HYDROLOGIC CYCLES OF LOCAL WATER IN LOS ANGELES, CA

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RESEARCH QUESTION

How does urbanization alter hydrologic fluxes in a semi-arid region through imported water, land cover change, and water policies?

Q1 Streamflow

Q2 Groundwater

Q3 Evapotranspiration

Q1 # Streamflow

Objective

Evaluate the impact of non-native vegetation surfaces, irrigation and conservation policies on urban streamflow in Los Angeles

Questions

- How does imported water and irrigated land cover play a role in altering streamflow?
- Can the influence of water conservation measures be observed in streamflow records?

STUDY AREA

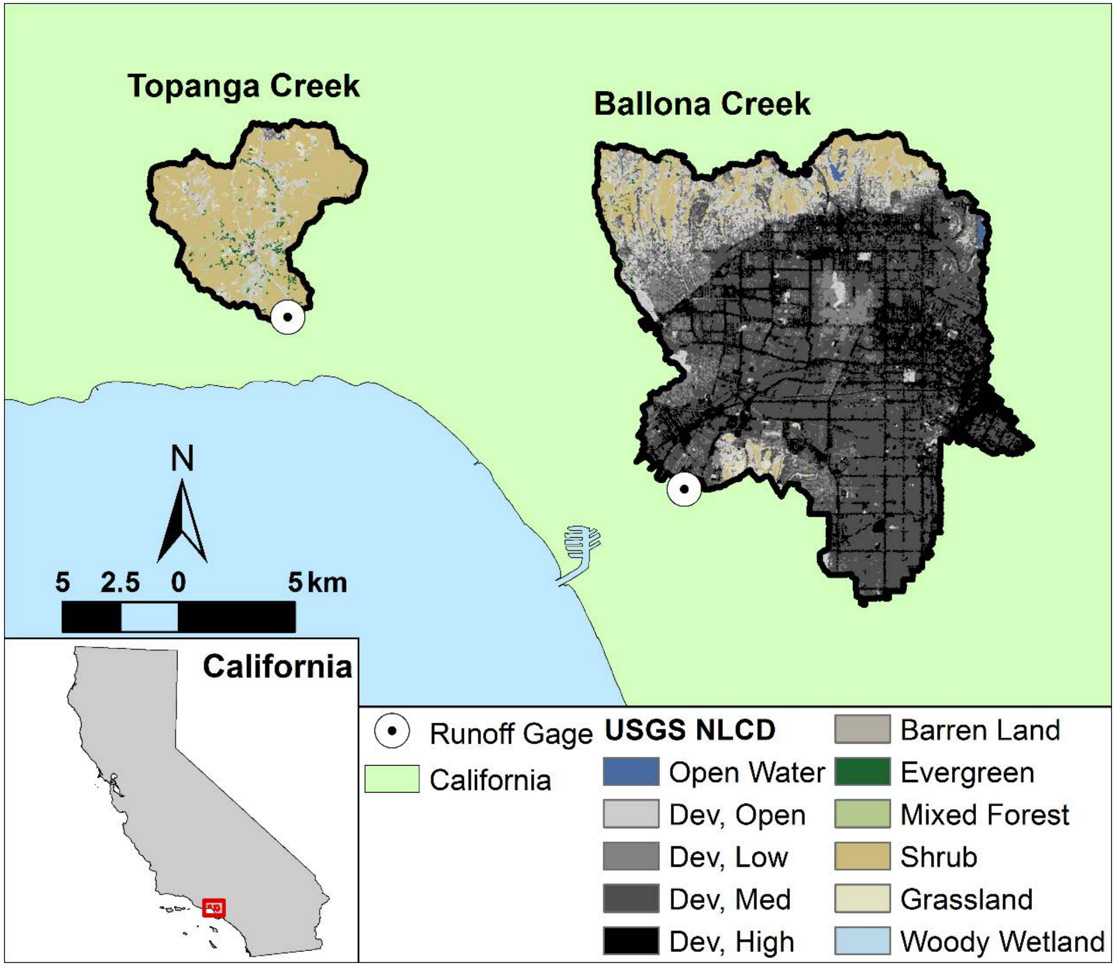
Selected two watersheds in close proximity to each other:

Urban: Ballona Creek

- Channelized in 1930s

Natural: Topanga Creek

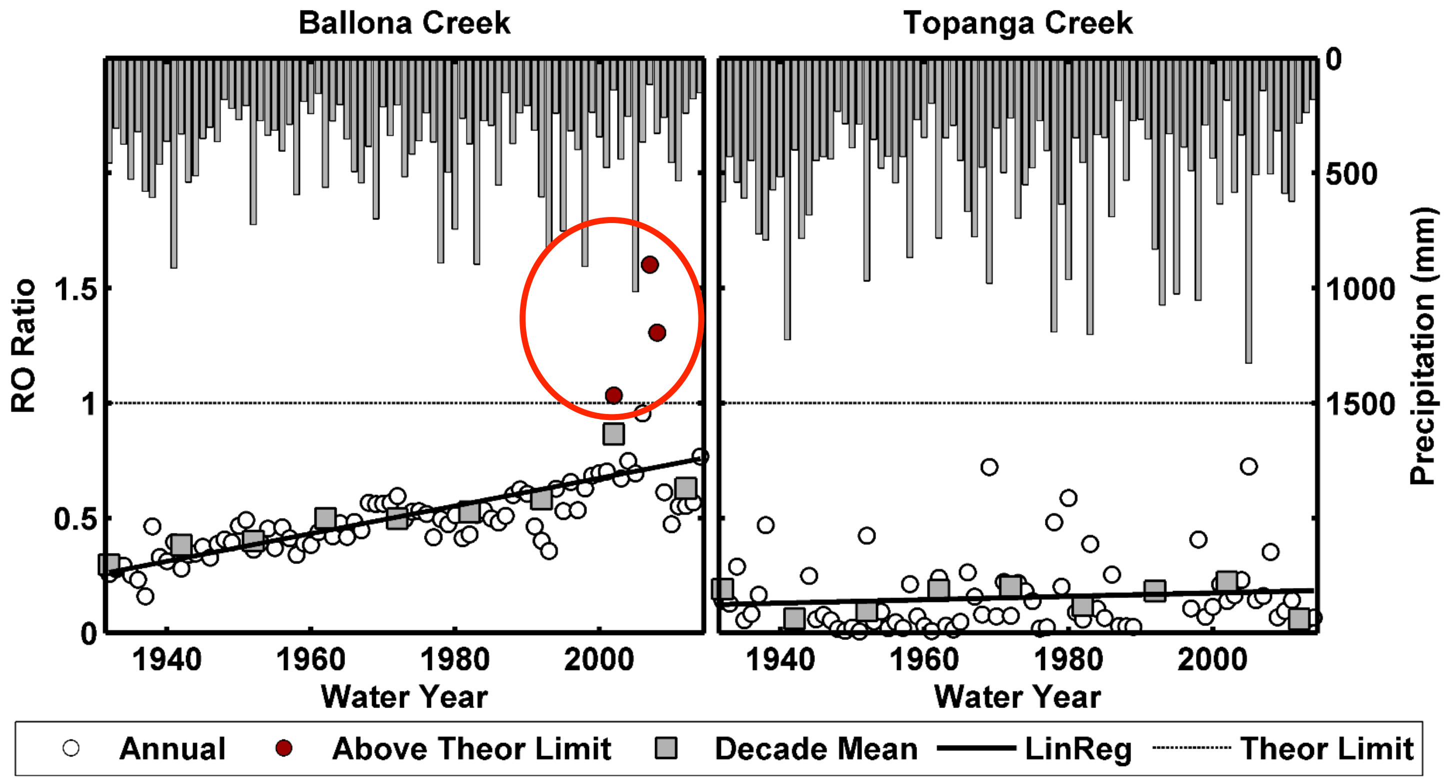
	Ballona	Topanga
Area (km^2)	230	47
Elev (m)	66	485
Precip (mm)	406	535
% Developed	91%	15%
% Impervious	54%	1%



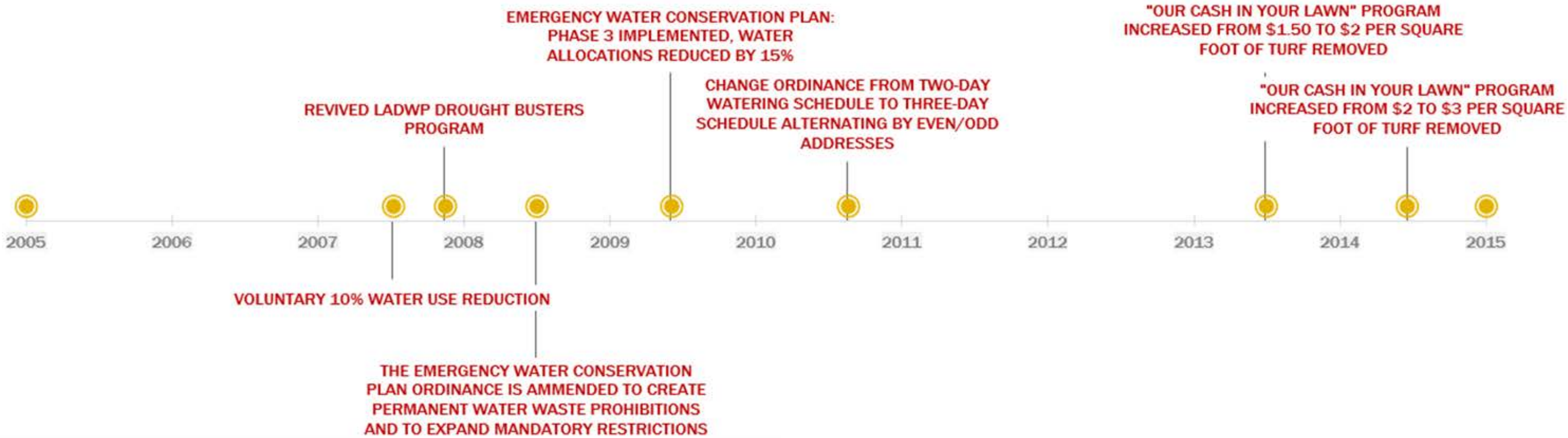
HOGUE HYDROLOGY·GROUP

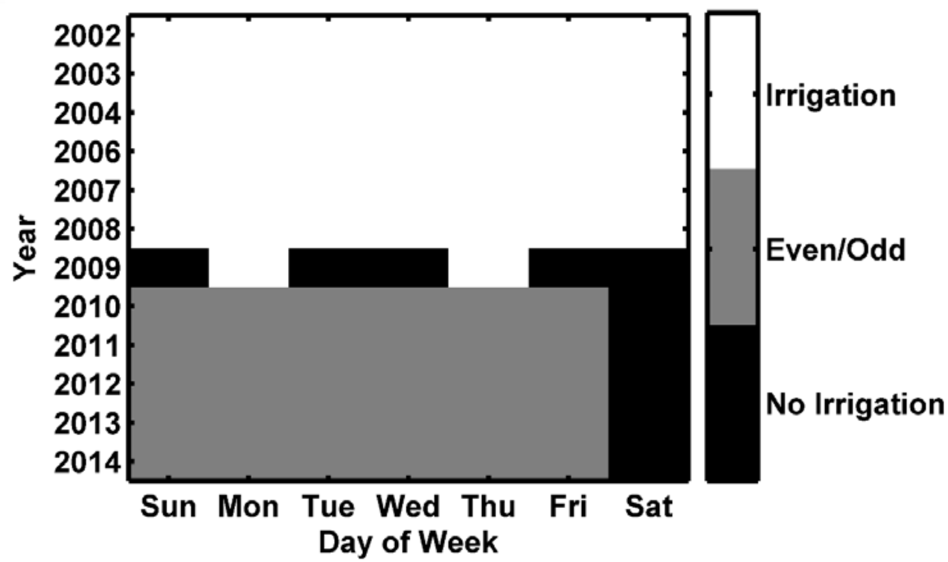
RUNOFF RATIO

- RO Ratio = streamflow/precipitation
- RO ratios exceeding the theoretical maximum indicate that increased runoff in urban watersheds is not only a result of increased impervious surfaces, it is also altered by imported outdoor water use.



WATER CONSERVATION



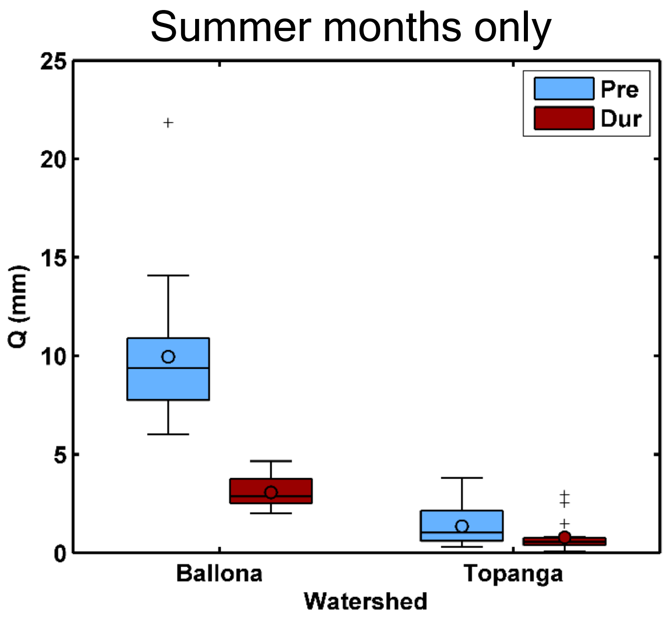


HOGUE HYDROLOGY GROUP

SUMMER PRE VS DURING

Var	Watershed	Annual			Summer			Winter		
		Pre	Dur	p-val	Pre	Dur	p-val	Pre	Dur	p-val
Q (mm)	Ballona Creek	264	169	0.112	30	9.2	0.000	116	98	0.218
	Topanga Creek	78	34	0.186	4.1	2.4	0.282	48	18	0.608
P (mm)	Ballona Creek	273	302	0.731	2.7	1.6	0.301	56	62	0.802
	Topanga Creek	376	371	0.966	4.2	1.5	0.491	83	76	0.834

- Statistically significant differences are only observed only in Ballona during the dry summer months
- Changes to flow only occur in urban watershed, providing further evidence that imported outdoor water use was contributing to runoff



Q1 CONCLUSIONS

- Runoff ratios exceeding the theoretical maximum of one indicate that an additional water source, imported water, is contributing to streamflow
- Appears that irrigation is a primary pathway allowing imported water to contribute to streamflow, as significant decreases in streamflow were observed during conservation.
- Influence of conservation measures are observable in streamflow records at the hourly, daily, and seasonal timescales

Q2 # Groundwater

Objective

Create spatial groundwater level maps from monitoring data to evaluate spatial and temporal patterns of groundwater due to land cover type in Los Angeles

Questions

- To what degree does imputation of missing groundwater data improve analysis of spatial groundwater fluxes?
- How does irrigated land cover type alter spatial and temporal patterns of groundwater recharge?

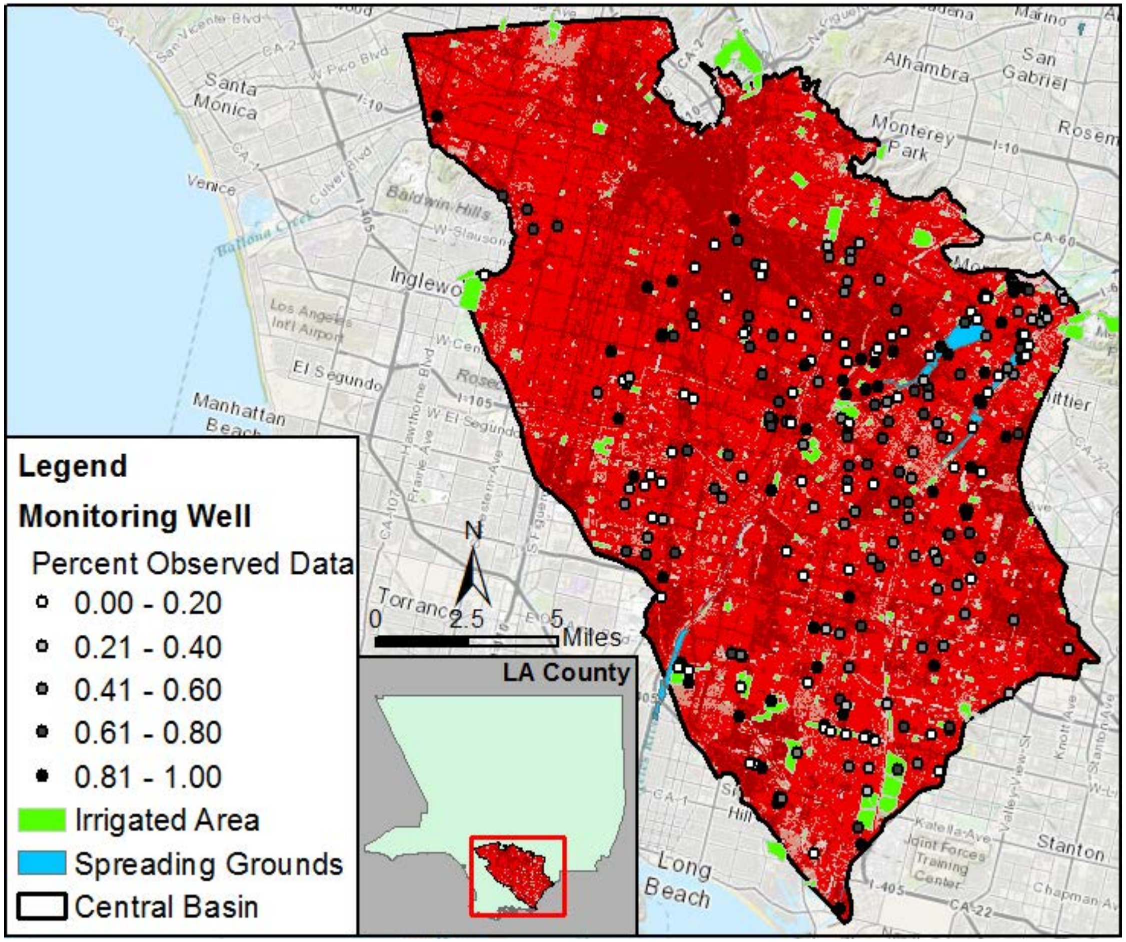
STUDY AREA

Central Basin

- 256 km^2
- 95% Developed
- Supplies water to LADWP
- Adjudicated in 1965

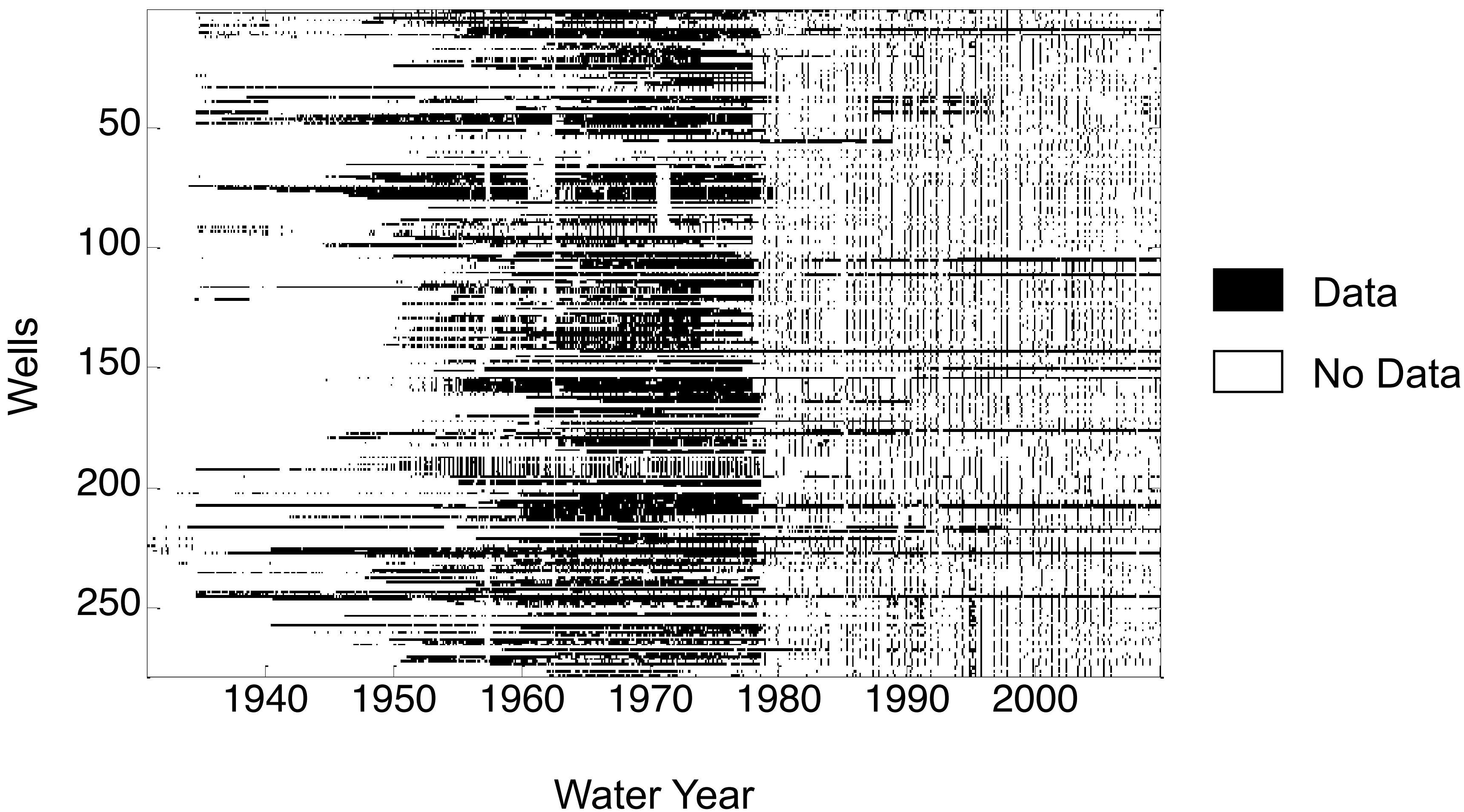
Data Source

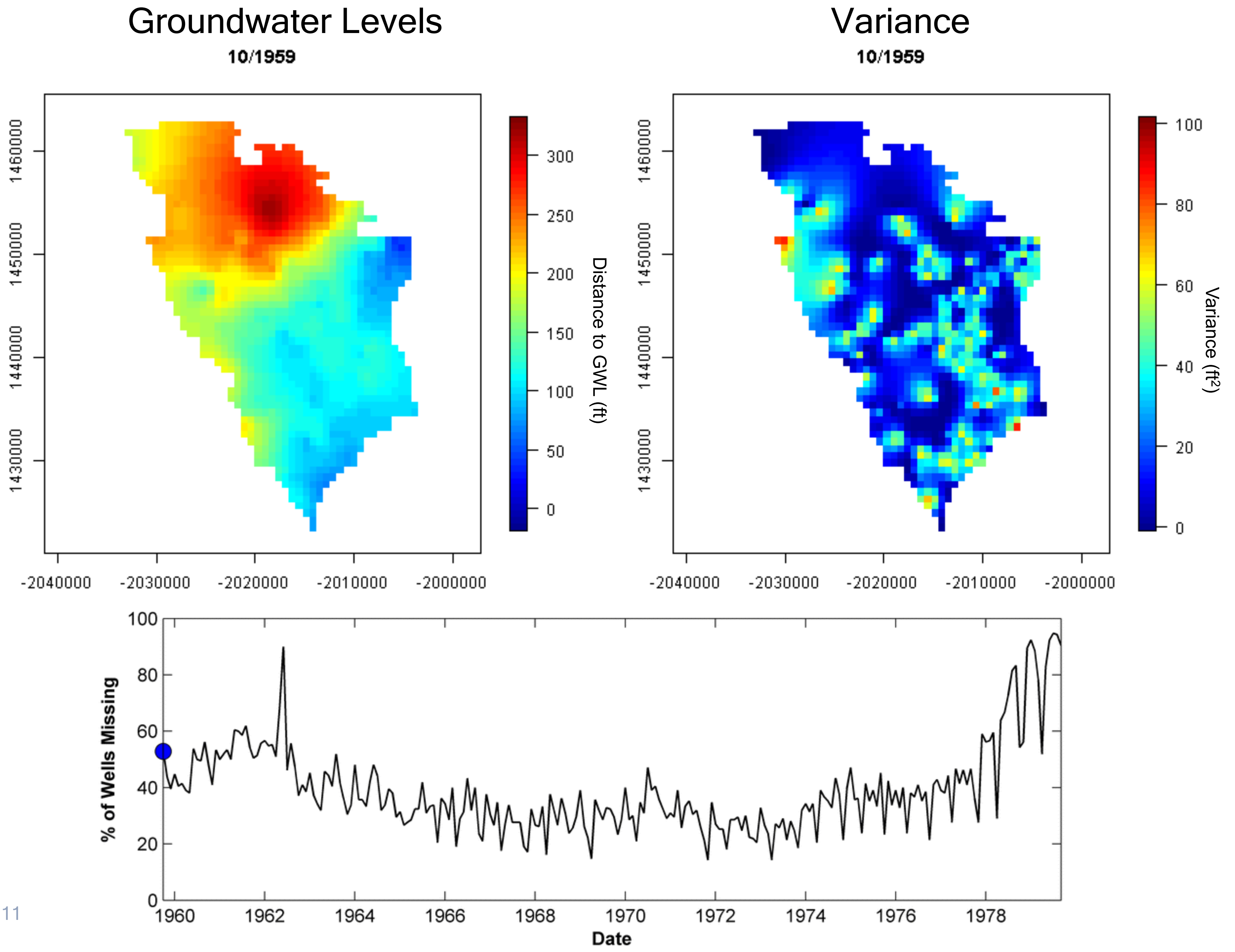
- Los Angeles County Dept of Public Works
- 210 Monitoring Wells



HOGUE HYDROLOGY GROUP

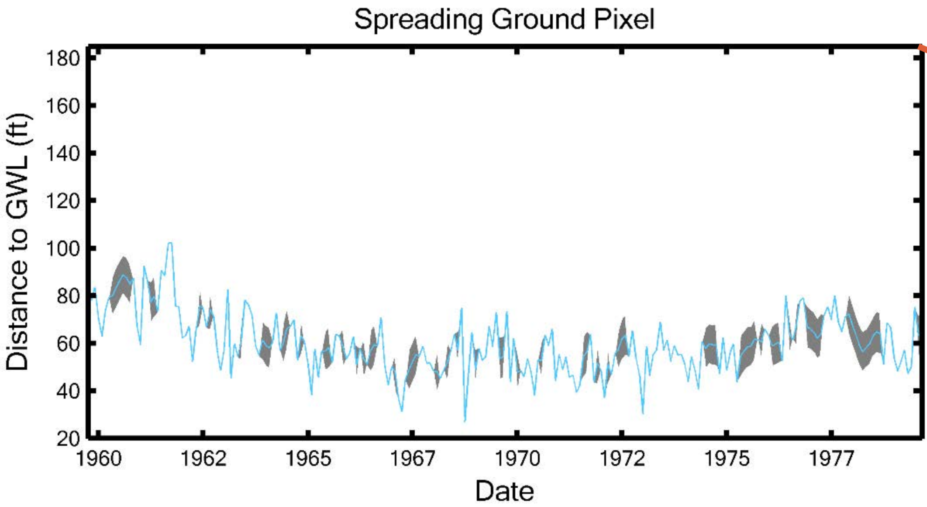
WELL TEMPORAL COVERAGE

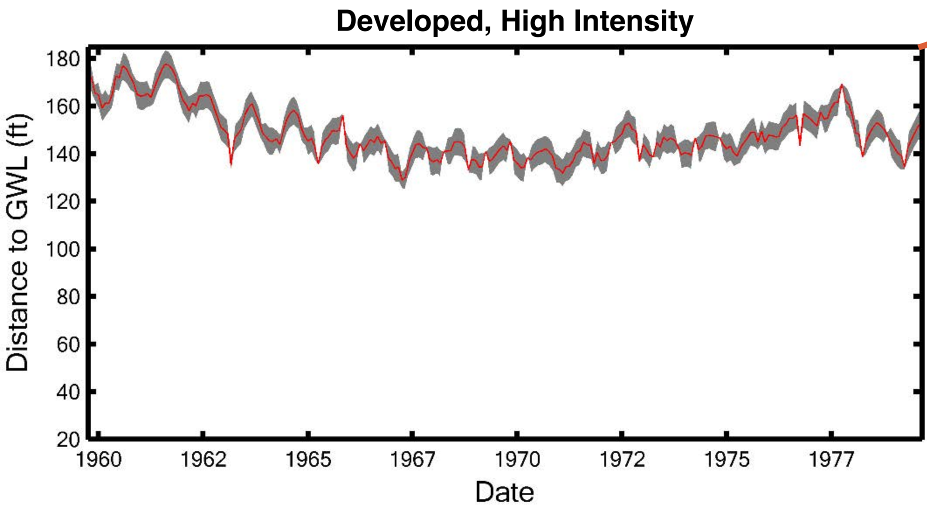


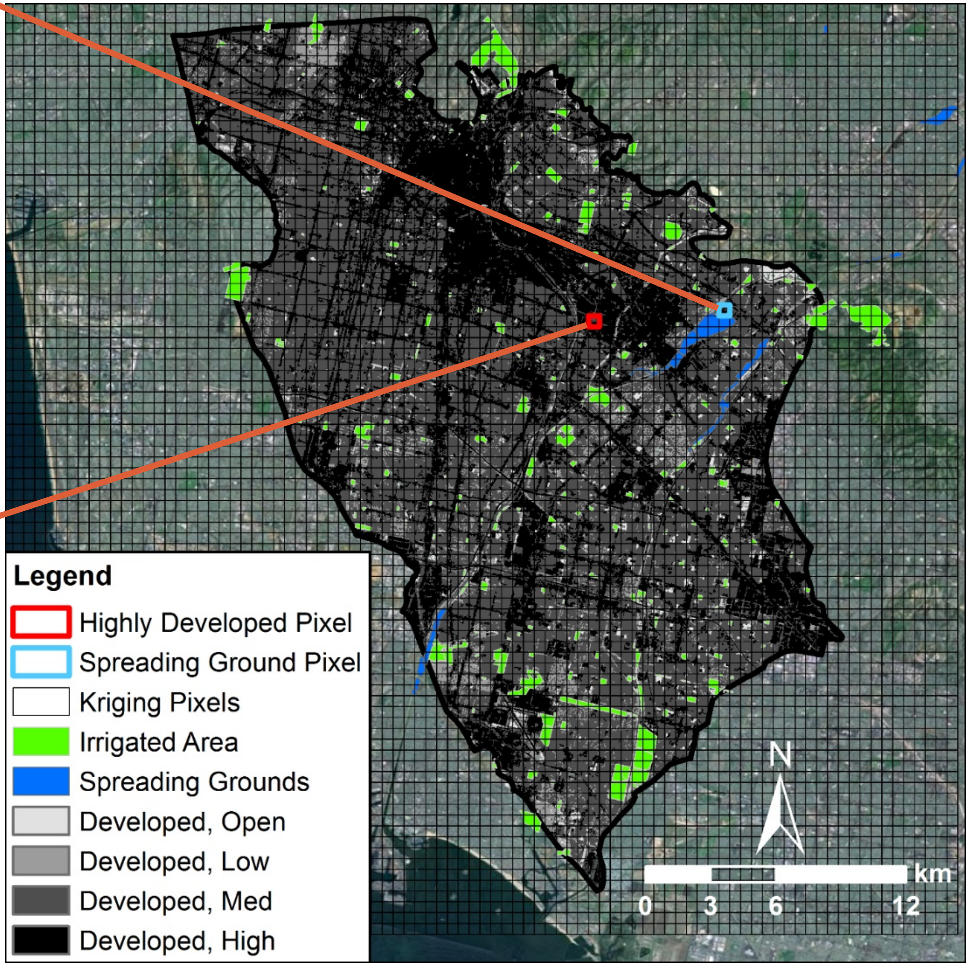


Groundwater Levels
10/1959
Variance
10/1959
Distance to GWL (ft)
Variance (ft²)
% of Wells Missing
Date

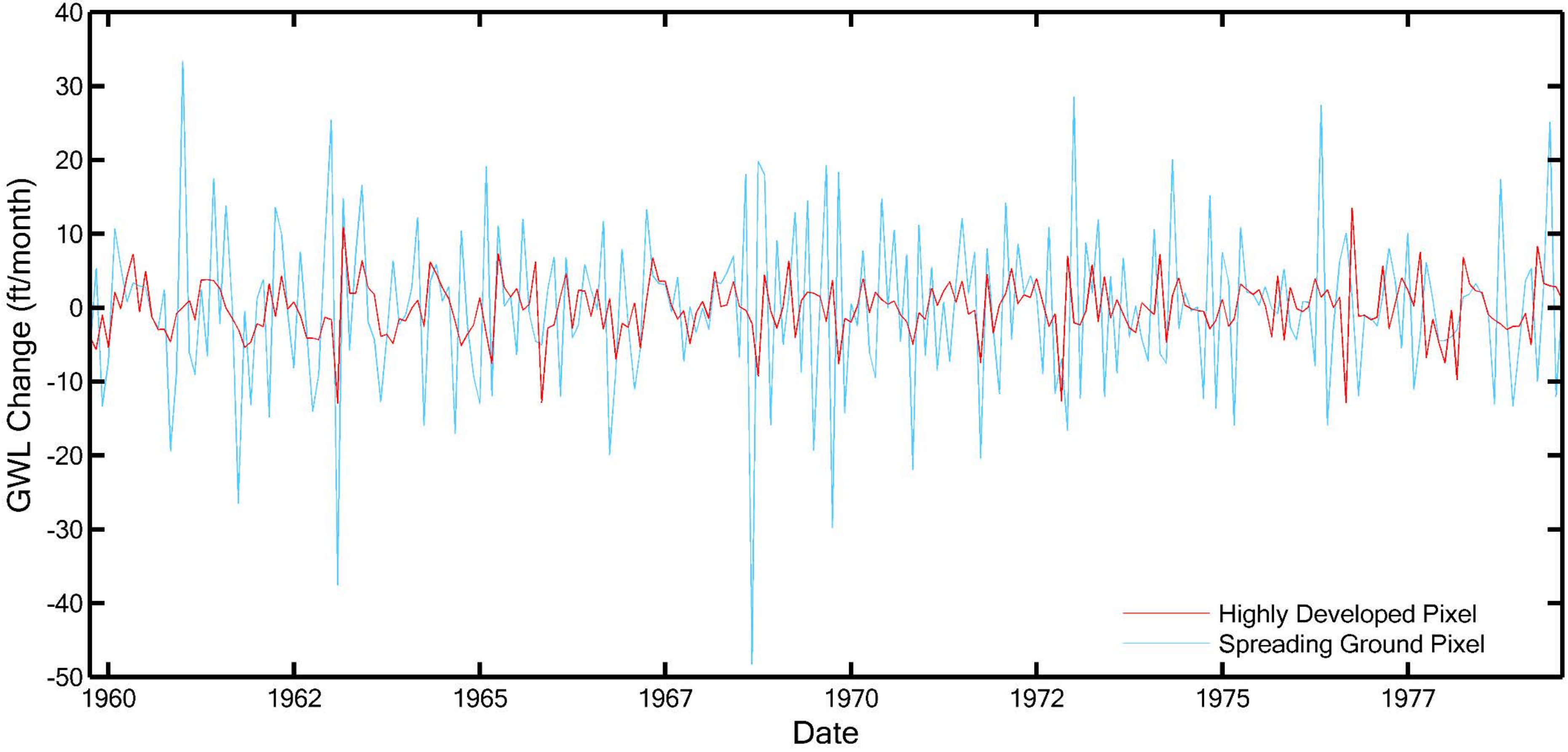
LAND COVER COMPARISON







LAND COVER COMPARISON



LAND COVER COMPARISON

Land Cover	Mean Change in GWL (ft)	n pixels
Irrigated Turfgrass	6.20	116
Spreading Ground	6.02	47
Developed – High Intensity	4.54	135

Q2 CONCLUSIONS

- Imputing multiple values of missing groundwater level data allows for creation of spatial maps throughout time with uncertainty estimates
- Irrigation causes greater seasonal fluctuations in groundwater levels

Q3 # Evapotranspiration

Objective

Evaluate the relation between urban land cover composition and ET in Los Angeles

Hypothesis

- What are the relative roles of different land cover types (specifically: irrigated trees, turfgrass lawns, and impervious surfaces) in shaping urban ET in a semi-arid city?
- How sensitive is ET to the physical characteristics of urban vegetated landscapes, such as vegetation types, percent canopy cover, and turfgrass shading regimes?
- How and to what extent does urban ET in Los Angeles differ from natural ET of its surroundings?

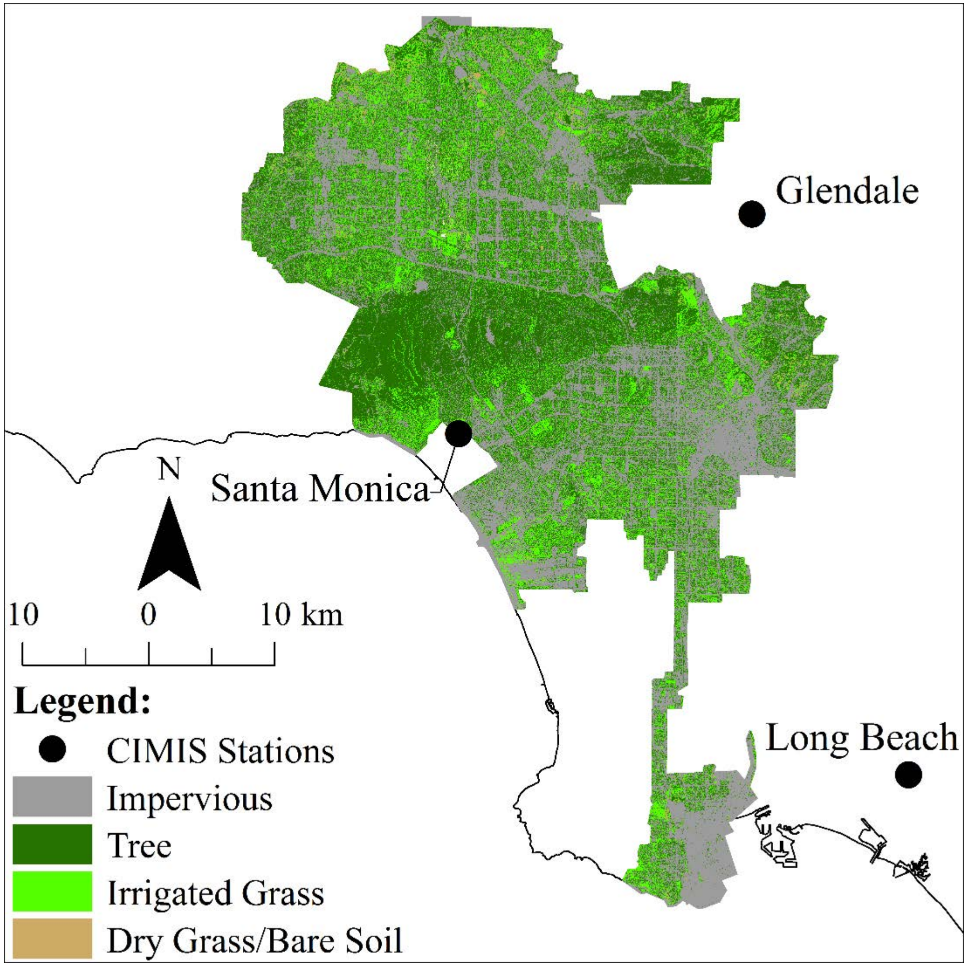
STUDY AREA

City of Los Angeles

Land Cover Composition (McPherson *et. al.*, 2008):

- 57% Impervious
- 26% Tree
- 11% Irrigated Grass
- 6% Dry Grass/Bare Soil

Source: McPherson, E.G., J.R. Simpson, Q. Xiao, and C. Wu, 2008. Los Angeles 1-Million Tree Canopy Cover Assessment. General Tachnical Report PSW-GTR-207. United States Department of Agriculture, Forest Service, Pacific Southwest Research Station.



METHODOLOGY

$$\Delta ET = ET_{urban} - ET_{natural}$$

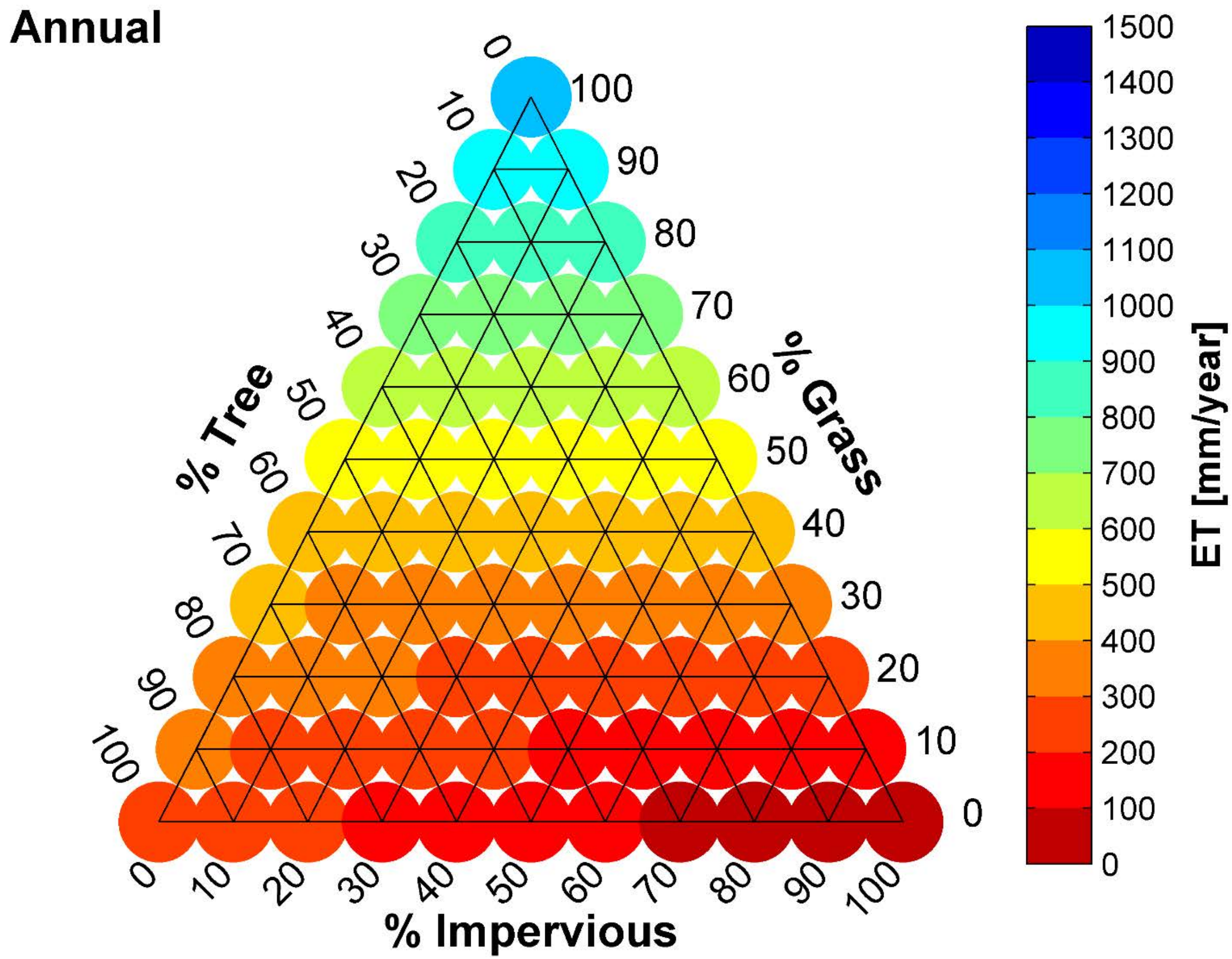
$$ET_{urban} = ET_{grass} + ET_{tree} + ET_{impervious}$$

- ET_{grass} and ET_{tree} estimated using empirical models developed from in situ measurements of ET (*Litvak*

Source:
Litvak, E. and D.E. Pataki, 2016. Evapotranspiration of Urban Lawns in a Semi-Arid Environment: An in Situ Evaluation of Microclimatic Conditions and Watering Recommendations. Journal of Arid Environments 134:87–96.
Litvak, E., H.R. Mccarthy, and D.E. Pataki, 2017. A Method for Estimating Transpiration of Irrigated Urban Trees in California. Landscape and Urban Planning 158:48–61. DOI: 10.1016/j.landurbplan.2016.09.021.

LA VEGETATION PARAMETERS

Study period: WY 2001-2010



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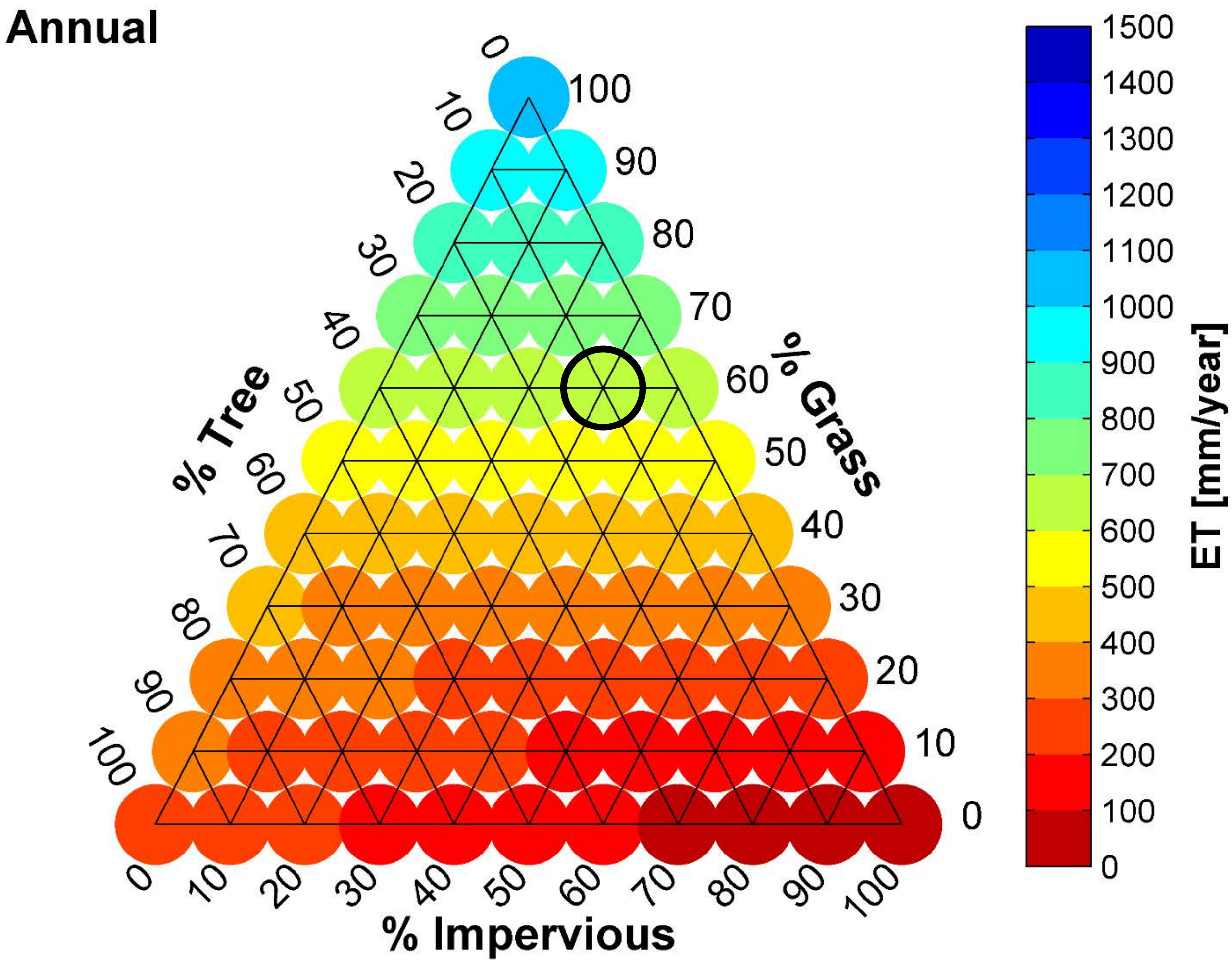
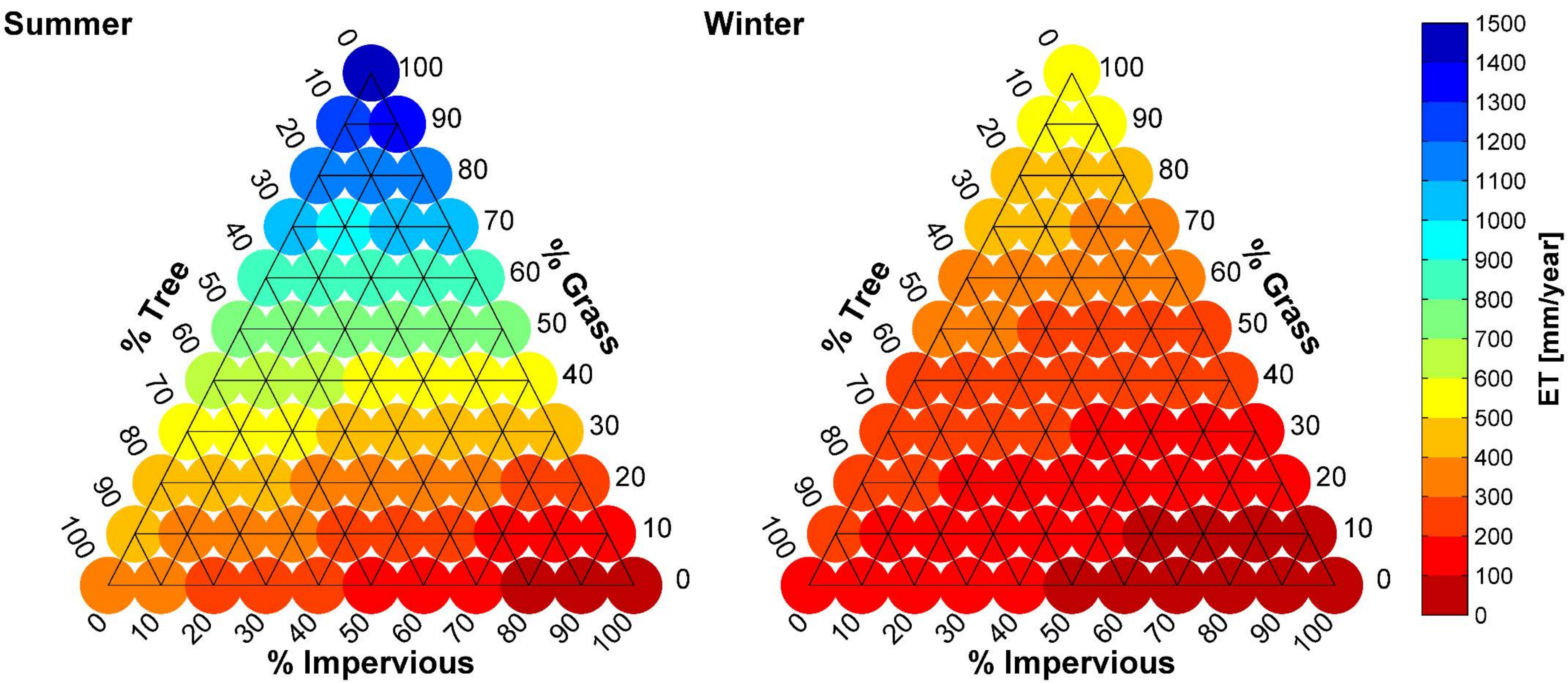


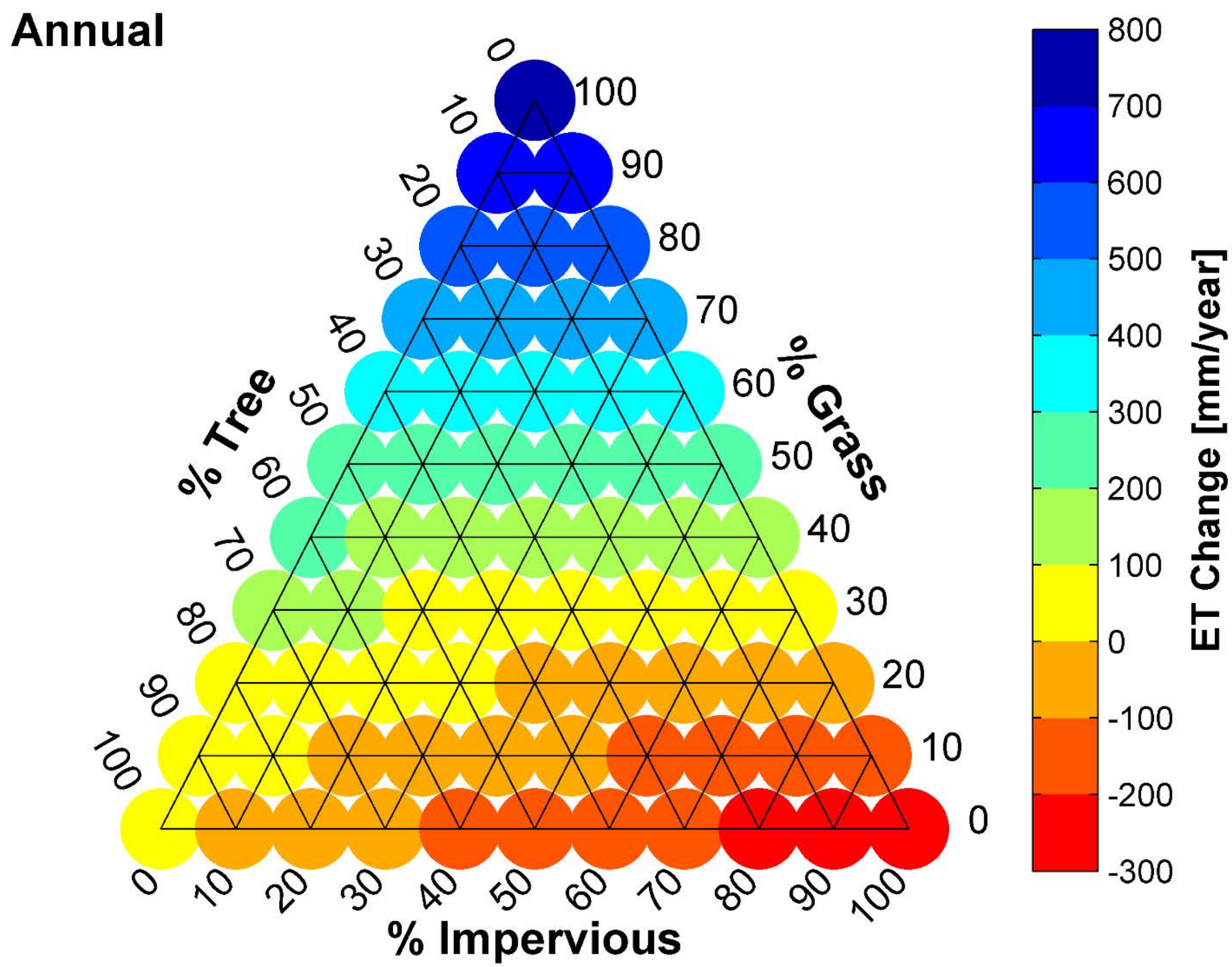
SEASONAL

Summer Months: June, July, August
Winter Months: December, January, February



COMPARISON TO NATURAL ET

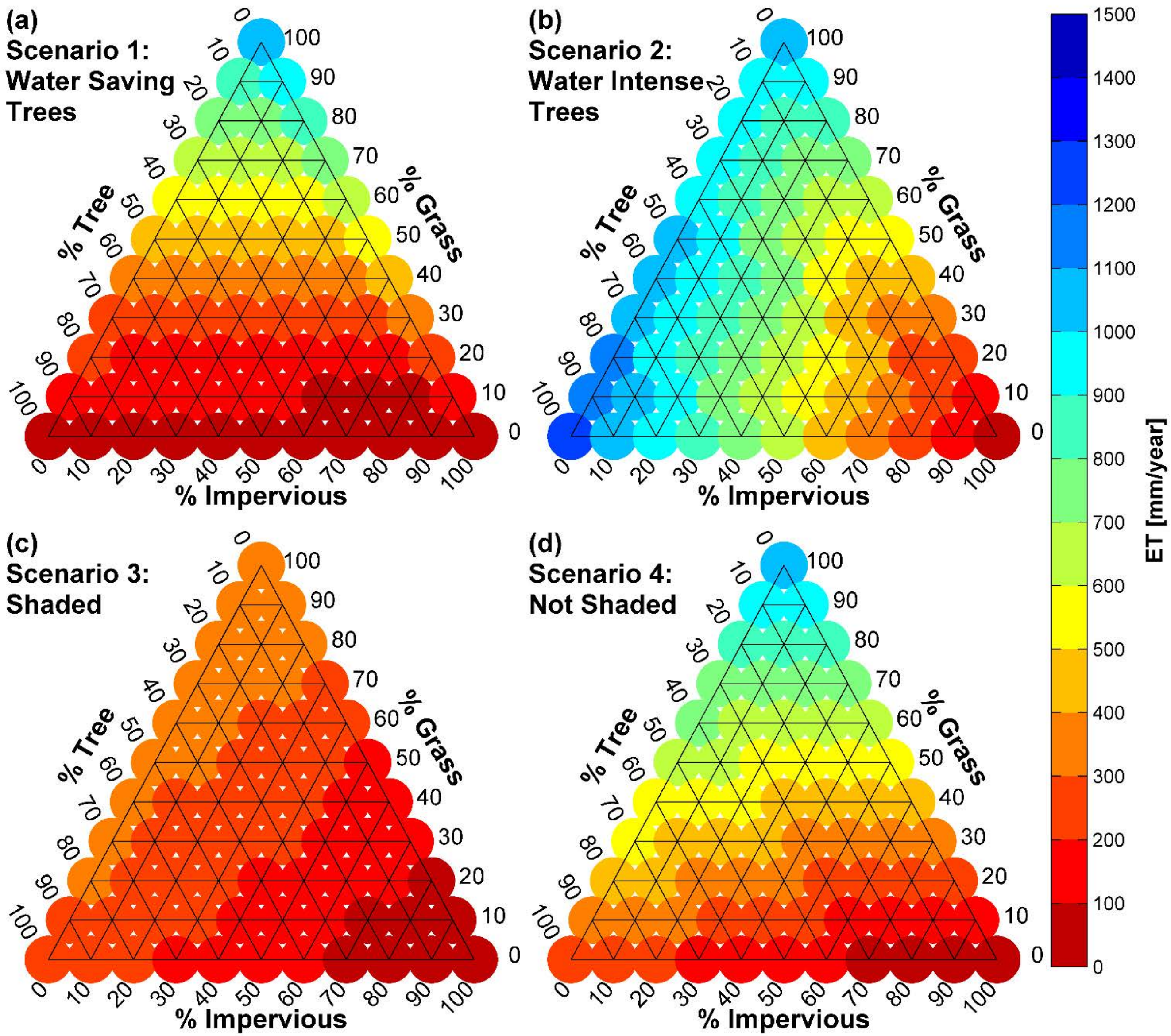
$\Delta ET = ET\downarrow urban - ET\downarrow natural$



SCENARIO ANALYSIS

Sc	Description	Tree Assumptions	Grass Assumptions
1	Low Water Use Trees	Trees w/sapwood area < 100 cm^2	Shaded by trees
2	High Water Use Trees	Trees w/sapwood area > 1000 cm^2	Shaded by tree
3	All Grass Shaded	Estimated LA tree parameters	All shaded
4	All Grass Not Shaded	Estimated LA tree parameters	No shade

SCENARIO ANALYSIS



WATER IMPLICATIONS

Scenario	ET Actual Composition (mm/year)	Control ET - Scenario ET (mm/year)	Customers served
Actual (Control)	349	NA	NA
1: Water Saving	281	68	444,843
2: Water Intense	657	-308	-2,014,879
3: Shaded	300	49	320,549
4: Not Shaded	431	-82	536,429
OTHER ET ESTIMATES:			
NLDAS	252		
CIMIS Reference ET	418		

Q3 CONCLUSIONS

- In Los Angeles, turfgrass primarily controls ET rates; where any land cover with greater than 10% grass results in an increase of ET rates.
- In general, ET is most sensitive to tree parameters due to the large range of sapwood areas and densities. Thus, selection of appropriate tree species in urban regions can aid in controlling ET rates.
- Overall, ET in Los Angeles has increased compared to natural ET rates