Effects of urbanization on small mammals

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Effects of urbanization – Overview

- Environmental changes
  - Habitat fragmentation
  - Increased noise, light, temperature
- Human factors interact with all of these
  - Human population density
  - Income levels
- Changes in resource availability
  - Human food waste, fewer natural food sources → caloric surplus?
- Possible consequences for small mammals
  - Species and community diversity
  - Individual performance and morphology


Photo credit: Michael S. Williamson


Photo credit: Sean Pavone

Small mammals in the big city

- Small mammals are excellent study system for effects of urbanization
  - Numerous
  - Diverse
  - Responsive to local conditions
  - Ecosystem services
  - Baseline biology well understood

Objectives and Hypotheses

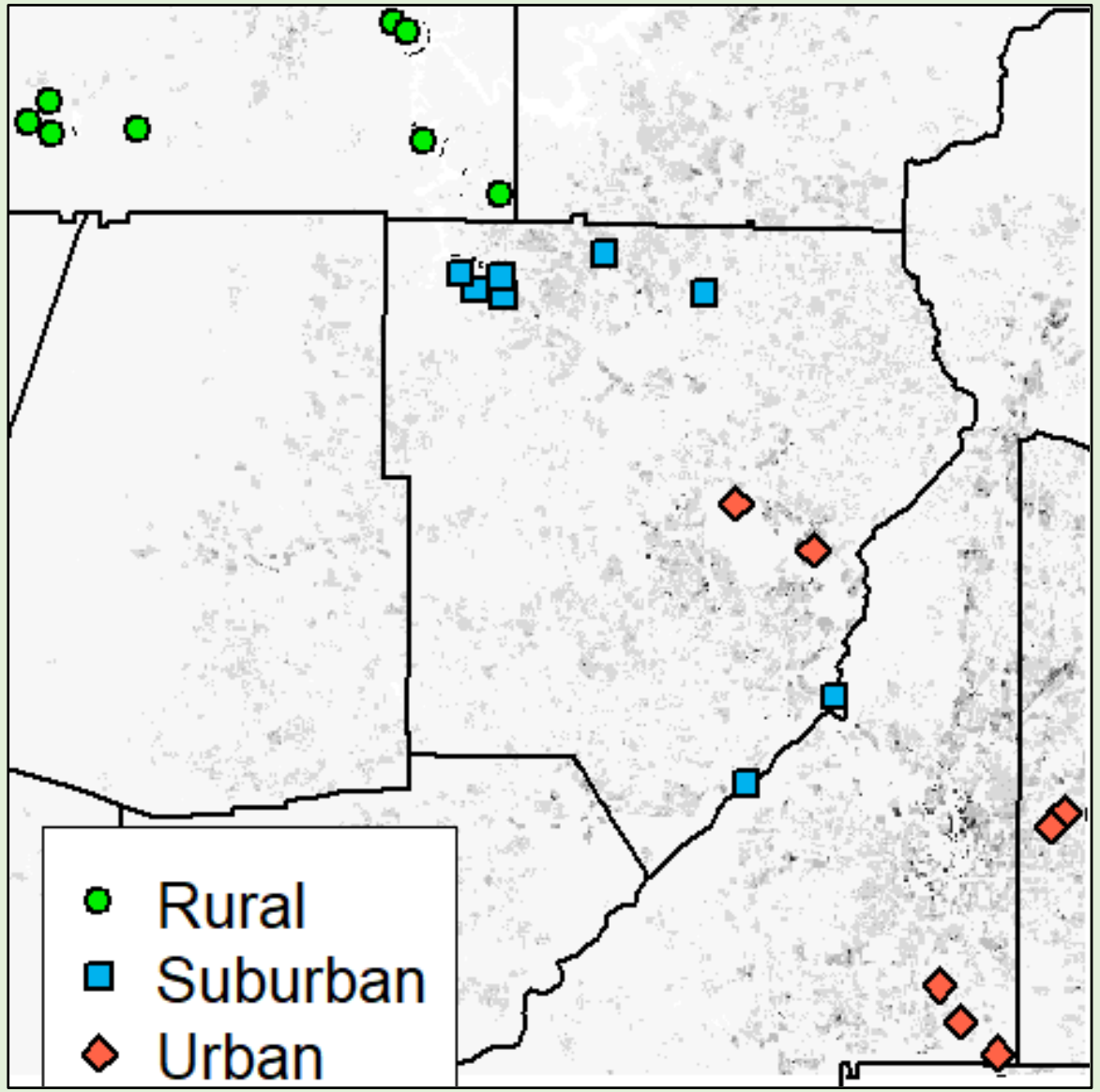
Main objectives:

1. Determine what geospatial, environmental, and socioeconomic factors affect small mammal community structure along an urban-rural gradient.
2. Investigate how urbanization affects small mammal morphology and physiology

Our **main hypothesis** was that urbanization alters small mammal ecology across levels of organization, from individuals to communities.

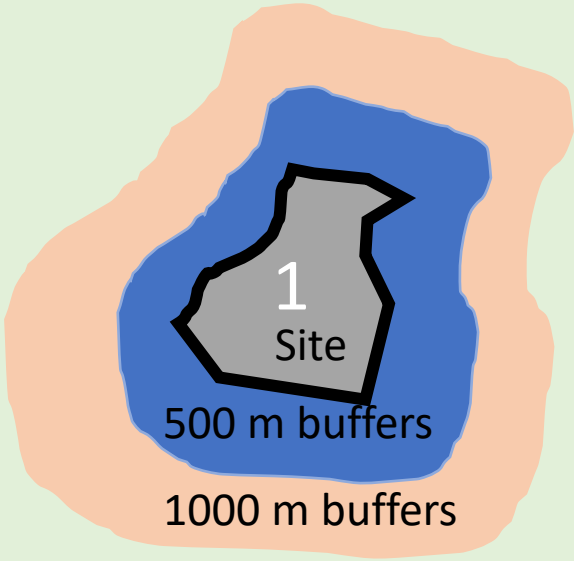
Methods: small mammal sampling

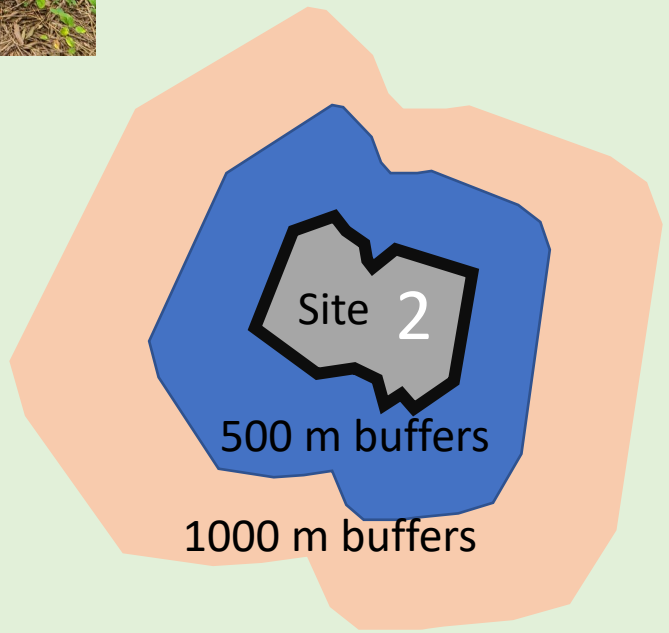
- 23 sites along urban-to-rural gradient from Atlanta to Bartow County.
- 14,720 total trapnights (640 per site)
- Individuals caught:
  - Identified to species
  - Weighed and measured
  - Assessed sex and reproductive status
  - Blood samples for lipid and hormonal assays
  - Tagged and released



Methods: variable collection

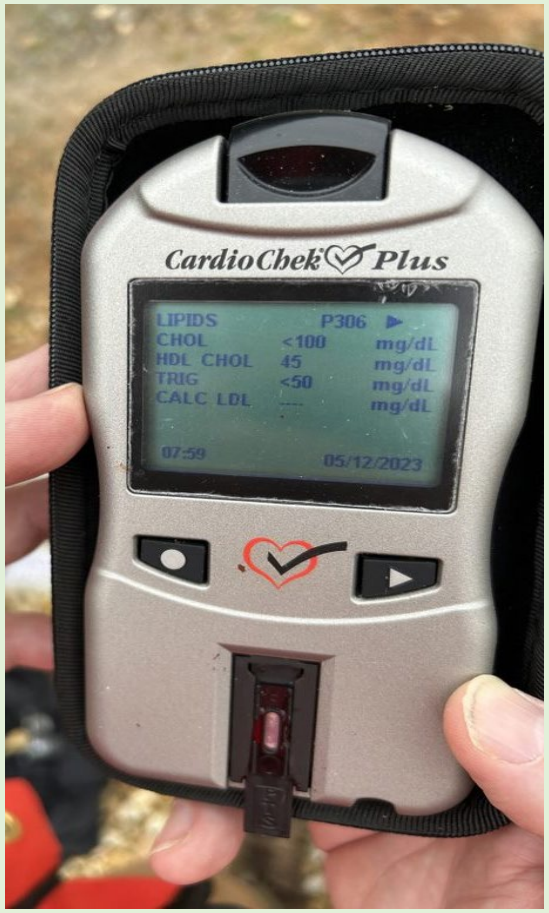
- Environmental variables collected in field
- Spatial variables of each site measured with GIS
- Socioeconomic variables found through U.S. Census Bureau
- Socioeconomic and environmental variables related to site level buffers





Methods: blood analysis

- Drew blood from submandibular vein
  - Measured TRIG and CHOL using CardioChek Plus in field
  - Took blood sample for later CORT analysis
- Pregnant and juvenile animals excluded from blood sampling
- Total: 118 lipid panels, 89 serum samples



Methods: community data analysis

- Endpoints (response variables)
  - Small mammal richness
  - Small mammal community structure (Simpson's Index, D)
  - Small mammal population density
  - Functional diversity
- Explanatory variables
  - Human population, land cover, elevation, ambient noise, temperature, socioeconomic variables

Approach

1. Screened for correlations between response and explanatory variables
2. Kruskal-Wallis tests for richness and Simpson's index
3. NMDS and MRPP to test for differences in community structure and functional groupings

Methods: physiological data analysis

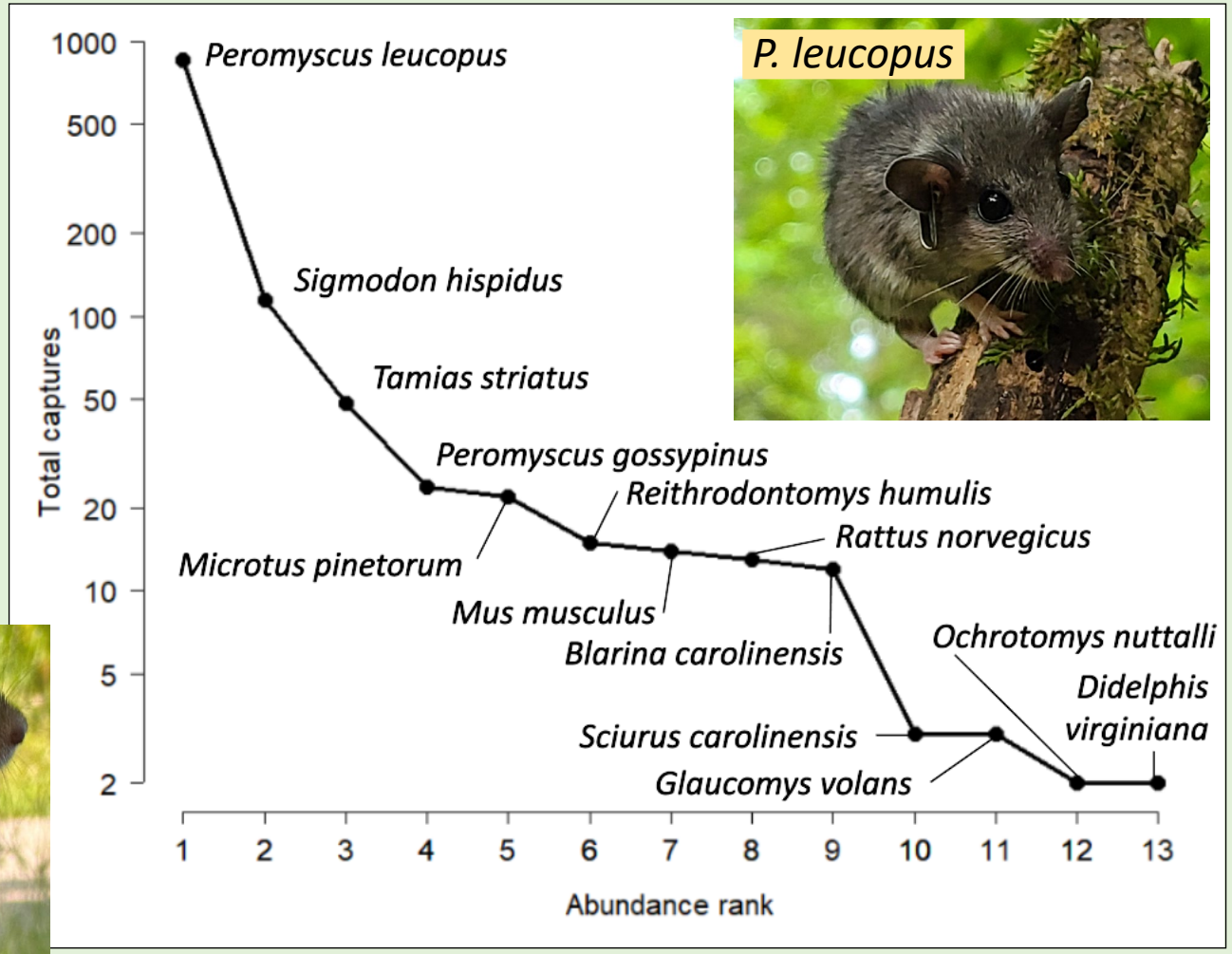
- Endpoints (response variables)
  - Individual size and mass:length residuals
  - CORT, CHOL, TRIG, HDL
- Explanatory variables
  - Urbanization, individual size and mass:length residuals, conspecific population density

Approach

1. Screened for correlations between response and explanatory variables
2. Linear models for most tests; nonparametric tests when appropriate
3. Censored regression (tobit) models for blood parameters

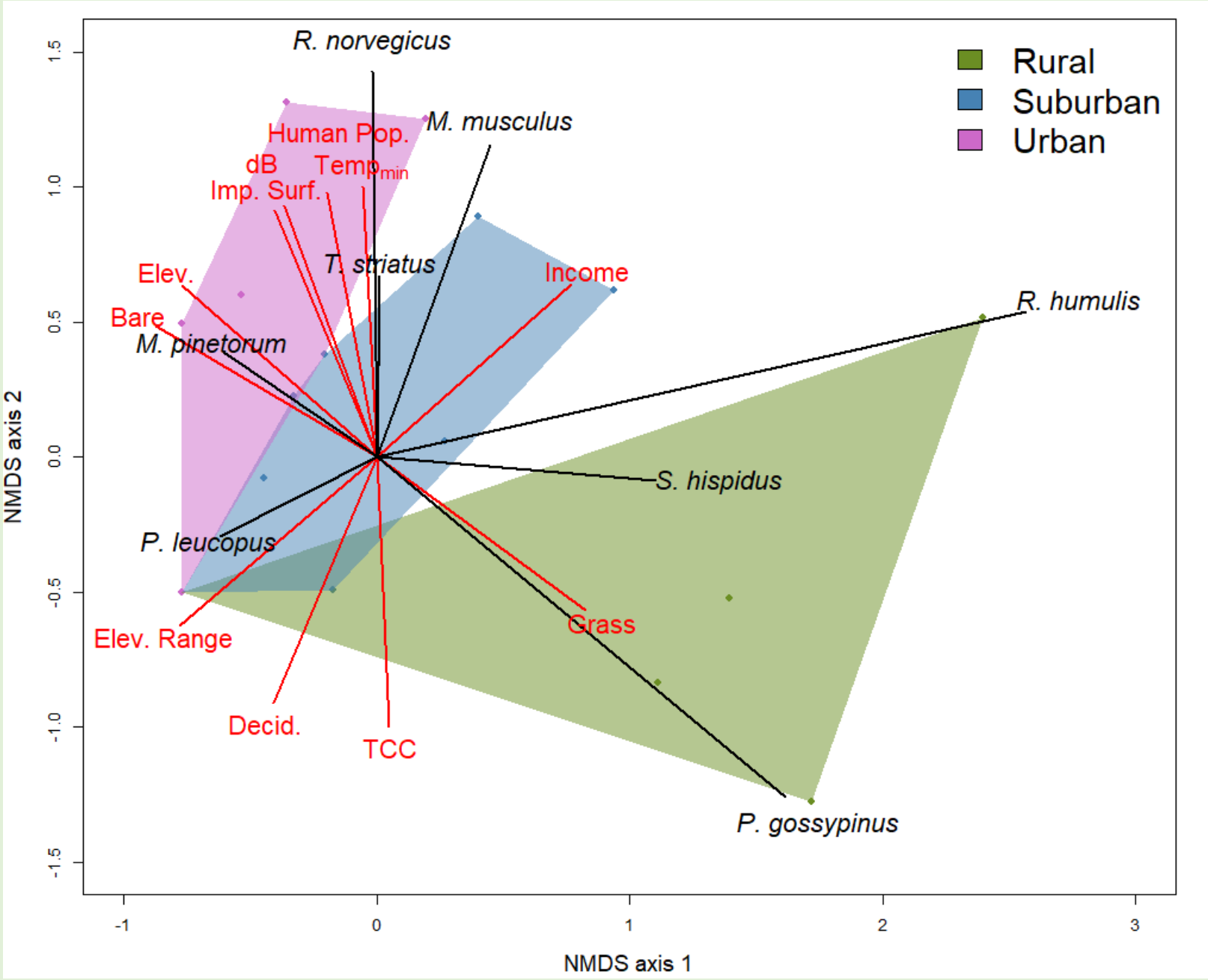
Results: rank abundance

- 1,135 total captures of 13 species
- Captures dominated by *P. leucopus*
- Species excluded: *G. volans, O. nuttali, S. carolinensis,* and *D. virgininana*
- Simpson's index and overall abundance did not differ significantly between treatments ($P > 0.05$)



Results

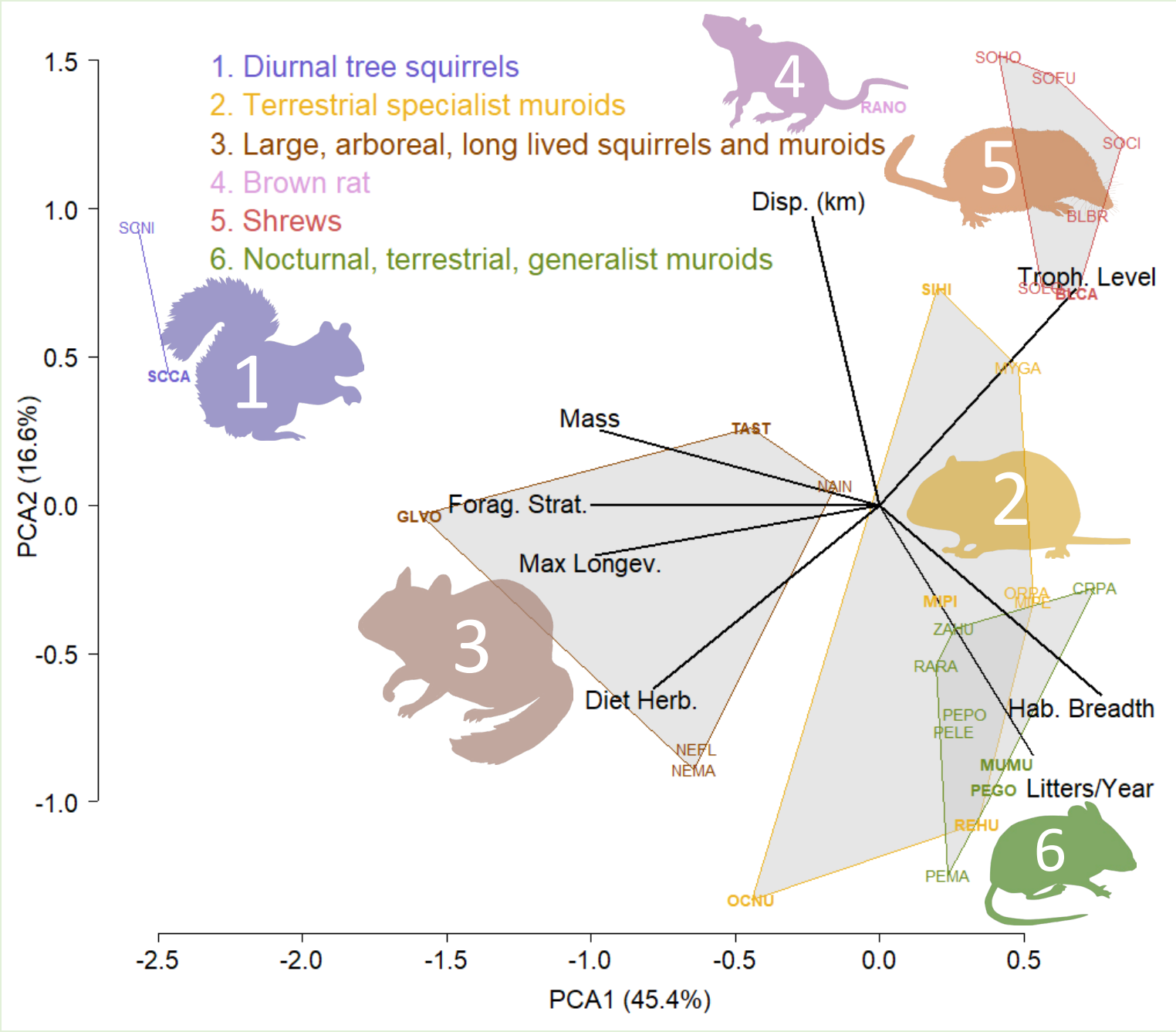
- Black lines show species densities
- Red lines show predictor variables
- Urban, suburban, and rural are significantly different from each other (MRPP $A = 0.11$, $P = \mathbf{0.021}$*)



NMDS ordination using variables in 1000 m buffer

Results

- Used *k*-means clustering to identify functionally similar groups of species (“functional groups”)
- Identified six groups among GA small mammals
- Calculated population densities of each functional group at each site

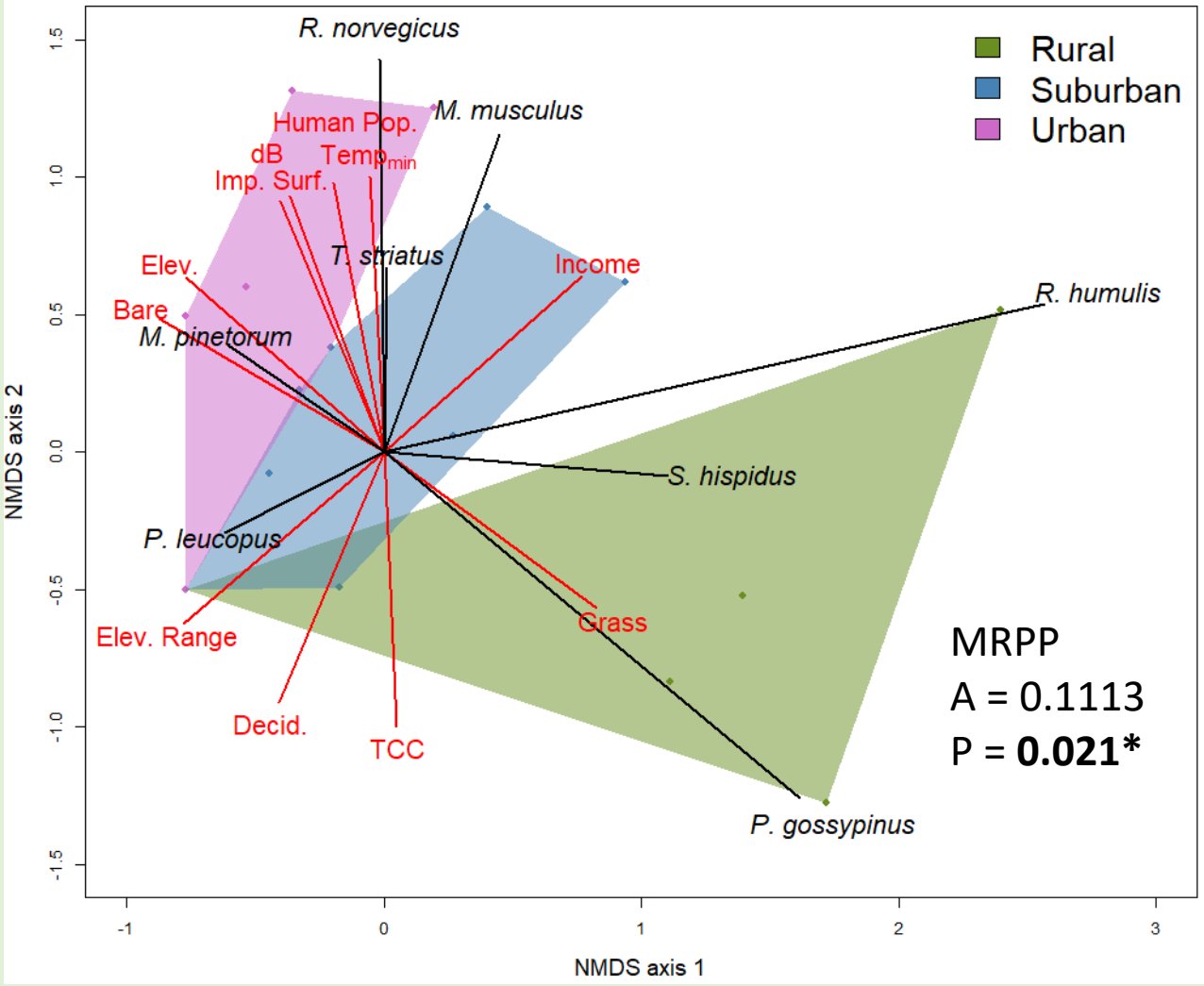


PCA of functional groups with selected life history traits

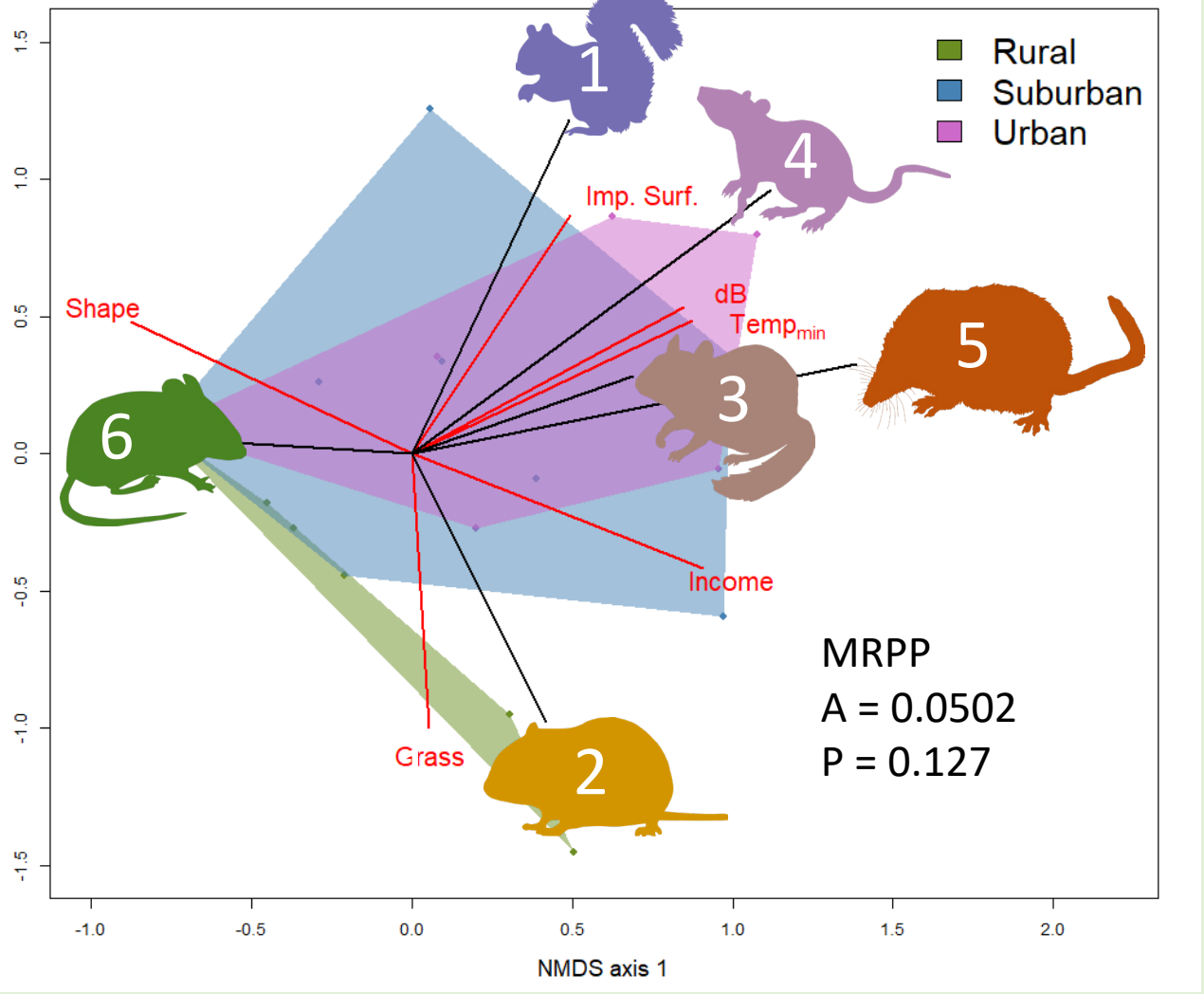
Silhouettes: *Tamias*: C. Schmidt. *Peromyscus*: E. price.

Results

NMDS ordination by species population densities



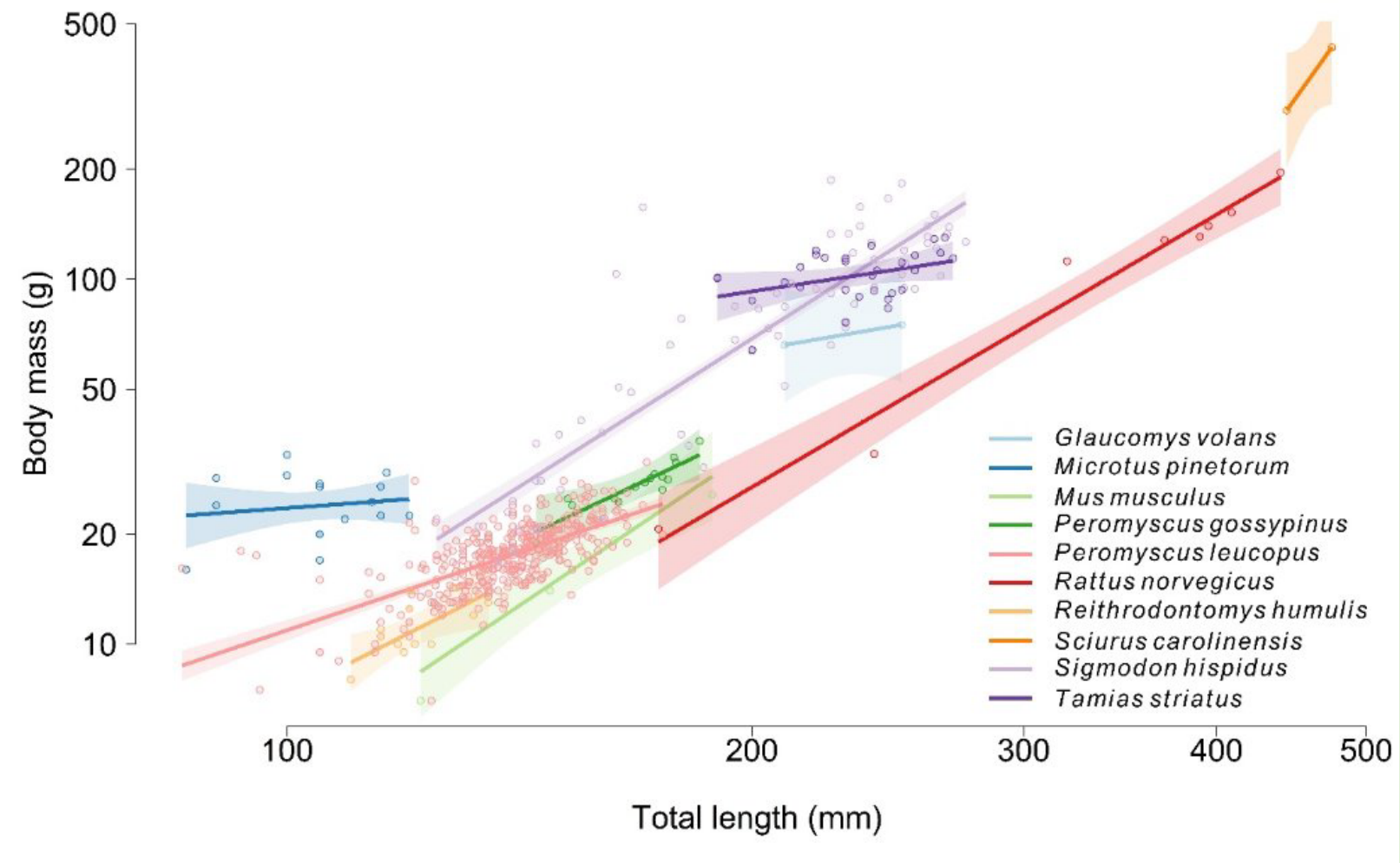
NMDS ordination by functional group population densities



Silhouettes: *Tamias*: C. Schmidt. *Peromyscus*: E. price.

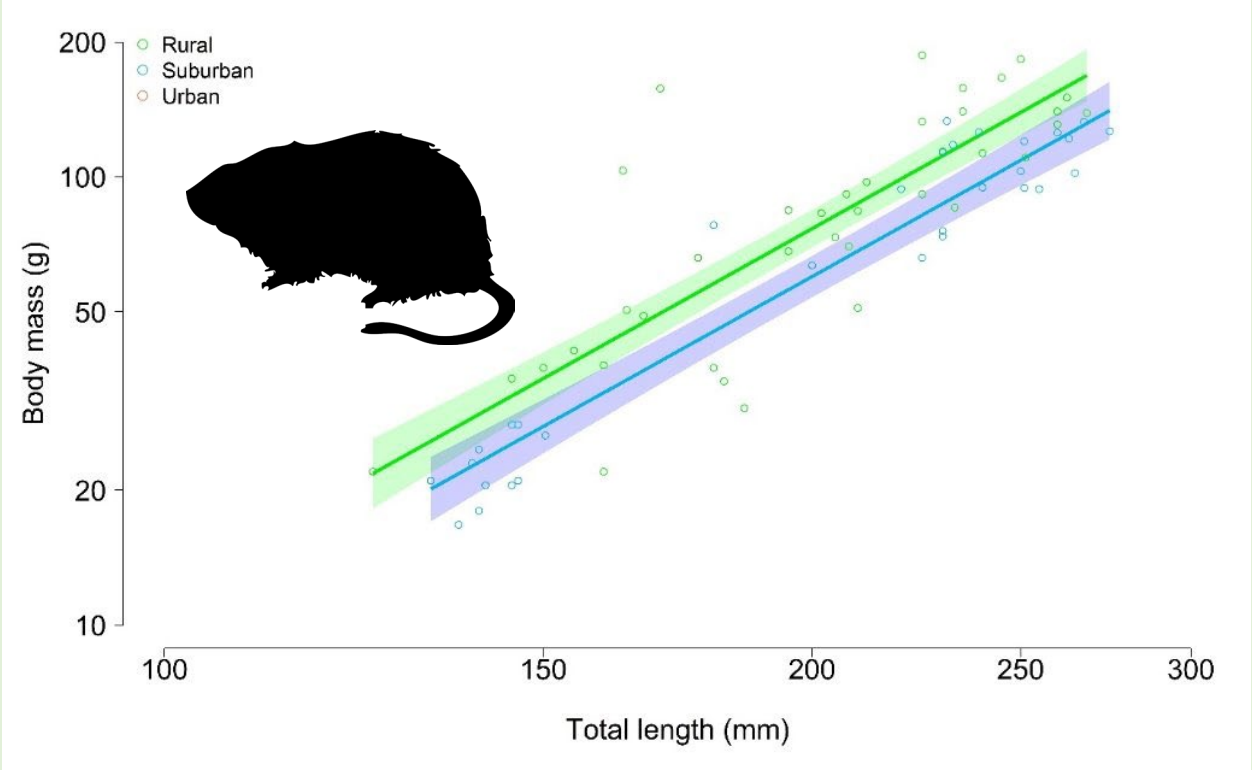
Results: Mass:Length Allometry by Species

- Fit power law of mass vs. length, with species-specific slopes
  - Model R^2 = 0.91 (omnibus $F_{10,557}$ = 575.60, $P < 0.01$).
- Then, compared residuals of this relationship to site characteristics (incl. urbanization)



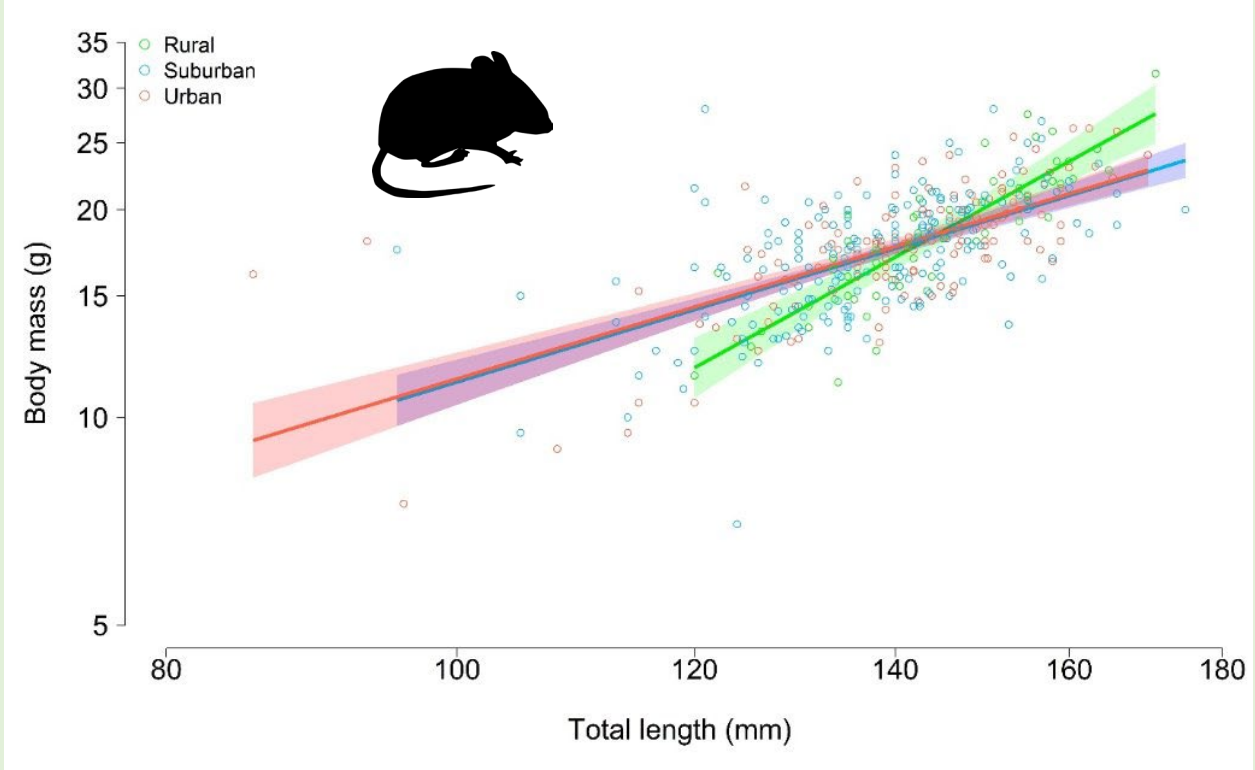
Results: Urbanization affected morphology in species-specific ways

Hispid cotton rats (*S. hispidus*)



Body mass and total length of hispid cotton rats (*S. hispidus*): Model R^2 = 0.807 (omnibus ANOVA $F_{3,65}$ = 95.73, P < **0.0001***)

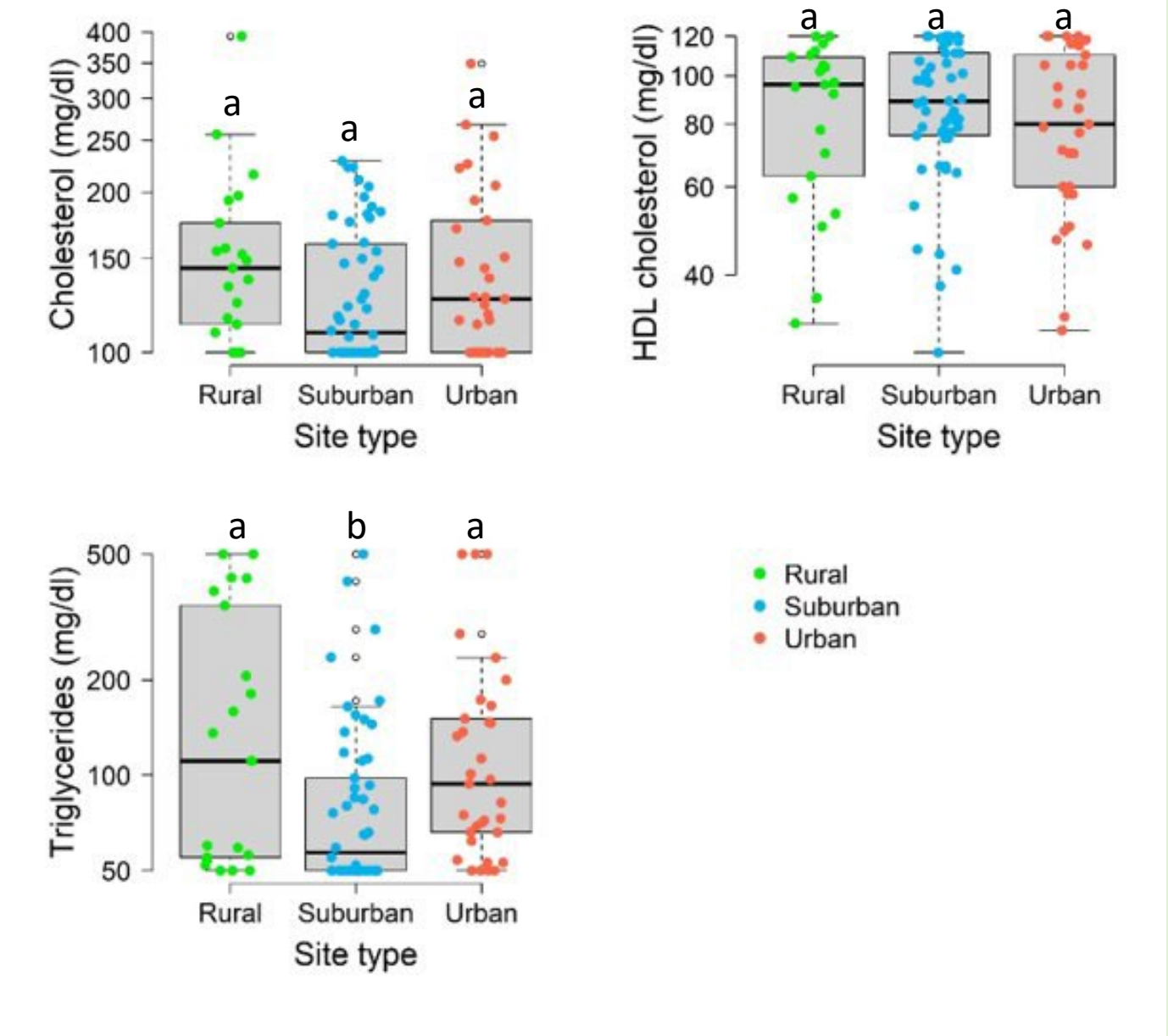
White-footed mice (*P. leucopus*)



Body mass and total length of white-footed mice (*P. leucopus*): Model R^2 = 0.448 (omnibus ANOVA $F_{5,401}$ = 66.8, P < **0.0001***) (Silhouette: E. Price).

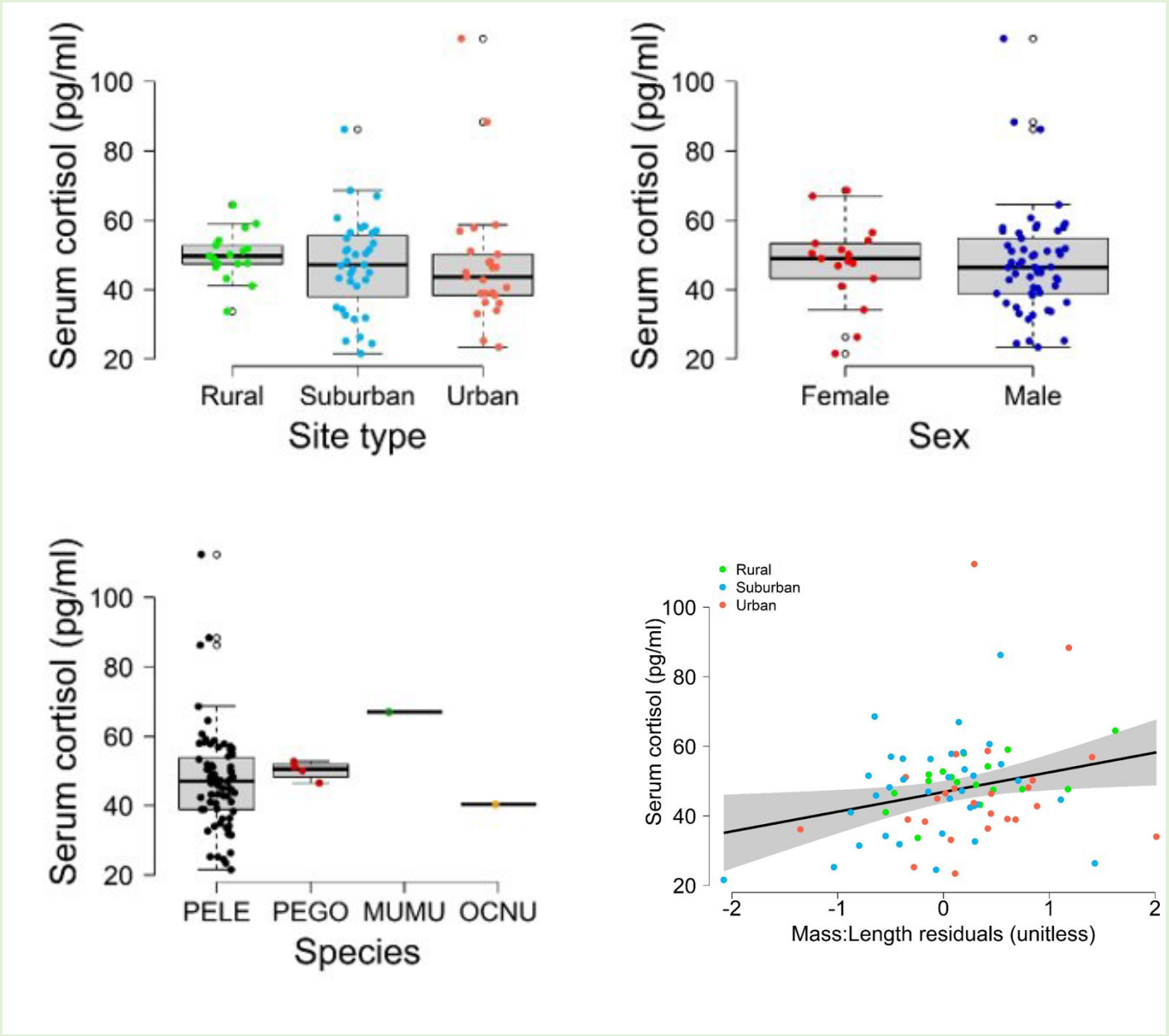
Results: Urbanization affected TRIG

- TRIG, but not CHOL or HDL, affected by urbanization:
  - Kruskal-Wallis tests:
  - Triglycerides (TRIG): χ^2 = 11.805, d.f., *P* = **0.0027**
  - Cholesterol (CHOL): χ^2 = 4.331, 2 d.f., *P* = 0.1147
  - High density lipoprotein (HDL) cholesterol : χ^2 = 0.966, 2 d.f., *P* = 0.6169).



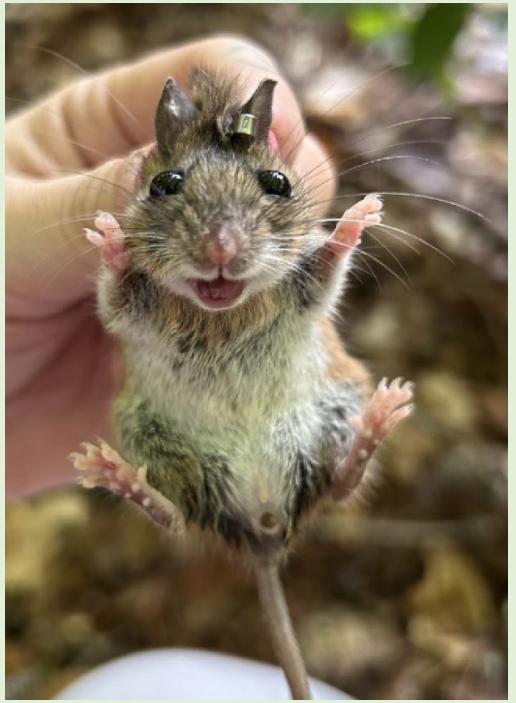
Results: CORT unaffected by urbanization

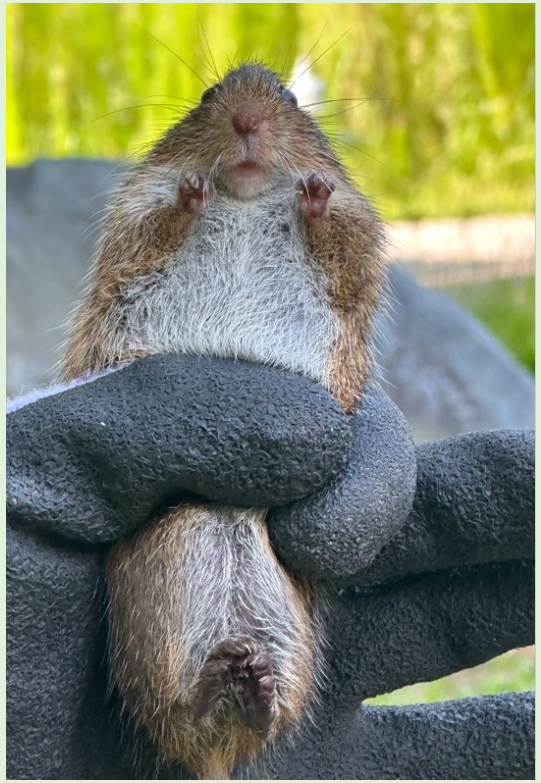
- Small mammal serum cortisol (CORT) was not affected by urbanization, species, or sex.
- CORT was weakly related to body size (mass:length residuals) ($F_{1,75}$ = 5.414, P = **0.022**, R^2 = 0.055).



Conclusions

- Small mammal densities driven by several environmental, spatial, and socioeconomic variables
- Urbanization associated with species turnover, but not functional loss.
- Caloric surplus was not evident in morphological or serological data.
- Little redundancy between morphological and physiological indicators of nutritional status.
- No relationship between urbanization and individual stress





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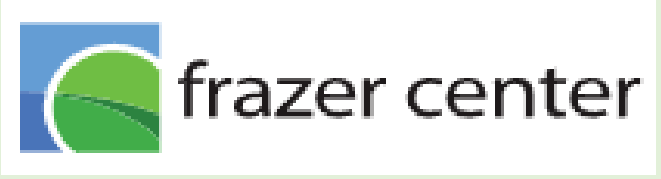
- Cobb County Parks Department
- Georgia Power at Plant Bowen
- Frazer Forest
- Fernbank Museum of Natural History
- Atlanta Expo Center
- The Conservation Fund



Green Quantitative Ecology

Thank you!

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