Collaborating / End-User Organization - City of Phoenix

CHANGING LANDSCAPES, URBAN HEAT ISLAND AND THE EFFECTS ON CITY WATER CONSERVATION POLICY

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PHX WATER SMART

Urban Green Spaces for Water Conservation and Heat Mitigation in a Desert City

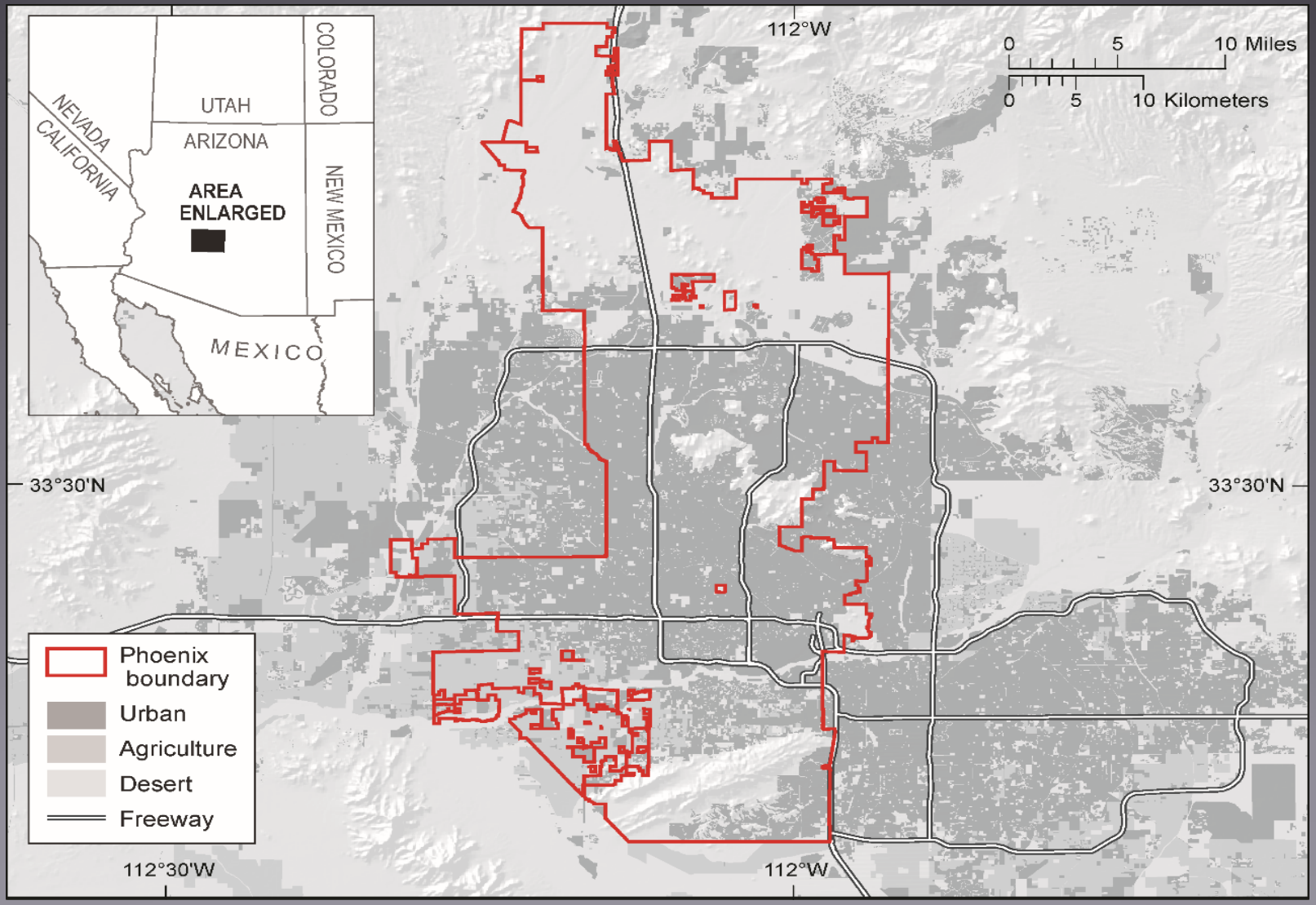
- Green infrastructure development helps to mitigate some of the negative impacts of urbanization: urban heat, carbon emission, biodiversity, physical and mental stress, and urban pollution. Increasing green spaces in a desert city, however, can lead to higher outdoor water use for irrigation, which is not ideally practical for urban sustainability.

Portland, OR

Singapore

Phoenix, AZ

Study Area (City of Phoenix)



Research Questions

- Where are hot and cold spots distributed?

- How do current parcel level outdoor water use records and satellite based Evapotranspiration (ET) data compare?

- Can we predict water use by vegetation type in current Landscape Categories?

- What are the associated relationships between levels of heat stress and water use to various customer types, water features, hardscapes & landscapes?

- Which areas have the greatest opportunity to lower surface temperatures most effectively?

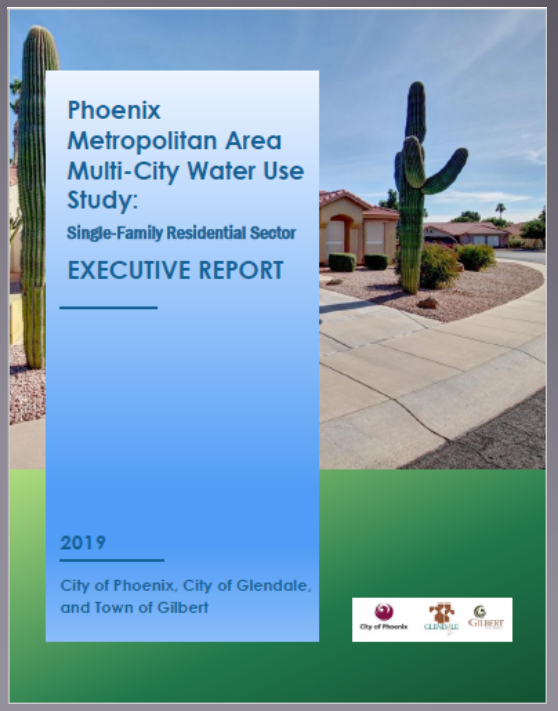
- How much water would be required to achieve specific levels?

- Which areas would benefit most from modifying landscapes and have the greatest opportunity to improve water conservation?

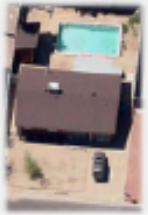
Background: Phoenix

- Phoenix has a unique climate compared to most of the U.S.
  - difficult to fit to previous models
  - does not have large areas of turf and tree canopy
  - year round landscape watering and pool makeup water

- 2019 MultiCity Water Use Study answered:
  - How do landscapes compare across the cities?
  - How does the existence of pools compare across the cities?
  - How does water use associated with irrigation and pool use compare?
  - How does the age of the home and lot size impact water use?



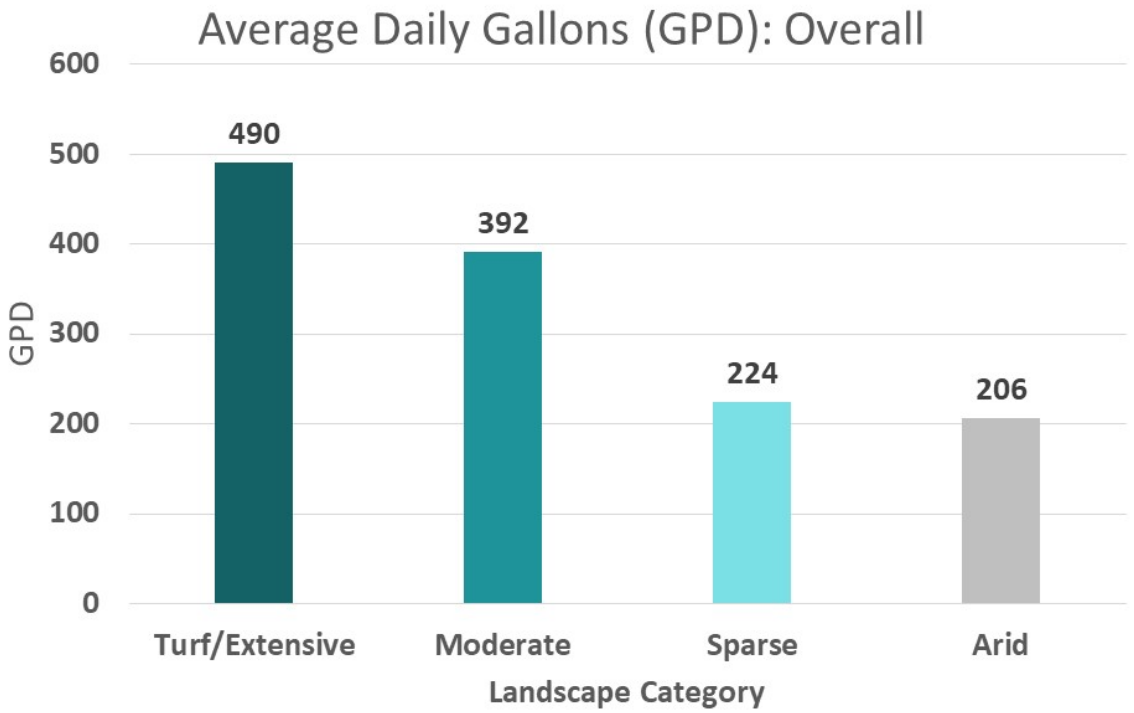
Description of Landscape Categories

Category	Image		Intensity
Turf		at least 35% of the total parcel is turf; extensive irrigation system is required	High -Very High
Extensive		only dense tree canopy is visible; may have turf; turf/ground cover beneath is difficult to see; irrigation system is required	High -Very High
Moderate		partially desert; mixture of decompressed granite/rock/dirt and/or turf or other vegetation; irrigation system is required	Moderate
Sparse		mostly desert; mixture of desert landscape and plants, but no turf; may or may not have irrigation provided	Low
Arid		entirely desert; mixture of desert landscape and plants requiring no irrigation once established; no turf	None
Transition		overall parcel appears to have been turf at one time	Unknown

2019 MultiCity Results

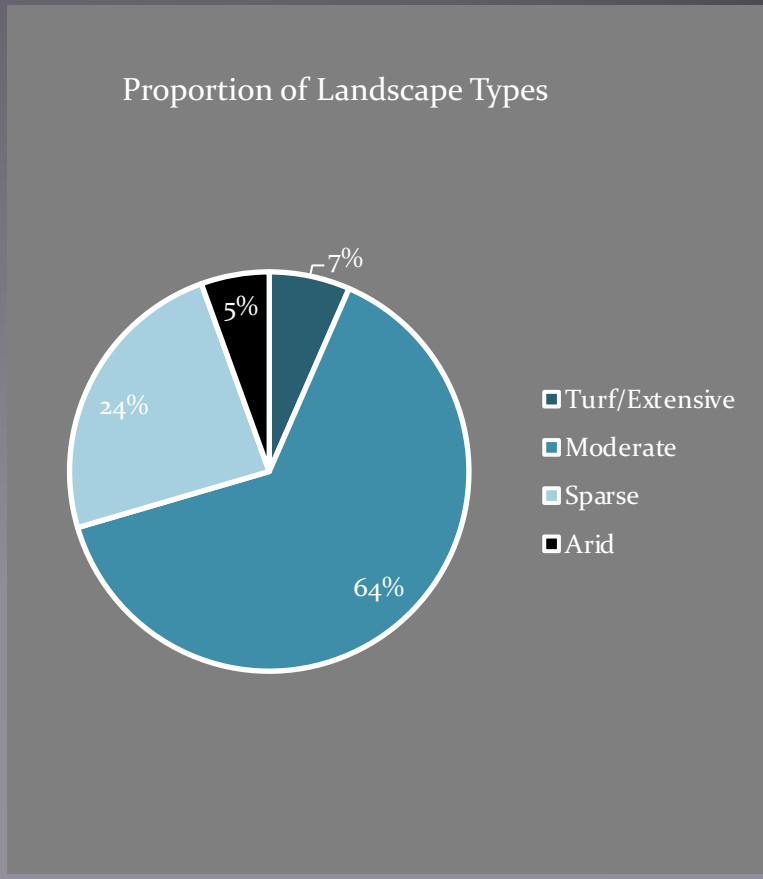
2019 MultiCity Results: Landscape Types and Water Use

- Coding categories translate to average water use demands
- Less water intensive landscapes (i.e. arid & sparse) have less overall water use
- Intuitively, outdoor water use trends makes sense since indoor water use is expected to be the same regardless of outdoor water use

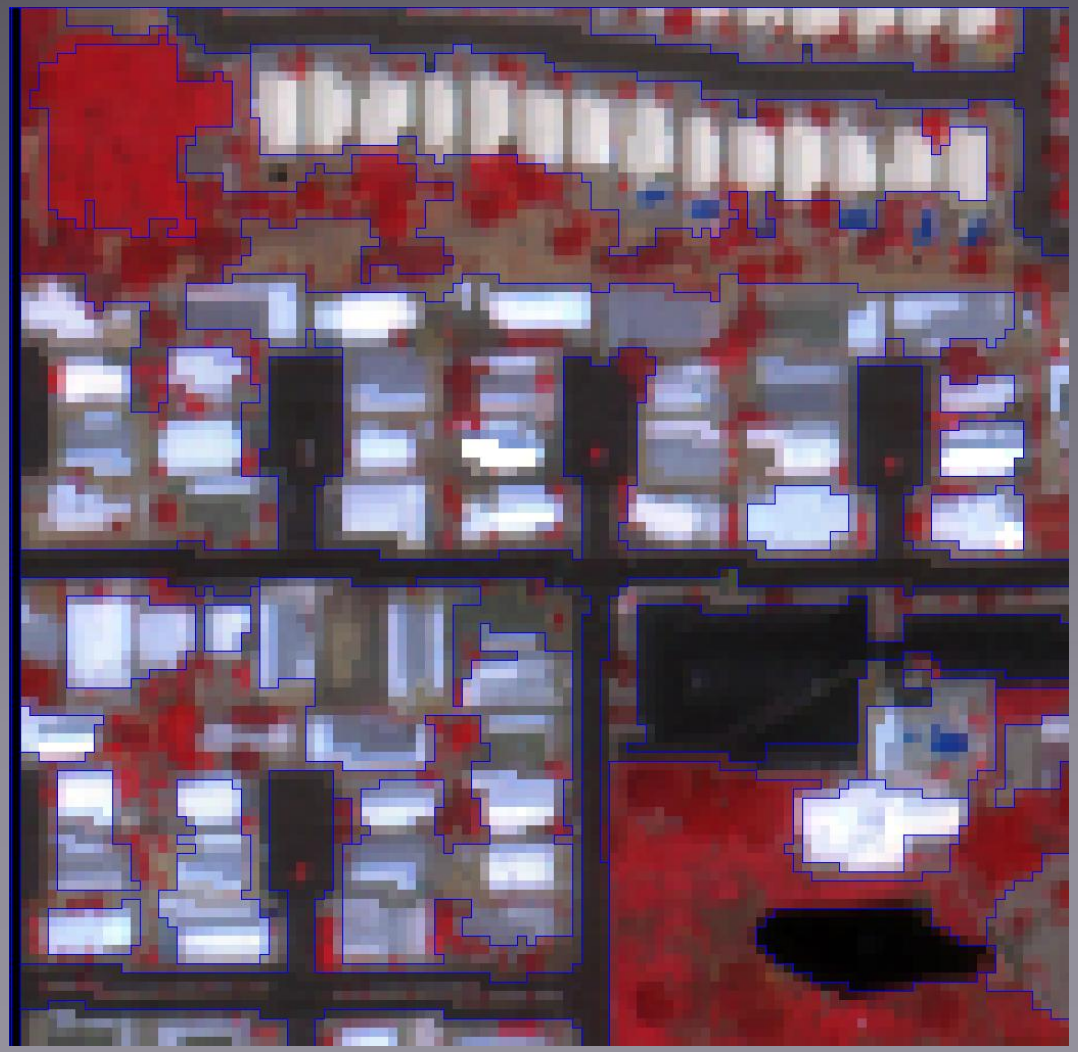


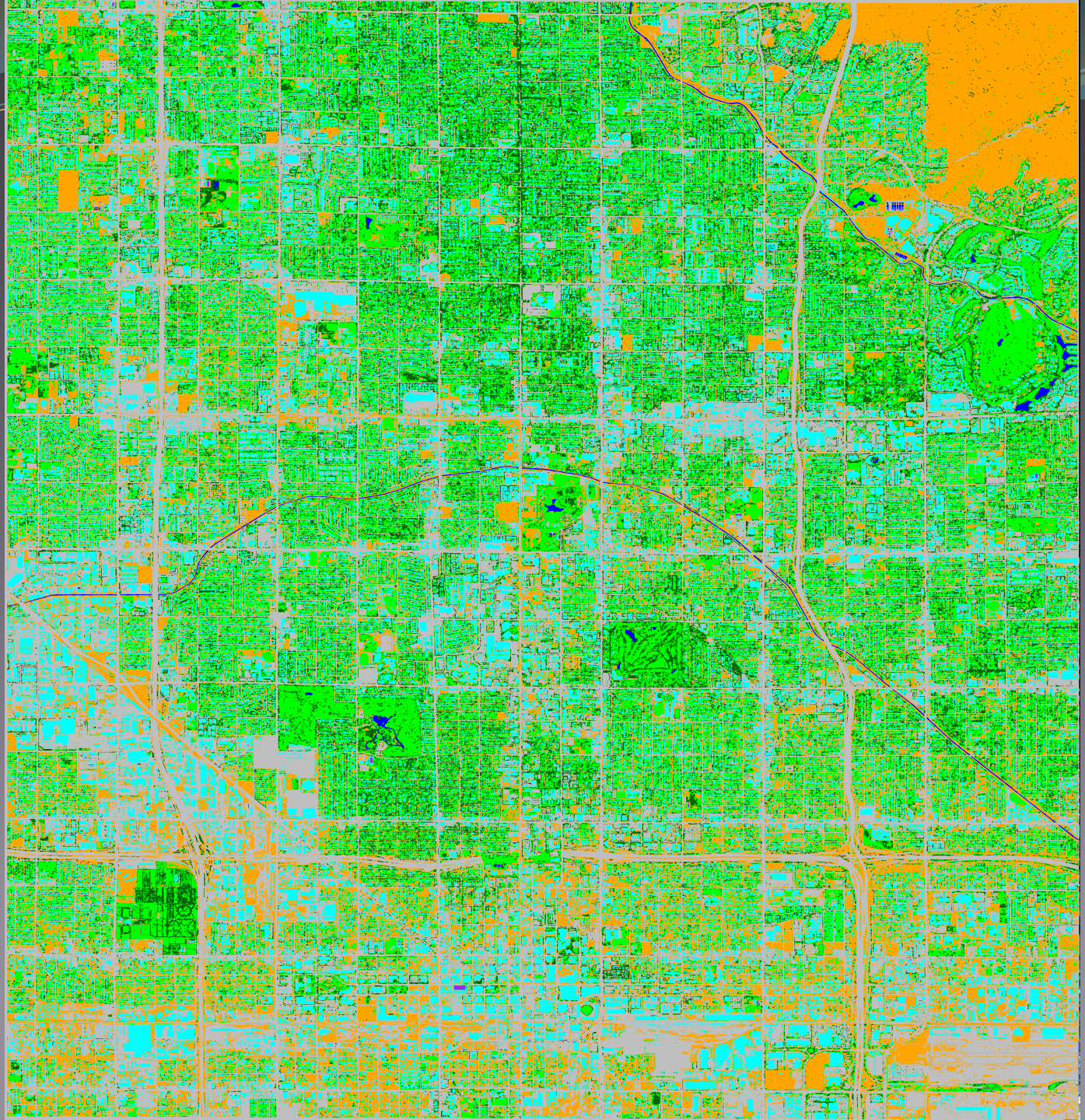
2019 MultiCity Results

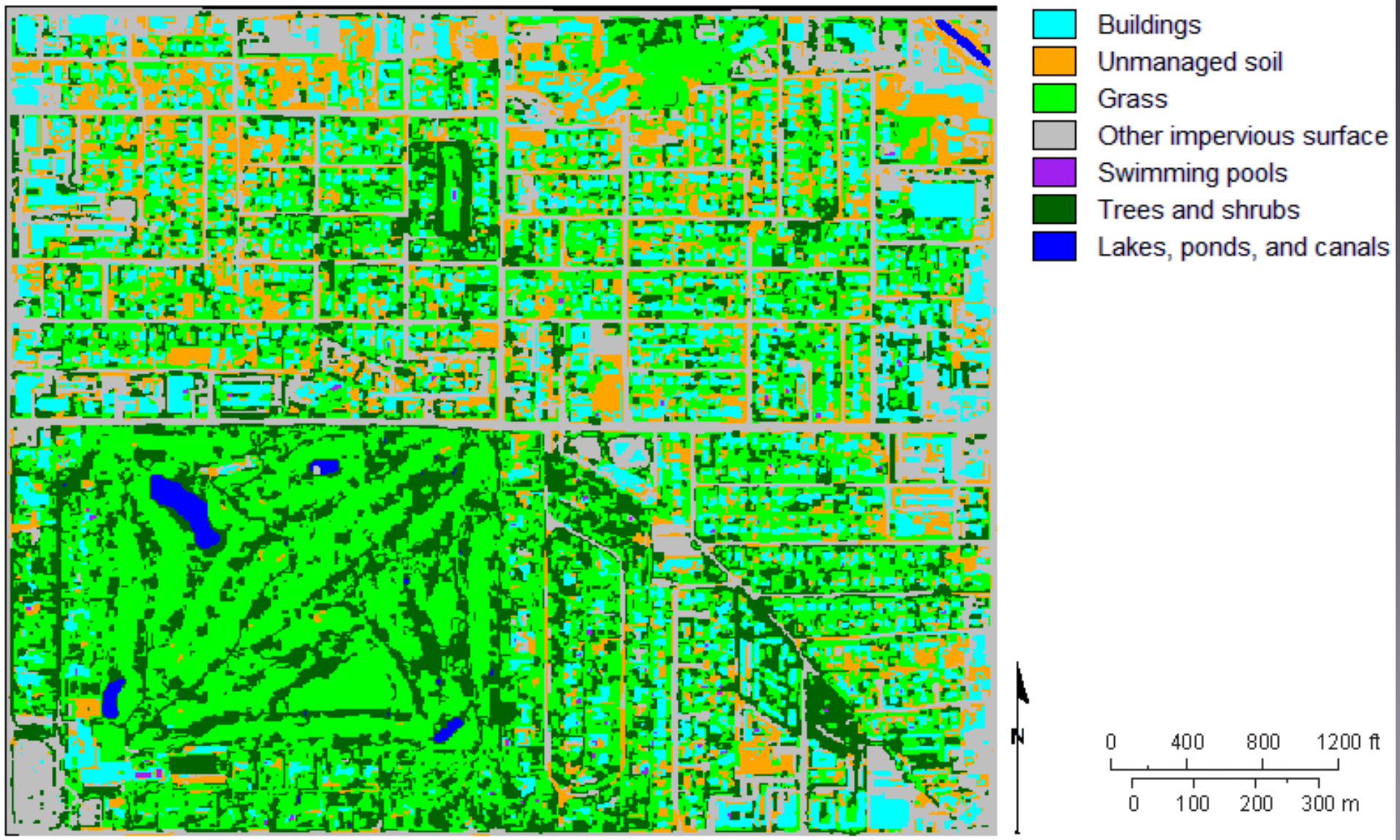
- Overall, the majority of all fell into either the Moderate or Sparse landscape categories.
- This indicates most homes have some sort of vegetation that would require irrigation, however, not to the extent that a large tree canopy or large area of turf would require.
- This has implications for not only water use, but urban heat island effects
- The City wishes to code all parcels to quantify these effects.



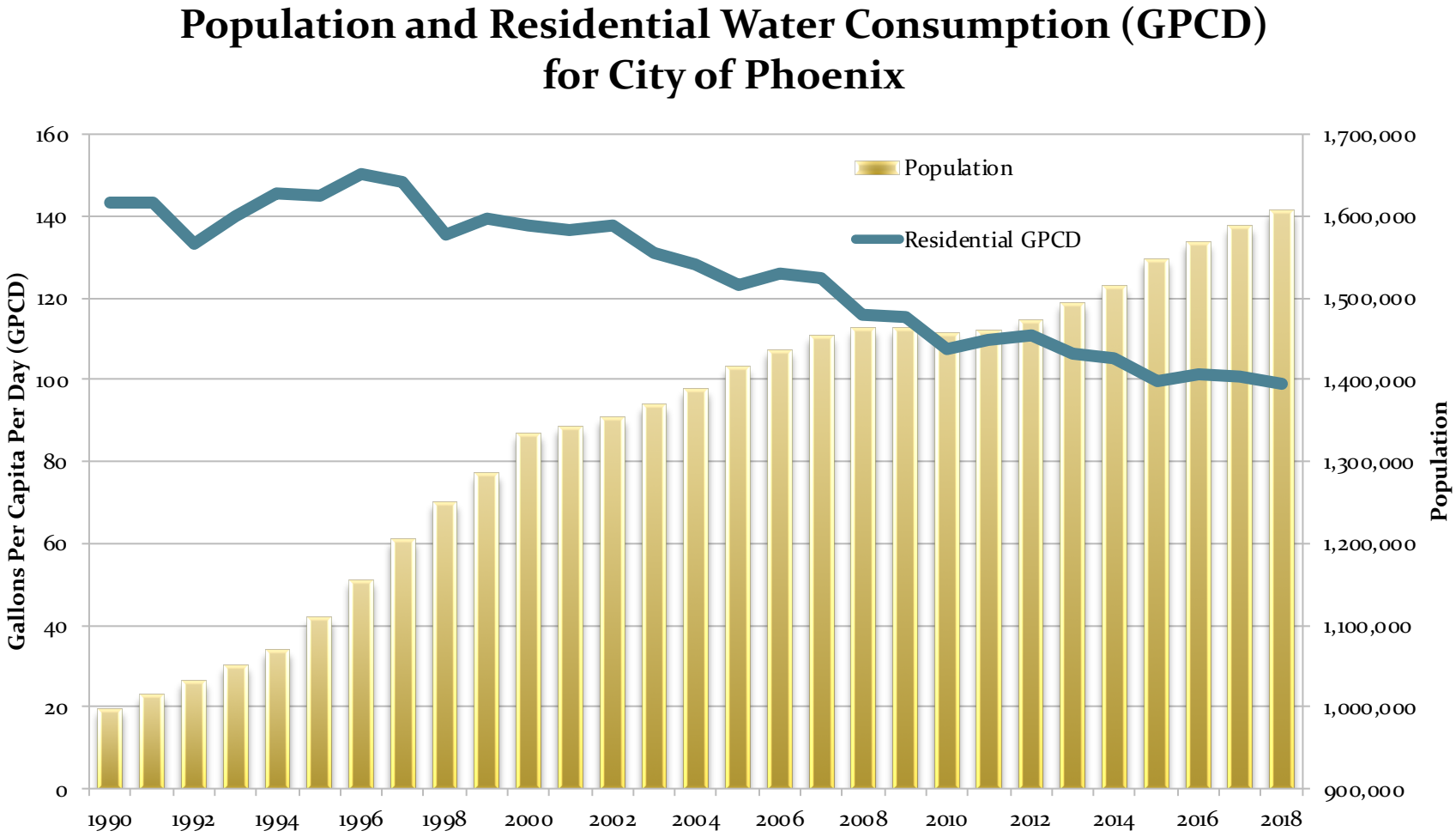
Example Image Classification
Segmented Images at Different Scales



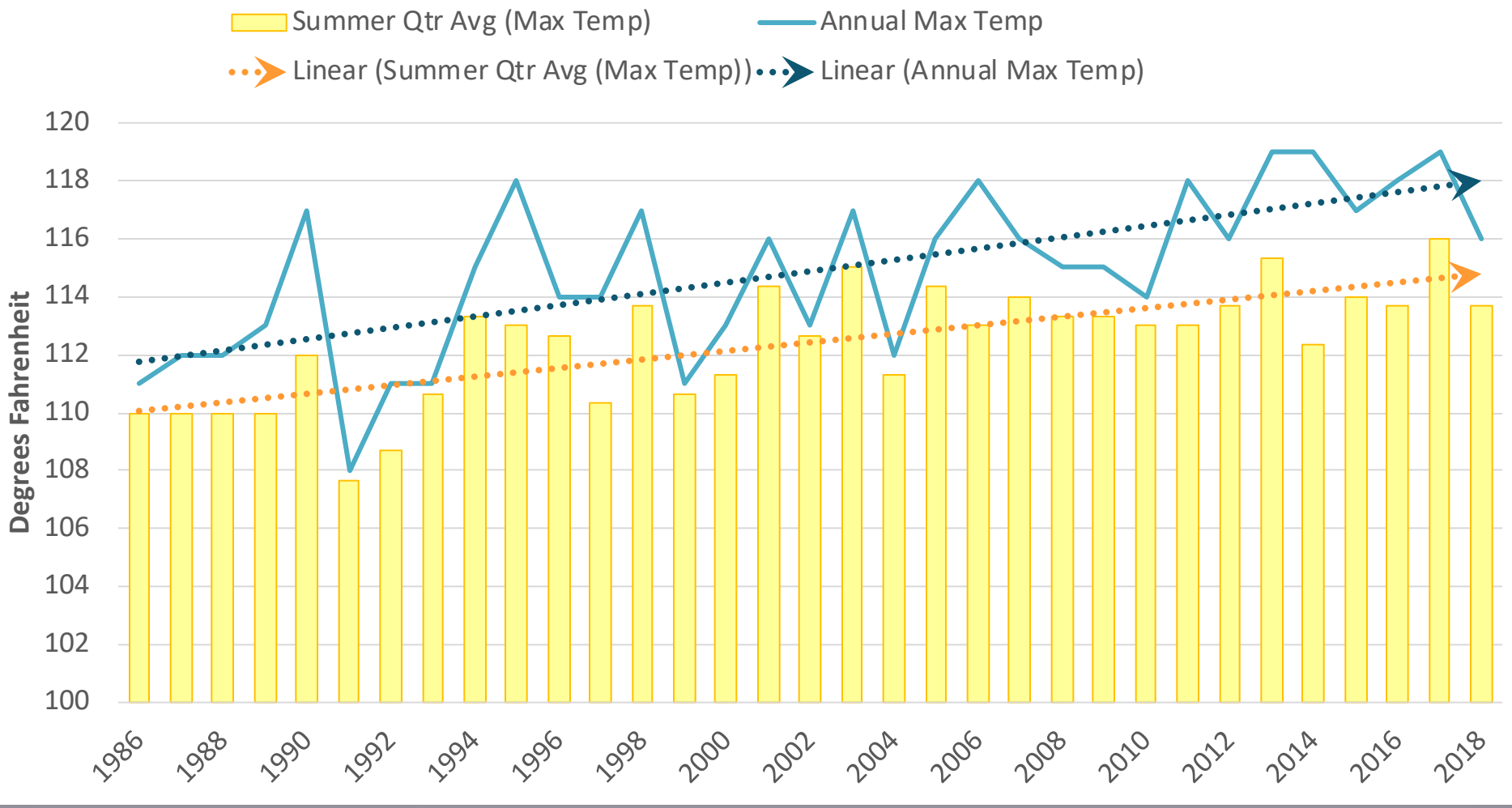



Buildings
Unmanaged soil
Grass
Other impervious surface
Swimming pools
Trees and shrubs
Lakes, ponds, and canals
N
0 400 800 1200 ft
0 100 200 300 m

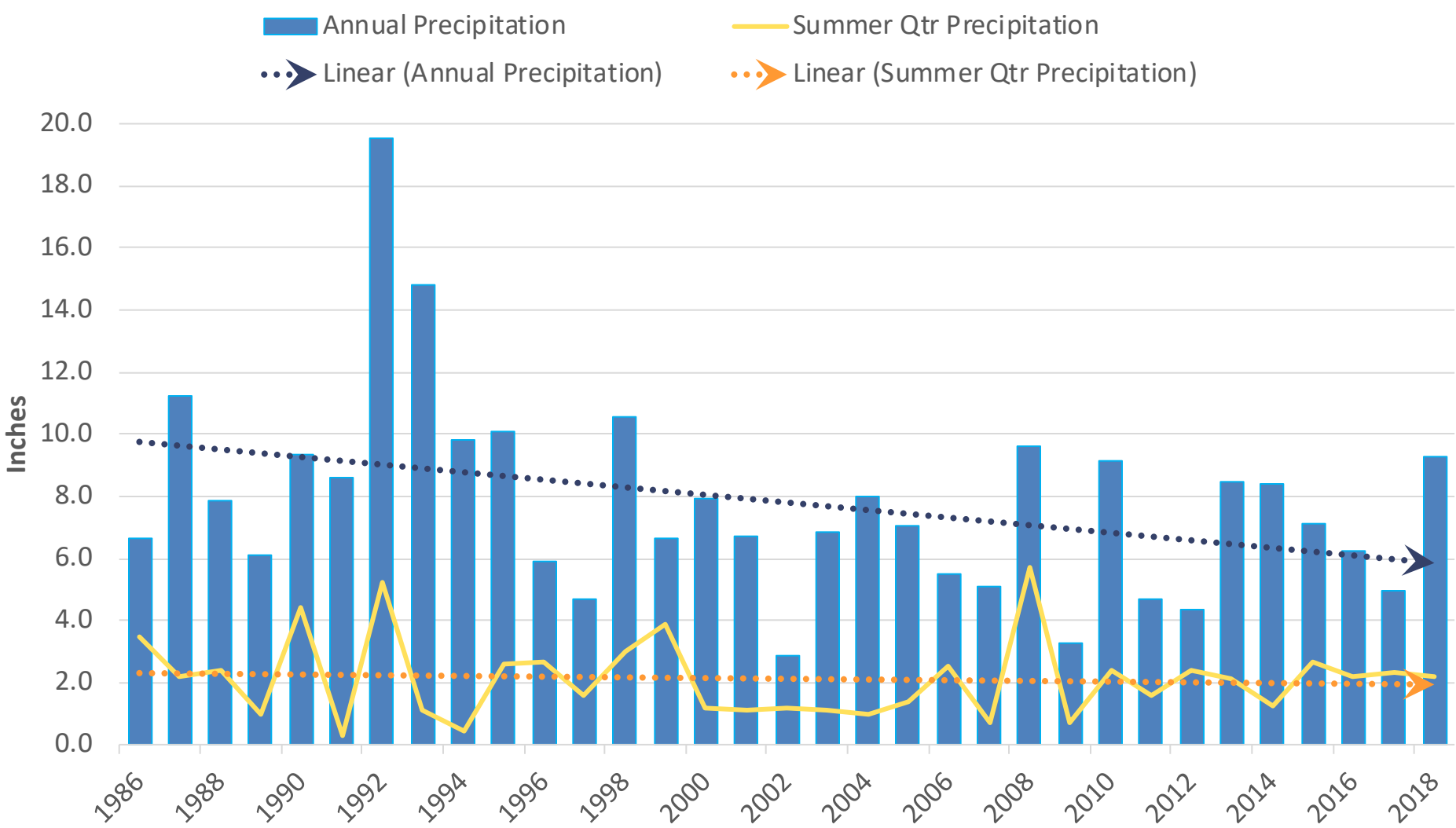
Water Use Trends



Temperature Trends



Precipitation Trends



Phoenix Tools for Research: Current Landscape Categories

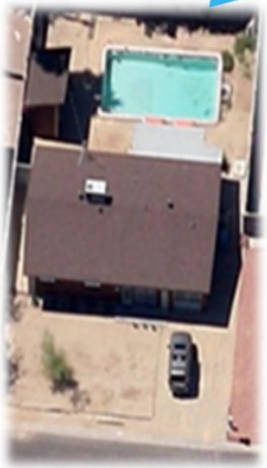
Water Use Intensity

Turf

Extensive

Moderate

Sparse

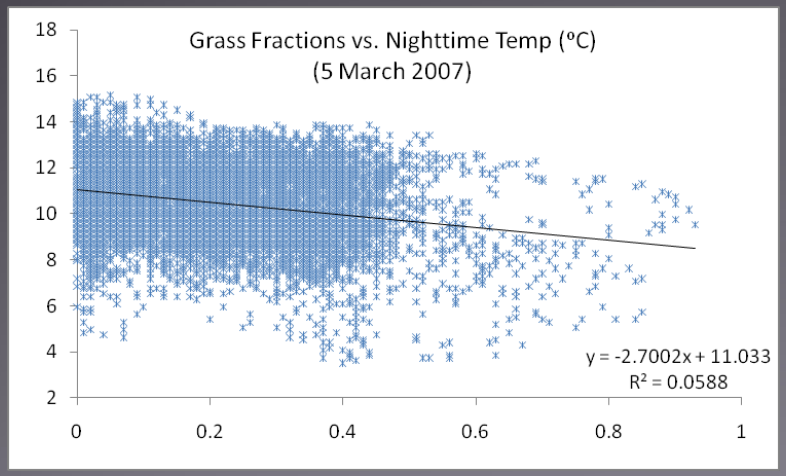


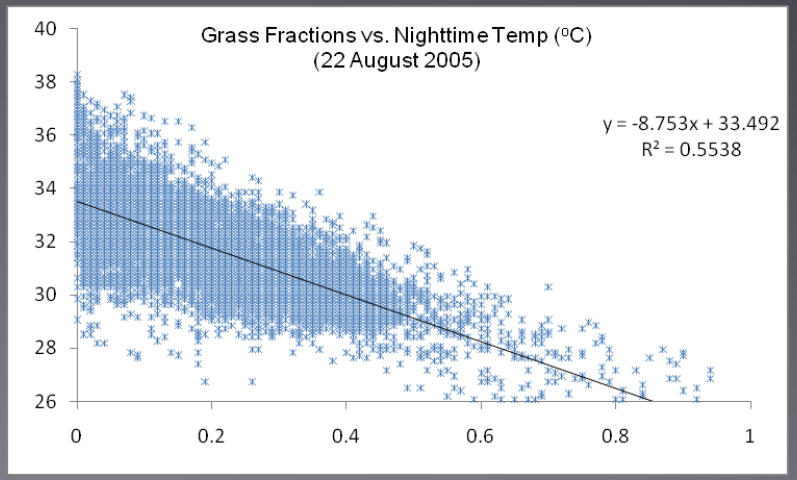
Arid

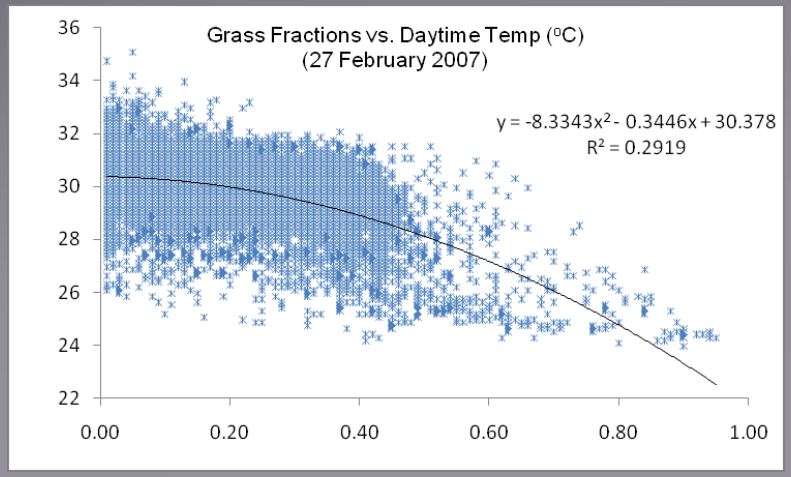
?

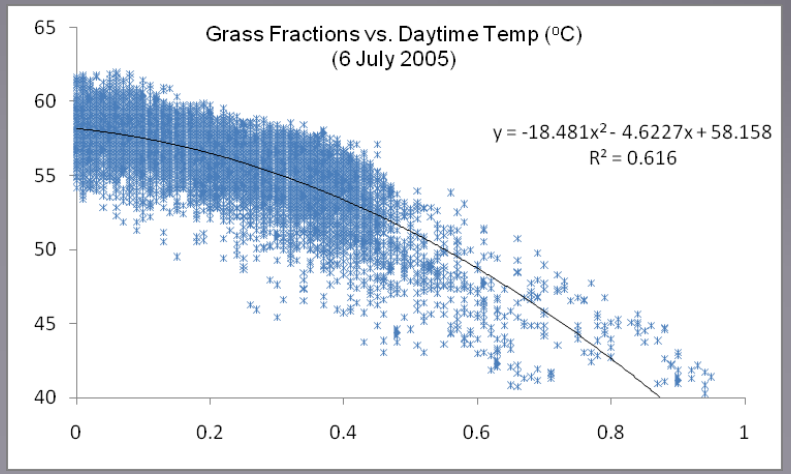
Transition

Grass vs. Temperatures

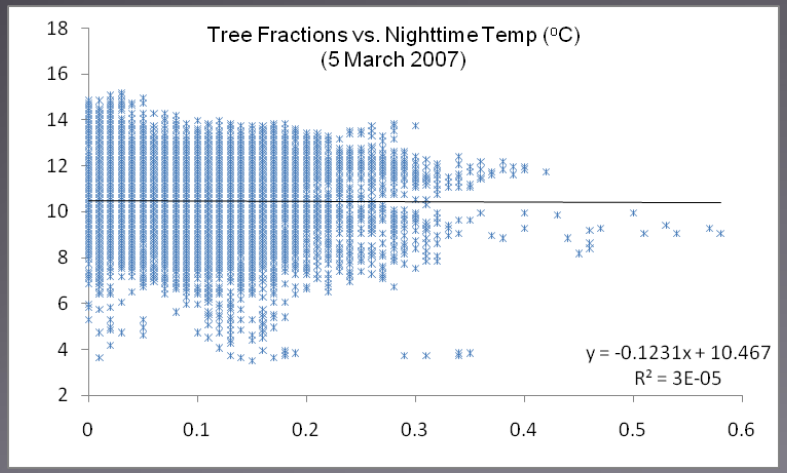


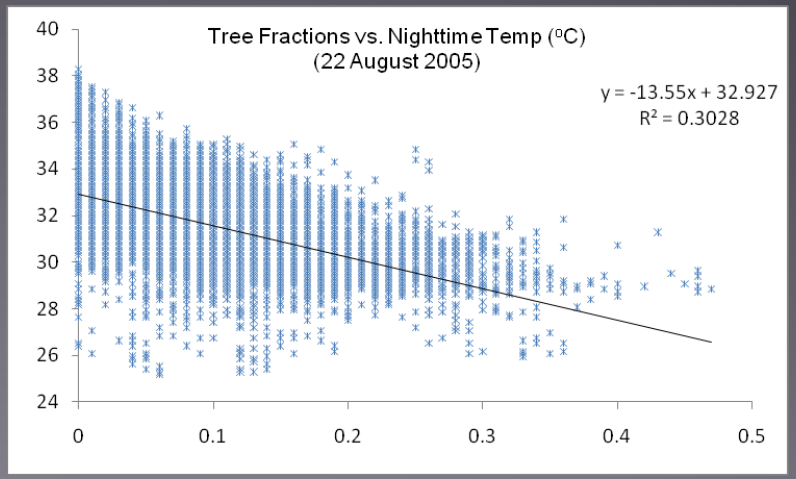


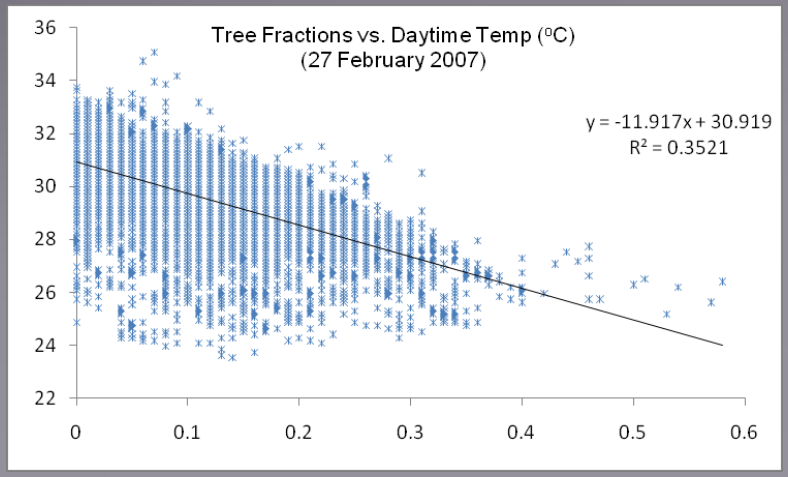


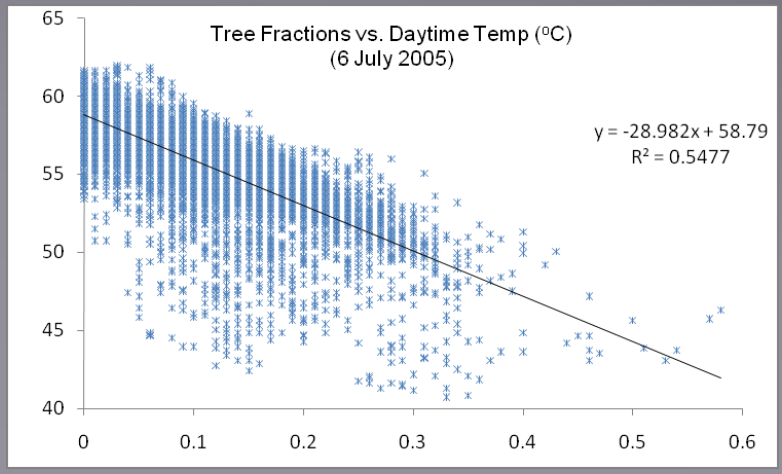


Trees vs. Temperatures

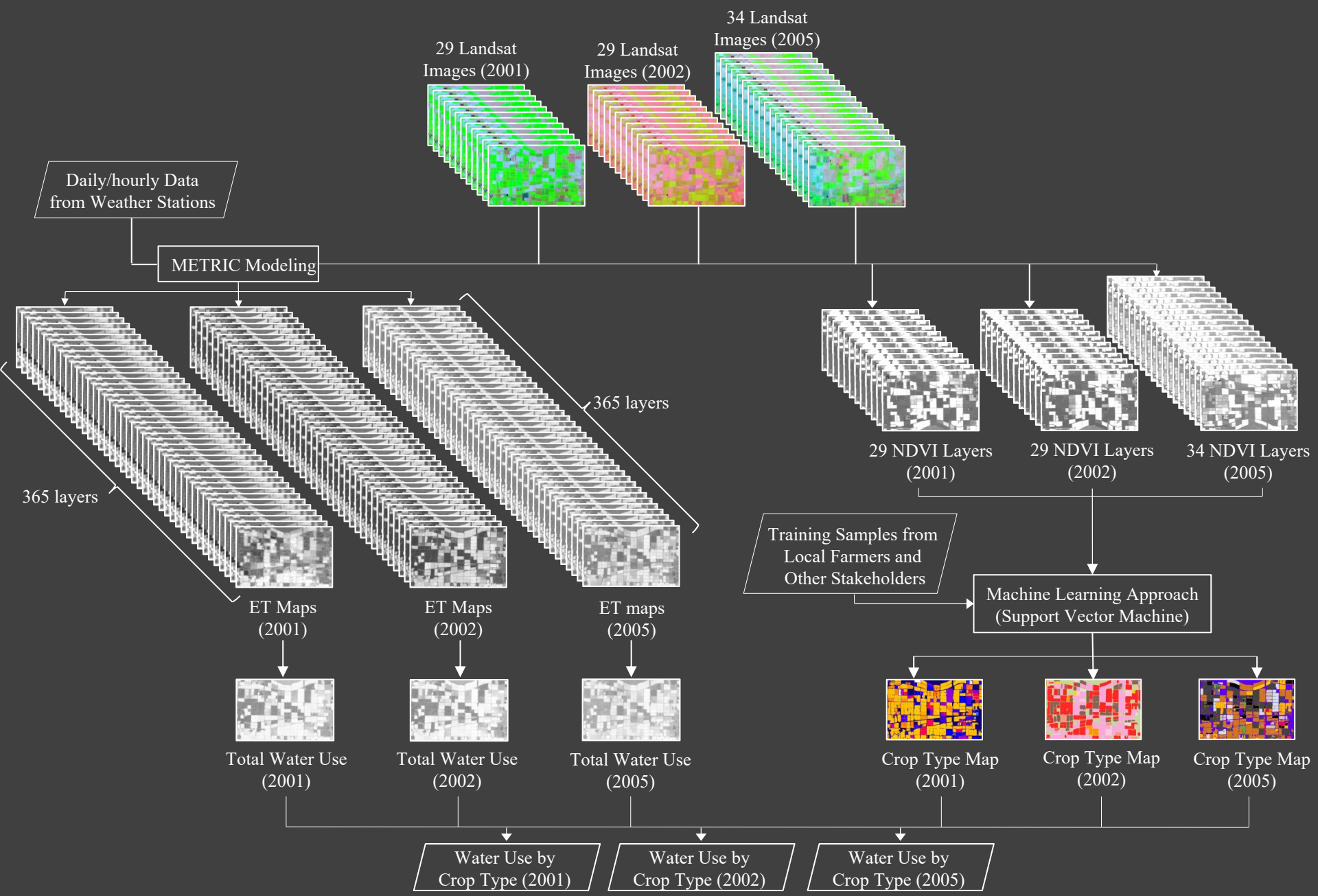




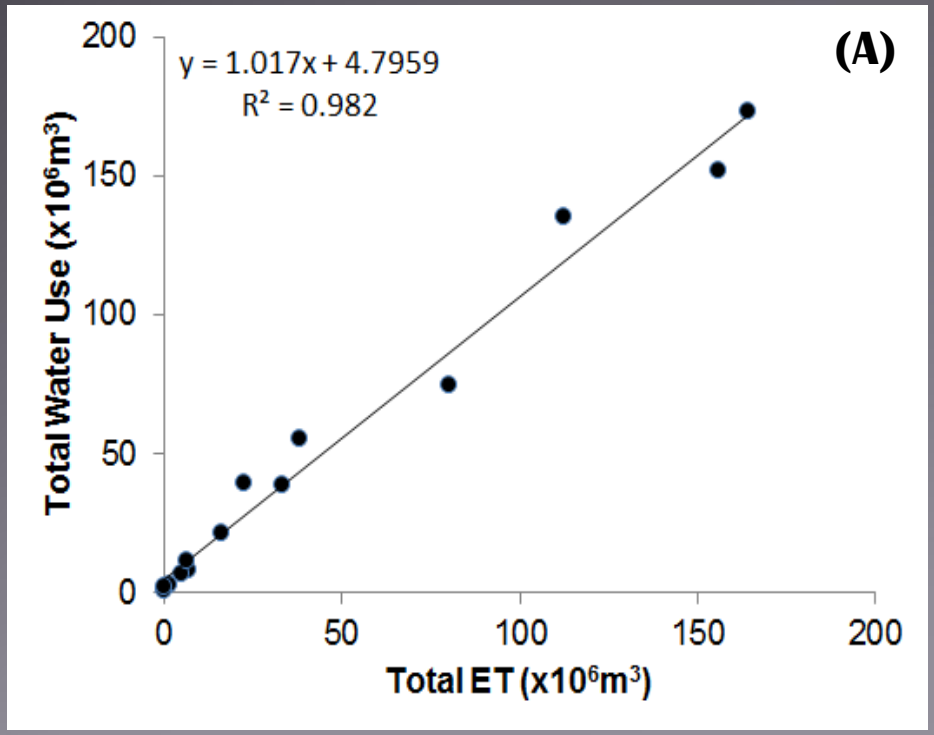




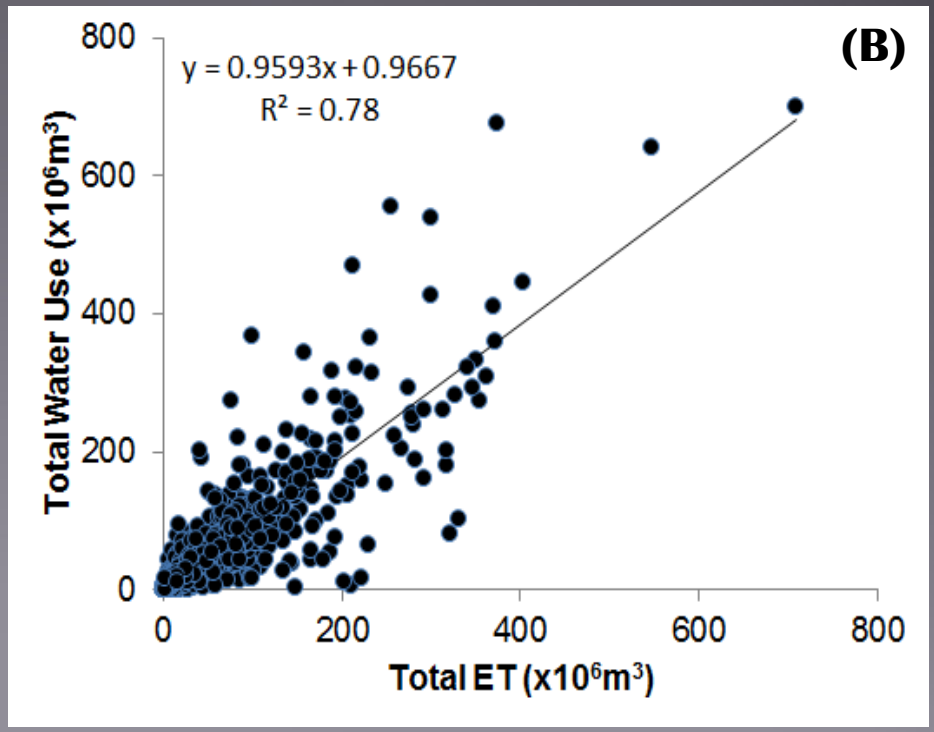
Example Study of Crop Water Use



Comparison between total annual ET and total water use (METTRIC Modeling Procedure)

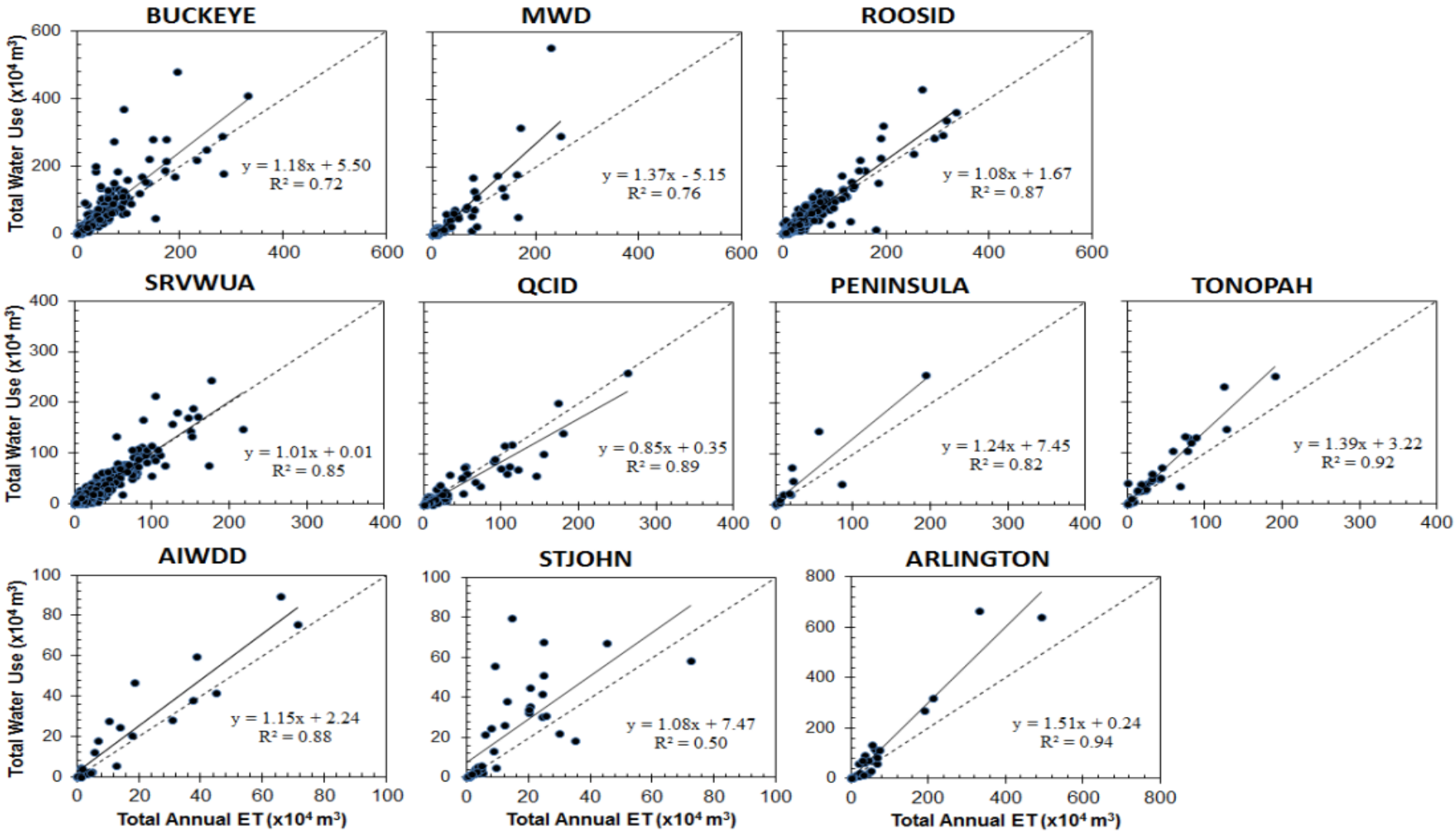


(A) Irrigation district level

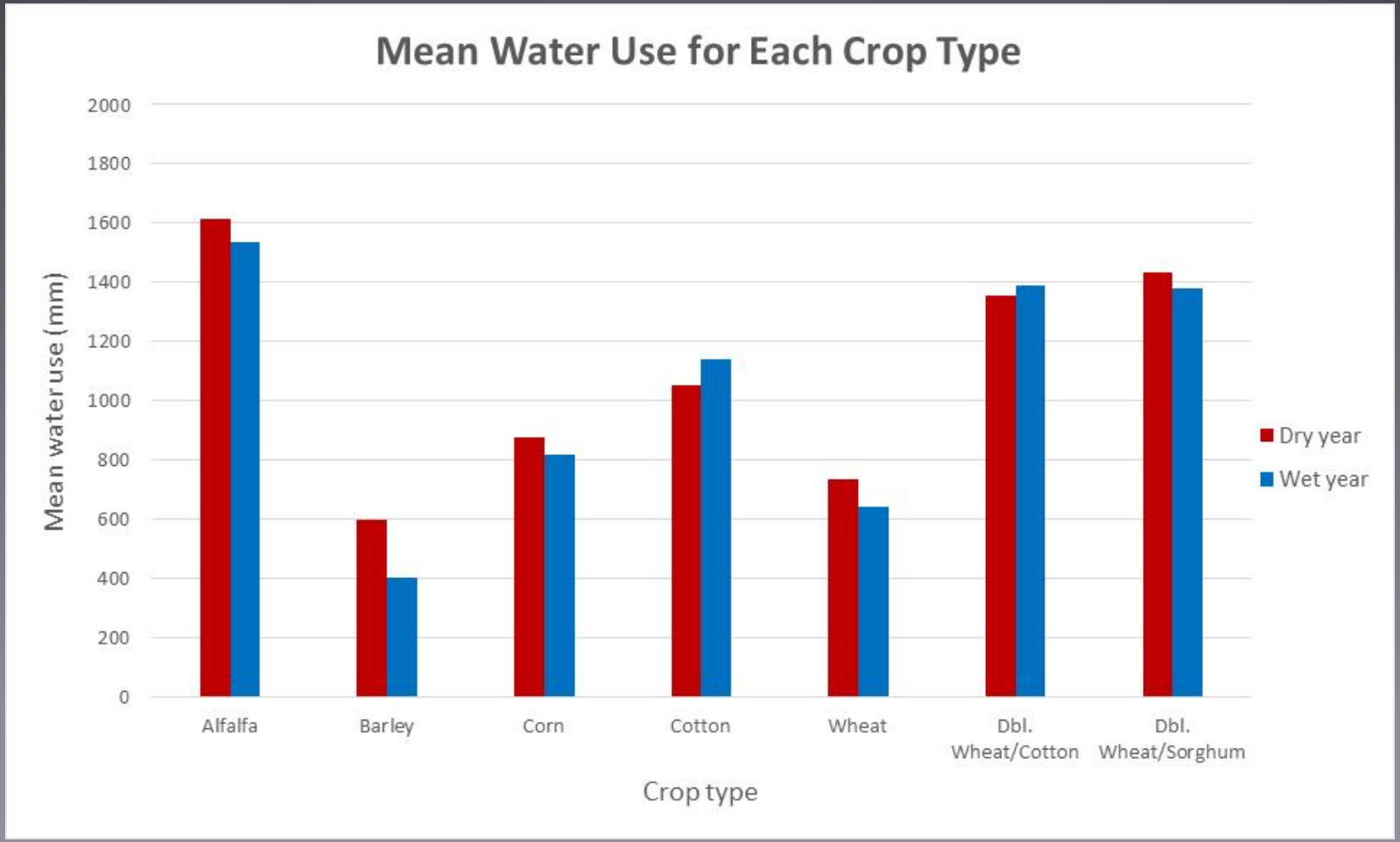


(B) Farm unit level

Comparison between total annual ET and total water use (farm unit level for each irrigation district)



WATER USE


Mean Water Use for Each Crop Type
Mean water use (mm)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Alfalfa
Barley
Corn
Cotton
Wheat
Dbl. Wheat/Cotton
Dbl. Wheat/Sorghum
Crop type
Dry year
Wet year

Significance test of crop water use

Number of obs =	98	R-squared	= 0.9530
Root MSE	= 101.781	Adj R-squared	= 0.9415

Source	Partial SS	df	MS	F	Prob > F
Model	16382967.6	19	862261.453	83.24	0.0000
crop_type	13644609.8	6	2274101.64	219.52	0.0000
district	1058549.38	12	88212.4482	8.52	0.0000
year	108394.45	1	108394.45	10.46	0.0018
Residual	808028.938	78	10359.3454		
Total	17190996.5	97	177226.769		

Preliminary Results

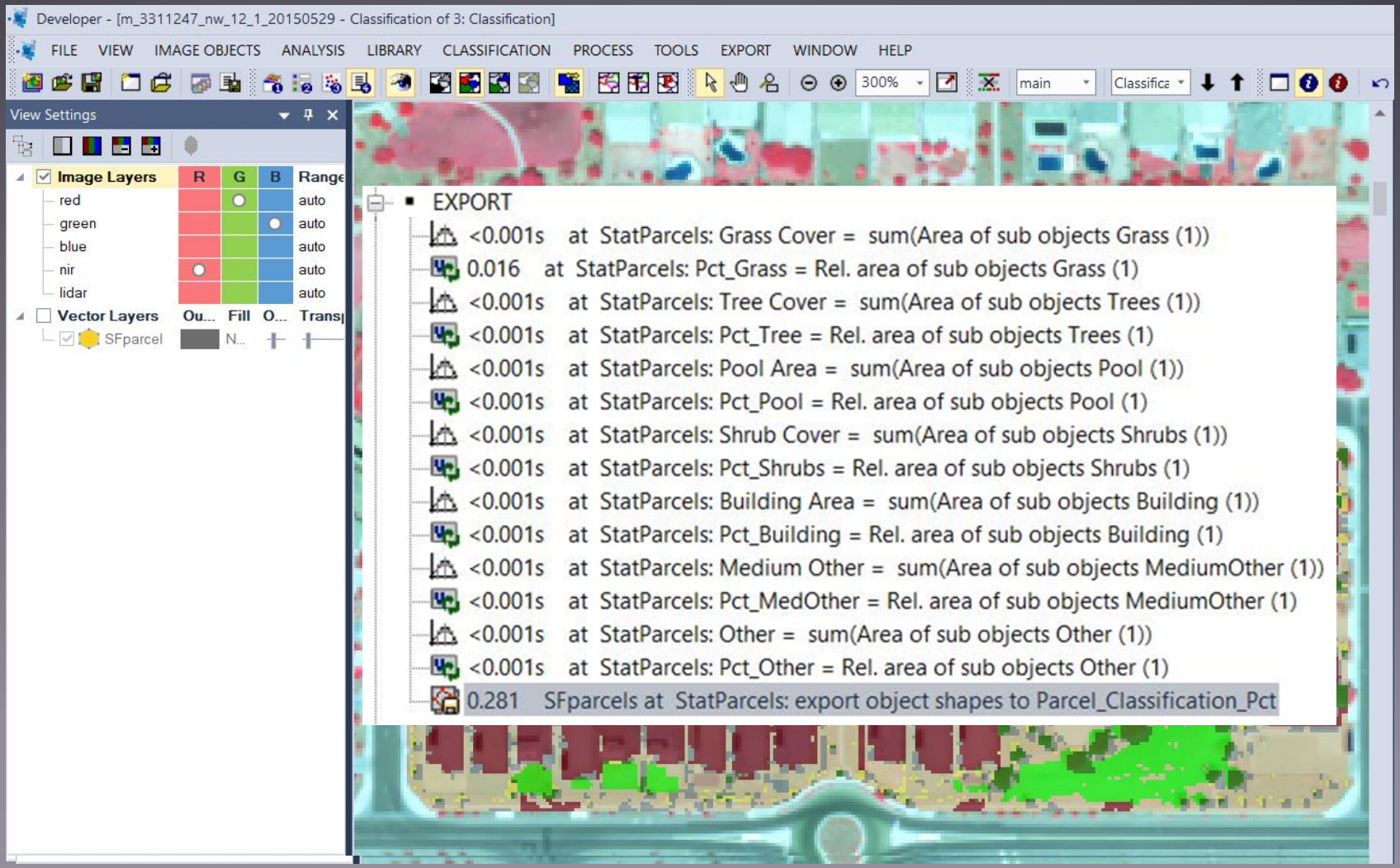
Table 1. Regression results for the relationship between *LST* and percent vegetation cover

R^2	Adj. R^2	MRSE	F	p
0.616	0.598	1.626	34.86	0.000
Variable	**β**	**Std. Err.**	**t**	**p**
G%	-0.135	0.042	-3.20	0.002
S%	-0.118	0.046	-2.57	0.012
T%	-0.243	0.029	-8.28	0.000
SL%	-0.009	0.020	-0.46	0.645
Intercept	54.186	1.120	48.36	0.000

Table 2. Regression results for the relationship between ET_a and percent vegetation cover

R^2	Adj. R^2	MRSE	F	p
0.517	0.495	77.11	23.32	0.000
Variable	**β**	**Std. Err.**	**t**	**p**
G%	10.172	1.997	5.09	0.000
S%	-1.586	2.175	-0.73	0.468
T%	3.680	1.390	2.65	0.010
SL%	-2.114	0.942	-2.24	0.027
Intercept	410.490	53.137	7.73	0.000

Validate Landscape Categories Using Object-based approach and Lidar



Deliverables

- Identification of hot and cold-spot areas

- Classification of opportunity areas where water use could be lowered.

- Urban cooling rate by vegetation cover types in each land use category.

- Water use by different vegetation cover types.

- Variations in water use by vegetation cover type in each land use.

- Identification of evaporative stress areas in each land use category.

- An interactive map showing areas of unmanaged soil or open land in the City of Phoenix in which users may add vegetation cover type (i.e., trees, shrubs, grass) and percent cover of the selected vegetation type to determine how much water per year is needed and how much surface temperatures will be reduced.

Thank you!