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California Citrus Freeze of December 1998: Place, Perception and Choice - Developing a Disaster Reconstruction Model

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SUMMARY

Following a December 22-27, 1998, severe cold weather event in the lower San Joaquin River Valley in central California, the authors surveyed citrus growers to determine the relationship between locational, contextual, and perceptual factors and their intentions to modify their land use. Of the approximately 1,200 citrus growing operations in Fresno, Kern, and Tulare counties, 182 responded to our mailed questionnaire. Though damage was extensive - over $700 million - it was not as severe as that caused by a 1990 freeze that hit this region. We examine the relationship of the locational, contextual, and perceptual factors to the extent and distribution of damage and to the motivation of growers to act to reduce or prevent damage. We can conclude a number of interesting relationships that might be worthy of future research.

We find that the locational characteristics of latitude and longitude were related to orchard risk and mitigation. Orchard size, age of operation, and membership in cooperative organizations predict loss. Experience influenced the propensity to mitigate. Together they reflect the perceptual framework within which the grower responded to the onset of the event and also the likelihood that recovery would be needed. Insurance appears to dissuade expensive loss reduction efforts. Some growers may believe that insurance provides the most certain protection from calamitous losses, distributing the individual's risk over a wide community of gamblers. The certainty of disaster assistance funding to recoup some of the $700 million lost during this event may compel less aggressive risk attenuation and the growth of the industry into marginal regions.

INTRODUCTION

The authors administered a survey to citrus growers in three freeze-impacted counties of California's Central Valley in 1999. The freeze of Christmas 1998 held the prospect of severe devastation not only to the annual harvest of oranges and lemons, but also to the trees in the orchards of Tulare, Kern, and Fresno counties. This quick response report presents the background, methodology, analysis, and conclusions drawn from the study of 182 responses to our mail survey, returned to us in August of 1999. We set out to understand how location, context, and perception influenced the damage to properties and the resultant decisions of growers in recovery and reconstruction following the event.

BACKGROUND

Cold air spread into the southern San Joaquin Valley of California on the night of December 21, 1998. For the next four nights, temperatures in the agricultural portions of Fresno, Tulare, and Kern counties dropped below 28° F for several hours at a time. In some locations, temperatures dipped into the teens. The freezing temperatures could not have come at a worse time. First of all, it had been an El Niño year. Heavy rains in southern California during the previous spring had slowed the maturation of fruits and vegetables around the region. The citrus crop had been about a month late and it was still very early in the season, as picking of the navel orange crop had just begun in late November. Worse yet, this freeze hit hard upon the region's recovery from a freeze in 1990, one of the most devastating freezes ever to hit the California industry. Losses in 1990 exceeded $800 million. Both fruit and trees had been destroyed, and the 1998 freeze occurred only a couple of years after production had returned to pre-1990 freeze levels.

Nationally, Tulare, Kern, and Fresno counties play an important role in the U.S. citrus industry. Whereas California produced about 23% of U.S. oranges and 88% of lemons produced in the U.S. in the 1996-1997 season (National Agricultural Statistics Service, 1997), the three-county region produces a large portion of the state's navel orange and valencia orange crops and nearly a fifth of all U.S. lemons (Figure 1). Tulare County produces more than half of the state's oranges in a nondisaster year. In 1997, the U.S. Department of Agriculture (1997) reported that Tulare had 2,105 citrus operations, covering 109,272 acres and comprising 12,901,372 trees. Those numbers are 26%, 35%, and 35%, respectively, of the state of California totals. The numbers for Kern County (180 farms comprising 45,130 acres and 5,183,969 trees) and Fresno County (577 farms comprising 31,110 acres and 3,446,784 trees) raise the portion of state citrus production found in these three counties to 36% of citrus orchard operations, 59% of acreage, and 58% of trees. The regional economy is dependent upon citrus production.

Orange, lemon, and lime trees respond naturally to colder weather by infusing sugars from their trunks into the maturing fruit to prevent freezing and the bursting of internal juice-sac membranes. The benefits gained by location in climates with cool to cold winters are reaped by harvest of sweeter, more marketable fruit. Mild fall or winter weather in citrus regions generates lower quality products. Thus the location of citrus orchards historically has tried to "toe the line" that separates the cold from too cold. Therefore, freeze loss mitigation plays a key role in the survival of both traditional and industrial citrus operations.

The primary tools of freeze mitigation include: electric and diesel-powered wind turbines, warm water flood irrigation of orchards during freezes, coating of trees and fruits with layers of ice for insulation, and the burning of wood or diesel fuel in smudge pots to produce warm smoke believed to displace cold air. Following the 1990 disaster, however, many growers purchased insurance policies to help absorb some of the losses from an inevitable freeze. Policies sold since 1990 ballooned from 162 to more than 2,730. Acreage covered by insurance spread from 7,355 acres to more than 131,000. Liability coverage increased from $8 million to over $114 million by 1998, and premiums paid by policyholders increased from $637,360 to over $7.4 million in 1998 (Risk Management Agency, 1999). The state was thus more prepared for monetary loss protection in 1998 than it was only eight years earlier. This rapid adoption of crop insurance, however, quickly shifted the risk burden off of individuals and onto the collective risk pool of the industry.

In December of 1998, citrus growers responded to the diving temperatures with efforts to reduce damage and losses. Orchard managers activated electric and diesel-powered wind turbines standing above orchards to mix the sinking cold air with the warmer air rising above the trees. A few growers spent thousands of dollars to employ helicopters to hover over their properties to accomplish the same task. Some orchards were flooded with 60° F water pumped from wells to transfer heat into the lower atmospheric layer by advection. Other growers sprayed their trees with water to generate layers of insulating ice that would protect both fruit and tree. Still other growers used low-technology diesel-fuel smudge pots that emitted warm smoke believed to effectively displace colder air. The most desperate growers simply "picked like hell" to harvest all they could before the produce was damaged.

Unlike many other types of disasters, a freeze disaster develops slowly and reveals the extent of its impact over a period of days to weeks and even months. Severe impacts, such as burst tree limbs or trunks, may be apparent during the most intense freeze episodes. The most economically injurious (severely frozen fruit) and long-term damage (dead buds or tree destruction) may only become evident weeks after the event. Early reports at the end of December of 1998 indicated that in Kern County alone more than 80% of citrus properties were damaged. Ninety percent of the county's navel oranges that remained on the trees were destroyed. The losses of lemons, grapefruits, tangerines, and tangelos were total (Owen, 1998). Therefore, the authors activated a quick response grant without complete knowledge of the severity of the impacts to orchards in order to evaluate the spatial responses of growers.

The total damage to all crops in California from the freeze amounted to $700.4 million (California Department of Food and Agriculture, 1999). Fresno, Kern, and Tulare counties accounted for 83% of the total monetary loss at $578.6 million. Only after our study had been completed was it known that there had been little damage to the trees and that the losses in citrus comprised only that year's crop. Statewide losses of oranges were valued at $587 million, those of lemons, $266 million, and $6 million for grapefruit.

The president issued a disaster declaration for eight counties in the state in February 1999: Fresno, Kern, Kings, Madera, Merced, Monterey, Tulare, and Ventura. Disaster unemployment assistance, job placement, mortgage and rental assistance, energy assistance, food assistance, legal services, social services, and referrals to local services were among the aid pledged to victims of the disaster. Federal and state programs made more than $6.9 million available for mortgage and rental assistance for displaced workers (Federal Emergency Management Agency, 1999).

LITERATURE

Disaster reconstruction research has drawn two conclusions about long-term changes generated by disasters. Either places do not change after a disaster, or an acceleration of spatial processes operating in areas hit by disasters occurs due to the event. Numerous studies have examined long-term changes caused by disasters (Bowden, 1982; Berke et al., 1993; Friesma et al., 1979; Geipel, 1982, 1991; Haas et al., 1977; Rossi et al., 1978; Rubin, 1981; Wright and Rossi, 1981; Wright et al., 1979). We consider these conclusions to gain a better understanding of recovery and postdisaster change. Which factors influence peoples' choices about their property after a disaster? What are the characteristics of a place that affect how it is reconstructed? Are places different after a disaster (i.e., has there been a permanent and profound deviation in land use patterns or organization?) or have disaster areas been catapulted forward toward predetermined ends?

This research surveys the precursors of change, the "expressed" decisions being formulated in the immediate wake of disaster, to determine the factors that are consciously considered by decision makers as they proceed with recovery and ultimately decide on reconstruction. The authors offer a conceptual model that describes the factors that effect land-use decision making. It contains the most important factors from three conceptual categories: location, contexts, and perception. Locational variables include descriptors of the physical nature of a property (a land unit). The contextual factors describe the local, regional, and national/international structure of predisaster activities undertaken on the land unit, as well as economic factors that might enter into the decision to change land use. Perceptual variables describe the experience of and mitigation practices employed by the land-use decision maker. The interplay of these factors determines the decision to rebuild in the predisaster form or to change in varying degrees in response to the disaster. We evaluate the model using survey data.

Numerous studies document changes in land use resulting from freeze events' impacts on citrus in northern Florida (Bein, 1971; Brey, 1985; Miller, 1988, 1991; Miller and Downton, 1993a, 1993b; Miller and Glantz, 1988; Ward, 1974). The result of these changes is a diminished amount of land devoted to citriculture. The distribution of citrus operations has changed in other parts of the United States as well. California's citriculture has all but disappeared from the Los Angeles area and is now found primarily in the vicinity of Riverside, in the southern San Joaquin Valley and in the Imperial Valley. Citrus growers in Texas once carried out operations as far north as the Beaumont and Port Arthur area (near the Louisiana border). Currently the citrus industry operates only in the Lower Rio Grande Valley from Mission and McAllen to Brownsville.

Have all of these observed changes resulted directly from freezes? Or was citriculture declining in the northern fringes of these areas irrespective of freeze events? Why do changes like these occur? What factors contribute to decisions to rebuild orchards, temporarily retreat from the business, shift to another agriculture crop, convert to nonagricultural land uses, or sell-out completely?

STUDY DESIGN

Any of the citricultural portions of four states (Arizona, California, Florida, or Texas) could experience a devastating freeze event in any given year. We designed the research to be easily portable between the three regions. California was the first region hit by cold weather, so in response to the unfolding disaster occurring in California, our team contacted agencies and organizations that might be able and willing to assist with the project. Initially, we planned to administer a survey in on-site face-to-face interviews with 150 to 200 growers. However, during a site visit in January, three weeks after the freeze, we determined that state agricultural departments, citrus marketing organizations, and citrus packing houses were unable to provide a mechanism to quickly contact growers in the freeze-ravaged areas in person. Rather, California's Citrus Research Board extended an invitation to mail the survey to all growers in the tri-county disaster area. The authors redesigned the survey (Appendix A) and mailed it to all growers in Fresno, Kern, and Tulare counties known by the California Citrus Research Board. Over 1,250 were sent out in late March of 1999. By July, 182 growers had returned usable surveys to the Citrus Research Board offices in Visalia.

The two-page survey included questions regarding the location and characteristics of each grower's orchards, their management practices, and loss and impact mitigation efforts based upon a theoretical variable structure (Table 1). The spatial description of the location of the property is an extremely important piece of information that is often not gathered in surveys of this type. Responses that included township-range-section data or, at the very least, the county in which the grower's property was located enables our connection of other survey information to locations to better understand the distributions of impacts and choices. We used a geographic information system to map a portion (118) of the survey responses (Figure 2). The survey instrument asked for detailed descriptions about the acreage, elevation, slope, and irrigation methods of orchard properties, as well as the types and varieties of citrus grown, to provide clues to explain the severity of impacts. We requested descriptions of contextual details, such as land tenure, ownership, management style, memberships, and packinghouse information, to evaluate their connections to mitigation, recovery, and decisions about reconstruction. Inquiries about previous freeze experience, the purchase of insurance, the use of disaster assistance, and mitigation measures employed provided measures of perception. Many of the growers had incomplete knowledge of the extent of their losses at the time the survey was mailed, therefore, we asked them about their expected actions in response to the freeze. Reported harvests and expected losses serve as surrogate measures of each grower's freeze impacts.

RESULTS

Location

Of the 182 survey responses returned by respondents (approximately 15% of those mailed out), 135 (74%) came from owners of Tulare County orchards (Table 2). Another 40 (22%) came from Fresno County, and 3 (2%) from Kern County. The bulk of citrus growers that responded (160, 88%) owned acreage of less than 200 acres. Sixty-three (35%) operated orchards of less than 25 acres. Only 20 (11%) managed more than 200 acres. Responses are therefore biased toward smaller private enterprises rather than industrial-scale operations.

Most of the agricultural land within the southeastern portion of the San Joaquin Valley of California ranges between 100 meters (328 feet) and 200 meters (556 feet) in elevation. Only 32 (18%) of the respondents had plots entirely below 100 meters, and 58 (31%) had orchards entirely above 100 meters. Ninety-five percent (172) irrigated. Most (126, 69%) used sprinklers. Twenty-four (13%) orchard owners used flood and open-furrow irrigation techniques, and 21 (12%) operators used drip or conservation methods.

Context

Respondents to the survey were almost exclusively (175, 96%) owners of orchards and most (108, 58%) orchard operations were more than 20 years old. Private owners accounted for three-fourths (134, 74%) of ownership. Twenty-six (14%) operations were partnerships and 19 (10%) were corporations. Most operators belonged to professional cooperative sales and marketing organizations. Sunkist membership was held by 118 respondents (65%). Seventy-seven (42%) belonged to California Citrus Mutual.

Perception

Most respondents were well acquainted with the freeze hazard. Eighty-eight percent (161) of the respondents reported previous freeze experience. Most of these (147) experienced losses from the devastating 1990 freeze that hit California, and 133 ranked their losses as very severe. More than half (117, 64%) lost more than three-fourths of their crops during the 1990 event. More than four-fifths (153, 83%) of respondents lost some portion of their crop during that freeze.

As expected, the 1990 experience triggered mitigation efforts. Sales of catastrophic crop loss insurance skyrocketed in California in the wake of the 1990 freeze, and it is no surprise that 123 (68%) of those surveyed reported having purchased this protection. Only 53 (29%), however, purchased buy-down policies to guard against changes in the value of the produce during a growing season.

In response to warnings of a pending freeze in December of 1998, the majority (137, 75%) of respondents took some action to mitigate the impact of cold weather. Some (64, 37%) conducted maintenance on wind machines and irrigation systems, 46 (25%) prepared to run warm water from wells into the orchards, 20 (11%) applied chemicals to their trees, and 2 (1%) furiously picked ripening fruit. Attempts to mitigate the impact of cold air on the orchards during the event included the use of wind machines, warm water, fire, or smudge pots or combinations thereof. Fifty-five growers (30%) reported using warm water only, 5 (3%) used only wind machines, and 91 (50%) used a combination of the three devices.

Impacts

The amount of loss averted using mitigation will never be known. The costs of the disaster speak to the impact of the event. Most respondents (145, 80%) had applied for or were in the process of applying for disaster assistance through federal and state programs. Only 11 (6%) had applied for small business administration loans to recover from their losses. As a result of the damage, 52

(29%) of the responding growers are likely to be replacing trees severely damaged by the freeze, 8 (4%) stated that they will be changing crops, and 4 (2%) intend to sell their property.

Statistical Analyses

The data from this small sample (182 of 1,250) are nominal, rank, and ratio variables, so we ran exploratory higher-order statistical analyses (Pearson chi-square (X^2) and nonparametric Spearman's rank correlation (þ) on some of the responses. The results provided some insight into these relationships. Only the significant relationships are reviewed.

Chi-square analysis showed that latitude, as measured by the township in which the orchards were located, was significantly ($X^2 = 10.0$, $p = 0.04$) indicative of the likelihood that growers were to have picked a portion of their crop before the freeze. The more northerly growers had a greater likelihood of completing up to 24% of their crop harvest prior to the freeze. This pattern probably indicates fruit maturity at different locations in the southern portion of the valley and may reflect El Niño rainfall distribution. Interestingly, more southerly growers also lost less in the 1990 freeze, which may have played a role in their 1998 harvest decisions ($X^2 = 4.5$, $p = .11$).

Citrus orchards in these three counties are located on the western side of the southern Central Valley, abutting the foothills of the Sierra Nevada to the east and the Tejon Hills and San Emigdio Mountains north of Tehachapi in Kern County (Figure 1). Larger operations (ownership of more than 100 acres) tend to be located to the east, while smaller operations appear to be evenly distributed throughout the citrus belt ($X^2 = 4.9$, $p = .09$). There is also an eastern bias in terms of tenure of operation (Figure 3). Though younger operations (fewer than 35 years old) are evenly distributed east to west, the oldest operations (more than 35 years old) are located along the eastern margins ($X^2 = 4.9$, $p = .09$).

Sunkist growers tended to lose a smaller proportion of their crops in the 1998 freeze ($X^2 = 4.2$, $p = .12$). Higher pre-freeze harvests led to lower percentages of lost crops ($X^2 = 25.0$, $p = .00$ and þ $= -0.171$, $p = .05$). Half (23 of 46) of the growers that harvested none of their orange crop prior to the freeze were Sunkist growers. Nine were members of California Citrus Mutual and the rest (14) belonged to both organizations. Sunkist-only growers accounted for 19 of 57 that harvested between 1% and 24% of their crop before the freeze, whereas California Citrus Mutual-only members accounted for 13 of these 57. Of the 40 growers that harvested more than 25% of their crops prior to the freeze, 26 had Sunkist-only membership and 8 Citrus Mutual-only membership. These relationships were statistically significant ($X^2 = 11.4$, $p = .02$) and, in light of the fact that Sunkist growers tended to lose less of their crops, might indicate that Sunkist growers get enough information to wisely harvest only the necessary portion of their crops. Stated succinctly: information leads to risk reduction.

Size of property was related to a number of the characteristics examined. Larger acreage operations tended to lose a higher percentages of their crops (þ $= 0.359$, $p = .00$) and also completed higher percentages of harvest after the freeze (þ $= 0.323$, $p = .00$). Years of ownership was directly and significantly correlated with acreage size (þ $= 0.184$, $p = .05$) and with percent of crop harvested after the freeze (þ $= 0.155$, $p = .04$).

Though growers employed mitigation efforts throughout the region, as indicated by the survey responses (Figure 4), losses tended to be focused in the northern portion of the region (Figure 5). As expected, impact reduction efforts in 1998 were inversely correlated with the likelihood that a grower will need to replace trees ($X^2 = 3.5$, $p = .06$). The more effort taken to reduce losses prior to and during the freeze, the less expected would be the need to replace trees. Very few growers planned to replace trees killed or damaged by the freeze (Figure 6).

A high concentration of growers who purchased catastrophic insurance is in central Tulare County (Figure 7). These growers were statistically more likely to purchase buy-down policies ($X^2 = 9.4$, $p = .002$ and þ = 0.326, $p = .00$), and were less likely to attempt pre-freeze mitigation measures (þ = -0.206, $p = .01$). Apparently, growers are either somewhat more complacent or acquiescent during a pending freeze if they have insurance, or they are more confident about the information they have received, their level of protection, and/or the level of adjustment they need to achieve in the face of disaster.

And finally, it appears that disaster assistance programs are an integral part of response of the citrus industry to freeze (Figure 8). Those that suffered impacts from the freeze disaster were certain to make use of disaster assistance programs. Higher loss percentages were directly indicative of higher rates of disaster assistance sought ($X^2 = 5.7$, $p = .02$).

CONCLUSIONS

The freeze of December 1998 did not deliver as severe a blow to the fruit, the trees, the growers, or the economy of the Central Valley of California as did the freeze of 1990. In its initial stages, this freeze raised the specter of the 1990 freeze, but it turned out to be less intense and therefore generated no postdisaster decisions regarding growers' plans to stay or leave the business. In this regard, the variables of the model cannot be tested against an expectation of land-use change. Instead, we examine the relationship of the locational, contextual, and perceptual factors to the extent and distribution of damage and to the motivation of growers to act to reduce or prevent damage. We can conclude a number of interesting relationships that would require specifically focused research to clarify and refine the information. With regard to location, we find that the place characteristics of latitude and longitude were connected to the orchard risk and mitigation. There is a relationship not only between latitude and freeze damage loss distribution, but also between latitude and the propensity to harvest crop in anticipation of the freeze - more northerly orchards suffered more loss and also harvested more prior to the freeze. Longitude was useful in predicting age and size of orchards - the older and larger operations were located eastward toward the Sierra foothills. In this way elevation was a somewhat relevant issue. Future research must strive for more detailed data with a larger sample. The use of micrometeorological models, digital elevation data, and detailed damage information would enhance understanding of spatial patterns of risk.

The contextual factors examined, specifically orchard size and the age of operation, ownership and management types, and membership in cooperative organizations, provide a few interesting predictors of loss. Larger operations lost higher percentages of their crops. Due to the direct relationship of size to the age of operation, the size and percentage lost is also predicted. Sunkist members lost smaller percentages of their crops and harvested more of their crops before the freeze. One explanation might be the amount and quality of information received from their organization. This too might be related to the sophistication of grove operations. Future research could investigate the problems associated with spatially larger operations and the relationship between risk and longevity of operations. Also, the information generated by the cooperative organizations that garner membership among growers could also be examined for the effectiveness of the timing and quality of information and guidance provided to the grower.

Experience influenced mitigation. Together they reflect the perceptual framework within which the grower responded to the onset of the event and also the likelihood that recovery would be needed. The freeze of 1990 generated a boom in catastrophic crop insurance and set the stage for response during the most recent disaster. Many growers had insurance. Those that had, tended to purchase buy-down policies to increase their protection. These growers tended not to perform prefreeze mitigation. Perhaps the safety net of insurance dissuades expensive efforts toward loss reduction. Or perhaps mitigation using wind, water, or smudge pots reflects desperation: if these growers do not strive to save the crop they will suffer drastic losses because they lack insurance. Some may believe that investment in insurance is more expensive than the cost of the time and resource expenses related to technological, natural, or active mitigation efforts. Others may believe that insurance provides the most certain protection from calamitous losses, distributing the individual's risk over a wide community of gamblers.

We must lastly acknowledge the role that disaster assistance appears to be playing in a culture of disaster developing among Central Valley citrus growers. The certainty of disaster assistance funding to recoup some of the $700 million lost during this event may compel less aggressive risk attenuation and the growth of the industry into marginal regions.

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