How Does Urbanization Affect Water Withdrawals? Insights from an Econometric-Based Landscape Simulation, by Daniel P. Bigelow, Andrew J. Plantinga, David J. Lewis, and Christian Langpap
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Appendix A. Supplemental tables and results

Table A1: Variables included in hedonic models

Variable	Description	Measurement	Time-varying?	Source
Year	=1 if year corresponding to parcel value is t, 0 otherwise; t=1973, 1980, 1986, 1992, 2000	Binary	Yes	CA
Year x UGB	=1 if parcel is in sample and inside of a UGB in year t, 0 otherwise	Binary	Yes	GIS; CA
UGB	=1 if parcel is inside of a UGB, 0 otherwise	Binary	No	GIS; DLCD
Distance to nearest city	= Euclidean distance to nearest city center of over 20,000 people	Miles	No	GIS; GM
Population density of nearest city	= population density of nearest city of over 20,000 people	1000s of ppl./sq. mi.	Yes	USCP
Household income of nearest city	=household income of nearest city with over 20,000 people	$ (in thousands)	Yes	USCP
Slope	=mean slope of parcel	Degrees	No	GIS; USGS
Elevation	=mean elevation of parcel	Meters	No	GIS; USGS
Parcel size	= area of parcel	Acres	No	GIS; CA
Improvement value	=inflation-adjusted value of parcel improvements	$ (in thousands)	Yes	CA
County	=1 if parcel is located in county c, 0 otherwise; c=Benton, Lane, Marion, and Washington	Binary	No	CA
High-quality soil	=1 if dominant land capability class (LCC) on parcel is 1 or 2, 0 otherwise	Binary	No	GIS; SSURGO
Medium-quality soil	=1 if dominant land capability class (LCC) on parcel is 3 or 4, 0 otherwise	Binary	No	GIS; SSURGO
Irrigation right	=1 if parcel has legally defined right to use water for irrigation, 0 otherwise	Binary	Yes	GIS; OWRD
Irrigation right priority date	=number of years since the water right was first obtained	Years	Yes	GIS; OWRD
Growing season precipitation	=mean historical growing season (April-October) precipitation	Inches	No	GIS; PRISM
Growing season temperature	=mean historical growing season (April-October) minimum temperature	^{0}C	No	GIS; PRISM
PNI	=1 if parcel is under private non-industrial ownership, 0 otherwise	Binary	No	GIS; OSFSL
River presence	=1 if parcel contains a river, 0 otherwise	Binary	No	GIS; EPA
High-quality forest soil	=1 if dominant land capability class (LCC) on parcel is 1, 2, 3, or 4, 0 otherwise	Binary	No	GIS; SSURGO
Distance to nearest mill	=distance to nearest timber processing mill	Miles	Yes	GIS; ODF
Distance to nearest UGB	= Euclidean distance to nearest UGB edge	Miles	Yes	GIS; DLCD

Notes: Acronyms in the Source column represent County assessor's office (CA), Geographic Information Systems (GIS), Soil Survey Geographic Database (SSURGO), Oregon Water Resources Department (OWRD), Parameter-Elevation Regressions on Independent Slopes Model (PRISM), United States Geological Survey (USGS), Department of Land Conservation and Development (DLCD), United States Census of Population (USCP), Oregon State Forestry Science Lab (OSFSL), Environmental Protection Agency (EPA), Oregon Department of Forestry (ODF), and Google Maps (GM).

Table A2: Hedonic model summary statistics

Developed land	Mean	Std. Dev.	Min.	Max.
Land value ($/acre)	260,078	160,750	2,400	1,727,333
Population density	3.65	0.60	2.57	4.66
Household income ($1000)	41.55	6.86	33.03	55.76
Improvement value ($1000)	96.98	112.57	0.00	2,619.54
Parcel acres	0.38	0.74	0.05	15.09
Dist. city center	4.12	4.69	0.06	39.92
Slope	2.35	2.76	0.00	23.23
UGB	0.93	0.26	0	1
Benton County	0.09	0.29	0	1
Lane County	0.22	0.42	0	1
Washington County	0.34	0.47	0	1
Agricultural land	Mean	Std. Dev.	Min.	Max.
Land value ($/acre)	6,276	3,909	67	27,978
Population density	3.57	0.39	2.57	4.66
Household income ($1000)	40.50	6.51	33.03	55.76
Dist. UGB edge	2.19	1.91	0.06	15.74
Irrigation right	0.47	0.50	0	1
Irrigation right priority date	21.97	25.33	0	95
Parcel acres	48.83	53.90	10.04	673.86
LCC 1,2	0.61	0.49	0	1
LCC 3,4	0.36	0.48	0	1
Precipitation	13.06	1.61	10.63	24.09
Minimum temp.	8.51	0.51	7.25	9.49
Slope	2.68	3.06	0.09	17.27
Benton County	0.09	0.28	0	1
Lane County	0.25	0.44	0	1
Washington County	0.42	0.49	0	1
Forest land	Mean	Std. Dev.	Min.	Max.
Land value ($/acre)	3,988	3,656	113	20,689
Population density	3.63	0.27	2.93	3.87
Household income ($1000)	39.26	5.57	33.03	55.76
Dist. UGB edge	5.86	3.91	0.08	26.43
Dist. mill	6.91	3.68	0.67	21.47
Parcel acres	103.18	172.46	10.00	1,881.91
Slope	11.52	5.43	1.65	33.45
Elevation	306.67	157.13	48.31	1,016.84
PNI ownership	0.59	0.49	0	1
River presence	0.13	0.34	0	1
LCC 1,2,3,4	0.38	0.49	0	1
Benton County	0.08	0.28	0	1
Lane County	0.24	0.43	0	1
Washington County	0.53	0.50	0	1

Notes: Listed above are summary statistics for the land parcel samples used to estimate the developed, agricultural, and forest HPV models. The summary statistics included here pertain to the full samples in the year 2000. Summary statistics for other sample years are available upon request.

Table A3: Summary of LCT data

	Agriculture Population	Agriculture Sample		Forest Population	Forest Sample
# of plots starting in ag.	389,218	41,840	# of plots starting in forest	293,164	31,476
Total % of plots developed	3.32	3.32	Total % of plots developed	1.13	1.11
% developed 1973-1980	0.59	0.59	% developed 1973-1980	0.19	0.24
% developed 1980-1986	1.07	1.05	% developed 1980-1986	0.14	0.10
% developed 1986-1992	0.75	0.66	% developed 1986-1992	0.39	0.34
% developed 1992-2000	0.92	1.02	% developed 1992-2000	0.41	0.43

Table A4: Sample selection model results

	1973		1980	
Variable	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
Distance to city center	-0.12	0.012***	-0.14	0.011***
Distance to city center^2	0.003	0.000***	0.004	0.000***
Benton county	0.26	0.106**	0.03	0.094
Lane county	-0.14	0.078*	-0.53	0.073***
Washington county	-0.05	0.08	-0.83	0.089***
Pop. density	0.25	0.078***	0.15	0.064**
HH income	-0.01	0.006**	0.03	0.008***
Irrigation right	-0.54	0.091***	-0.77	0.078***
Slope	-0.04	0.008***	-0.05	0.007***
Constant	0.03	0.371	-0.27	0.378
Number of parcels	3306		3513	

	1986		1992		2000	
Variable	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
Distance to city center	-0.17	0.012***	-0.18	0.012***	-0.33	0.016***
Distance to city center^2	0.004	0.000***	0.005	0.000***	0.01	0.001***
Benton county	-0.09	0.0902	-0.12	0.0871	-0.50	0.116***
Lane county	-0.52	0.069***	-0.47	0.068***	0.25	0.090***
Washington county	-0.83	0.083***	-0.98	0.086***	-1.77	0.167***
Pop. density	0.23	0.053***	0.25	0.047***	0.34	0.075***
HH income	0.02	0.006***	0.03	0.006***	0.08	0.011***
Irrigation right	-0.87	0.074***	-0.98	0.074***	-1.65	0.089***
Slope	-0.06	0.007***	-0.06	0.007***	-0.11	0.008***
Constant	-0.20	0.311	-0.48	0.301	-0.74	0.588
Number of parcels	3587		3653		3709	

Notes: The above results pertain to the status of individual land parcels being included in each year's sample used for estimating the developed land hedonic model. A binary probit model was estimated for each sample year. Parcels were recorded as '1' if they are included in that year's developed land sample, and are otherwise recorded as '0'.

Table A5: First-stage Hausman-Taylor results for developed hedonic model

Variable	**Coefficient**	**Std. Error**
Year1980	0.7792	0.0063***
Year1986	0.5023	0.0072***
Year1992	0.5151	0.0070***
Year2000	0.5328	0.0096***
UGB*Year1980	0.2111	0.0016***
UGB*Year1986	0.1645	0.0018***
UGB*Year1992	0.2180	0.0013***
UGB*Year2000	0.4442	0.0006***
Pop. density	-0.0012	0.0006*
Pop. density^2	0.0002	0.0001*
HH income	-0.0005	0.0001***
HH income^2	0.0000	0.0000***
Improvement value	0.0000	0.0000
Inverse Mill's ratio	-0.0013	0.0002***
Weak identification test (Cragg-Donald Wald F-statistic)	3,171	

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. The above results were generated with the *xtoverid* post-estimation command in Stata for the *xthtaylor* (Hausman-Taylor) estimator. The variables listed above represent the means of the time-varying variables included the developed hedonic specification, and constitute the instruments that are excluded from the final set of Hausman-Taylor estimates.

Appendix B. Water use measurement

To establish a link between land development patterns and urban household water use, we construct an aggregate residential water demand function by calibrating recently reported empirical findings in the water resource economics literature to our study area.[1] Previous studies suggest that urban water demand is driven by the marginal price of water, pricing structure (uniform, increasing block rate, etc.), and income, with weather and seasonal variation also playing a significant role (Olmstead et al. 2007; Olmstead 2009; Olmstead 2010; Bell and Griffin 2011; Mansur and Olmstead 2012). Additionally, aggregate water demand should depend on the size of the city, through both the number of residents (population) and land area (population density) (Gaudin 2006). Table B1 lists the elasticity parameters used for calibration and the studies from which they were derived. The resulting residential water demand function is thus specified as:

$$ln(\bar{Q}^d(t)) = -(2.93 + 0.611^* IBR) - 0.6^* P^w(t) + \cdots$$

$$\ldots + ln(P(t)) + (0.13 + 0.05^* IBR)^* I(t) - 0.048^* D(t), \qquad \text{[B1]}$$

where $\bar{Q}^d(t)$ represents mean daily residential water use for the entire city in year t and IBR is an binary variable indicating whether the municipality uses an increasing block rate pricing structure. The variables $P(t)$, $I(t)$, and $D(t)$ denote, respectively, the population level, mean income level, and population density of the city in year t. The price of water, $P^w(t)$, is measured in dollars per ccf (hundred cubic feet). We assume that prices change over time at the same rate as average cost. Using data from EPA (2009), average cost is specified as:

[1] In reality, total urban water demand would also depend on non-residential water users, such as those in the industrial and commercial sectors. However, in our simulation framework (described in Section IV) we assume that land development is undertaken for the purpose of residential housing construction. This assumption is necessary, as our developed land hedonic model is based on residential and multi-family land value observations. As such, accommodating industrial and commercial water demand would only affect our baseline demand calculation, not any changes that occur over the course of the simulation.

$$AC(t) = 0.748^{*}e^{(11.2-0.885^{*}\,ln(P(t))+0.091^{*}\,ln(P(t))^{2}-0.003^{*}\,ln(P(t))^{3})}. \quad [B2]$$

Water prices, therefore, change in response to population growth. Since population growth is exogenous in our closed-city modeling framework, prices are also determined exogenously.

To incorporate seasonal effects into urban water use, we first scale daily demand, $\bar{Q}^{d}(t)$, up to total annual water demand. We then break down the total annual demand into the demand for indoor and outdoor uses using the following:

$$Q^{d}(t) = Q^{O}(t) + Q^{I}(t) = (\alpha^{*}Q^{d}(t) + (1-\alpha)^{*}Q^{d}(t)), \quad [B3]$$

where $Q^{d}(t)$ represents total residential water demand in year t, $Q^{O}(t)$ denotes total residential water demand for outdoor uses in year t, $Q^{I}(t)$ denotes total residential water demand for indoor uses in year t, and α represents the share of total annual demand devoted to outdoor water uses. We approximate α using a time-series of OWRD monthly water use data for Salem, OR, one of the cities featured in our landscape simulations.[2]

Figure B1 plots average monthly water use (in acre-feet) in Salem for water delivered by the Salem Public Works Department. Also plotted in Figure B1 is a horizontal line representing mean water use during the "wet season", which includes January, February, March, April, November, and December. The area between the monthly water use curve and the wet season average as represents the total amount of water used outdoors, as previous research has confirmed that indoor use varies minimally across seasons (Mansur and Olmstead 2012). For

[2] Similar data were not available for the other two simulation cities, Eugene and Woodburn. However, since dry-season precipitation patterns are nearly identical in all three cities, it seems reasonable to assume that the share of annual water use that is used outdoors is the same in the three cities.

Salem, our estimate of α is 0.17, which we augment to incorporate the effects of decreased precipitation on outdoor water use in our simulations.[3]

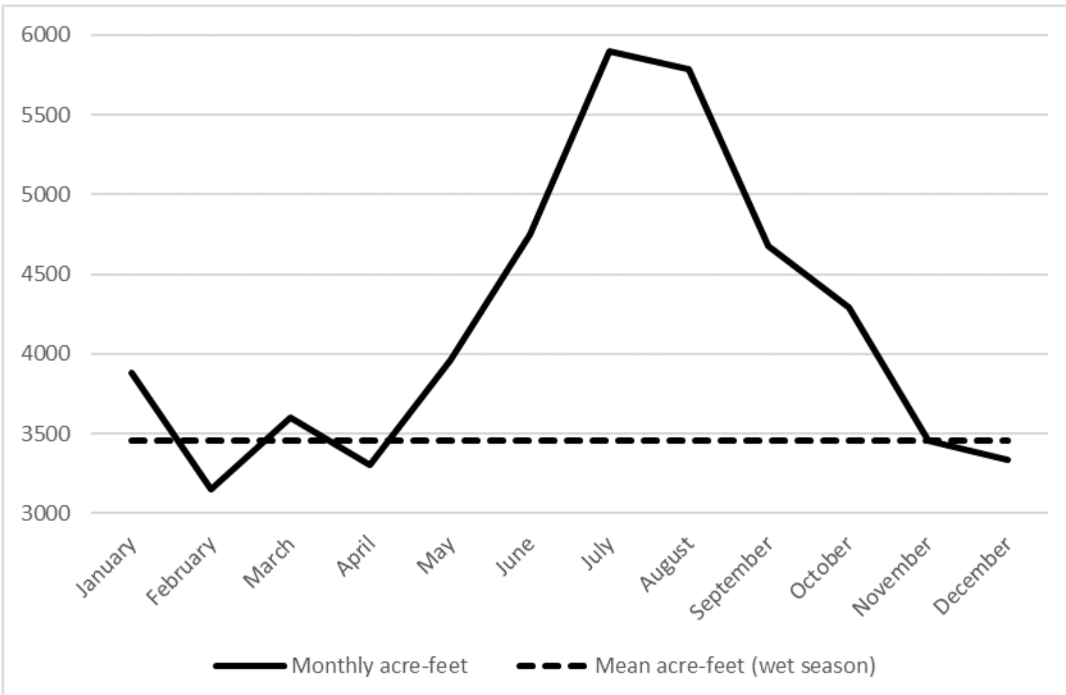

Figure B1. Salem Public Works Average Monthly Water Use, 1994–2013

We estimate water withdrawals by agricultural users using GIS data on water rights from OWRD. In the Willamette Valley, agricultural irrigators are allowed to withdraw a maximum volume (or "duty") of 2.5 acre-feet per acre of irrigated land (Cooper 2002). We assume that water rights are always honored and exercised. These assumptions may not hold if farmers either have their water rights shut off or use an amount of water that is less than what is allowable under their water right. However, the results of our analysis are focused on comparing how total

[3] Note that we are implicitly assuming uniform per-unit land area water use across all outdoor users serviced by the Salem Public Works Department, which includes commercial and industrial users in addition to the residential users that are the focus of our analysis.

water use changes given different rules regarding UGB expansion and changes to precipitation. As such, our results will only be influenced by the assumption that water rights are exercised in full if there is a systematic difference in how irrigation water is used, conditional on a water right being in place, in outlying areas relative to areas that are closer to an urban center, a difference for which we have no a priori rationale to believe exists.

Table B1: Coefficient estimates used to calibrate the urban water demand model

Variable	Description	Coefficient	Source
Price	Long-term price elasticity of demand	-0.6	Olmstead 2010
Income (flat rate)	Income elasticity for flat rate pricing	0.13	Olmstead et al. 2007
Income (block rate)	Income elasticity for increasing block rate pricing	0.18	Olmstead et al. 2007
Population	Demand elasticity for total population	1.0	Portland Water Bureau 2010
Density	Demand elasticity for population density	-0.048	Gaudin 2006

Notes: Coefficient estimates represent the effect of each variable on per-capita residential water demand.

Appendix C. Full set of simulation results

Table C1: UGB scenario simulation results for Salem

	Year			
Variable	**2010**	**2030**	**2050**	**2070**
Total population (number of persons)	189,817	246,746	304,484	364,199
Average real household income ($1000)	43.8	55.2	75.3	95.0
Urban water price ($/ccf)	2.02	1.99	1.96	1.93
	60% UGB expansion threshold (high sprawl)			
Area of UGB (acres)	65,579	69,730	79,327	91,257
Area of private developed land inside UGB (acres)	36,929	39,296	44,780	51,524
Area of private forest land (acres)	20,892	20,889	20,884	20,875
Area of private agricultural land (acres)	165,751	163,905	159,570	154,027
Area of private irrigated agricultural land (acres)	66,561	65,474	64,054	62,680
Population density (thousands of people per square mile)	3.42	4.15	4.71	4.82
Water withdrawals for agricultural irrigation (af/yr)	165,157	162,440	158,889	155,455
Water withdrawals for urban residential consumers (af/yr)	15,084	20,242	26,092	32,399
Total water withdrawals (af/yr)	180,241	182,682	184,981	187,854
Std. dev. of total water withdrawals (af/yr)	96	132	171	212
	70% UGB expansion threshold (moderate sprawl)			
Area of UGB (acres)	52,486	55,647	62,678	70,031
Area of private developed land inside UGB (acres)	34,985	36,730	41,145	46,042
Area of private forest land (acres)	20,893	20,891	20,887	20,880
Area of private agricultural land (acres)	166,034	164,615	161,105	157,216
Area of private irrigated agricultural land (acres)	66,794	66,028	65,065	64,158
Population density (thousands of people per square mile)	3.56	4.41	5.07	5.32
Water withdrawals for agricultural irrigation (af/yr)	165,739	163,825	161,417	159,150
Water withdrawals for urban residential consumers (af/yr)	15,054	20,183	26,000	32,247
Total water withdrawals (af/yr)	180,793	184,009	187,417	191,396
Std. dev. of total water withdrawals (af/yr)	83	97	95	126
	80% UGB expansion threshold (compact development)			
Area of UGB (acres)	43,977	46,330	51,013	55,642
Area of private developed land inside UGB (acres)	33,440	35,246	38,940	41,970
Area of private forest land (acres)	20,896	20,894	20,891	20,886
Area of private agricultural land (acres)	166,095	164,828	161,918	159,379
Area of private irrigated agricultural land (acres)	66,820	66,125	65,446	65,046
Population density (thousands of people per square mile)	3.72	4.59	5.31	5.74
Water withdrawals for agricultural irrigation (af/yr)	165,805	164,067	162,368	161,370
Water withdrawals for urban residential consumers (af/yr)	15,022	20,145	25,943	32,130
Total water withdrawals (af/yr)	180,826	184,212	188,311	193,500
Std. dev. of total water withdrawals (af/yr)	81	90	62	66

Notes: Unless otherwise noted, the values the above represent the mean value derived by averaging across 100 model simulations. To conserve space, results are only shown for every other simulation decade. The complete set of simulation results are available upon request.

Table C2: UGB scenario simulation results for Woodburn

	Year			
Variable	**2010**	**2030**	**2050**	**2070**
Total population (number of persons)	21,634	27,846	34,148	40,688
Average real household income ($1000)	37.1	47.2	64.7	81.7
Urban water price ($/ccf)	3.26	3.22	3.18	3.15
	60% UGB expansion threshold (high sprawl)			
Area of UGB (acres)	7,038	7,648	9,064	11,151
Area of private developed land inside UGB (acres)	4,176	4,535	5,353	6,529
Area of private forest land (acres)	6,619	6,619	6,618	6,617
Area of private agricultural land (acres)	192,612	192,361	191,728	190,774
Area of private irrigated agricultural land (acres)	136,032	135,842	135,493	135,011
Population density (thousands of people per square mile)	3.50	4.09	4.51	4.39
Water withdrawals for agricultural irrigation (af/yr)	338,149	337,674	336,803	335,599
Water withdrawals for urban residential consumers (af/yr)	1,506	2,002	2,563	3,170
Total water withdrawals (af/yr)	339,655	339,676	339,365	338,769
Std. dev. of total water withdrawals (af/yr)	43	59	77	80
	70% UGB expansion threshold (moderate sprawl)			
Area of UGB (acres)	5,452	5,928	7,096	8,427
Area of private developed land inside UGB (acres)	3,788	4,114	4,911	5,821
Area of private forest land (acres)	6,619	6,619	6,619	6,618
Area of private agricultural land (acres)	192,647	192,431	191,889	191,180
Area of private irrigated agricultural land (acres)	136,063	135,902	135,604	135,237
Population density (thousands of people per square mile)	3.82	4.51	4.98	4.84
Water withdrawals for agricultural irrigation (af/yr)	338,227	337,824	337,079	336,162
Water withdrawals for urban residential consumers (af/yr)	1,499	1,992	2,551	3,155
Total water withdrawals (af/yr)	339,727	339,817	339,630	339,317
Std. dev. of total water withdrawals (af/yr)	35	60	67	73
	80% UGB expansion threshold (compact development)			
Area of UGB (acres)	4,313	4,758	5,623	6,398
Area of private developed land inside UGB (acres)	3,439	3,780	4,463	5,071
Area of private forest land (acres)	6,619	6,619	6,619	6,618
Area of private agricultural land (acres)	192,672	192,477	192,018	191,566
Area of private irrigated agricultural land (acres)	136,085	135,944	135,704	135,453
Population density (thousands of people per square mile)	4.26	4.95	5.40	5.45
Water withdrawals for agricultural irrigation (af/yr)	338,283	337,931	337,330	336,702
Water withdrawals for urban residential consumers (af/yr)	1,492	1,983	2,541	3,137
Total water withdrawals (af/yr)	339,775	339,915	339,871	339,839
Std. dev. of total water withdrawals (af/yr)	30	45	46	56

Notes: Unless otherwise noted, the values the above represent the mean value derived by averaging across 100 model simulations. To conserve space, results are only shown for every other simulation decade. The complete set of simulation results are available upon request.

Table C3: UGB scenario simulation results for Eugene

	Year			
Variable	**2010**	**2030**	**2050**	**2070**
Total population (number of persons)	209,050	243,635	276,056	302,949
Average real household income ($1000)	36.8	46.4	63.4	80.0
Urban water price ($/ccf)	1.24	1.23	1.22	1.21
	60% UGB expansion threshold (high sprawl)			
Area of UGB (acres)	74,515	75,261	76,720	79,916
Area of private developed land inside UGB (acres)	40,470	40,868	41,650	43,407
Area of private forest land (acres)	63,721	63,699	63,663	63,600
Area of private agricultural land (acres)	121,256	120,940	120,297	118,842
Area of private irrigated agricultural land (acres)	26,557	26,395	26,200	25,961
Population density (thousands of people per square mile)	3.34	3.85	4.31	4.59
Water withdrawals for agricultural irrigation (af/yr)	65,738	65,333	64,847	64,248
Water withdrawals for urban residential consumers (af/yr)	20,009	24,304	29,132	33,375
Total water withdrawals (af/yr)	85,747	89,637	93,979	97,623
Std. dev. of total water withdrawals (af/yr)	40	63	83	99
	70% UGB expansion threshold (moderate sprawl)			
Area of UGB (acres)	61,756	62,598	63,911	66,353
Area of private developed land inside UGB (acres)	39,217	39,587	40,365	41,904
Area of private forest land (acres)	63,723	63,706	63,677	63,623
Area of private agricultural land (acres)	121,322	121,109	120,588	119,315
Area of private irrigated agricultural land (acres)	26,610	26,524	26,400	26,223
Population density (thousands of people per square mile)	3.44	3.97	4.45	4.74
Water withdrawals for agricultural irrigation (af/yr)	65,871	65,656	65,347	64,903
Water withdrawals for urban residential consumers (af/yr)	19,981	24,269	29,090	33,324
Total water withdrawals (af/yr)	85,852	89,925	94,436	98,228
Std. dev. of total water withdrawals (af/yr)	28	49	57	72
	80% UGB expansion threshold (compact development)			
Area of UGB (acres)	48,779	48,779	49,010	52,355
Area of private developed land inside UGB (acres)	37,136	37,312	37,878	39,694
Area of private forest land (acres)	63,725	63,711	63,685	63,637
Area of private agricultural land (acres)	121,355	121,192	120,750	119,592
Area of private irrigated agricultural land (acres)	26,629	26,567	26,475	26,336
Population density (thousands of people per square mile)	3.61	4.19	4.72	5.01
Water withdrawals for agricultural irrigation (af/yr)	65,919	65,765	65,533	65,186
Water withdrawals for urban residential consumers (af/yr)	19,933	24,207	29,008	33,236
Total water withdrawals (af/yr)	85,852	89,971	94,541	98,422
Std. dev. of total water withdrawals (af/yr)	21	37	42	52

Notes: Unless otherwise noted, the values the above represent the mean value derived by averaging across 100 model simulations. To conserve space, results are only shown for every other simulation decade. The complete set of simulation results are available upon request.

Table C4: Precipitation scenario simulation results for Salem

	Year			
Variable	**2010**	**2030**	**2050**	**2070**
Total population (number of persons)	189,817	246,746	304,484	364,199
Average real household income ($1000)	43.8	55.2	75.3	95.0
Urban water price ($/ccf)	2.02	1.99	1.96	1.93
	2-inch precipitation reduction			
Area of UGB (acres)	52,585	55,977	63,328	71,092
Area of private developed land inside UGB (acres)	35,046	36,924	41,577	46,757
Area of private forest land (acres)	20,893	20,891	20,887	20,880
Area of private agricultural land (acres)	165,986	164,456	160,770	156,615
Area of private irrigated agricultural land (acres)	66,758	65,919	64,851	63,746
Population density (thousands of people per square mile)	3.56	4.39	5.03	5.25
Water withdrawals for agricultural irrigation (af/yr)	165,650	163,552	160,882	158,120
Water withdrawals for urban residential consumers (af/yr)	15,451	20,719	26,697	33,117
Water withdrawals for urban residential consumers - no substitution (af/yr)	15,054	20,187	26,011	32,266
Total water withdrawals (af/yr)	181,101	184,271	187,580	191,237
Total water withdrawals - no substitution (af/yr)	180,703	183,738	186,893	190,386
Std. dev. of total water withdrawals (af/yr)	84	102	98	145
	6-inch precipitation reduction			
Area of UGB (acres)	52,807	56,789	64,926	74,333
Area of private developed land inside UGB (acres)	35,184	37,419	42,646	48,928
Area of private forest land (acres)	20,893	20,891	20,886	20,880
Area of private agricultural land (acres)	165,876	164,069	159,941	154,834
Area of private irrigated agricultural land (acres)	66,680	65,663	64,315	62,499
Population density (thousands of people per square mile)	3.56	4.36	4.93	5.08
Water withdrawals for agricultural irrigation (af/yr)	165,455	162,913	159,543	155,003
Water withdrawals for urban residential consumers (af/yr)	16,245	21,793	28,095	34,875
Water withdrawals for urban residential consumers - no substitution (af/yr)	15,054	20,195	26,035	32,318
Total water withdrawals (af/yr)	181,700	184,706	187,638	189,878
Total water withdrawals - no substitution (af/yr)	180,509	183,108	185,578	187,321
Std. dev. of total water withdrawals (af/yr)	79	95	112	164

Notes: Unless otherwise noted, the values the above represent the mean value derived by averaging across 100 model simulations. To conserve space, results are only shown for every other simulation decade. The complete set of simulation results are available upon request.

Table C5: Precipitation scenario simulation results for Woodburn

	Year			
Variable	**2010**	**2030**	**2050**	**2070**
Total population (number of persons)	21,634	27,846	34,148	40,688
Average real household income ($1000)	37.1	47.2	64.7	81.7
Urban water price ($/ccf)	3.26	3.22	3.18	3.15
	2-inch precipitation reduction			
Area of UGB (acres)	5,470	5,980	7,271	8,759
Area of private developed land inside UGB (acres)	3,800	4,151	5,031	6,039
Area of private forest land (acres)	6,619	6,619	6,619	6,618
Area of private agricultural land (acres)	192,639	192,399	191,804	190,999
Area of private irrigated agricultural land (acres)	136,056	135,874	135,530	135,089
Population density (thousands of people per square mile)	3.82	4.48	4.89	4.70
Water withdrawals for agricultural irrigation (af/yr)	338,211	337,756	336,896	335,792
Water withdrawals for urban residential consumers (af/yr)	1,289	1,713	2,195	2,716
Water withdrawals for urban residential consumers - no substitution (af/yr)	1,256	1,670	2,139	2,648
Total water withdrawals (af/yr)	339,501	339,469	339,090	338,509
Total water withdrawals - no substitution (af/yr)	339,468	339,426	339,035	338,440
Std. dev. of total water withdrawals (af/yr)	37	62	69	88
	6-inch precipitation reduction			
Area of UGB (acres)	5,516	6,156	7,694	9,758
Area of private developed land inside UGB (acres)	3,831	4,271	5,323	6,699
Area of private forest land (acres)	6,619	6,619	6,619	6,618
Area of private agricultural land (acres)	192,620	192,312	191,581	190,452
Area of private irrigated agricultural land (acres)	136,040	135,799	135,336	134,632
Population density (thousands of people per square mile)	3.82	4.39	4.66	4.37
Water withdrawals for agricultural irrigation (af/yr)	338,170	337,569	336,409	334,651
Water withdrawals for urban residential consumers (af/yr)	1,354	1,802	2,311	2,864
Water withdrawals for urban residential consumers - no substitution (af/yr)	1,256	1,671	2,144	2,657
Total water withdrawals (af/yr)	339,524	339,371	338,720	337,515
Total water withdrawals - no substitution (af/yr)	339,426	339,240	338,553	337,308
Std. dev. of total water withdrawals (af/yr)	38	64	77	115

Notes: Unless otherwise noted, the values the above represent the mean value derived by averaging across 100 model simulations. To conserve space, results are only shown for every other simulation decade. The complete set of simulation results are available upon request.

Table C6: Precipitation scenario simulation results for Eugene

	Year			
Variable	**2010**	**2030**	**2050**	**2070**
Total population (number of persons)	209,050	243,635	276,056	302,949
Average real household income ($1000)	36.8	46.4	63.4	80.0
Urban water price ($/ccf)	1.24	1.23	1.22	1.21
	2-inch precipitation reduction			
Area of UGB (acres)	61,774	62,692	64,070	66,641
Area of private developed land inside UGB (acres)	39,228	39,632	40,464	42,087
Area of private forest land (acres)	63,723	63,706	63,677	63,623
Area of private agricultural land (acres)	121,315	121,082	120,514	119,151
Area of private irrigated agricultural land (acres)	26,606	26,508	26,358	26,133
Population density (thousands of people per square mile)	3.44	3.97	4.44	4.73
Water withdrawals for agricultural irrigation (af/yr)	65,861	65,616	65,243	64,678
Water withdrawals for urban residential consumers (af/yr)	20,500	24,900	29,848	34,196
Water withdrawals for urban residential consumers - no substitution (af/yr)	19,981	24,267	29,087	33,322
Total water withdrawals (af/yr)	86,362	90,516	95,091	98,874
Total water withdrawals - no substitution (af/yr)	85,779	89,748	94,213	97,814
Std. dev. of total water withdrawals (af/yr)	28	53	63	77
	6-inch precipitation reduction			
Area of UGB (acres)	61,819	62,921	64,507	67,536
Area of private developed land inside UGB (acres)	39,256	39,753	40,740	42,686
Area of private forest land (acres)	63,723	63,706	63,677	63,623
Area of private agricultural land (acres)	121,296	121,007	120,292	118,669
Area of private irrigated agricultural land (acres)	26,596	26,462	26,223	25,835
Population density (thousands of people per square mile)	3.44	3.96	4.42	4.68
Water withdrawals for agricultural irrigation (af/yr)	65,835	65,501	64,904	63,935
Water withdrawals for urban residential consumers (af/yr)	21,539	26,164	31,367	35,945
Water withdrawals for urban residential consumers - no substitution (af/yr)	19,981	24,272	29,097	33,345
Total water withdrawals (af/yr)	87,374	91,665	96,270	99,880
Total water withdrawals - no substitution (af/yr)	85,816	89,773	94,001	97,280
Std. dev. of total water withdrawals (af/yr)	28	57	77	95

Notes: Unless otherwise noted, the values the above represent the mean value derived by averaging across 100 model simulations. To conserve space, results are only shown for every other simulation decade. The complete set of simulation results are available upon request.

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