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SOCIAL IMPLICATIONS OF SEVERE SUSTAINED DROUGHT: CASE STUDIES IN CALIFORNIA AND COLORADO[1]

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ABSTRACT: Survey data collected in the San Joaquin Valley of southern California and the Grand Valley of western Colorado reveal that residents of both areas believe that a severe sustained drought is likely to occur within the next 20-25 years and that their communities would be seriously impacted by such an event. Although a severe sustained drought affecting the Colorado River Basin would cause major economic and social disruptions in these and other communities, residents express little support for water management alternatives that would require significant shifts in economic development activities or in water use and allocation patterns. In particular, residents of these areas express little support for strategies such as construction and growth moratoriums, mandatory water conservation programs, water transfers from low- to high-population areas, water marketing, or reallocations of water from agricultural to municipal/industrial uses. This rejection of water management strategies that would require a departure from "business as usual" with respect to water use and allocations severely restricts the capacity of these and similar communities to respond effectively should a severe sustained drought occur.
(KEY TERMS: drought; social and political; water management; water conservation; water policy/regulation/decision making.)

INTRODUCTION

Human social systems are integrally linked to ecological systems (Duncan, 1961). They are therefore highly vulnerable to major environmental changes, especially if changes are either poorly anticipated or occur extremely rapidly (Little and Krannich, 1989). Both the literature on social response to natural disasters (e.g., Erikson, 1976; Couch and Kroll-Smith, 1991) and that addressing social and economic consequences of large-scale resource developments (e.g., Murdock and Leistritz, 1979; Krannich and Cramer, 1993) have documented the potential for major disruptions when human communities are confronted by conditions that exceed the response capabilities of existing organizations and social structures.

The potential for disruptive consequences is clearly present with respect to periods of severe sustained drought conditions. Although water management systems and water users can generally adapt to short-term periods of water scarcity, response capabilities are likely to be seriously strained when drought conditions are very extreme and of long duration. Even in the case of relatively short-term "normal" droughts, efforts to respond to water scarcity through adaptive mechanisms such as water conservation practices have met with considerable difficulty and mixed success (Hamilton, 1985; Howe *et al.*, 1980). The major adjustments and reallocations that would be required under conditions of severe sustained drought could be expected to create far-reaching social and economic impacts in affected areas. Such impacts would likely be especially severe where water resource availability is already marginal, where demand for water resources is accelerating, or where economic activities and human social structures are highly water-dependent.

The research reported here addresses possible consequences of water scarcity and public response to water management alternatives in two areas of the southwestern United States: the Grand Valley area in western Colorado and the Kern County area of southern California. Throughout the region encompassing these communities, access to water resources is of central importance to local development patterns and the economic and social well-being of area residents (see Brown and Ingram, 1987; Field *et al.*, 1974; Reisner and Bates, 1990; Vaux, 1986). As such, impacts of

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severe sustained drought would be experienced both regionally and at the community level. For example, in areas that are highly dependent on irrigated agriculture, the repercussions of severe and long-lasting reductions in water availability would extend beyond farm operators to encompass a broad spectrum of other economic activities and social organizations linked directly or indirectly to the agricultural sector (see Brown *et al.*, 1992; Easterling and Riebsame, 1987; Gibson, 1984; Schaffer and Schaffer, 1984).

At the same time, it is also important to recognize that significant social and economic consequences of severe, sustained drought would be differentially distributed across segments of affected communities (see Flynn, 1985; Little and Krannich, 1989). Within broadly-defined communities of water users, there are population segments exhibiting highly variable relationships to, dependency on, and vulnerability regarding water resources (see Bradshaw *et al.*, 1983). These relationships, which can be conceptualized as ecological niches within broader water communities (Hardesty, 1977), need to be taken into account when attempting to understand the potential social consequences of drought and the acceptability of various policy or management alternatives that might be implemented to prevent or mitigate water shortages.

RESEARCH APPROACH

Study Areas

The research summarized here involved a comparative case study approach designed to address some of the social implications of water scarcity conditions that may emerge under both "normal" drought and a hypothetical severe sustained drought. This hypothetical drought scenario, based on hydrologic models involving tree ring studies designed to reconstruct pre-historic flows in the Colorado River system (Tarboton, 1993), was characterized as extending for up to two decades, a far longer time frame than any previously-experienced drought periods. The research was conducted in two very different types of water community settings – an area that relies primarily on water withdrawals from the main stem of the upper Colorado River, and an area heavily dependent on both ground water reserves and imported surface water supplies.

The Grand Valley study area, which is centered around the city of Grand Junction in western Colorado, is highly dependent on the availability of Colorado River system water for agricultural, industrial, and municipal uses. Although this area did experience some effects of the 1986-92 drought that engulfed much of the western U.S., water supplies derived from the main stem of the river and most tributary rivers and steams generally remained adequate to maintain normal use patterns. More significant shortages were experienced in some outlying areas reliant on water from smaller tributary streams.

Despite the absence of major area-wide water shortages during this recent drought, water supply issues were (and continue to be) a focus of considerable public interest in the Grand Valley area. Long-term conflicts over diversion of water supplies from western Colorado to the state's east-slope metropolitan areas have created a sociocultural and political context in which water rights and water supply issues are frequent topics of debate. Growing regional demands on Colorado River flows, including increased demands from the lower basin states, have heightened area residents' levels of awareness and concern about their vulnerability to drought.

The Kern County study area encompasses the Bakersfield metropolitan area and much of surrounding Kern County in California's San Joaquin Valley. Although not directly dependent upon water flows in the Colorado River Basin, the area is indirectly linked to conditions in the Basin due both to geographic proximity and hydrologic linkages with areas of southern California that do rely more directly on Colorado River water.

Unlike the Grand Valley area, the Kern County study area is dependent on a highly complex water supply and delivery system that relies on both diversion of surface water from distant sources in the Sierra Nevada range and northern California and extensive ground water pumping. Expanding water demands associated with urban-area development pressures and irrigation use by large-scale commercial agriculture have made this area extremely vulnerable to water scarcity (see Vaux, 1986). The 1986-1992 drought resulted in severely curtailed supplies of water imported from the north as well as significant reductions in ground water reserves as pumping was increased to make up for reduced surface water supplies (see Kern County Water Agency, 1992). While surface water allocations to municipal and industrial users were cut by as much as 70 percent, municipal systems were able to rely on increased ground water pumping and the purchase of additional allocations from northern California. Although water conservation programs were implemented, restrictions on residential and commercial water use were generally modest. In contrast, agricultural users experienced reductions ranging as high as 100 percent of their normal irrigation allocations, and the high cost of purchasing additional allocations

from the north proved prohibitive for most agricultural operators (Kern County Water Agency, 1992).

Data Collection Procedures

Data collection procedures involved administration of highly similar self-administered sample surveys in each study area. In the Kern County study area, multi-wave mail survey procedures (see Dillman, 1978) were used to deliver questionnaires to a probability sample of 1,053 households in early 1992. Sample households were drawn from a composite sampling frame derived from local municipal water utility customer listings, Bakersfield telephone directory listings, and listings of agricultural water users provided by several irrigation districts (for details on sampling procedures, see Keenan, 1993). A total of 618 usable questionnaires were completed and returned by adult decision-makers in the sampled households, representing an overall response rate of 59 percent.

In Grand Valley, surveys were administered to a probability sample of 200 households drawn from listings of residential properties maintained by the Mesa County assessor's office. Using a personalized drop-off/pick-up technique, questionnaires were delivered to an adult decision-maker in each of the sampled households. A total of 147 completed surveys were returned, representing an overall response rate of 74 percent. A summary of respondent characteristics for both study areas is presented in Appendix 1.

Analysis Approach

As a first step in the analysis, survey responses were compared in order to ascertain possible similarities and differences across water user communities. This comparative analysis focused on residents' perceptions of current and possible future drought conditions, levels of perceived vulnerability to water scarcity, and views about the relative acceptability of various management strategies and alternatives for preventing or mitigating future water shortages. In addition, multivariate analyses were conducted to address the question of differential response among various water user niches, as represented by respondents' sociodemographic attributes and their attitudes and perceptions about water resource conditions.

FINDINGS

Current Drought Perceptions

Consistent with the nature of 1986-92 drought experiences outlined previously, residents of the Kern County study area were substantially more likely to consider recent water shortages to be a serious problem in their area than were residents of the Grand Valley area. As depicted in Figure 1, on a response scale ranging from 0 ("Not At All Serious") to 10 ("Extremely Serious"), approximately 75 percent of responses from the Kern County area were on the "serious" side of the scale (responses in the 6-10 range); the mean response was 7.2. In contrast, the mean response in the Grand Valley area was only 4.5, and just 30 percent of responses were above the scale midpoint.

In both study areas, respondents were substantially less likely to report that their own households had been seriously affected by recent drought conditions. As indicated in Figure 2, just 9 percent of responses from Grand County respondents were on the "serious" side of the 0-10 scale midpoint, and the mean response value was just 1.8. In the Kern County study area, the mean response was higher at 3.8, but still only about one-fourth (27 percent) of responses were in the scale range (6-10) that would suggest relatively serious effects of water scarcity on respondents' households.

In general, these response patterns indicate the relatively high degree of success that both areas experienced in adapting to water scarcity during the 1986-1992 drought period. Despite very substantial reductions in Colorado River system flows through the Grand Valley and in surface water allocations to Kern County, both areas were substantially buffered from experiencing widespread negative impacts by the ability to draw upon stored water reserves – Colorado River system impoundments in the case of Grand Valley, and ground water reserves in Kern County. Even though the 1986-1992 drought was serious and of unusually long duration, the buffering effects of these reserves allowed most water users to experience limited inconveniences rather than major adverse effects.

Perceptions of the Likelihood of Severe, Sustained Drought

In an attempt to link the analysis of social consequences with the broader study of severe sustained drought, the survey questionnaire presented respondents with a scenario describing a hypothetical severe

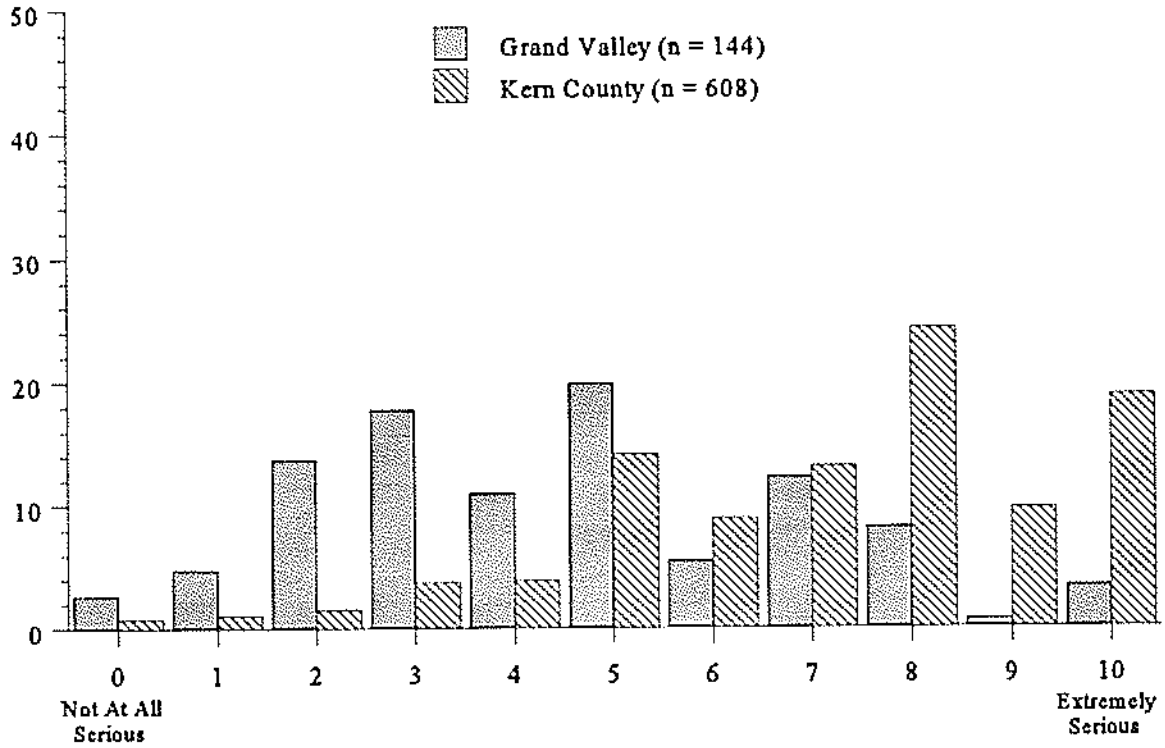

Figure 1. Perceived Seriousness of Recent Water Shortage in Grand Valley, Colorado, and Kern County, California, Study Areas (percentages).

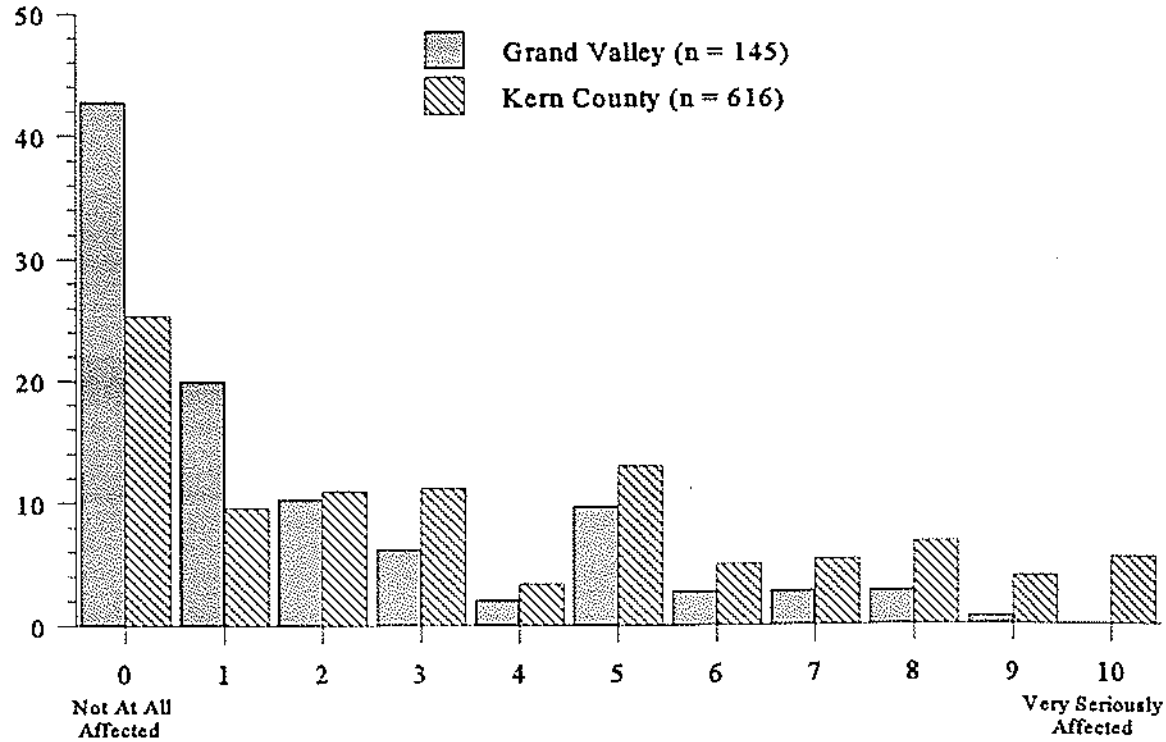

Figure 2. Extent of Negative Effects on Household Resulting From Recent Water Shortages in Grand Valley, Colorado, and Kern County, California, Study Areas (percentages).

long-term drought that would "last for an uninterrupted period of about 20 years." The scenario further indicated that the "total available supply of water in your local area would be more severely limited than has ever occurred before. Water from surface supplies such as rivers, reservoirs and canals would be reduced, and community water systems would be able to supply only one-half of the amount of water that they can provide to users under normal conditions."

Residents of both study areas tended to believe that such a severe sustained drought is only moderately likely in the near term but that there is a substantial likelihood that such conditions will be experienced within a more extended time frame. As indicated in Figure 3, most respondents in both the Grand Valley and Kern County study areas considered it only moderately likely that a severe sustained drought would impact their area within the next five years. In contrast, a majority of respondents in both study areas considered it highly likely that such drought conditions will affect their areas within the next 20-25 years (Figure 4). Although recent water shortage experiences have generally been more negative in Kern County, residents of the two study areas expressed similar views regarding the likelihood of a severe sustained drought within this time period.

Multiple (ordinary least-squares) regression analyses were conducted to address the question of how perceptions about the likelihood of severe sustained drought might be differentially distributed across various types of residents who might occupy differing water user niches. Several sociodemographic variables corresponding to respondents' personal and household characteristics, as well as respondents' views about the seriousness of recent water scarcity problems, were included as potentially important predictors of the perceived likelihood of future severe sustained drought within the next 20-25 years. The results of this part of the analysis, which are reported in Table 1, indicate that these variables were generally not useful in predicting the perceptions of the likelihood of severe drought. For the Grand Valley sample, the nine independent variables jointly accounted for very little of the variation in the dependent variable, as indicated by R^2 values. Only perceived seriousness of recent water scarcity and occupation exhibited substantively important partial associations with the perceived likelihood of severe drought (it would be misleading to base comparisons strictly on statistical significance of coefficients because of sample size differences; therefore, standardized regression coefficients with an absolute value of at least 0.15 are considered to represent nontrivial relationships). In the Kern County study area, the independent variables exhibited similarly weak predictive power. Although several of the partial

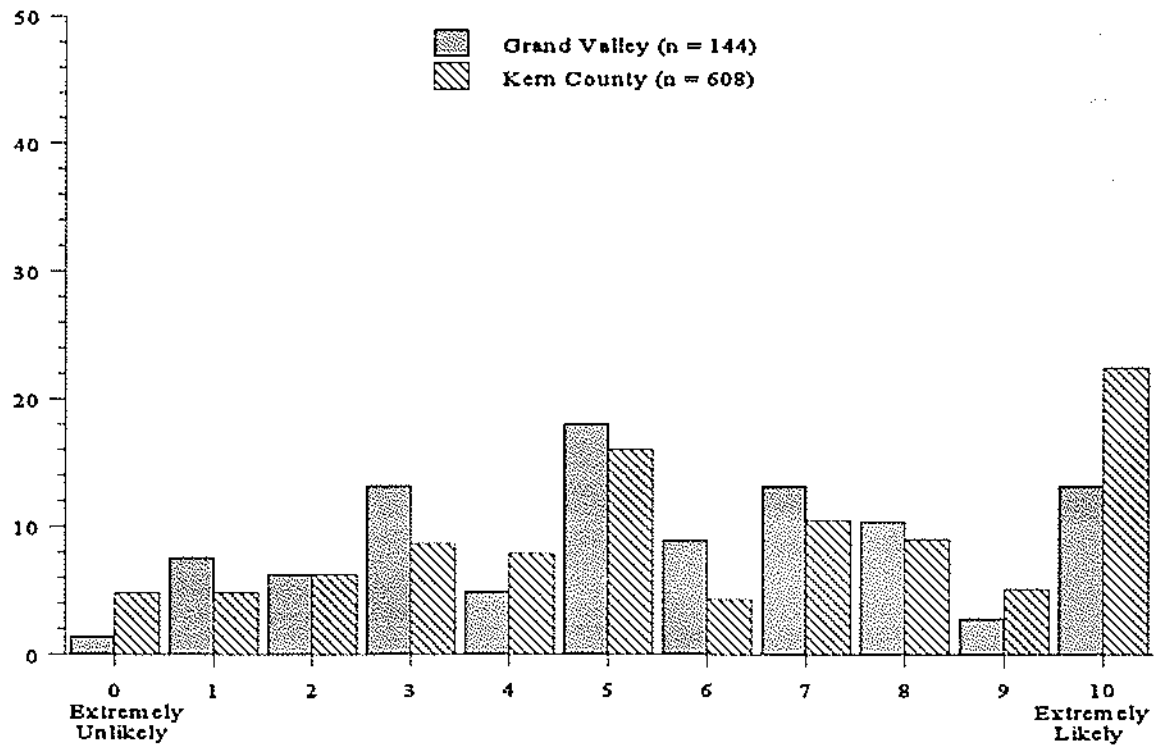

Figure 3. Perceived Likelihood of Severe Sustained Drought Conditions Within the Next Five Years in Grand Valley, Colorado, and Kern County, California, Study Areas (percentages).

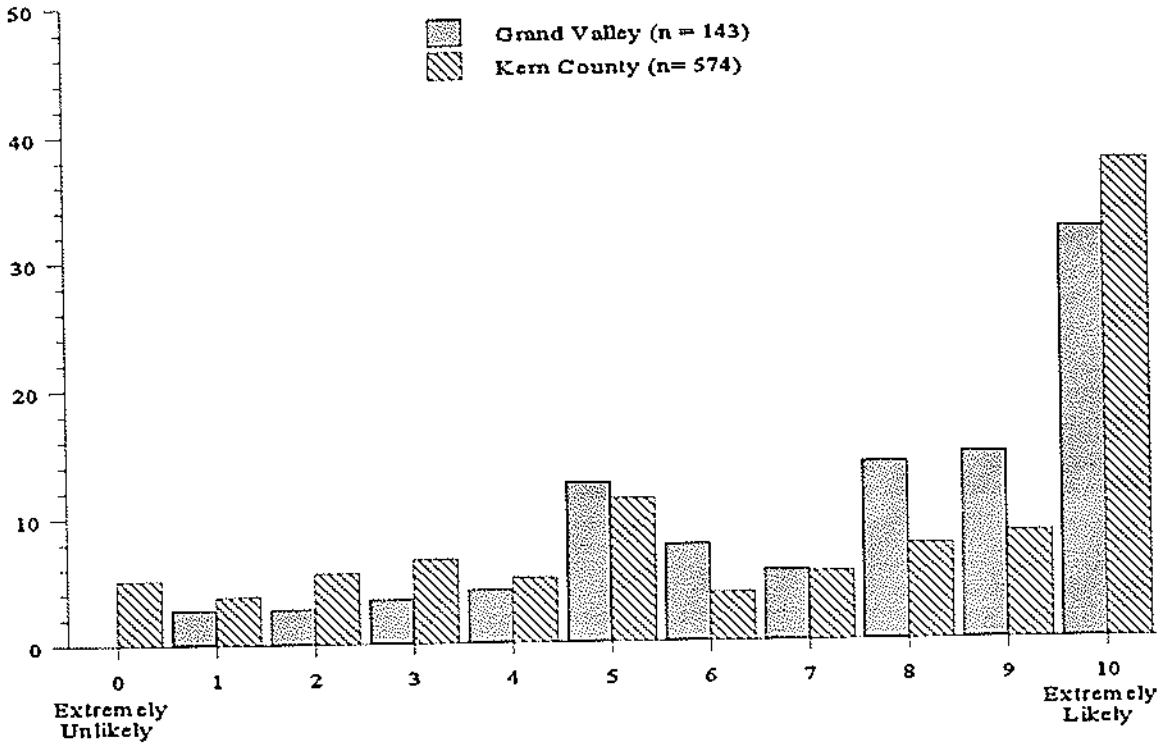

Figure 4. Perceived Likelihood of Severe Sustained Drought Conditions Within the Next 20-25 Years in Grand Valley, Colorado, and Kern County, California, Study Areas (percentages).

TABLE 1. Multiple Regressions of Respondent Sociodemographic Characteristics and Perceived Seriousness of Recent Water Scarcity on Perceived Likelihood of Severe Sustained Drought During the Next 20-25 Years (standardized regression coefficients).

Independent Variables	Grand Valley	Kern County
Age (years)	−.081	−.058
Education (0=high school or less; 1=post high school)	−.001	−.028
Gender (0=female; 1=male)	−.050	−.101**
Length of Residence in Area (years)	.089	.121**
Occupation (1=agriculture; 0=other)	−.158	.083*
Home Ownership (1=own or buying home; 0=other)	.107	.008
Household Size (no. of persons)	.060	−.009
Household Income (8 categories)	−.057	.054
Perceived Seriousness of Recent Water Scarcity	.177*	.163**
R^2	.079	.064

**P ≤ .05.
*P ≤ .10.

coefficients attained statistical significance (due primarily to the larger sample size in the Kern County study area), only perceived seriousness of recent water scarcity exhibited a substantively important relationship with the dependent variable.

Thus, in both study areas, residents who perceived recent water scarcity to be a serious problem tended also to believe that severe sustained drought conditions are likely to occur in the future. Also, there was little evidence that perceptions of the likelihood of future severe drought tend to vary meaningfully across categories of residents defined by personal or household sociodemographic attributes.

Concerns About Vulnerability to Severe Sustained Drought

Kern County respondents were somewhat more concerned about the vulnerability of themselves and the broader community to severe sustained drought than were residents of the Grand Valley study area. This is likely due in part to the considerable importance of irrigated agriculture to the broader economic fortunes of Kern County. As depicted in Figure 5, concern about the potential for personal financial losses from severe sustained drought was lower in Grand

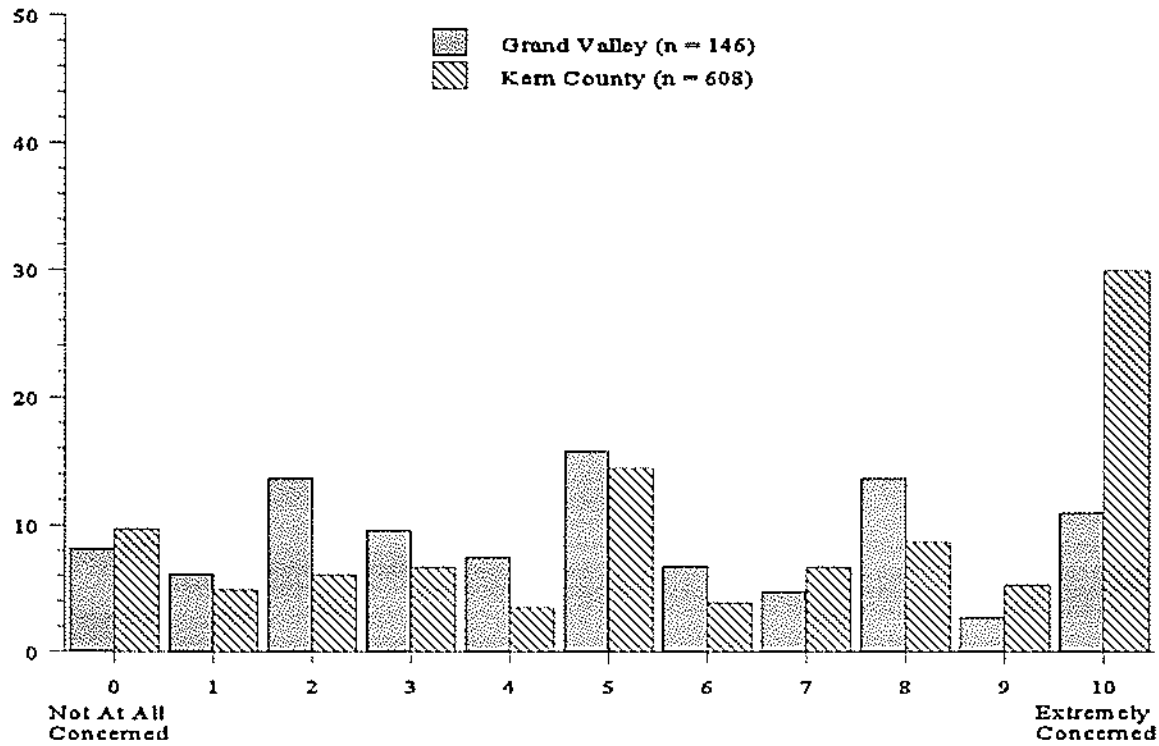

Figure 5. Levels of Concern About Potential for Personal Financial Losses From Severe Sustained Drought in Grand Valley, Colorado, and Kern County, California, Study Areas (percentages).

Valley (mean = 4.9) than in the Kern County study area (mean = 6.1). Similarly, Figure 6 indicates that a higher proportion of Kern County respondents anticipated "very serious" effects on local area economic opportunities than was the case among Grand Valley respondents.

Multivariate analyses designed to predict variation in these two measures of perceived vulnerability to severe sustained drought are presented in Tables 2 and 3. As with the multivariate analysis focusing on the likelihood of severe drought, these analyses incorporated both sociodemographic characteristics and perception measures as independent variables.

Table 2 summarizes regression results incorporating perceived vulnerability to personal financial loss as the dependent variable. Unlike the analysis of perceived likelihood of severe drought, several variables exhibit substantial predictive power in explaining variation in this dependent variable. Considering first the Grand Valley sample, we find that in combination the sociodemographic and perceptual measures account for about 35 percent of the variation in perceived personal vulnerability. Substantively large partial coefficients associated with occupation, household size, and perceived likelihood of severe drought suggest that perceived personal vulnerability is greatest among persons who are involved in agriculture, have large households, and perceive a high likelihood of future severe drought. Results for the Kern County study area indicate a similar level of overall predictive power, with partial coefficients indicating that perceived personal vulnerability tends to be highest among males, persons engaged in agriculture, those who perceive recent water scarcity to be serious, and those who perceive a high likelihood of future severe drought.

Table 3 presents a similar set of regression analysis results, focusing on concern about local area economic effects from severe sustained drought as the dependent variable. In the Grand Valley study area, the overall explained variation is fairly high ($R^2 = 0.29$), although only the perceived seriousness of recent scarcity and perceived likelihood of severe drought exhibited substantively important partial associations with concerns about area economic effects. These same two variables are the only substantively important predictors in the Kern County study area, although the overall level of explained variation is substantially lower there ($R^2 = 0.15$) than was observed for the Grand Valley data.

These results suggest that perceived personal vulnerability to severe sustained drought is differentially distributed with respect to both perceptual measures of recent drought severity and future drought probabilities and some sociodemographic characteristics such as occupation and household size. Concerns

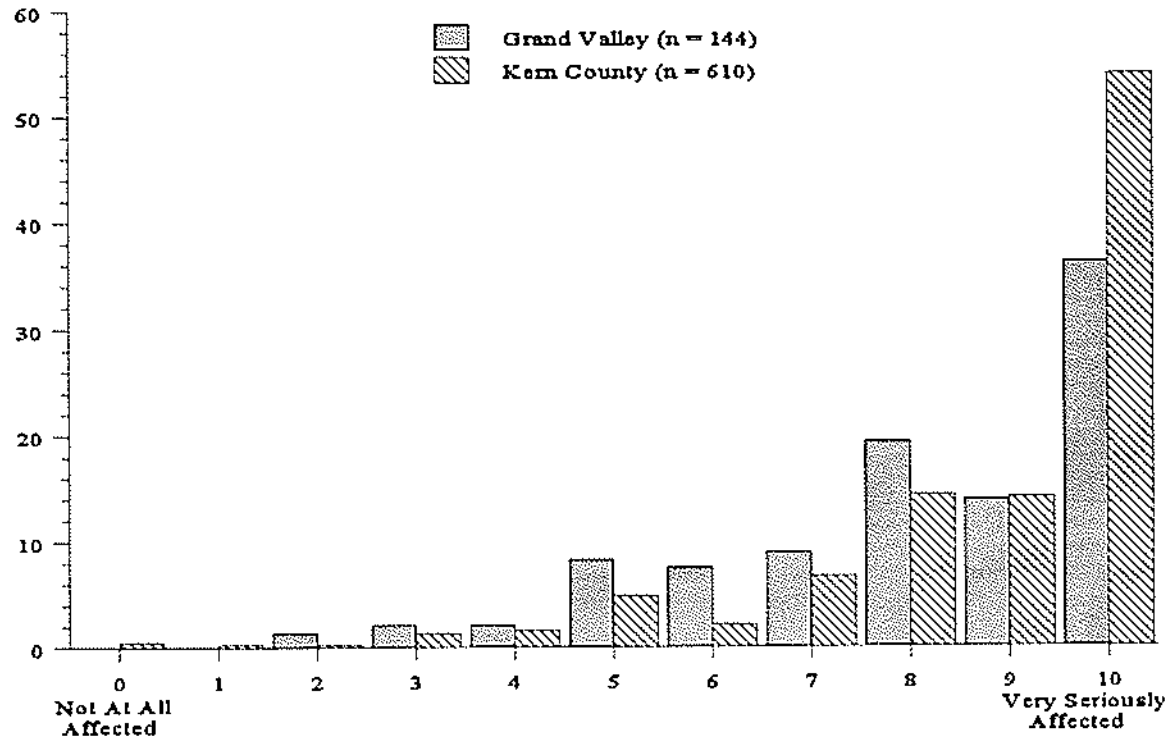

Figure 6. Anticipated Levels of Severe Sustained Drought Effects on Overall Local Area Economic Opportunities in Grand Valley, Colorado, and Kern County, California, Study Areas (percentages).

TABLE 2. Multiple Regressions of Respondent Sociodemographic Characteristics, Perceived Seriousness of Recent Water Scarcity, and Perceived Likelihood of Severe Sustained Drought on Concern About Vulnerability to Personal Financial Loss Under Severe Drought Conditions (standardized regression coefficients).

Independent Variables	Grand Valley	Kern County
Age	.136	–.070
Education (high school or less/ post high school)	.116	.033
Gender	–.024	.119**
Length of Residence in Area	–.061	.095**
Occupation (agriculture/other)	.408**	.287**
Home Ownership (own or buying home/ other)	–.025	–.026
Household Size	.378**	.079*
Household Income	.057	.077*
Perceived Seriousness of Recent Water Scarcity	.128	.165**
Perceived Likelihood of Severe Sustained Drought	.301**	.256**
R^2	.357	.311

**P ≤ .05.
*P ≤ .10.

TABLE 3. Multiple Regressions of Respondent Sociodemographic Characteristics, Perceived Seriousness of Recent Water Scarcity, and Perceived Likelihood of Severe Sustained Drought on Concern About Local Area Economic Conditions Under Severe Drought Conditions (standardized regression coefficients).

Independent Variables	Grand Valley	Kern County
Age	.036	–.058
Education (high school or less/ post high school)	–.017	.083*
Gender	–.133	.018
Length of Residence in Area	.012	.041
Occupation (agriculture/other)	.100	.057
Home Ownership (own or buying home/ other)	–.028	.083*
Household Size	.138	–.037
Household Income	.039	.005
Perceived Seriousness of Recent Water Scarcity	.156*	.256**
Perceived Likelihood of Severe Sustained Drought	.440**	.178**
R^2	.291	.150

**P ≤ .05.
*P ≤ .10.

about area-wide drought vulnerability also are associated with perceptions of recent and future drought but appear to be less closely related to sociodemographic characteristics.

Acceptability of Alternative Management Strategies

Although many water supply and delivery systems appear capable of adapting successfully to "normal" drought conditions, adaptation to severe sustained drought conditions would require unprecedented shifts in water system management procedures and water policies. However, resource management and policy decisions are often constrained by the degree to which they are deemed acceptable by various public interests. Consequently, it is important to examine the relative acceptability of various response strategies that might be considered when addressing water scarcity problems.

One type of response strategy involves establishing priorities for allocating available water supplies during periods of scarcity. Survey respondents were therefore asked to consider the degree to which various types of users should be given priority in receiving water allocations under conditions of severe sustained drought. As depicted in Figure 7, mean response values were generally quite similar for the two study areas. In both areas, respondents indicated that highest priority should be given to users requiring irrigation supplies for permanent agricultural crops such as fruit trees or vineyards. Existing residential households and irrigators growing nonpermanent crops were also considered to be high-priority users in both study areas. New residential developments and recreational water users were viewed as

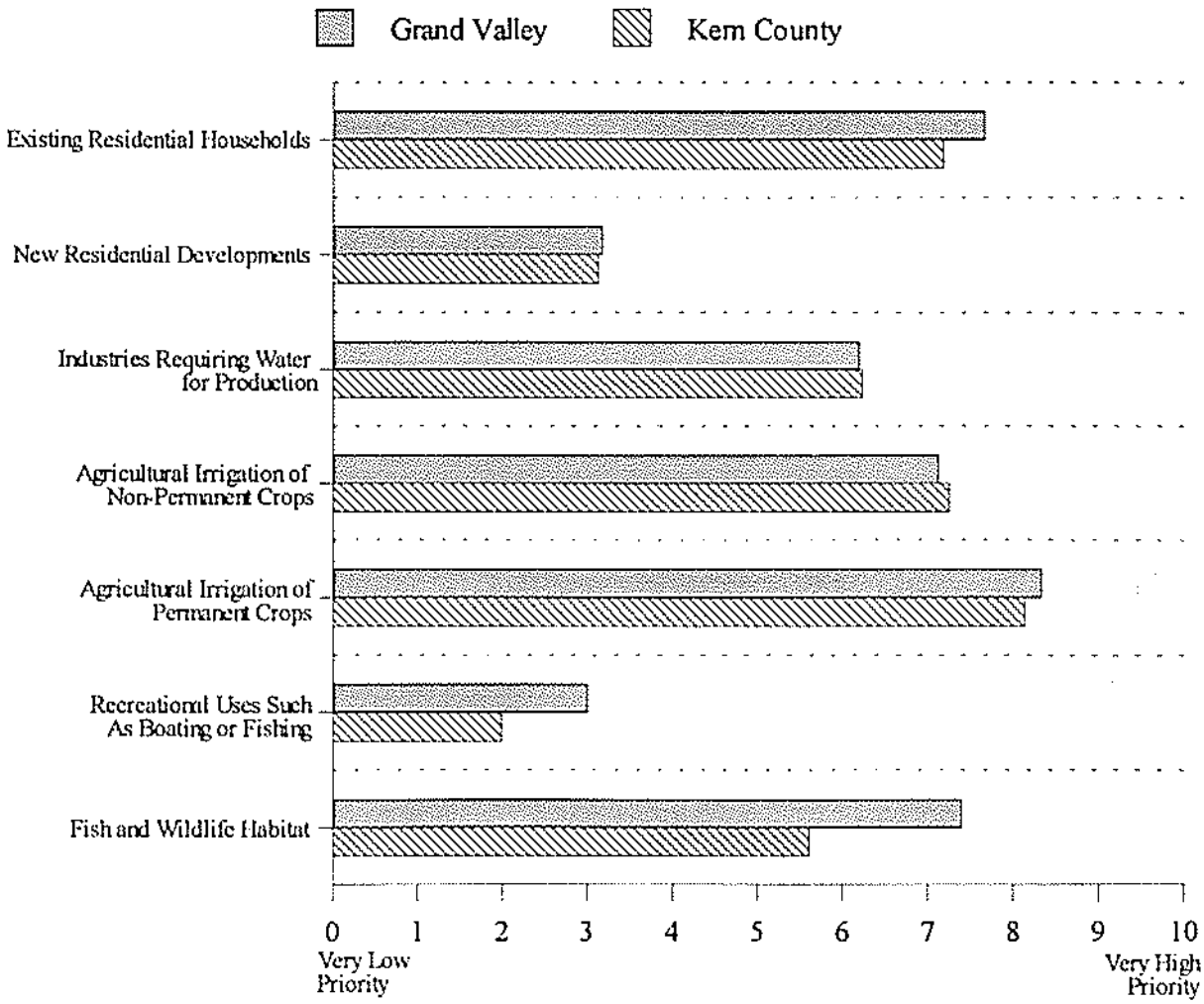

Figure 7. Mean Response Values Representing Attitudes About Priorities for Allocation of Water Supplies During Periods of Severe Sustained Drought, Grand Valley, Colorado, and Kern County, California, Study Areas.

having low priority for water allocations in both study areas.

Another category of response alternatives to water scarcity problems involves various approaches to increasing water supplies, decreasing demands, or reallocating water use to different categories of users. In both study areas, respondents were asked to evaluate the acceptability of nine different management strategies for addressing water scarcity problems. These ranged from approaches involving relatively little personal sacrifice or change from "business as usual" (e.g., implementation of voluntary education/conservation programs) to alternatives involving potentially radical departures from current water management practice (e.g., mandated reallocations of water from agricultural to municipal/industrial uses).

Response means summarized in Figure 8 reveal that Grand Valley and Kern County residents provided very similar evaluations about the relative acceptability of various alternatives involving these types of response. In both areas, the three "most acceptable" alternatives were voluntary education/conservation programs, use of water-saving irrigation technologies, and construction of new water storage/delivery systems – all "business as usual" strategies that would be unlikely to seriously disrupt the water niche structures of the study areas.

Respondents were considerably more ambivalent about approaches that would potentially impose personal or area-wide costs, such as construction moratoriums/growth limitations or mandatory conservation enforced by fines or penalties. Grand Valley respondents in particular were opposed to either within-state or across-state transfers of water supplies from low-population to high-population areas. This finding is hardly surprising, given the existence of long-standing tensions over transfers of water from western Colorado to the east-slope metropolitan areas of

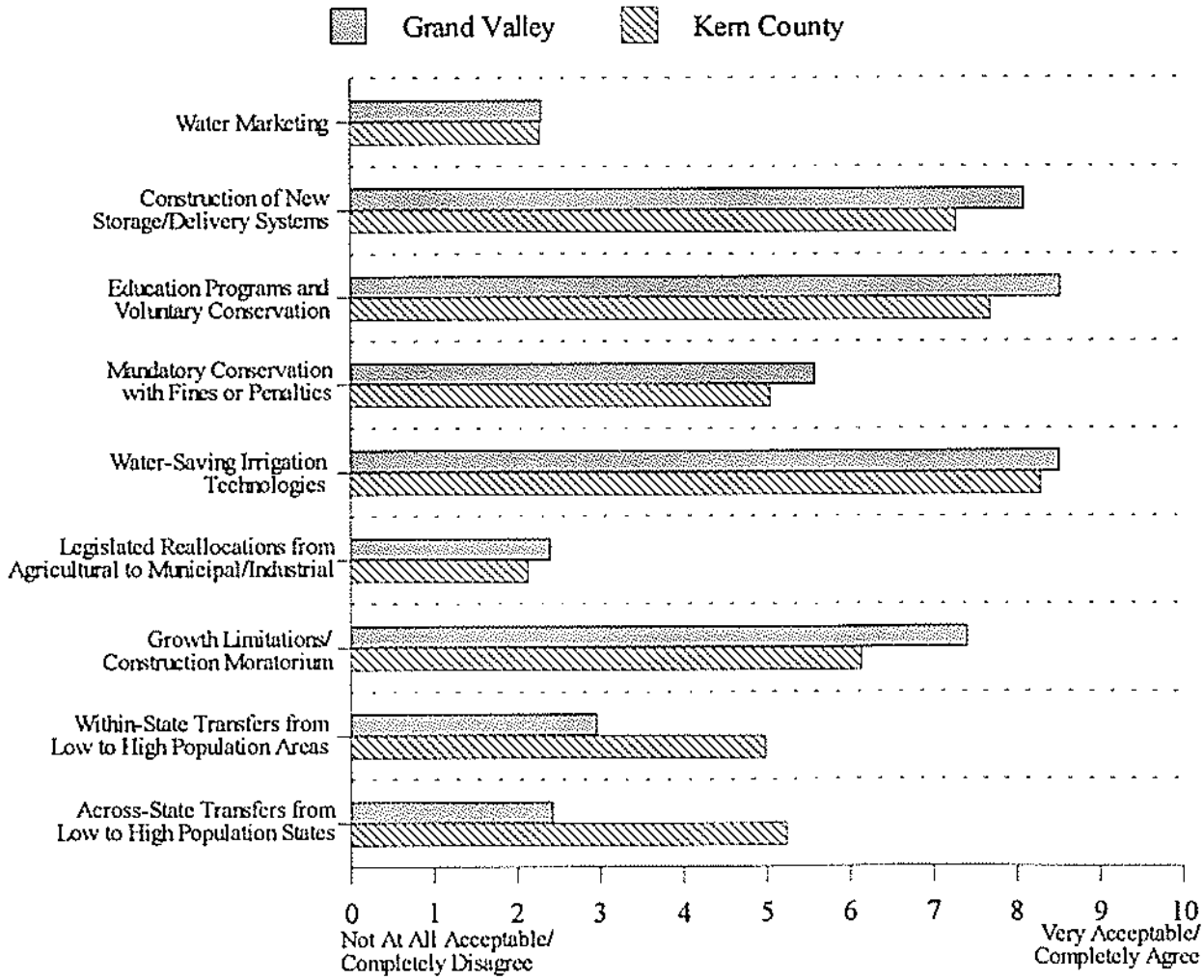

Figure 8. Mean Response Values Representing Acceptability of Various Water Scarcity Response Strategies, Grand Valley, Colorado, and Kern County, California, Study Areas.

the state. Responses to such transfers were more evenly mixed in Kern County, an area that currently benefits from transfers of water from the north but is also vulnerable to growing demands for water from the Los Angeles area to the south. Respondents from both areas expressed considerable opposition to either water marketing or legislated reallocations of water from agricultural to municipal/industrial uses as alternatives for addressing water scarcity problems.

Additional multiple regression analyses were conducted to address the question "who supports the more 'radical' management response alternatives?" Results of these analyses are presented in Table 4 (construction moratoriums/growth limits), Table 5 (mandatory conservation enforced by fines), Table 6 (water marketing), and Table 7 (legislated reallocations from agriculture to municipal/industrial).

As indicated in Table 4, in the Grand Valley the variables exhibiting non-trivial partial associations with acceptability of growth controls were education, gender, home ownership, household income, perceived likelihood of severe drought, and perceived personal vulnerability to severe drought. These coefficients indicate that, other things being equal, acceptance of growth controls is higher among those with post-high school education, men, homeowners, those with lower household incomes, those who believe future severe drought is likely, and those less concerned about personal vulnerability to severe drought. In Kern County, statistically significant but small partial coefficients were observed only for length of residence, occupation, and perceived likelihood of severe drought, and overall explanatory power was very low.

Results summarized in Table 5 indicate that, in the Grand Valley, acceptance of mandatory conservation tended to be greater among those who reported shorter length of residence in the valley, owned or were buying their homes, had larger households, reported post-high school education, and were older. In Kern County, acceptance of mandatory conservation was

TABLE 4. Multiple Regressions of Respondent Sociodemographic Characteristics, Perceived Seriousness of Recent Water Scarcity, Perceived Likelihood of Severe Sustained Drought, and Perceived Vulnerability of Self and Area to Severe Drought on Acceptability of Growth Controls and Development Limitations to Address Water Scarcity Problems (standardized regression coefficients).

Independent Variables	Grand Valley	Kern County
Age	.129	.002
Education (high school or less/ post high school)	.243**	−.053
Gender	.201**	.053
Length of Residence in Area	.034	.102*
Occupation (agriculture/other)	.120	.072**
Home Ownership (own or buying home/ other)	.149	−.057
Household Size	.036	−.028
Household Income	−.207**	.006
Perceived Seriousness of Recent Water Scarcity	.070	.010
Perceived Likelihood of Severe Sustained Drought	.209**	.158**
Perceived Personal Vulnerability to Severe Drought	−.211**	−.067
Concern About Area Economic Effects of Severe Drought	−.011	.054
R^2	.209	.061

**P ≤ .05.
*P ≤ .10.

TABLE 5. Multiple Regressions of Respondent Sociodemographic Characteristics, Perceived Seriousness of Recent Water Scarcity, Perceived Likelihood of Severe Sustained Drought, and Perceived Vulnerability of Self and Area to Severe Drought on Acceptability of Mandatory Conservation to Address Water Scarcity Problems (standardized regression coefficients).

Independent Variables	Grand Valley	Kern County
Age	.166	−.082
Education (high school or less/ post high school)	.171	−.046
Gender	.111	−.136**
Length of Residence in Area	−.185*	−.025
Occupation (agriculture/other)	.008	−.041
Home Ownership (own or buying home/ other)	.180*	.056
Household Size	.220**	−.004
Household Income	−.087	−.084*
Perceived Seriousness of Recent Water Scarcity	.031	.084*
Perceived Likelihood of Severe Sustained Drought	−.054	.170**
Perceived Personal Vulnerability to Severe Drought	.041	.142**
Concern About Area Economic Effects of Severe Drought	.087	.108**
R^2	.163	.138

**P ≤ .05.
*P ≤ .10.

associated with being female, belief that future severe drought is likely, and perceived personal vulnerability to drought. However, the explanatory power of the independent variables was fairly low in both study areas.

Table 6 summarizes results with acceptability of water marketing as the dependent variable. In the Grand Valley there was a weak tendency for higher acceptance of marketing among younger respondents and those concerned about area economic effects of severe drought. In Kern County acceptance of marketing was somewhat greater among those with higher incomes. However, in both study areas the overall explanatory power of the independent variables was very weak, indicating that variation in support for water marketing is generally independent of the sociodemographic characteristics or perceptual variables considered here.

Finally, Table 7 presents results of regressing the sociodemographic and perceptual variables on acceptance of legislated reallocations of water supplies from agricultural use to municipal/industrial uses. In both areas only a modest amount of variation in the dependent variable was explained by the independent variables. In the Grand Valley those who tended to support such mandated reallocations were generally older and reported shorter periods of residence in the area, lower levels of concern about area economic vulnerability to severe drought, and greater perceived personal vulnerability to severe drought. In Kern County, acceptance of legislated reallocations tended to be higher among those who were less educated, reported shorter periods of residence in the area, were in nonagricultural occupations, had lower household incomes, perceived recent water scarcity as less serious, and were less concerned about area economic vulnerability to severe drought.

TABLE 6. Multiple Regressions of Respondent Sociodemographic Characteristics, Perceived Seriousness of Recent Water Scarcity, Perceived Likelihood of Severe Sustained Drought, and Perceived Vulnerability of Self and Area to Severe Drought on Acceptability of Water Marketing to Addressing Water Scarcity Problems (standardized regression coefficients).

Independent Variables	Grand Valley	Kern County
Age	−.141	−.011
Education (high school or less/ post high school)	−.096	.051
Gender	.222	.012
Length of Residence in Area	.083	.018
Occupation (agriculture/other)	−.005	.074
Home Ownership (own or buying home/ other)	.010	.001
Household Size	.107	.064
Household Income	−.018	.139**
Perceived Seriousness of Recent Water Scarcity	−.080	−.025
Perceived Likelihood of Severe Sustained Drought	.022	−.019
Perceived Personal Vulnerability to Severe Drought	.105	.012
Concern About Area Economic Effects of Severe Drought	−.132	.046
R^2	.077	.045

**P ≤ .05.
*P ≤ .10.

TABLE 7. Multiple Regressions of Respondent Sociodemographic Characteristics, Perceived Seriousness of Recent Water Scarcity, Perceived Likelihood of Severe Sustained Drought, and Perceived Vulnerability of Self and Area to Severe Drought on Acceptability of Legislated Reallocations From Agriculture to Municipal/ Industrial Uses to Address Water Scarcity Problems (standardized regression coefficients).

Independent Varinbles	Grand Valley	Kern County
Age	.163	−.061
Education (high school or less/ post high school)	−.062	−.127**
Gender	−.078	.025
Length of Residence in Area	−.269**	−.124**
Occupation (agriculture/other)	−.127	−.148**
Home Ownership (own or buying home/ other)	−.055	.078*
Household Size	.093	−.025
Household Income	−.080	−.117**
Perceived Seriousness of Recent Water Scarcity	−.023	−.105**
Perceived Likelihood of Severe Sustained Drought	−.015	.093**
Perceived Personal Vulnerability to Severe Drought	.162	.028
Concern About Area Economic Effects of Severe Drought	−.250**	−.142**
R^2	.151	.125

**P ≤ .05.
*P ≤ .10.

DISCUSSION

The results obtained from the comparative case study analyses reported here suggest several relevant conclusions. First, differential response patterns obtained from these two very distinct study areas reinforce the observation that efforts to assess water scarcity impacts need to focus attention on specific water user communities. Although there were some interesting response similarities across the study areas, the distinctions in their drought vulnerability and in the responses of residents to both recent drought experiences and a hypothetical severe sustained drought indicate that efforts to assess social impacts of severe drought must focus specifically at the level of individual water user communities. Substantial differences in both water resource conditions and the social/economic/political context of potentially impacted areas imply a potentially broad range of variability in the type and extent of impacts that might ensue from a severe sustained drought.

In addition, relationships between measures of drought perception, perceived vulnerability and acceptability of water management practices, and various sociodemographic and attitudinal characteristics of survey respondents highlight the potential for differential drought response across water user niches. In these study areas, it is obvious that the niche occupied by persons engaged directly in agricultural enterprise is highly vulnerable to the effects of a severe sustained drought. At the same time, it is important to recognize that other segments of these communities are also extremely vulnerable to the effects of a severe sustained drought, even if they do not perceive that vulnerability. The absence of experience with drought conditions that even approach the level of severity envisioned under a severe sustained drought scenario makes it extremely difficult for residents of these communities to provide a realistic assessment of either their vulnerability or their probable responses to such conditions. Although serious effects might be felt earliest and most sharply in some water user niches such as the agricultural segment of the population, such effects would undoubtedly extend to affect a much broader range of community segments as the effects of drought extended beyond the 5-6 year time frame often associated with a severe but more "normal" drought to a period of 10, 15, or 20 years or more.

More generally, the results suggest that severe sustained drought has considerable potential for causing disruptive social consequences in both the Grand Valley and Kern County and, by extension, in other water user communities throughout the Colorado River Basin. At first glance, this conclusion may appear inconsistent with some of the survey results since respondents in both areas reported only minimal consequences of recent drought. Despite the relative severity of the 1986-1992 regional drought, water storage capabilities (surface water supplies in western Colorado and ground water supplies in Kern County) allowed both areas to avoid broad-ranging social and economic dislocations.

Nevertheless, highly disruptive impacts would be almost inevitable under the types of severe sustained drought conditions that were a focus of the broader project from which this research is drawn. Under such circumstances it is difficult to envision a scenario that would not include widespread economic dislocations across virtually all economic sectors. Such effects would likely contribute to significant shifts in demographic patterns, initially in the form of reduced levels of population growth and, eventually, in at least some level of outmigration as economically displaced persons moved elsewhere. There would also inevitably be substantial lifestyle shifts due both to income reductions and an inability to pursue many water-dependent activities such as landscaping, gardening, and some recreational activities. All of these effects would in turn have consequences for the levels of satisfaction and subjective sense of well-being experienced by members of affected communities, and for the type and extent of social and political conflicts that would arise in response to competition for increasingly scarce water resources.

Although it seems self-evident that severe sustained drought would cause major social disruptions, the evidence generated by this research provides relatively little reason for optimism about the capacity of these or other water user communities to respond effectively. Indeed, the ability of these communities to sustain more or less normal social and economic functioning during their recent experiences with water scarcity may actually work to the detriment of local response capabilities in the event of a severe sustained drought, for many people now think that it is possible to maintain "business as usual" rather than adopting more radical shifts in water resource management practices.

Residents of both areas are generally in agreement that there is a substantial likelihood of severe sustained drought in their areas within the next 20-25 years. They also express high levels of concern about the economic vulnerability of their communities to drought, although concern about personal financial vulnerability is somewhat lower. However, perceptions of vulnerability appear not to translate into support for water management practices and priorities that would run counter to "business as usual." Although there was a surprisingly high level of support in both areas for growth limitations or a

construction moratorium to address water scarcity, there was substantial opposition to mandatory water conservation programs, and little support (especially in Colorado) for transfers of water from low- to high-population areas. Respondents from both areas expressed considerable opposition to water marketing and legislated reallocations of water from agricultural to municipal/industrial uses. They also assigned high priority to maintaining water availability for existing residential, agricultural, and industrial uses. Thus, any future efforts to implement some of the more "radical" water management strategies that would significantly reduce water allocations to some water communities or some types of users would likely generate considerable public outcry. Moreover, it is important to note that none of the management strategies addressed in the survey generated a consensus of opinion among local residents. The diversity of opinion about water management alternatives and the presence of some significant associations between acceptance of several of these alternatives and various respondent attributes such as education, length of residence, and income suggests a potential for conflicts to emerge between residents who support such approaches and those who are opposed.

Obviously, any attempts to project the impacts of water scarcity conditions as extreme as those envisioned under severe sustained drought are limited by the inherently hypothetical nature of such circumstances. Although hydrological models suggest that long-term extreme drought has occurred in the Southwest in the distant past, such events are beyond the scope of historically recorded experience in the study areas or any other part of North America. As a result, residents and water institutions have no base of relevant experience upon which to build response capabilities in the event of such a drought. Indeed, past experiences have largely reinforced the belief that social and economic conditions can be maintained at essentially normal levels for the duration of more or less "normal" short-term droughts, and at near-normal levels even when drought conditions persist for several years, as in the case of the 1986-1992 drought affecting the western United States. To some extent, the observation that support for more drastic water management alternatives tends to be higher among residents who perceive a higher likelihood of severe sustained drought and are more concerned about the consequences of such drought can be viewed as a hopeful sign that educational efforts regarding water communities' vulnerability to major disturbances in water availability could elicit more effective response capabilities. However, in the absence of information that could convincingly demonstrate that a drought will not be "normal" but instead be of unprecedented severity and duration, there is little likelihood that either residents or water institutions will be capable of effective or timely response. Implementation of more "radical" management responses will almost inevitably occur too late, when emergency conditions already exist. Unfortunately, unless this scenario of inadequate and delayed response can be changed, the potential for severe sustained drought to cause major social and economic dislocations is extraordinarily high.

APPENDIX 1. SUMMARY OF SELECTED CHARACTERISTICS OF SURVEY RESPONDENTS

Percentages may not total to 100 percent due to rounding error

	Grand Valley (percent)	Kern County (percent)
Age		
Under 30	10.7	4.3
30 to 39	26.5	18.0
40 to 49	24.3	24.2
50 to 59	16.3	19.6
60 to 69	12.0	17.2
70 or older	10.2	16.7
Education		
Less than High School Diploma	9.8	13.8
High School	25.2	19.4
Some College/Post High School	37.1	35.5
College Degree	19.6	21.7
Graduate Degree	8.4	9.7
Gender		
Male	55.6	75.8
Female	44.4	24.2
Length of Residence in Area		
Under 5 Years	14.9	7.4
5 to 10 Years	9.8	8.8
11 to 20 Years	24.6	12.4
Over 20 Years	50.7	71.4
Home Ownership		
Own or Buying Home	83.9	90.4
Renting or Other	16.1	9.6
Household Size		
One	16.3	12.0
Two	29.1	40.3
Three	17.0	16.7
Four	23.4	18.2
Five or More	14.1	12.8
Household Income		
Under $10,000	3.7	7.8
$10,000 to $19,999	18.5	10.4
$20,000 to $29,999	29.6	12.1
$30,000 to $39,999	19.3	12.3
$40,000 to $49,999	11.9	13.0
$50,000 to $59,999	2.2	10.5
$60,000 to $69,999	6.7	7.3
$70,000 or More	8.1	26.8

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LITERATURE CITED

Bradshaw, Ted K., Edward Vine, and Gunther Barth, 1983. Lifestyles. *In:* Competition for California Water, E. Englebert and A. Scheuring (Editors). University of California Press, Berkeley, California, pp. 113-135.

Brown, F. Lee and Helen M. Ingram, 1987. Water and Poverty in the Southwest. University of Arizona Press, Tucson, Arizona.

Brown, William P., Jerry R. Skees, Louis E. Swanson, Paul B. Thompson, and Laurian J. Unnevehr, 1992. Sacred Cows and Hot Potatoes: Agrarian Myths in Agricultural Policy. Westview Press, Boulder, Colorado.

Couch, Stephen R. and J. Stephen Kroll-Smith (Editors), 1991. Communities at Risk: Collective Responses to Technological Hazards. Pert Lang Publishing, New York, New York.

Dillman, Don A., 1978. Mail and Telephone Surveys: The Total Design Method. John Wiley and Sons, New York, New York.

Duncan, Otis Dudley, 1961. From Social System to Ecosystem. Sociological Inquiry 31:140-149.

Easterling, William E. and William E. Riebsame, 1987. Assessing Drought Impacts and Adjustments in Agriculture and Water Resource Systems. *In:* Planning for Drought: Toward a Reduction of Societal Vulnerability, D. Wilhite and W. Easterling (Editors). Westview Press, Boulder, Colorado, pp. 189-213.

Erikson, Kai T., 1976. Everything In Its Path: Destruction of Community in the Buffalo Creek Flood. Simon and Schuster, New York, New York.

Field, Donald R., James C. Barron, and Burl F. Long (Editors), 1974. Water and Community Development. Ann Arbor Science, Ann Arbor, Michigan.

Flynn, James, 1985. A Group Ecology Method for Social Impact Assessment. Social Impact Assessment 99/100:12-24.

Gibson, Lay James, 1984. Social Impacts Upon Urban Communities." *In:* Water Scarcity, E. Englebert and A. Scheuring (Editors). University of California Press, Berkeley, California, pp. 331-353.

Hamilton, Lawrence C., 1985. Self-Reported and Actual Savings in a Water Conservation Campaign. Environment and Behavior 17(3):315-326.

Hardesty, Donald L., 1977. Ecological Anthropology. John Wiley and Sons, New York, New York.

Howe, Charles W., Paul K. Alexander, JoAnne Goldberg, Steven Sertner, and Hans Peter Studer, 1980. Drought-Induced Problems and Responses of Small Towns and Rural Water Entities in Colorado: The 1976-1978 Drought. Colorado Water Resources Research Institute, Completion Report No. 95, Fort Collins, Colorado.

Keenan, Sean P., 1993. Contextual Perceptions of Drought Hazard and Acceptance of Water Management Alternatives in the Southern San Joaquin Valley, California. Unpublished Masters Thesis, Utah State University, Logan, Utah.

Kern County Water Agency, 1992. Water Supply Report 1991. Kern County Water Agency, Bakersfield, California.

Krannich, Richard S. and Lori A. Cramer, 1993. Social Impacts of Energy Development in the Western USA: The Case of the Boom Town. *In:* The Greening of Rural Policy: International Perspectives, S. Harper (Editor). Belhaven Press, London, England, pp. 151-166.

Little, Ronald L. and Richard S. Krannich, 1989. A Model for Assessing the Social Impacts of Natural Resource Utilization on Resource-Dependent Communities. Impact Assessment Bulletin 6(2):21-35.

Murdock, Steve H. and F. Larry Leistritz, 1979. Energy Development in the Western United States: Impact on Rural Areas. Praeger, New York, New York.

Reisner, Marc and Sara Bates, 1990. Overtapped Oasis: Reform or Revolution for Western Water. Island Press, Washington, D.C.

Schaffer, Albert and Ruth C. Schaffer, 1984. Social Impacts on Rural Communities. *In:* Water Scarcity, E. Englebert and A. Scheuring (Editors). University of California Press, Berkeley, California, pp. 309-330.

Tarboton, David, 1993. The Source Hydrology of Severe Sustained Drought in the Southwestern United States. Unpublished manuscript, Utah Water Research Laboratory, Logan, Utah.

Vaux, Henry J., 1986. Water Scarcity and Gains from Trade in Kern County, California. *In:* Scarce Water and Institutional Change, K. Frederick and D. Gibbons (Editors)`. Washington, D.C.: Resources for the Future, Washington, D.C., pp. 67-101.