

5/91

Risk Analysis
Version

**Perceived Risk, Stigma, and Potential Economic Impacts
of a High-Level Nuclear Waste Repository in Nevada**

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Abbreviated title: Risk Perception and Nuclear Waste

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ABSTRACT

This study investigates the potential impacts of the proposed nuclear waste repository at Yucca Mountain, Nevada, upon tourism, retirement and job-related migration, and business development in Las Vegas and the state. Adverse impacts may be expected to result from perceptions of risk, stigmatization, and socially amplified reactions to "unfortunate events" associated with the repository (major and minor accidents, discoveries of radiation releases, evidence of mismanagement, attempts to sabotage or disrupt the facility, etc.). The conceptual underpinnings of risk perception, stigmatization, and social amplification are discussed and empirical data are presented to demonstrate how nuclear images associated with Las Vegas and the State of Nevada might trigger adverse economic effects. The possibility that intense negative imagery associated with the repository may cause significant harm to Nevada's economy can no longer be ignored by serious attempts to assess the risks and impacts of this unique facility. The behavioral processes described here appear relevant as well to the social impact assessment of any proposed facility that produces, uses, transports, or disposes of hazardous materials.

Key Words: perceived risk, stigma, economic impacts, nuclear waste, social impact assessment

Perceived Risk, Stigma, and Potential Economic Impacts

of a High-Level Nuclear Waste Repository in Nevada

New Orleans, Louisiana -- This is New Orleans! Air conditioning ... Al Hirt ... Andrew Jackson ... antebellum plantations ... antiques ... Antoine's ... Arnaud's ... Audobon Park ... bananas Foster ... Basin Street ... Battle of New Orleans ... bayous ... Bourbon Street ... breakfast at Brennan's ... Cafe du Monde ... cafe au lait and beignets ... Cajun ... Canal Street ... chicory coffee ... "cities of the dead" ... Commander's Palace ... courtyards ... Creole cuisine ... Dixieland ... Duelling Oaks ... French Market ... French Quarter or "Vieux Carre" ... Galatoire's ... Garden District ... Lafitte ... lace balconies ... Lake Pontchartrain ... levees ... Longue Vue Gardens ... the Longs of Louisiana ... Mardi Gras ... Old Absinthe House ... oysters Rockefeller ... Neville Brothers ... pecan pralines ... Pete Fountain ... Preservation Hall ... Ramos gin fizz ... riverboats ... shrimps ... St. Charles streetcar ... Storyville ... streetcar named Desire ... Sugar Bowl ... Superdome ... Uptown ... voo-doo!¹

The National Environmental Policy Act passed by Congress in 1969 established the requirement for an environmental impact statement for any "major federal actions significantly affecting the quality of the human environment." Section 101 of this act states that its major purpose is not only to maintain environmental quality but also to "fulfill the social, economic, and other requirements" of U.S. citizens. This requirement for a social and behavioral science component with every environmental impact statement led to the birth of a field known as social impact assessment.⁽¹⁻³⁾ The present study attempts to demonstrate the importance of perceived risk in social impact assessment, within the context of a specific project--the proposed national repository for disposal of high-level nuclear waste.

¹ Images characterize places, as is illustrated by this introduction to the announcement for the 1989 Annual Meeting of the American Psychological Association in New Orleans, Louisiana (*American Psychologist*, March 1989, p. 583).

In December, 1987, the U.S. Congress amended the Nuclear Waste Policy Act and authorized the Department of Energy to determine whether Yucca Mountain, Nevada, is a geologically sound and technically feasible site for disposal of high-level nuclear waste. If the site passes a set of prescribed technical criteria, a repository will be constructed there to dispose of nuclear waste from the nation's commercial power plants.

Much effort has been, and will continue to be, devoted to characterizing the physical and biological risks associated with construction and operation of this unique facility, which must safely contain a large volume of highly radioactive material for a time period that is twice as long as recorded human history. Socioeconomic risks, though less studied, are also important. This paper addresses the following question pertaining to social impacts: What is the potential for a high-level nuclear waste repository at Yucca Mountain to have adverse economic effects on the city of Las Vegas and the State of Nevada during the period of constructing and filling the repository (approximately 40-60 years)?

The economic impacts of concern to us here include reduction in short-term visits to the city and state by vacationers or conventioners, effects on long-term residents (moving out of the region, reduced in-migration of retirees), and reduced ability to attract new businesses. Assessment of these impacts is obviously important to citizens and officials of Nevada, who need to know what economic consequences to expect if Yucca Mountain is developed as the repository. Information about possible economic impacts may also be relevant to the final decision itself, regarding the acceptability of the Yucca Mountain site.

Empirical research on this topic faces some major obstacles, however. Changes in scientific knowledge and changes in public opinion are inherently difficult to forecast. For

example, both scientific and public views about the risks of nuclear energy have changed dramatically since the "Atoms for Peace" program began in the 1950's. An obstacle to survey research is the fact that people may not really know how the repository will affect their future preferences and decisions. For example, asking people to project the repository's impacts on vacation decisions to be made many years hence may, in effect, be asking them to "tell more than they can know."⁽⁴⁾ Studies by Baker, Moss, West and Weyant⁽⁵⁾ and West and Baker⁽⁶⁾ indicate that answers to questions about the impact of nuclear facilities on future behavior may not be trustworthy.

Despite these difficulties, there are theoretical reasons to expect that the repository may produce adverse economic impacts. In this study we develop a method for assessing impacts that is not dependent on direct questioning of people who are unfamiliar with the decisions of concern here. We then use this method to assess the potential impacts from a repository at Yucca Mountain.

BACKGROUND AND THEORY

Adverse impacts from the proposed Yucca Mountain repository may be expected to result from two related social processes. One has to do with perceptions of risk and socially amplified reactions to "unfortunate events" associated with the repository (major and minor accidents, discoveries of radiation releases, evidence of mismanagement, attempts to sabotage or disrupt the facility, etc.). The second process that may trigger significant adverse impacts is that of stigmatization.

Perceptions of Risk and Social Amplification of Risk

Nuclear waste has several unique characteristics that strongly suggest the potential for a repository to have adverse effects upon the region in which it is located.

1. Although technical experts are supremely confident that nuclear wastes can be transported and disposed of safely^(7,8), the technology of high-level nuclear waste disposal is complex and largely untried. There are genuine hazards associated with such a facility, and the nature of these hazards is only partly understood.

2. From the time that radioactivity was discovered shortly before 1900, nuclear energy has been unique in the power of the imagery and symbolism that has surrounded it. Weart⁽⁹⁾ traces the salience and persistence with which both positive and negative meanings have become attached to things nuclear. His analysis demonstrates the strength of nuclear imagery and its broad penetration into our social and cultural consciousness over the past 90 years.

3. Contemporary evaluations of nuclear power and nuclear waste could hardly be more negative. Nuclear power stands out in studies of risk perception as unknown, uncontrollable, and dreaded, with the perceived potential to produce immense numbers of fatalities, even in future generations.^(10,11) Nuclear waste tends to be perceived in a similarly negative way.^(12,13)

These public perceptions have evoked harsh reactions from experts. One noted psychiatrist wrote that "the irrational fear of nuclear plants is based on a mistaken assessment of the risks" (Dupont¹⁴, p. 8). A nuclear physicist and leading advocate of nuclear power contended that "...the public has been driven insane over fear of radiation [from nuclear power]. I use the word 'insane' purposefully since one of its definitions is loss of contact with reality.

The public's understanding of radiation dangers has virtually lost all contact with the actual dangers as understood by scientists" (Cohen¹⁵, p. 31).

Research on risk perception paints a different picture, demonstrating that people's deep anxieties are linked to numerous realities, including the reality of radiation's unique and powerful qualities, the reality of nuclear power's links to nuclear weapons proliferation and war, the reality of many serious examples of mismanagement (e.g., the releases of radioactive material into the environment from military reactor sites), and the reality of extensive media coverage documenting major and minor problems and controversies involving nuclear technologies. Attempts to "educate" or reassure the public and bring their perceptions in line with those of industry experts face great difficulties because industry and government lack trust and credibility and because evidence of incompetence is much more persuasive than evidence of competence.

Perceptions of risk play a key role in a process labeled "social amplification of risk."⁽¹⁶⁾ Social amplification is triggered by the occurrence of an adverse event, which could be a major or minor accident, a discovery of pollution, an incident of sabotage, and so on. Risk amplification reflects the fact that the adverse impacts of such an event sometimes extend far beyond the direct damages to victims and property and may result in massive indirect impacts such as litigation against a company or loss of sales, increased regulation of an industry, and so on. In some cases, all companies within an industry are affected, regardless of which company was responsible for the mishap. Thus, the event can be thought of as a stone dropped in a pond. The ripples spread outward, encompassing first the directly affected victims, then the responsible company or agency, and, in the extreme, reaching other companies, agencies, or industries.

Examples of events resulting in extreme higher-order impacts include the chemical manufacturing accident at Bhopal, India, the disastrous launch of the space shuttle Challenger, the nuclear-reactor accidents at Three Mile Island and Chernobyl, the adverse effects of the drug Thalidomide, the Exxon Valdez oil spill, and the adulteration of Tylenol capsules with cyanide. An important feature of social amplification is that the direct impacts need not be too large to trigger major indirect impacts. The seven deaths due to the Tylenol tampering resulted in more than 125,000 stories in the print media alone and inflicted losses of more than one billion dollars upon the Johnson & Johnson Company, due to the damaged image of the product.⁽¹⁷⁾

It appears likely that multiple mechanisms contribute to the social amplification of risk. First, extensive media coverage of an event can contribute to heightened perceptions of risk and amplified impacts.⁽¹⁸⁾ Second, a particular risk or risk event may enter into the agenda of social groups, or what Mazur⁽¹⁹⁾ terms the partisans, within the community or nation. The attack on the apple growth-regulator "Alar" by the Natural Resources Defense Council demonstrates the important impacts that special-interest groups can trigger.⁽²⁰⁾

A third mechanism of amplification arises out of the interpretation of unfortunate events as clues or signals regarding the magnitude of the risk and the adequacy of the risk-management process.^(10,18) The informativeness or signal potential of a mishap, and thus its potential social impact, appears to be systematically related to the perceived characteristics of the hazard. An accident that takes many lives may produce relatively little social disturbance (beyond that caused to the victims' families and friends) if it occurs as part of a familiar and well-understood system (e.g., a train wreck). However, a small accident in an unfamiliar system (or one perceived as poorly understood), such as a nuclear waste repository or a recombinant DNA

laboratory, may have immense social consequences if it is perceived as a harbinger of future and possibly catastrophic mishaps.

The concept of accidents as signals helps explain our society's strong response to mishaps involving nuclear power and nuclear wastes. Because the risks associated with nuclear energy are seen as poorly understood and catastrophic, accidents anywhere in the world may be seen as omens of disaster everywhere there are nuclear reactors and wastes, thus producing responses (e.g., increased regulation; public opposition) that carry large socioeconomic impacts.

Stigmatization

Substantial socioeconomic impacts may also result from the stigma associated with a nuclear waste repository. The word stigma was used by the ancient Greeks to refer to bodily marks or brands that were designed to signal infamy or disgrace--to show, for example, that the bearer was a slave or a criminal. As used today, the word denotes someone "marked" as deviant, flawed, limited, spoiled, or generally undesirable in the view of some observer. When the stigmatizing characteristic is observed, the person is denigrated or avoided. Prime targets for stigmatization are members of minority groups, the aged, homosexuals, drug addicts, alcoholics, and persons afflicted with physical deformities or mental disabilities.

Although the sociological and psychological treatment of stigma typically pertains to interpersonal contexts far removed from that of radioactive waste disposal, the concept of stigma can clearly be generalized from persons to environments.⁽²¹⁾ Times Beach, Missouri, and Love Canal, New York, come quickly to mind as examples of stigmatized environments.

A dramatic example of stigmatization involving radiation occurred in September, 1987, in Goiania, Brazil, where two men searching for scrap metal dismantled a cancer therapy device

in an abandoned clinic. In doing so, they sawed open a capsule containing 28 grams of cesium chloride. Children and workers nearby were attracted to the glowing material and began playing with it. Before the danger was realized, several hundred people became contaminated and four persons eventually died from acute radiation poisoning. Publicity about the incident led to stigmatization of the region and its residents.⁽²²⁾ Hotels in other parts of the country refused to allow Goiania residents to register; airline pilots refused to fly with Goiania residents on board; automobiles driven by Goianians were stoned; hotel occupancy in the region dropped 60% for six weeks following the incident and virtually all conventions were canceled during this period. The sale prices of clothing and other products manufactured in Goiania dropped by 40% after the first news reports and remained depressed for a period of 30-45 days, despite the fact that none of these items was ever shown to have been contaminated.

RATIONALE AND METHOD

Building on the theoretical concepts and research described above, we designed a series of studies to determine the potential for a nuclear-waste repository at Yucca Mountain to have adverse effects on tourism, migration, and business location decisions.

Our first efforts followed the direct approach of asking people in a national survey to indicate whether a nuclear waste repository located 100 miles from a site would reduce the desirability of that site as a place to attend a convention, vacation, raise a family, retire, or locate a new business. Depending upon which of these activities was targeted in the question, between 41% (attend a convention) and 73% (raise a family) said that a repository would reduce the desirability of the region. It appeared that the more time people thought they would be

spending in an area, the more likely they were to assert that the repository would make it a less desirable place in which to be.

In response to direct questions, interviewees consistently anticipated that a repository would decrease the attractiveness of a place. However, in light of the aforementioned problems with projecting impacts far into the future on the basis of answers to hypothetical questions, such data are suspect. Therefore, the present studies employed an indirect strategy, based on the notion of environmental imagery. Studies of environmental imagery appear to have the potential to provide a sound and defensible theoretical framework from which to understand and project possible impacts of a nuclear-waste repository on tourism and other important behaviors. Accordingly, the present studies were designed to:

- demonstrate the concept of environmental imagery and show how it can be measured
- assess the relationship between imagery and choice behavior
- describe economic impacts that might occur as a result of altered images and choices.

The concept of imagery is not new to the study of environment and behavior. Geographers, cognitive and environmental psychologists, marketing strategists, and consumer theorists have written at length about the importance of images in our environmental consciousness and our behavior.^(9,23-27) However, to our knowledge, no one has used a design such as ours to link imagery to the behaviors of concern here.

Our research was designed to test the following three propositions:

- 1) Images associated with environments have diverse positive and negative affective meanings that influence preferences (e.g., in this case, preferences for sites in which to vacation, retire, find a job, or start a new business).

2) A nuclear-waste repository evokes a wide variety of strongly negative images, consistent with extreme perceptions of risk and stigmatization.

3) The repository at Yucca Mountain and the negative images it evokes will, over time, become increasingly salient in the images of Nevada and of Las Vegas.

If these three propositions are true, it seems quite plausible that, as the imagery of Las Vegas and of Nevada becomes increasingly associated with the repository and things nuclear, the attractiveness of these places to tourists, job seekers, retirees, and business developers will decrease and their choices of Las Vegas and Nevada within sets of competing sites will decrease.

Support for these three propositions, therefore, would demonstrate the mechanism whereby the repository could produce adverse affects upon tourism, migration, and business development in Nevada and this demonstration would occur without having to ask people to make introspective judgments about their future behaviors.

Survey Design

In order to test the propositions described above, we first conducted three extensive studies of imagery and preference. Studies 1 and 2 surveyed representative samples of residents in Phoenix, Arizona. Study 1 elicited images for four cities and asked people to indicate their preferences among these cities as places to vacation, take a new job, or retire. Study 2 did the same for four states. Study 3 surveyed a national sample of business executives, asking for their images of each of four cities and their preferences among these cities as places to open a new business or expand an existing business. All three surveys were conducted by telephone. Each survey had a sample size of about 400 persons.

The survey questions in Studies 1 and 2 were nearly identical. The *cities questionnaire* asked respondents to provide images for San Diego, Las Vegas, Denver, and Los Angeles. The *states questionnaire* elicited imagery for California, Nevada, Colorado, and New Mexico. These cities and states, in addition to Las Vegas and Nevada, were chosen for the study because they are important vacation destinations for residents of Phoenix.

The images were elicited using a version of the "method of continued associations,"⁽²⁸⁾ adapted for use in a telephone interview.² Image elicitation was always the first task in the survey. In the cities survey, the elicitation interview proceeded as follows:

"My first question involves word association. For example, when I mention the word baseball, you might think of the World Series, Reggie Jackson, summertime, or even hot dogs. Today, I am interested in the first SIX thoughts or images that come to mind when you hear the name of a PLACE.

Think about _____ for a minute. When you think about _____,
[CITY] [CITY]
what is the first thought or image that comes to mind?

What is the next thought or image you have when I say _____?
[CITY]

_____. Your next thought or image?
[CITY]

What is another thought or image you have about _____?"
[CITY]

² The study of associations has a long history in psychology, going back to Galton⁽²⁹⁾, Wundt⁽³⁰⁾, and Freud.⁽³¹⁾ Szalay and Deese argue that word-association techniques are easy and efficient ways of determining the contents and representational systems of human minds without requiring those contents to be expressed in the full discursive structure of human language. In fact, they argue, we may reveal ourselves in associations in ways we might find difficult to do if we were required to spell out the full propositions behind these associations through answers to questions.

This continued until six associations were produced or the respondent drew a blank. Then the procedure was repeated for the next city. The order of the cities was rotated across respondents. The procedure was identical for the states and business location surveys.

Following the elicitation of images, respondents were asked to rate each image they gave on a scale ranging from very positive (+2), somewhat positive (+1), neutral (0), somewhat negative (-1), or very negative (-2).

Respondents in Studies 1 and 2 were then asked to rank the cities/states according to their preference for a vacation site (long weekend vacation for cities; week or longer vacation for states). Subsequent questions asked for a preference ranking among these cities or states as retirement sites or places to move to assuming equally attractive job offers in each place, much in the same manner as vacation preferences were elicited. Additional questions assessed the extent of previous visits or living experiences in each of the cities or states, and the existence of family or close friends in each of those places.

Next, up to six images were elicited to the stimulus "underground nuclear waste storage facility" and the stimulus "nuclear test site."

The survey also asked "in which state has the federal government proposed to build an underground facility for storing radioactive wastes?" and "in which state is the nuclear test site located?"³

The survey of corporate decision makers first elicited images for each of four cities--Phoenix, Las Vegas, Denver, and Albuquerque--and then asked the respondents to

³ The nation's nuclear weapons test site is located in Nye County, Nevada, adjacent to the proposed repository site at Yucca Mountain.

evaluate these images on the -2 to +2 rating scale, as in the other surveys. These individuals were then asked to rank these cities in order of preference as a location for opening or expanding a business, assuming that market conditions and cost conditions were about equal.

Survey Samples

Adults 18 years of age and older in Phoenix were surveyed with the cities questionnaire during the period April 13 through May 4, 1988. The states telephone survey was conducted in Phoenix between May 16 and June 8, 1988. The survey of corporate decision makers took place between June 9 and July 29, 1988.⁴ In each survey, more than 70% of the initial contacts resulted in completed interviews.

RESULTS

Cities Survey

Respondent characteristics. When asked "who in your household makes the final decision on vacations?", about 80% of the respondents said either that they did this themselves, or did so jointly with their spouse or partner. The percentage of respondents that had visited the target cities during the past five years ranged from 40% (Denver) to 65% (Los Angeles). Of those persons, the percentage that had spent a weekend in these cities during the past two years ranged between 50% (Denver) and 76% (San Diego). These self reports support the choice of Phoenix residents as an appropriate target population for Las Vegas tourism and support the selection of San Diego, Los Angeles, and Denver as appropriate competing sites for vacations.

⁴ The sample was selected from the 1988 edition of *Who's Who in Corporate Real Estate*.

Images. In response to the stimulus word "Las Vegas," images associated with gambling, casinos, hotels, bright lights and entertainment were dominant, followed by imagery pertaining to the climate and physical landscape, money, crime, and immorality. Imagery related to nuclear waste and the nuclear test site was very infrequent (only 2 images out of more than 1500). Table I presents the hierarchy of images elicited by the stimulus phrase "underground nuclear waste storage facility." The imagery was overwhelmingly negative. By far, the most frequent associations were dangerousness and death and their synonyms, followed by pollution, negative concepts, and radiation. Although we did not ask people to score these images, it seems likely that most of them would have been judged "very negative," a -2 on our five-point scale. Although some images pertaining to "necessity" came at the 17th position, they were very few in number (17) and included the phrase "necessary evil" given by two respondents. The words "Nevada" and "Las Vegas" were weakly associated with the repository, which was not surprising, given the low level of awareness of where the site is proposed to be located.⁵

Insert Table I about here

Images of the nuclear test site were similarly negative and exhibited considerable overlap in content with the images of a nuclear-waste storage facility. Major test-site images included

⁵ Only 19.6% of the cities sample knew that Nevada had been selected as the leading candidate for an underground facility for disposing of radioactive wastes and 46.8% knew that the nuclear weapons test site is in Nevada.

radiation, death, danger, cancer, destruction, and Nevada. More people associated Nevada with the test site (82 mentions) than with the repository.

Predicting preferences from images. To predict preferences among cities from images, we developed a scoring rule, the summation model, which simply sums the ratings for all the images a respondent produced for each city. A person's preferences among cities are hypothesized to be predictable from these sums.

An example, illustrating the application of the summation model to the data of one respondent, is given in Table II. For this respondent, the rank order of summation scores exactly matched the preference order for vacation sites.

Insert Table II about here

When ranks generated by the summation model were compared to the actual ranks generated by the respondents when they stated their preferences, the model did quite well, correctly predicting 55% of the number 1 ranked vacation cities and 56% of the fourth ranked cities, with somewhat less accuracy in predicting intermediate ranks (if the model lacked predictive validity, we would expect a 25% hit rate by chance). The exact rank order of four cities generated by the summation model matched the exact rank order of the respondent 26.4% of the time (perfect matching of ranks would be expected by chance only 4.2% of the time).

A second set of tests was conducted with the summation model. Each of the four cities was paired with every other cities--making six pairs in all. For every respondent and every pair, the image score for city B was subtracted from the image score of city A. The resulting 2,346

A-B scores across all respondents were ordered from extreme negative to extreme positive and this distribution was partitioned into five subsets, as equal in size as possible (range = 419 to 511 comparisons in each subset). Finally, within each subset, the percentage of respondents who ranked city A more favorably than city B as a vacation site was calculated. The plot of the mean A-B difference was most negative (mean = -6.2), A was preferred as a vacation site for only 27.4% of the pairs. For the subset in which the mean difference was most in favor of A (mean = +11.4), 90.7% of the preferences favored A. The best fitting regression line through these five points had a slope of .037, indicating that every one-point increase in the mean difference score was associated with a 3.7% increase in the percentage of choices favoring city A.

Insert Figure 1 about here

Figure 1 illustrates the performance of the summation model across all pairs of cities. The choice proportions for specific pairs of cities (e.g., Las Vegas vs. Denver), were found to be quite similar to the combined plot in Figure 1.

The data in Figure 1 shows that imagery and preference for vacation cities are strongly related. If city B has a more positive set of images than city A (as indicated by simply summing the affect ratings across however many images were produced for each city), then city B is more likely to be preferred as a vacation site. If city A has more positive imagery, then city A is more likely to be preferred as a vacation site.

Predicting Job and Retirement Preferences

The summation model was applied in similar fashion to the prediction of job preferences and retirement preferences for the cities survey. The hit rates were similar to those reported earlier for vacation preferences. The functional relationships relating job and retirement preferences to image scores were almost identical to the relationship shown in Figure 1.

Results: States Survey

As in the cities survey, more people (41.0%) knew the location of the nuclear weapons test site than knew the location being considered for the repository (24.5%). The summation model was found to be about as accurate in predicting vacation, job, and retirement preferences among states as it was for predicting preferences among cities.

Imagery associated with "a nuclear waste storage facility" and the "nuclear test site" was extremely negative for respondents in the states survey and was almost identical to the imagery obtained in the cities survey. Whereas few people in the cities survey expressed nuclear-related imagery in response to the stimulus words "Las Vegas," about 10% of respondents in the states survey produced nuclear imagery in response to the stimulus "Nevada." Such images included the terms nuclear testing, nuclear bomb, nukes, explosions, and radiation. The mean image score for Nevada for these persons was 0.18. The mean image score for persons who did not associate Nevada with things nuclear was 2.56 (a statistically significant difference; $p < .001$). As expected, persons with nuclear imagery assigned lower (poorer) preference rankings to Nevada than did persons without such images (see Table III). These findings are important because they suggest that Nevada has already undergone some stigmatization as a "nuclear place."

Insert Table III about here

Results: Corporate Decision Makers Survey

Parallel analyses were carried out with the images and preferences of the corporate decision makers. The summation model correctly predicted 47% of the first-choice locations for siting a new business and the functional relationship between image scores and preferences for pairs of cities looked much like the relationship for vacation preferences in Figure 1.

In summary, three separate surveys totaling more than 1200 respondents demonstrated that a simple summation model applied to sets of images did a good job of predicting expressed preferences for cities and states in which to vacation, take a new job, retire, or site a business. The slopes of the best-fitting lines relating preferences among pairs of cities/states to differences in image values were quite steep, indicating that a change in one or two images could imply a substantial shift in preference probability.

Additional Analyses

Additional studies were done on these data to test and evaluate the link between imagery and preference.

Independent raters. The predictive accuracy of the summation model was quite high. One possible criticism of the data collection method is that the high degree of predictability is an artifact of allowing respondents to rate their own images. People's ratings may have influenced their preferences, thus inflating the relationship.

To test this hypothesis, we conducted a fourth study, using samples of young adults from Eugene, Oregon as subjects. One group of subjects (N = 150) produced images for four cities and ranked the same cities according to their attractiveness as vacation sites, much as was done

in the survey of Phoenix residents. Some respondents produced images first and then indicated their vacation preferences. Others gave their preferences first. Unlike the Phoenix surveys, however, subjects in the Oregon survey did not score their own images. Instead, the more than 2000 different images produced by the subjects were rated by a different group of 28 subjects. The "artifact" hypothesis predicts that the summation model would have much poorer predictability in this study, because there is no possibility that image ratings can influence the preferences (or vice-versa).

The results of this study were surprising. The model's hit rates were excellent (66% accuracy in predicting first choices) and the functions relating differences in image scores to preference probability were again remarkably linear, with slopes only slightly less steep than those obtained in the Phoenix survey. The high predictive accuracy of the image models in the Phoenix surveys does not appear to be an artifact of the image evaluation procedure used in those studies.

Insensitive gamblers. Another challenge to the summation model was devised in the form of a hypothesis that people who like to gamble will not be influenced much by other attributes of Las Vegas. This hypothesis was tested using 246 respondents in the cities survey who produced the term "gambling" as one of their images of Las Vegas. These individuals were separated into subgroups according to the value they assigned to the gambling image. Next, a separate analysis of the relationship between image difference scores and preference probability for Las Vegas, analogous to the analysis in Figure 1, was performed within each subgroup. Difference scores were computed by pairing Las Vegas with each of the other cities and subtracting the score for the other city from the score for Las Vegas.

The hypothesis predicts that those who see "gambling" as extremely positive (i.e., who rated it as a +2) would have vacation preferences for Las Vegas that are less sensitive to image differences compared to the preferences of people who are less favorable toward gambling (i.e., who rate "gambling" as intermediate or negative in value). The data did not support the hypothesis. The curves relating image score differences to preference probabilities for Las Vegas were not significantly different for groups of people who differed in their evaluation of gambling. In other words, people who viewed gambling as a very positive feature of Las Vegas were just as much influenced by other positive and negative images as were people who had less positive views of gambling.

Effects of repository knowledge and test-site knowledge. Additional analyses were conducted using the states survey data to determine the impact of knowledge about the state being considered for the nuclear waste repository and knowledge about the state in which the nuclear-test site is located upon images and preferences for Nevada as a vacation site. These two types of knowledge were found to be related. Persons who knew that the repository was being considered for Nevada were somewhat more likely to know that the test site is in Nevada (71%) as compared to those who lacked knowledge of the repository (55% knew the test-site location). Similar results were obtained in the cities survey, where the corresponding values were 70% and 41%.

Additional analyses showed that the presence of a nuclear image in one's image set for Nevada was determined more by knowledge of the test-site location than by knowledge of the repository location. Nuclear imagery was produced by 15% of those persons who knew the test-

site location compared to 2% of those who did not know the location. Corresponding figures associated with knowledge and lack of knowledge of the proposed repository were 12% and 9%.

Summarizing the results from these analyses, we see that the proposed Yucca Mountain repository has not yet infiltrated people's images of Nevada and has not yet had much effect on their stated vacation preferences. The test site, which has been a feature of Nevada for many years, has had a stronger influence on images and preferences. Knowledge that the weapons test site is in Nevada appears to have led to an increase in nuclear-related imagery for Nevada and nuclear imagery is associated with decreased preference for Nevada as a vacation site.

Imagery and vacation behavior. The previous analyses demonstrated that images could predict expressed preferences for vacation sites. Can image scores also predict actual vacation trips? To address this question we attempted to resurvey the 802 respondents from our 1988 Phoenix surveys some 16-18 months later (October - December, 1989). We were successful in re-interviewing about 130 persons in each of the two samples (cities survey and states survey) studied earlier.⁶ Again, we elicited word associations to each of the same four cities or four states and asked for positive/negative ratings of each image produced. In addition, we asked the respondents to indicate in which of these cities (or states) they had vacationed since the previous survey was conducted.

⁶ Across the two repeat surveys, about 60% of the original respondents could not be reached because no one answered the phone (despite repeated callbacks), the number was no longer valid, or the answering person said that the target individual no longer lived there. Of the original respondents who were contacted, 83.3% completed the repeat survey.

The predictive capability of the word-association image scores was tested by means of logistic regression analysis using a person's 1988 image score for a state or city to estimate the probability that that person would vacation in a place during the subsequent 16-18 months (until the date of the repeat survey). The estimated probabilities for both cities and states are presented in Figures 2 and 3. These data show that the affective qualities of a person's images of a place were clearly related to the probability that the person would subsequently vacation there, with the relationship being stronger for states than for cities.

Insert Figures 2 and 3 about here

Image stability. The resurveying of the Phoenix samples provided us with an opportunity to examine the stability of image scores for states and cities across a 16-18 month time span. We found moderate stability. More than 60% of the paired image sets provided by the same person had at least one identical association in both sets. When the 1988 and 1989 image scores were compared for the same person-same stimulus, they were found to correlate .52 for cities and .42 for states, across persons. The two image scores were identical in 11.4% of the cases. Almost 70% of the paired scores were within a range of ± 4 points.

The changes in a person's image scores likely reflect both systematic changes over time and unreliability. The unreliability can be reduced by averaging a person's 1988 and 1989 images scores for each city or state. When this is done, the relationship between imagery and vacations taken between May, 1988 and Autumn, 1989 became even stronger than that shown in Figures 2 and 3. For example, when images scores were averaged, the predicted probability

of vacationing in a state ranged from about .03 for the lowest mean image score (-12) to about .70 for the highest mean score (+12). This contrasts with a range between .07 and .61 when only the 1988 image score is used as a predictor.

DISCUSSION

The present study developed and applied a methodology based upon imagery in order to overcome concerns about the validity of direct questions regarding the potential influence of a nuclear waste repository at Yucca Mountain upon economically important behaviors. The results supported the three propositions that the research aimed to test: Images of cities and states, derived from a word-association technique, exhibited positive and negative affective meanings that were highly predictive of preferences for vacation sites, job and retirement locations, and business sites (Proposition 1). The concept of a nuclear-waste storage facility evoked consistent, extreme, negative imagery (Proposition 2). The nuclear-weapons test site, which has been around far longer than the Yucca Mountain nuclear-waste project, has led to a modest amount of nuclear imagery becoming associated with the state of Nevada. This provides indirect evidence for Proposition 3, which asserts that nuclear-waste related images will also become associated with Nevada and Las Vegas if the Yucca Mountain Project proceeds. Nuclear imagery, when present in a person's associative responses, was found to be linked with much lower preference for Nevada as a vacation site. The verification of these propositions implies that the repository also has the potential to cause an increase in nuclear imagery which, in turn, will produce adverse impacts on tourism and other economically important activities in Nevada.

In our opinion, these findings provide a partial answer to the question that motivated the inquiry. The mechanisms of perceived risk, social amplification, and stigma are observable in the record of past experience with nuclear and other types of hazards. In the context of the Yucca Mountain Repository, these mechanisms appear to have the potential to cause substantial losses to each of the various economics sectors at risk. We believe that it would be unwise and unfair for development of the nation's high-level nuclear waste repository to proceed without taking these potential economic impacts into consideration.

Some analysts have suggested that the nuclear weapons test site provides evidence against the above conclusions, in view of the strong expansion of the Las Vegas visitor economy during the years in which this facility has been operating. We disagree. Judging from the Phoenix survey, the test site has worked its way into the imagery of Nevada for only a small percentage of people and is rarely associated with Las Vegas. Moreover, the operations of the test site have been restricted and unavailable to full public scrutiny. Nuclear-waste transport, the operation of the waste repository, and any controversies over the safety of these activities will likely be far more visible to the public and the media. In particular, tens of thousands of nuclear-waste shipments by truck or rail throughout the United States will be a prominent reminder of the repository and its risks. As these shipments converge upon Las Vegas, nuclear associations with that city may be built to a far greater extent than has occurred with the secret, contained, underground explosions at the test site. Finally, there is no evidence that the small degree of association of the test site with the region has not actually impaired tourism and business development. Apart from the gambling industry, business development has shown little progress despite the potential attractiveness of Las Vegas for many kinds of industries.

It may also be the case that the test site and the repository will interact in a synergistic way to produce nuclear imagery to an extent that is greater than the sum of the individual contributions from each facility. Little is known about the dynamics of the process by which images become salient. It is certainly true, however, that individuals have a number of images associated with any particular place. There may be some threshold of repetition that moves a weak or unstable image from the periphery into the core image of a place. If so, Nevada's link to the nuclear weapons test site may increase its potential for stigmatization from the repository relative to a state with no existing base of nuclear imagery.

Historical analysis of major risk events has documented substantial socioeconomic impacts, but these impacts have often been transitory. Will the same impermanence hold for impacts triggered by a nuclear waste repository? In considering this question, we suggest that it is useful to distinguish two different kinds of stimuli emanating from the repository. First, there are the multitude of discrete events that are associated with the project. Second, there is the cumulative experience with the project, which reflects the characteristics of the project plus the experience across all project-related events. It is reasonable to suppose that an isolated, solitary event will generate a transitory response. It is also reasonable, however, to expect that the imagery of Nevada and Las Vegas held by the general population will reflect their cumulative experience with the repository program. Each of the discrete events that might result from the program, therefore, would have the potential to trigger two kinds of consequences--responses to the event itself, the duration of which would be related to the nature of the event, and responses based upon the cumulative image of the repository to which this event makes a contribution on the margin. Just as this cumulative image will take time to develop, it may also

be more durable. In fact, to the extent that strong nuclear imagery became associated with the repository, the host region, or major communities along waste-transportation routes, the stigmatization could remain for a long time. The sort of associative material that builds an image is illustrated by the magazine photograph and excerpt shown in Figure 4.

Insert Figure 4 about here

Although this research has clarified the mechanisms by which adverse economic impacts can be generated, predicting the precise magnitude and duration of those impacts is impossible. The uncertainties involved in repository development make it inevitable that the actual impacts--physical, biological, social, and economic--will differ from the best of impact projections. There are at least four categories of uncertainty. First, the Department of Energy (DOE) plans are still largely unspecified on crucial matters; for example, it is impossible to know at this time whether waste shipments will be made by truck or rail, over which routes, and with what frequency or safeguards. Second, the risk-management policies to be followed by state and local governments are largely unknown, and could have a powerful influence on impacts. Third, there will certainly be external perturbations and surprises that may cause the repository development to differ from anything that can be foreseen at this time. Fourth, economically relevant decisions are always made in the context of alternatives; quantitative prediction requires currently unavailable knowledge of the alternatives that individuals and society will be able to choose among in the future.

In sum, our analysis indicates that the development of the Yucca Mountain Repository will, in effect, force Nevadans to gamble with their future economy. The nature of that gamble cannot be specified precisely, but it appears to include credible possibilities (with unknown probabilities) of substantial losses to the visitor economy, the migrant economy, and the business economy.

As the potential for the repository to have adverse economic impacts becomes recognized by citizens of Nevada and their government officials, the already strong political opposition to the site can be expected to intensify, making it extremely difficult for the federal government to proceed with the project.⁷

Beyond Yucca Mountain. The present inquiry has implications for social-impact analysis that transcend the conflicts and concerns surrounding the proposed Yucca Mountain repository. The processes of social amplification and stigma appear relevant, as well, to the analysis of impacts from any major facility that produces, uses, transports, or disposes of hazardous materials. The numerous proposed sites for disposal of low-level radioactive wastes and the many sites being considered for chemical-waste incinerators and landfills will face similar problems of perceived risk and its impacts, though probably to a lesser degree than the problems posed for Nevadans by a Yucca Mountain repository. The present study has demonstrated that

⁷ In June, 1989, the Nevada State Legislature passed a bill, AB 222, making it unlawful for any person or governmental entity to store high-level radioactive waste in Nevada. Concern that a high-level radioactive waste repository could severely damage the economy and environment of the state was cited by the legislature as a major factor in the passage of this bill. In current litigation between the State of Nevada and the Department of Energy, lawyers from the state's Attorney General's Office have repeatedly cited potential adverse economic impacts to support the state's opposition to the repository program.

the so-called "standard effects" of large engineering projects on local employment, housing, and transportation have the potential to be dwarfed by the "special effects" of risk perception and stigma. However, just as physical or technical risks can be mitigated by proper safety design and management, effects of perceived risk may be mitigated by means of management processes that instill and maintain trust and that work to protect the economic base of those individuals and communities whom the facility puts at risk.

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Table I

Images Associated with an "Underground Nuclear Waste Storage Facility"

Category	Frequency	Images Included in Category
1. Dangerous	179	dangerous, danger, hazardous, toxic, unsafe, harmful, disaster
2. Death/Sickness	107	death, dying, sickness, cancer
3. Negative	99	negative, wrong, bad, unpleasant, terrible, gross, undesirable, awful, dislike, ugly, horrible
4. Pollution	97	pollution, contamination, leakage, spills, Love Canal
5. War	62	war, bombs, nuclear war, holocaust
6. Radiation	59	radiation, nuclear, radioactive glowing
7. Scary	55	scary, frightening, concern, worried, fear, horror
8. Somewhere Else	49	wouldn't want to live near one, not where I live, far away as possible
9. Unnecessary	44	unnecessary, bad idea, waste of land
10. Problems	39	problems, trouble
11. Desert	37	desert, barren, desolate
12. Non-Nevada Locations	35	Utah, Arizona, Denver
13. Nevada/Las Vegas	34	Nevada (25), Las Vegas (9)
14. Storage Location	32	caverns, underground salt mine
15. Government/Industry	23	government, politics, big business

Basis: N = 402 respondents in Phoenix, Arizona

Table II

Images, Ratings, and Summation Scores for Respondent 132

Sample Subject	Image Number	Image Rating	
SAN DIEGO	1	2	very nice
SAN DIEGO	2	2	good beaches
SAN DIEGO	3	2	zoo
SAN DIEGO	4	1	busy freeway
SAN DIEGO	5	1	easy to find way
SAN DIEGO	6	2	pretty town
		<u>Sum =</u>	10
LAS VEGAS	1	-2	rowdy town
LAS VEGAS	2	-1	busy town
LAS VEGAS	3	-1	casinos
LAS VEGAS	4	-1	bright lights
LAS VEGAS	5	-2	too much gambling
LAS VEGAS	6	0	out of the way
		<u>Sum =</u>	-7
DENVER	1	2	high
DENVER	2	0	crowded
DENVER	3	2	cool
DENVER	4	1	pretty
DENVER	5	-2	busy airport
DENVER	6	-2	busy streets
		<u>Sum =</u>	1
LOS ANGELES	1	-2	smoggy
LOS ANGELES	2	-2	crowded
LOS ANGELES	3	-2	dirty
LOS ANGELES	4	-1	foggy
LOS ANGELES	5	0	sunny
LOS ANGELES	6	-2	drug place
		<u>Sum =</u>	-9

Note: Based on these summation scores, this person's predicted preference order for a vacation site would be: San Diego, Las Vegas, and Los Angeles.

Table III

**Preference for Nevada as a Vacation Site Among Respondents
Who Do and Do Not Exhibit Nuclear Imagery**

	Nevada Preference Rank				Mean Rank
	1	2	3	4	
Nuclear Imagery Present (N = 39)	3	3	46	49	3.41
Nuclear Imagery Absent (N = 354)	6	16	51	27	2.98

Note: Cell entries are percentages within each row.

Figure Captions

Figure 1. Relationship between mean image score differences (City A-City B) and proportion of times (P) City A was ranked higher than City B in the respondent's preference rankings for vacation sites. All possible pairs of cities are included in this analysis.

Figure 2. Probability of vacationing in a particular city after June, 1988 as a function of image scores elicited prior to that date (Phoenix survey). Upper row of numbers indicates the number of people with that image score who vacationed in the city; lower row is the number who did not vacation in the city; X marks the proportion who vacationed. The curve is the best fit logistic function to these proportions.

Figure 3. Probability of vacationing in a particular state after June, 1988 as a function of image scores elicited prior to that date (Phoenix survey). Upper row of numbers indicates the number of people with that image score who vacationed in the state; lower row is the number who did not vacation in the state; X marks the proportion who vacationed. The curve is the best fit logistic function to these proportions.

Figure 4. Many kinds of associations contribute to the development of an image (Source: *The Bulletin of the Atomic Scientists*, 1990, 46(2), p. 10).

P

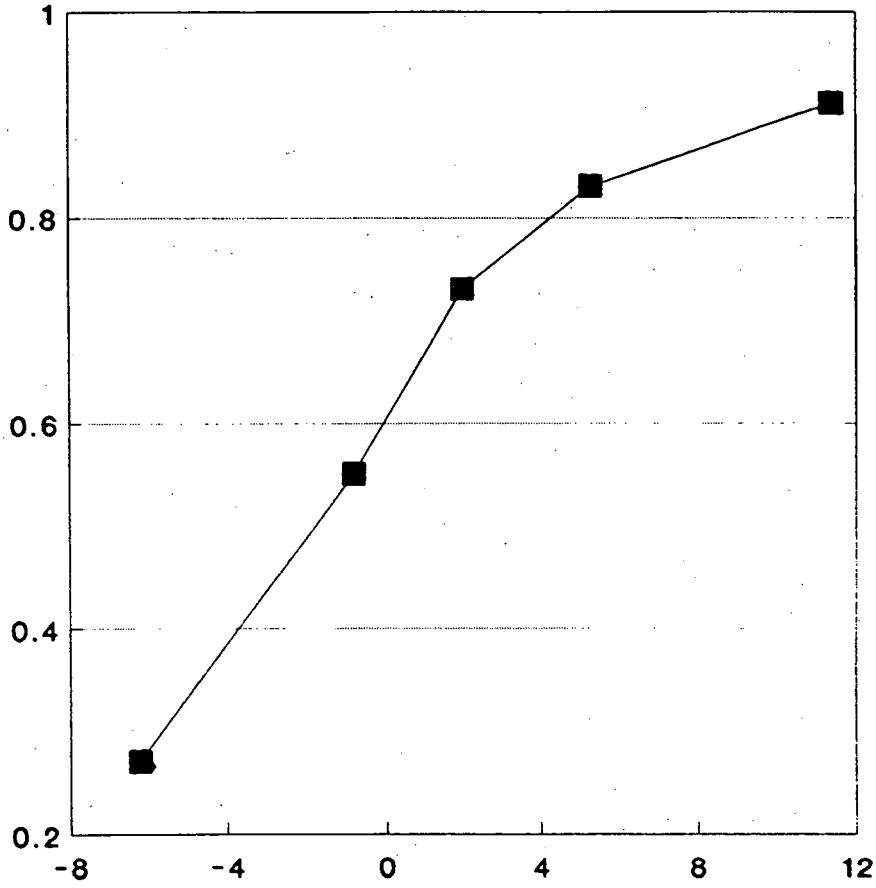
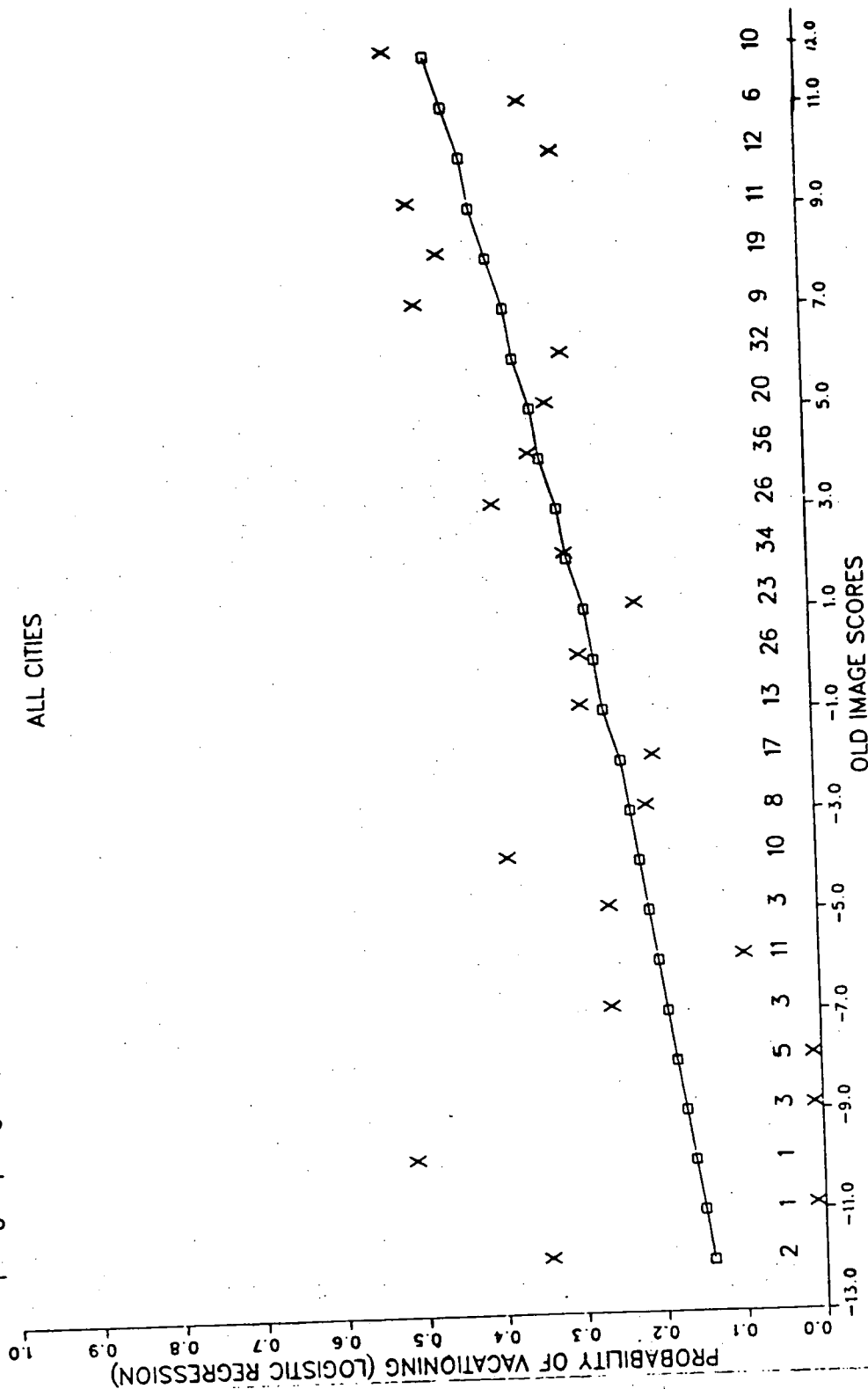
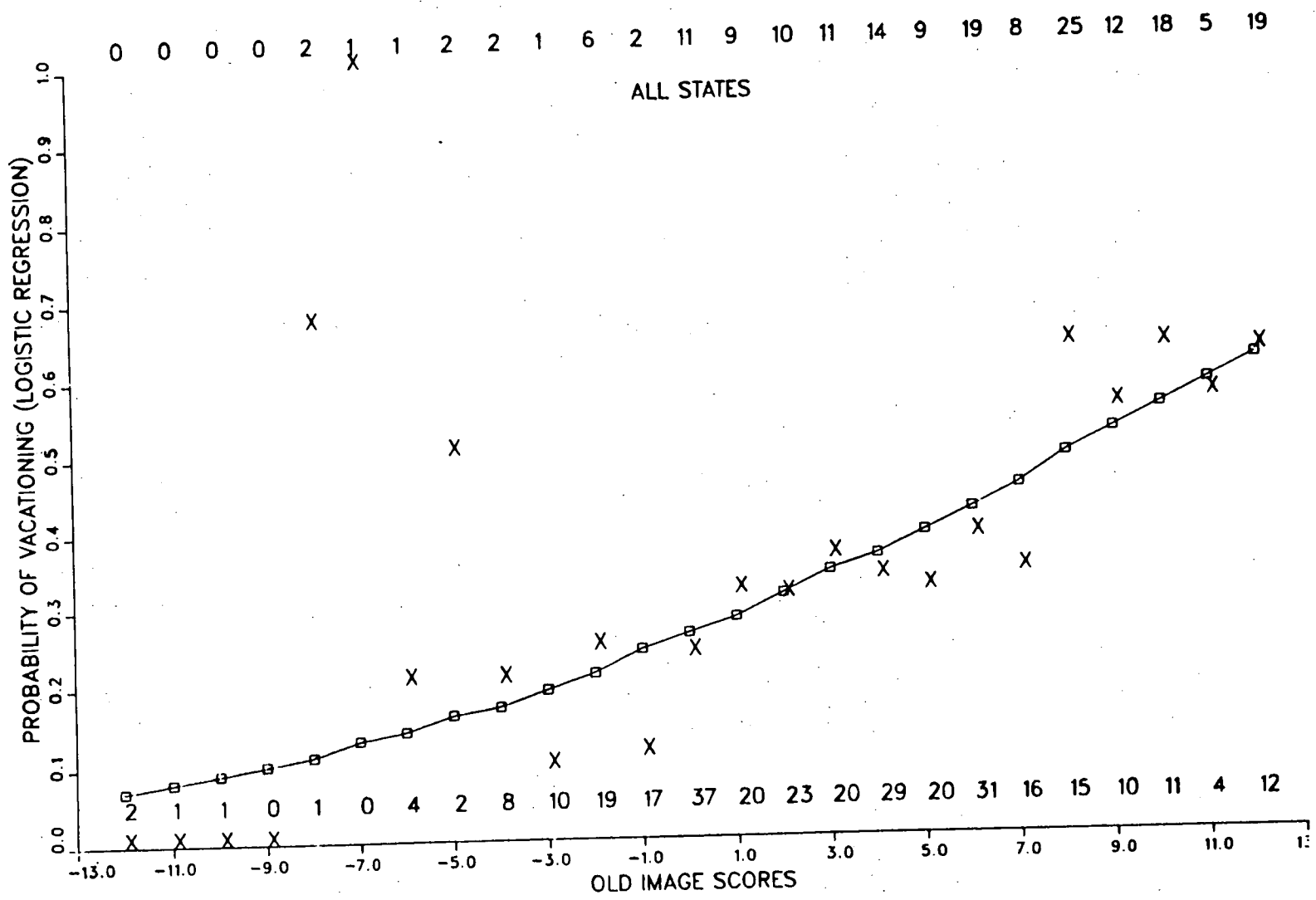


IMAGE SCORE DIFFERENCE
Vacations - Cities Survey

1 0 1 0 0 1 1 1 6 2 4 5 10 6 14 16 18 9 13 8 15 10 5 3 10

ALL CITIES





NUCLEAR TESTING

Nevada, U.S.S.R.

By PETER ZHEUTLIN



A new Soviet antinuclear group called Nevada—a name chosen to attract the attention of U.S. antinuclear activists—has had an impressive first year. . . .