DISCUSSION PAPER

February 2015 ■ RFF DP 15-01

Understanding Flood Risk Decisionmaking

Implications for Flood Risk Communication Program Design

Carolyn Kousky and Leonard Shabman

1616 P St. NW
Washington, DC 20036
202-328-5000 www.rff.org

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Abstract

Floodplain land-use decisions are made by individuals in households, businesses, and local governments. Whatever the venue, the decisions made are the outcome of multiple interacting influences, with one being consideration of flood risk. The goal of a flood risk communication program may be to improve the understanding of flood risk among those making decisions. An alternative goal may be to change the decisions made. Understanding how individuals make decisions and the mental strategies they employ, as well as understanding the larger context of decisionmaking, will contribute to better defining the goals of a flood risk communication program and then designing a program that will secure those goals.

Key Words: flood risk, decisionmaking, risk communication, biases and heuristics

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Carolyn Kousky and Leonard Shabman*

1. Introduction

Federally planned and funded flood hazard reduction projects are no longer the focus of national flood risk[1] management policy. Over the last several decades, policy has shifted away from building flood hazard control projects and toward expecting those who locate in flood-prone areas to be more informed about flood risk and more responsible for bearing the costs of risk reduction measures and the residual risk of flood damage. This can be seen by the declining amount spent on new flood hazard reduction projects and the importance of the National Flood Insurance Program (NFIP) in managing financial risks of floods. In addition, increasing federal disaster relief spending has drawn attention to floodplain land use and flood risk reduction measures, as seen following Hurricane Sandy in 2012. All of this has made flood risk communication an essential part of federal flood risk management programs.

The agencies involved in managing flood risk have taken different approaches and have multiple programs to communicate flood risk. For example, the US Army Corps of Engineers has created a levee safety program[2] for flood hazard reduction infrastructure that may need renewal or upgrading when the original design performance of the structures is exceeded because of changing hydrology or changes in population and assets exposed to hazards. Given its limited federal budget allocations, the Corps' emphasis is on helping nonfederal units of government understand changes in flood risk—communication efforts—and take actions for levee enhancement and maintenance. The Corps has also developed the Silver Jackets program[3] to help communities appreciate their flood risk, become aware of federal programs available to them,

* Fellow and resident scholar, respectively, Resources for the Future. The authors would like to thank the following individuals for helpful feedback and discussions on this paper: Paul Scodari, Doug Woolley, Mark Lorie, and Howard Kunreuther.

[1] The term flood risk as used in this report refers to the likelihood of a flood (the flood hazard) and the adverse consequences to communities, households, and businesses if a flood does occur. For a rigorously developed comprehensive vocabulary of terms, see Shabman et al. (2014).

[2] See http://www.usace.army.mil/Missions/CivilWorks/LeveeSafetyProgram.aspx.

[3] See http://www.nfrmp.us/state/.

and most importantly, take action to reduce and manage that risk. The Federal Emergency Management Agency (FEMA) has made communication of flood risk one goal of the NFIP, through floodsmart.gov, floodplain mapping activities, and free tools such as Hazus. The National Oceanic and Atmospheric Administration (NOAA) provides tools to help communities understand storm surge and sea level rise risk, including online mapping viewers. The US Geological Survey uses the Flood Inundation Mapping Program to communicate flood risk information to communities.[4] In addition, interagency partnerships are being organized around flood risk communication.[5]

These federal agencies are seeking to ensure that local governments and individuals appreciate their flood risk.[6] Congress, through legislation, has also emphasized the importance of risk communication. For example, Section 9 of the Homeowners Flood Insurance Affordability Act, passed in early spring 2014, calls on FEMA to make "[a]ccurate communication to consumers of the flood risk associated with their properties" part of its flood insurance reform efforts. Executive branch initiatives have made understanding and then communicating flood risk a high priority. The Obama administration has reconvened the Federal Interagency Flood Management Task Force, which has flood risk communication as one focus.[7]

This increasing federal commitment to flood risk communication begins with the recognition that elected and appointed officials in local government jurisdictions,[8] as well as individual landowners, renters, and business owners, are most responsible for decisions on floodplain land use and the adoption of flood risk reduction and management actions. The federal role, therefore, is often limited to influencing these choices through information provision and communication of expert knowledge. It follows that the design of effective risk

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[4] See: http://water.usgs.gov/osw/flood_inundation/toolbox/files/ProgramDevelopmentTools/FIMProgramFactSheetoptimized.pdf

[5] See, for example, https://www.fema.gov/coastal-flood-risks-achieving-resilience-together.

[6] Federal risk communication programs should include more than information on the flood hazard, likelihood of the flood and potential consequences. Information must also include descriptions of federal flood risk management program missions and capabilities as part of risk communication efforts so that floodplain decision makers have a realistic basis for determining how program services may affect their available choices and costs.

[7] See https://www.fema.gov/floodplain-management/federal-interagency-floodplain-management-task-force.

[8] The word jurisdiction emphasizes that government authorities at the sub state level, including such special-purpose governments as levee districts, have revenue, spending, and regulatory authorities that can influence flood risk within their boundaries.

communication programs requires an understanding of how such choices are made by the actual decision makers. To advance that understanding, this paper describes the complex system of influences faced by individuals in local governments when making regulatory, tax, and spending decisions; the influences faced by businesses owners when making decisions on land development and use; and the influences faced by households when choosing to occupy properties in a floodplain and invest in any risk reduction measures. We also review what is known about how individuals process and evaluate risk information. We provide an overview of individual decisionmaking in the presence of risk, drawing on the rich literature on this topic. Only by appreciating how these decisions are made can the goals of flood risk communication programs be defined and then the success of those programs in meeting their objectives evaluated.

The next section of this report provides an overview of decisionmaking related to flood risk by households, businesses, and local governments. Section 3 reviews the literature on how individuals process risk information and make risk-related decisions. The report next discusses the implications of the literature for risk communication practices (section 4) and risk communication program goals (section 5). Section 6 describes how the effectiveness of risk communication can be affected by the content of the message and who is the messenger.

2. Floodplain Location and Risk Management Choices

This section seeks to describe, in broad terms, flood risk management decisions and who makes them. Floodplain land use begins with decisions made by landowners, within constraints imposed by law and regulation. Beginning with vacant land (which here includes agricultural land), the alternatives for a landowner are to not develop, develop and sell, develop and occupy, or develop and lease. If the floodplain land is already developed, the alternatives include whether to occupy the site "as is" or further develop the site, with or without accompanying actions to reduce flood risk exposure (e.g., remove all or part of a structure, elevate the building) and vulnerability (e.g., wet or dry flood proofing, moving back-up generators to a higher elevation) or to increase resiliency (e.g., purchase insurance). This means that available flood risk management options are place-specific and the actions taken in response to a flood risk communication program cannot be the same in every location (Box 1).

Most generally, whether a household or business chooses to remain in or newly locate in a floodplain and how local officials regulate floodplains will be based, in some rough fashion, on a consideration of the "benefits" of that location weighed against the costs, including the possible adverse consequences of flooding and the costs of any risk reduction or management action. The

determinants of flood risk are the likelihood of the hazard and the consequences of the hazard if it occurs. As we will discuss, an individual's understanding of probability and likelihood as well as the consequences of flooding may differ from an expert's and vary across individuals. Individuals' evaluation of the consequences of flooding will also include their understanding and perception of federal flood risk programs and their role.[9] (The formation of expectations of flood risk is discussed in detail in Section 3.) Understanding of flood risk is only one of multiple interacting influences on floodplain land-use decisions.

Box. 1. Options for Floodplain Management

Decisions that affect flood risk rarely begin from a blank slate. Past hazard reduction project investments and land settlement choices can constrain or otherwise influence communities' and individuals' possible subsequent choices. For example, historically, people often settled in floodplains to realize the benefits of fertile soils, access to water transportation, and opportunities to be near the recreational and aesthetic amenities provided by proximity to bodies of water. Thus there are many places where people and assets are already in areas subject to flood risk, so the available measures for dealing with that flood risk may be limited. For example, moving structures and utilities on a large scale can be costly and is typically judged to be impractical or undesirable by the community and residents themselves. Individuals who own properties that experience flood damage (especially if flooding has been recent) will realize lower property values, which in turn reduce their ability to sell and move to safer locations; thus, rebuilding in place is often considered the best available option. In such cases, adjustments to flood risk might be the construction or improvement of a levee, some flood proofing, and increased purchase of insurance. A decision to construct or improve a levee could influence future flood risk reduction and management actions. Those future actions may be in response to changes in the economic value of the land in the floodplain, changes in the population settled in the floodplain, or changes in hydrology that have altered the flood hazard.

Local government decisionmaking related to floodplain land use is also highly constrained by physical topography. In some jurisdictions, the best available land for community expansion

[9] FEMA NFIP flood insurance rate maps, insurance purchase requirements, and premium levels may serve as risk communication to households. Expectations for a new or upgraded Corps hazard reduction project, or Corps or FEMA assessments of the soundness of a levee and may alter household perceptions of the adverse consequences should a flood occur, as might expectations for different types and levels of disaster assistance.

may have some flood risk, even if the likelihood of flooding is remote. In other jurisdictions, land available for development is well outside the floodplain. Communities also face different types of flood risks, such as slow and easily predicted rates of rise in a river due to rainfall or upstream snowmelt versus flash floods. And almost every community has small streams with relatively small drainage areas where flooding may result from rapid changes in the hydrograph during intense storm events; such stormwater flooding is especially prevalent in rapidly urbanizing areas.

2.1 Household Decisions

A household's[10] perceived expected "net benefits"[11] from a floodplain location are based on an evaluation of the amenities and dis-amenities from choosing that location. Amenities and dis-amenities can be divided into neighborhood and location characteristics and attributes of the specific property. Characteristics of the neighborhood or location include factors such as the crime rate and property tax rate; those of the specific location may include the size of the lot, layout of the structure, and proximity to public transit, the workplace, and recreational areas, such as beaches, trails, and parks. Of course, when deciding where to locate or whether to remain in a location, individuals also face a household budget constraint. In addition, local or federal regulations may constrain their choices. For example, households with a federally backed or regulated mortgage in a FEMA-mapped high flood risk area must purchase a flood insurance policy or local jurisdictions may regulate building in high-risk areas.

Some amenities, like water views and aquatic recreation, are directly associated with the flood risk at the property. Hence, a household may need to weigh the immediate and readily understood advantages of a property with the uncertain prospect of suffering the unfamiliar consequences of flooding (e.g., property replacement and repair, inconvenience, post flood trauma). Perceptions of the extent of federal pre flood and post flood assistance programs can affect the perceived cost of the location decision.

[10] The word household refers to a renter or an owner-occupant, although flood damages experienced by a renter are limited to the contents of a residence.

[11] The expected net benefits are the judgment made by the household (not by an outside observer) about the effect on its well-being from the location choice.

2.2 Business Decisions

Whether a business is a small proprietorship or a large corporation, it will base its decisions on the profitability of a location choice. Possible measures of profitability include return on investment, payback period in relation to expected time at that location, or positive cash flow. Location characteristics that can influence profitability include distance to suppliers, customers, competitors, complementary business, and skilled employees, plus transport access and goodwill based on longevity at the location. Some variables that can influence profitability may be associated with flood risk at the property: for example, proximity to navigable waters or the topography of the site. Joint consideration of these influences will yield expectations for profitability, which take into account the firm's evaluation and knowledge of potential flood losses.

The location decision is intertwined with—and can be influenced by—what the firm believes to be the flood risk reduction and management options available to it. If a business feels that it could take risk-reducing actions at a cost less than the returns for that location choice, it may be more likely to locate in a flood-prone area. A business may deem a floodplain location profitable if it believes that the cash flow will be adequate to pay for flood insurance premiums.

These profitability calculations depend on expected flood risk, which can vary across different businesses. Large corporations considering making investments in flood-prone areas may have the ability to carefully assess available data to determine flood risk. They may also have the assets to self-insure or otherwise absorb the risk of flood losses. Smaller businesses, especially proprietor-owned small businesses, may need to rely on publicly available information, which they may seek out to various extents. Or a small business may observe other, larger businesses that have located in the area and make inferences about flood risk based on their investment decisions. And, as for households, perceptions of federal pre flood and post flood assistance programs can affect the expected costs of the location decision.

2.3 Local Government Jurisdictions' Decisions

Household and business decisions are influenced by the decisions of local government jurisdictions. Local government decisions vary from issuing and enforcing land regulations to implementing a local flood hazard reduction project with tax implications for every resident of the community. These local government decisions are sometimes the outcome of a public debate that is finalized through a referendum. In other cases local decisions emerge from internal deliberations within the government bureaucracy and are approved by locally elected representatives.

Each decision is a result of who participates, the roles of the participants, and the rules by which a decision is made. The participants and the decision processes vary across and within communities. Those who believe they are most affected by any decision may be most vocal in expressing their views and attempting to influence the authorities. For any given decision, these "stakeholders"[12] may include neighborhood coalitions, labor groups, business and real estate interests, construction contractors, environmental groups, and other bureaus of government.

Local decision authorities—those with the legally sanctioned responsibility to take regulatory action, levy taxes and fees, and make spending decisions—are not supposed to be a blank slate on which the preferences of the most influential stakeholders are written. Rather, these authorities are expected to advance the general welfare of the citizens; as a general matter, most interpret that duty as securing a favorable business climate to increase jobs and incomes and tax revenues needed to support desired levels of public services within a local government budget.

To be sure, these local government decisions on floodplain land-use regulations and community hazard reduction are influenced by both stakeholder groups and community officials' perceptions of and attitudes toward flood likelihoods and potential consequences. But these are not the only considerations in any decision; trade-offs and budget constraints are always relevant. This reality is best illustrated by an example. Imagine a decision on whether a new critical facility—a police station[13]—might be located at the inside edge of the 1 percent floodplain. However, also suppose that a building is available and can be readily adapted to the police needs at a price affordable to the community, and there are other police stations that are not at risk of flooding. Also assume that the surrounding area has a high incidence of crime, which the new police facility is expected to deter. In this situation, even recognizing flood risk, a responsible decision might be locating the police station in the available but possibly flood-prone building.

[12] Each stakeholder advocates to decision authorities for policies, programs, tax and spending decisions that will serve his or her objectives. At times, advocacy may be for self-serving decisions and at other times the decisions advanced may be argued to be good for the community as a whole. Indeed, the typical argument is that decisions that benefit a particular stakeholder also benefit the community at large. As one example, a land developer may argue that a zoning change to allow the construction of residential and commercial buildings in part of a floodplain will spin off jobs and create affordable housing. Meanwhile, other stakeholders may advocate for a bike path or park in that same area, arguing that this use of the land will add to the community's quality of life.

[13] A police station is defined in Executive Order 11988 as a critical facility that should not be placed in that location.

3. Perceptions of and Attitudes toward Flood Risk

Flood risk communication programs seek to influence individuals' floodplain location and flood risk reduction and management choices. As just discussed, these choices are made by individuals in their roles in a household, business, or community. The preceding section described the larger context that may influence those choices. This section focuses on how individuals form an understanding of the likelihood of the flood hazard and the consequences of their exposure and vulnerability to the hazard.

Research in the behavioral sciences has explored individuals' attitudes toward risk as well as the ways in which individuals perceive that risk and act on that understanding. Researchers have defined three categories of risk attitudes, found two systems of thinking, and within one system, identified mental shortcuts, called heuristics, which individuals may use when making decisions about risk. Differences in risk attitudes and how these may affect decisions about flood risk specifically are discussed first in Section 3.1, followed by explanation of the two systems of thinking and then the decision heuristics. In each section, implications for the understating of and acting on flood risk are noted.

One caution about this review is necessary. The literature is most often a report from a controlled experiment where a single heuristic from among many, or a focus on risk attitudes, is isolated in order to be studied. However, as will be evident, some heuristics taken in isolation will suggest one conclusion about how a decision would be made, and others taken in isolation will suggest a different decision. As a result, in a real-world setting, different individuals may employ different and contradictory heuristics or have different risk attitudes. Thus, an initial step in developing a risk communication program might be describing which system of thinking, risk attitude, and heuristics will govern an individual's choice making, but that may be difficult to do.

3.1 Risk Attitudes

Decisionmaking about flood risk requires the individual to recognize a range of possible outcomes of any decision and anticipate the likelihood of each and its associated net benefit. Attitudes toward flood risk refer to an individual's willingness to accept that risk. More specifically, some individuals can be risk averse, some risk seeking, and others risk neutral. Risk-neutral individuals are indifferent to the likelihood of different outcomes and make decisions based on the expected value of all possible outcomes. Risk-averse individuals prefer a certain to an uncertain outcome, even if the expected benefit of all the possible uncertain outcomes could be greater. Risk seekers are the reverse, being willing to forgo the expected benefits of certain outcome with the hope of a much larger payoff.

Illustrations from business decisionmaking about floodplain location can be instructive in understanding how context may affect risk attitude. For example, consider two kinds of businesses making a decision about opening a store at the same location. If the store is part of a large chain that has many locations around the country, such that the loss of one store is not going to bankrupt the company, the business may base the decision on the expected profit. But if the store is the only outlet of a small business whose total assets and operations are in that one location, the owner might be risk averse and choose a less profitable location where the risk of bankruptcy due to a flood would be sharply reduced.

Beyond the effect of context, individuals may have a different risk attitude (willingness to accept risk) depending on their perceived nature of the risk or its consequences. Risk attitudes are known to be affected by whether individuals feel they have control over the risk, whether they accepted it voluntarily, and whether it could be catastrophic (Slovic 1987). Returning to the business illustration above, the small business owner's risk attitude may depend on whether a flood could be catastrophic or cause only shallow flooding and minimal damage.[14] The behavioral findings discussed below indicate, however, that individuals may make decisions that differ from simple predictions based on risk attitudes or that risk attitudes can be more complex functions of the decisionmaking setting.

3.2 Systems of Thinking and Flood Risk Perception

The behavioral science literature often builds off a description of two different mental processes by which individuals receive, interpret, and then act on risk information (e.g., Kahneman 2013). "System 1" describes "intuitive" choice-making that employs decision heuristics, or mental shortcuts. This leads to faster decisionmaking. (An extended discussion of System 1 thinking follows in the next section.) Individuals also have the capacity to employ "System 2" thinking, which allows for complex choice-making. System 2 thinking is considered a deliberative and time-consuming process that may rest on sophisticated analytical processes.

[14] The lower expected damages in this illustration would be reflected in an expected net benefits decision criterion. If the decisionmaker was risk neutral, then the expected value would be the choice criterion. The risk attitude in this illustration is a result of an effect of the possibility of catastrophic loss on the choice criterion itself, making the individual risk averse.

System 2 thinking might be understood as how technical experts[15] with professional responsibilities in flood risk management would come to understand the likelihood and consequences of flooding. These experts would use best available technologies for securing data on the phenomena of interest, then use statistical procedures or simulation models to assess the data and report the results of that analysis as risk information.[16] That said, it should be noted that experts are not always immune from the potential biases of System 1 thinking. It has been shown that experts can have different risk perceptions across disciplines, for example, or by place of employment (e.g., Bostrom 1997).

We can expect most individuals to use System 1 thinking when faced with flood risk decisionmaking. Indeed, expecting people to employ System 2 thinking for infrequent events (like flooding) may be unrealistic, since they would need to invest time in acquiring relevant information and converting complex information into an understanding of the risk, assessing how different actions will reduce and manage that risk, and finally assessing the relative benefits and costs of the actions they might take.

Interestingly, at different times the same person may use different systems of thinking, even about the same problem. For example, people may think analytically about a flood immediately after the event. Risk communication must therefore accommodate both kinds of thinking. Risk communication programs will be more effective if managers recognize that both systems of thinking may be present, depending on the audience and the context of the decisionmaking.

3.3 Heuristics and Flood Risk Perceptions

The literature on System 1 thinking (mental shortcuts, or heuristics) is vast and has its own language (e.g., Kahneman and Tversky 1982). This section summarizes some of this literature, with commentary on how particular heuristics may be relevant for flood risk perception. Although professional consensus on a "correct" list of heuristics is lacking, the

[15] Experts are people with the credentials and skills needed to understand the likelihood and consequences of flooding.

[16] A distinction is drawn between data and information. Data include measurements of physical phenomena and may extend to objective descriptions of policies and programs. Information is created by the interpretation of data. For example, historical measurements of stream flow are data, but a stage-frequency curve that relies on those data is information.

heuristics discussed in this section are well established in the literature and were chosen as most relevant to flood risk.

3.3.1 Availability

The Availability Heuristic suggests that people assess the likelihood of an event by how readily examples come to mind (Tversky and Kahneman 1973). People assign relatively more weight to events that are salient and memorable, and for which there is vivid evidence (Rabin 1998). Threats that are viewed as particularly salient because of recent experience or media coverage, for example, are easier to imagine and are thus assessed as more likely to occur.

The Availability Heuristic would cause an individual to assign a higher probability of future flooding at a location after a major flood, since the event is now salient and easier to imagine. Seemingly confirming this possibility, previous experience with flooding leads to higher assessed likelihood of future flooding (Keller et al. 2006; Siegrist and Gutscher 2006), and people who have been flooded in the past are more likely to implement risk reduction measures (e.g., Laska 1986; Pynn and Ljung 1999). The effect of past experience on risk perception (i.e., the strength of the Availability Heuristic) appears to depend on the time since the flood and on how severely the flood affected the individual (Burn 1999). Availability is similar to a documented "recency effect" in which individuals place more weight on recent outcomes (e.g., Hertwig et al. 2004). This can lead to over- or underestimation of risks, depending on what the individual has just experienced. It is also possible that newsworthy events reinforce the tendency of people to apply the Availability Heuristic to other types of events. For instance, after Hurricane Katrina, residents of California appeared to pay more attention to earthquake risk than before Katrina (San Francisco Chronicle 2005).

Evidence for the Availability Heuristic and its diminished effect over time can be found in the way property values change after flood events (e.g., Kousky 2010). Some studies have found that land prices decline precipitously immediately after the land is flooded, and then recover slowly over time, although prices may not rise to the levels for comparable unflooded properties (e.g., Shabman and Stephenson 1996; Atreya et al. 2013; Bin and Landry 2013).

The Availability Heuristic as a mental shortcut for understanding risk suggests that immediately after a major flood—regardless of where it occurs—there may be a window of opportunity to encourage the adoption of risk reduction and management measures. For example, purchase of flood insurance increases right after a flood event (Gallagher 2014). Similarly, earthquake insurance purchase in California increased after the 1989 Loma Prieta earthquake (Palm 1995). However, commitments to maintain the insurance policy (or other risk reduction or

management measures) may diminish over time, as has been observed for flood insurance (Michel-Kerjan et al. 2012).

Finally, the Availability Heuristic refers specifically to estimates about the probability of an event and not the magnitude of its consequences. Some surveys have found that previous experience with flooding does *not* alter what individuals view as an extreme or dangerous flood (McPherson and Saarinen 1977; Green et al. 2007). Assessment of the possible consequences of flooding may not be influenced by the Availability Heuristic. A recent review of multiple studies finds that previous experience with a hazard increases risk perceptions; however, if previous experience was not associated with large adverse consequences for the individual, the opposite can occur (Wachinger et al. 2013). Thus, it is also possible for previous experience to lead to an underestimation of risks of rare events (Burningham et al. 2008). This carries over into near-misses, where those who by chance were not hit by a disaster perceive a lower risk (Dillon et al. 2011).

3.3.2 Gambler's Fallacy

The Gambler's Fallacy is the belief that systems are self-correcting (Rabin 2002). For example, after a coin has been tossed several times and come up heads each time, someone invoking the Gambler's Fallacy would think a tail was more likely on the next toss. This is one component of what Tversky and Kahneman (1982) refer to as the belief in the "law of small numbers." That is, individuals believe that small samples are representative of a population and that sampling is a self-correcting process.

With regard to flood risk, this heuristic helps explain why some individuals believe that two "100-year floods" (1 percent annual chance) will not occur in the same area within a few years' time. It also helps explain why people who go many years without experiencing a flood believe the area is not subject to flood hazard. Individuals conclude that, say, a decade without a flood is a representative sample of the risk, when in actuality, hundreds of years of observations would be needed to estimate the likelihood of severe flood events. The Gambler's Fallacy could make it difficult to discourage people from locating in a high flood hazard area or to encourage them to adopt risk reduction and management measures if the area has not flooded in recent years.

Interestingly, immediately after a flood, the Gambler's Fallacy could conceivably offset the Availability Heuristic for some people, though direct evidence for this possibility is limited. Although a recent flood may lead people to perceive a higher likelihood of future flooding in the area, the Gambler's Fallacy may lead some people to believe that the odds of another flood's

occurring in the area in subsequent years have fallen. Which heuristic is dominant may depend on the language used to discuss the flood, such as whether it is referred to as a 100-year flood, a 1 percent chance flood, or some other term.

3.3.3 Truncation

Individuals sometimes ignore low-probability events or treat them as having zero probability of occurring (Kunreuther 1978; Camerer and Kunreuther 1989). One hypothesis offered to explain this observation is that individuals have only a limited amount of time and mental energy to devote to contemplating risk, and if they did not dismiss some low-probability risks, they would become overburdened in decisionmaking (Kunreuther and Slovic 1978). This could explain the hypothesis by some floodplain managers that property owners behind levees often seem to ignore the residual risk. This has been referred to as the "levee effect" (White 1945; Tobin 1995). A study in Harris County, Texas, however, found that some households overestimate hurricane risk and evacuate when they do not need to (Dueñas-Osorio et al. 2012). This contradiction of the truncation heuristic may be the result of the availability heuristic, if there have been recent storms.

3.3.4 Optimism

Individuals can be optimistic in assessing whether they will be victims of a disaster, often believing that they are less at risk than the average person (Camerer and Kunreuther 1989; Viscusi and Zeckhauser 2006). This has been documented, to varying degrees, across different cultures (Gierlach et al. 2010). Individuals often assess their personal risk as low, perhaps to reduce the stress caused by worry. This heuristic has been noted by the director of emergency management for King County, Washington, who was quoted in *Time* magazine as saying that people often have four stages of denial about earthquakes: "One is, it won't happen. Two is, if it does happen, it won't happen to me. Three: if it does happen to me, it won't be that bad. And four: if it happens to me and it's bad, there's nothing I can do to stop it anyway" (Ripley 2006). This same heuristic applies to flood risk. Surveys have found that individuals tend to believe they are unlikely to be victims of flooding even if they reside in a flood-prone area (Krasovskaia et al. 2001). A study in the Sacramento–San Joaquin Delta of California found that residents behind levees do not fully understand their risk of being flooded, but it is unclear whether optimism or other factors played a role (Ludy and Kondolf 2012).

Whether optimism or truncation is the reason individuals believe that they will not be flooded, even after being given risk information or seeing others experience a flood, is unclear, but the effect on decisionmaking is the same: they minimize the risk of flooding.

3.3.5 Certainty Effect

Individuals have been shown to place added value on certainty. This certainty effect (Kahneman and Tversky 1979) is seen in the Russian roulette thought experiment of Richard Zeckhauser and cited by Kahneman and Tversky (1979). With a six-cylinder gun aimed at them, most people are willing to pay more to remove one bullet if it is the only bullet in the gun than if there are two (or more) bullets in the gun. That is, a reduction in risk from 1/6 to zero is worth more to them than the reduction from 2/6 to 1/6, even though they are equal reductions in the probability of death. Applied to flood risk, this may mean that individuals are willing to pay more for measures that would completely, or nearly completely, eliminate the likelihood of being flooded. Thus, if individuals believe that constructing a levee would reduce flood risk to near zero, then they may be willing to pay more for it than for other actions to prevent flooding. Even if they are informed of the residual risk from the levee, the truncation heuristic would suggest that that small residual likelihood may be treated as zero.

3.3.6 Framing Effect

How a question is asked or how a choice is presented may influence the response (e.g., Thaler and Sunstein 2008). These so-called framing effects can offer important lessons for flood risk communication program design. One well-documented framing effect is that individuals tend to make decisions in relation to a reference point. If this reference point is current conditions, individuals tend to disproportionally stick with the status quo (Samuelson and Zeckhauser 1988), as shown by "opt in, opt out" experiments. For example, in some countries people are considered to be organ donors upon death unless they have explicitly stated otherwise. In other countries, the opposite is true—people are assumed not to be donors unless they have explicitly given their prior consent. Under both situations, most individuals stay with the default option, and thus rates of organ donation are dramatically higher in countries where the default is to donate (Johnson and Goldstein 2003). Similarly, when car insurers offer an option that limits drivers' rights to sue in exchange for lower premiums, sticking with the default choice is much more likely (Johnson et al. 1993). This research suggests that if flood insurance were the default and automatically renewed each year, but households were given an "opt out" option, more individuals might choose to carry flood insurance.

Another implication of the framing effect relates to understanding of natural disasters. It has been observed that whether a natural hazard is framed as an unavoidable "act of God" or as something caused by land development strategies can influence what risk management measures are chosen (Stefanovic 2003). Regarding floods, Stefanovic suggests that the former framing leads people to seek hazard reduction measures such as levees, whereas the latter framing leads people to seek risk reduction by reducing their exposure and vulnerability.

A third implication of the framing effect is that how flood risk information is presented can alter risk perceptions. For example, an individual could think that an event characterized as a 100-year flood, or even a 1 percent chance flood, is less of a concern than a flood event characterized as having a 26 percent chance of occurring during the life of a 30-year mortgage, even though both characterizations depict the same risk.

3.3.7 Cascading and Herd Behavior (Peer Effects)

This heuristic suggests that what other people do can influence an individual's choice. Schelling's (1998) classic example is hockey helmets: a player did not want to be the only one wearing a helmet, so if no one else wore one, he would not either. But if some players wore them, other players would be willing to do so. Models of cascades and herding behavior, two specific types of "peer effects," demonstrate that an individual's choice is influenced by the decisions of others (e.g., Scharfstein and Stein 1990; Banerjee 1992; Bikhchandani et al. 1998). This effect has been used in behavioral research to explain asset investments, stock market crashes, cultural fads, capital allocation, technology adoption, and other phenomena where individuals may make choices that differ from the choices they would make if they had not observed the decisions of others.

In flood risk decisionmaking, an individual may implement a risk reduction action after observing a neighbor doing so. A third person may think that the risk is too low to justify the action, but after observing the first and second persons, she may revise her risk assessment and also adopt the measure. In this way, cascades of behavior can occur. For instance, a 2003 survey of Florida homeowners found that in neighborhoods with relatively high rates of hurricane shutter use, the shutters were of higher quality and were more likely to include envelope protection (measures to prevent roof failure during a hurricane) than the shutters used in neighborhoods with lower rates of shutter use (Peacock 2003).

When and where this effect plays a role in decisionmaking deserves further research, as it is not always found to be important. For example, one survey found that cascading effects were

not evident in the case of carrying flood insurance (Pynn and Ljung 1999), perhaps because flood insurance is less visible to the neighbors than, for example, storm shutters.

3.3.8 Affect Heuristic

The Affect Heuristic causes individuals to mentally "tag" things as positive or negative and use these immediate emotions in making decisions (Finucane et al. 2000). This emotional tagging can be used to evaluate risk, with individuals not wanting "good" things to be risky. As a result, individuals judge risks that have high benefits as being low, and vice versa (Alhakami and Slovic 1994; Finucane et al. 2000). When situations are emotion-laden (affect rich), individuals have been found to overweight small probabilities and underweight large probabilities (Rottenstreich and Hsee 2001). When negative affect (e.g., fear) is emphasized, as through viewing photographs of flood destruction, individuals perceive a greater risk associated with flooding (Keller et al. 2006), and when tourists are fearful of hurricanes, they are more likely to evacuate (Villegas et al. 2013). In general, it has been noted that emotional evaluation of risk can lead to different behavior than cognitive evaluation and that this can depart from what a nonemotional individual would view as the best choice (Loewenstein et al. 2001). The Affect Heuristic could explain the link between experiencing a hazard and investing in flood risk reduction actions. One study found that those who had not experienced flooding strongly underestimated the negative affect of a flood (Siegrist and Gutscher 2008).

Of special note in relation to flood risk, studies have found that individuals do not want to regret their decisions (Camerer and Kunreuther 1989) and consider ways to avoid regret when making decisions. In a recent experiment, individuals were more likely to indicate they would purchase insurance after suffering a hypothetical uninsured loss, and thus regret not having been insured (Kunreuther and Pauly 2014). Also, individuals have been shown to consider multiple dimensions of a hazard and often put added importance on avoiding "dreaded" threats (Slovic 1987). Fear has been shown to amplify perceptions of risk, whereas anger lowers risk perceptions (Slovic and Peters 2006). Sometimes emotions can completely dominate an individual's risk analysis. When considering risk reduction and management actions—particularly with respect to emotionally charged risks—individuals sometimes neglect the probability of a threat and focus entirely on the consequences (Sunstein 2002). Thus, risk communication efforts that highlight the adverse consequences of flooding might make people more likely to adopt risk reduction and management actions. This may be especially justified in the risk communication program design if heuristics that lead to an underestimate of flood likelihood (Gambler's Fallacy, truncation) appear to be present.

4. Implications for Risk Communication

The discussion of heuristics has described how people might often evaluate risk information by employing mental shortcuts that could skew their understanding of flood risk. It has also shown that the same experiences, data, or information can be interpreted in completely different ways by different individuals or even the same individual in different contexts. As a result, it is difficult to predict which mental shortcuts will be dominant for which persons in which contexts.

Nevertheless, knowledge of heuristics can inform the design of a risk communication program, as suggested by the following example. Federal agencies are promoting an initiative called Know Your Line: Be Flood Aware (https://www.fema.gov/about-high-water-mark-initiative), in which communities are encouraged to mark historical flood heights on buildings. The assumption is that high-water marks can convey basic and objective data about flood possibilities and "improve the public's awareness of flood risk and encourage them to take action to reduce it." Given the preceding literature review, what can we say about high-water marks and risk understanding?

One possibility is that high-water marks will provide otherwise hard-to-acquire information on the severity of rare flood events and thus trigger System 2 thinking to evaluate these risks through deliberate, careful analysis. If the marks lead to appreciation of low-probability risks that otherwise would be neglected, they may encourage risk reduction and management actions. Another possibility is that System 1, heuristic thinking will prevail, and then the question is which shortcuts will dominate people's evaluations. Perhaps the high-water marks will increase the salience of the risk and lead observers to perceive flood risk as higher. They could even lead individuals to overestimate the likelihood of flooding and make cost-*in*effective risk reduction actions. However, if the large floods were infrequent or in the distant past, then the Gambler's Fallacy, truncation, or optimism heuristics may cause individuals to ignore the high water marks. A broader understanding of community and individual characteristics might help shed light on how the program would affect decisionmaking. The point here is not to criticize or endorse the Know Your Line program. Rather, the point is that an appreciation of systems of thinking and the larger decision context might indicate ways to modify or add to the effort and suggest different or complementary communication programs.

Each of the risk communication programs being developed by federal agencies has its own intended behavioral outcome for an intended audience. For that reason the specific design features of each program may need to differ. For example, Mileti (2003) draws on the literature

reviewed above to provide specific advice for the design of risk communication for an emergency preparedness program. However, it is beyond the scope of this review paper to provide program-by-program suggestions. Instead, the next two sections draw two general lessons for risk communication program design.

5. Implications for Risk Communication Program Goals

Flood risk communication may seek to increase individuals' understanding of flood risk so that they can make more informed choices when weighing the benefits and costs of location and risk reduction and mitigation decisions—that is, to encourage greater use of System 2 thinking about flood risk. A common approach involves two steps. First, the program provides individuals with data, interpretations of data, and perhaps simplified (but not simplistic) analytical processes for their use in understanding flood risk. Second, the conclusions from expert flood risk assessments are presented in formats and media such that a nonexpert's understanding of the flood risk will align with that of the experts. Individuals then evaluate the relative benefits and costs of a flood plain location decision and the merits of undertaking risk reduction and management measures.

That approach implicitly assumes that System 2 thinking will prevail. However, with limited time and attention and myriad other determinants of choices, individuals may never engage in a detailed analysis. Events that are remote in time and infrequently experienced may not be "worth thinking about," or people may not have time to consider every risk, from floods and hurricanes to nuclear disasters and epidemics. So it is reasonable to assume that in many instances individuals will employ System 1 thinking—despite efforts to promote System 2 thinking—and heuristics will influence decisionmaking. Recognizing this possibility has two implications for a risk communication program.

First, risk communication can be designed to harness decision heuristics in various ways, depending on the objectives of the program. For example, the Availability Heuristic could be used to develop flood risk communication efforts that consistently remind people of past flood events as a way to encourage them to assess risk as higher and therefore adopt risk reduction and management actions that they might otherwise not adopt. Here the goal is encouraging a certain choice and heuristics are used to motivate that choice. As another example, a well-recognized problem in flood risk communication is the public's misunderstanding of the term "100-year flood" (it leads them to fall prone to the Gamblers Fallacy). To avoid that misunderstanding, the thought has been to instead emphasize the concept of the 1% annual chance flood. However, people might then engage in truncation and consider 1 percent to be so small a likelihood that

they ignore or dismiss the risk. Recognizing this, risk communicators have considered framing this flood probability as having a 26 percent chance of occurring during the life of a 30-year mortgage. When flooding is presented this way, individuals perceive a higher threat (Keller et al. 2006), even though the basic information about flood risk is the same. The same result has been shown for risks from earthquakes and failing to wear a seatbelt and suggests that framing could offset the tendency of people to ignore or dismiss low-probability risks (Kunreuther et al. 2002).

Second, risk communicators can set a different goal: directing individuals toward a particular decision (e.g., to purchase flood insurance, or to adopt building codes and zoning restrictions in floodplains). Guiding individuals toward particular choices, rather than simply providing data and information to inform choices, is what some authors call "nudges" (Thaler and Sunstein 2008). Thaler and Sunstein justify nudges by proposing the concept of "libertarian paternalism," in which individuals retain freedom to make choices but are encouraged in one direction or another by the way the choices or information is presented. That nudge might be in a direction that the experts believe is in the best interests of the individuals deemed to be at risk. Or the nudge might be to secure a particular policy and program purpose. For example, reducing post flood disaster aid payouts may require nudging more individuals to participate in the NFIP.

Thaler and Sunstein refer to "choice architects," who design choice contexts so that people make choices that improve their lives; that is, choice architects can nudge people in beneficial directions. Choice architecture design uses knowledge of heuristics to direct choices in particular ways. Consider again the example of framing flood probability as a 26 percent chance over the course of a 30-year mortgage. Because this framing makes individuals perceive a higher threat, it nudges them toward taking flood risk reduction and management actions, as opposed to providing more or better information. Kuran and Sunstein (1999) link the Availability Heuristic with cascading behavior and develop the notion of "availability entrepreneurs"—individuals who work to trigger cascades "by fixing people's attention on specific problems, interpreting phenomena in particular ways, and attempting to raise the salience of certain information." Clearly this falls in the category of using knowledge of decision heuristics to nudge decisions in a particular direction.

6. The Messenger and the Message

Individuals can receive information on flood risk from three types of sources: (1) official sources, such as flood insurance rate maps, government websites and published documents, statements by elected officials, and lenders; (2) their social network, including family, friends, and colleagues; and (3) their own personal experiences and observations. Individuals may not

trust these sources equally and may discount information provided by certain sources. The literature shows that the level of trust that individuals place on the source of flood risk information plays a role in how they perceive and act on risks. They may be more likely to accept information when it comes from someone whose values they share, does not threaten their cultural values, and fits into their existing narratives (Kahan et al. 2010). They must view the information as credible (scientifically accurate), salient (relevant to the issue), and legitimate (unbiased and fair) to trust and incorporate it into their decisionmaking (Cash et al. 2003). Transparency in communication can also increase trust in risk managers (e.g., White and Eiser 2006).

Because this report focuses on risk communication programs, we discuss here official sources of risk information and the way risk is conveyed in these sources. Of particular note is that trust is much easier to destroy than create (e.g., Slovic 1993). For that reason it is important to recognize the tension between providing information (or nudging) and earning trust. Program designers should keep three points in mind.

First, the risk communicator's message might be interpreted as self-serving and hence not trustworthy. For example, FEMA efforts to update maps and alter the area of the base floodplain have sometimes been interpreted as a way to sell more policies and thereby cover its fiscal deficit. Likewise, the Corps of Engineers' effort to describe the limits of its aging levees and encourage local efforts to reduce community exposure and vulnerability to flooding has been described by some stakeholders as a way to absolve itself of responsibility for any inadequacies of the levees.

Second, risk communicators should avoid presenting information as if it were neutral if they are embedding their own views of acceptable risks and justified risk reduction and management actions. Individuals may resist being nudged if the experts do not admit that they are offering expert advice based their own judgment. People may not reject expert advice, and may seek it out, but the experts must distinguish describing a risk situation from recommending how people should respond to that risk.

Third, risk communicators must accept the judgment of the individuals who face the complexity of making a place-based choice in consideration of their own sense of benefits, costs, and constraints. This can be difficult for risk experts, given the ample evidence that people simplify decisionmaking through heuristics. It is for this reason that Thaler and Sunstein proposed libertarian paternalism, under which the policy designer defines a "preferred choice,"

offers "expert advice," and can even nudge people toward a choice by conscious deployment and use of decision heuristics, but individuals can make a different choice.

One implication of those three points is that there may need to be a different messenger than the agency expert, even if the message is the same. Federal agencies can also increase the trust in their risk message by engaging households, business leaders, and community officials in a mutual exploration of the nature of flood risk and the appropriate response. A risk communication program might support analyses of the likelihoods and consequences of flooding through an extended stakeholder process, with sufficient time to foster System 2 thinking, to yield a more complete and more permanent understanding of flood risk. However, some people may not be able to commit the necessary time for such a learning process. The Corps has a long-standing commitment to improve its procedures for public participation in decisionmaking, but in practice "public participation" largely consists of technical experts speaking to communities and individuals. A recent report has recommended ways that the Corps could improve public participation in the context of the new emphasis on shared responsibility for flood risk management (Creighton et al. 2010). The central message is that Corps public participation programs should move from the one-way transmission of information to engaging affected stakeholders in "mutual problem-solving." The report makes specific recommendations on involving local stakeholders in decisions about hazard reduction project rehabilitation and improvement.

7. Summary

Flood risk communication programs, whether motivated by a desire to increase understanding of flood risk or to nudge individuals toward particular choices, will introduce new information into an existing and already complex choice setting of financial and physical constraints, perceptions of benefits and costs of location choices, attitudes toward risk taking, and alternative systems of thinking. As a result, no risk communication program can guarantee that people's decisions will be different than they would have been in its absence.

In fact, improved understanding may not result in different choices. For instance, risk perception was not found to be correlated with evacuation decisions in North Carolina (Horney et al. 2010). And a survey of homeowners in 10 cities found that only 40 percent of property owners who reported that they were aware they were in a floodplain area carried flood insurance, while only 13 percent of property owners who were unaware did so (Bollens et al. 1988). This finding suggests that although data and information on flood risk may affect choice behavior for some individuals, the complexity of their decision frameworks means that improved

understanding of flood risk will not necessarily change everyone's choices. Having realistic expectations for the effect of flood risk understanding on choice making will be essential to the design and execution of a flood risk communication program.

References

Alhakami, A. S., and P. Slovic. 1994. A psychological study of the inverse relationship between perceived risk and perceived benefit. *Risk Analysis* 14(6): 1085–96.

Atreya, A., S. Ferreira, and W. Kriesel. 2013. Forgetting the flood? An analysis of the flood risk discount over time. *Land Economics* 89(4): 577–96.

Banerjee, A. 1992. A simple model of herd behavior. *Quarterly Journal of Economics* 107(3): 797–817.

Bikhchandani, S., D. Hirshleifer, and I. Welch. 1998. Learning from the behavior of others: Conformity, fads, and informational cascades. *Journal of Economic Perspectives* 12(3): 151–70.

Bin, O., and C. E. Landry. 2013. Changes in implicit flood risk premiums: Empirical evidence from the housing market. *Journal of Environmental Economics and Management* 65: 361–76.

Bollens, S. A., E. J. Kaiser, and R. J. Burby. 1988. Evaluating the effects of local floodplain management policies on property owner behavior. *Environmental Management* 12(3): 311–25.

Bostrom, A. 1997. Risk perceptions: "Experts" vs. "lay people." *Duke Environmental Law and Policy Forum* 8(1): 101–13.

Burningham, K., J. Fielding, and D. Thrush. 2008. "It'll never happen to me": Understanding public awareness of local flood risk. *Disasters* 32(2): 216–38.

Burn, D. H. 1999. Perceptions of flood risk: A case study of the Red River Flood of 1997. *Water Resources Research* 35(11): 3451–58.

Camerer, C. F., and H. Kunreuther. 1989. Decision processes for low probability events: Policy implications. *Journal of Policy Analysis and Management* 8(4): 565–92.

Cash, D. W., W. C. Clark, F. Alcock, N. M. Dickson, N. Eckley, D. H. Guston, J. Jäger, and R. B. Mitchell. 2003. Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences* 100(14): 8086–91.

Dillon, R. L., C. H. Tinsley, and M. Cronin. 2011. Why near-miss events can decrease an individual's protective response to hurricanes. *Risk Analysis* 31(3): 440–49.

Dueñas-Osorio, L., B. Buzcu-Guven, R. Stein, and D. Subramanian. 2012. Engineering-based hurricane risk estimates and comparison to perceived risks in storm-prone areas. *Natural Hazards Review* 13(1): 45–56.

Finucane, M. L., A. Alhakami, P. Slovic, and S. M. Johnson. 2000. The Affect Heuristic in judgments of risks and benefits. *Journal of Behavioral Decisionmaking* 13(1): 1–17.

Gallagher, J. 2014. Learning about an Infrequent Event: Evidence from Flood Insurance Take-Up in the United States. *American Economic Journal: Applied Economics* 6(3): 206-233.

Gierlach, E., B. E. Belsher, and L. E. Beutler. 2010. Cross-cultural differences in risk perceptions of disasters. *Risk Analysis* 30(10): 1539–49.

Green, C. H., S. M. Tunstall, and M. H. Fordham. 2007. The risks from flooding: Which risks and whose perception? *Disasters* 15(3): 227–36.

Hertwig, R., G. Barron, E. Weber, and I. Erev. 2004. Decisions from experience and the effect of rare events in risky choice. *Psychological Science* 15(8): 534–39.

Horney, J. A., P. D. M. MacDonald, M. Van Willigen, P. R. Berke, and J. S. Kaufman. 2010. Individual actual or perceived property flood risk: Did it predict evacuation from Hurricane Isabel in North Carolina, 2003? *Risk Analysis* 30(3): 501–11.

Johnson, E. J., and D. Goldstein (2003). Do defaults save lives? *Science* 302(November 21).

Johnson, E., J. Hershey, J. Meszaros, and H. Kunreuther. 1993. Framing, probability distortions, and insurance decisions. *Journal of Risk and Uncertainty* 7: 35–51.

Kahan, D. M., H. Jenkins-Smith, and D. Braman. 2010. Cultural cognition of scientific consensus. *Journal of Risk Research* 14(2): 1–28.

Kahneman, D. 2012. *Thinking, fast and slow.* New York: Farrar, Straus and Giroux.

Kahneman, D. 2003. A perspective on judgment and choice: Mapping bounded rationality. *American Psychologist* 58(9): 697–720.

Kahneman, D., and A. Tversky. 1979. Prospect theory: An analysis of decision under risk. *Econometrica* 47(2): 263–92.

Kahneman, D., P. Slovic, and A. Tversky (eds.). 1982. *Judgment under uncertainty: Heuristics and biases.* Cambridge, UK: Cambridge University Press.

Keller, C., M. Siegrist, and H. Gutscher. 2006. The role of the affect and availability heuristics in risk communication. *Risk Analysis* 26(3): 631–39.

Kousky, C. 2010. Learning from extreme events: Risk perceptions after the flood. *Land Economics* 86(3): 395–422.

Krasovskaia, I., L. Gottschalk, N. R. Saelthun, and H. Berg. 2001. Perception of the risk of flooding: The Case of the 1995 flood in Norway. *Hydrological Sciences* 46(6): 855–68.

Kunreuther, H. C. (ed.). 1978. *Disaster insurance protection: Public policy lessons.* New York City: John Wiley and Sons.

Kunreuther, H., and M. Pauly. 2014. Role of deliberative thinking and emotions in insurance decisionmaking: An experimental study. Working Paper 2014-03. Risk Management and Decision Processes Center, Wharton School, University of Pennsylvania.

Kunreuther, H., and P. Slovic. 1978. Economics, psychology, and protective behavior. *American Economic Review* 68(2): 64–69.

Kunreuther, H., R. Meyer, R. Zeckhauser, P. Slovic, B. Schwartz, C. Schade, M. F. Luce, S. Lippman, D. Krantz, B. Kahn, and R. Hogarth. 2002. High stakes decisionmaking: Normative, descriptive and prescriptive considerations. *Marketing Letters* 13(3): 259.

Kuran, T. and C. R. Sunstein. 1999. Availability Cascades and Risk Regulation. *Stanford Law Review* 51(4): 683-768.

Laska, S. B. 1986. Involving homeowners in flood mitigation. *Journal of the American Planning Association* 52(4): 452–56.

Loewenstein, G. F., E. U. Weber, C. K. Hsee, and N. Welch. 2001. Risk as feelings. *Psychological Bulletin* 127(2): 267–86.

Ludy, J., and G. M. Kondolf. 2012. Flood risk perception in lands “protected” by 100-year levees. *Natural Hazards* 61(2): 829–42.

McPherson, H. J., and T. F. Saarinen. 1977. Flood plain dwellers' perception of the flood hazard in Tucson, Arizona. *Annals of Regional Science* 11(2).

Michel-Kerjan, E., S. Lemoyne de Forges, and H. Kunreuther. 2012. Policy tenure under the U.S. National Flood Insurance Program. *Risk Analysis* 32(4): 644–58.

Mileti, D. S. 2003. Public hazards communication and education: The state of the art. National Hazards Research and Applications Information Center, Institute for Behavioral Science, University of Colorado.

Palm, R. 1995. The Roepke Lecture in Economic Geography - Catastrophic Earthquake Insurance: Patterns of Adoption. *Economic Geography* 71(2): 119-131.

Peacock, W. G. 2003. Hurricane mitigation status and factors influencing mitigation status among florida's single-family homeowners. *Natural Hazards Review* 4(3): 149–58.

Pynn, R., and G. M. Ljung. 1999. Flood insurance: A survey of Grand Forks, North Dakota, homeowners. *Applied Behavioral Science Review* 7(2): 171–80.

Rabin, M. 1998. Psychology and economics. *Journal of Economic Literature* 36(1): 11–46.

Rabin, M. 2002. Inferences by believers in the Law of Small Numbers. *Quarterly Journal of Economics* 117(3): 775–816.

Ripley, A. 2006. Floods, tornadoes, hurricanes, wildfires, earthquakes … Why we don't prepare. *Time* August 20.

Rottenstreich, Y., and C. K. Hsee. 2001. Money, kisses, and electric shocks: On the affective psychology of risk. *Psychological Science* 12(3).

Samuelson, W., and R. Zeckhauser. 1988. Status quo bias in decisionmaking. *Journal of Risk and Uncertainty* 1: 7-59.

San Francisco Chronicle. 2005. California's hurricane. September 1.

Scharfstein, D. S., and J. C. Stein. 1990. Herd behavior and investment. *American Economic Review* 80(3): 465–79.

Schelling, T. C. 1978. *Micromotives and macrobehavior.* New York: W. W. Norton & Company, Inc.

Shabman,L and K.Stephenson.1996. Searching for the Correct Benefit Estimate: Empirical Evidence for an Alternative Perspective. Land Economics 72(4): 433-449.

Shabman, L., P. Scodari, D. Woolley, and C. Kousky. 2014. Vocabulary of flood risk management terms. In L. Shabman and P. Scodari (eds.), *From flood damage reduction to flood risk management: Implications for USACE policy and programs*. USACE Institute for Water Resources, Appendix A. http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/2014-R-02_AppendixA.pdf.

Siegrist, M., and H. Gutscher. 2006. Flooding risks: A comparison of lay people's perceptions and expert's assessments in Switzerland. *Risk Analysis* 26(4): 971–79.

Siegrist, M., and H. Gutscher. 2008. Natural hazards and motivation for mitigation behavior: People cannot predict the affect evoked by a severe flood. *Risk Analysis* 28(3): 771–78.

Slovic, P. 1993. Perceived risk, trust, and democracy. *Risk Analysis* 13(6): 675–82.

Slovic, P. 1987. Perception of risk. *Science* 236(4799): 280–85.

Slovic, P., and E. Peters. 2006. Risk perception and affect. *Current Directions in Psychological Science* 15(6): 322–25.

Stefanovic, I. L. 2003. The contribution of philosophy to hazards assessment and decisionmaking. *Natural Hazards* 28: 229–47.

Sunstein, C. R. 2002. Probability neglect: Emotions, worst cases, and law. *Yale Law Journal* 112(1): 61–107.

Thaler, R. H., and C. R. Sunstein. 2008. *Nudge: Improving decisions about health, wealth, and happiness.* London: Penguin Books.

Tobin, G. A. 1995. The Levee Love Affair: A Stormy Relationship. *Water Resources Bulletin* 31(3): 359-367.

Tversky, A., and D. Kahneman. 1973. Availability: A heuristic for judging frequency and probability. *Cognitive Psychology* 5: 207–32.

Tversky, A., and D. Kahneman. 1982. Belief in the Law of Small Numbers. In D. Kahneman, P. Slovic and A. Tversky (eds.), *Judgment under uncertainty: heuristics and biases.* Cambridge, UK: Cambridge University Press, 23–31.

Villegas, J., C. Matyas, S. Srinivasan, I. Cahyanto, B. Thapa, and L. Pennington-Gray. 2013. Cognitive and affective responses of Florida tourists after exposure to hurricane warning messages. *Natural Hazards* 66(1): 97–116.

Viscusi, W. K., and R. J. Zeckhauser. 2006. National survey evidence on disasters and relief: Risk beliefs, self-interest, and compassion. *Journal of Risk and Uncertainty* 33: 13–36.

Wachinger, G., O. Renn, C. Begg, and C. Kuhlicke. 2013. The risk perception paradox—implications for governance and communication of natural hazards. *Risk Analysis* 33(6): 1049–65.

White, G. F. 1945. Human Adjustment to Floods. Department of Geography Research Paper no. 29. Chicago, Illinois, University of Chicago.

White, M. P., and J. R. Eiser. 2006. Marginal trust in risk managers: Building and losing trust following decisions under uncertainty. *Risk Analysis* 26(5): 1187–203.