Resilience in urban socioecological systems: residential water management as a driver of biodiversity

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Regional/Global

Natural Environment

Human Impact

Ecosystem

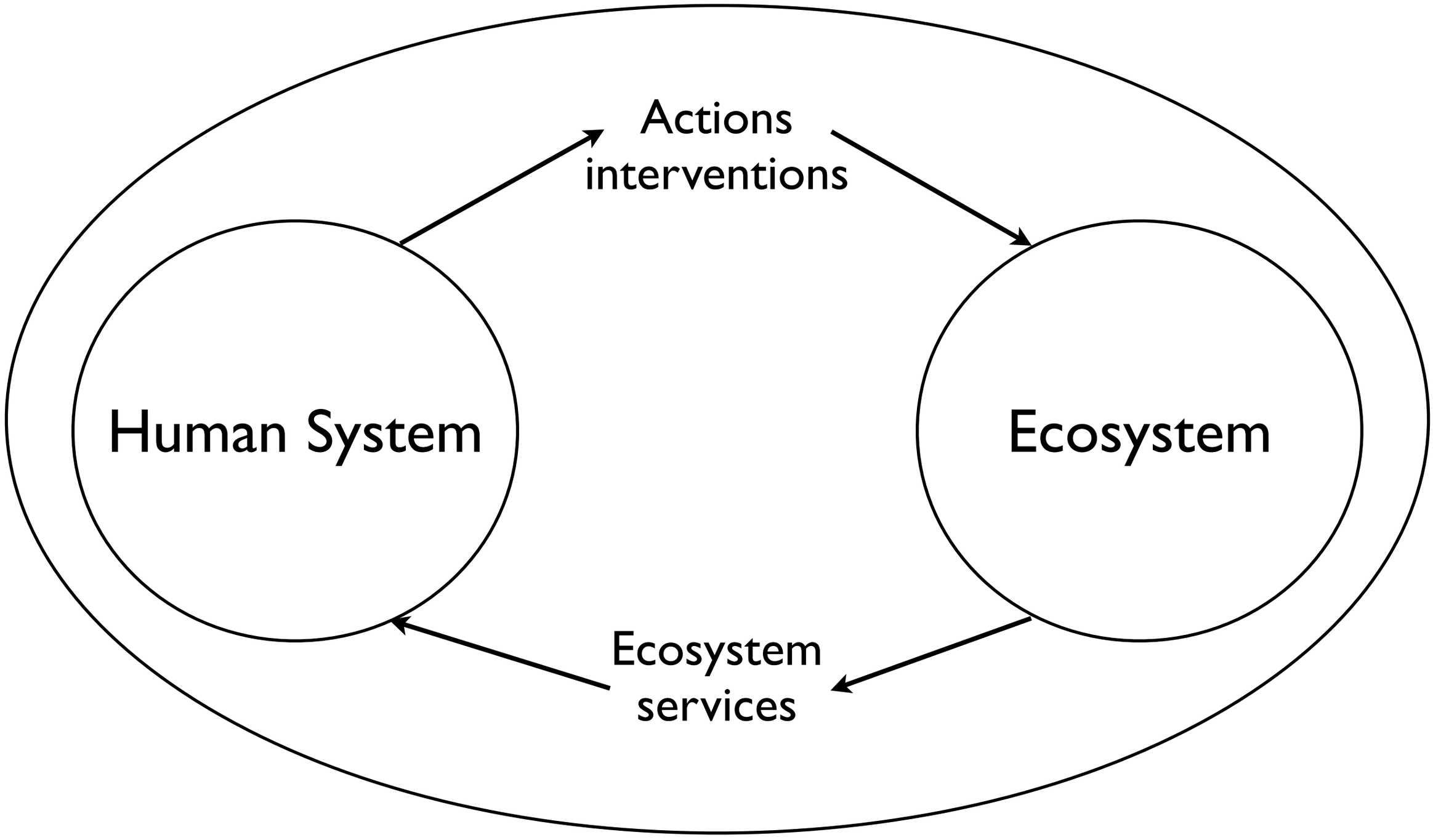
Community

Population

Individual responses

Behavior, Physiology, Life History

A coupled socioecological system (SES)



Unpacking the black box of "human impact"

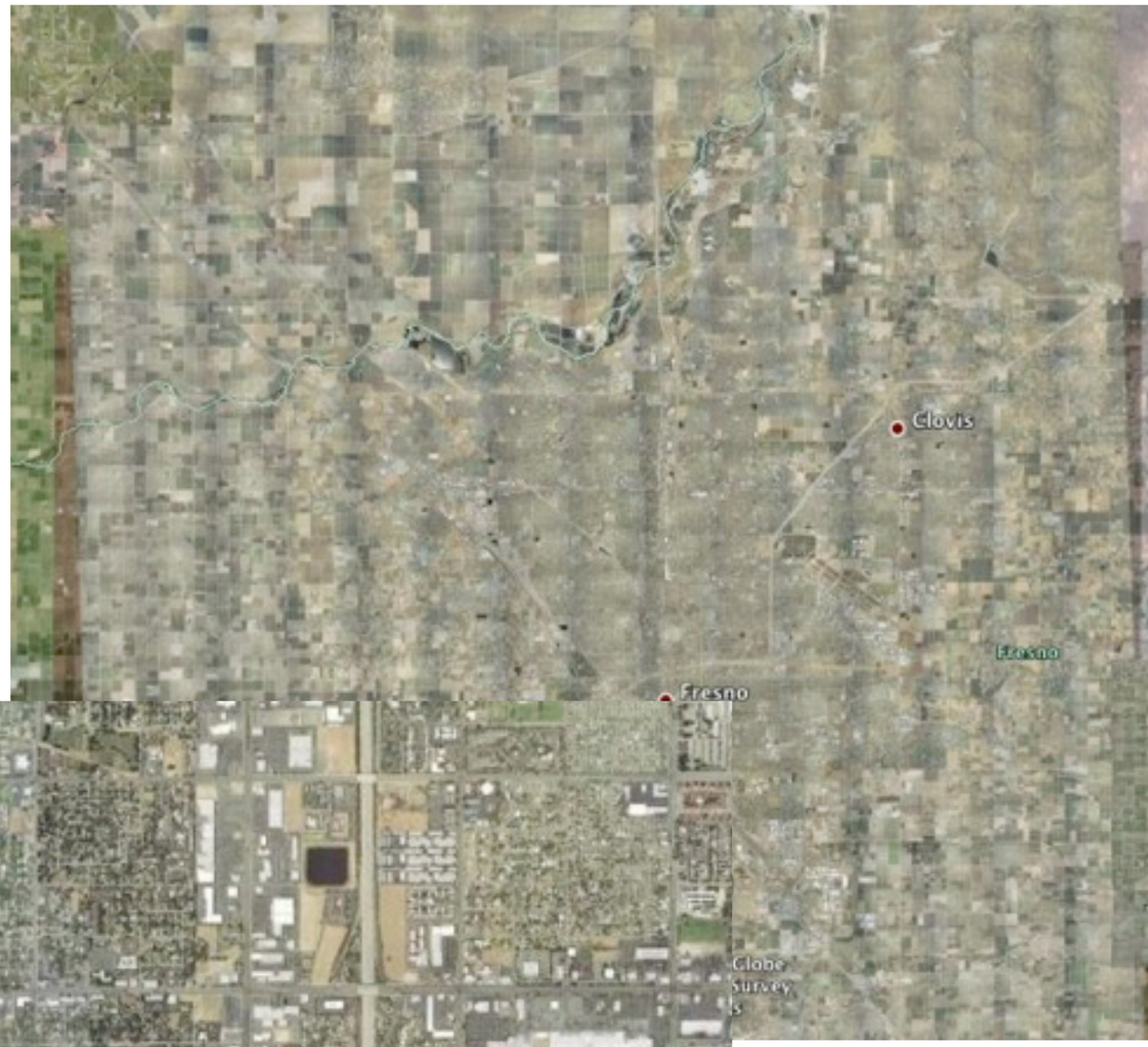
- Human actions alter the ecosystem (directly and indirectly), e.g. by altering land-use/land-cover (LULC) with diverse effects on other species
- Human actions are complex products of interactions among many variables:
  - economic characteristics
  - sociological arrangements
  - cultural characteristics and background
  - institutional arrangements
  - politics

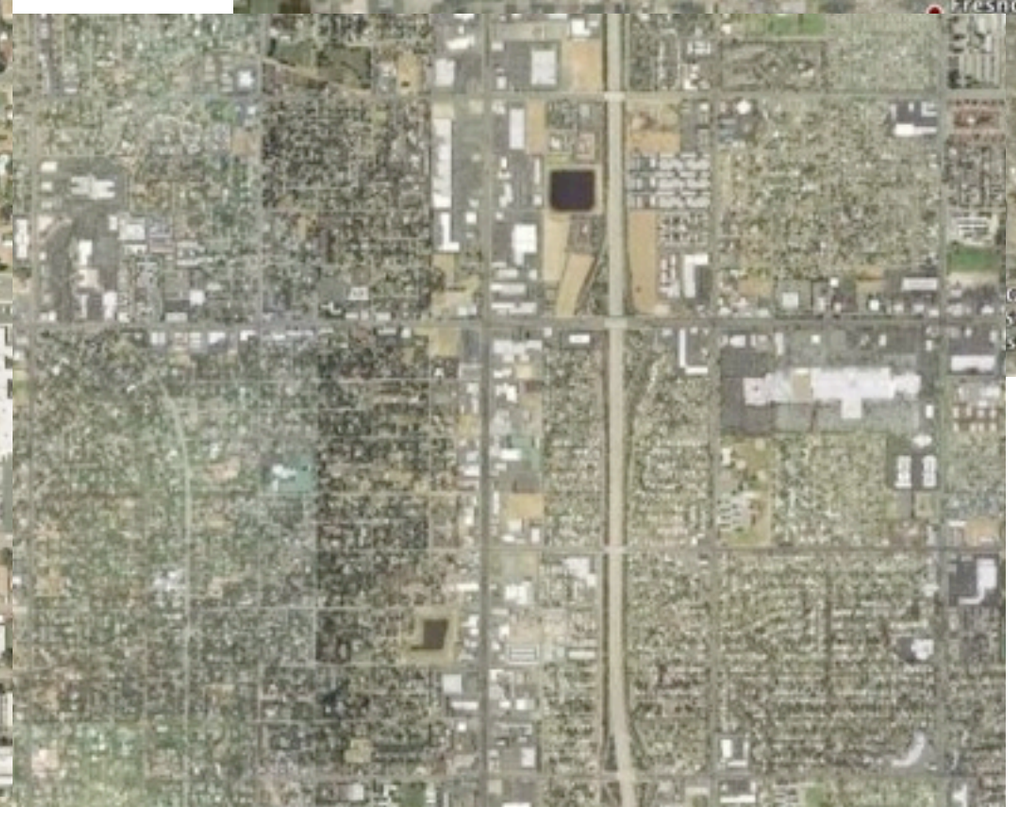
Residential water use in Fresno

- Currently, 51% of water is used residentially
- 70% of residential water used for irrigation
- Starting in 2013, flat rate water will be replaced by metered water
- As water becomes more expensive, residents are expected to reduce consumption
- Residential irrigation is therefore predicted to decrease
- Decreased irrigation is in turn predicted to alter bird diversity
- The effects may be more extreme in impoverished urban areas

Challenges and Data Needs for Urban Ecology

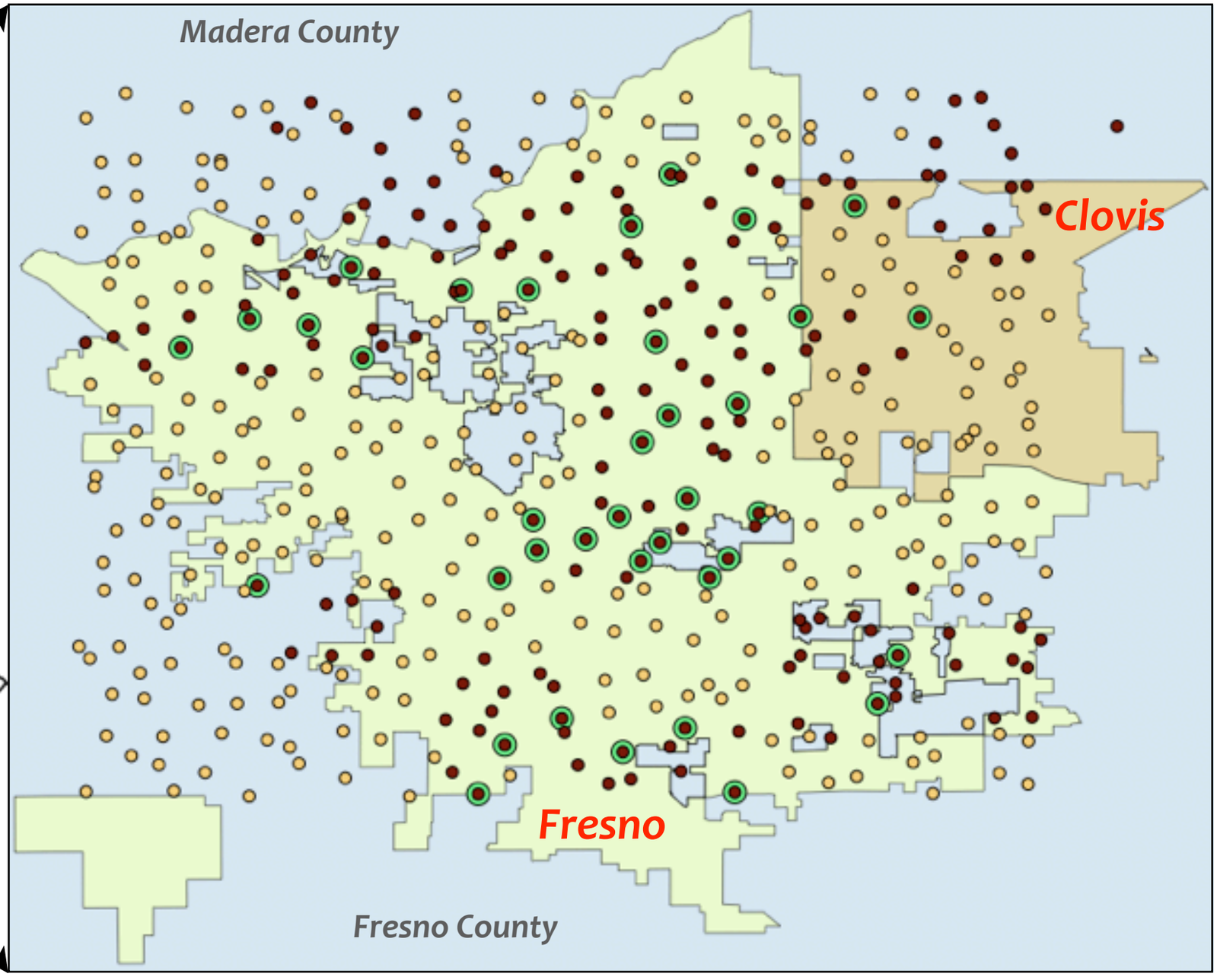
- Urban habitats are highly variable
  - many different land uses
  - rapid changes over short distances
  - need many sites for data precision
- Many species of birds
- Measurements must be repeatable at same sites over years





Fresno-Clovis Metro Area (FCMA)

Fresno Bird Count Study Area



- FBC site (N=460)
- Censused in 2008 (N=200)
- Habitat surveyed (N=38)

Fresno Bird Count - April 15-May 15:

Survey Design & Census Methodology

- 460 sites on a 1Km X 1Km grid
  - each site located randomly within a single grid cell
- Grouped into 58 clusters (routes) of 7-8 sites each
  - possible to cover all sites in a single morning
- Counts conducted within 4 hours after sunrise
- Point Count
  - 5-minute duration
  - count all birds seen & heard
  - within a 40m-radius circle
- ~200 points surveyed during 2008 and 2009 each

Fresno Bird Count - April 15-May 15:

Habitat and Socioeconomic Assessment

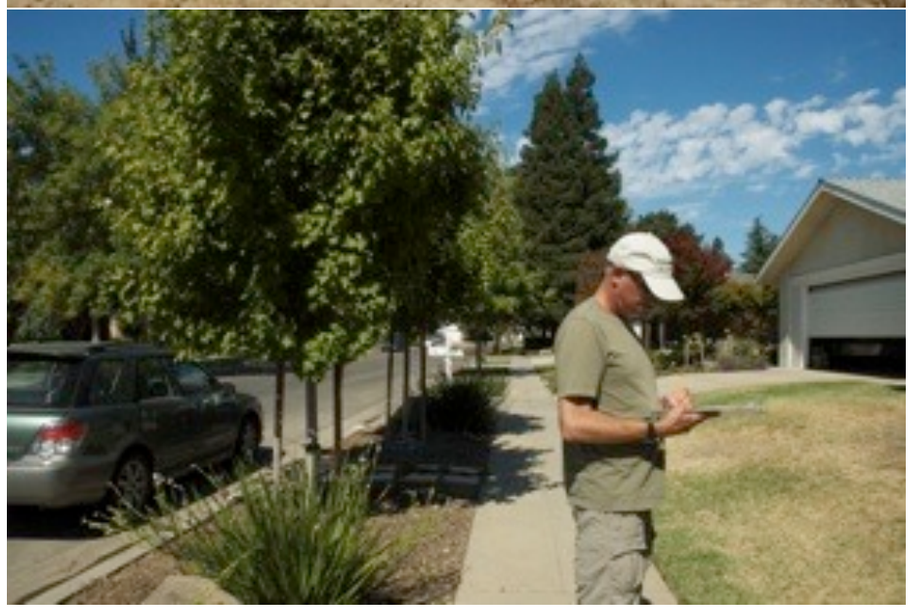
- A subset of 38 points, located in residential areas only
- Rapid survey of habitat variables at 20m-radius plots
  - % Canopy Cover
  - Ground cover: % grass, impervious, dirt/mulch, buildings, gravel
  - Number of Trees
  - Average Tree Height
  - Number of Shrubs
  - Average Shrub Height
  - Grass Height
  - Irrigation intensity score (4 point scale: 0-3) for each residence overlapping plot; *Mode of score is used in analyses presented here*
  - % population in surrounding census block group living below poverty level (<$18,310/yr for a family of three)*

**US Census, Department of Health and Human Services 2008 - 2009*

Examples of Irrigation Regimes

0

2



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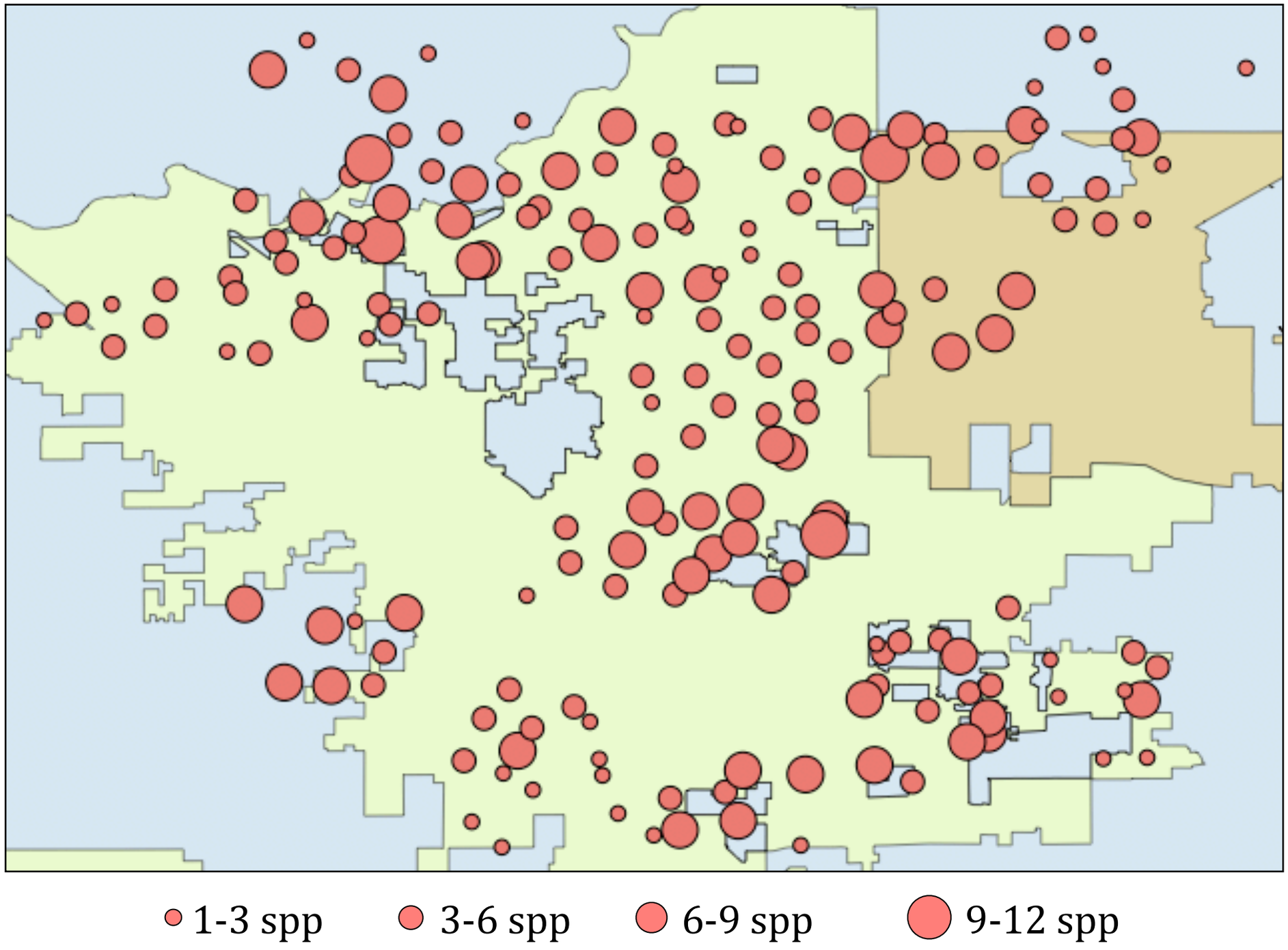
Distribution of Bird Species Richness in the FCMA

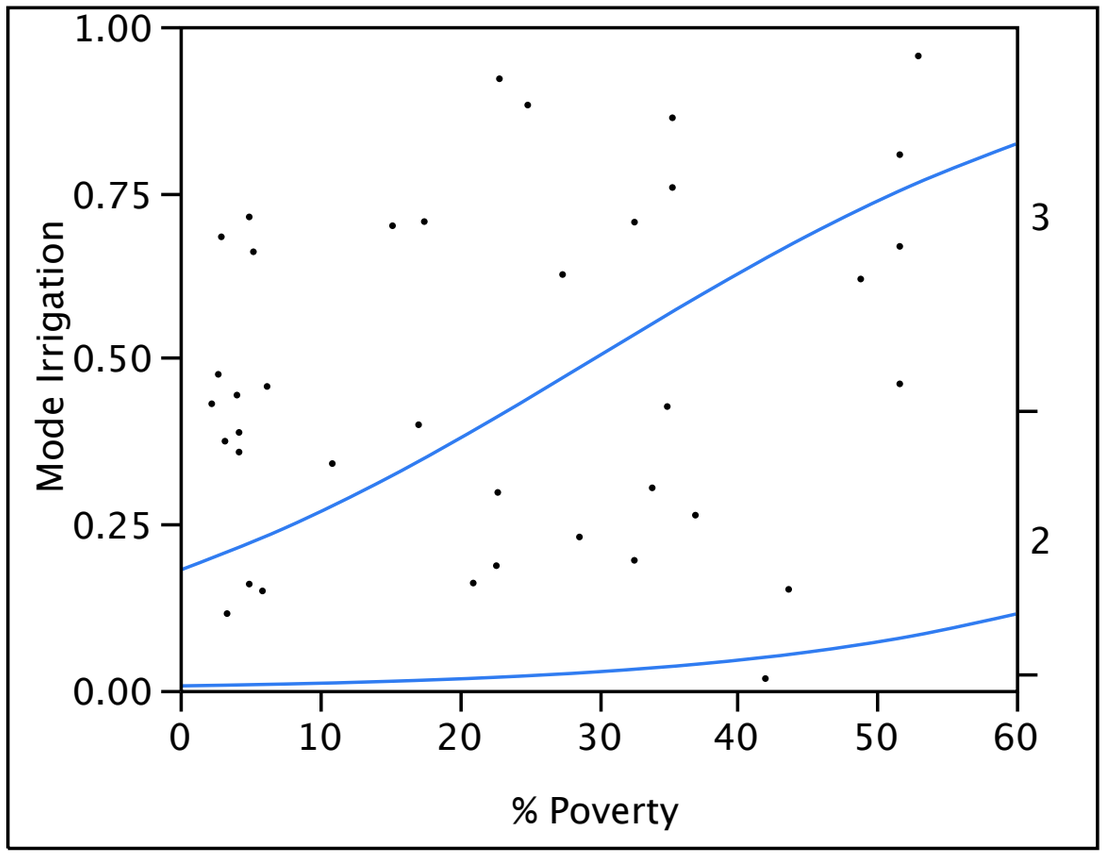
In 2008

- 186 points surveyed by 35 volunteers
- 86 bird species recorded
- 3263 total birds seen
- Average species richness per site: 5.13 ± 0.16 SE



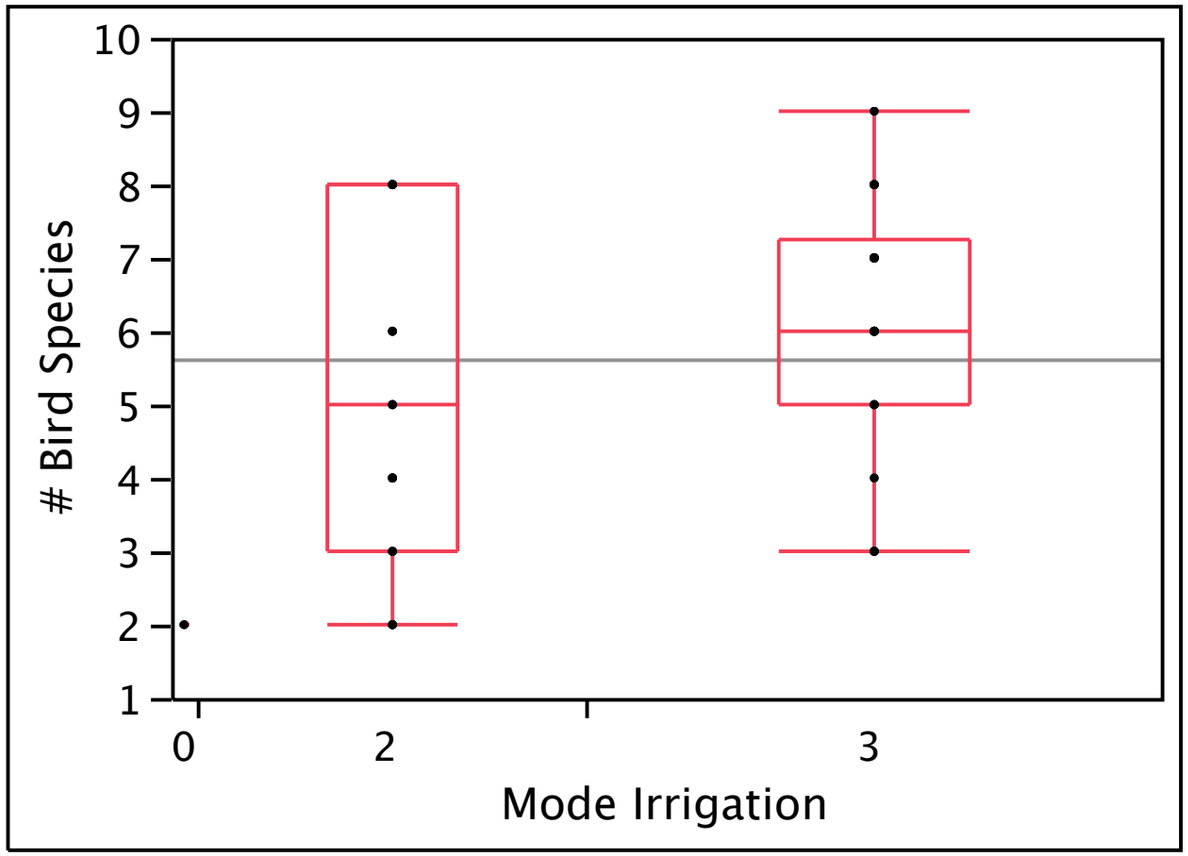
Irrigation is correlated with...

Poverty



$R^2(U) = 0.10$, X^2 p $= 0.01$, N=38

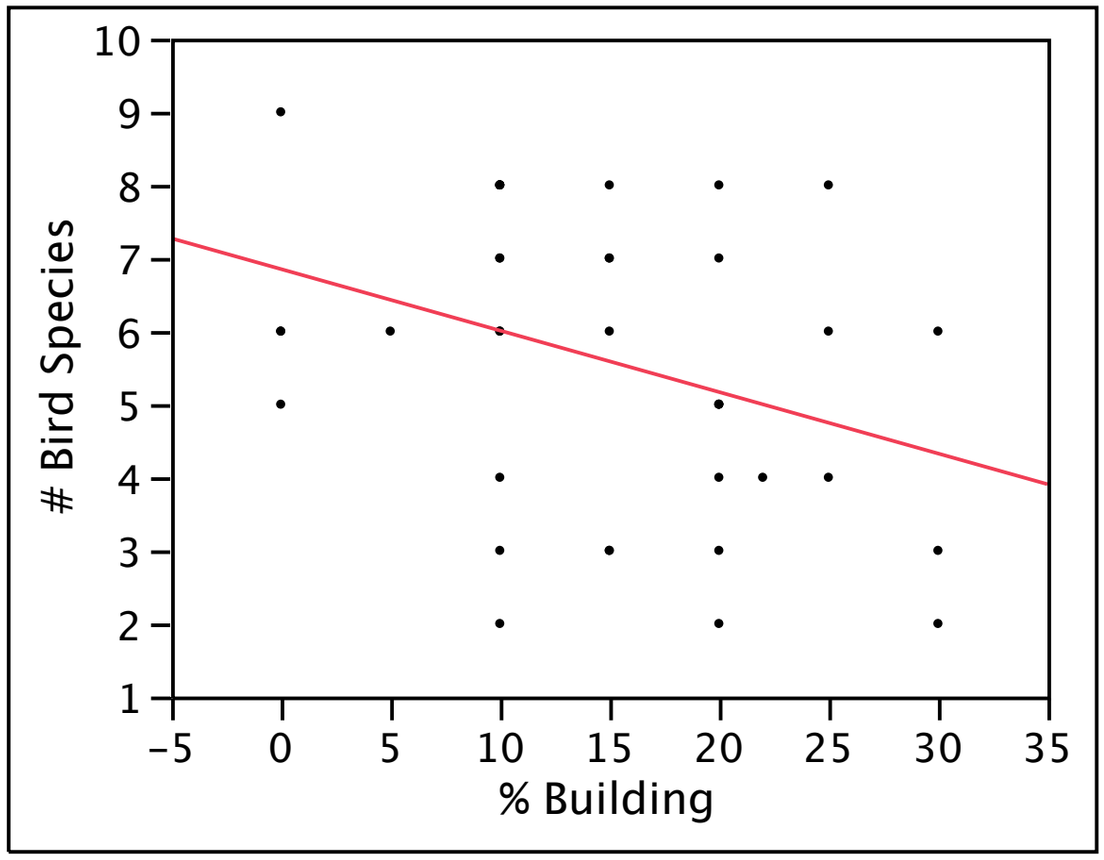
Bird Species Richness



$F_{2,35} = 3.18$, p $= 0.05$, $R^2 = 0.15$

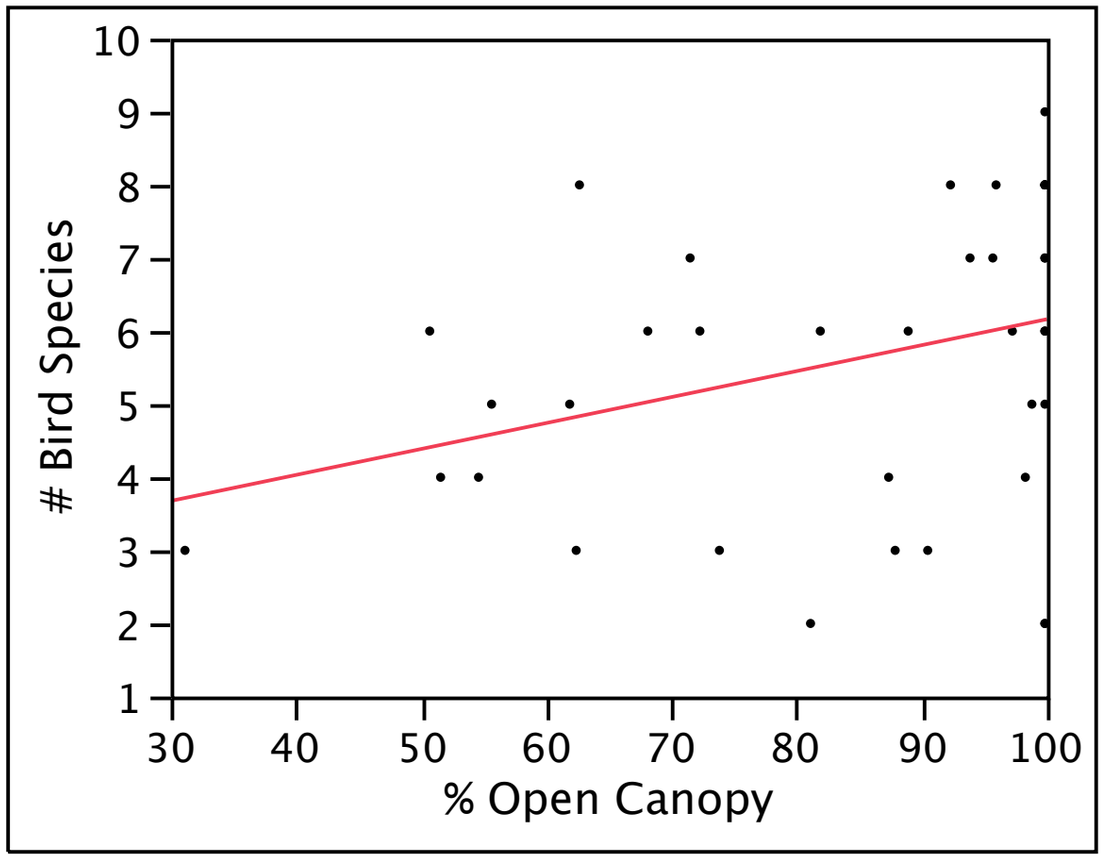
Bird Species Richness is also correlated with...

% Building



R^2 =0.12, p =0.04, N=38

Open Canopy



R^2 =0.11, p =0.04, N=38

Multivariate Drivers of Bird Diversity in the FCMA

- Stepwise regression: 9 variables, 8 interaction terms, mixed procedure
- Best fit model as shown in table below
- Whole model R^2=0.64 (adj. R^2=0.53), $F_{(8,24)}$=5.43, P=0.0006

Source	+/-	F-ratio	Prob >F
Mean Grass Height * Mode Irrigation Score	+	**10.71**	**0.003***
% Building	-	**7.93**	**0.0096***
Mean Grass Height (cm)	-	**4.81**	**0.038***
% Poverty * Mode Irrigation Score	+	**4.33**	**0.048***
% Poverty * % Building	+	2.55	*0.12*
Mean Shrub Height (m)	-	2.16	*0.16*
Mode Irrigation Score	+	0.86	*0.36*
% Poverty	-	0.048	*0.83*

- *Model comparison based inference supported the above results; the lowest AICc = 119.665 for comparison of 56 8-paramater models*

Conclusions from the FCMA

- Urban bird diversity increased significantly with residential irrigation intensity.
- Residential irrigation intensity decreased significantly with increasing poverty levels.
- Neighborhood poverty level (i.e., economic status) has strong effects on irrigation intensity even without water metering.
- Poverty also has strong indirect effects on bird diversity through intermediate variables including irrigation intensity, grass height, % building cover, and shrub height.

Conclusions from the FCMA

- Socioeconomic status and related irrigation / landscape management practices by residents appear to be strong drivers of habitat structure for birds, and overall bird diversity in the FCMA.
- In an arid region like the San Joaquin Valley irrigation dramatically alters the landscape and may provide resources (food and cover) otherwise unavailable to bird species.

Differences in landscape structure

Phoenix:

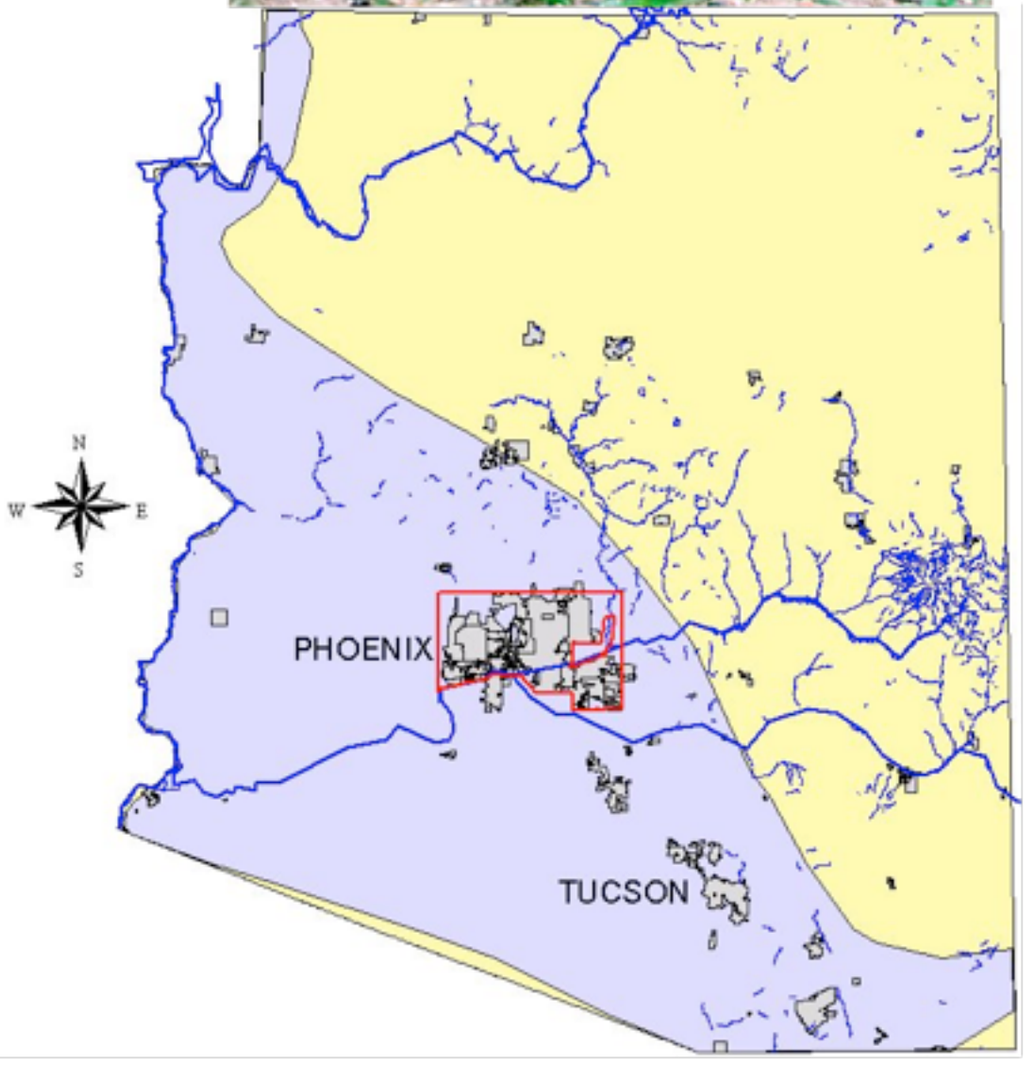
- ✦ Stream channels larger, more perennial
- ✦ More irrigation, pseudo-riparian vegetation, golf courses
- ✦ mesic yards

Tucson:

- ✦ Mostly seasonal washes
- ✦ xeric yards

Abert's Towhee

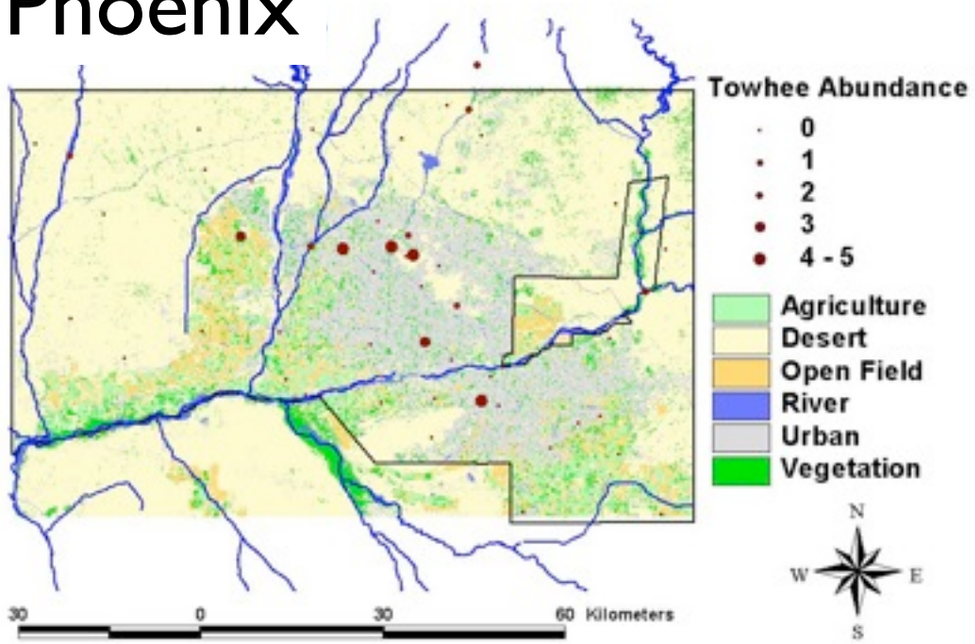
Pipilo aberti



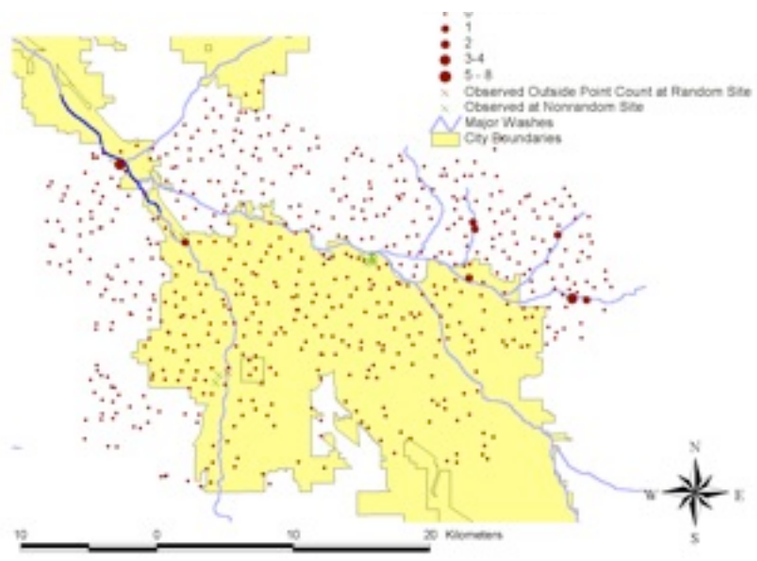
- Endemic to lower Sonoran desert
- Prefers riparian habitat, especially for breeding

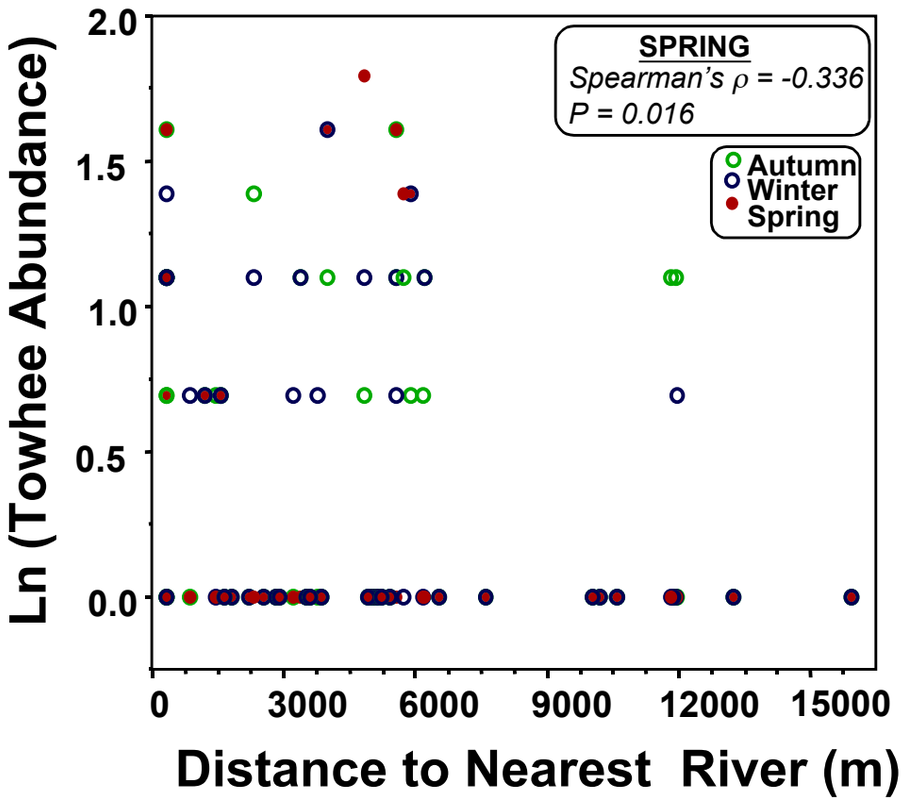
Abert's Towhee in two cities

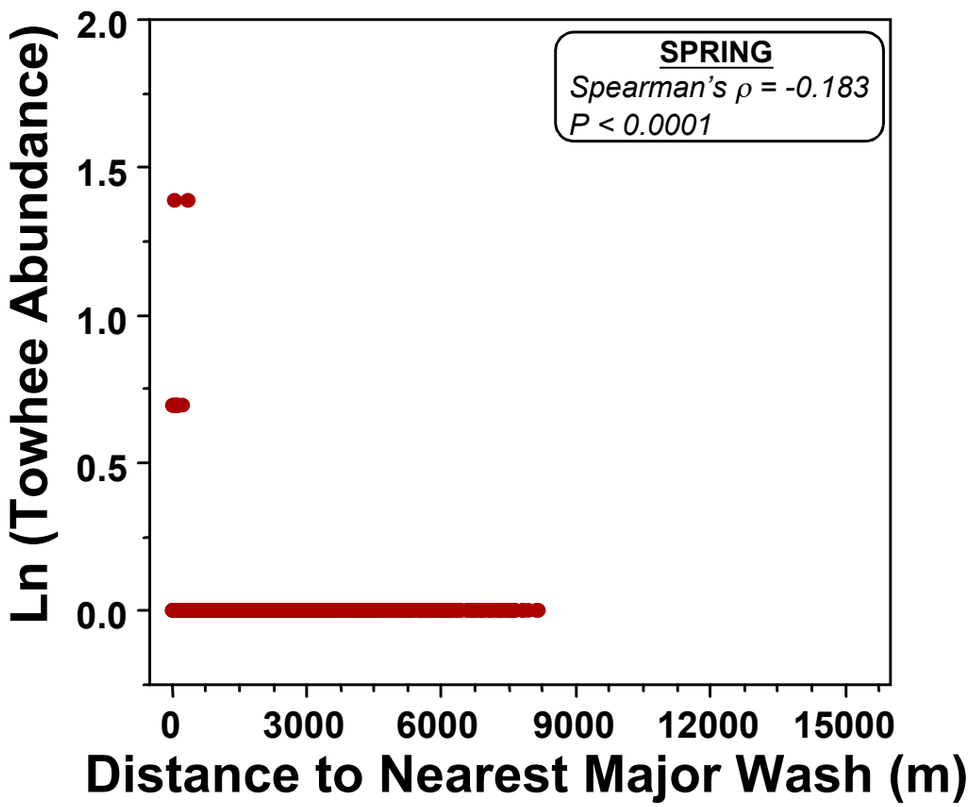
Phoenix



Tucson





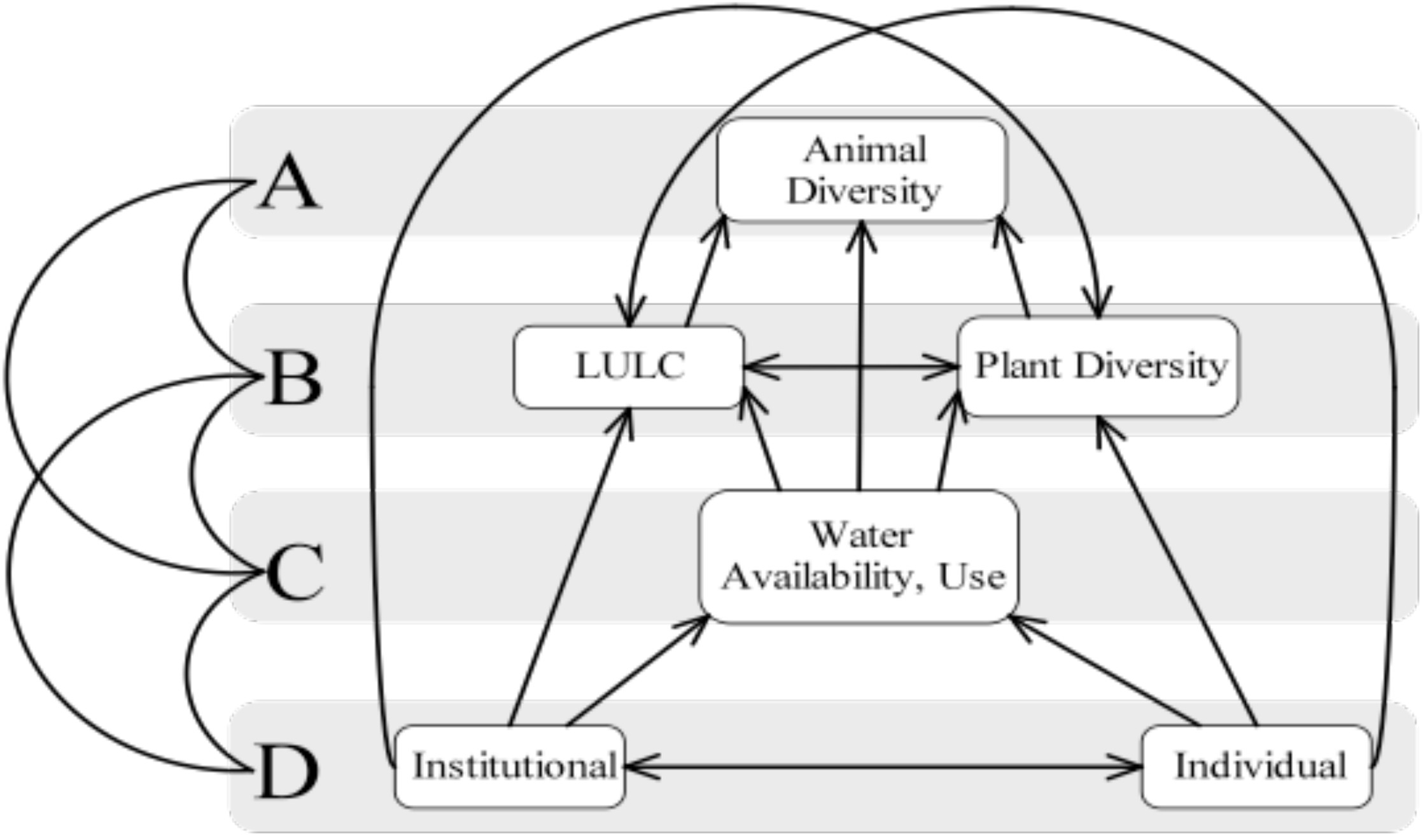


*M. Katti, **W. Turner**, E. Shochat (2001)*

Ongoing and proposed research in the FCMA

- Results provide baseline (Before) data as part of a Before-After-Control-Impact experiment (*a "found" experiment*)
- Mapping of tree cover and species diversity
- Detailed socioeconomic and cultural surveys of individual homeowners (to begin in 2010)
- Survey of institutional agents
- Analysis of water policies
- Detailed Land-Use/Land-Cover (LULC) modeling
- Develop and test a more comprehensive model of the urban socioecological system (SES)

A conceptual model of an urban SES focusing on water



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