Science Advances

Supplementary Materials for

Changes in water consumption linked to heavy news media coverage of extreme climatic events

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This PDF file includes:

- Demand modeling
- Breakpoint analysis
- fig. S1. BAWSCA service areas.
- fig. S2. *K*-means clustering of service areas.
- table S1. BAWSCA service area cities and proxies used for unemployment.

Supplementary Materials

Demand modeling

Study area

We modeled water use for service areas represented by the Bay Area Water Supply and Conservation Agency (BAWSCA), a regional public agency that represents the agencies that receive water from the San Francisco Regional Water System. These service areas are located in Alameda, San Mateo, and Santa Clara counties (fig. S1), and they vary dramatically in size, demographics, climate, and water use (*30*). Twenty of the 28 BAWSCA service areas were evaluated in this study (table S1): two service areas (Stanford University and Guadalupe Valley MID) were excluded due to their unique customer base while six service areas (City of East Palo Alto, City of Brisbane, San Jose Municipal Water System, Alameda County Water District, City of San Bruno, and Westborough County Water District) were excluded due to incomplete water use data.

Data

Water consumption

BAWSCA provided total water consumption in hundreds of cubic feet (CCF) and the number of accounts for each sector for each service area. The temporal scale of reporting varies by utility—some agencies report water consumption monthly and others bimonthly, while most service areas report the number of accounts on a yearly basis. To allow for an equal comparison between all service areas, average water use per account was calculated for each bimonthly period from July 2005 to June 2015. We focus exclusively on single-family residential (SFR) customers to evenly compare service areas and as the study area is mostly residential: 87% of accounts in the BAWSCA region are residential, and over 90% of these residential customers are SFR customers accounting for 58% of water use in the

BAWSCA region (*31*). SFR water consumption is highly seasonal in all service areas, with average summer water use more than double average winter water use in the BAWSCA region.

Climate

To account for the many micro-climates in the San Francisco Bay Area, spatially explicit climate data from the Parameter-elevation Regressions on Independent Slopes Model (PRISM) climate dataset from Oregon State University was used to evaluate climatic conditions in each service area during each bimonthly period (*45*). We processed the PRSIM data in ArcGIS to calculate the spatially averaged mean monthly temperature and cumulative monthly precipitation values for each service area. Temperature values were averaged and precipitation values were cumulatively added to convert the data from monthly to bimonthly. In total, 120 raster files were downloaded to ArcGIS for analysis—one average daily temperature raster file and one cumulative precipitation raster file for each month in the 10-year period. The PRISM raster dataset is provided at a 4-km resolution, which is equivalent to 0.041667 degrees, or 02'30". Rasters were resampled to a 1-km resolution, or 0' 37.5" to account for the small spatial size of some BAWSCA service areas. The spatially averaged value for each raster within each service area shapefile was then calculated, yielding the mean monthly temperature and cumulative monthly precipitation values for each service area. To account for long-term climatic trends, PDSI values were also incorporated into the model. The PDSI is calculated regionally; the entire San Francisco Bay Area is located within California Division 04- Central Coast Drainage. Monthly PDSI values for this region were downloaded from the National Climatic Data Center (*32*) and averaged to bimonthly values.

Median household income and demographics

Census block-group level median household income and demographic values were extracted from the U.S. Census and the American Community Survey (ACS) and spatially averaged to each service area

(*47*). Five demographic characteristics (percentage of owner-occupied housing, percentage of the population speaking Spanish, percentage of the population speaking Asian languages, population percentage with higher education, and population density) of each service area were extracted from the 2010 Census. Median household income was calculated yearly, and linear interpolation was used to calculate values for the years 2005, 2006, and 2007, which fell between the 2000 Census and 2008 ACS. Income values were assumed to represent the midpoint of each year, July 1, and values were linearly interpolated for each bimonthly period. Bimonthly income was adjusted for inflation using the monthly Consumer Price Index (CPI) from the U.S. Bureau of Labor Statistics to June 2015$, the end of our study period.

State of the economy

Given the diversity in service area demographics and affluence, non-seasonally adjusted unemployment rates at the city level were used from the U.S. Department of Labor, Bureau of Labor Statistics, Local Area Unemployment Statistics (*46*). If a service area served more than one city, or served a mostly rural area, the main city in the service area was used. Data was available for 14 of 20 cities/service areas in the study, and for the remaining six for which no data was available, proxy cities were used that exhibited similar demographic characteristics (table S1). These assumptions were confirmed with BAWSCA, which has a deep knowledge of each agency.

Price

Because pricing and rate structures vary between service areas (*31*), we included price as the average price per hundred cubic feet (CCF) of water for a SFR household. Average monthly SFR water use and average SFR water bills were provided by BAWSCA for each year of analysis. The average price for one CCF of water for a SFR customer was calculated by dividing the average price that customers paid for their water bill by the average amount of water consumed. The data was presented yearly and was

not interpolated for each bimonthly period, assuming the same average price was paid throughout the entire fiscal year (July 1–June 30). Prices were adjusted for inflation using the monthly CPI from the Bureau of Labor Statistics to June 2015$, the end of our study period.

Breakpoint analysis

Data processing and outlier analysis

As a broader effort to increase water sustainability in the service area, the City of Redwood City started installing customer-level advanced metering infrastructure (AMI) in 2008. Water consumption is measured by AMI at the customer-level in sub-hour intervals and was provided to us aggregated to the daily level. We analyzed water use for SFR and nonresidential commercial irrigation (COMM-IRR) customer sectors from July 1, 2010—Dec 31, 2015. We did not include water consumption for all customers in the service area, instead we only examined average water use *by customers with AMI* in our analysis.

Given that the AMI system has only been implemented recently, the daily data contained errors that prompted us to perform an outlier analysis. First, all negative numbers and values over 100 CCF in any given day were removed from the database. For each consequently missing value for a given account, we assigned that day the average value of the week. After the outlier analysis, we aggregated daily water use observations to weekly observations. The results of the outlier analysis did not significantly alter the database. We then summed all weekly observations and divided by the number of accounts to find average weekly water use per account per sector in the service area (for customers with AMI).
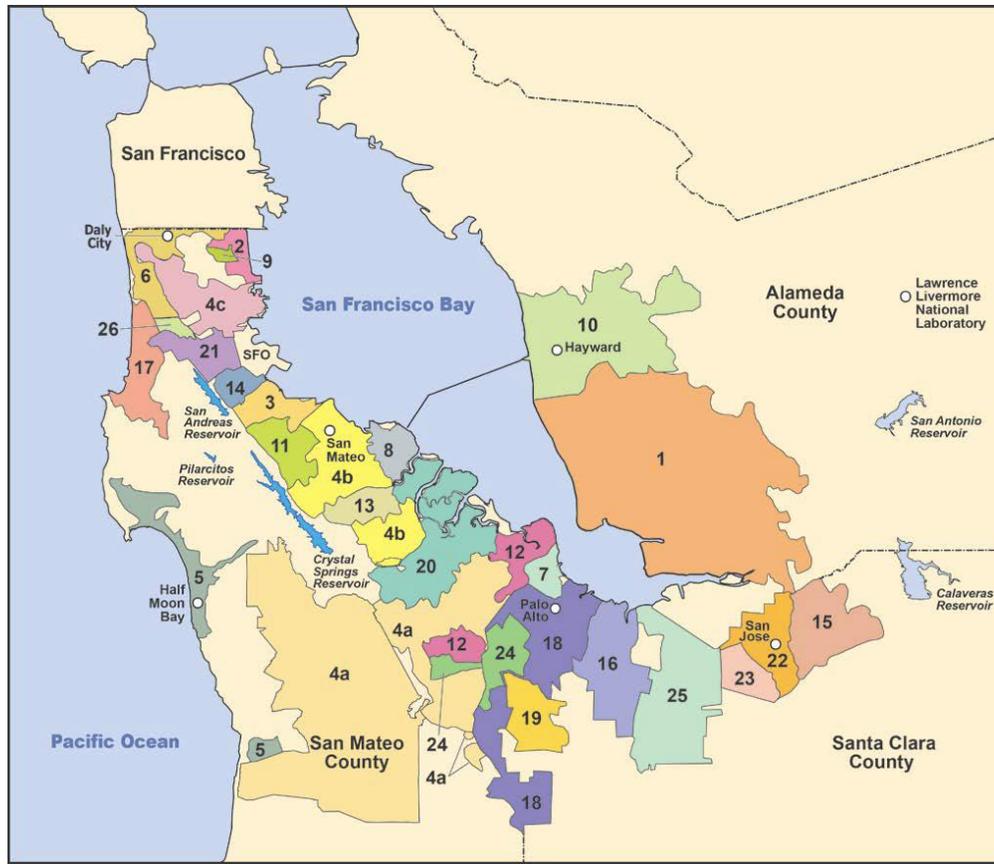
Legend

1 Alameda County Water District	13 Mid-Peninsula Water District
2 City of Brisbane	14 City of Millbrae
3 City of Burlingame	15 City of Milpitas
4a CWS – Bear Gulch	16 City of Mountain View
4b CWS – Mid-Peninsula	17 North Coast County Water District
4c CWS – South San Francisco	18 City of Palo Alto
5 Coastside County Water District	19 Purissima Hills Water District
6 City of Daly City	20 City of Redwood City
7 City of East Palo Alto	21 City of San Bruno
8 Estero Municipal Improvement District	22 San Jose Municipal Water System
9 Guadalupe Valley MID	23 City of Santa Clara
10 City of Hayward	24 Stanford University
11 Town of Hillsborough	25 City of Sunnyvale
12 City of Menlo Park	26 Westborough Water District

fig. S1. BAWSCA service areas. Source: (*31*)
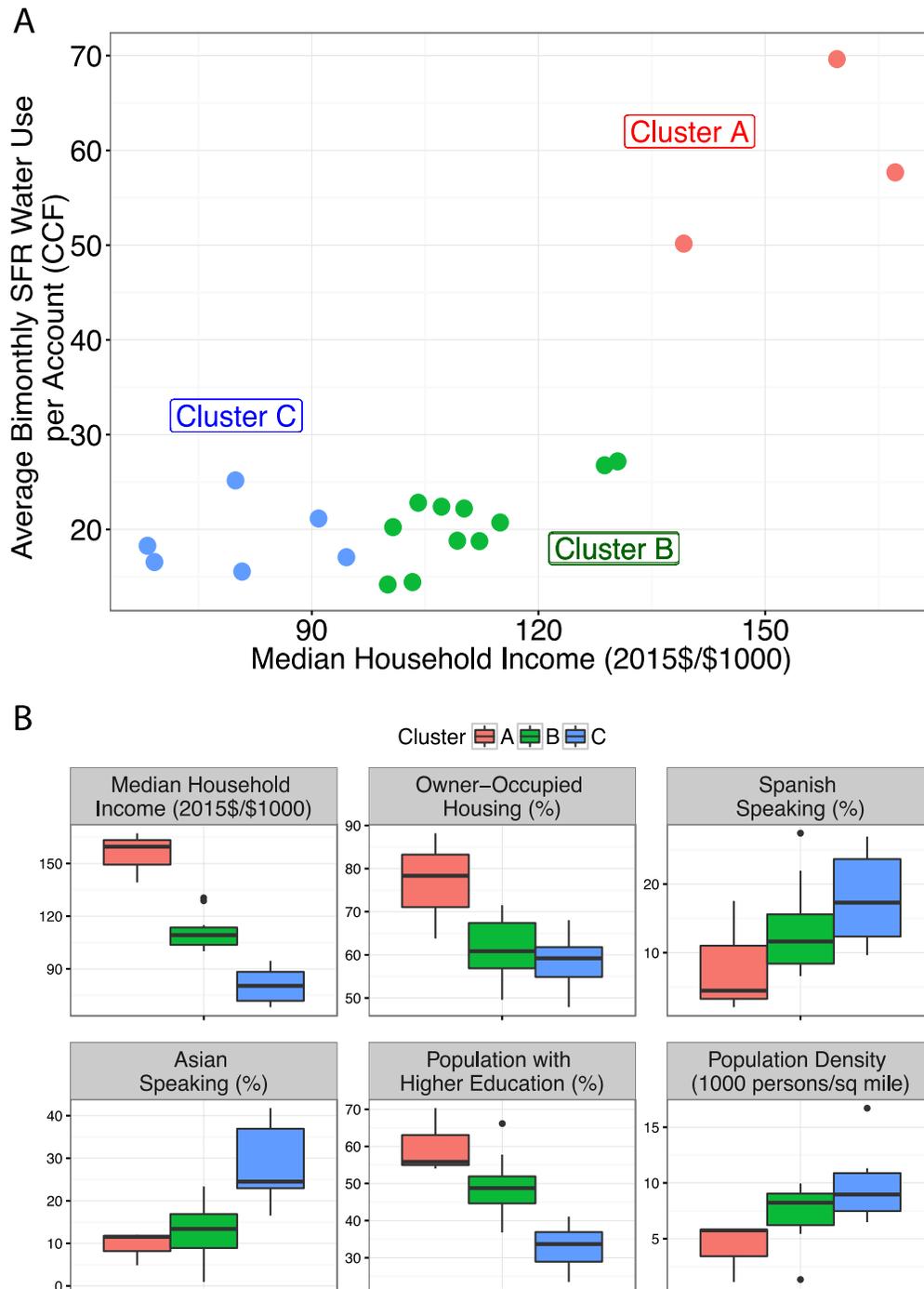
fig. S2. *K*-means clustering of service areas. (A) Algorithm results and (B) cluster demographic characteristics. Median household income represents the average over the study period while the other five metrics are from the 2010 Census.

table S1. BAWSCA service area cities and proxies used for unemployment.

BAWSCA study service areas with main city in BLS database	
Service Area	**Main City in Service Area**
City of Hayward	Hayward
City of Palo Alto	Palo Alto
City of Mountain View	Mountain View
City of Santa Clara	Santa Clara
City of Sunnyvale	Sunnyvale
City of Burlingame	Burlingame
City of Daly City	Daly City
City of Menlo Park	Menlo Park
City of Redwood City	Redwood City
Estero Municipal Improvement District	Foster City
Mid-Peninsula Water District	Belmont
CWS – Mid-Peninsula	San Carlos
North Coast County Water District	Pacifica
CWS – South San Francisco	South San Francisco

BAWSCA service areas with proxy cities for unemployment		
Service Area	**Main City in Service Area**	**Proxy City in BLS Database**
City of Millbrae	Millbrae	Burlingame
CWS – Bear Gulch	Portola Valley	Los Altos
Coastside County Water District	Half Moon Bay	Pacifica
Town of Hillsborough	Hillsborough	Burlingame
City of Milpitas	Milpitas	San Jose
Purissima Hills Water District	Los Altos Hills	Los Altos