

# This presentation premiered at WaterSmart Innovations

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# RECLAMATION

*Managing Water in the West*

## **Correlating Urban Water Demand, Surface Temperature and Vegetation in an Arid Environment**



U.S. Department of the Interior  
Bureau of Reclamation

# Research Questions:

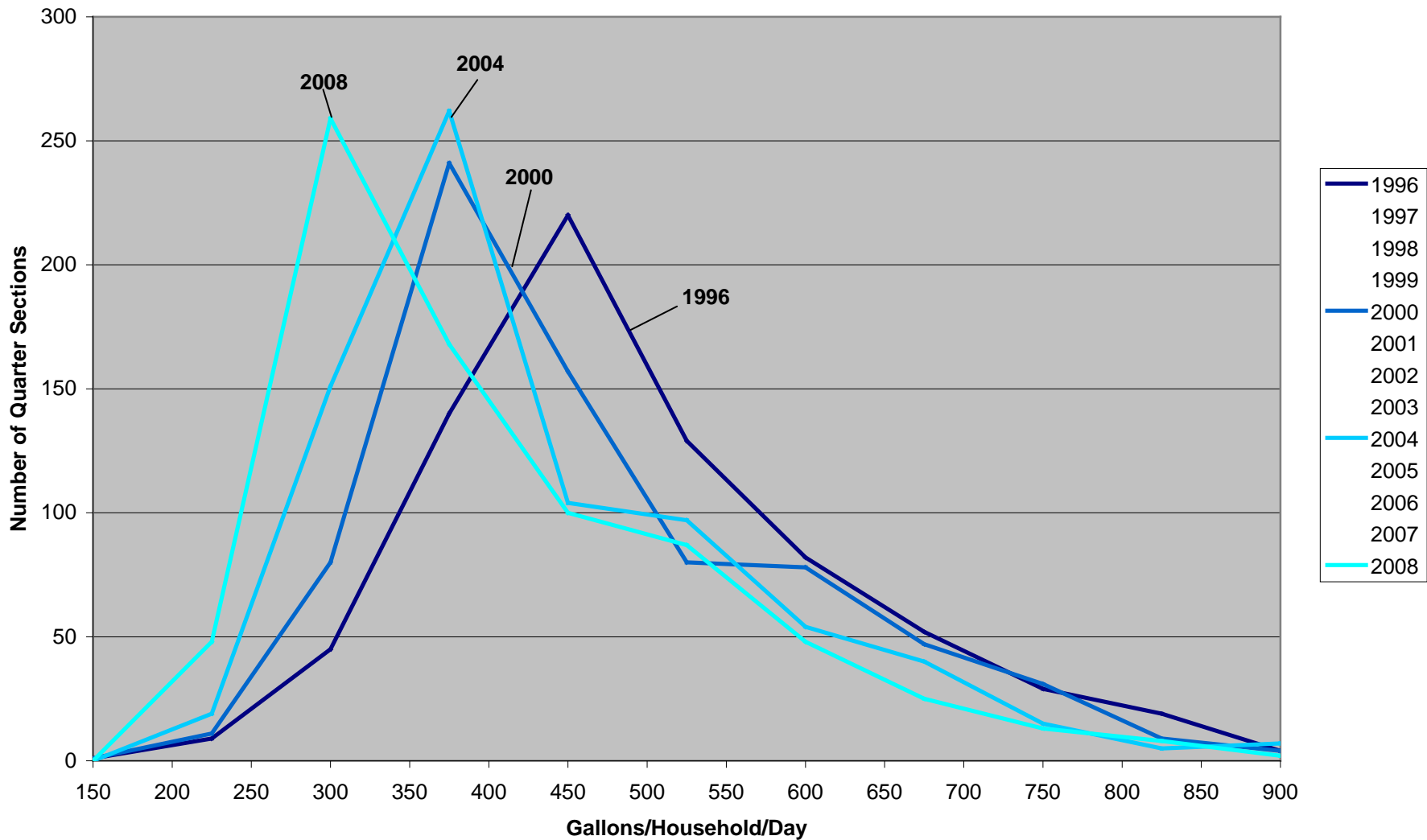
- What are the effects of reduced household water use between 1996 and 2008 on the urban climate of Tucson, AZ?
- Do reductions in household water use result in lower NDVI (“greenness”)?

*Focus on warm, pre-monsoon months (April, May, June) when green vegetation is most likely due to irrigation.*

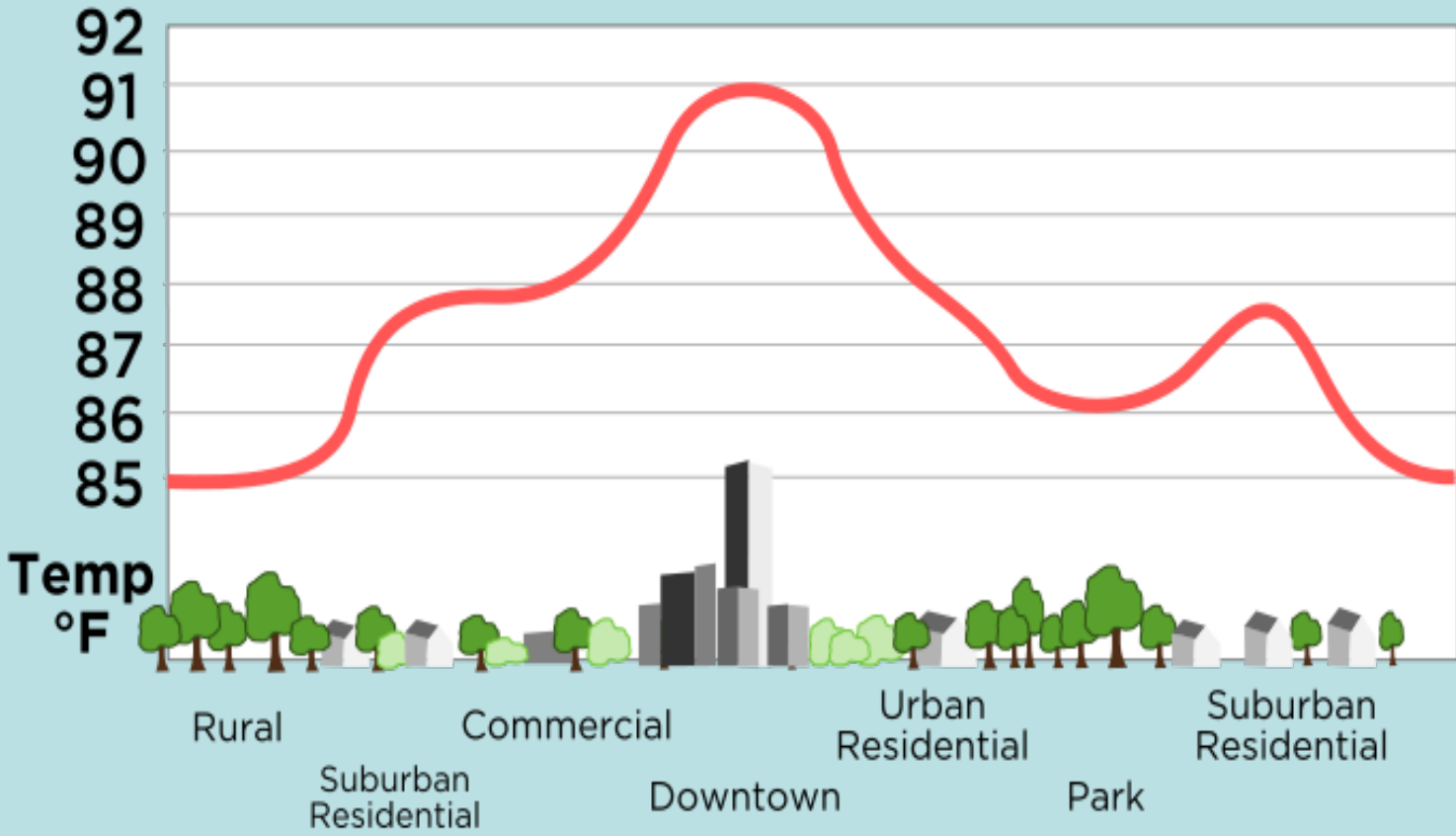
# Data Sets

- **20 Landsat TM and ETM+ images (30 m), 1984 -2006**
  - April, May, June dates
  - Normalized Difference Vegetation Index (NDVI)
- **Single Family Residential Water Use by quarter-section (area 1/2 mile on a side) 1995-2008**
- **Temperature data:**
  - Average of Monthly Minimums
  - Average of Monthly Maximums

# Histograms of AMJ Average Daily Use for SFRs by Quarter Section



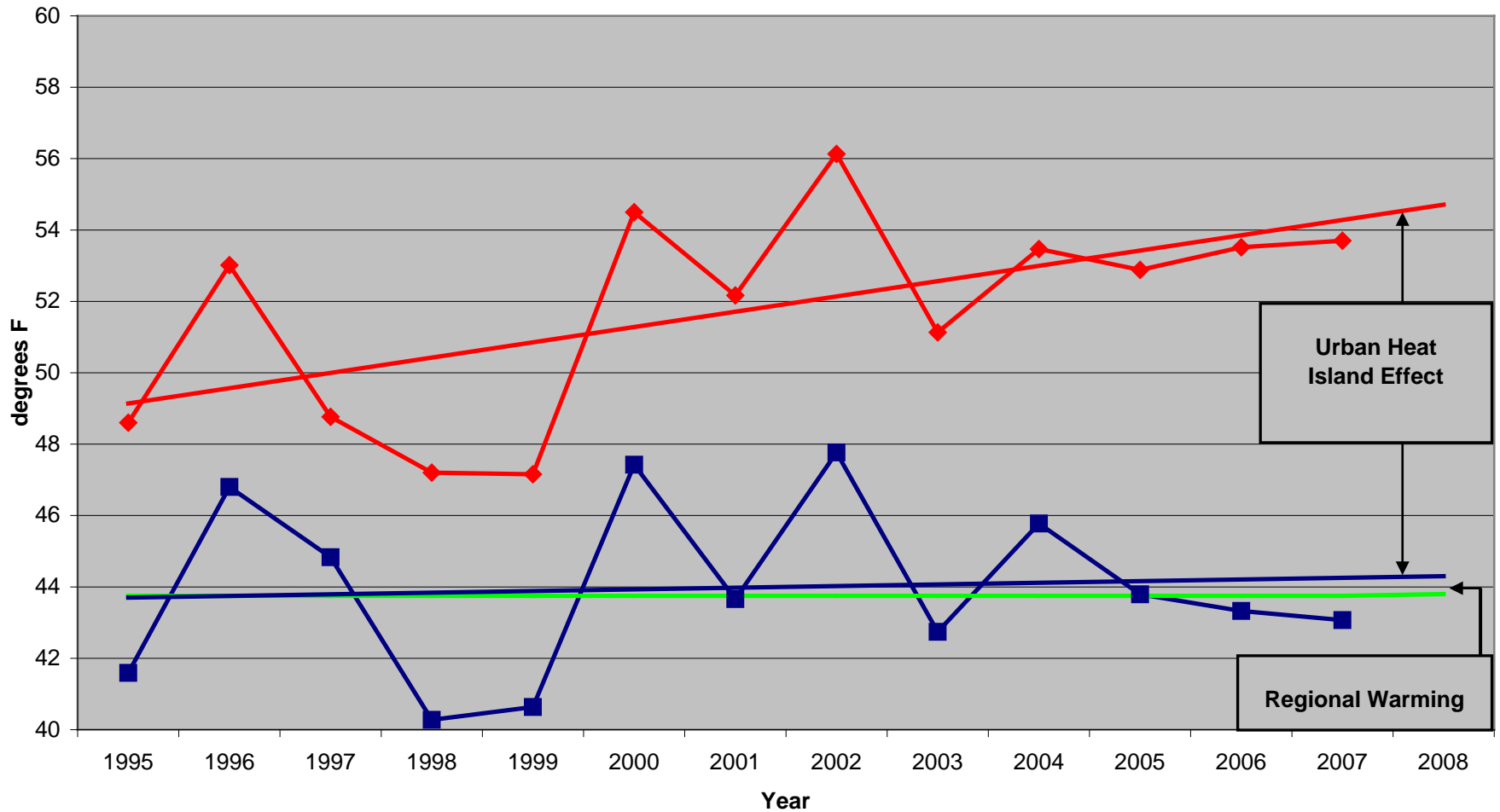
# URBAN HEAT ISLAND PROFILE



Source: Wikipedia

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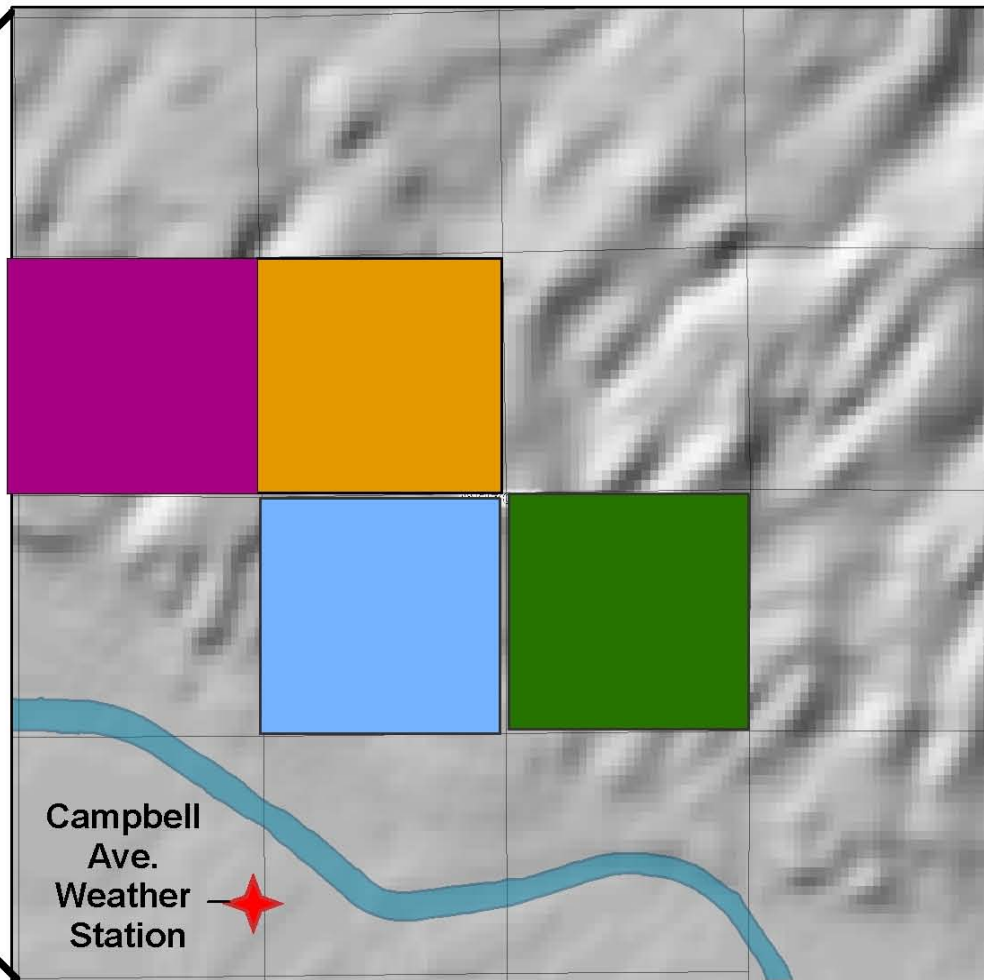
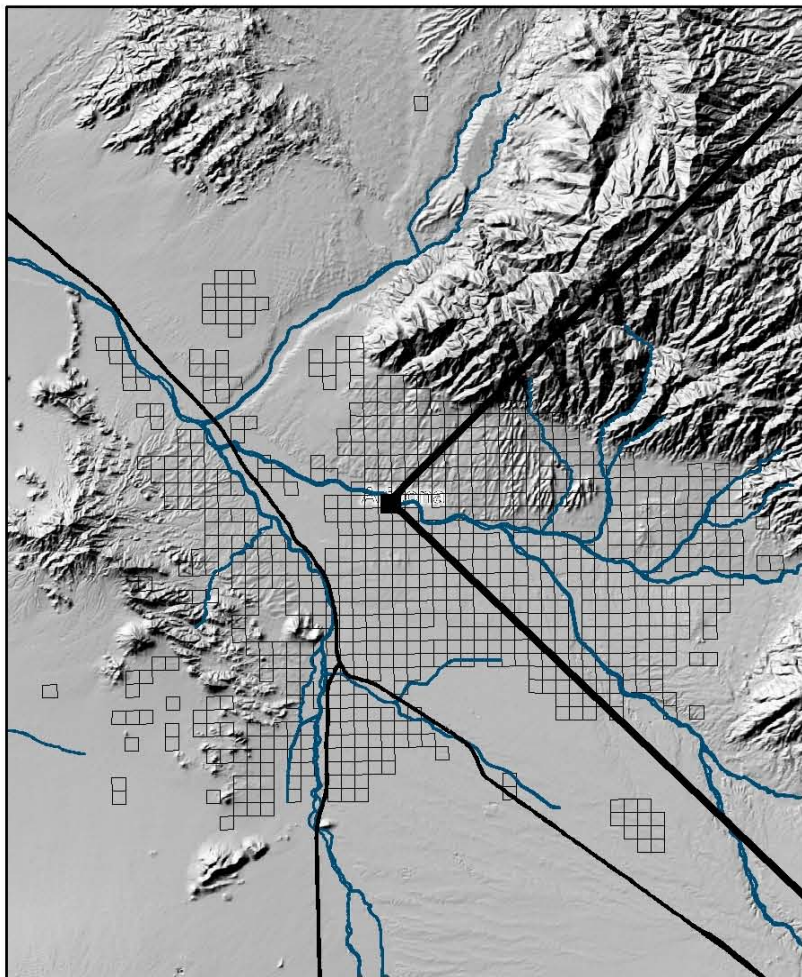
## Example of Urban Heat Island Effect - April average monthly minimums F, Tucson



2 urban stations (Campbell Ave #28796, Tucson WFO #28815) & 4 nonurban stations (Anvil Rnch #20287, Cascabel #21330, Oracle 2SE #26119, Santa Rita Exp Rng #27593)

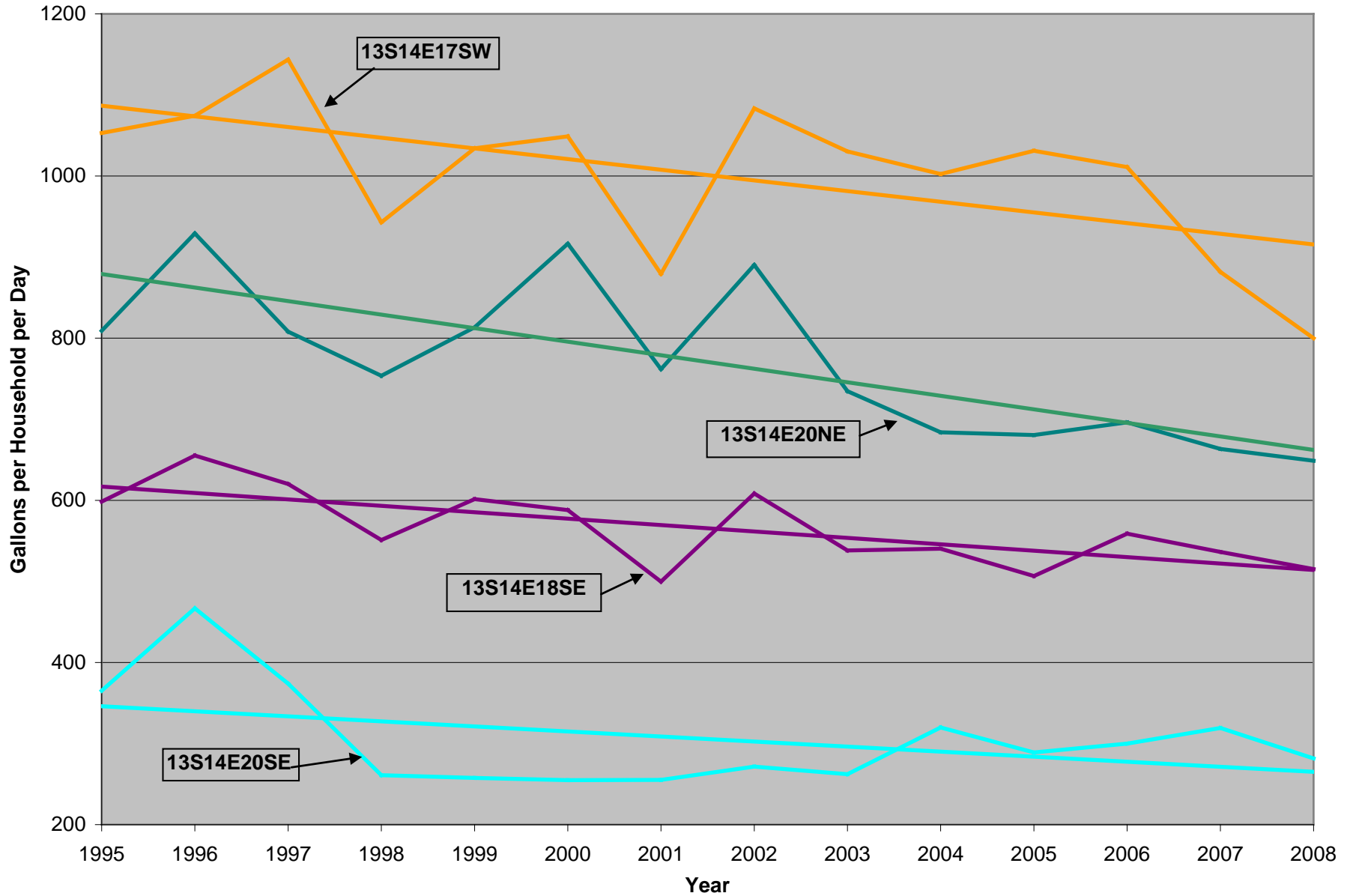
■ Nonurban 
 ◆ Urban 
 — 1995 Non-Urban 
 — Linear (Nonurban) 
 — Linear (Urban)

# Focus on Quarter-Sections Near Campbell Ave Weather Station

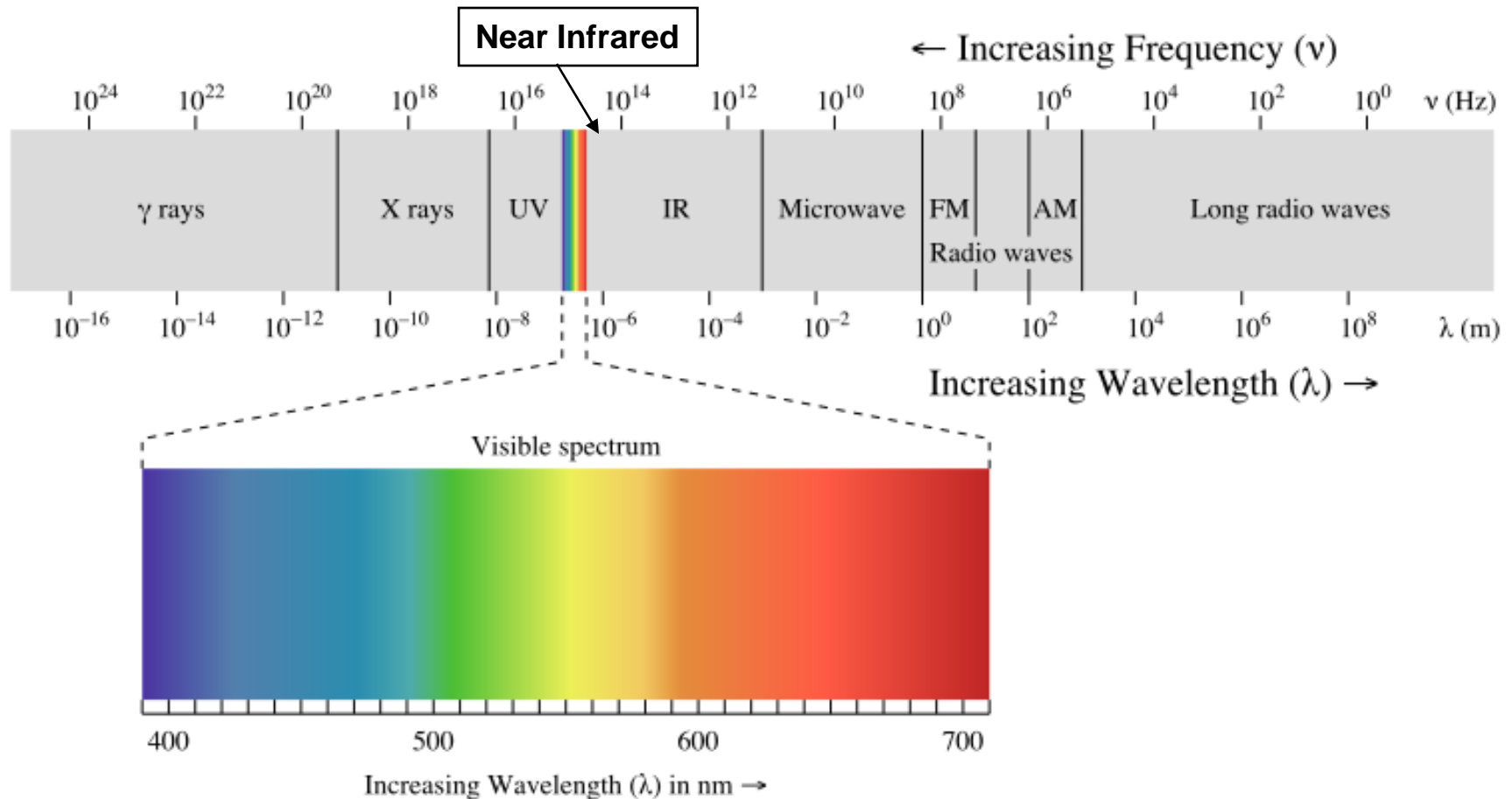




Average of April, May and June Daily Household Use, 1995 - 2008



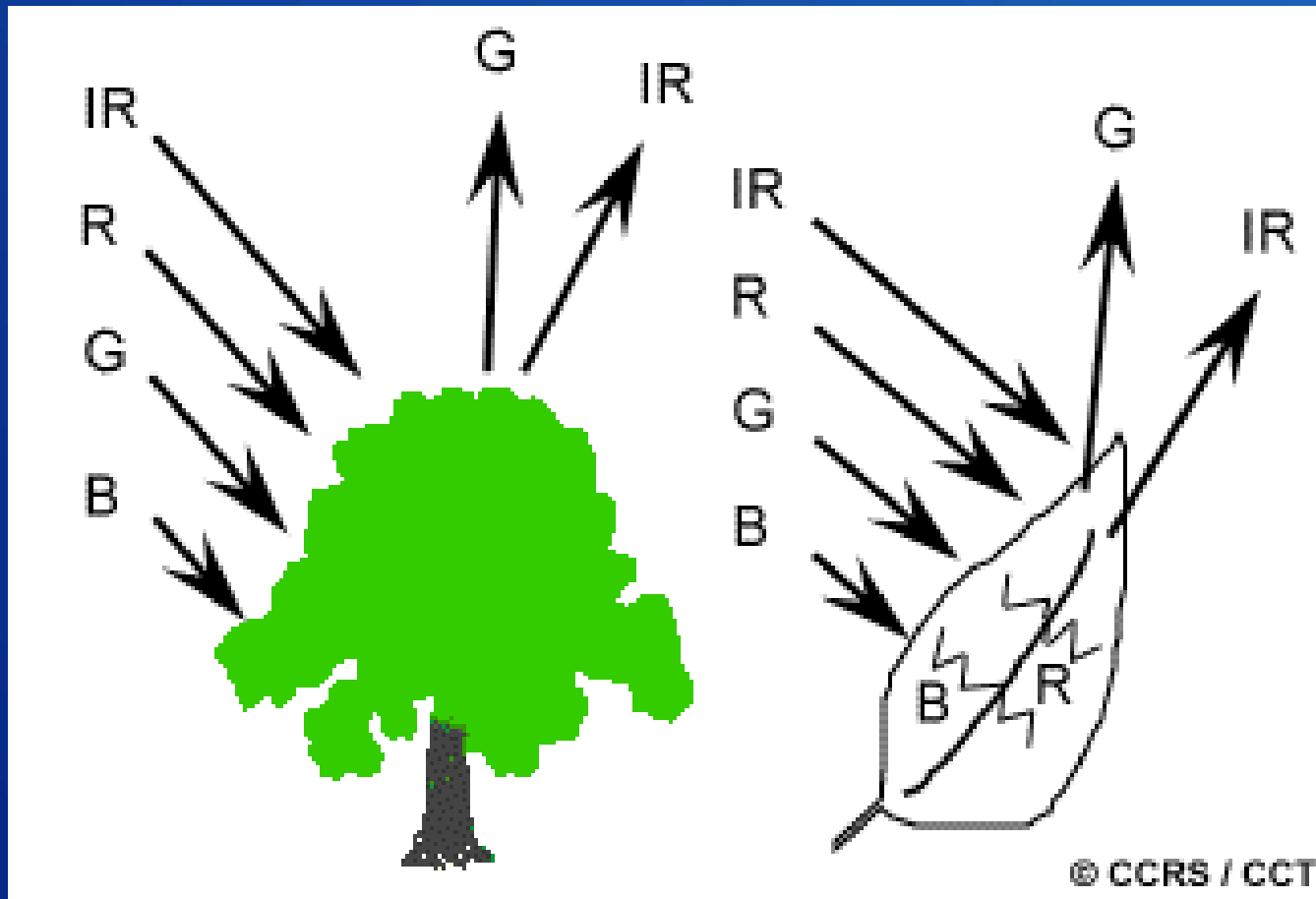
# Electro-magnetic spectrum



Courtesy of Philip Ronan and Wikipedia

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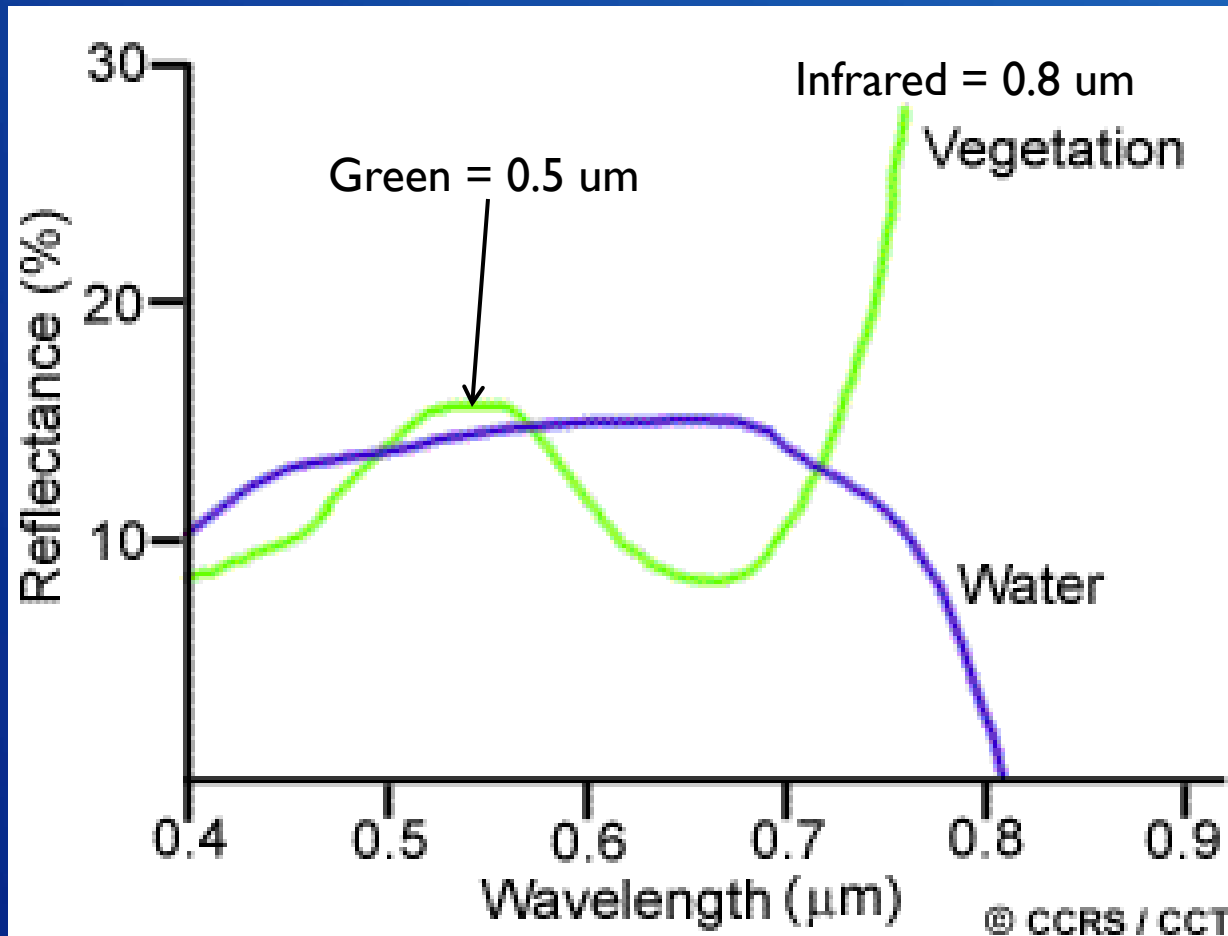
# Green plants reflect green and infrared wavelengths



Source: Natural Resources Canada

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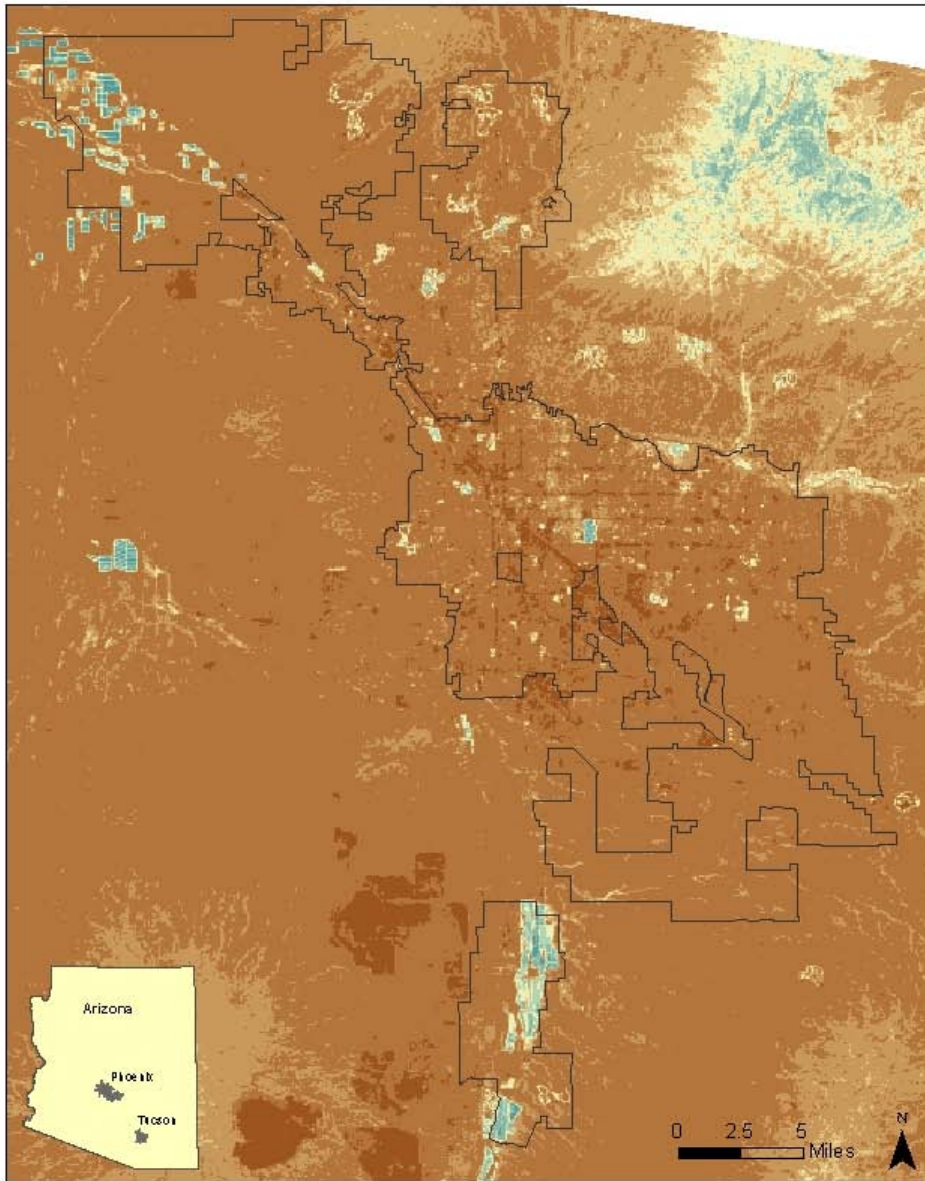
# Green vegetation has a unique “spectral signature”



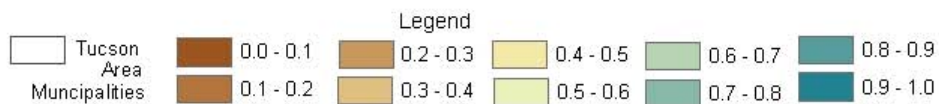
Source: Natural Resources Canada

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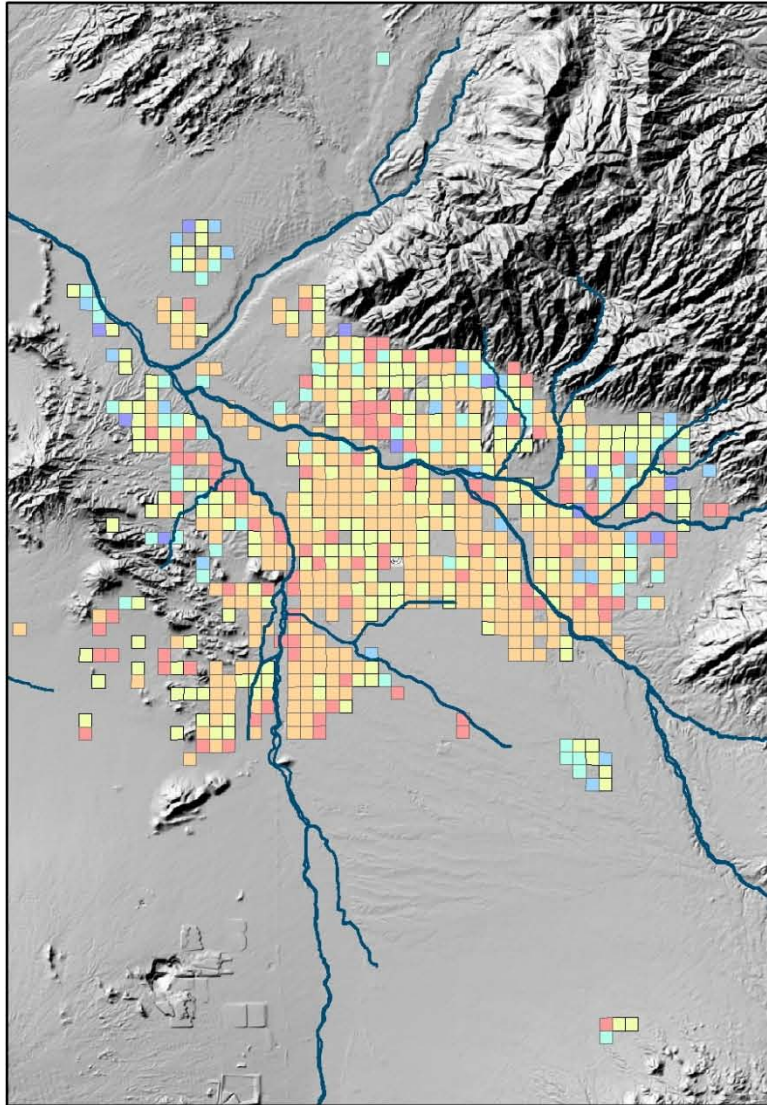
NDVI on 05/06/2003  
Tucson Metropolitan Area



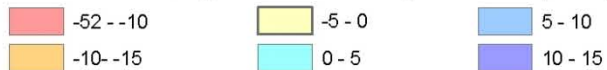
# NDVI for Tucson Metro Area



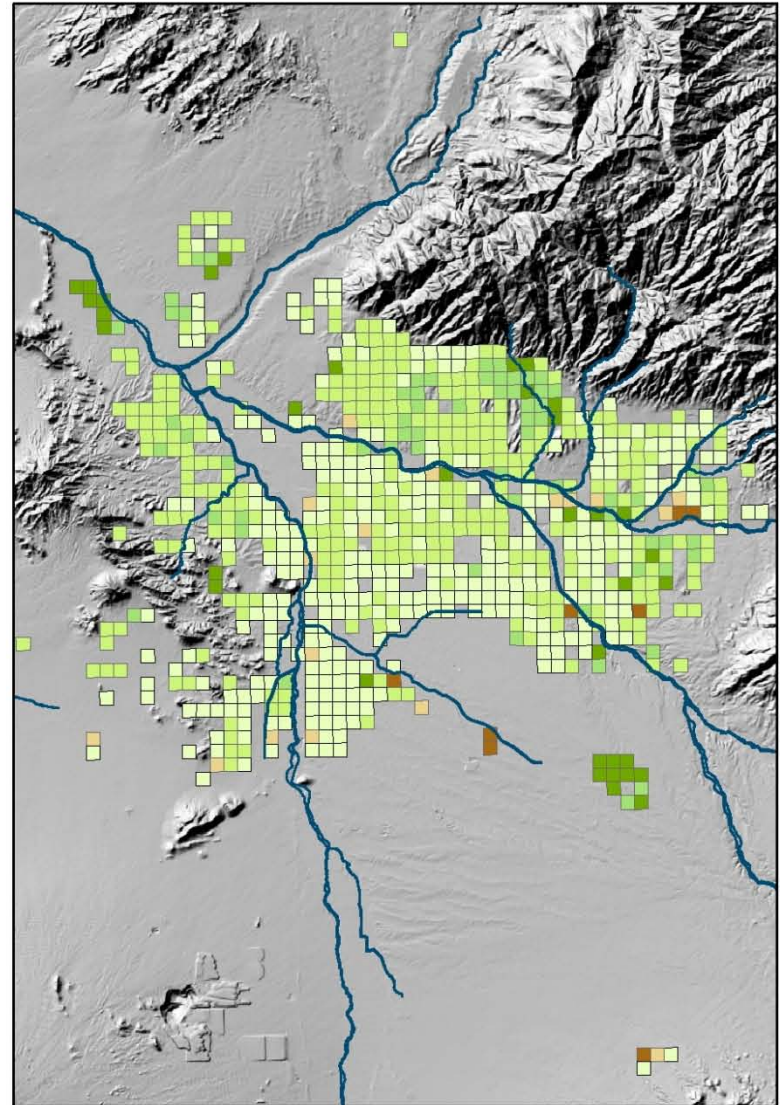
Trend of AMJ SFR use by QS, 1996 - 2008



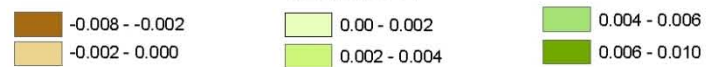
Trend of AMJ SFR Avg Water Use - Gallons per Household per Day



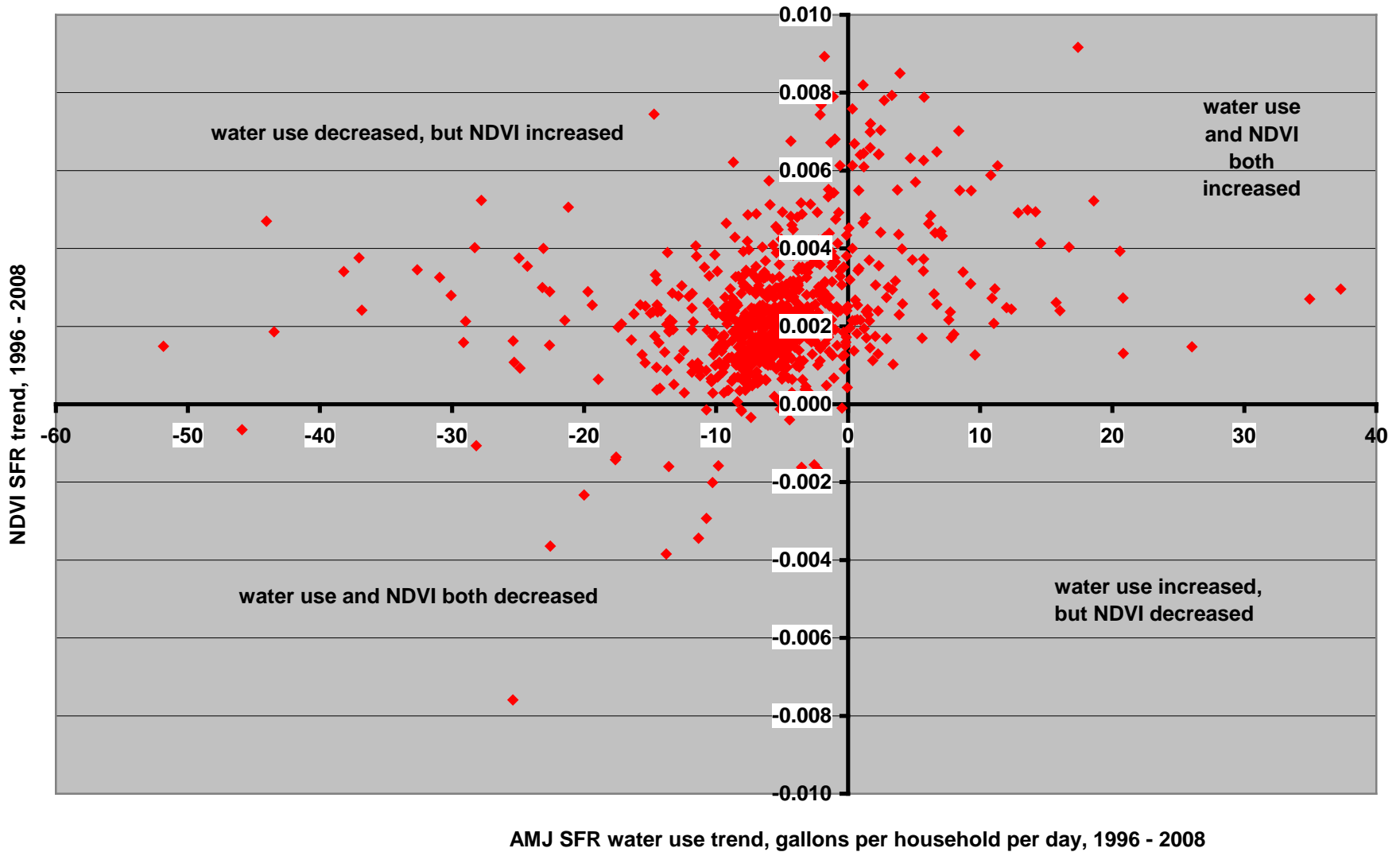
Trend of Landsat NDVI by QS, 1996 - 2008



NDVI SLOPE



**NDVI trend vs. AMJ SFR trend, for quarter sections with full 14 y record**  
**Units: gallons per household per day**



# Interim Conclusions

- Most quarter-sections are using less water per household
- Minimum and maximum temperatures rose in Tucson between 1995 and 2008
- However, NDVI for most quarter-sections also increased slightly. Why?
- Possibility of change from water intensive to desert landscaping



# Acknowledgements:

- **Investigators:**
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- **Pima County Department of Transportation GIS Program**
- **U.S. Bureau of Reclamation**