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Compliance by the Numbers:

Assessing the Effectiveness of Water Waste Enforcement Activities Using a Data-Driven Approach

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Austin
WATER

CITY OF AUSTIN · FOUNDED 1839

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City of Austin, Texas

- Serves a population of 1.1M
  - Projected to quadruple in next 100 years
  - 584 square mile service area

- Draws water from the Colorado River into three regional water treatment plants (combined capacity of 335 MGD)

- Located in Central Texas between the deserts of the SW and the more humid SE
  - Long, hot summers – short, mild winters
  - Annual average of 34" of rain, wettest during spring and fall
 - Region prone to cycles of drought and flooding

History of Water Ordinances

- The City of Austin has a long history of managing water demand through ordinances

- 1983 – Watering restrictions imposed due to treatment system constraints

- 2001 – City adopted an ordinance making water waste a misdemeanor (maximum $500 fine) through poorly designed irrigation systems or failure to repair leaks
  - Austin Water added staff to make regular patrols and field inspections to enforce ordinances

- 2008 – Central Texas entered a historic drought which triggered twice-a-week watering restrictions in May and once-a-week restrictions in May of 2009

- 2012 – Water use ordinance updated to allow for Administrative Fines

- 2016 – To prepare for future droughts, City Council approved permanent once-a-week watering restrictions for automatic sprinkler systems

Other Water Ordinances

- Car washes
  - Equipment and facility certification requirements (2008)

- Cooling towers
  - New and replacement towers must achieve at least five cycles of concentration and have conductivity controllers, makeup and blowdown meters, overflow alarms, and drift eliminators (2008)
  - Registration and inspection of all towers using potable water, and require new towers over 100 tons use reclaimed or onsite alternative sources such as AC condensate (2017)

- Irrigation and landscape requirements for new construction
  - Automatic irrigation system and landscape (e.g., soil depth, plant types) design standards
  - 2008 for commercial and multi-family residential, in the works for single-family residential

- Mandatory reclaimed hookup
  - New multi-family residential and commercial facilities within 250 ft of reclaimed line (2013)

- Facility irrigation assessments
  - Commercial & multi-family parcels an acre or larger must pass assessment by licensed irrigator every two years (2013)

Historical GPCD
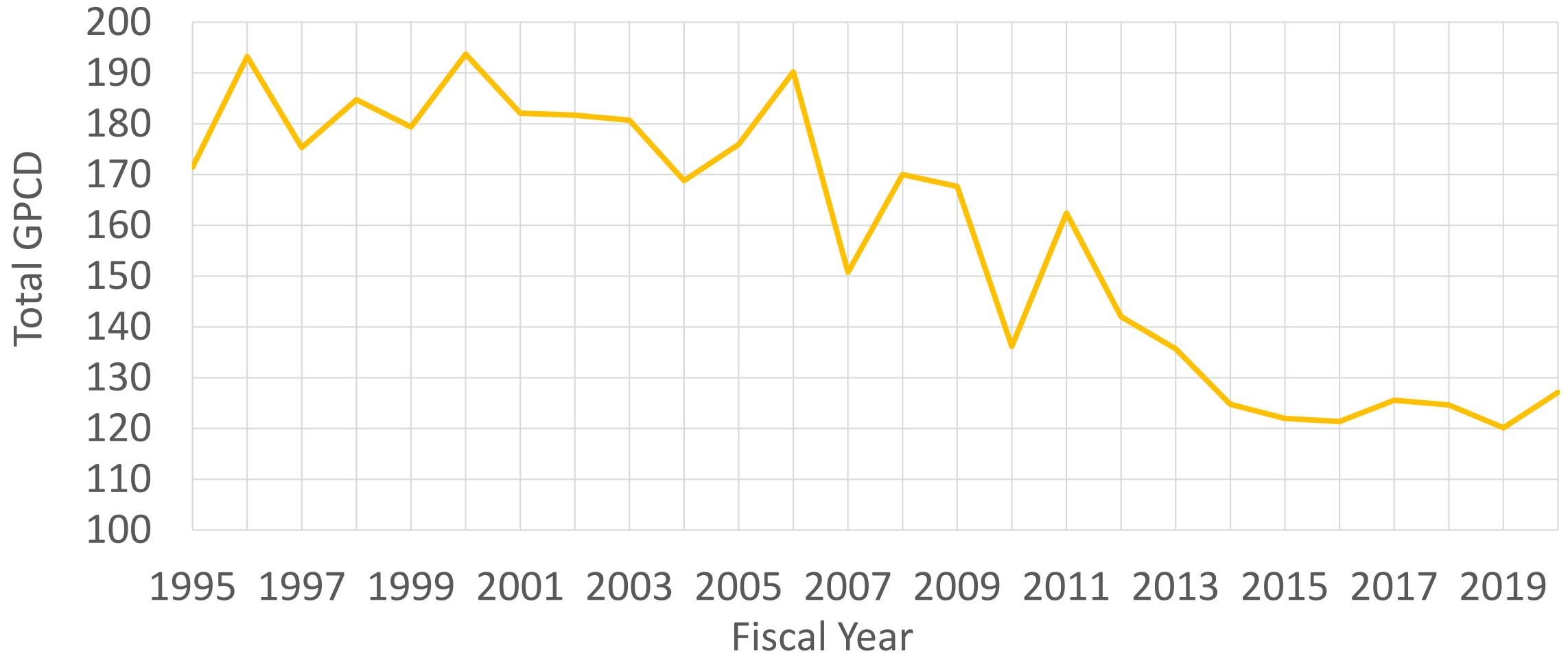
Weather-Normalized GPCD
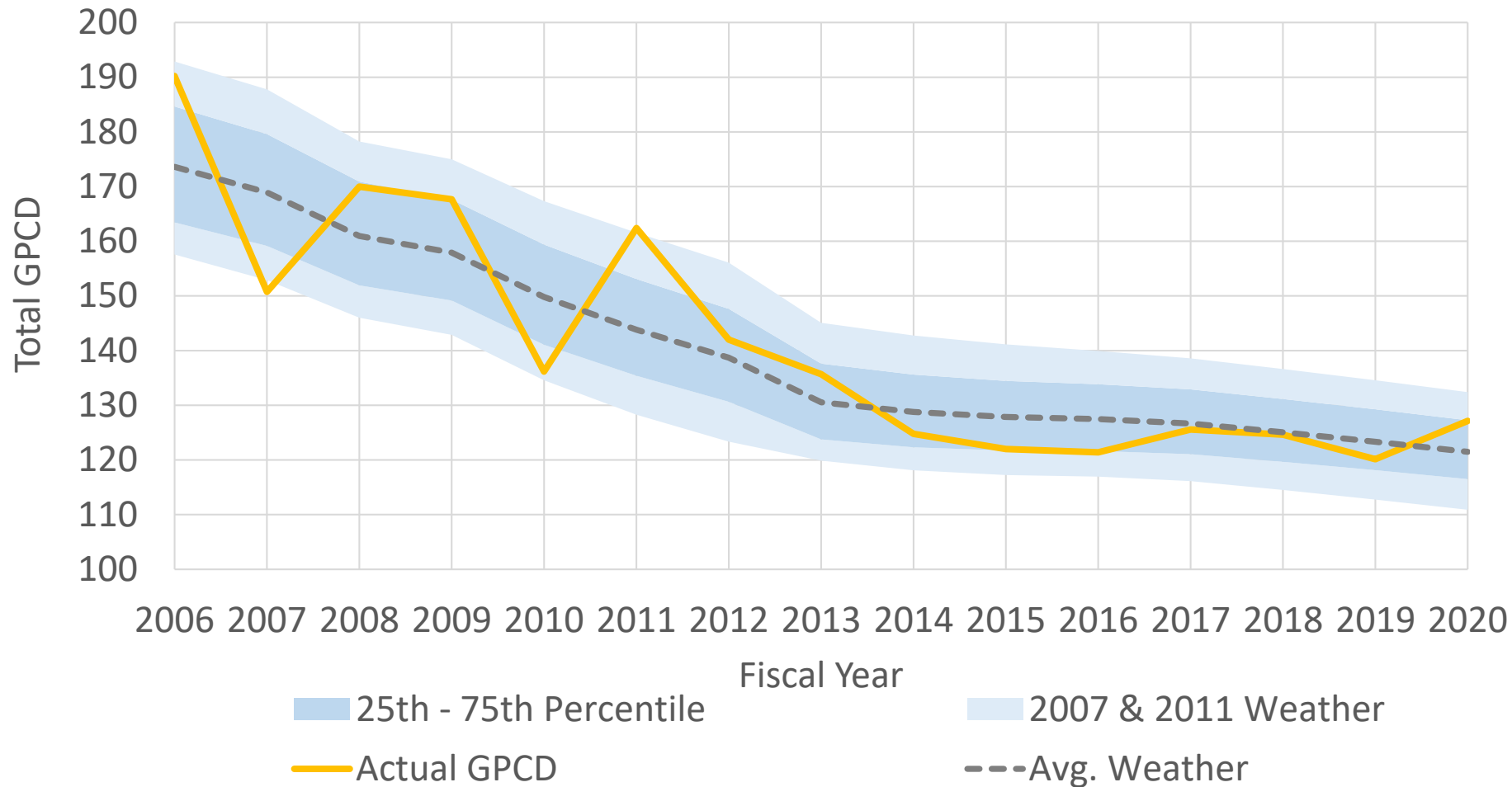
- Actual 2011 GPCD = 162

- Modeled 2020 GPCD using 2011 weather = 132

- Corresponds to 18% reduction in total water demand

- At the customer level, ~25% increased usage during this time

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AWE 2020 Study Results (for Austin)

- "Use and Effectiveness of Municipal Irrigation Restrictions During Drought."
  - Maddaus Water Management, Inc. & Western Policy Research

- Across all utilities studied reduced annual demand by 18-30% and peak monthly by 20-42%

- **To be effective, irrigation restrictions need codified rulemaking to include provisions that are enforceable on non-compliant customers**

Season and Intensity of Restrictions	Demand Reduction
2 days/week, Mandatory	
Winter (December-February)	10%
Spring/Fall (March-May, October, November)	10%
Summer (June-September)	11%
1 day/week, Mandatory	
Winter	15%
Spring/Fall	14%
Summer	21%
1 day/week-Automatic, 2 days/week-Hose, Mandatory	
Winter	12%
Spring/Fall	16%
Summer	22%

Watering and Water Waste Enforcement

- Water waste patrol conducted by Austin Water staff
  - Proactive and reactive patrols, frequency increases with drought stage
  - Violations documented with photograph and GIS
- Watering restrictions
  - Day and time restrictions change depending on drought stage
- Water waste
  - Broken head, leak, misalignment, misting, ponding, runoff, fountain, car wash

- Enforcement notifications
  - Report of violation: citizen-generated water waste via 311; report address sent reminder notice of current restrictions
  - Official warnings: issued to account holder in violation observed by staff
  - Administrative fees: issued after multiple warnings; account holder can dispute fines; fines assessed on customer's bill; fine amount increases with occurrences and drought stage
  - Citations: issued for sixth violation; class C misdemeanor charges filed in municipal court; largely replaced by administrative fee process in 2013
  - Annual avg. over past eight years: 838 official warnings; 86 administrative fees; 5 citations

Drought Stages & Other Response Triggers

- **Conservation Stage – Above 1.4 million AF**
  - Residential: One day per week with automatic irrigation or two days per week with hose-end. No irrigation between 10am and 7pm.
  - Commercial: One day per week, automatic and hose-end. No irrigation between 10am and 7pm.

- **Stage 1 – Below 1.4 million AF**
  - All: One day per week; Automatic: No irrigation between 8am and 7pm; Hose-end: No irrigation between 10am and 7pm

- **Stage 2 – Below 900,000 AF**
  - All: One day per week; Automatic: No irrigation between 5am and 7pm; Hose-end: No irrigation between 10am and 7pm

- **Stage 3 – Below 600,000 AF**
  - All: One day per week; Automatic: No irrigation after 6am; Hose-end: No irrigation before 7am and after 10am or before 7pm and after 7pm
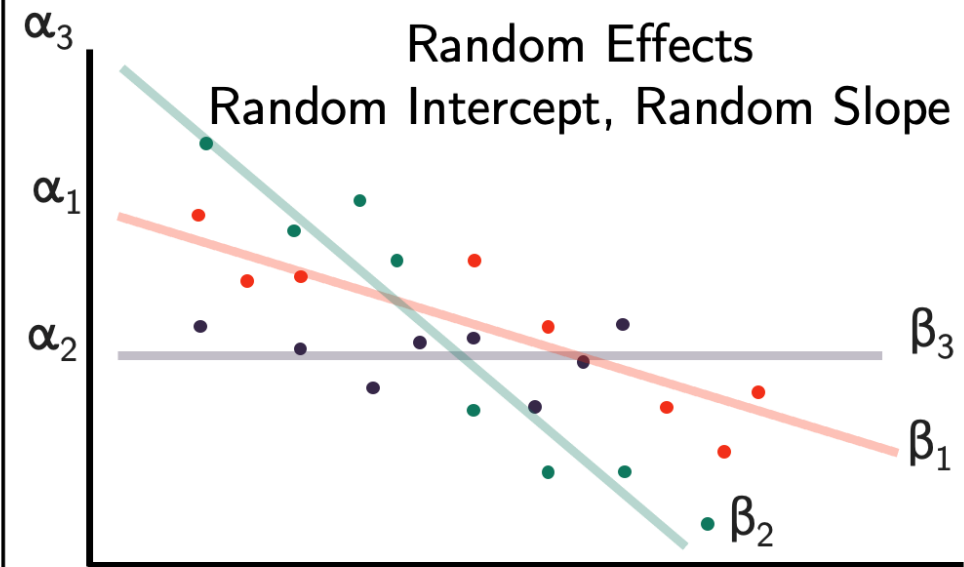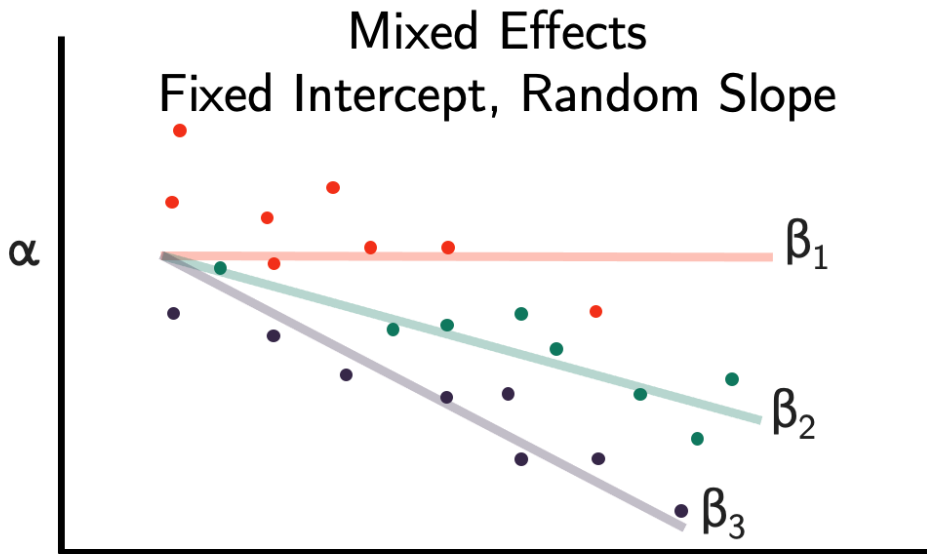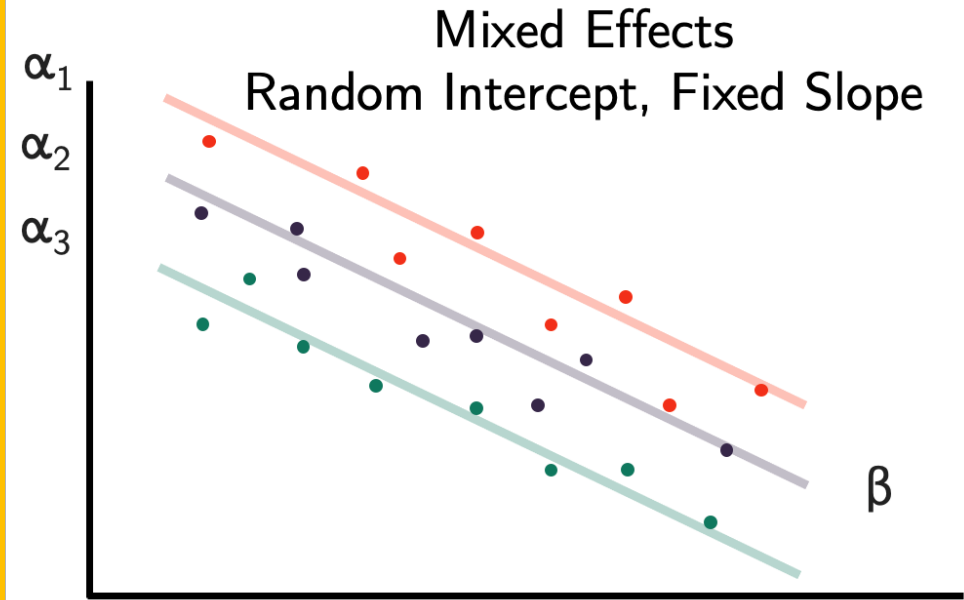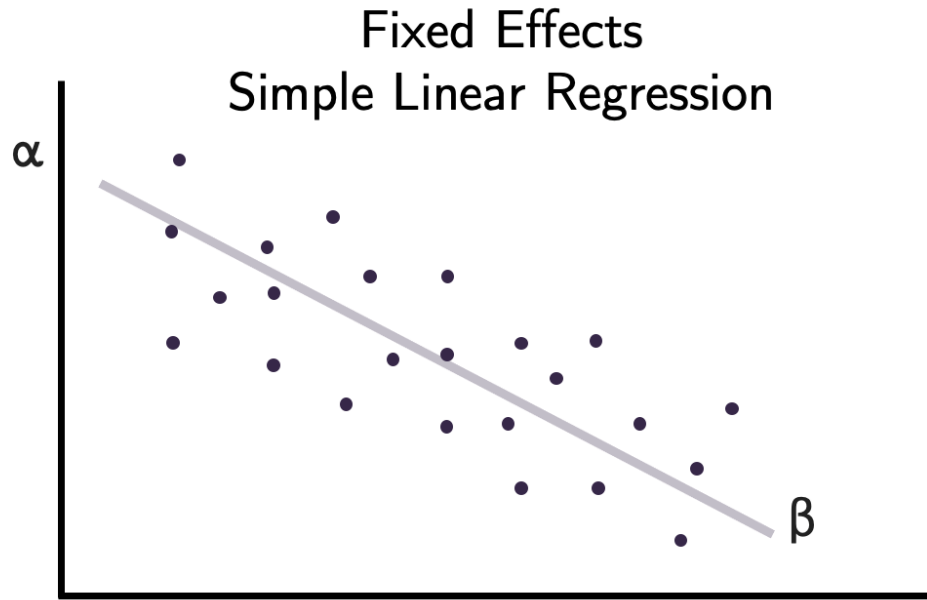
- **Emergency**
  - Outdoor water use prohibited

- **Demand**
  - 300 MGD for three consecutive days; 320 MGD for one day

Water Waste Enforcement: Analysis Plan

- **Analysis goal**: Determine statistically significant water demand impact of issuing water waste warnings by type

- Used monthly water billing at the parcel from 2013-2020 (n = 96 months)
  - 2013 is first year where once-per-week watering restrictions fully baked in
  - Warning activity from 2014-2019 to allow for at least one year of usage pre/post warning
  - Only included parcel monthly usage where the customer was the same (isolate agent)

- Employed fixed-effects panel regression to quantify water demand impacts
  - Focused solely on single-family residential (SFR) & properties which only got issued a singular warning (largest sample size & simplify analysis)
  - "Warning Binary" variable (0/1) to denote pre/post warning for each month
  - "Days Before Warning" & "Days After Warning" variables to account for time-variant change in usage leading up to and after warning
  - Included variables to assess water demand impacts due to weather (avg. vs. peak)

Fixed Effects
Simple Linear Regression

Mixed Effects
Random Intercept, Fixed Slope

Mixed Effects
Fixed Intercept, Random Slope

Random Effects
Random Intercept, Random Slope

Midway, S. (2021) "Data Analysis in R" https://bookdown.org/steve_midway/DAR/

Water Waste Enforcement: Panel Regression Results

Water Waste Warning	Parcels	Obs.	Month Value	ETc; [Precip]	COVID; [COVID Days]	Warning Binary	Days Before Warning; [log]	Days After Warning [log]	Month Value * ETc	Binary * ETc	Days Before * ETc	Days After * ETc	Days After * log(Days After [*Etc]
Wrong Day	1,766	85,863	5.89E-03	2.98E+04 [-3.80E+01]	3.90E+01	4.67E+01	[-3.20E+01]	[-4.49E+01]	-5.40E-01	-3.37E+03	[-5.89E+02]	[6.53E+02]	
Runoff	478	24,703	-9.21E-02	-3.55E+04	3.84E+01		-7.25E-02	[3.29E+01]	9.85E-01		5.78E-01	[-5.95E+02]	
Wrong Time	292	14,765	-1.42E-01	-3.76E+04	5.69E+01	4.53E+02	[-1.36E+02]	2.69E+00 [-4.02E+02]	9.93E-01	-6.28E+03	[7.93E+02]	-2.76E+01 [4.06E+03]	-6.84E-01 [7.10E+00]
Misalign	178	9,168		5.91E+03	[1.92E-01]			[6.33E+00]				[-2.22E+02]	
Leak	36	1,703	-2.25E-02	-4.37E+04	2.73E+01	-1.49E+03	[-3.78E+02]	[1.84E+02]	8.16E-01	1.74E+04	[4.29E+03]	[-2.66E+03]	
All	**2,163**	**106,866**	**-1.78E-03**	**2.62E+04 [-3.25E+01]**	**3.88E+01**	**-1.95E+01**	**[-3.96E+01]**	**[-2.53E+01]**	**-4.66E-01**	**-2.56E+03**	**[-4.49E+02]**	**[4.73E+02]**	

- Only included explanatory variables with a p-value < 0.10
- No intercept, given fixed-effects panel regressiomodel
- *Denote interaction variable; Bracketted values denote additonal coefficients (condensed formatting)
- K_c coefficients adjust ETo to ETc by incorporating sector-specific seasonality effects

SFR	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
ETo (in/d)	0.08	0.10	0.14	0.17	0.20	0.22	0.23	0.22	0.17	0.13	0.09	0.07
Kc	0.66	0.51	0.41	0.38	0.36	0.38	0.43	0.48	0.53	0.57	0.70	0.78

Water Waste Enforcement: Analysis Results

Water Waste Warning	Parcels	Obs.	Initial Impact		Impact Over Two Years	
			Avg. Weather (GPD)	Aug. Weather (GPD)	Avg. Weather (GPD)	Aug. Weather (GPD)
Wrong Day	1,766	85,863	-110	-172	-108	-149
Runoff	478	24,703	-14	-44	-24	-73
Wrong Time	292	14,765	-32	-97	-64	-89
Misalignment	178	9,168	-14	-25	-24	-42
Leak	36	1,703	-143	92	-151	-3
All	**2,163**	**106,866**	**-85**	**-124**	**-76**	**-100**

💧 Insufficient sample sizes to individually assess the water demand impact of broken head, misting, ponding, fountain, and car wash water waste warning activities

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Facility Irrigation Assessment

- Station by station inspection for City of Austin defined water waste
  - Misting due to high pressure, broken components, runoff, overspray, leaks
- Odd/even address due for assessment on odd/even years
- Applies to commercial, multi-family residential, and industrial properties on parcels larger than an acre
- Form responses: Does Not Apply, Compliance Plan, Irrigation Assessment
- Fines administered for non-compliance ($200 initial late fee; $25 a day accrual)

Facility Irrigation Assessment: Analysis Plan

- **Analysis goal**: Determine statistically significant water demand difference between compliant and non-compliant properties

- Used property list for the past four years (2017-2020)

- Employed fixed-effects panel regression to quantify water demand impacts
  - Relied on monthly metered irrigation (n = 48)
  - Removed "Does Not Apply" and "Compliance Plan" properties
  - "Compliance Binary" variable (0/1) to denote compliance status
  - "Compliance Days Since" variable to account for time-variant compliance effects
  - Often removed 2020 usage due to water demand impact of COVID
  - Included variables to assess water demand impacts due to weather (avg. vs. peak)
  - Disaggregated properties by land use classification to arrive at more homogeneous groups

Facility Irrigation Assessment: Panel Regression Results

Land Use Code	Description	Parcels	Obs.	Month Value	ETc	Compliance Days Since	Month Value * ETc	ETc * Binary	ETc * Compliance Days Since	COVID	COVID Days	Kc
220	Apartment/Condo	104	3,727	-2.88E-01	-7.33E+05	3.31E+00	2.04E+01		-3.70E+01	5.08E+02		MFR
300	Commercial	152	3,873	-1.07E+00	-9.69E+05	8.70E-01	2.23E+01	3.70E+04	-1.70E+01			MFR
400	Office	139	3,190		5.20E+04	5.52E-01			-1.42E+01			COM
510	Manufacturing	30	796		7.52E+04	2.59E+00			-4.43E+01			COM
520	Warehousing	31	780		2.31E+04	-1.79E+00			2.69E+01			COM
600	Institutional	115	4,063		6.75E+04	-1.01E+00						MFR
	All Others	93	3,441		4.58E+04	6.44E-01			-1.18E+01	-3.46E+02	3.69E+00	COM

- Only included explanatory variables with a p-value < 0.12
- * Denote interaction variable
- Kc coefficients adjust ETo to ETc by incorporating sector-specific seasonality effects
- No intercept, given fixed-effects model

Kc	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
COM	0.47	0.44	0.38	0.37	0.38	0.40	0.45	0.53	0.65	0.70	0.70	0.56
MFR	0.58	0.46	0.36	0.35	0.34	0.35	0.39	0.48	0.62	0.70	0.84	0.79

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Facility Irrigation Assessment: Analysis Results

Land Use Code	Description	Compliant Parcels	Non-Compliant Parcels	% Compliant	Total Parcels	% of Total	Water Demand Impact of Compliance	
							Avg. Weather (GPD)	Aug. Weather (GPD)
220	Apartment / Condo	269	19	93%	288	19%	229	-198
300	Commercial	324	23	93%	347	23%	-131	-327
400	Office	336	8	98%	344	23%	-179	-399
510	Manufacturing	77	4	95%	81	5%	-246	-934
520	Warehousing	80	3	96%	83	6%	70	487
600	Institutional	147	5	97%	152	10%	-369	-369
	All Others	178	4	98%	182	12%	-82	-265
	Total	**1,411**	**66**	**96%**	**1,477**	**100%**	**-86**	**-303**

Conclusions

Water Waste Warnings:

- Overall weighted-average savings of 85 and 124 GPD for average and peak (August) weather conditions, respectively

- Estimated total avg/peak savings of 71,200 and 104,000 GPD for avg. number of parcels annually impacted (838 official warnings)

Facility Irrigation Assessment:

- Water demand impacts shown to be land use dependent
- Weighted-average savings of 86 and 303 GPD for average and peak (August) weather conditions, respectively
- Estimated total avg/peak savings of 0.21 and 0.75 MGD for parcels that submitted passing assessments in 2019 & 2020 (2,477 total)

Future Work

- Expand water waste enforcement analysis to:
  - Other sectors (e.g., multi-family residential, commercial)
  - Other activities (e.g., fines, postcards, multi-warning properties)

- Use hourly AMI to produce more robust results using near-real-time data

- Analyze other compliance programs
  - Cooling towers
  - Car washes
  - Landscape
  - Onsite reuse

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