

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



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

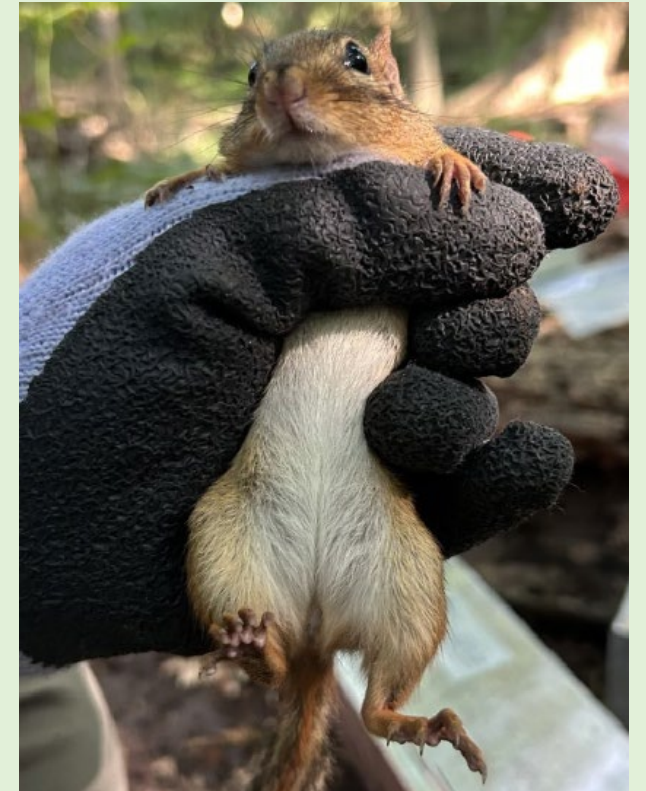


Objectives and Hypotheses

Main objectives:

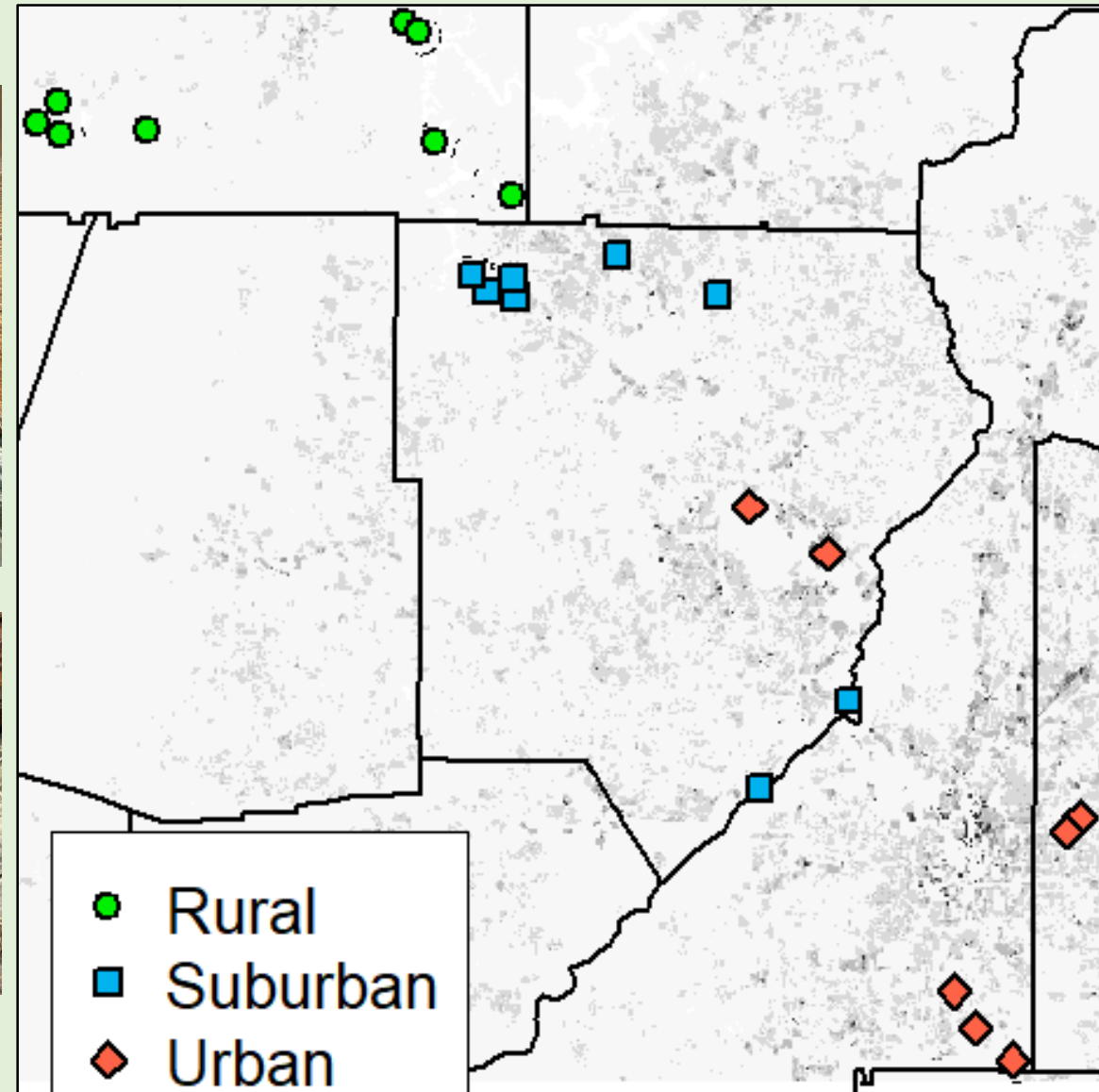
1. Determine what geospatial, environmental, and socioeconomic factors affect small mammal community structure along an urban-rural gradient.
2. Investigate how urbanization affects small mammal morphology and physiology

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



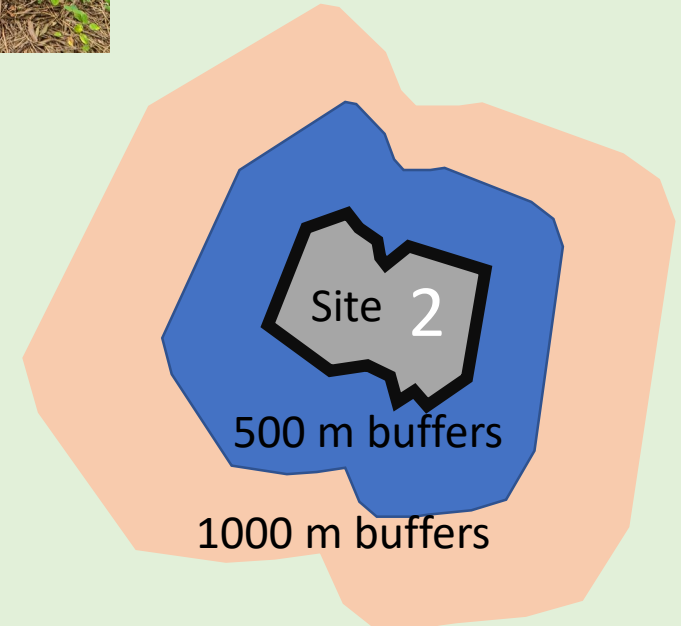
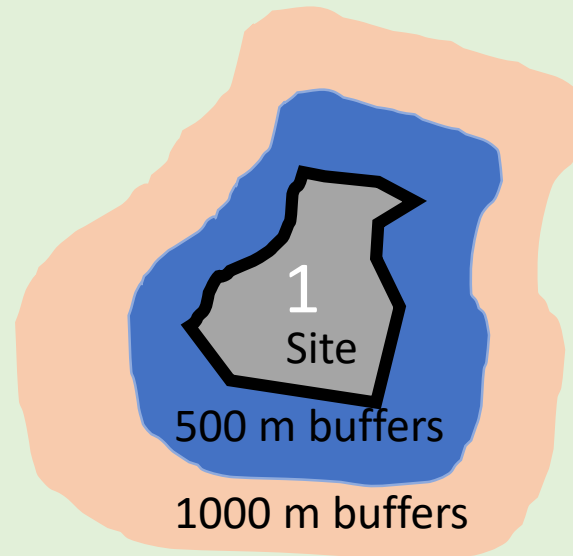
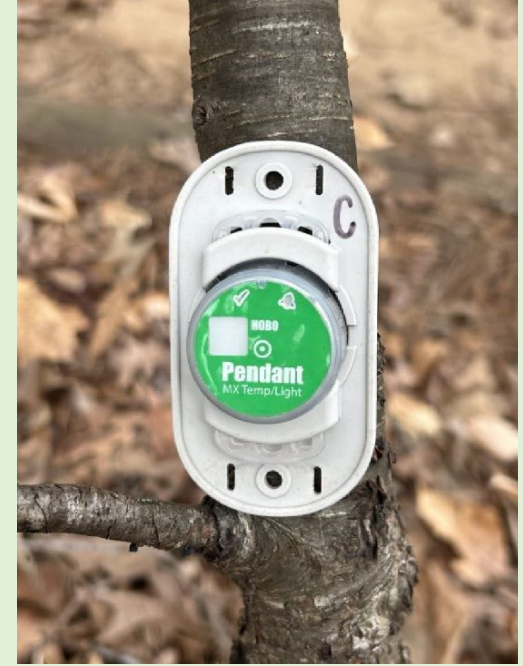
Methods: small mammal sampling

- 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



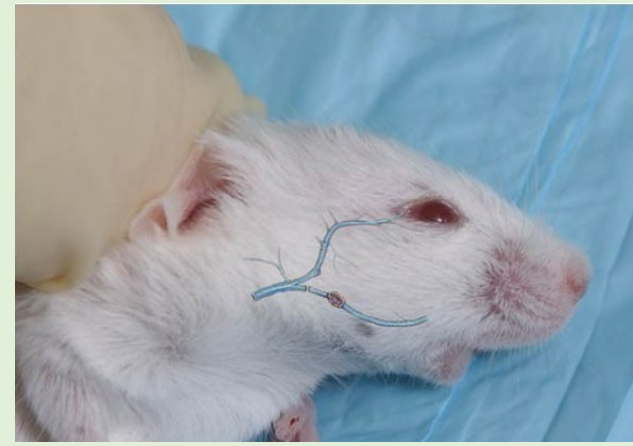
Methods: variable collection

- 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

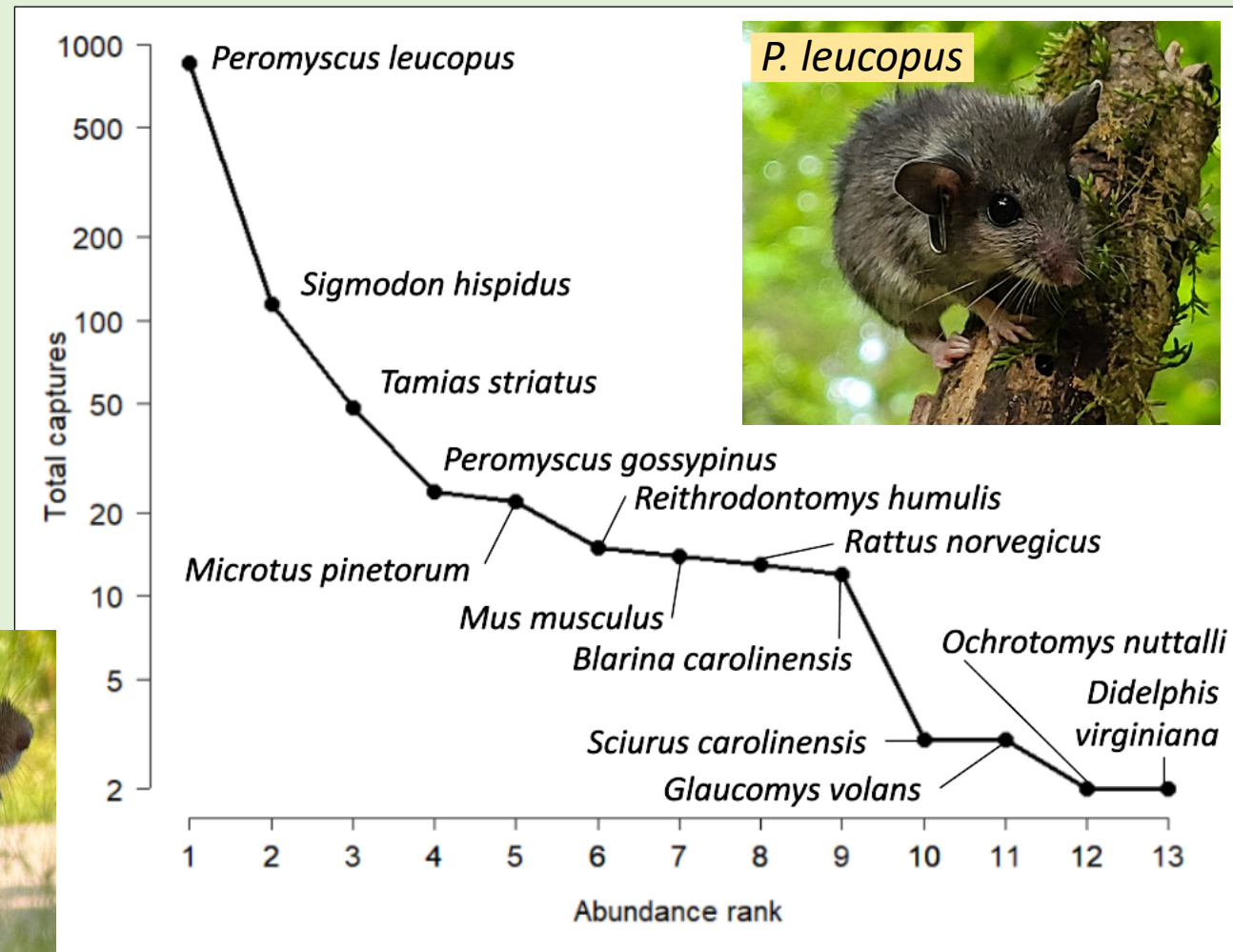
Approach

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



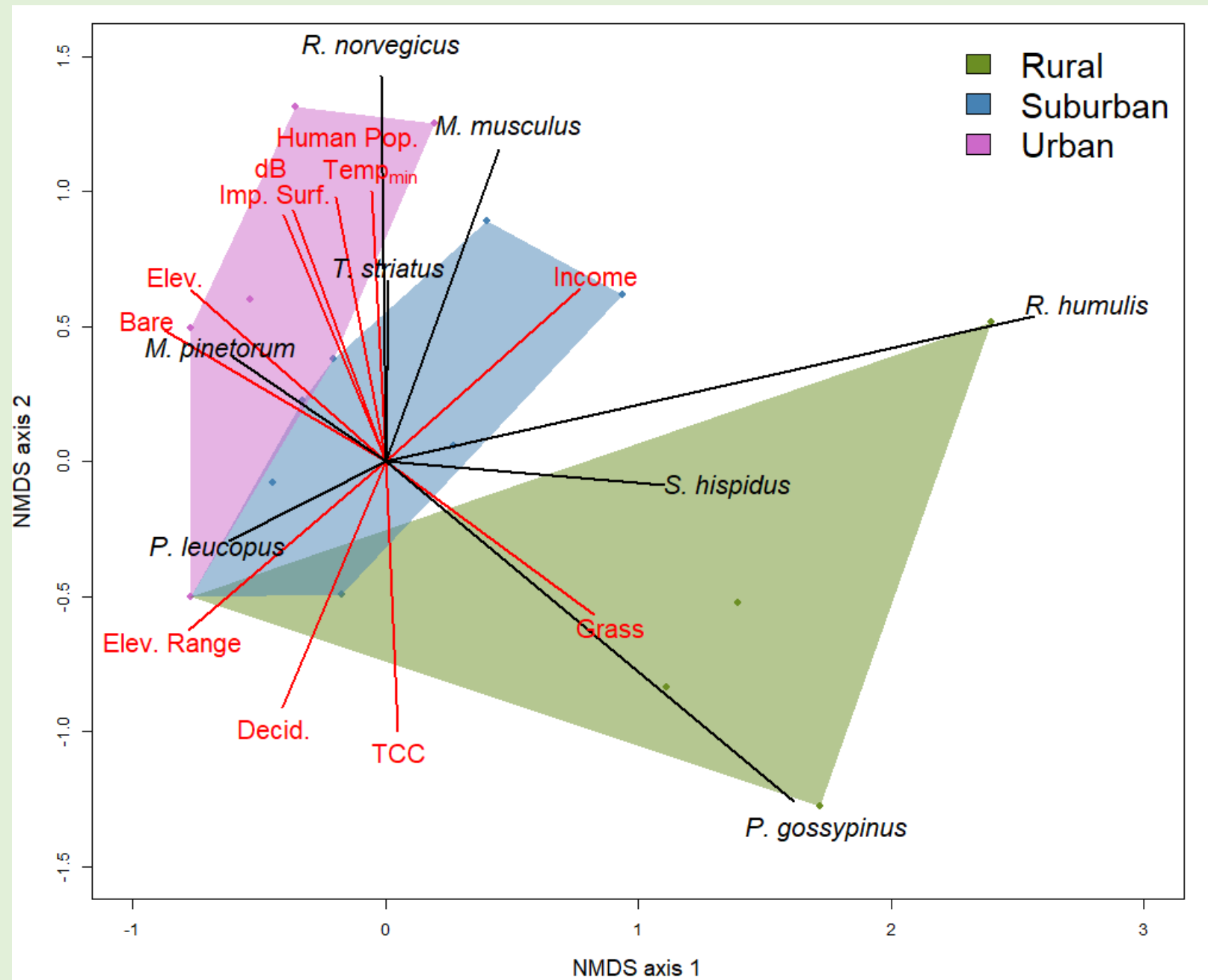
Results: rank abundance

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



Results

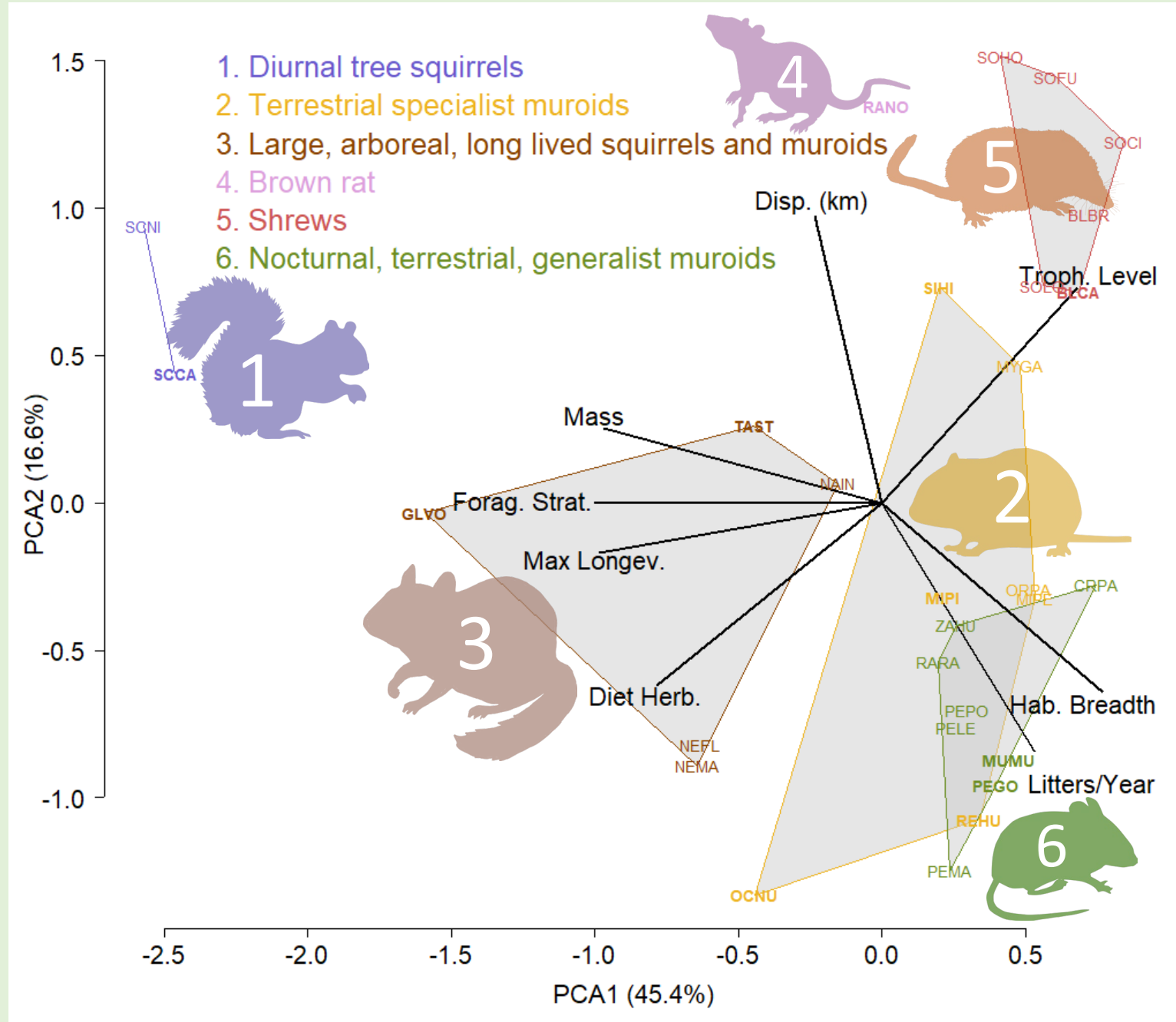
- Black lines show species densities
- Red lines show predictor variables
- Urban, suburban, and rural are significantly different from each other (MRPP A = 0.11, $P = 0.021^*$)



NMDS ordination using variables in 1000 m buffer

Results

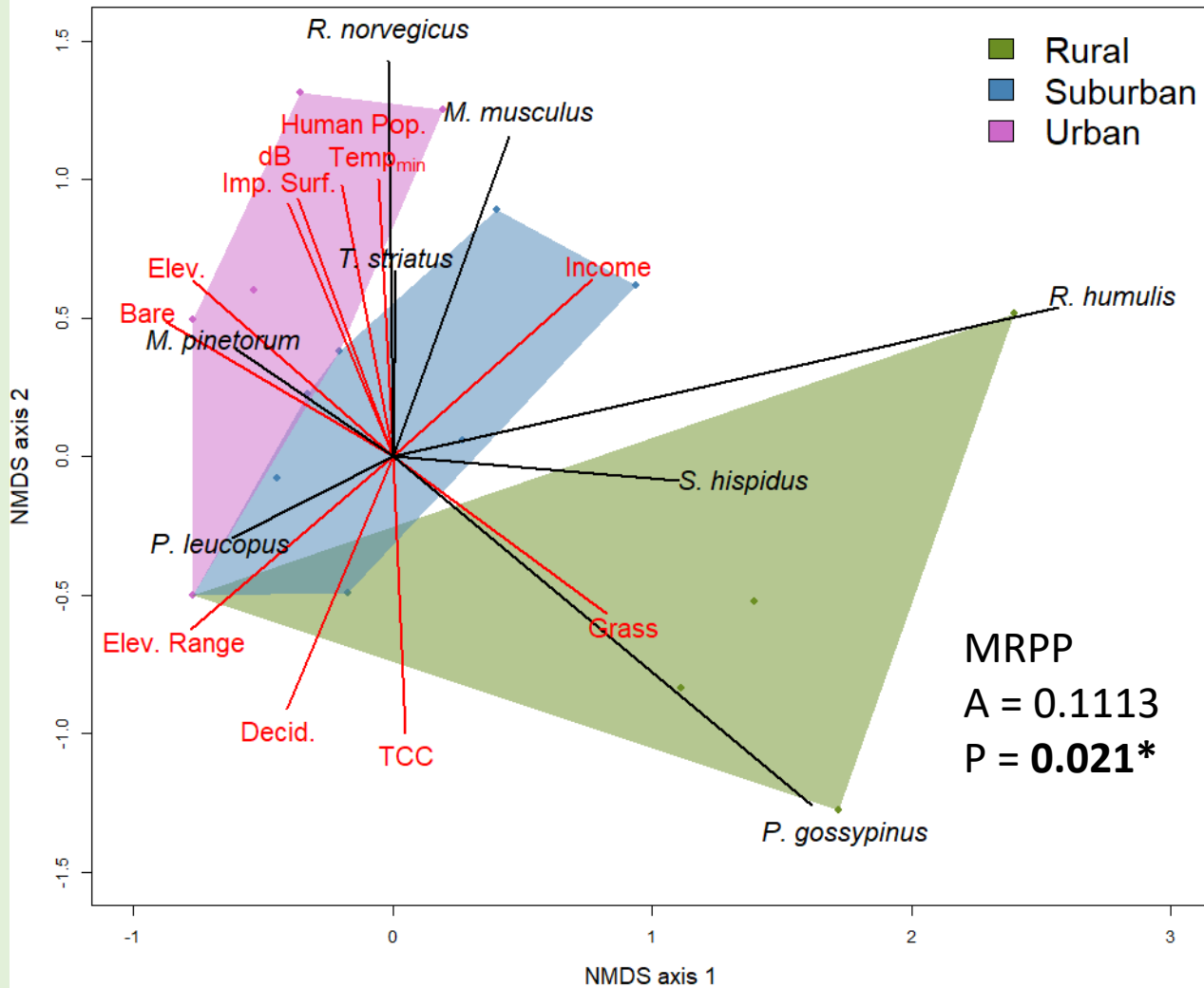
- Used *k*-means clustering to identify functionally similar groups of species (“functional groups”)
- Identified six groups among GA small mammals
- Calculated population densities of each functional group at each site



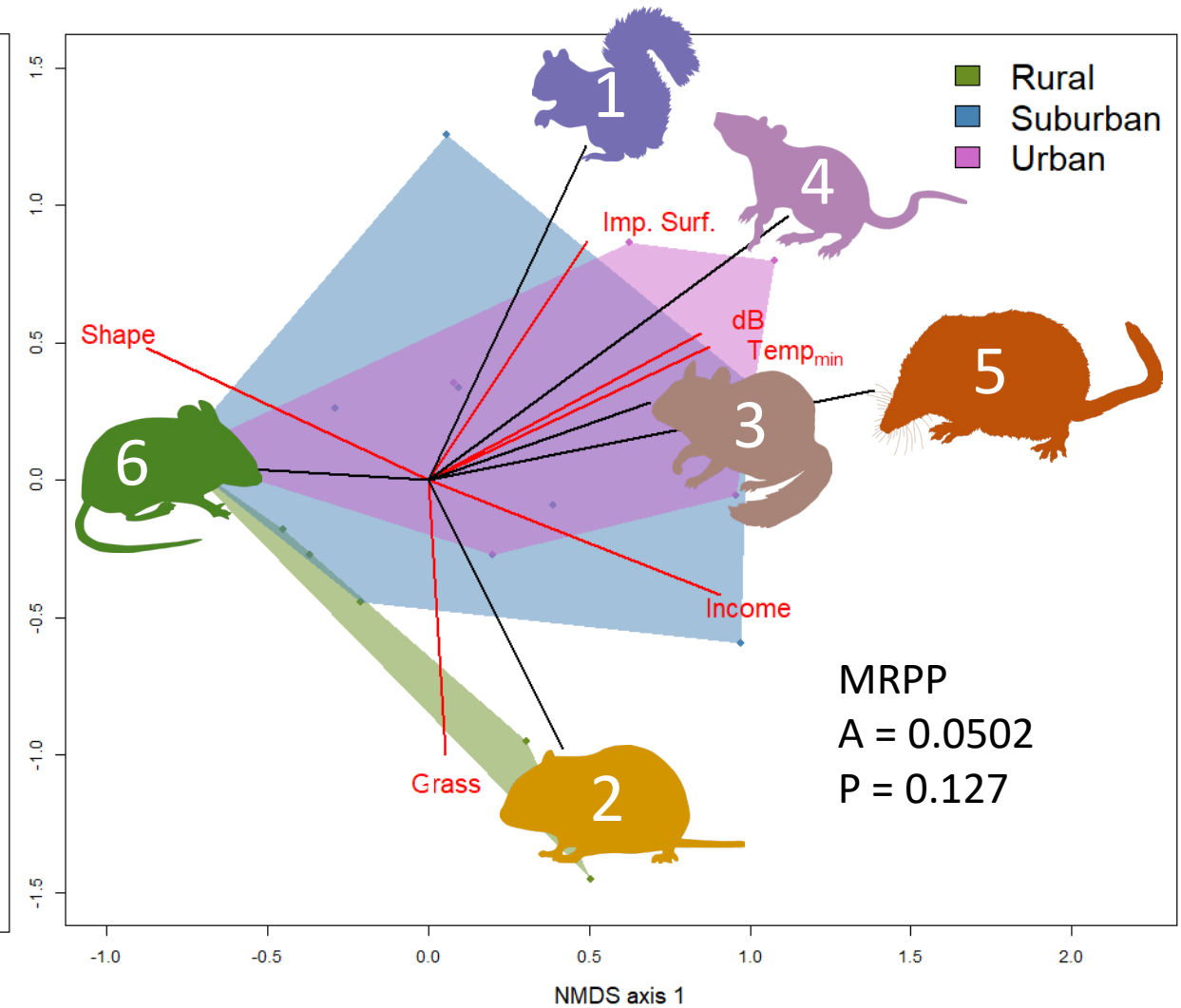
PCA of functional groups with selected life history traits

Results

NMDS ordination by species population densities

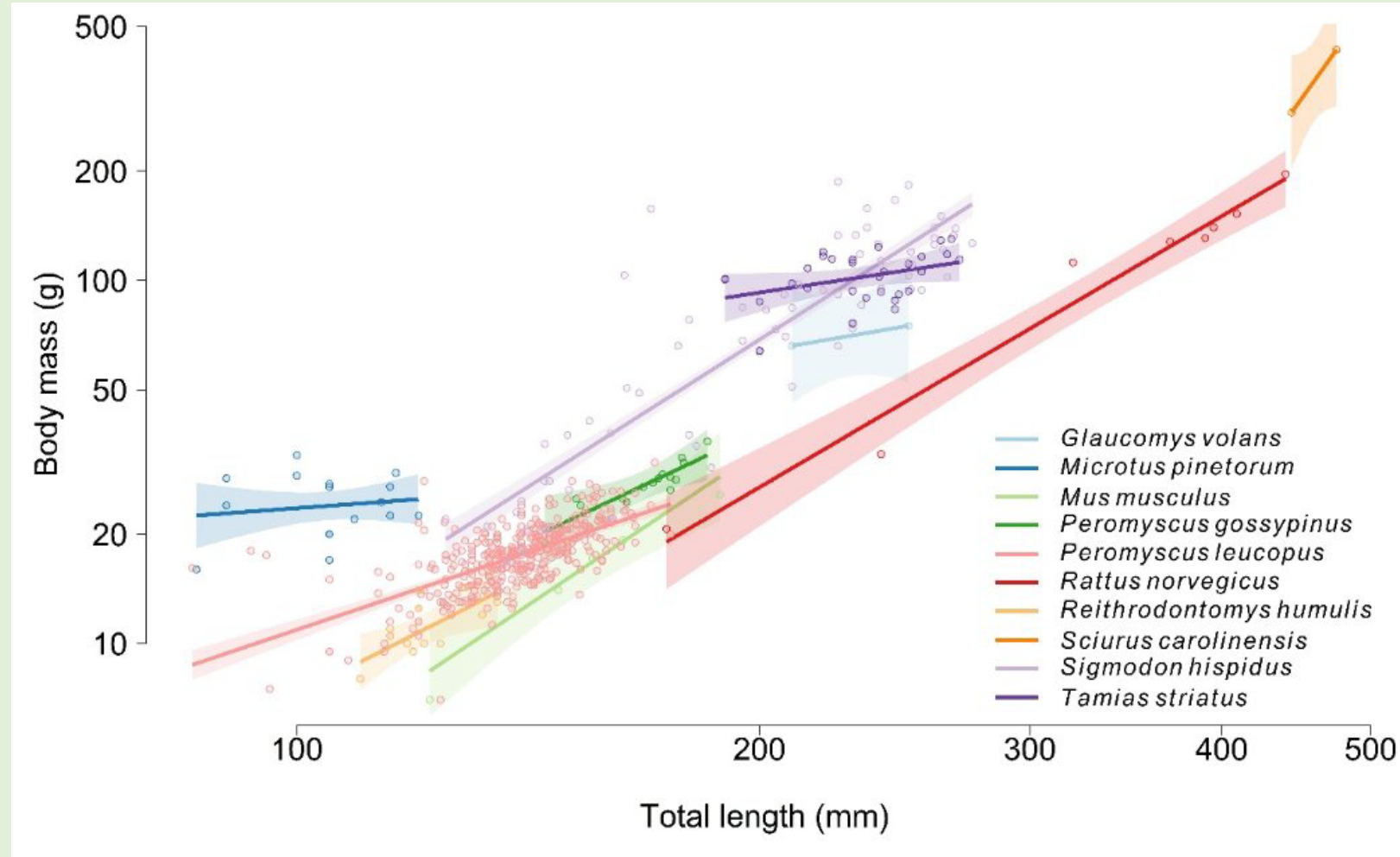


NMDS ordination by functional group population densities



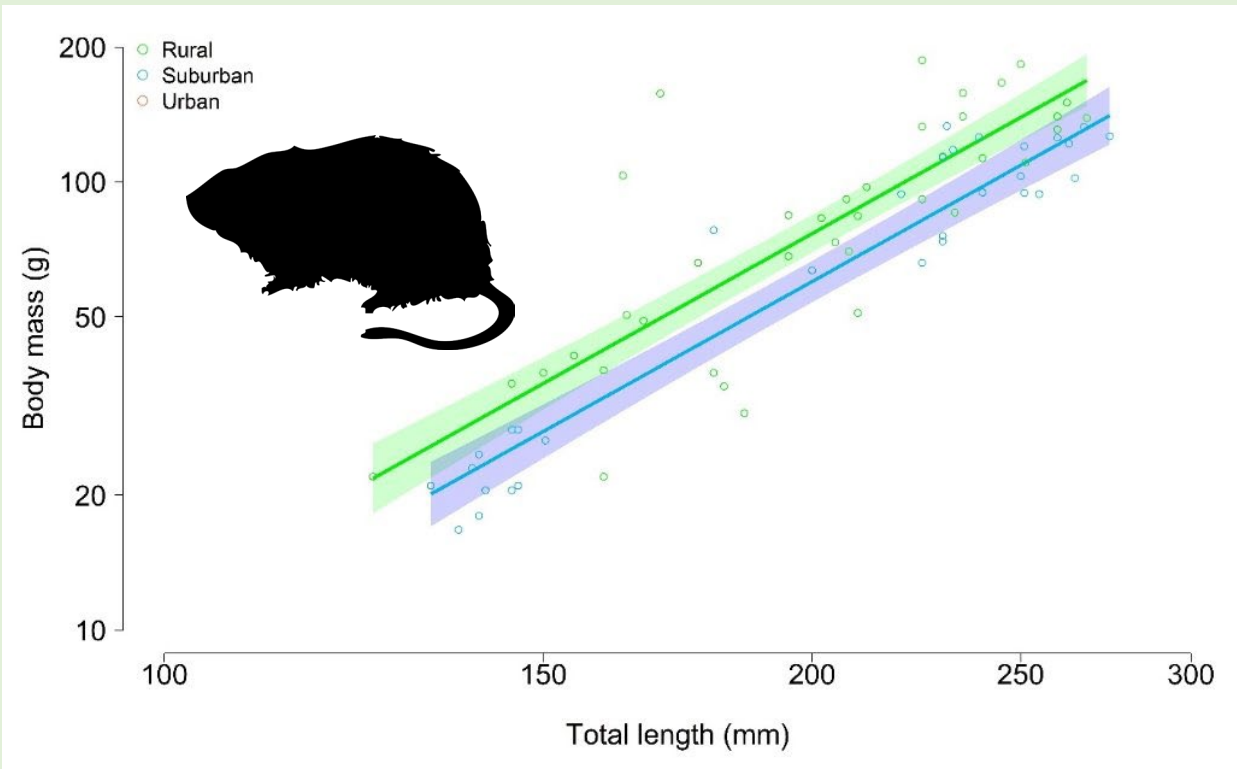
Results: Mass:Length Allometry by Species

- 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)



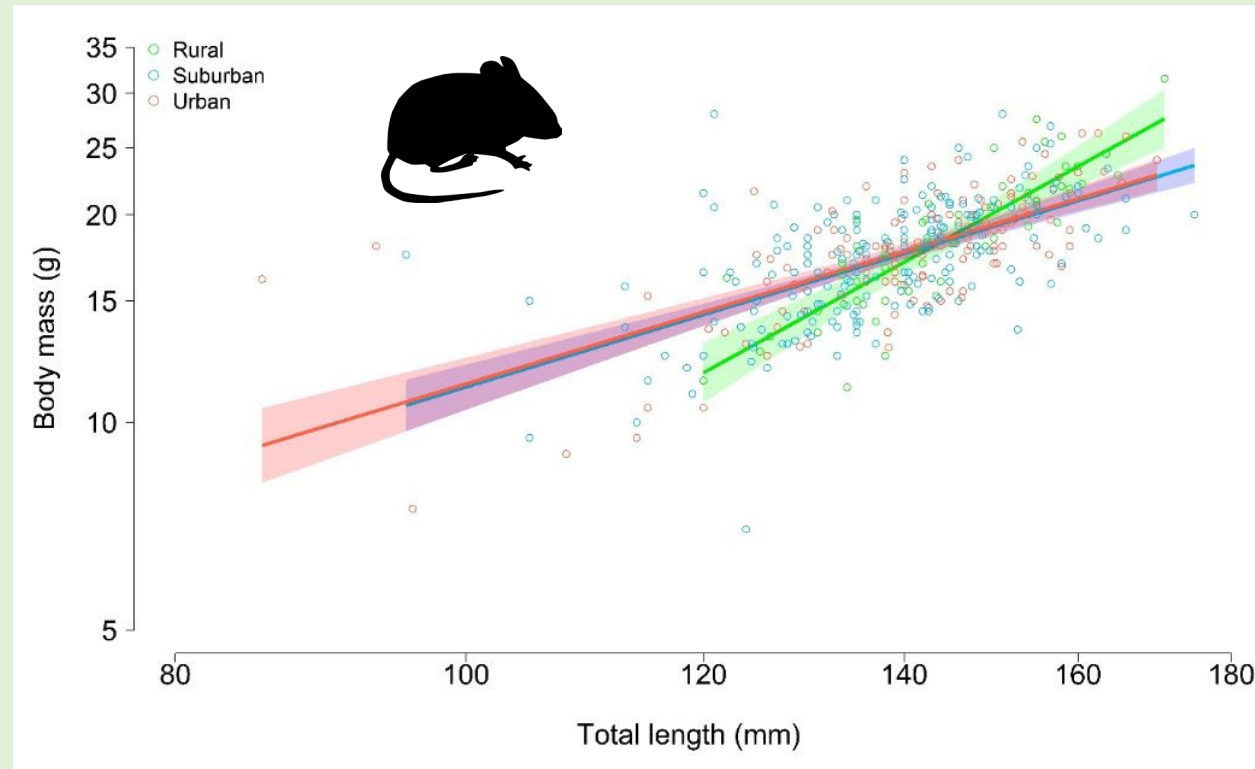
Results: Urbanization affected morphology in species-specific ways

Hispid cotton rats (*S. hispidus*)



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

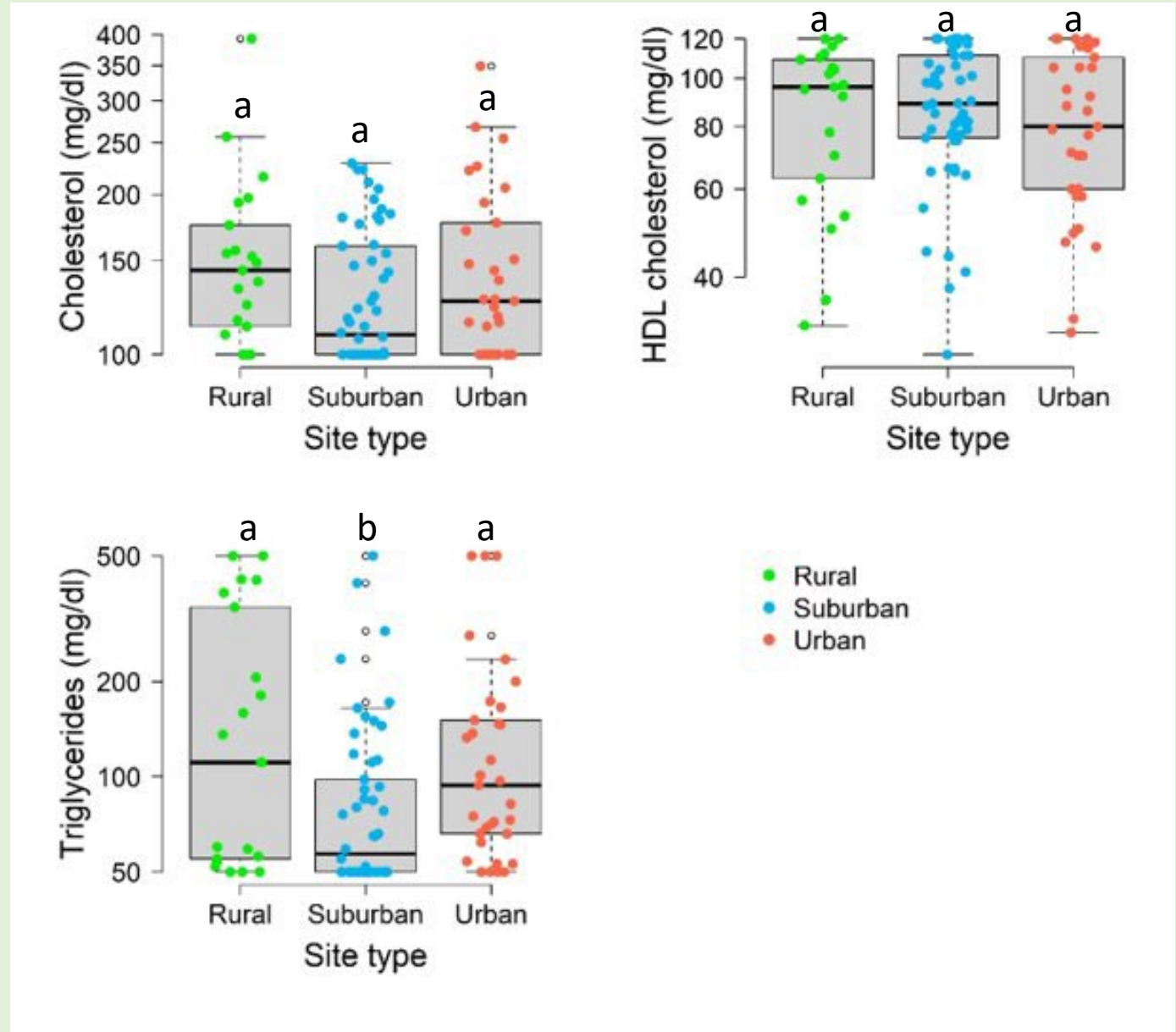
White-footed mice (*P. leucopus*)



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

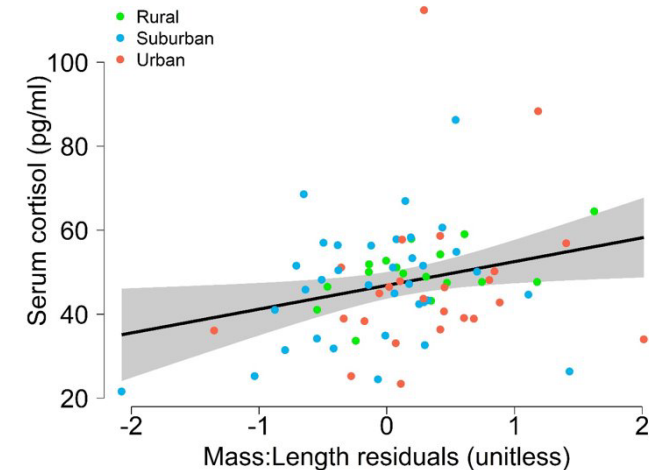
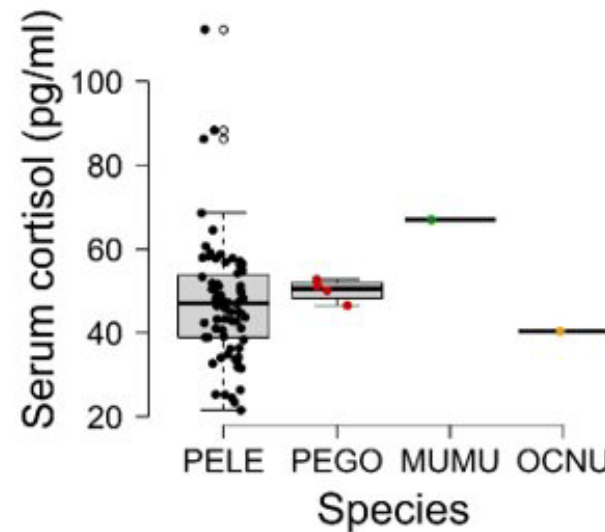
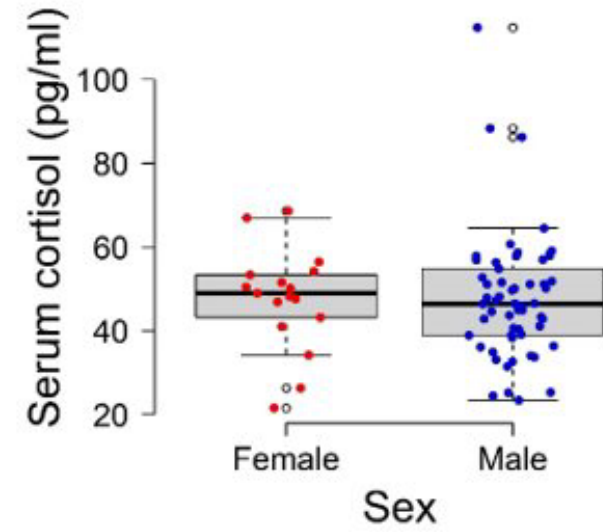
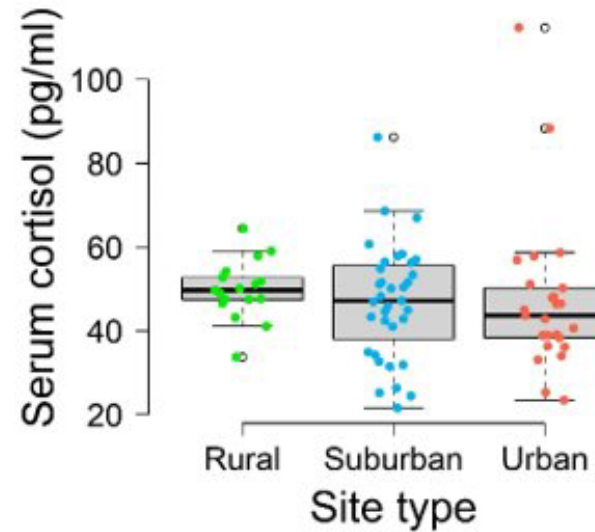
Results: Urbanization affected TRIG

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



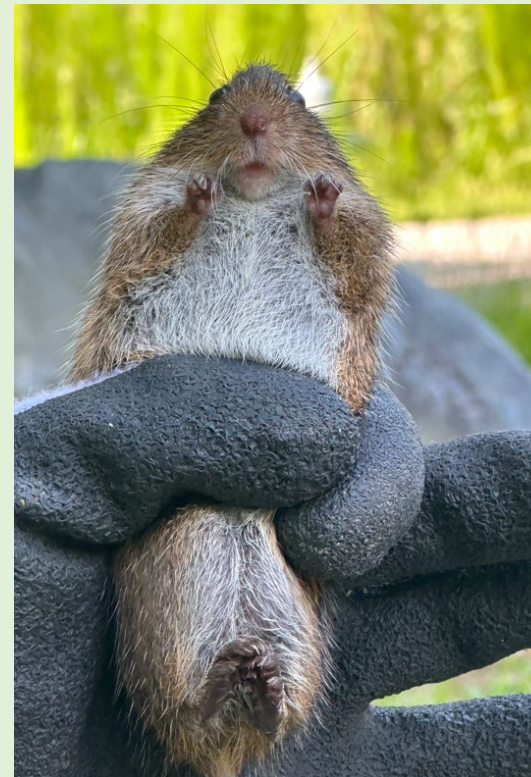
Results: CORT unaffected by urbanization

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



Conclusions

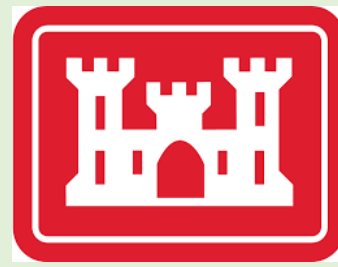
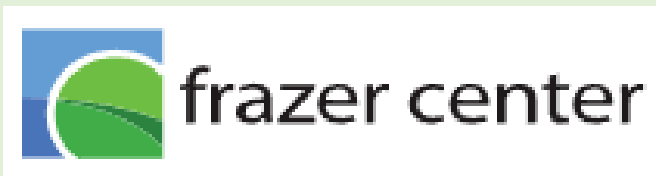
- Small mammal densities driven by several environmental, spatial, and socioeconomic variables
- Urbanization associated with species turnover, but not functional loss.
- Caloric surplus was not evident in morphological or serological data.
- Little redundancy between morphological and physiological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



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- Fernbank Museum of Natural History
- Atlanta Expo Center
- The Conservation Fund





Thank you!

