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Drought, Risk, and Institutional Politics in the American Southwest[1]

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Although there are multiple causes of the water scarcity crisis in the American Southwest, it can be used as a model of the long-term problem of freshwater shortages that climate change will exacerbate. We examine the water-supply crisis for 22 cities in the extended Southwest of the United States and develop a unique, new measure of water conservation policies and programs. Convergent qualitative and quantitative analyses suggest that political conflicts play an important role in the transition of water-supply regimes toward higher levels of demand-reduction policies and programs. Qualitative analysis using institutional theory identifies the interaction of four types of motivating logics—development, rural preservation, environmental, and urban consumer—and shows how demand-reduction strategies can potentially satisfy all four. Quantitative analysis of the explanatory factors for the variation in the adoption of demand-reduction policies points to the overwhelming importance of political preferences as defined by Cook's Partisan Voting Index. We suggest that approaches to water-supply choices are influenced less by direct partisan disagreements than by broad preferences for a development logic based on supply-increase strategies and discomfort with demand-reduction strategies that clash with conservative beliefs.

KEY WORDS: climate change; conservation policy; environment; institutional theory; political conflict; water scarcity.

INTRODUCTION

Among the predicted environmental concerns associated with climate change, water-related problems—including the rise of sea level, the loss of ice caps and glaciers, and potential changes in weather patterns that result in flooding and

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drought—are often of paramount concern. In some areas, droughts may be longer and more frequent, and freshwater-supply systems may be at increased risk (Cayan et al. 2010). In many parts of the world, water-supply systems already face severe stress due to nonclimate factors such as contamination, demand growth, deforestation, and aquifer depletion. The addition of climate change to the sources of stress for freshwater-supply systems not only enhances the risk of supply shortages but also increases the uncertainty of future water availability projections. Demand for water by the energy sector is also likely to grow as temperatures rise, a change that is one example of increasing strains within the food-energy-water nexus (van Vliet et al. 2012).

We argue that cities located in arid climates with extensive histories of drought can provide a model of future conditions in which climate change could lead to more severe and prolonged droughts that threaten shortages in water supply. For example, cities in the American Southwest from Texas to California have faced severe water shortages due to the interaction of drought with long-term growth of water demand, and there is some evidence that the extended drought of the current period is related to climate change (e.g., Diffenbaugh, Swain, and Touma 2015). No matter what the causes of the current drought are, we argue that an analysis of responses to water-supply stress in the region can provide a basis for relating climate change and societal responses at a local level. We do so by examining how the central cities in the 22 largest metropolitan statistical areas (MSAs) in this region are responding to potential shortfalls in their water supply.

There are two possible strategies for reducing the risks associated with a predicted shortage of water supply. First, cities and regional water management units can attempt to gain additional water sources. They can increase the water supply by building pipelines for new surface water, by drilling new production wells, by acquiring new surface water and storage rights, by recharging aquifers for future withdrawal or for the improvement of aquifer water quality, by increasing the storage capacity of surface-water reservoirs, and by building desalination plants. Second, cities can also focus on demand reduction by implementing conservation measures and by recycling waste water.

From the perspective of climate-change mitigation, the two strategies are not equal. Attempts to increase water supply can involve energy-intensive, Promethean infrastructure projects, whereas attempts to decrease water demand can have the additional dividend of reducing energy consumption and greenhouse gas emissions. Because water-supply and treatment systems represent about 30%–40% of a city's energy consumption, choices between supply-increase and demand-reduction strategies can have important implications for a city government's greenhouse gas emissions (Ghimire and Barkdoll 2007; U.S. Environmental Protection Agency 2015). Water conservation can also reduce the 50 million metric tons of annual carbon emissions due to domestic water heating in the United States (Dietz et al. 2009). Thus, our project focuses on the potential for metropolitan regions to transition to water-supply regimes that have a strong portfolio of demand-reduction programs and policies.

CONCEPTUAL FRAMEWORK

In this study, our interdisciplinary team of scientists, engineers, and social scientists developed a contribution to the problem by focusing on water-supply policy as a contested political process. We seek to explain why demand-reduction approaches have become important in some cities and remain unimportant in other cities, even in a region where hydrological conditions are quite similar. To address this research problem, we pursue a mixed-methods approach that asks two fundamental research questions:

> 1. What conflicts do cities face with respect to water-supply strategies, and how are these conflicts related to sociological factors, specifically institutional logics associated with different political constituencies?
>
> 2. What hydrological and social factors explain the variation in the degree to which cities have adopted demand-reduction strategies?

Our analysis draws on three referent social science literatures for the orienting concepts: transition theory, institutional theory, and urban growth theory. Transition theory has emerged from the sociology of technology and from innovation studies to examine the conditions under which large technological systems undergo regime changes, and a substantial portion of that literature is focused on environmental and sustainability transitions (Markard, Raven, and Truffer 2012). A regime is a configuration of a large technological system that includes three dimensions: natural (e.g., water sources, climatic and weather conditions, and physical geography); sociotechnical (e.g., infrastructure, supply organizations, government agencies, civil society, the private sector, and households); and cultural (e.g., systems of meaning that orient discourses and practices of the sociotechnical system). Regimes often undergo changes when niches, where new technologies and organizations develop, scale up and replace the existing regime or result in major changes in the regime as it incorporates and transforms the niches (Geels and Schot 2007). For water-supply systems, it is possible to develop an ideal typical trajectory of three phases of water-supply regime transition: first, reliance on local groundwater and surface-water sources while the population is low and demand is low; second, a transition to reliance on long-distance pipelines and distant reservoirs that import water under interstate and intrastate agreements and regulations (Chowdhury, Lant, and Dziegielewski 2013); and third, after cities exhaust traditional sources of water supply, the development of new methods such as aquifer recharge, desalination, and demand-reduction programs (Richter et al. 2013). These water-supply transitions are driven by complex combinations of the cost of different water sources, existing water rights, hydrological conditions, and the politics of multilevel governance (Caniglia et al. 2016; Tidwell et al. 2014). This transition typology is schematic, and in practice cities often pursue a mixture of strategies, including the more intensive development of local water sources associated with the first phase.

From the perspective of institutional theory, changes in water-supply regimes can be understood as shifts in the underlying institutional logics of the large technological system. The term *institutional logic* is historically derived from the anthropological culture concept and therefore is similar to the cultural dimension of a large technological system (Friedland and Alford 1991). Although the term *institutional logic* was originally linked to broad societal institutions (e.g., the government, family, religion, business, civil society), increasingly the literature has analyzed institutional logics as contending cultural systems in more specific social fields such as a single industry (Thornton, Ocasio, and Lounsbury 2012). Thus, the concept of institutional logics provides a way to think about the social meanings of the political conflicts over the transitions of water-supply regimes.

Feunfschilling and Truffer (2014) have demonstrated that a combination of transition and institutional logics frameworks can be applied to the problem of water-supply systems. Based on a discourse analysis of policy documents for the Australian water-supply sector, they identify three main institutional logics. They describe the traditional "hydraulic logic" as based largely on the profession of engineers who develop supply projects such as surface reservoirs, who work in vertically integrated government agencies, and who enact a value system based on securing the water supply as a public good. Feunfschilling and Truffer argue that over time new institutional logics emerged in the governance of water-supply systems, including a "water-sensitive" logic based on community organizations and their associated values of environmental sustainability and livability.

Because we are interested in the political conflicts that have emerged over the transition to greater development of demand-reduction policies, we adopt a somewhat different approach to the relevant institutional logics than Feunfschilling and Truffer (2014). We build on their approach, which combines transition theory and institutional logics, by including a specifically political sociological dimension. To do so, we draw on the third theoretical framework of urban growth theory. Urban sociologists have shown that growth coalitions often have a dominant role in urban politics, and the coalitions steer policy in directions that increase land development. Logan and Molotch (2007[1987]) drew attention to the ways in which urban spaces are produced to enable the "urban growth machine" to capture rents from real estate development. Although often the growth coalitions dominate local politics, they can be hostage to large corporations, which have the ability to move if the local conditions are not favorable to them. Thus, there is competition among cities to recruit and retain footloose corporate partners. However, the pressure to maintain a hospitable investment climate leads to conflicts between the growth coalition and neighborhoods, and in some cities the neighborhood coalitions can become the dominant political force (Gendron and Domhoff 2008). Thus, different types of political regimes can emerge from this underlying conflict between growth coalitions and residents (Logan, Whaley, and Crowder 1999; Stone 1993). In the United States, development regimes generally dominate urban politics with the exception of middle-class, progressive regimes that are most often found in university towns (Domhoff 2014).

As Jonas and Wilson (1999:8) note, growth coalitions "must convince people of the importance of growth to their well-being," and thus "ideologies and discourses are a recognized part of growth machines." In the terminology of contrasting institutional logics, growth coalitions support a "development" logic that convinces voters of the benefits of having a good environment for investment in general and for real estate development in particular. The development logic is consistent with the hydraulic logic of water engineers and water-supply organizations, but we view it as a governing political logic that shapes the kinds of future projects that are deemed more or less desirable. Although there is preference for increasing water supplies by gaining access to inexpensive, distant water sources, the development logic can be consistent with demand-reduction strategies, provided that they are not economically onerous and do not send the wrong signal to investors. However, we argue that growth coalitions tend to view demand-reduction strategies as inadequate, and instead they tend to favor projects that increase the supply of freshwater.

Occasionally the connections between water-supply strategies and the development logic are explicit in the statements of local political leaders and administrators. One example is the desire of growth coalitions in Oklahoma to divert some of the economic development from the Dallas-Fort Worth area. As Water Resources Board member Richard Sevenoaks commented regarding the projected growth in the Dallas-Fort Worth area, "If they don't get water from Oklahoma, they won't have that development. So why don't we position ourselves to take that development, let them cross the river and grow the southern part of Oklahoma?" (Carter 2011). Another example is the use of water banking (aquifer replenishment) in Arizona, where Active Management Areas (AMAs) limit and measure groundwater withdrawals, govern the expansion of irrigated agriculture, and require new development to have an assured supply of water for 100 years. The development logic behind the water-banking strategy is evident in this statement by Phoenix Councilwoman Thelda Williams in favor of the storage of water underground: "If we want to really continue to grow and have economic development in this state, we have to have a guarantee to people coming into this state that the water is going to be there . . . and this is the mechanism" (McGlade 2014).

We argue that the politics of water-supply strategies and the transition toward greater reliance on demand-reduction programs and policies are defined by the interaction of the development logic with three other institutional logics: preservation, environmentalism, and consumerism. The preservation logic is based on rural constituencies that, like the neighborhood opposition groups in urban growth machine theory, mobilize to preserve local use values against disruptive supply-increase policies such as new pipelines and reservoirs. The environmental logic (like the water sensitive logic above) is based on civil society organizations that mobilize to stop supply-increase policies that lead to environmental destruction and also to support demand-reduction policies because they conserve energy and water. The consumer logic emerges from households and businesses that reject some supply-increase and demand-reduction strategies if they are deemed to cause economic hardship or, in the case of water conservation mandates, unwanted lifestyle changes.

The preservation, environmental, and consumer logics interact with the development logic as opposing systems of meanings and values that are the basis for political challenges to the efforts of growth coalitions to develop water-supply strategies. As we shall show, opposition can emerge for both supply-increase and demand-reduction strategies. We argue that these political conflicts affect the choices among different water-supply strategies and the pattern of transition of water-supply systems.

METHODS

The analysis is based on the construction of a unique data set of the 22 largest MSAs of the extended American Southwest, which is defined as the contiguous states of Arizona, California, Colorado, Nevada, New Mexico, Oklahoma, Texas, and Utah. The American Southwest was selected because it is has faced extended drought that allows us to study how cities are adapting to stresses on their water supplies. Furthermore, the region is geographically and hydrologically connected by major river systems (e.g., the Colorado, Red, and Rio Grande). With a few exceptions (mostly in the eastern and northwestern portions of the region), the region is semiarid to arid, and during the early twenty-first century it faced extended drought. The depletion of both groundwater sources and surface storage reservoirs are also problems in the area. The cities studied are, in descending order of population for the MSA, as follows: Los Angeles, Dallas-Fort Worth, Houston, San Francisco-Oakland, Phoenix, Riverside-San Bernardino, San Diego, Denver, San Antonio, Sacramento, Las Vegas, San Jose, Austin, Oklahoma City, Salt Lake City, Tucson, Tulsa, Fresno, Albuquerque, Bakersfield, Oxnard-Ventura, and El Paso. The analysis of these 22 cities is part of a larger project that examines demand reduction in 200 U.S. MSAs from a multidisciplinary perspective.

Research Question 1: Qualitative Analysis

To address research question 1, we used a qualitative method. Qualitative methods are good for documenting the existence of a particular type of social phenomenon and for developing typologies that reveal relationships and processes. To obtain an overview of supply-increase strategies in the 22 cities, we used city water department and utility documents as well as media reports to identify supply-increase projects that are currently planned and under way. We gathered estimates of water volume for each project but ultimately rejected an effort to quantify the volume of future water sources. Many projects were long-term plans, whereas others were projects under way, and measurement units were not consistent and convertible across projects.

All cities have some demand-reduction programs. For the reasons explained above, this was the focus of our research on water-supply strategies, and we analyzed these programs in more detail. Based on a comprehensive review of public documents and city ordinances in the 22 cities, we developed an index of the relative development of demand-reduction strategies. The Vanderbilt Water Conservation Index (VWCIb) is a count of the water conservation policies and programs within a city. Due to time and resource constraints, we were unable to collect data for all of the cities within an MSA; instead, we selected the largest city as a proxy for the level of water conservation within each MSA. This is the most comprehensive index to date for demand-reduction strategies (programs and policies) at an urban-metropolitan level. The index was constructed by Wold, with input from the team of coauthors and assistance from a team of eight undergraduate students whose work was cross-checked in weekly team meetings. The VWCIb is the beta version, developed for this group of 22 cities, that was later modified when the full set of 200 MSAs was analyzed. It is based on the sum of 117 metrics of water demand-reduction policy that include pricing policies, mandates, incentives, recycling, and a miscellaneous category. We use this index as a measure of the extent of the transition of the water-supply regimes toward portfolios that are more heavily reliant on demand reduction. Validity was checked by comparing the VWCIb with the much more restricted index that was calculated using survey responses from an American Water Works Association (2010) data set, and the correlation was high for this sample ($r = 0.7$).

To analyze the political conflicts over supply-increase and demand-reduction strategies, we conducted a systematic review of media reports of water policies. We began with information that emerged in our search for projected supply-increase and demand-reduction strategies, and we did additional keyword searches on Google News. We then wrote brief descriptions of each conflict and coded the conflicts by the reason for the conflict and by types of actors involved (e.g., cities pursuing supply-increase strategies versus rural communities). We then classified the conflicts based on preservation, environmental, consumer, and development logics. Thus, the goal of the qualitative analysis was to use the institutional logics perspective to classify the range of political conflicts that have emerged over urban water-supply systems.

Research Question 2: Quantitative Method

To address research question 2, we used a quantitative method to understand what factors best explain the strength of demand-reduction strategies in the overall water-supply regime. We used the VWCIb score for each city as the dependent variable. For independent (predictor) variables, we tested two main groups: sociopolitical and hydrological. For the sociopolitical variables, we reasoned that cities with a higher population and higher average cost of living would have greater resources and more diversified water-supply strategies; cities with a rapidly growing population would be more likely to consider demand reduction as one strategy for meeting projected demand growth; and cities that lean toward the Democratic Party would have greater openness to water conservation policy because of its association with the preservation and environmental logics and because of its potential conflict with consumer logics. With respect to the hydrological variables, we reasoned that cities with a higher temperature, lower average precipitation, lower dependence on surface water (greater dependence on groundwater), and longer experience with drought would be more likely to have more developed water conservation policies. We used the following variables: *pop* (population in 2014; U.S. Census Bureau 2015), *popGrowth* (percent population increase from 2010 to 2014; U.S. Census Bureau 2015), *RPP* (regional price parity 2012, U.S. Bureau of Economic Analysis 2015), *PVI* (Partisan Voting Index, Cook Political Report 2014), *temp* (mean annual temperature 1900–2010), *precip* (mean annual precipitation 1900–2010), *surfaceWater* (percent of domestic public supply that is surface water, 2010; from the USGS water use report of Maupin et al. 2014), and *drought* (longest consecutive series of months with

Palmer Hydrological Drought Index, a widely used drought index, below –3, 1900–2010; calculated using MATLAB software provided by Jacobi et al. 2015). The precipitation and temperature data are from the University of Delaware's reanalysis climate data set (Matsuura and Willmott 2012). The PVI was calculated for each MSA using the county-level, two-way, Democrat and Republican, presidential vote data averaged for 2008–2012, and normalized by the national presidential election results. A negative number indicates that an MSA is more Republican than the national average, and a positive number indicates a more Democratic MSA.

Because of the small size of the data set, we recognize that caution must be exercised with the choice of formal analytic methods. We employ a decision-tree model, which is a nonparametric representation that divides the predictor variable values into distinct regions (Hastie, Tibshirani, and Friedman 2009). The method has advantages over the frequently used alternative in sociology (qualitative comparative analysis) because it can specify the relative contribution of different variables more precisely and because it can handle elegantly multicollinearity and missing data. Each MSA that falls into the same final region (same "leaf" at the bottom of the upside-down "tree") is based on the values its predictor variables are predicted to have for the same value of the VWCIb score. A "tree is grown" by making successive binary splits in the predictor variable space that continue to reduce prediction error at the margin until a small number of observations lie in each region of the predictor variable space. In effect, this method searches for an approximately optimal choice for variables to split and the threshold values of those variables where the split should be made. We use leave-one-out cross-validation to determine model accuracy on held-out data.

Using this decision tree approach, we also construct a random forest model using many trees that enables us to rank across all trees the importance of variables in predicting the VWCIb score of each city. To "grow forests," we randomly sample observations from the training set, grow a tree on each random sample, predict the remaining observations, and repeat 1,000 times. Randomness is further added by forcing each tree to consider different randomly selected sets of predictor variables at each split in order to reduce overall variance by reducing correlation between trees. This results in a "bootstrapped aggregation" of models that is almost always more accurate than its constituent models (Hastie et al. 2009). Each MSA's VWCIb is predicted over 300 times and averaged. The Random Forest model keeps track of the prediction error associated with each tree and provides a rank of the variables based on their importance in accurately predicting the VWCIb score (Liaw and Wiener 2002).

RESULTS: RESEARCH QUESTION 1

Our analysis of supply-increase strategies indicates that new pipelines are the most popular option followed by reservoirs and induced groundwater recharge (see Table I). Most of the cities in the data set approximate the ideal type of the second phase of water-supply transition, that is, reliance on building more pipelines and surface reservoirs for distant water sources. However, eight of the cities

Table I. Types of Supply-Increase Strategies for the 22 Cities

City	State	New Surface Water (Pipelines)	Surface Water Storage (e.g., Reservoirs)	Groundwater Recharge (Storage, etc.)	New Desalination Plants
Albuquerque	NM	X	X		
Austin	TX	X		X	
Bakersfield	CA	X	X		
Dallas-Fort Worth	TX	X		X	
Denver	CO	X		X	
El Paso	TX	X	X	X	X
Fresno	CA	X	X		
Houston	TX	X		X	
Las Vegas	NV	X	X	X	
Los Angeles	CA	X	X	X	
Oklahoma City	OK	X		X	
Oxnard	CA		X		X
Phoenix	AZ		X	X	
Riverside	CA	X	X	X	
Sacramento	CA	X			
Salt Lake City	UT			X	
San Antonio	TX	X	X		X
San Diego	CA	X	X	X	X
San Francisco	CA	X	X	X	X
San Jose	CA	X	X		X
Tucson	AZ	X	X		
Tulsa	OK	X			

approximate the third transition phase (reliance on nontraditional water-supply sources). These cities had an estimate of over 50% of planned new water sources from desalination and/or aquifer recharging (Bakersfield, El Paso, Oxnard, Phoenix, San Antonio, San Francisco-Oakland, San Jose, and Tucson). We found that aquifer recharging projects were in some cases water banking from surface water allotments, so in this sense the "new" water-supply strategy was continuous with the phase-2 focus on water importation. In short, even in this water-stressed part of the country, the emphasis remains on importation and on building storage capacity.

Turning to demand-reduction strategies, the VWCIb score for the 22 cities shows a range from 12 to 55, which indicates that all cities have some implementation of demand-reduction strategies, but there is substantial variation in the level of implementation (Table II).

Our inventory of conflicts that have developed with respect to both supply-increase strategies and demand-reduction strategies suggests two main types of conflicts (Table III):

1. Supply-increase strategies that involve the construction of infrastructure (generally dams and pipelines, but in some cases desalination plants and increased groundwater production) create opposition from three types of constituencies: rural constituencies that have an economic and social stake in the preservation of the landscape; environmentalists who identify environmental and endangered species concerns; and urban constituents who are concerned with the impact of costly infrastructure on water prices. In terms of institutional logics, these conflicts involve the development logic versus preservation, environmental, and consumer logics.

Table II. Vanderbilt Water Conservation Index (Beta) Scores for the 22 Cities

	Residential			Commercial					Other					
	Require-ments	Rebates	Other	Require-ments	Rebates	Other	Drought Plan	Billing Structure	Public Information Programs	Permanent and Full-Time Conservation Staff	Enforcement Mechanisms for Requirements	Metering	System-Wide Water Audit, Leak Detection, and Repair	VWCIb Score
Albuquerque	7	6	2	12	6	1	5	0	1	1	1	1	0	43
Austin	7	6	2	12	5	2	4	3	1	1	1	1	1	46
Bakersfield	3	3	2	4	0	1	4	2	1	0	0	1	1	22
Dallas	4	1	2	5	1	3	5	3	1	1	1	1	0	28
Denver	8	3	3	11	5	1	5	4	1	1	1	1	0	44
El Paso	8	1	2	10	2	2	4	3	1	1	1	1	1	37
Fresno	10	4	3	10	4	2	4	0	1	1	1	1	1	42
Houston	1	1	2	1	0	2	4	1	1	1	1	1	1	17
Las Vegas	8	8	3	11	1	1	4	3	1	1	1	1	1	44
Los Angeles	8	5	1	15	8	3	4	6	1	1	1	1	1	55
Oklahoma City	3	1	1	3	0	1	4	3	1	1	1	1	0	20
Oxnard	9	4	1	13	7	2	4	3	1	1	1	1	1	48
Phoenix	2	1	1	4	0	2	5	0	1	1	1	1	1	20
Riverside	6	5	1	9	8	2	4	6	1	1	1	1	1	46
Sacramento	5	4	2	6	4	3	4	0	1	1	1	1	1	33
Salt Lake City	8	1	2	9	1	2	4	3	1	1	0	1	1	34
San Antonio	7	4	3	12	5	3	5	4	1	1	1	1	1	48
San Diego	7	6	3	12	8	2	4	2	1	1	1	1	1	49
San Francisco	9	5	2	12	5	2	5	2	1	1	1	1	0	46
San Jose	10	5	3	10	6	2	4	2	1	1	1	1	0	46
Tucson	3	3	2	4	1	2	5	2	1	1	1	1	0	26
Tulsa	2	0	1	2	0	1	4	0	1	0	0	1	0	12

Table III. Political Conflicts Over Water-Supply Plans and Strategies

Institutional Logic:	Description:	Cases
	Supply-Increase Plans and Strategies	
Development vs. preservation	Opposition from farmers, rural interests, tribal groups	Albuquerque: litigation from farmers and Native Americans over water rights and water quality Austin: conflict with rice farmers over water access Dallas: east Texas reservoirs (e.g., Marvin Nichols) Denver: rural interests in western Colorado Las Vegas: coalitions against eastern Nevada pipeline Oklahoma City: tribal opposition to Sardis Reservoir project San Antonio: conflict over rights from Lower Colorado River Authority
Development vs. environmental	Opposition from environmentalists based on endangered species, habitat destruction, aquifer depletion	Albuquerque: San Juan Chama project (Rio Grande silvery minnow), aquifer depletion Dallas: east Texas reservoirs Denver: litigation over Chatfield Reservoir Reallocation Project, historical conflict over Two Forks Project El Paso: aquifer depletion Fresno: conflict over salmon restoration and water rights, Temperance Flat dam Houston: aquifer depletion (subsidence) Oklahoma City: litigation over Sardis Reservoir project (endangered species) Salt Lake City: Bear River Project San Antonio: Edwards Aquifer (endangered species) San Diego: desalination (effects on ocean species)
Developmentvs. consumer	Opposition from consumers based on cost of proposed infrastructure projects	Austin: Water Treatment Plant 4 Fresno: litigation and city council conflict over cost of water infrastructure improvement projects San Antonio: expense of Vista Ridge project San Diego: expense of Carlsbad desalination plant
	Demand-Reduction Plans and Strategies	
Development and/ or environmental vs. consumer	Opposition from consumers (residential and industrial) to costs or lifestyle changes associated with demand reduction	Austin: opposition to rate increases and to submetering plan Dallas: some homeowners associations ban xeriscaping and rain collection El Paso: Hispanic Chamber of Commerce against water connection fee Fresno: residential noncompliance with lawn watering restrictions Los Angeles: city council dispute over lawn watering, wealthy communities not in compliance with outdoor watering restrictions Phoenix: general opposition to mandates, rebates (see discussion) Sacramento: opposition to costs of installation of sidewalk water meters Salt Lake City: opposition to proposal to end property tax subsidy of water

Table III. (Continued)

Institutional Logic:	Description:	Cases
		San Diego: opposition to some price hikes, wealthy suburbs reject lawn watering restrictions San Francisco: third tier of pricing eliminated after public opposition San Jose: opposition to water police in area city and to water budget rules from the San Jose utility Tucson: historical opposition to pricing policy of New Democrats, opposition to 2015 price increases

2. Demand-reduction strategies that utilize tiered pricing and mandates draw opposition from urban consumers who are concerned with price increases and with mandatory changes in their customary water uses such as green lawns. In terms of institutional logics, these conflicts involve an environmental and/or development logic that supports demand reduction and a consumer logic that supports status quo pricing and usage patterns.

Supply-Increase Strategies and Conflicts of Institutional Logics

When urban growth coalitions attempt to increase their water supply by developing new water sources from regional importation projects, their supply-increase strategy can run into conflicts from rural constituencies, environmentalists, and urban consumers. Rural constituencies such as farmers, local industries reliant on recreation and tourism, and Native American communities voice a preservation logic when confronted with plans to build new reservoirs or to tap into local aquifers. Of the 22 cities surveyed, these conflicts were especially evident for supply-increase projects in Oklahoma City, Dallas, and Las Vegas. We noted above that the state of Oklahoma was interested in keeping its surface water resources from being used by the Dallas-Fort Worth area partly because the state's growth coalition wants to channel economic development from Texas. To this end, Oklahoma City has been attempting to develop new surface water supplies, and in 2010 the Water Utilities Trust of Oklahoma City purchased a water storage contract for 136,000 acre-feet of water in Sardis Lake from the state's Water Resources Board. Sardis Lake is located 180 miles away in the southeastern part of the state (one of the wetter areas in the eight states), and the city has targeted additional water sources in that part of the state for future development. However, in 2011 the Choctaw and Chickasaw nations sued the Water Utilities Trust over rights to Sardis Lake, and negotiations have not reached a settlement to date.

The second type of conflict involves environmental constituencies. Environmental conflicts were prominent for Albuquerque (San Juan Chama Project), Dallas (Nichols Reservoir), Denver (Two Forks Dam), Salt Lake City (Bear River Project), San Antonio (Edwards Aquifer), and cities in the San Joaquin–Sacramento River watershed. One example of the conflict between development and environmental logics was the response to California's Proposition 1 of 2014, a ballot initiative to authorize the state to borrow billions of dollars to restore watersheds and build reservoirs. Environmentalists worried about the impacts of the dams on the Sacramento–San Joaquin Bay Delta and species such as the Chinook salmon, smelt, and steelhead. Furthermore, they argued in favor of demand reduction as an alternative water-supply strategy that is more consistent with their environmental logic: "the state should invest in water conservation, efficiency and recycling strategies" instead of building more dams (Blood 2014).

Frequently, both rural preservation and environmental constituencies join in defense of planned infrastructure projects. For example, the city of Dallas has been trying to gain approval to build reservoirs in east Texas, where there is available surface water. Ramon Miguez, the assistant city manager for Dallas, articulated the link between water and the city's development logic as follows: "The north central Texas region is the economic engine of the state, bar none. The only way that this region can sustain its economic growth has to be working a mutually agreeable agreement with a region that is richer than we are [in water resources] and simply does not need the water as we do" (Campoy 2009). The strategy has resulted in strong opposition from east Texas residents. For example, one resident commented, "What they want is to destroy our wildlife so they'll have enough water for their grass" (Campoy 2009). The city of Dallas also sued the U.S. Fish and Wildlife Service in order to gain access to part of the Neches River, where it hopes to build a reservoir.

Supply-increase strategies that involve significant investments in new infrastructure can result in costs that are passed on to consumers, who can mobilize against the infrastructure projects and express a consumer logic. A good example of ratepayer backlash against a Promethean project occurred in 2014 in San Antonio. The San Antonio Water System (SAWS) and the city council approved the Vista Ridge pipeline, a $3.4 billion plan to bring 50,000 acre-feet of water per year from a well field in Burleson County. The projected expense was greater than the $2.4 billion annual city budget, and the expected unit cost of the water from the pipeline was about seven times that of water from the Edwards Aquifer. The growth coalition represented by the city's chamber of commerce and business leaders supported the project, but environmentalists and low-income advocates opposed it. City councilman Rey Saldaña commented, "For a good portion of those folks, today's water rates are already an issue for them. It is not lost on me that any rate increase would hurt them even more" (Satija 2014).

In summary, urban growth coalitions have focused on obtaining new water supplies, generally from distant surface and groundwater sources. This approach is consistent with phase 2 of the ideal typical scheme of water-supply transitions. In very rapidly growing areas such as the Texas cities, many of which expect population to double by 2050, there is a sense that demand-reduction strategies will not be enough to accommodate economic growth. This does not mean that phase-3 strategies (demand-reduction, desalination, and aquifer recharging) are incompatible with the development logic. But it shows that some cities are still trying to pursue water importation via new infrastructure development, and their plans trigger opposition from rural constituencies, environmentalists, and consumers.

Demand-Reduction Strategies and Conflicts of Institutional Logics

In conflicts over supply-increase plans that have significant impacts on rural constituencies and environmentally sensitive natural areas, the opponents sometimes argue that cities should first reduce their water consumption before attempting to gain new sources of water. As noted above, environmentalists point to water conservation as a good way to meet the demand for water because demand reduction is often less detrimental to the environment, results in energy savings and greenhouse gas emissions reductions, and can be less expensive than infrastructure development. Thus, demand-reduction strategies can be configured as part of an environmental logic. However, cities that face growing populations and restricted water resources can also include demand reduction as a "source" of new water that is needed for continued economic growth. In several of the cities that we studied, annual declines in per capita water consumption were high enough to keep total water consumption constant even as the population grew. Thus, demand-reduction strategies can be consistent with an urban development logic as well as an environmental logic. Because demand reduction does not require changes in rural land uses, it can also be consistent with the preservation logic, and because it is often less expensive that Promethean importation projects, it can be consistent with the consumer logic.

Despite this win–win scenario for demand-reduction, our analysis indicated that it also sparked political opposition under some conditions. Our inventory of conflicts over water-supply policies showed that consumers tend to be relatively tolerant of voluntary demand-reduction strategies such as rebates and incentives but that opposition emerges against mandatory policies and against tiered pricing schemes. Thus, we argue that the politics of demand-reduction strategies can involve a conflict between, on the one hand, an environmental logic that is consistent with a development logic, and, on the other hand, consumer logics that oppose the transition.

With respect to mandates, the most common is a limitation on outdoor lawn watering, which tends to be imposed during drought conditions and is often accepted as a necessary temporary measure. However, more permanent mandates on lawn watering can run into conflicts with a consumer logic when homeowners wish to preserve an accustomed way of life based on green lawns and other outdoor water uses. Some cities have ordinances that impose a fine if people do not keep their lawns green, and in California the state legislature has had to step in to override these ordinances and fines. Mandates also require enforcement, and enforcement mechanisms can trigger consumer backlash. Cities have tended to tread lightly on water enforcement fines partly because of concern with voter backlash.

The second type of demand-reduction policy that has triggered significant opposition in some cities is tiered pricing and price increases. The case of Tucson shows the interplay of development, environmental, and consumer logics. In 1975, a group of reform candidates called the New Democrats gained control of the city council and enacted a "controlled growth" agenda that also opposed plans to build an elevated highway through the city. They worked with the Tucson Water Department to initiate a series of water conservation policies that included higher rates, a "lift charge" to pay for water pumping to wealthy foothill developments, and summer peak-use reduction (Gottlieb 1988). However, consumers rejected the 22% increase in prices, and real estate developers were unhappy with the measures. A subsequent recall election led to the reinstatement of the city's growth coalition. Nevertheless, when it was restored to political power, the coalition accepted some of the demand-reduction policies. The pricing scheme and peak-use plan remained in place, but the lift charge (the one element of the demand-reduction policies that was most in conflict with real estate development) was dropped. In 1977, the city leaders launched the "Beat the Peak" campaign, which helped to reduce summer peak demand and per capita water use. In turn, the conservation efforts made it easier for the city to continue building more developments. According to Gottlieb (1988:148), the annual campaign "created a political model for the water industry" in which growth politics were linked to water conservation. Thus, in this second phase of the Tucson case, demand-reduction policies were made consistent with the urban development logic.

Summary

We argue that attention to four kinds of institutional logics—a development logic associated with an urban growth coalition; a preservation logic associated with rural constituencies that have an economic and cultural stake in preserving existing patterns of land and water use; an environmental logic associated with the protection of endangered species and natural landscapes but also with water conservation; and a consumer logic associated with the maintenance of existing consumer practices and prices—provides a general framework for interpreting the sociology of urban water-supply politics. As a qualitative approach, the analysis of conflicting institutional logics provides a set of typological categories that can guide the interpretation of the relationship between meanings and constituencies. The analysis also suggests that political considerations are likely to play an important role in the outcomes of policy proposals that significantly alter an urban area's future water supply.

RESULTS: RESEARCH QUESTION 2

As noted above, demand-reduction strategies provide a unique, win–win solution to the conundrum of meeting demand for urban water supply in water-stressed areas. These strategies can allow a city's growth coalition to work within existing supply constraints and still have economic growth, but the strategies also provide environmental benefits, preservation benefits to rural constituencies by reducing the need for infrastructure development, and consumer benefits through rebates that reduce water bills and through savings in water costs due to leak detection and infrastructure repair. Yet, despite this potential for demand reduction to satisfy all four institutional logics, cities and water utilities have not rushed uniformly to embrace demand reduction even in this region of high water stress and drought.

To explain this variation, the quantitative analysis first grew a single tree for visualization. The top value inside the boxes of Fig. 1 [Left] is the mean value of the

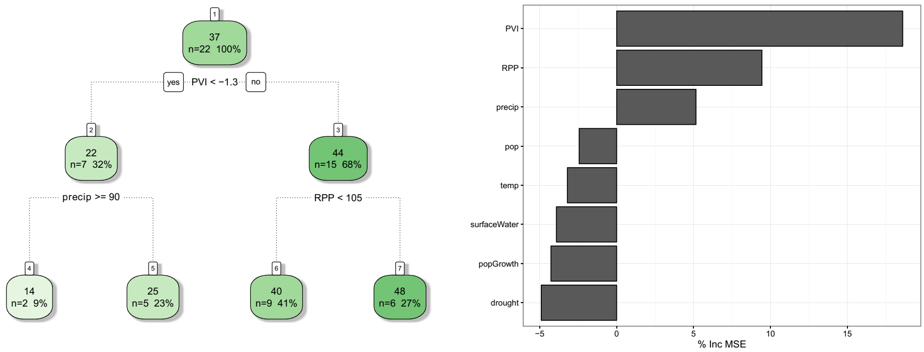

Fig. 1. [Left] Regression Tree with four terminal nodes, [Right] Variable Importance Plot from Random Forest model.

VWCIb for the *n* observations in that ode. The algorithm chose a first split point at a PVI value of –1.3, which means the MSAs on the left branch are greater than 1.3 percentage points more Republican than the national average. The next split to the left and right divides the observations by precipitation (precip) and regional price parity (RPP), respectively. Following the tree to the left, we see that the model predicted the lowest VWCIb scores (14) for MSAs with a negative Republican PVI (PVI < –1.3) in a climate that receives more than 90 cm of precipitation a year (VWCIb = 14, n = 2, MSAs = Tulsa and Houston). Following the tree to the right, the model predicts the highest VWCIb scores (48) for MSAs with a positive PVI (PVI > 1.3) and with high regional price parities (RPP > 105, VWCIb = 48, n = 6, MSAs = Los Angeles, Oxnard-Ventura, Riverside-San Bernardino, San Diego, San Francisco, and San Jose).

The variable importance plot shows the overwhelming importance of the PVI as a predictor of the VWCIb. (See Fig. 1, right.) As with the single tree analysis, the PVI is followed in importance by regional price parity and precipitation. The *x*-axis in Fig. 1 [Right] is the percentage increase in the prediction error if a predictor variable was dropped from the model. For example, removing PVI would *increase* the prediction error by almost 20%, but removing the drought predictor would *decrease* the prediction error by 5%. We conducted additional multivariate analyses (including multiple types of regularized regression) that confirm the importance of the PVI and show that location of cities in California is not driving the results. When PVI is included, the predicative capability of most other variables drops out.

DISCUSSION

The qualitative and quantitative analyses converge by suggesting that political factors play an important role in the adoption of water-supply policies in general and in the transition to regimes with high levels of demand-reduction policies in particular. The qualitative analysis shows that different types of conflicts emerge based on different constituencies and their associated institutional logics, and the quantitative analysis points to a specific type of political factor that involves differences in levels of support for political parties. Putting the two findings together, we suggest that demand-reduction strategies may be generally associated with environmentalism and therefore caught up in the general polarization between political parties in the United States on environmental policies and beliefs (McCright, Xiao, and Dunlap 2014). However, other than the case of Tucson discussed above, we do not find much evidence of explicit partisan differences over water conservation policies in our data set. One explanation is that in most of the cities in the data set, political power is in the hands of Democrats, and even where there are Republican mayors, they often must adopt moderate positions that appeal to the wide range of urban constituencies. Thus, the sharp partisan differences that appear in state governments and in the federal government may be more muted at the urban government level, at least for this issue.

We suggest instead that the political differences associated with the PVI variable are related to broader differences in political culture for the cities that lead to contrasts in the relative acceptability of demand-reduction strategies. Specifically, the tension between environmental and consumer logics may have overtones of progressive and conservative ideology: progressives may be happy with strong demand-reduction policies because they are environmentally beneficial, and progressives may not be as concerned with local government mandates that penalize heavy water consumers with higher prices and that require changes in household behavior. In contrast, conservatives may be skeptical of demand reduction because of its associations with environmentalism and with intrusive government policy into consumer choice.

Additional research will be required to investigate the hypothesis that political differences identified by the PVI suggest broader differences in political culture that leads to contrasts in the relative acceptability of demand-reduction strategies. With our existing data set, we can draw some contrasts between otherwise similar cities to suggest how these associations among political preferences and demand-reduction policies might work. Specifically, we compare the paired cities of Austin (high VWCIb and PVI) and Dallas-Fort Worth (low VWCIb and PVI) and Albuquerque (high VWCIb and PVI) and Phoenix (low VWCIb and PVI).

In a survey of water conservation of Texas cities, the politically liberal city of Austin (VWCIb 46, PVI 8.25) had the most progressive rate structure for water pricing, the highest level of funding for water conservation per connection, and the highest number of toilets replaced (McCormick et al. 2010). The city also had a strong outdoor watering ordinance and had an overall per capita water reduction goal that met the state standard of 1% per year. The environmentalist group Save Our Springs, which was founded in 1990 to preserve Barton Springs and the Barton Creek watershed from development, has provided advocacy support for increases in the city utility's water conservation programs.

In contrast, the programs in Dallas and Fort Worth (VWCIb 28, PVI −3.61) were ranked only moderate (McCormick et al. 2010). Dallas did not meet the state's 1% annual reduction goal and had the highest per capita water consumption among major cities in the state. As noted above, Dallas has sought water sources from eastern Texas, and the expansion of water sources has created conflicts. Opponents of plans to develop new reservoirs in eastern Texas argue that the Dallas is a "water hog" and that the Dallas-Fort Worth area should first focus on deepening its water conservation programs and policies (Campoy 2009). To escape from the reputation, the cities have increased water conservation programs, but their programs are not as advanced as those of Austin (McCormick et al. 2010).

Another contrast is between Albuquerque (43 VWCIb, 10.80 PVI) and Phoenix (20 VWCIb, –3.14 PVI). These are the two largest cities in the neighboring states of New Mexico and Arizona, and both cities are located in the desert of the American Southwest. Albuquerque has extensive water conservation policies as well as graywater recycling for city parks and a summer surcharge based on winter usage levels. One can see from Table II that the number of requirements and rebates is much higher than for Phoenix. Our review of media reports showed that the utility has had to increase prices in order to cover revenue shortfalls from conservation and to pay for infrastructure repairs that reduce water main breaks, but there has been little opposition to these measures. The main issue of political contention during recent years is a plan to build a 38,000 home development in the suburban area of Albuquerque. Farmers and area residents have opposed the measure and cited water consumption as a main concern (Provost and Bienvenue 2015).

Because there are few opportunities for surface water development, the city of Phoenix has engaged in extensive water banking from its Colorado River allotment. However, the city's water conservation policy is controversial due to the low use of common policy instruments such as requirements and rebates, and the region has a history of conflict between growth coalitions and the state government over mandates for water conservation (Larson, Gustafson, and Hirt 2009). Instead, the focus of the city's water conservation efforts is on infrastructure leak repair, educational programs, and structural changes (e.g., low-flow toilets). As the deputy water services director Brandy Kelso commented, "I don't want to mean that we don't do conservation. We just approach it differently" (Santos 2013). The city's Water Services Department notes, "Water use restrictions simply have not been necessary due to wise planning and use" (City of Phoenix 2014).

In summary, these two pairs of contrasts suggest how the PVI index may be linked to broad political cultures that in the more conservative cities tend to favor supply-increase strategies (new reservoirs for Dallas and water banking for Phoenix) and only modest approaches to demand reduction.

CONCLUSION

Although there are many sources of risk for the freshwater-supply systems of cities, drought conditions present severe challenges because of the dependence of homes and businesses on a stable supply of freshwater. These challenges are exacerbated by the combination of climate change, population growth, and commercial and agricultural practices that are not adapted to local hydrological conditions. Of the potential responses to risks for freshwater-supply systems, demand-reduction strategies promise broad environmental benefits and can double as climate mitigation strategies. Yet, we find substantial variation in the implementation of demand-reduction strategies even in the American Southwest, where water-supply risks are severe and the climate conditions are similar.

From a theory perspective, we show the value of combining the study of transitions of sociotechnical systems with frameworks from institutional and urban sociology. We build on the growing attention to political and institutional dimensions of transitions (e.g., Grin, Rotmans, and Scot 2011) by suggesting the value of an institutional logics framework that is grounded in the conflicts between urban growth coalitions and countervailing constituencies. Demand-reduction policies can be configured to be consistent with all institutional logics, but we also identified some conflicts with the urban consumer logic regarding mandates and price increases that are often part of demand-reduction strategies. Consumers sometimes reject strong mandates, water police and fines, and steep price increases. The quantitative analysis suggests that concerns with these consumer issues may be higher in cities with a negative PVI (more Republican leaning) and where the political culture is contrary to policies associated with environmental regulation as well as to government policies that result in mandates and increased consumer costs. However, we do not find evidence that the conflicts over urban water-supply systems are closely tied to urban party conflict. Rather, we suggest that there are broad differences in urban political culture, specifically the political valences of the environmental and consumer logics, which affect the level of support for demand-reduction strategies, especially when those strategies are configured in the ideologically more sensitive form of mandates and tiered pricing.

We suggest that future research might seek to explore this insight in more detail and to address specifically the design of demand-reduction policies from a political perspective to understand better what types of demand-reduction policies are more likely to have broad appeal across the political spectrum. This project is similar to work on political ideology and the politics of renewable energy and energy efficiency, which shows that policies configured as mandates (e.g., renewable portfolio standards) have lower levels of support than policies configured as reductions in regulations or tax credits (Hess et al. 2015). Thus, the approach that we have outlined here may have practical policy implications that could improve the capacity of advocates of demand-reduction strategies to win greater support.

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