predictor variables (the means of the groups do not appear to be different).

Another set of statistics is associated with the overall discriminant function. The eigenvalue is the ratio of the between-groups to within-groups sums-of-squares. Since "good" discriminant functions have large between-group variance and little within-group variance, large eigenvalues denote good functions and small eigenvalues denote poor functions.

Finally, the percentage correctly classified is a general description of the fit of the discriminant function. One assumes that a random set of variables functions no better than chance and correctly classifies 1 out of 2 (50 percent) of the cases correctly. A function that classifies more than 50 percent correctly intuitively has greater power and one that correctly classifies 100 percent of the observations is a very good discriminator.

Logistic Analysis

We also analyzed the relationships, testing for goodness of fit, using logistical regression or logit analysis. This statistical method is used in empirical situations such as ours where the dependent variable represents a discrete choice-buying or not buying insurance. The model assumes the existence of a threshold beyond which the individual switches from one alternative to another. The threshold involves some level of one or more of the independent variables (e.g., income, home value, education, level of perceived vulnerability) which causes a shift in behavior (Kmenta, 1986).

Logistic regression permits a relaxation of some of the requirements of discriminant analysis. When the dependent variable can have only two values, as in insurance status, its functional form is not linear but more closely approximates the logistic curve (Wrigley, 1985; Kmenta, 1986). In logistic regression, the probability of an event occurring (the purchase of insurance) is estimated from a series of independent variables (age, income, etc.) with maximum likelihood estimates. The calculation provides regression coefficients that describe the amount of change in the dependent variable for a change of one unit in the independent variable (Norusis/SPSS, 1989). For our analysis, the relative strength of the regression coefficients is supplemented for an assessment of the goodness of fit of the model, and a comparison of this goodness of fit between Puerto Rico and California. Goodness of fit is described in a classification table that indicates the percentage of predicted cases correctly classified, as well as statistics (chi-square) indicating the improvement of the model as opposed to the use of a constant.

Demographic/Socioeconomic Characteristics and Insurance Adoption

A discriminant function using information on age, income and residential history was calculated to test the discriminatory powers of this set of variables on data collected in the California and Puerto Rico surveys (Table 6.5). Although the discriminant functions for both areas were statistically significant (Wilk's Lambda significant for both at the .01 level), the Puerto Rico function provided better explanation. The Puerto Rico function correctly classified 72.9 percent of the cases while the California function correctly classified only 64.5 percent. In Puerto Rico, the variables significantly related to the discriminating function were years of school completed, home value and family income — all reflections of economic status. In California, the discriminant function was

composed primarily of demographic variables: age of head of household, length of tenure in the house, age of the house itself, and years of school completed. These differences in the strength of the discriminating function in distinguishing the insured from the uninsured and in the nature of the variables related to the discriminating function were borne out by other tests of the factors distinguishing the insured from the uninsured.

Table 6.5
Discriminant Analysis Between Socioeconomic/Demographic Variables and Insurance Purchase: Homeowners with No Mortgage
(Variables identified in forced entry procedure)

Structure Matrix	Puerto Rico	California
Age of head of household	.16	.78**
How long lived in house	.07	.62**
Age of house	-.26	-.55**
Years of education	.52*	-.57**
Home value	.76**	-.11
Family income	.75**	-.50*
Percent correctly classified	72.9	64.5
Eigenvalue	.13	.09
Canonical Correlation	.33	.29
Wilk's Lambda	.89**	.92**

* significant at the .05 level
** significant at the .01 level

Linear combinations of demographic and economic characteristics proved to be good discriminators of insurance purchase for Puerto Rican households without a mortgage — those who were free to choose to buy or not to buy earthquake insurance. Although the socioeconomic and demographic function also was statistically significant in discriminating the insured from the uninsured for Californians with no mortgage, the function was not as effective in correctly classifying individual cases. But again, caution is urged in interpreting the relationships in the data for Puerto Rico because of the relatively small number of Puerto Rican respondents with no mortgage who voluntarily purchased earthquake insurance.

Environmental Risk and Insurance Adoption

If homeowners are rational in their decision to purchase earthquake insurance, they may include some assessment of the actual risk of their house being damaged by an earthquake. To determine risk, they need information on the probability of damage to their site from a given earthquake, as well as on the response of the house of a given construction type to ground motion. Those living in areas of greater risk might be expected to be more likely to purchase insurance.

But do households actually have the information they need to assess risk? At the metropolitan scale, does adverse selection describe the insurance purchase patterns of homeowners? The answer to these questions in Puerto Rico is clearly "no." Unlike California, Puerto Rico is not underlain with a series of fault rupture zones, and microzonation maps have not been created for the entire island. The earthquake hazard is generally undifferentiated by location on the island except for recognition of the obvious vulnerability of certain areas to shaking or liquefaction because of ground conditions or to tsunamis because of low elevation near coast. Hurricane vulnerability is also not zoned. Here, certain areas are more susceptible to damage by flooding because of their coastal location or location proximate to a river or to a poorly drained area. As for wind damage vulnerability, there is a popular belief that El Junque, a mountain in northeastern Puerto Rico, protects residents to the west; this belief is not borne out by meteorological analysis or previous damage patterns.

Thus, in Puerto Rico, publicly available information does not provide facts to households on earthquake or windstorm risk. Although Puerto Rico participates in the federal floodplain program, little or no information about risk associated with tsunamis, wind damage, liquefaction or ground shaking is provided to prospective homeowners. Puerto Ricans are thus even less likely to be aware of the hazards associated with particular home sites than are Californians, to whom site-specific risk including proximity to a surface fault rupture and liquefaction or shaking potential are routinely disclosed in the purchase process. In Puerto Rico, objective risk is not spatially concentrated, and its distribution is unlikely to be disclosed to local residents. The distribution of objective risk is thus less likely to be a significant predictor of behavior than the distribution of perceived risk.

Perceived Risk and Insurance Adoption

Measurement of Perceived Risk. To assess the importance of perceived risk, we asked homeowners in both Puerto Rico and California a series of questions to elicit their beliefs on the likelihood of a future earthquake affecting their homes and also the probable dollar damage associated with such an earthquake. The questions used in Puerto Rico were a variant on those previously used in

California, which were designed to follow up on questions posed by Kunreuther et al. (1978) in 1973-74. In the California studies, we were able to stay very close to the wording used by the Kunreuther study. However, for the Puerto Rico survey, our advisory committee advised us to modify the probability questions to create closed-ended response choices. We also pre-tested the extent to which these questions were clear and straightforward to our respondents in a small mail pretest survey. The questions for the risk perception test are given in Appendix 1.

Relationship of Perceived Risk to Economic/Demographic Characteristics. Before reviewing the direct relationships between risk perception and insurance adoption, it is useful to assess any relationships between perceived risk and demographic characteristics. For example if wealthier people are more likely to perceive themselves at risk, then any relationship between income and insurance adoption must be re-analyzed to detect the intermediate effects of risk perception.

To test the relationship between demographic characteristics (age of the head of household) and socioeconomic characteristics (family income and years of school completed) and perceived risk, we calculated a series of correlations. Where the variables were not continuous we performed a chi-square test. (Table 6.6).

In Puerto Rico, age of head of household was strongly and consistently related to perceived risk. Younger households were more likely to estimate higher probabilities of damaging earthquakes affecting the community and higher dollar damage to their own homes from a major earthquake. Years of school completed and income level were not related to perceived vulnerability in Puerto Rico, except for a relationship between estimated dollar damage (not standardized for home value) and age. In California, none of the demographic and economic variables was related to risk perception except for a relatively weak relationship between income level associated with estimated dollar damage from a major earthquake.

Although age does not affect risk perception in California, in Puerto Rico the younger population consistently showed a higher perceived risk. Educational attainment and income did not have a major effect on risk perception in either area.

Relationship of Perceived Risk to Insurance Purchase? In theory, perceived risk should be closely associated with the adoption of a mitigation measure such as the voluntary purchase of earthquake insurance. Elsewhere (Palm, 1990), we have argued that for individuals to respond to a hazard, two conditions must hold: (1) they must be aware of the existence of the hazard and (2) the hazard must be salient to them — they must translate this awareness into a belief that their own lives and property are susceptible to danger. Since the perception questions test the presence and strength of these two conditions, they should be good predictors of insurance purchase behavior.

But the relationship between awareness, salience and behavior may be clouded by other biases. One such bias is termed "the optimistic bias." Studies of individual response to technological hazards have documented the tendency to overestimate the harm of some problems (such as nuclear accidents or toxic wastes) and underestimate other hazards (such as automobile accidents or asthma) (Slovic, 1986; Johnson and Covello, 1987). Weinstein (1989b) suggests that individuals are more optimistic than they should be when they have little personal experience of the hazard, or when the hazard is low in probability, or when they feel they cannot personally control the hazard.

Table 6.6
Relationships Between Perception vs. Demographic and Economic Variables for Those Without a Mortgage
(Spearman rank correlations or chi-square significance)

	Puerto Rico	California
Estimated probability of a damaging earthquake affecting community		
Age of head of household	-.18**	-.04
Years of education	-.10	.06
Income level[1]	.07	.48
Estimated dollar damage from a major earthquake		
Age of head of household	-.18**	-.05
Years of education	.15**	-.03
Income level[1]	.99	.04*
Estimated dollar damage from a major earthquake (as a percentage of home value)		
Age of head of household	-.23**	-.04
Years of education	.04	-.19**
Income level[1]	.51	.27

* significant at the .05 level
** significant at the .01 level
[1]chi-square significance level

The optimistic bias is defined as undue optimism about safety from a given hazard. This bias may arise when individuals believe that they are less likely than the average person to suffer harm. It may also arise when ambiguous risk factors are misinterpreted. But since the converse of the optimistic bias — the pessimistic bias — almost never appears, Weinstein suggests that the optimistic bias is "actively constructed, rather than arising from simple mental errors" (1989b, p. 1232) to create self-serving predictions about future events.

The optimistic bias may hinder the adoption of hazard mitigation measures. In Puerto Rico the optimistic bias may cause homeowners — who have little

personal experience with a major earthquake, estimate the hazard as having a low probability, and regard the hazard as not controllable by personal action — to deny the possibility of personal risk.

The notion of optimistic bias, then, is a useful tool in understanding patterns of insurance adoption or nonadoption. Weinstein (1989b) suggests that such biases "may seriously hinder efforts to promote risk-reducing behaviors" (p. 1232). If Puerto Rican homeowners have an optimistic bias about the probability of major damage to their own homes and property, then they would be less likely to adopt mitigation measures, particularly those (such as insurance) that require substantial financial investment. In contrast, those without optimistic bias would not have such an interference and might be more disposed to adopt insurance.

In short, the belief of the existence of an environmental risk that might personally threaten the life and property of the individual will motivate the individual to action. We would therefore expect to see a relationship between belief of personal vulnerability and adoption of a mitigation measure such as insurance.

A statistically significant relationship was found between perceived likelihood of damage to home and the probability of purchasing insurance in Puerto Rico as in California. However, the relationship in California was stronger and more consistent (Table 6.7). In Puerto Rico, a higher percentage of both the insured and the uninsured felt that it was very likely that their home would be seriously damaged by an earthquake. Curiously, more than 50 percent of the *uninsured* in Puerto Rico (but only 31 percent of the insured) felt it was very likely that their home would be seriously damaged by an earthquake. On the other hand, only 7.7 percent of the insured but 17.1 percent of the uninsured felt it was not very likely that their home would be seriously damaged. The insured in Puerto Rico more often responded that it was at least somewhat likely (92 percent as opposed to 83 percent). However, the modal response of the insured population was that it was only "likely" that their home would be damaged, while the modal response of the uninsured was that it was "very likely." We note again that only 13 insured respondents had no mortgage, and therefore any interpretation of these findings must be tempered with caution.

In contrast, the California responses were more clearly differentiated. The modal response (of nearly 3 out of 4 respondents) of the insured was that it was "somewhat likely" or "somewhat unlikely" that their home would be damaged: less than 16 percent said it was "not very likely." For the uninsured, less than 50 percent said it was "somewhat likely" or "somewhat unlikely", but another 43 percent noted that it was "not very likely" that their own home would be damaged. Thus, the insured in California were far more likely to expect that their own home would be seriously damaged by an earthquake, and this relationship was monotonic across the 5 categories. In Puerto Rico, the uninsured tended to believe that it was "very likely" that their home would be damaged, while the insured felt it was only "likely."

Table 6.7
Risk Perception and Insurance Purchase: Likelihood of Damage to Home

Likelihood of own home being seriously damaged by earthquake	Puerto Rico* (no mortgage)	California** (no mortgage)
Very Likely (Altamente probable o Muy Probable)		
Insured - percentage (number)	30.8 (4)	9.6 (8)
Uninsured - percentage (number)	54.3 (95)	8.1 (13)
Somewhat likely / Somewhat unlikely (Probable)		
Insured - percentage (number)	61.5 (8)	74.7 (62)
Uninsured - percentage (number)	28.6 (50)	49.1 (79)
Not Very Likely (Poco Probable o muy poco probable)		
Insured - percentage (number)	7.7 (1)	15.7 (13)
Uninsured - percentage (number)	17.1 (30)	42.8 (69)

* difference between insured and uninsured significant at .05
** difference between insured and uninsured significant at .01

This contrast between the impacts of perceived risk and insurance purchase in the two areas is highlighted by responses concerning estimated damage to the home from a major earthquake (Table 6.8). In California, the insured were far more likely to believe that their home would suffer at least $50,000 in damage from a major earthquake (almost 80 percent of the insured respondents gave this answer), while the uninsured were less likely to believe that there would be large dollar damage to their homes. Although 15 percent of the uninsured believed there would be less than $10,000 in damage to their home from a major earthquake, only 1.4 percent of the insured believed there would be so little damage.

In Puerto Rico, no statistically significant difference was found between the insured and the uninsured in their expectations concerning dollar damage from a major earthquake. Almost two-thirds of both the insured and the uninsured believed there would be between $10,000 and $50,000 in damage from a major damaging earthquake. The insured were only slightly (not statistically significant) more likely to give a higher damage estimate from a major earthquake than the uninsured in Puerto Rico (Table 6.8).

Perception Function. Finally, given the importance of perception of the seismic risk in the California studies, we hypothesized that the variables measuring perceived risk might provide a statistically significant discriminating function in Puerto Rico (Table 6.9). When discriminant functions composed of the three common perception responses were calculated for homeowners with no mortgage in both Puerto Rico and California, the pattern of differences in

explanatory variables between the two regions noted before was reinforced. The function in California correctly classified more than 62 percent of the respondents and the Wilk's Lambda for the entire function was statistically significant. The function in Puerto Rico correctly classified only 57.2 percent of the respondents and was not statistically significant. Thus perception characteristics did not effectively discriminate between the insured and the uninsured in Puerto Rico but did effectively discriminate between these two groups in California. This finding again underlines the differences in decision-making factors in the two areas: in Puerto Rico demographic and economic factors are far more likely to discriminate the insured from the uninsured, whereas measures of perceived vulnerability are relatively unimportant; the reverse holds true in California. This test suggests that while economic factors are primary in Puerto Rico in predicting insurance purchase for those for whom insurance is not mandatory, it is mainly perceived risk that discriminates between these groups in California. Again, it is useful to recall that, Puerto Ricans are more likely to respond that they are particularly at risk of damage from an earthquake. But it is not perceived risk, but instead economic capability, that predicts the actual purchase of insurance.

Table 6.8
Risk Perception and Insurance Purchase: Estimated Damage to Home, Percentage of Home Value that Would Be Damaged

Percentage of home value	Less than 10%		10-74%		75% +	
	insured	uninsured	insured	uninsured	insured	uninsured
Puerto Rico (no mortgage)	9.1	10.4	63.6	39.6	27.3	50.0
California* (no mortgage)	13.9	30.8	40.3	26.5	45.8	42.7

* difference between insured and uninsured significant at .05

To assess the combined power of socioeconomic, demographic and perception characteristics in predicting insurance purchase, we conducted tests to compare the strength and effectiveness of a final set of discriminant functions combining these variables (Table 6.10). In addition, a set of logistic regressions were calculated to estimate the parameters of each of these variables in predicting the state of insurance purchase.

Discriminant Analysis. The results of the two functions for Puerto Rico and California suggest additional contrasts between the factors that discriminate the insured from the uninsured among those households with no mortgage in the

two study areas. In Puerto Rico, the discriminant function was statistically significant at the .01 level and correctly classified 75.8 percent of the households. The variables most closely associated with the function were income, home value and years of school completed, all of which tended to predict adoption of insurance. The California function was also statistically significant, and correctly classified 70.4 percent of the cases. The variables most closely associated with the discriminant function in California were perceived risk (estimated dollar damage to the home in the event of a major earthquake, estimated probability of an earthquake damaging the home) and age of the head of household (with older households tending to purchase insurance). Economic variables (income, home value, education) separated the insured from the uninsured in Puerto Rico, whereas perceived risk was most significant in discriminating between these two groups in California. In Puerto Rico, the perception variables added little or no explanatory power, while in California these variables were the key factors separating the insured from the uninsured. Again, these contrasts reflect the sharp contrasts in economic and political structure between the two areas, as well as the differences in risk perception and its significance for behavior.

Table 6.9
Discriminant Analysis Between Perception Characteristics and Insurance Purchase: Homeowners with No Mortgage (Variables identified in forced entry procedure)

	Puerto Rico	**California**
Variable	Standard Canonical Scores:	
Estimated dollar damage	-.26	-.71**
Estimated probability of a damaging earthquake affecting community	.76	.25
Estimated probability of a damaging earthquake affecting home	.77	.72**
Percent correctly classified	57.2	62.3
Eigenvalue	.00	.12
Canonical Correlation	.05	.33
Wilk's Lambda	.99	.89**

* significant at the .05 level
** significant at the .01 level

Table 6.10
Discriminant Analysis Between All Variables and Insurance Purchase:
Homeowners with No Mortgage
(Variables identified in forced entry procedure)

Variable	Puerto Rico Standard Canonical Scores:	California
Income	.73**	.31*
Home Value	.65**	.12
School years completed	.50**	.40**
Age of head of household	.19	-.48**
How long lived in home	.08	-.40**
Age of house	-.29	.39**
Estimated dollar damage	.13	.48**
Estimated probability of a damaging earthquake affecting community	-.06	-.16
Estimated probability of a damaging earthquake affecting home	-.06	-.50**
Percent correctly classified	75.8	70.4
Eigenvalue	.20	.30
Canonical Correlation	.41	.48
Wilk's Lambda	.83**	.77**

* significant at the .05 level
** significant at the .01 level

Logistic Regression. We also completed a logit analysis to identify variables that would predict insurance status. The variables included in this analysis were length of time in the home, home value, likelihood of an earthquake damaging the community, likelihood of an earthquake causing major damage to the home, age of the home, family income, age of the respondent and educational level of the respondent. Only home value was statistically significant in a stepwise procedure. The model produced correctly classified 92.5 percent of the cases overall, but only 8.3 percent of those who did not buy insurance were correctly classified. When all variables were entered in the equation in a forced-entry procedure, the overall performance of the equation remained the same, but the percentage of insured correctly classified increased to 16.7 percent (Table 6.11). In Puerto Rico, no individual variable was statistically significant at the .05 level. In California, the only variable with a

beta weight that was statistically significant was estimated probability of a damaging earthquake affecting the home.

Although the small numbers in Puerto Rico caution against a broad interpretation of the statistical findings, the insurance decision appears to be motivated by different factors here than in California. In Puerto Rico, homeowners with no mortgage on their house are free to purchase or eschew insurance. Most of them forego the insurance, with only a small minority voluntarily adopting earthquake insurance. The insurance adopters tend to have

Table 6.11
Logistic Regression: All Variables and Insurance Purchase for Homeowners with No Mortgage
(Variables identified in forced entry procedure)

Variable	**Puerto Rico** Beta coefficient	**California** Beta coefficient
Income	-.47	.18
Home Value	-1.32	-.05
School years completed	-.07	.08
Age of head of household	-.02	-.02
How long lived in home	.05	-.49
Age of house	-.05	.01
Estimated probability of a damaging earthquake affecting community	.09	-.10
Estimated probability of a damaging earthquake affecting home.	-.02	-.66**
Percent correctly classified	92.5	70.0
Model Chi square	15.6*	37.6**

* significant at the .05 level
** significant at the .01 level

higher family incomes and higher home values. In California, where the entire population is free to purchase or not purchase insurance, perceived vulnerability is a key predictor. Here, although demographic variables such as age of the respondent and level of education are predictors, so too are such variables as estimated dollar damage from an earthquake and estimated probabilities of the home being damaged by an earthquake. Perceived vulnerability seems to be a far greater predictor of insurance purchase in California, while economic status is the key predictor variable in Puerto Rico.

Decision to Update Insurance Coverage: The Co-Insurance Gap

Most homeowners who voluntarily purchase insurance have no mortgage financing on their home. However, homeowners whose house has risen in value must decide whether to update or increase their insurance to the full value of the house and contents. When insurance coverage falls below the actual value of the property, the difference is called the "co-insurance gap."

Co-insurance is defined as a sharing of the losses between the insured and the insurance company. However, the co-insurance gap refers specifically to a "reduced-rate contribution clause," intended to ensure that homeowners pay for at least a certain percentage of the value of the home (Riegel, et al., 1976; Williams and Heins, 1989). The co-insurance clause states that "if the insured does not take at least a certain required percentage of insurance to value, any loss shall be paid in the proportion that the amount of insurance taken bears to the insurance required, up to the face of the policy" (Riegel et al, p. 209).

The rationale behind a co-insurance clause is to encourage large amounts of insurance relative to the value of the property. Since most claims are for relatively small percentages of the value of the insured property, the cost of insuring a large fraction of the value is not monotonically proportional to that of insuring a small fraction: it does not cost twice as much to insure $80,000 of the $100,000 building as it does $40,000 since most of the probable losses will be small. For this reason, the premium rate (the rate per $1000 of coverage) for only $40,000 of coverage should be higher than the premium rate for $80,000 of coverage. The co-insurance clause is one means of equalizing premium rates by discounting coverage once the rate of insurance drops below a fixed required minimum percentage (for example, 80 percent).

In Puerto Rico, when this gap reaches or exceeds 20 percent (that is, when insurance coverage is less than 80 percent of the appraised value), the homeowner is penalized when making an insurance claim. For example, let us assume that a property is worth $100,000, with a co-insurance clause requiring 80 percent insurance (or a minimum of $80,000), and the homeowner has let the policy drop to a value of only $75,000 coverage. The co-insurance clause means that the homeowners will only be able to recover the proportion of the loss that the insurance bears to the insurance required (in this instance, 75/80ths). If an earthquake causes $40,000 damage to the home, the homeowner can claim only 75/80 x $40,000 or $37,500. If, however, the homeowner had $80,000 of insurance, he could claim the full $40,000 in losses.

In another example, if a homeowner with a property valued at $100,000 and no co-insurance gap (at least 80 percent insurance coverage) suffers a total loss on the home, that individual would be able to claim the full $100,000 minus a deductible (for example, 10 percent), for a total claim of $90,000. If the homeowner has a 25 percent co-insurance gap, then the total amount claimed would be only $90,000 after the deductible, minus the co-insurance penalty of

$5,625 for a claim of $84,375. Thus, the existence of a co-insurance gap can have serious implications for loss claims following a disaster.

The major problem for the homeowner is calculating adequate insurance levels. When property values fluctuate, for example, when house prices rise quickly but unevenly in the metropolitan area, it is difficult for the homeowner to calculate whether he/she has adequate but not excessive coverage — enough to avoid the co-insurance penalty but not more than necessary.

Related Theoretical Research

The issue of permitting the accumulation of a co-insurance gap is closely related to that of purchasing catastrophic insurance when a small mandatory policy is in effect. How does the existence of mandatory insurance in Puerto Rico affect the decision to purchase voluntary insurance to eliminate the co-insurance gap? Previous research would predict either (1) an aversion to voluntary insurance purchase to eliminate the co-insurance gap (based primarily on "positive responsiveness" or "prospect theory" as well as the notion of "pseudocertainty" that accompanies the purchase of a small policy) or (2) a tendency toward voluntary insurance purchase and elimination of the co-insurance gap (based primarily on the notion of the "availability" heuristic or "regret" theory).

According to the first set of theories, the homeowner would not buy enough insurance to eliminate the co-insurance gap. Elements of the "positive responsiveness" theory include the existence of an ongoing, valued activity (in this case, peace of mind concerning vulnerability from a major catastrophic earthquake associated with the purchase of earthquake insurance) that carries with it the possibility of causing serious harm (insurance premiums that exceed the amount budgeted for this purpose). If the probability of the damaging event (an earthquake) becomes sufficiently small, homeowners will terminate an activity that traditional decision theory indicates should be continued. In other words, when risk is seen as a mixture of gains and losses, the demand for risk amelioration (voluntary insurance purchased) is reduced (Noll and Krier, 1990, pp. 760-1 and 771).

"Prospect theory" suggests a similar outcome (Kahneman and Tversky, 1979). Some relevant aspects of this theory are (1) that the decision-maker derives a value function based on some reference point, (2) that changes in status are more painful as losses than as gains, and that (3) great importance is attached to outcomes that are certain rather than those that are uncertain. Since mandatory insurance continues at a steady level and changes in status are seen as painful, a level of certainty may be attained and a tendency not to change level of insurance coverage induced. In addition, Slovic et al. (1985) suggest an application of "pseudocertainty" (Tversky and Kahneman, 1981) that would have similar effects on the purchase of voluntary insurance to eliminate the co-insurance gap.

The issue of ambiguity in risk-aversion has been the subject of a great deal of work (Kahneman and Tversky, 1979; Ellsberg, 1961; Einhorn and Hogarth,

1985). Ambiguity occurs when the underlying distribution and frequency of risk are unknown. In Puerto Rico, ambiguity arises because homeowners have little or no means to assess their objective vulnerability to losses resulting from natural disasters. As a result, they do not wish to reconsider their insurance status. Many studies have hypothesized an aversion to ambiguity, demonstrating that consumers prefer certain losses or gains to uncertainty. A model linking subjective probabilities, ambiguity and choice has been suggested by Hogarth and Kunreuther (1989). An empirical test of the Einhorn-Hogarth model (1985) suggested that (1) people tend to anchor on an initial estimate of probability and adjust this value by simulating other values the probability could take; (2) increased ambiguity (uncertainty about the true distribution of probabilities) increases the alternative values of the simulated probability; and (3) the relative weight given to alternative values is a function of the individual's attitude toward the ambiguity. Experimental work showed that for low-probability events, consumers showed aversion to ambiguity. In contrast, the experimental work of Camerer and Kunreuther (1989), specifying ambiguity as a second-order probability distribution, showed that their measures of ambiguity had little significant effect on consumer behavior and concluded that "the argument that ambiguity cripples insurance markets receives little support from our data" (Camerer and Kunreuther, 1989, p. 288).

Finally, an even simpler notion could account for a decrease in subscription to catastrophic insurance. If a household has a fixed budget to spend on insurance (included in the monthly mortgage payment), any increase in insurance premiums might tip the balance against a voluntary increase in insurance coverage.

Competing theoretical work would predict a greater tendency toward the purchase of supplementary insurance. Part of the theoretical justification for this expectation is based on the "availability effect" (Tversky and Kahneman, 1974). If the earthquake risk becomes more salient because homeowners are reminded of the necessity of updating and upgrading their insurance policies, then they might also take other actions including the purchase of catastrophic insurance to prevent losses.

Another theoretical explanation for the purchase of supplementary insurance and a minimization of the co-insurance gap is based on "regret theory" (Sugden, 1985; Loomes and Sugden, 1983). This theory postulates that a decision to forego full insurance coverage might induce anticipated regret. Within this framework, individuals are assumed not only to regret decisions after they turn out badly, but also foresee the possibility of such regret before the decision is made. The anticipation of self-recrimination, a central part of "regret theory," might motivate a diminution of any co-insurance gap.

Empirical Analysis of Co-insurance Gap

To calculate a co-insurance gap, we needed accurate answers to two questions: (1) "*¿cual es el limite de su cubierta de seguro contra terremotos?*" (what is the limit of your earthquake insurance coverage?), and (2) "*¿En cuanto*

considera usted que se venderia su casa, incluyendo el terreno, si estuviera en venta actualmente? De esta cantidad, ¿cuanto seria el valor de la estructura (casa) solamente?" (What is the market value of your house and land if you were to sell it today? Of this quantity, what would be the value of the structure only?). Of the 636 Puerto Rican respondents, only 125 provided answers to both of these questions. In analyzing these responses, we assumed that the estimates of market value, structure value, and insurance coverage were correct — an assumption that is probably unwarranted. Since we had no alternative information, we used the values provided by the respondents.

The total co-insurance gap ranged from -43 percent (where the insurance coverage exceeded the cost of the house) to +95 percent (where only a small fraction of the value of the house was covered by insurance). Only 11 of the 125 respondents had a co-insurance gap of less than 20 percent, with the median gap at about 48.6 percent.

Respondents reporting a high co-insurance gap tended to have lived in their houses for a longer time, own older houses, and have more equity in their homes (Table 6.12). None of the other economic variables was related to the co-insurance gap, nor was there any relationship between the co-insurance gap and measures of earthquake hazard.

Table 6.12
Variables Correlated with the Co-Insurance Gap: Earthquake Insurance
(Pearson Correlation Coefficients)

Age of Structure	-.36*
How long lived in house	-.35*
Percentage of equity	-.33*
Estimated damage from earthquake	-.18
Years of school completed	-.18
Family income	-.14
Estimated value of home	.14
Likelihood of earthquake in community	-.07

* Significant at .001

Since the percentage of respondents analyzed in this portion of the study was small, and we found such an astounding rate of error in estimated insurance coverage, these associations should not be over-interpreted. Indeed, we are probably measuring the *perceived* co-insurance gap here rather than the actual co-insurance gap. Therefore, we may conclude from this analysis that the expected relationships between full insurance coverage and length of time in residence hold true: those who have lived in their homes for longer periods of time (and therefore live in older homes and have more equity in their homes) are likely to believe that they have a lower proportion of their current estimated home value

covered by insurance. Whether this belief reflects the reality of their insurance coverage cannot be conclusively determined from this survey.

Conclusion

Whether a homeowner is deciding to update insurance (and close the co-insurance gap) or to purchase insurance, economic and demographic variables are very important in Puerto Rico in distinguishing the insured from the uninsured. Although Puerto Ricans tend to see themselves at greater risk than their counterparts in California, this variable — perceived risk — does not distinguish the insured from the uninsured. Thus the two study regions show sharply different patterns in the prediction of insurance purchase. In California, economic and demographic variables tend to distinguish the insured from the uninsured among those with no mortgage, although these variables have virtually no discriminating power for the full population of owner-occupiers. In Puerto Rico, where mortgagees have no choice in the purchase of insurance, the economic and demographic variables most clearly distinguish voluntary insurance purchase from nonpurchase. Perceived risk, though higher in Puerto Rico, is not the primary distinguishing variable; instead it is income, home value, and educational level. These empirical findings suggest real differences in the impacts of cultural values and political economy on both individual perception and the conversion of this perception of risk into hazard mitigation behavior.

7

The Impacts of Experience

A primary goal of this research was to probe the impacts of experience with Hurricane Hugo on subsequent attitudes and adoption of mitigation measures to protect against future disasters. Previous social science research in other contexts suggests that experience affects both perception and behavior. In addition, research by the authors in California showed that direct experience with the 1989 Loma Prieta earthquake induced the voluntary purchase of earthquake insurance and the adoption of new mitigation measures (Palm and Hodgson, 1992). In this chapter, we review studies that show the relationships between insurance purchase patterns and awareness of risk, experience with the hazard, and perception of risk. We then present the results of an empirical analysis of the impacts of experience with Hurricane Hugo on both voluntary insurance adoption and the adoption of other mitigation measures in Puerto Rico.

Risk Communication and Changes in Risk Perception

Previous research shows a relationship between the ways that risks are communicated and their salience to individuals. Three conclusions from this research are particularly relevant. First, the communication must make the hazard memorable. For example, if a risk is reported extensively in the media, it probably becomes exaggerated in people's minds. For this reason, individuals overestimate dramatic or sensational causes of death, whereas they underestimate less dramatic, constant, but nonetheless serious ones (Slovic, 1986; Lichtenstein et al., 1978). When the media cover an event, they create bias that changes public perception of a risk, even when their coverage is accurate. This bias arises because the media tend to dramatize the event (Combs and Slovic, 1979). This finding explains why people tend to overestimate the dangers of terrorist attacks or natural disasters and underestimate the impacts of auto accidents or diseases.

For Hurricane Hugo in Puerto Rico, news coverage was dramatic and memorable. Although only one death was attributable to the hurricane, a great deal of newspaper space and television news time focused on the destruction of

homes and the inconveniences associated with the hurricane. Hugo was blamed for a number of ills and system failures. Thus, the hurricane was dramatized and came to signify a major event in the history of the island.

Second, since people tend to prefer certainty to probability statements, they reduce the anxiety associated with an uncertainty by denying the existence of low probability events or by wishfully believing that the hazard is being handled by some external group, such as the government. This desire for zero risk, called a "thirst for certitude" (Ruckelshaus, 1983), results in a "low tolerance for uncertain formulations of risks and in objections to cautious expressions of scientific knowledge" (Keeney and von Winterfeldt, 1986), which in turn make accurate risk communication more difficult.

Third, the presentation of information, or its framing, can affect its salience, particularly when the audience does not already have strong opinions about the risk (Slovic, 1986; Tversky and Kahneman, 1981). For example, a real estate agent can lessen the impact of such information as a house's location in a flood-prone area by making this disclosure after the client has seen the house, mentally arranged furniture in it, and decided to buy it.

In short, the relationship between communication of a risk and society's attention to that risk is fairly well understood, at least in the short run. This relationship can be manipulated by policymakers attempting to increase or lessen public concern for environmental hazards.

Experience with Hazard and Behavior Change

Many studies have linked previous experience with a hazard with subsequent behavior changes. We have reviewed some of these studies in chapter 1. Here, the empirical findings will be linked with specific expectations for the work in Puerto Rico.

Previous experience changes both perceived vulnerability and subsequent behavior. Personal experience affects the perceived likelihood of future victimization since accessibility from memory influences probability judgments, unless the risk is believed to be cyclical and therefore expected to be lower after victimization (Kahneman and Tversky, 1979; Perloff, 1983; Slovic, et al., 1974). This factor means that those who suffered damage or inconvenience from Hurricane Hugo should be more likely to believe that they will suffer from future hurricanes — and therefore have a higher propensity to adopt mitigation measures. However, popular beliefs about recurrence intervals for natural disasters may convey a false notion of safety. If a major hurricane is expected to occur approximately once every fifteen years, then residents may believe that once an area has experienced such a hurricane, it is safe for another 14 years. In this case, those who have experienced the hurricane may mistakenly perceive themselves as safer during the next time period.

Personal experience also provides information about the possible severity of the harm and the existence of preventative measures. Thus experience with the Hurricane Hugo would inform residents of the northeastern portion of Puerto Rico about the susceptibility of their own homes. In addition, the many newspaper and television stories circulated immediately after the hurricane, and particularly the disturbing stories of social disorganization in the neighboring Virgin Islands, would increase public awareness of certain mitigation measures.

Experience adds to the concreteness of information (Nisbett and Ross, 1980). Although homeowners may understand the possibility of a hurricane in their community, the event itself makes the destruction and inconvenience more obvious. Since the last major hurricane to strike Puerto Rico occurred in 1975, many homeowners had not experienced such an event directly. Hurricane Hugo made the concept of hurricanes far more concrete. This information should increase attention to the hurricane hazard, possibly also inducing the adoption of mitigation measures. Experience also makes events more "available" to recall (Fazio, et al., 1978), increasing the agreement between attitudes and behaviors (Fazio, et al., 1982), so that those already predisposed to adopt mitigation measures are motivated to take action.

At the same time, experience reduces uncertainty about the event (Fazio, et al., 1978). An imagined hurricane may induce exaggerated levels of fear or underestimation of the damage and destruction that follows. Experience with a hurricane induces greater certainty about the effects on an individual's family and the susceptibility of one's own property. This increase in certainty about hurricane effects should cause more realistic concern about its risks and the adoption of mitigation measures.

Experience with the hurricane increases the salience of an event (Janis, 1967; Averill, 1987). While a hypothetical hurricane might cause some concern, an actual hurricane in one's own community makes the hurricane hazard real and immediately important. This increase in salience should result in the adoption of mitigation measures.

Experience with an event, such as a hurricane, is positive demonstration that individuals are not invulnerable (Janoff-Budman, 1985; Perloff, 1983; Weinstein, 1987). This increase in perceived vulnerability, which should occur with damage to one's own property, should induce behavior changes.

Society influences individuals to adopt precautions to avoid further victimization, since individuals may expect blame rather than sympathy if they become victims a second time (Janoff-Budman, 1985). This finding arises from the ideology of privatism: individuals and households are generally regarded as responsible for their own well-being. If an accident or act of God causes destruction, an outpouring of sympathy and aid will follow. However, individuals are expected to take measures to ensure that they are not victims from an identical future accident. This belief in privatism should induce those who have suffered damage to adopt mitigation measures to prevent future victimization.

Previous research shows that specific situations motivate people to attend to messages that may change attitudes (Petty and Cacioppo, 1986; Chaiken and Stangor, 1987; Doyle et al., 1991). Although federal and state agencies may send out messages about hurricane risk and mitigation measures before a hurricane, these will probably be attended to far more carefully by people who have recently experienced a hurricane. Thus experience with the hurricane may motivate people to attend to public information and change their attitudes to future risk and preventative behavior.

An "optimistic bias" may distort the relationship between hazard and action. Individuals construct an overly optimistic bias about safety from a given hazard to create self-serving predictions about future events (Weinstein, 1989b). Such a bias "may seriously hinder efforts to promote risk-reducing behaviors" (p. 1232), interfering with the adoption of mitigation measures or voluntary insurance purchase. The optimistic bias may cause individuals to underestimate any future hurricane damage using arguments such as (1) the hurricane struck in 1989 and now we are safe for another 14 years or (2) our house withstood this hurricane; therefore, it is safe against any future hurricane.

Finally, empirical work by the authors demonstrated the workings of these mechanisms in California. In our studies of the response of homeowners in California before Loma Prieta (in 1989) and after Loma Prieta (in 1990), we investigated two measures of behavior change: insurance purchase and the adoption of other mitigation measures such as structural repairs to the house and strapping of water heaters. In both surveys, few homeowners invested any money toward earthquake mitigation other than the purchase of insurance. In 1990, a larger number of Santa Clara residents reported expenditures for earthquake mitigation measures, but virtually all these respondents were actually reporting expenses related to damage suffered in the Loma Prieta earthquake. Insurance purchase did show an increase that seems attributable to experience with the earthquake. Between the October 1989 Loma Prieta earthquake and our survey in summer 1990, 65 of the 996 respondents purchased earthquake insurance. Of these, approximately one-half (32) lived in Santa Clara County. Another one-fourth (16) were in Contra Costa County. In other words, the two northern counties accounted for 74 percent of the respondents who purchased earthquake insurance after the Loma Prieta earthquake.

This review of research findings suggests that voluntary insurance purchase and the adoption of other mitigation measures should be affected by experience with the hurricane. Those who directly experienced Hurricane Hugo would be expected to be more concerned about future hurricanes and to increase the rates of adoption of mitigation measures including insurance purchase.

Research Hypotheses

The research reviewed above suggests that experience with a hurricane should affect both perception and behavior. This is the primary research

hypothesis tested in the current study. The survey did not provide a longitudinal test of the effects of experience on either attitude or behavior shift (in contrast to the post-Loma Prieta study), but does give an indication of the impacts of experience with Hurricane Hugo.

Two hypotheses were tested: (1) perceived vulnerability varies with experience with Hugo and (2) those with a more intense experience with the hurricane are more likely to take subsequent mitigation measures, including voluntary insurance purchase.

Coding of Experience

The selection of study municipios was generally equivalent to selection of different levels of experience: the two easternmost municipios (Vieques and Fajardo) experienced relatively large amounts of damage, the central municipios (Bayamon and Caguas) had moderate levels of damage, and the western municipios (Mayaguez and San German) had little or no damage (Figure 3.4).

An even more finely differentiated measurement of experience distinguished the respondents within the municipios. A new variable--intensity--was created to analyze experience at the household level. Individuals were coded as "severe" if the damage to their home exceeded 10 percent of its value; "moderate" if they experienced damage from the hurricane but less than 10 percent of the home value; "indirect" if there was no damage to the home but a family member's home had some damage or there was at least $1000 in damage to a home within 10 km of the house; and "no experience" for all other respondents. For the full sample, 59 respondents (about 10 percent) had "severe" experience with Hugo, 177 had "moderate" experience, 242 had "indirect" experience, and 148 had "no experience" (Figure 7.1).

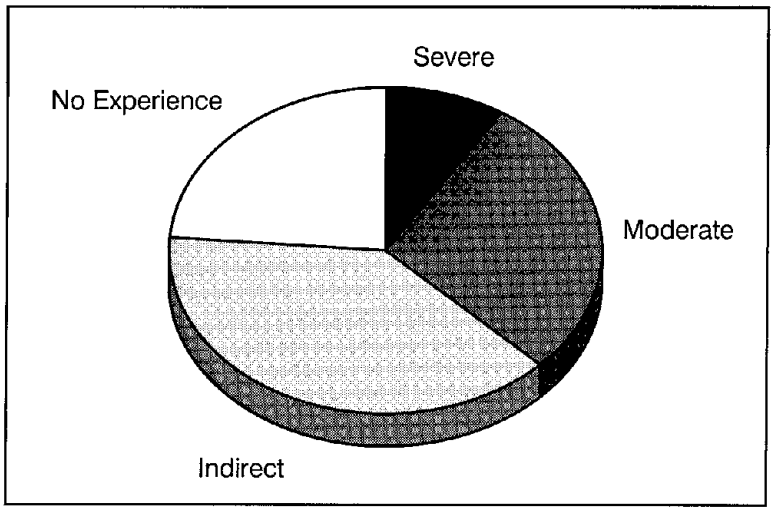

Figure 7.1 Levels of Experience with Hurricane Hugo: Puerto Rico

Experience and Perceived Vulnerability

Was level of experience associated with attitudes toward the hazard? Three measures of perceived hazard vulnerability were assessed: likelihood that the community would be affected by a hurricane like Hugo in the next 10 years, likelihood that the house would experience at least $1000 in damage from a hurricane like Hugo in the next 10 years, and degree of concern that a hurricane would cause serious damage to the home. The nonparametric Kruskal-Wallis one-way analysis of variance was used to ascertain the presence of differences among the categories in ranking the perception variables.

A consistent and strong relationship was shown between experience with the hurricane and perceived vulnerability. The crudest measure of experience was home municipio — Vieques and Fajardo represented intense experience and Mayaguez and San German represented least intense experience. Analysis of variance for all three measures of perceived vulnerability showed significant differences for the municipio groupings, with the Vieques and Fajardo respondents consistently evaluating higher probabilities of a hurricane affecting their home and their community and their concern for hurricanes than their counterparts in other municipios. Interestingly, the municipios in the San Juan area (Bayamon and Caguas), although intermediate for impacts of Hurricane Hugo, ranked lowest for perceived vulnerability of the home or the community. (Table 7.1).

When individual levels of experience were compared with responses to these three questions, the relationship between experience and perceived vulnerability became even stronger. Those with severe impacts of Hurricane Hugo had far higher expectations of future damage to their home and their communities as well as greater concern with hurricanes as a natural hazard than the other respondents. Further, the level of perceived vulnerability was monotonically related to intensity of experience, except that those with no experience had slightly higher perceived vulnerability scores than those with indirect experience (Table 7.2).

Thus, as expected, experience with Hurricane Hugo increased perceived vulnerability to future hurricanes. This finding supports theoretical work on the linkage between experience with the event and fear of future vulnerability, and agrees with our empirical findings in California where experience with the Loma Prieta earthquake increased perceived vulnerability to other future earthquakes.

Experience and Mitigation Behavior

Our second question was whether experience with the hurricane induced changes in behavior: the adoption of insurance or other mitigation measures to protect against windstorm damage. With respect to the adoption of insurance, analysis was limited to respondents who had no mortgage on their home: for

whom the adoption of insurance was voluntary behavior. Of the 155 responses analyzed in this section, 24 were considered "severe," 59 "moderate," 49 "indirect," and 23 "no experience." The analysis of variance showed no difference among the various classifications of experience with respect to the purchase of windstorm insurance (Table 7.3).

Table 7.1
Kruskal-Wallis ANOVA on Perceived Vulnerability by Municipio Group

Likelihood that home would be damaged by a hurricane like Hugo within the next ten years

Municipio group	**Mean Rank**
Vieques/Fajardo	340
Bayamon/Caguas	293
Mayaguez/San German	318

Chi square corrected for ties: 8.03 Significance: .02

Likelihood that community would be affected by a hurricane like Hugo within the next ten years

Municipio group	**Mean Rank**
Vieques/Fajardo	338
Bayamon/Caguas	299
Mayaguez/San German	313

Chi square corrected for ties: 4.83 Significance: .05

Level of concern that a hurricane will cause serious damage to the home

Municipio group	**Mean Rank**
Vieques/Fajardo	350
Bayamon/Caguas	304
Mayaguez/San German	287

Chi square corrected for ties: 14.70 Significance: .00

Table 7.2
Kruskal-Wallis ANOVA on Perceived Vulnerability by Level of Experience

Vulnerability measure: likelihood that home would be damaged by a hurricane like Hugo within the next ten years

Experience level	**Mean Rank**
Severe	409
Moderate	346
Indirect	277
No Experience	296

Chi square corrected for ties: 36.34 Significance: .00

Vulnerability measure: likelihood that community would be affected by a hurricane like Hugo within the next ten years

Experience level	**Mean Rank**
Severe	368
Moderate	341
Indirect	292
No Experience	294

Chi square corrected for ties: 16.24 Significance: .00

Vulnerability measure: level of concern that a hurricane will cause serious damage to the home

Experience level	**Mean Rank**
Severe	415
Moderate	355
Indirect	272
No Experience	286

Chi square corrected for ties: 49.97 Significance: .00

Table 7.3
Kruskal-Wallis ANOVA on Insurance Adoption by Level of Experience

Experience level	Mean Rank
Severe	81.8
Moderate	79.8
Indirect	73.9
No Experience	78.3

Significance of chi-square: .44

Homeowners could have taken a wide variety of other mitigation measures besides house repairs. The survey posed the following question: "After Hurricane Hugo, have you taken some measures to reduce the damage to your house that would be caused by a hurricane?" Excluding damage repair, a total of 134 households (11.5 percent) responded that they had taken some action. The most frequent mitigation measures adopted was the reinforcement of windows and doors or the installing of bars on windows and doors (undertaken by 85 respondents or 13.3 percent). Next most frequent was rebuilding the undamaged dwelling unit using concrete (21 respondents), purchasing emergency supplies, equipment or an emergency generator (19 respondents), and reinforcement of the roof (15 respondents).

These mitigation measures were adopted largely in the municipios that suffered hurricane damage — Vieques and Fajardo. Of the 85 respondents who reinforced or installed bars on windows and doors, 42 were from these two municipios. Similarly, of the 21 who rebuilt undamaged homes with concrete, 14 were from Vieques and Fajardo.

Statistical testing corroborated the observation of a relationship between hurricane experience and the adoption of nonrepair mitigation measures. To test for this response, we needed to eliminate from our analysis all those who reacted to the Hurricane Hugo simply by repairing damage. Those who had invested in mitigation were defined as (1) those who did not have damage from Hurricane Hugo but nonetheless invested in hurricane-related mitigation measures and (2) those who did have damage and made investments that went beyond repairing damage from the hurricane.

We found that experience with the hurricane had a clear impact on the adoption of nonrepair mitigation measures.

The Kruskal-Wallis one-way analysis of variance on municipio groups (Table 7.4) showed a significant relationship between location and the adoption of mitigation measures. Similarly, households with more intense experience

with the hurricane were far more likely to adopt hurricane mitigation measures than those with less direct or no experience (Table 7.5).

Table 7.4
Kruskal-Wallis ANOVA on Adoption of Mitigation Measures by Municipio Group

Municipio group	**Mean Rank**
Vieques/Fajardo	340
Bayamon/Caguas	293
Mayaguez/San German	318

Chi square corrected for ties: 8.03 Significance: .02

Table 7.5
Kruskal-Wallis ANOVA on Adoption of Mitigation Measures by Level of Experience

Experience level	**Mean Rank**
Severe	341.8
Moderate	348.3
Indirect	296.9
No Experience	285.0

Significance of chi square: .00

Conclusion

We found that experience with Hurricane Hugo was strongly associated both with perceived vulnerability to future hurricane hazards and with propensity to adopt certain mitigation measures. Experience was unrelated to the purchase of windstorm insurance by those with no mortgage, however. This latter finding contrasts with the post-Loma Prieta findings in California but may result from economic constraints, which make insurance purchase financially difficult. In addition, we have reason to believe that many homeowners do not know whether

or not they have hazards insurance and, therefore, some of the respondents may have erred in reporting their insurance status.

Experience with Hurricane Hugo had a direct and measurable effect, not only on those who experienced damage themselves, but on those residents of municipios whose own home escaped damage but whose neighbors were not so lucky. Direct testing to explain more definitively relationships between experience and mitigation behavior will require time-series data to track attitude and behavior changes resulting from future events or policy changes.

8

Conclusions and Policy Implications

Hurricane Hugo in September 1989 provided an opportunity not only to investigate response to this devastating event but also to question the preparedness for future hurricanes and other natural hazards in Puerto Rico. Since Puerto Rico is vulnerable to a panoply of natural hazards — earthquakes, tsunamis, hurricanes, flooding, landslides and subsidence — it is an ideal area in which to compare relative degrees of perceived vulnerability to various natural hazards and the impacts of this variability in perceptions to associated responses. In addition, given its relatively low income level (compared to that in U.S. states) and high unemployment rate, Puerto Rico provides a context to study the way in which individuals with relatively little discretionary income invest in mitigation measures for natural hazards. Finally, the very complex relationships between Puerto Rico and the United States add another dimension of interest, particularly since the institutional constraints and regulations affecting hazard response significantly impact the behavior of local institutions and therefore individual households.

This study set forth three general goals. First, we documented the attitudes and behavior of homeowners in Puerto Rico with respect to natural hazards both for the general population, and also for the population stratified by geographic location and by mortgage status. We discovered that a large portion of the population was not aware of their insurance coverage against natural disasters.

Second, we assessed the effects of different intensities of experience with a hurricane (Hurricane Hugo) on preparation for subsequent natural disasters. We expected that individuals who had personally suffered damage from the hurricane — who had experienced major damage to their home or its contents — would be more likely to perceive themselves as vulnerable to future events and to adopt mitigation measures to protect themselves from such events. To assess the effects of intensity of experience on perceived vulnerability and response, we stratified the municipios on the island, choosing two municipios in each of three categories for study: those in the north and east which experienced the greatest

damage; those in the central part of the island which experienced moderate damage, and those in the west which escaped the direct impacts of the hurricane.

Our third general goal was to compare the factors associated with insurance adoption in two different physical, cultural and political settings — California and Puerto Rico. Since the research team had recently completed two major surveys in California — one just before and a second just after the Loma Prieta earthquake of October 1989 — we compared responses to these natural disasters in different physical, social and economic contexts. We found that some of the research hypotheses we developed for Puerto Rico based on our empirical findings in California were corroborated; however, significant and systematic differences were evident in the responses of homeowners in the two areas and the relationships between attitudes toward hazards and the adoption of mitigation measures. These differences reflect contrasts both in the nature of the objective vulnerability of the two regions and in the political-economic context and cultural values of the respondents.

Prior assessments have noted repeatedly that individuals' responses cannot be studied in a vacuum. Instead, individuals are constrained from adopting mitigation measures by many factors. They must be aware both of the hazard and of the ways in which its impacts can be mitigated. We found that the respondents in both areas were highly aware of their vulnerability to natural disasters. In California, a vast majority of homeowners, whether insured or uninsured, were convinced that a major damaging earthquake is likely to affect their community or their home in the next ten years. In Puerto Rico, such feelings of vulnerability, not only to hurricanes but also to earthquakes and flooding, are very high. Thus the populations in both areas show a state of heightened awareness and perceived vulnerability.

The second part of the equation is the extent to which people are aware of mitigation measures and believe in their capabilities to undertake action that would mitigate against major impacts of the disaster. Here the answers are less clear. Many respondents in both areas commented that one can do nothing to mitigate against the most serious impacts of natural hazards: the more frequently this belief is held, the less likely individuals are to investigate possible means to prevent damage to their own home.

Further, even if people are aware of the hazard and believe that they can undertake strategies to reduce damage, they may still be impeded in adopting these strategies. Adoption depends on access to resources and the salience of this particular hazard in daily life. In an area where homeowners have relatively low incomes and little discretionary money, such as Puerto Rico, access to resources is a major impediment to undertaking costly mitigation measures. Furthermore, the salience of various natural hazards to Puerto Rican residents is not clear. For example, the last major earthquake struck Puerto Rico more than 70 years ago. When compared with the pressing problems of daily life — high unemployment, drug abuse, violent crime — hazards such as earthquakes can be expected to claim only low levels of attention.

Not surprisingly, we found that residents in neither area exhibit widespread investment in disaster mitigation preparedness. In both areas, relatively few homeowners had spent anything to strengthen the home, prepare cupboard doors, strap water heaters, and so forth — simple measures that would reduce damage if a future natural disaster occurred. In Puerto Rico, we found that households in communities affected by Hugo were more likely to prepare for a future hurricane, but even this population was a small minority. However, direct experience was clearly associated with an increase in perceived vulnerability and in the adoption of noninsurance mitigation measures. For insurance, no relationship was found between hurricane experience and voluntary insurance adoption. Instead, we found that a myriad of other factors affected the adoption of mitigation measures, particularly the voluntary purchase of insurance.

Although Puerto Ricans are highly aware of the natural hazards they confront, and indeed tend to exaggerate the vulnerability of their home district to such hazards, their general level of preparedness is very low. Few Puerto Rican households voluntarily adopt mitigation measures, particularly if such measures cost more than $100.

Interpretation of Research Results

The results of the previous empirical research in California led us to expect five research outcomes in Puerto Rico. First, given the low propensity to adopt mitigation measures in California even after lengthy and expensive public information campaigns, we expected a similar low adoption rate for voluntary mitigation measures in Puerto Rico. This expectation was borne out by the empirical work in Puerto Rico. In no municipio did more than 5 percent of the respondents indicate that they had spent more than $100 on measures to protect their houses or personal property from natural disasters, aside from the purchase of insurance. Furthermore, despite FEMA regulations affecting construction in designated floodplains, Puerto Ricans have built homes in marsh lands and in areas highly susceptible to coastal flooding. Many of these areas have been rebuilt after Hurricane Hugo, setting up a context for future disaster. Finally, despite the requirement of flood insurance for homes located within 100-year flood zones, only 18 percent of such homes within our survey actually had flood insurance.

Second, we expected that the political economic structure and the organization of the insurance/lending industry would have a major impact on the propensity to adopt earthquake insurance and on the awareness of the size and nature of coverage. This expectation was clearly corroborated. The primary factor that predicts insurance purchase is mortgage status: virtually all those with home mortgages have earthquake insurance, whereas those without mortgages adopt earthquake insurance at a relatively low rate. The reason for this association of insurance purchase with mortgage status is simple: the secondary mortgage market — particularly Fannie Mae — requires earthquake insurance as

a condition for the purchase of mortgage packages originated in Puerto Rico. This requirement exists in Puerto Rico but in no mainland state, including California, Alaska, Washington, and Missouri where the annualized probable loss from earthquakes is much greater than in Puerto Rico. This requirement clearly had a marked impact on insurance purchase requirements in Puerto Rico. Further, we found that members of our advisory committee from the lending industry did not realize that Puerto Rico alone was singled out for this requirement. Thus, although these individuals knew the amount of coverage required by their clients and carefully monitored the co-insurance gap, they were not well aware of the national institutional context within which they have been operating.

A related finding was the lack of awareness of insurance status by individual homeowners in Puerto Rico. Our California surveys had found that more than 95 percent of homeowners correctly identified their insurance status — if they had insurance, they knew it; if they did not, they also knew it. In Puerto Rico, we found that a very large percentage of homeowners who had mortgages (and were therefore required to have earthquake insurance) were unaware that they had coverage. This lack of knowledge came about because Puerto Ricans do not purchase insurance separately as do Californians. Instead, their mortgage payment includes earthquake insurance and homeowner's insurance as part of a single premium. This lack of awareness suggests that following a disaster homeowners might file for federal aid without realizing that they have paid premiums for private insurance coverage. Clearly, the lending industry and the insurance industry have an unmet responsibility to educate the Puerto Rican population about their insurance coverage. The insurance commission and the lending regulators in Puerto Rico should act immediately to require lenders and insurers to notify homeowners and buyers of their coverage.

Third, we expected that the Puerto Rican homeowner who is more concerned with future natural disasters would be more likely to adopt mitigation measures, including earthquake insurance. This expectation was not supported by the empirical evidence. The primary analysis involved the extent to which insurance was adopted when not mandatory; the population subsample was those homeowners who did not have mortgage financing on their homes (20 to 25 percent of the respondents).

In California, we had previously found that perceived vulnerability was a clear predictor of earthquake insurance purchase. Those who felt that a major damaging earthquake was likely to affect their home or their community in the next ten years were more likely to purchase earthquake insurance. Thus, based on the California studies, we expected that perceived vulnerability would play a large role in differentiating those who voluntarily purchased insurance from those who eschewed insurance purchase.

We found, however, that although Puerto Ricans tend to see themselves at greater risk from earthquake damage than their counterparts in California, this variable — perceived risk — does not distinguish the insured from the uninsured. Thus the two regions show sharply different patterns in the prediction of

insurance purchase. We were surprised by both the levels of concern expressed by Puerto Ricans concerning earthquake vulnerability and the fact that this variable did not predict voluntary insurance purchase.

In California, economic and demographic variables have only limited power to distinguish the insured from the uninsured among those with no mortgage and virtually no discriminating power for the full population of owner-occupiers. The Puerto Rican findings were in sharp contrast. In Puerto Rico, only those homeowners with no mortgage have the option to purchase or not purchase earthquake insurance. Among this population, economic and demographic variables most clearly distinguish voluntary insurance purchase from nonpurchase. Thus, perceived risk, while higher in Puerto Rico, is not the primary distinguishing variable; instead it is income, home value, and educational level. These empirical findings suggest real differences in the impacts of cultural values and political economy on both individual perception of risk and the conversion of this perception into hazard mitigation behavior.

Our fourth expectation was that residents of municipios that had suffered more damage from Hurricane Hugo would have greater awareness of the risk, greater fears about future hurricanes, and greater tendencies to adopt mitigation measures including voluntary insurance. We found that with the exception of voluntary insurance purchase, experience with Hugo did seem to impact attitudes toward hazard vulnerability and the propensity to undertake other mitigation measures. Although this finding concerning insurance purchase contrasts with the post-Loma Prieta findings in California, this difference but may be partly explained by the economic constraints affecting households with no mortgage loan and by the fact that the hazard experienced event in Puerto Rico was a hurricane rather than an earthquake.

Fifth, we expected that since hurricanes occur more frequently than earthquakes in Puerto Rico, homeowners would be more concerned about hurricane hazards. Instead we found that, regardless of insurance status, Puerto Ricans are more concerned with earthquake hazards than with hurricanes, even after Hugo. This finding is surprising since the last major earthquake in Puerto Rico occurred in 1918, long before most respondents were born. This earthquake caused major damage to seaside communities on the west coast. This concern with earthquakes may be explained by studies (Slovic, et al., 1974) which suggest that more catastrophic, dramatic and sudden hazards are more likely to evoke feelings of fear and dread.

A related finding concerned the impacts of home location on areas perceived to be at risk. We found a myopic focus on the home municipio as susceptible to damage. Regardless of the hazard and the actual distribution of objective risk, people tend to focus on the vulnerability of their local municipio. This focus suggests that there is a feeling of vulnerability among Puerto Rican respondents. This widespread perceived vulnerability might be used by local and Commonwealth officials to educate homeowners to increase their security from natural disasters by adopting simple mitigation measures.

Policy Implications

This study has revealed several facts about the response of Puerto Ricans to natural hazards that should be useful for public policy. First, to our surprise, Puerto Ricans are far more concerned with the earthquake hazard than with the more common occurrences of flooding or hurricane damage. This concern should be used by the recently formed seismic safety commission in Puerto Rico to bring about land use controls, upgrade construction regulations, and induce investment in inexpensive and simple measures to increase household mitigation and preparedness in areas susceptible to damage from ground amplification, shaking, liquefaction or tsunamis.

A second finding is the lack of awareness by Puerto Rican homeowners of their insurance coverage. This lack of awareness is caused by two factors: (1) the requirement by Fannie Mae that earthquake insurance be purchased on mortgages originated in Puerto Rico to be resold on the secondary market and (2) the cooperation between lenders and insurers which makes the purchase of insurance an effortless and automatic part of obtaining mortgage financing. The lending industry in Puerto Rico might reasonably question the Fannie Mae requirements of earthquake insurance, which increase the cost of homeownership in Puerto Rico and are not applied in areas of greater seismic risk (Alaska, California). Further, the insurance purchase decision should be made clearer to home buyers so that they know the amount of coverage they are purchasing and the payment for that coverage.

A Final Word

The residents of Puerto Rico — local officials and citizens alike — responded in an organized and effective way to Hurricane Hugo, the most devastating hurricane to affect the island in more than 30 years. But disaster awaits. Studies suggest that the Commonwealth is vulnerable to earthquakes of a magnitude equivalent to the Loma Prieta earthquake in California and to a major hurricane each year between June and November. Puerto Rican homeowners who have invested little in mitigation measures are economically vulnerable to a future natural disaster, especially the uninsured, lower income population who carry no mortgage debt. This survey has shown a high level of concern on the part of Puerto Ricans to natural disasters in their local areas. We hope that this concern can be translated into a heightened degree of preparedness against the next major hurricane or earthquake to threaten the island.

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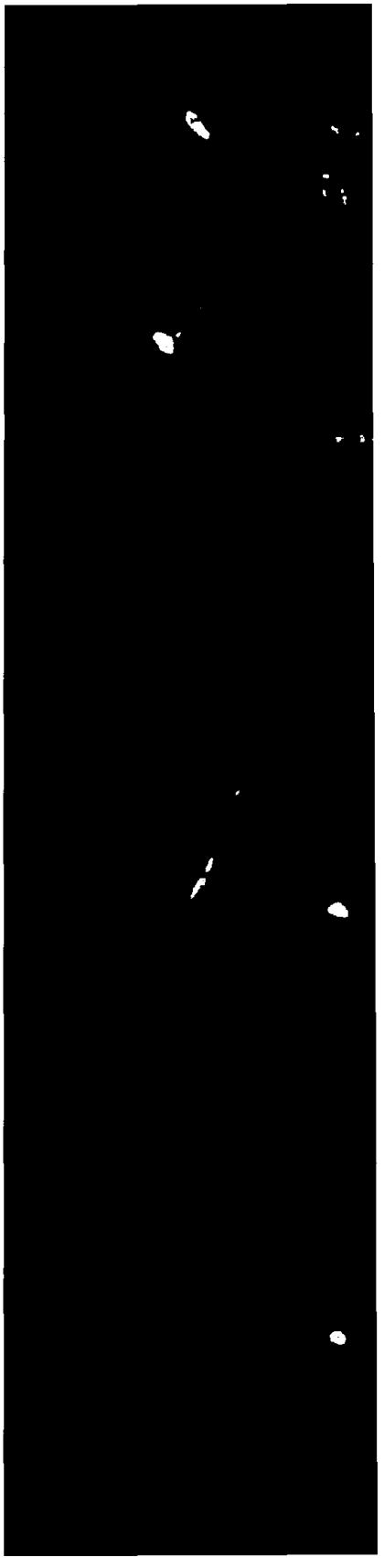

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Appendix: Puerto Rico Questionnaire

INSTRUCCIONES
[Instructions]

Este cuestionario tiene el propósito de obtener su opinión sobre los riesgos asociados a los huracanes, terremotos e inundaciones en Puerto Rico, así como otra información relacionada con su hogar. No le debe tomar más de 15 minutos contestar este formulario.

[The purpose of this questionnaire is to solicit your opinion about the risks associated with hurricanes, earthquakes and floods in Puerto Rico as well as other information about your household. It should not take more than 15 minutes to fill out this form.]

Agradecemos su cooperación - sus respuestas son muy importantes para los resultados de nuestro estudio.

[We appreciate your cooperation - these responses are very important for our study.]

P-1 ***Haga un círculo alrededor de la contestación que corresponda.***

[Circle your answer]

SI [yes] ***NO*** [no] ***¿Es usted el propietario de la casa cuya dirección aparece en la carta que acompaña este cuestionario?***

[Are you the owner of this house?]

SI [yes] ***NO*** [no] ***¿Es ésta su residencia principal?***

[Is this your principal residence?]

P-2 ***Indique el tipo de vivienda. Haga un círculo alrededor del número que mejor corresponda a su respuesta.***

[Indicate the type of housing unit - circle your answer]

1 ***Casa individual separada de otras*** [single family detatched]

2 ***Casa tipo "duplex"*** [double house; duplex]

3 ***Casa tipo "townhouse"*** [townhouse]

4 ***Un edificio de 3 pisos o más*** [3 or more dwelling units]

5 ***Otros (especifique)***
_____[other - specify]

P-3 ***Indique el principal material de construcción de la casa. Haga un círculo alrededor del número que mejor corresponda a su respuesta.*** [Indicate the construction material - circle your answer]

1 ***Concreto o bloque*** [concrete or block]
2 ***Concreto y zinc*** [concrete and zinc]
3 ***Madera y zinc/madera u otro***
[wood and zinc, wood and other]
4 ***Mampostería o ladrillo*** [masonry or brick/tile]
5 ***Otro (especifique)*** _____[other-specify].

P-4 ***¿Desde cuándo vive en esta dirección?***
_____***(año)***
[How long have you lived at this address?]

P-5 ***¿En qué año aproximadamente se construyó esta casa?*** _____***(año)***
[In what year, approximately, was this house built?]

PELIGROS DE HURACAN
[Hurricane hazards]

P-6 ***Piense en la posibilidad de que un huracán como Hugo azote <u>su comunidad</u>. ¿Cuán probable es que su comunidad se vea afectada por un huracán de ese tipo en los próximos 10 años? Haga un círculo alrededor del número que mejor corresponda a su respuesta.***
[Consider the possibility that a hurricane such as Hugo struck your community? What is the likelihood that your community would be affected by a hurricane of this type within the next 10 years?]

1 ***muy poco probable*** [not very likely]

2 ***poco probable*** [somewhat likely]
3 ***probable*** [likely]
4 ***muy probable*** [very likely]
5 ***altamente probable*** [highly likely]

P-7 ***¿Cuál cree usted que es la posibilidad de que <u>su casa</u> se vea afectada (por lo menos $1,000 en daños) por un huracán como Hugo en los próximos 10 años? Haga un círculo alrededor del número que mejor corresponda a su respuesta.***
[What is the probability that your house would be affected [at least $1000 in damage] by a hurricane like Hugo within the next 10 years? Circle your answer.]

1 ***muy poco probable*** [not very likely]
2 ***poco probable*** [somewhat likely]
3 ***probable*** [likely]
4 ***muy probable*** [very likely]
5 ***altamente probable*** [highly likely]

P-8 ***Supongamos que un huracán devastador azote su comunidad. ¿A cuánto cree usted que ascenderían los daños causados, <u>tanto a su casa como a su contenido</u>?***
[Suppose that a devastating hurricane struck yoiur community. How much damage do you think would be caused to your house as well as its contents?]

$_____ (valor en dólares de los daños a la casa y a su contenido)
[dollar value of damage to the house and its contents]

PELIGROS DE TERREMOTO
[Earthquake hazards]

P-9 ***Piense en la posibilidad de que un terremoto fuerte como el de México en 1985 afecte <u>su</u>***

<u>comunidad</u> en los próximos 10 años. ¿Cuán probable es que su comunidad se vea afectada por un terremoto de esa magnitud? Haga un círculo alrededor del número que mejor corresponda a su respuesta.

[Think of the possibility of an earthquake as strong as the 1985 Mexico City earthquake affecting your community in the next 10 years. What is the likelihood that your community would be affected by an earthquake of this magnitude? Circle your answer.]

1 ***muy poco probable*** [not very likely]
2 ***poco probable*** [somewhat likely]
3 ***probable*** [likely]
4 ***muy probable*** [very likely]
5 ***altamente probable*** [highly likely]

P-10 ¿Cuál cree usted que sería la posibilidad de que <u>su casa</u> se vea afectada (por lo menos $1,000 en daños) por un terremoto de tal magnitud en los próximos 10 años? Haga un círculo alrededor del número que mejor corresponda a su respuesta.

[What do you think is the probability that your house would be affected (at least $1000 in damage) by an earthquake of such a magnitude within the next ten years? Circle your answer]

1 ***muy poco probable*** [not very likely]
2 ***poco probable*** [somewhat likely]
3 ***probable*** [likely]
4 ***muy probable*** [very likely]
5 ***altamente probable*** [highly likely]

P-11 Supongamos que un terremoto devastador afecte su comunidad. ¿A cuánto cree usted que

ascenderían los daños causados, <u>tanto a su casa como a su contenido</u>?
[Let us suppose that a devastating earthquake struck your community. How much damage do you think would be caused to your house as well as to its contents?]

$_____(valor en dólares de los daños a la casa y a su contenido)
[dollar value of damage to the house and its contents]

PELIGROS DE INUNDACION
[Flood hazards]

P-12 ¿Cuál es la posibilidad de que <u>su comunidad</u> sufra serios daños por inundaciones en los próximos 10 años? Haga un círculo alrededor del número que mejor corresponda a su respuesta.
[What is the probability that your community would suffer serious damage from flooding within the next 10 years? Circle your answer.]

1 ***muy poco probable*** [not very likely]
2 ***poco probable*** [somewhat likely]
3 ***probable*** [likely]
4 ***muy probable*** [very likely]
5 ***altamente probable*** [highly likely]

P-13 ¿Cuál cree usted que es la posibilidad de que <u>su casa</u> se vea afectada (por lo menos $1,000 en daños) por inundaciones en los próximos 10 años? Haga un círculo alrededor del número que mejor corresponda a su respuesta.

[What do you think is the probability that your house would be affected (at least $1000 in damage) by a flood within the next ten years? Circle your answer]

1 ***muy poco probable*** [not very likely]

2 ***poco probable***
[somewhat likely]
3 ***probable*** [likely]
4 ***muy probable*** [very likely]
5 ***altamente probable*** [highly likely]

P-14 ***Supongamos que una inundación mayor afecte su comunidad. ¿A cuánto cree usted que ascenderían los daños causados, tanto a su casa como a su contenido?***

[Let us suppose that a major flood occurred in your community. How much damage do you think would be caused to your house as well as to its contents?]

$_____(valor en dólares de los daños a la casa y a su contenido)
[dollar value of damage to the house and its contents]

COMPAREMOS VARIOS DESASTRES NATURALES
[Comparisons of various natural hazards]

P-15 ¿Cuán preocupado está usted de que cada uno de los siguientes desastres le cause serios daños a su casa? Haga un círculo alrededor del número que mejor corresponda a su respuesta para cada uno de los desastres.
[How concerned are you about the following natural disasters causing serious damage to your home? Circle your answer.]

Huracán [hurricane]
1 ***muy poco preocupado***
[Very little concerned]
2 ***poco preocupado***
[Slightly concerned]
3 ***preocupado***
[Moderately concerned]
4 ***muy preocupado***

[Very Concerned]
5 ***altamente preocupado***
[Highly concerned]

Inundación [flooding]
1 ***muy poco preocupado***
[Very little concerned]
2 ***poco preocupado***
[Slightly concerned]
3 ***preocupado***
[Moderately concerned]
4 ***muy preocupado***
[Very Concerned]
5 ***altamente preocupado***
[Highly concerned]

Terremoto [earthquake]
1 ***muy poco preocupado***
[Very little concerned]
2 ***poco preocupado***
[Slightly concerned]
3 ***preocupado***
[Moderately concerned]
4 ***muy preocupado***
[Very Concerned]
5 ***altamente preocupado***
[Highly concerned]

Derrumbe de tierra [landslide]
1 ***muy poco preocupado***
[Very little concerned]
2 ***poco preocupado***
[Slightly concerned]
3 ***preocupado***
[Moderately concerned]
4 ***muy preocupado***
[Very Concerned]
5 ***altamente preocupado***
[Highly concerned]

ESTA SECCION SE REFIERE AL HURACAN HUGO DE SEPTIEMBRE DE 1989. EL HURACAN HUGO HA SIDO EL MAS INTENSO QUE HA AFECTADO A PUERTO RICO EN MUCHAS DECADAS.
[This section refers to Hurricane Hugo of September 1989. Hurricane Hugo was the most intense hurricane in Puerto Rico in many decades.]

P-16 ¿Causó el huracán Hugo algún tipo de daño a su casa o su contenido? Haga un círculo alrededor del número que mejor corresponda a su respuesta.
[Did Hurricane Hugo cause damage to your house or its contents? Circle the answer.]

2 ***NO*** [no]
1 ***SI*** [yes]

Si contestó afirmativamente,Indique por favor ¿cuán afectada quedó su casa y su contenido? Haga un círculo alrededor del número que mejor corresponda a su respuesta.
[If yes, to what degree did your house suffer damage? Circle your answer.]

1 ***daños muy ligeros***
[very light damage]
2 ***daños ligeros*** [light damage]
3 ***daños considerables***
[considerable damage]
4 ***daños muy considerables***
[very considerable damage]
5 ***daños severos***
[severe damage]

Por favor estime la cantidad total de los daños a su casa y su contenido.
[Please estimate the total dollar damage to your house and its contents.]

$____(valor en dólares de los daños a la casa y a su contenido)
[Dollar value of damage to the house and its contents]

P-17 ***Estime cuán distante de su hogar está <u>la casa más cercana</u> que haya sido afectada (más de $1,000 en daños) por el huracán Hugo. Haga un círculo alrededor del número que más se aproxime a su respuesta.*** [Estimate the distance between your home and the nearest house that suffered at least $1000 damage from Hurricane Hugo. Circle your answer.]

1 ***a menos de 10 metros (30 pies)*** [less than 10 meters (30 feet]
2 ***de 10 a 100 metros (entre 30 y 300 pies)*** [10-100 meters (30-300 feet)]
3 ***de 100 a 1,000 metros (entre 300 pies y media milla)*** [100-1000 meters (300 feet - 1/2 mile)]
4 ***de 1 a 10 kilómetros (entre media milla y 3 millas)*** [1/2 mile-3 miles]
5 ***a más de 10 kilómetros (más de 3 millas)*** [more than 3 miles]

P-18 ***¿Tiene usted familiares o amigos cuyas casas y/o contenido fueron afectadas por el huracán? Haga un círculo alrededor del número que mejor corresponda a su respuesta.***
[Do you have family or friends whose houses or their contents were damaged by the hurricane? Circle your answer.]

1 ***SI*** yes]
2 ***NO*** [no]
3 ***NO SE*** [dont know]

P-19 ***¿Interrumpió el huracán Hugo su rutina diaria?***
[Was your daily routine interrupted by Hurricane Hugo?]

2 ***NO*** [no]
1 ***SI*** [yes]
Si la contestó afirmativamente, Describa detalladamente de qué forma fue interrumpida su rutina diaria:

[If yes, describe the way in which your daily routine was interrupted.]

P-20 Después del huracán Hugo, ¿ha tomado usted alguna medida para reducir los daños que podría causar un huracán a su casa? No incluya la compra de seguros.

[Since Hurricane Hugo, have you taken any measures to reduce potential damage to your house from a hurricane? Do not include the purchase of insurance.]

1 ***SI*** [yes]

Si contestó afirmativamente, [if yes,]

¿Qué hizo? ***Mes/Año*** ***Costo $***

[What have you done? Month/year Cost]

---

2 ***NO***[no]

Si contestó negativamente, [If no]

Indique por qué no ha tomado medidas para proteger su casa. Haga un círculo alrededor de los números que correspondan.

[Why didn't you take measures to protect your house. Circle your answer.]

1 ***Es muy costoso*** [too expensive]
2 ***No es necesario*** [not necessary]
3 ***El seguro cubrirá los costos*** [insurance will cover the costs]
4 ***Nunca me decidí a hacerlo*** [I never got around to it]
5 ***No tengo el tiempo*** [I dont have the time]
6 ***Falta de recursos economicos*** [I dont have enough money]
7 ***No se que medidas tomar*** [I dont know what measures to take]

8 Otra razón (explique)
[Other, describe]

P-21 ***¿Está asegurada su propiedad contra huracanes?***
[Is your property insured against hurricanes?]

2 NO [no]

1 SI [yes]

Si contestó afirmativamente,
¿Cuál es el límite de su cubierta de seguro contra huracanes?
[If yes, what is the limit of your coverage against hurricanes?]

$_____(escriba la cantidad en dólares) [in dollars]

¿Cubre su póliza de seguro contra huracanes el valor actual de su casa?
[Does your hurricane insurance policy cover the full value of your house?]

1 SI [yes]
2 NO [no]

Si contestó negativamente:
¿Cuáles son las razones por las que decidió no actualizar su seguro contra huracanes al valor actual de su casa?
[If no, why did you decide to have less than the full value of your house insured against hurricanes?]

_____

P-22 ***Puerto Rico también es vulnerable a <u>terremotos</u>. ¿Ha tomado usted alguna medida para reducir los daños que podría causar un terremoto a <u>su casa</u>. No incluya la compra de seguros.***

[Puerto Rico is also vulnerable to earthquakes. Have you taken measures to reduce damage to your home that could be caused by an earthquake?]

1 ***SI*** [yes]
Si contestó afirmativamente, [If yes,]

¿Qué hizo?	***Mes/Año***	***Costo $***
[What have you done?	Month/year	Cost]

2 ***NO*** [no]
Si contestó negativamente, [If no,]

Indique por qué no ha tomado medidas para proteger su casa. Haga un círculo alrededor de los números que correspondan.
[Why didn't you take measures to protect your house. Circle your answer.]

1 ***Es muy costoso*** [too expensive]
2 ***No es necesario*** [not necessary]
3 ***El seguro cubrirá los costos***
[insurance will cover the costs]
4 ***Nunca me decidí a hacerlo***
[I never got around to it]
5 ***No tengo el tiempo*** [I dont have the time]
6 ***Falta de recursos economicos***
I dont have enough money]
7 ***No se que medidas tomar***
[I dont know what measures to take]
8 ***Otra razón (explique)*** [Other.

P-23 ¿Está asegurada su propiedad contra terremotos?
[Is your property insured against earthquakes?]

2 ***NO*** [no]

1 SI [yes]

Si contestó afirmativamente, ¿Cuál es el límite de su cubierta de seguro contra terremotos? [If yes, what is the limit of your coverage against earthquakes?]

$_____(escriba la cantidad en dólares) [in dollars]

¿Cubre su póliza de seguro contra terremotos el valor actual de su casa?
[Does your earthquake insurance policy cover the full value of your house?]

1 SI [yes]
2 NO [no]

Si contestó negativamente: ¿Cuáles son las razones por las que decidió no actualizar su seguro contra terremotos al valor actual de su casa?
[If no, why did you decide to have less than the full value of your house insured against earthquakes?]

P-24 Puerto Rico también es vulnerable a inundaciones. ¿Está su casa localizada en una zona inundable?
[Puerto Rico is also vulnerable to flooding. Is your house in a flood zone?]

1 SI [yes]
2 NO [no]
3 NO SE [dont know]

P-25 ¿Ha tomado usted alguna medida para reducir los daños que podrían causar las inundaciones a <u>su casa</u>. No incluya la compra de seguros. [Have you

taken any measures to reduce the damage that could be caused by flooding to your house? Do not include insurance purchase.]

1 SI

Si contestó afirmativamente, [If yes,}

¿Qué hizo?	***Mes/Año***	***Costo $***
[What have you done?	Month/year	Cost]

2 ***NO*** [no]

Si contestó negativamente,[If no,]

Indique por qué no ha tomado medidas para proteger su casa. Haga un círculo alrededor de los números que correspondan.

[Why didn't you take measures to protect your house. Circle your answer.]

1 ***Es muy costoso*** [too expensive]
2 ***No es necesario*** [not necessary]
3 ***El seguro cubrirá los costos***
[insurance will cover the costs]
4 ***Nunca me decidí a hacerlo***
[I never got around to it]
5 ***No tengo el tiempo***
[I dont have the time]
6 ***Falta de recursos economicos***
[I dont have enough money]
7 ***No se que medidas tomar***
[I dont know what measures to take]
8 ***Otra razón (explique)*** [Other,

P-26 ¿Está asegurada su propiedad contra inundaciones?

[Do you have flood insurance?]

2 ***NO*** [no]

1 ***SI*** [yes]
¿Cuál es el límite de su cubierta de seguro contra inundaciones?
[If yes, what is the limit of your flood insurance coverage?

$_____(escriba la cantidad en dólares) [in dollars]

P-27 ***¿Conoce usted a alguien que tenga su propiedad asegurada contra inundaciones?***
[Do you know anyone who has bought flood insurance?]

1 ***SI*** [yes]
2 ***NO*** [no]

P-28 ***¿Ha sido su casa actual afectada por inundaciones o un huracán que no sea Hugo?***
[Has your house ever been damaged by floods or hurricanes other than Hugo?]

2 ***NO*** [no]

1 ***SI*** [yes]
Si contestó afirmativamente,

¿En qué año?_____[If yes, in what year?]

¿A cuánto ascendieron los daños? [How much damage?]

$_____(valor en dólares de los daños a la casa y su contenido)
[dollar damage to the house and its contents]

P-29 ***¿Ha vivido usted en otra casa que haya sufrido daños por huracanes o inundaciones?***
[Have you ever lived in another house that suffered damage from hurricanes or floooding?]

1 ***SI*** [yes]
2 ***NO*** [no]

P-30 De acuerdo a su apreciación, ¿qué pueblo o municipio de Puerto Rico es más vulnerable a daños causados por:
[In your opinion, which town or county in Puerto Rico is most vulnerable to damage caused by:]

Huracanes [hurricanes]
:_____

Terremotos [earthquakes]
:_____

Inundaciones[floods]:_____

Derrumbes de tierra [landslides]: _____

FINALMENTE QUEREMOS HACERLE ALGUNAS PREGUNTAS ACERCA DE SU CASA PARA PROPOSITOS ESTADISTICOS.[
Finally, we have some questions about your household for statistical purposes.]

P-31 Aproximadamente, ¿cuál fue el ingreso total de su familia en 1990? Haga un círculo alrededor del número que mejor corresponda a su respuesta.
[Approximately what was your total gross family income in 1991. Circle your answer.]

1 $75,000 *ó más*
2 $50,000 - 74,999
3 $25,000 - 49,999
4 $15,000 - 24,999
5 $10,000 - 14,999
6 $5,000 - 9,999

7 ***menos de*** **$5,000**

P-32 En qué año nació usted? [In what year were you born?]
19____

(año nació)

P-33 Haga un círculo alrededor del número que mejor corresponda al grado más alto completado:
[Circle the number that corresponds with the highest educational level completed.]

1. ***Primero a sexto grado*** [1-6 grade]
2. ***Séptimo grado*** [7 grade]
3. ***Octavo grado*** [8 grade]
4. ***Noveno grado*** [9 grade]
5. ***Décimo grado - Escuela Superior***
[10th grade - high school]
6. ***Undécimo grado - Escuela Superior***
[11th grade - high school]
7. ***Duodécimo grado - Escuela Superior***
[12th grade - high school]
8. ***Primer año de Universidad***
[1st year of university]
9. ***Segundo año de Universidad***
[2nd year of university]
10. ***Tercer año de Universidad***
[3rd year of university]
11. ***Cuarto año de Universidad***
[4th year of university]
12. ***Estudios graduados de Maestría***[M.A. degree]
13. ***Estudios graduados de Doctorales***
[Ph.D. or M.D. degree]
14. ***Otros (por favor especifique)***___[Other, specifiy]

P-34 ¿En cuánto considera usted que se vendería su casa, incluyendo el terreno, si estuviera en venta actualmente?
[What is the market value of your house?]

$_____***(valor en el mercado de la estructura y el terreno)*** [market value of the structure and land]

P-35 De esta cantidad, ¿cuánto sería el valor de la estructura (casa) solamente?
[Of this market value, what is the value of the house (structure) only?]

$_____***(valor de la estructura)*** [value of the structure]

P-36 Aproximadamente, ¿cuánto debe usted de la hipoteca de la casa?
[Approximately how large is the mortgage on the house?]
$_____***(balance hipotecario adeudado)*** [mortgage balance]

LE DAMOS LAS MAS EXPRESIVAS GRACIAS POR SU COOPERATION CON ESTA ENCUESTA
[We thank you for your cooperation in this survey.]