Individual, population, and community responses of small mammals to the Atlanta urban-to-rural gradient

Bri Casement, Leslie Lopez, Kaitlyn Nestor,
Sydney Morton, and **Nicholas Green**
Department of Ecology, Evolution, and Organismal Biology
Kennesaw State University

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Effects of urbanization – Overview

- Environmental changes
  - Habitat fragmentation
  - Increased noise, light, temperature
  - Driven by human population density and other choices
- Changes in resource availability
  - Human food waste, fewer natural food sources → caloric surplus?
  - Altered predation risks
- 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 and diverse
  - Relatively easy to sample
  - Responsive to local conditions
  - Ecosystem services
  - Baseline biology well understood

Objectives and Hypotheses

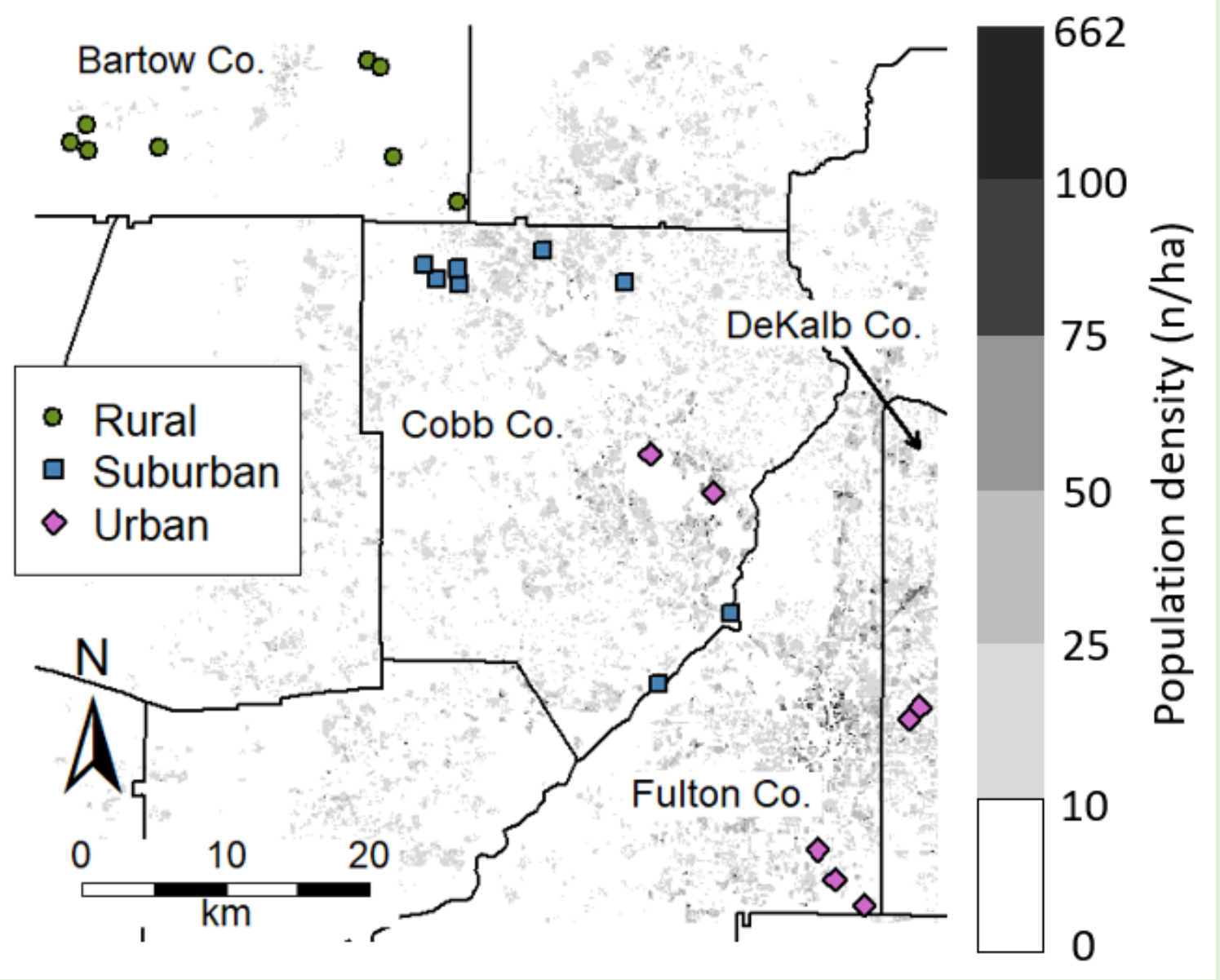
Main objectives:

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

- Trapped small mammals at 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



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Methods: variable collection

- Local habitat variables, plant cover collected in field
- Spatial characteristics and land cover surrounding of each site measured with GIS
- Socioeconomic variables obtained from U.S. Census Bureau
- Human population from WorldPop project
- Socioeconomic and environmental variables related to 1000 m buffers around sites

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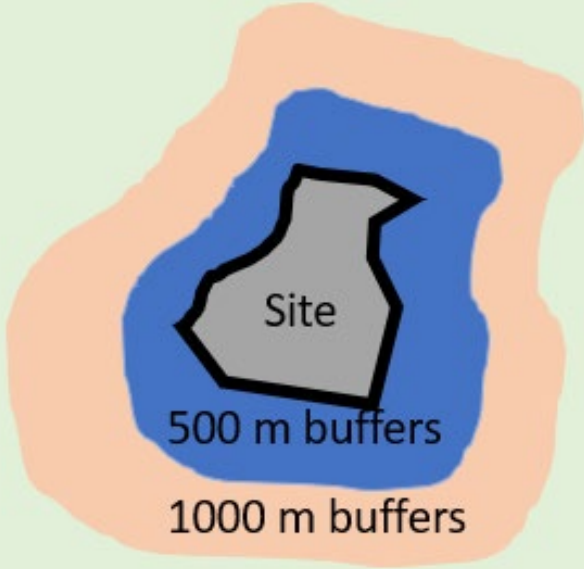
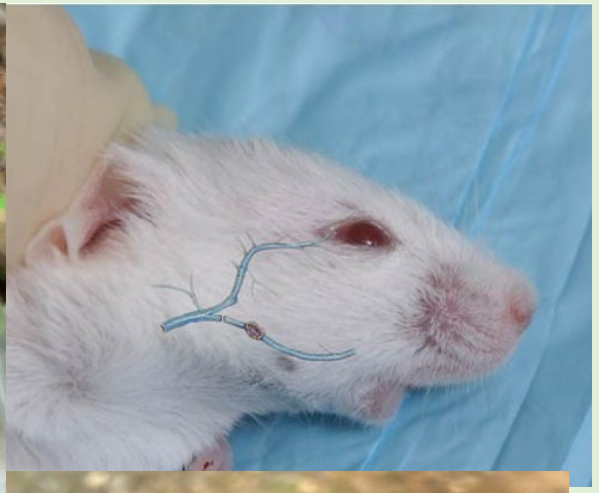
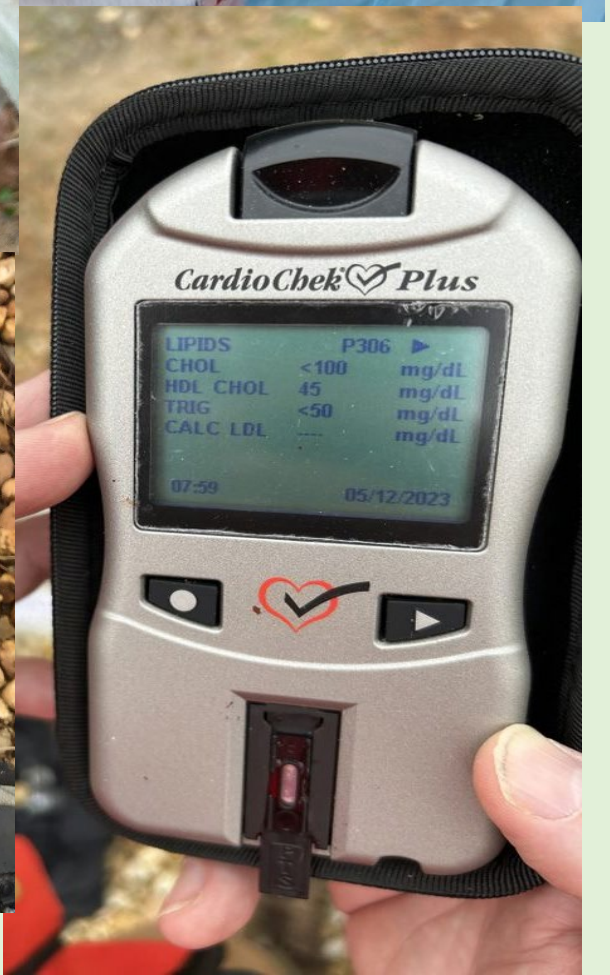


Methods: blood analysis

- 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





Results: capture summary

- 1,135 total captures of 13 species
  - 7.7 captures / 100 trap-nights
- Captures dominated by *P. leucopus*
  - Few human commensals (*M. musculus*, *R. norvegicus*)
  - Excluded *D. virginiana* from analysis, included all others
- Used observed movement distances and MNKA to calculate population density at each site

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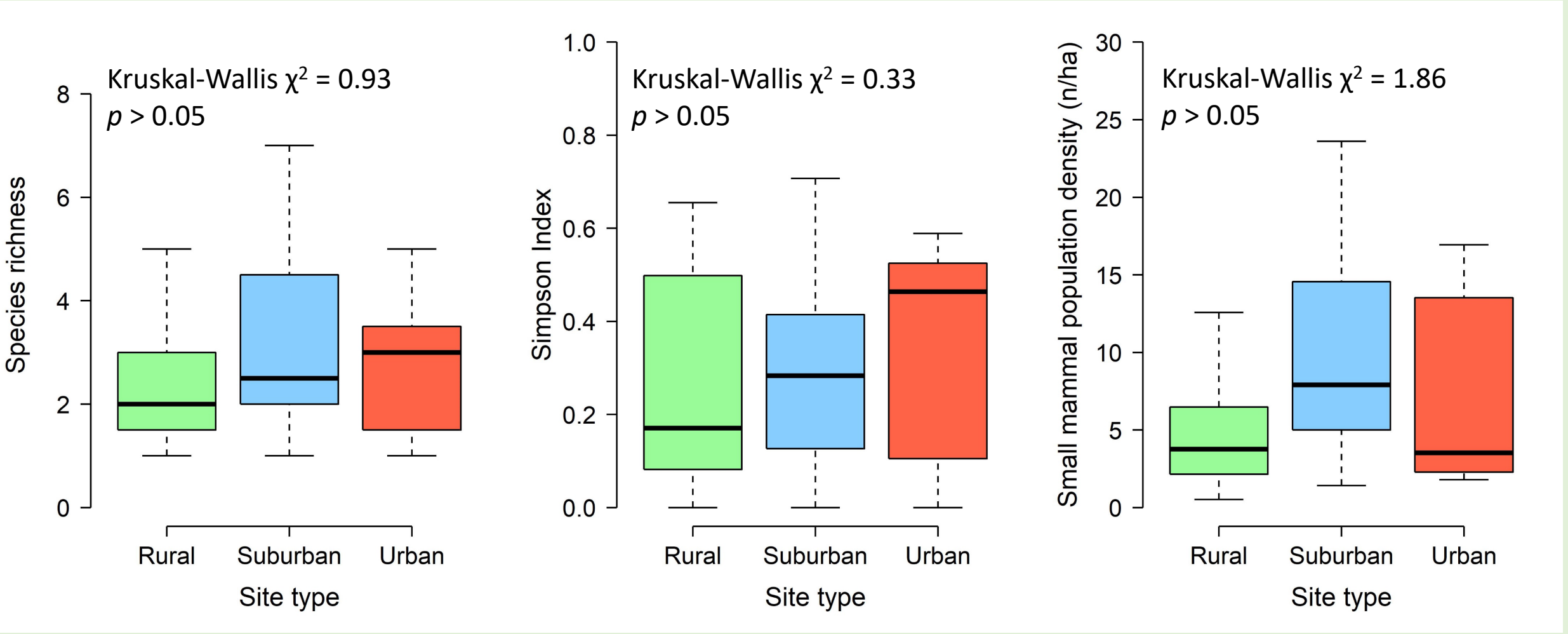
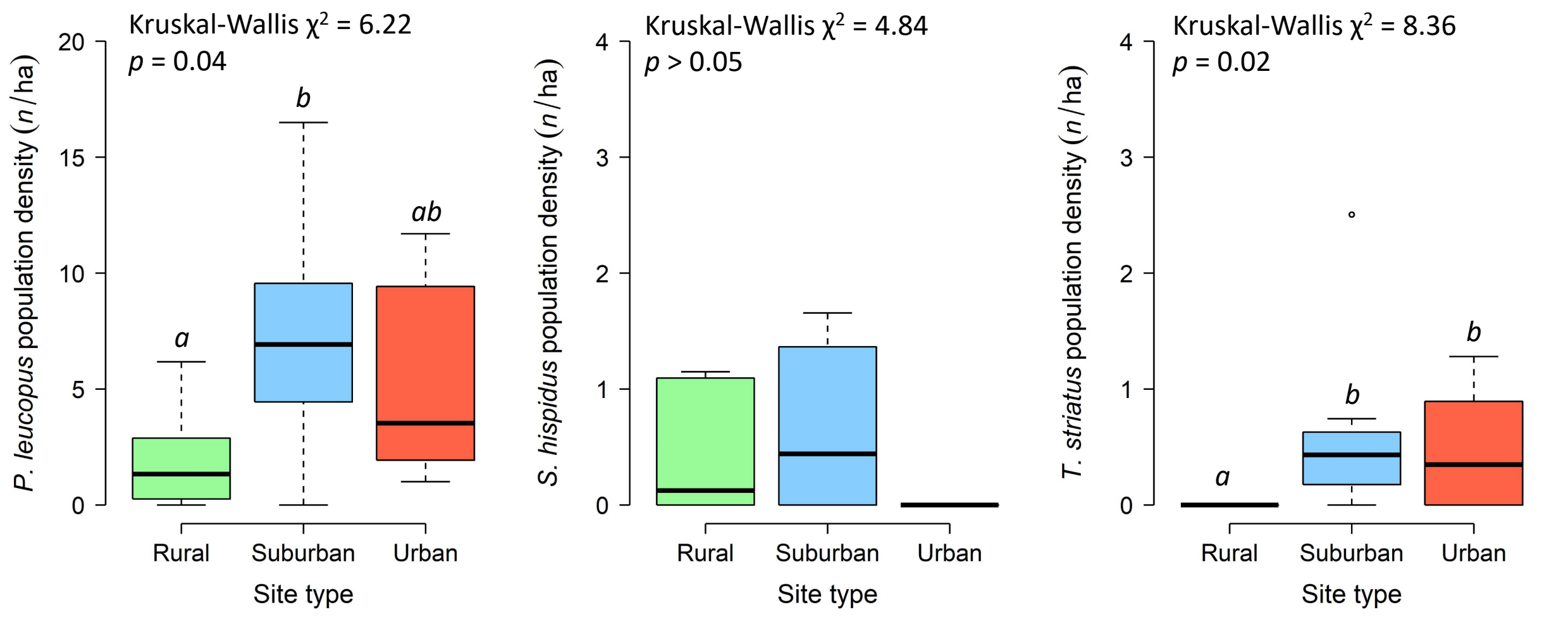
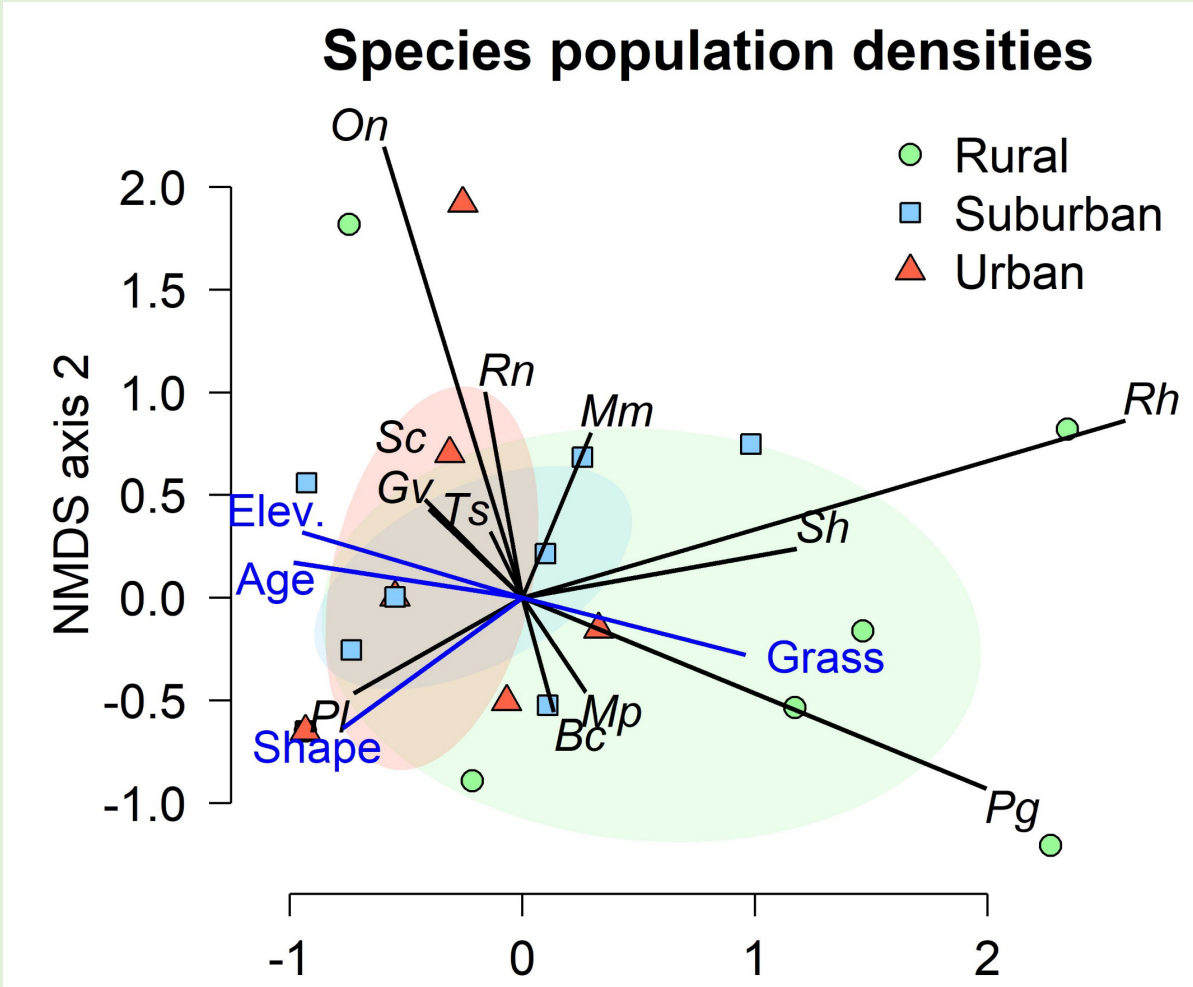
Results – Community metrics



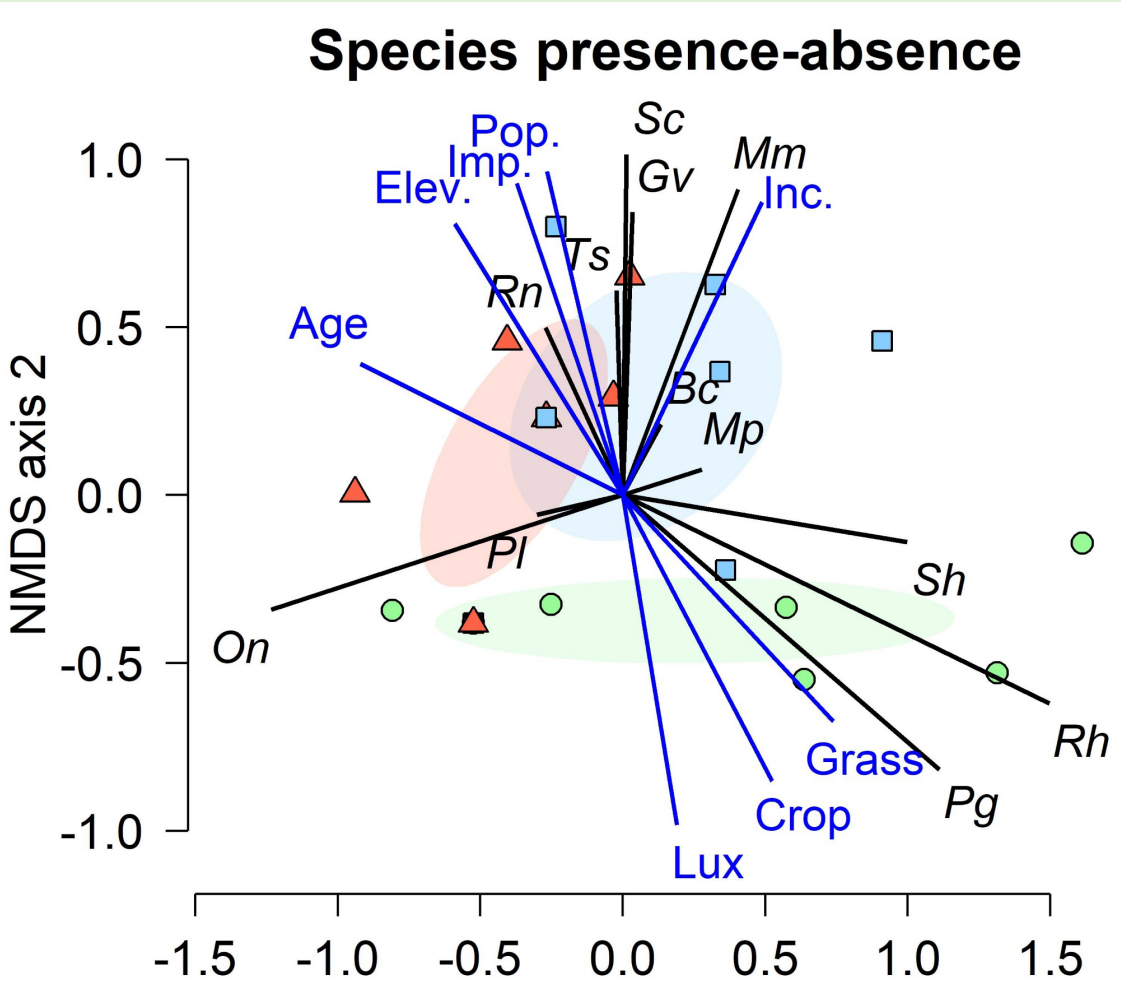
Results – Population densities



Results – Community structure



PERMANOVA $F_{2,20} = 2.16$
$p = 0.02$, $R^2 = 0.18$



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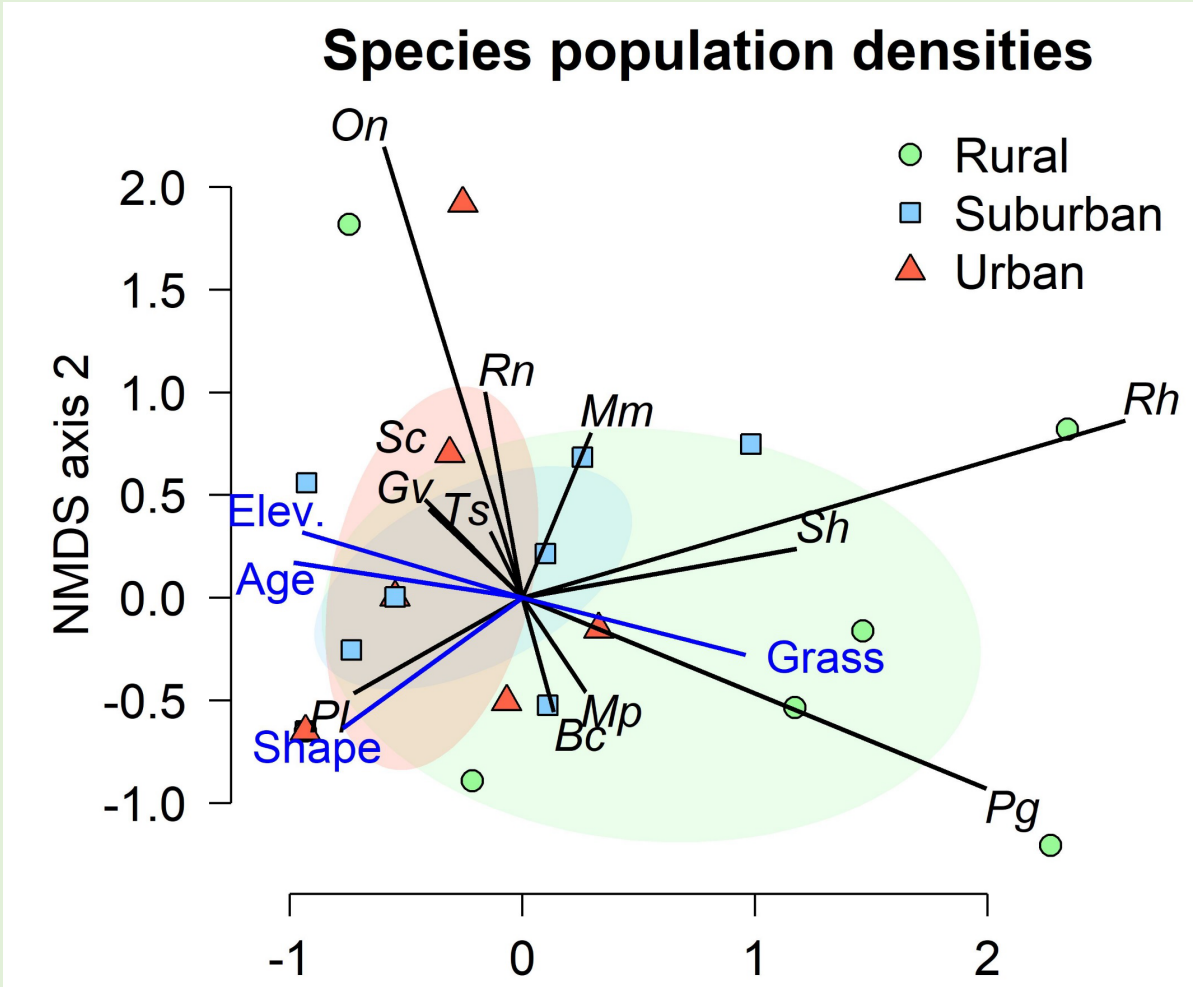

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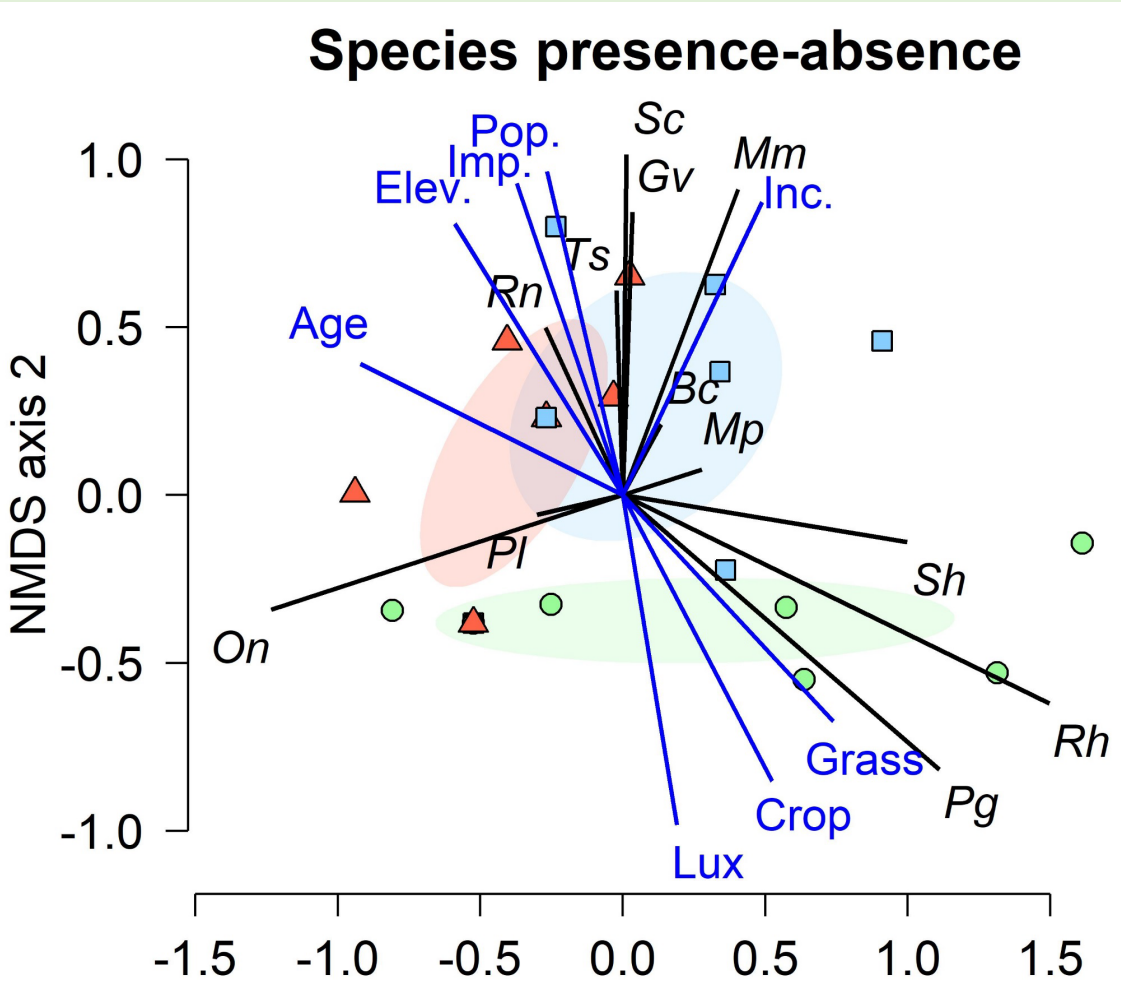

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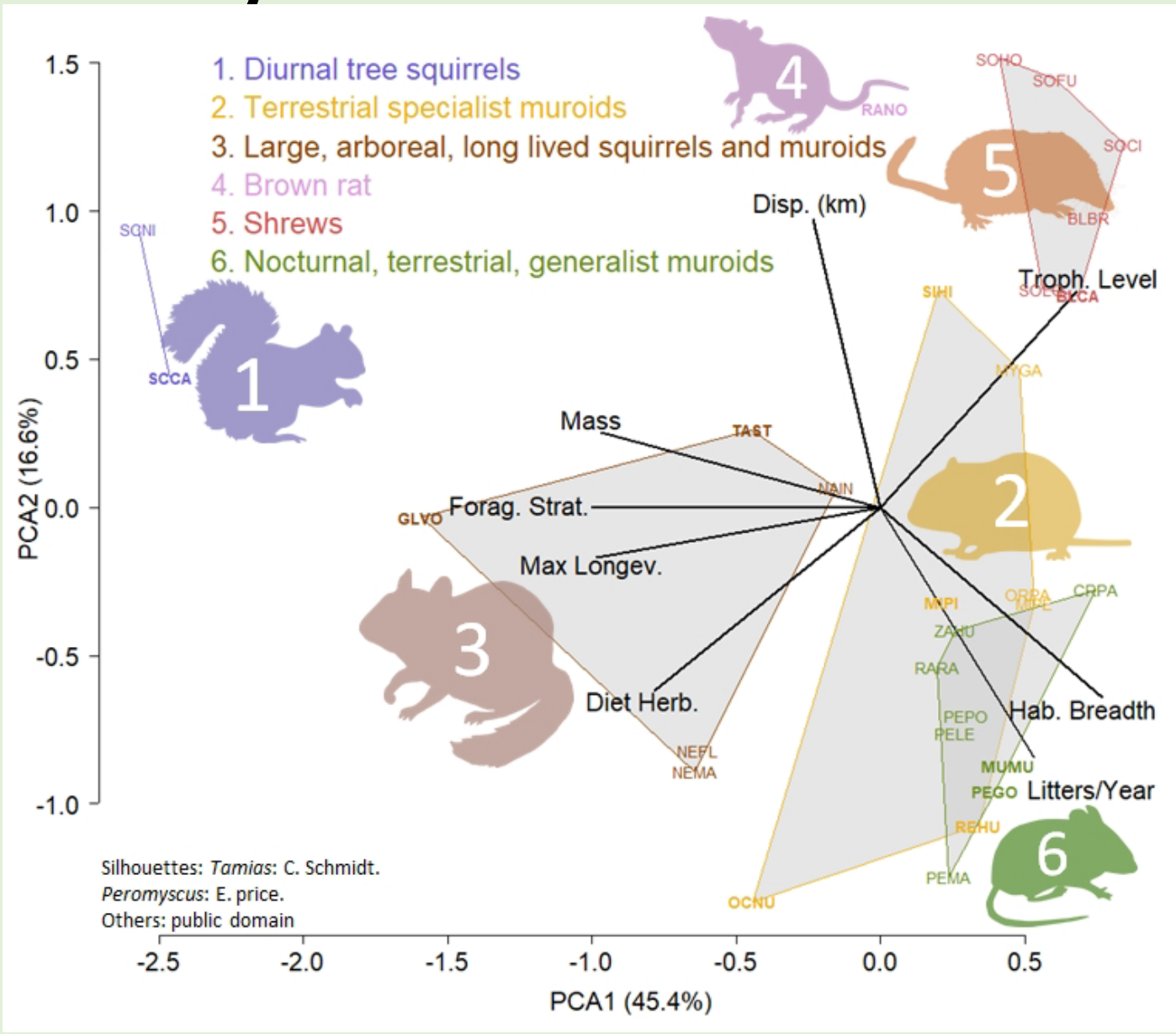
Results – Functional diversity

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



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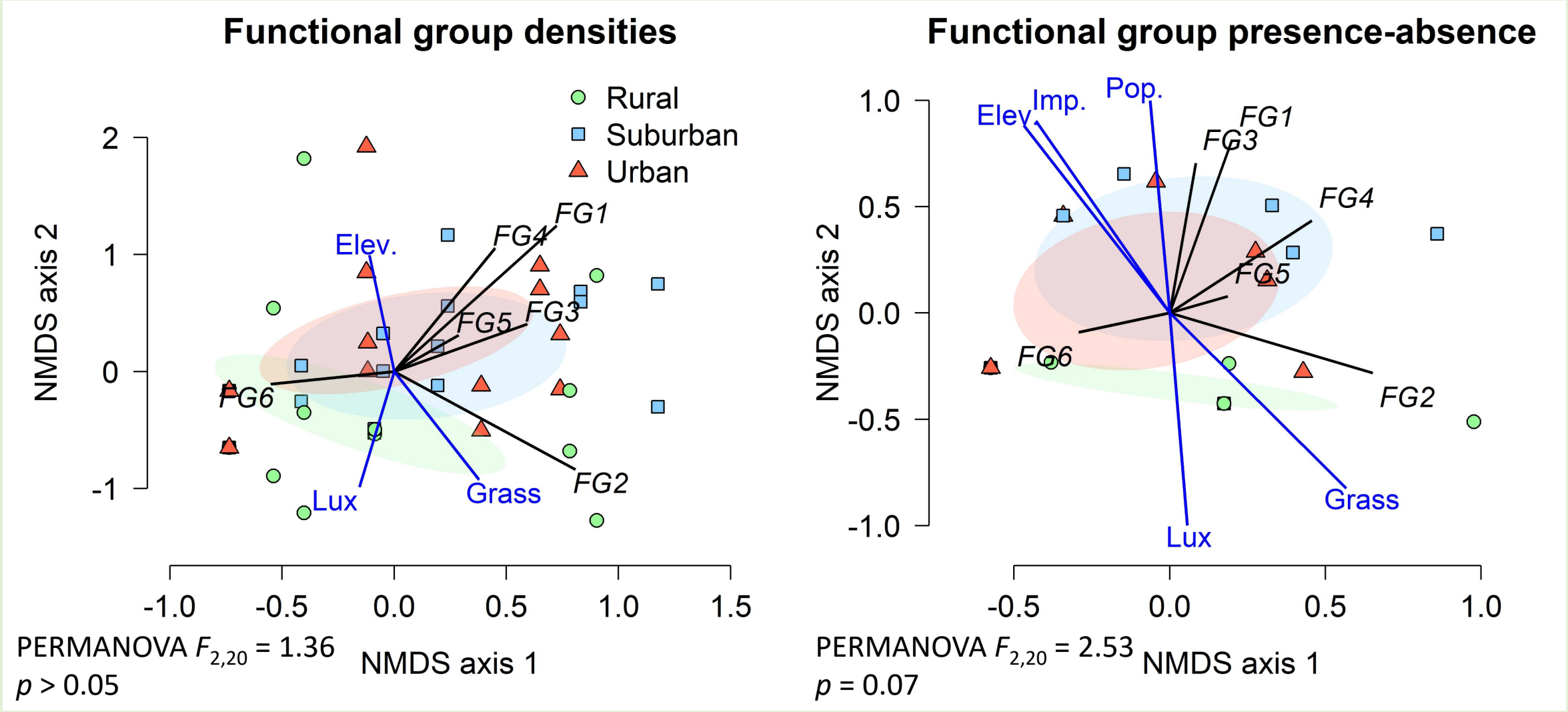
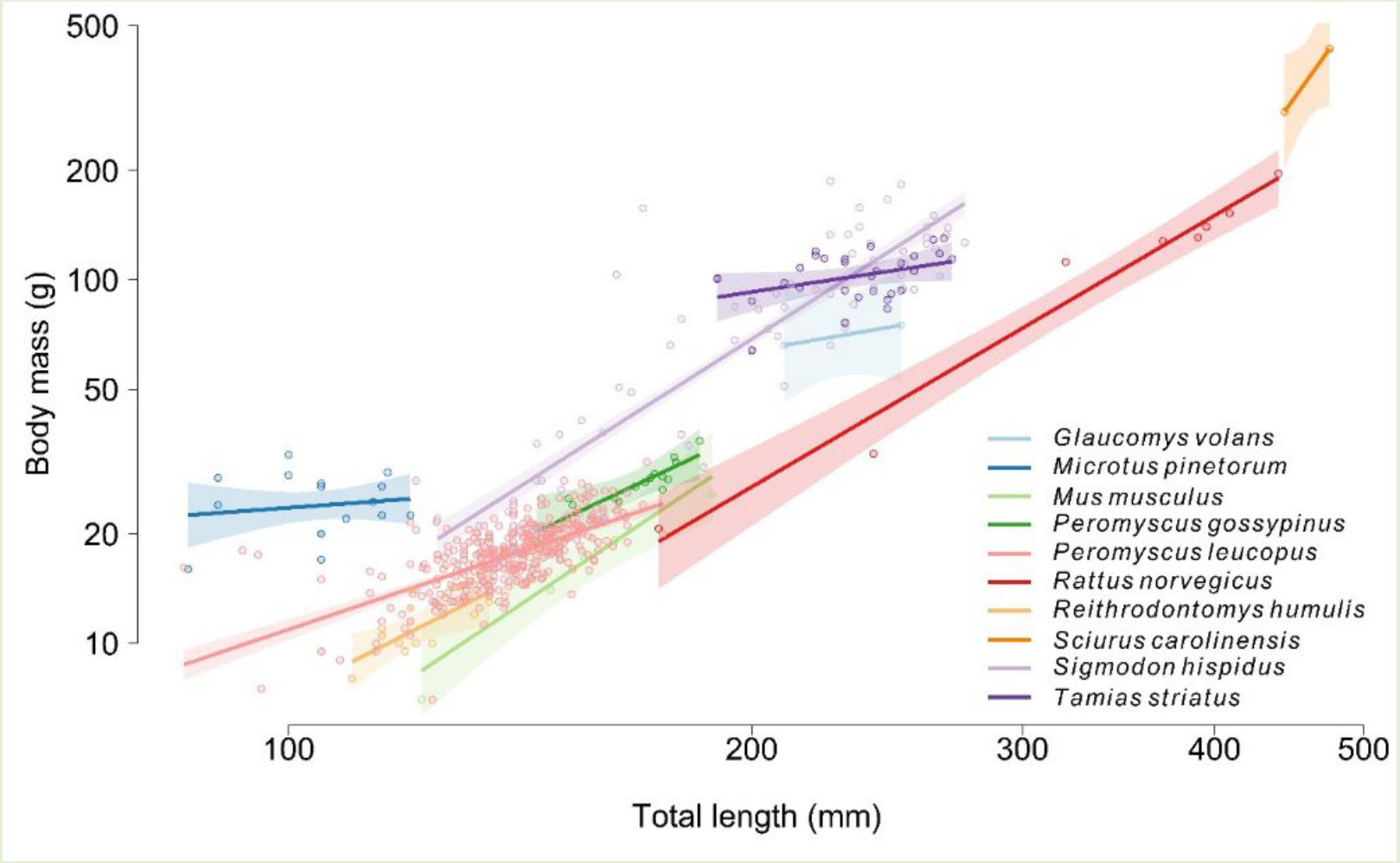


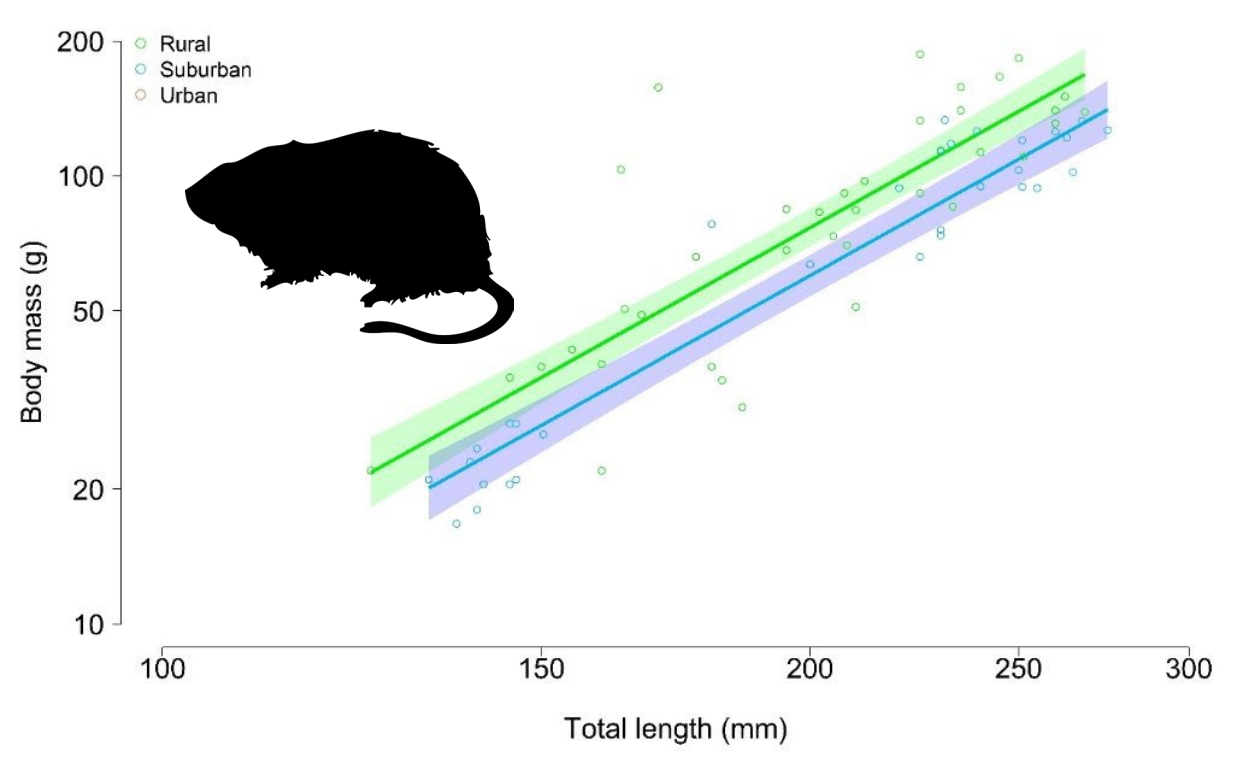
Results: Mass-length allometry

- 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)



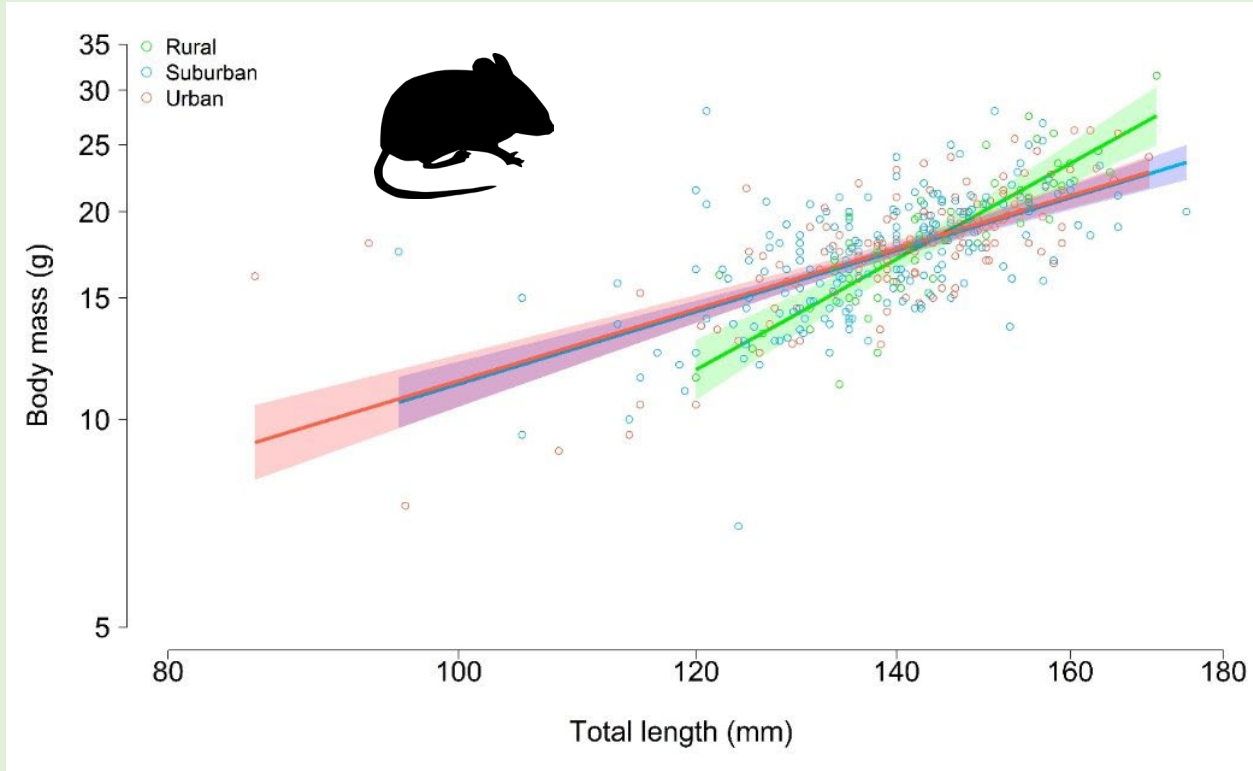
Results: Mass-length allometry

Hispid cotton rats (*S. hispidus*)



Body mass and total length of hispid cotton rats (*S. hispidus*): Model $R^2 = 0.807$ (omnibus ANOVA $F_{3,65} = 95.73$, $P < 0.01$)

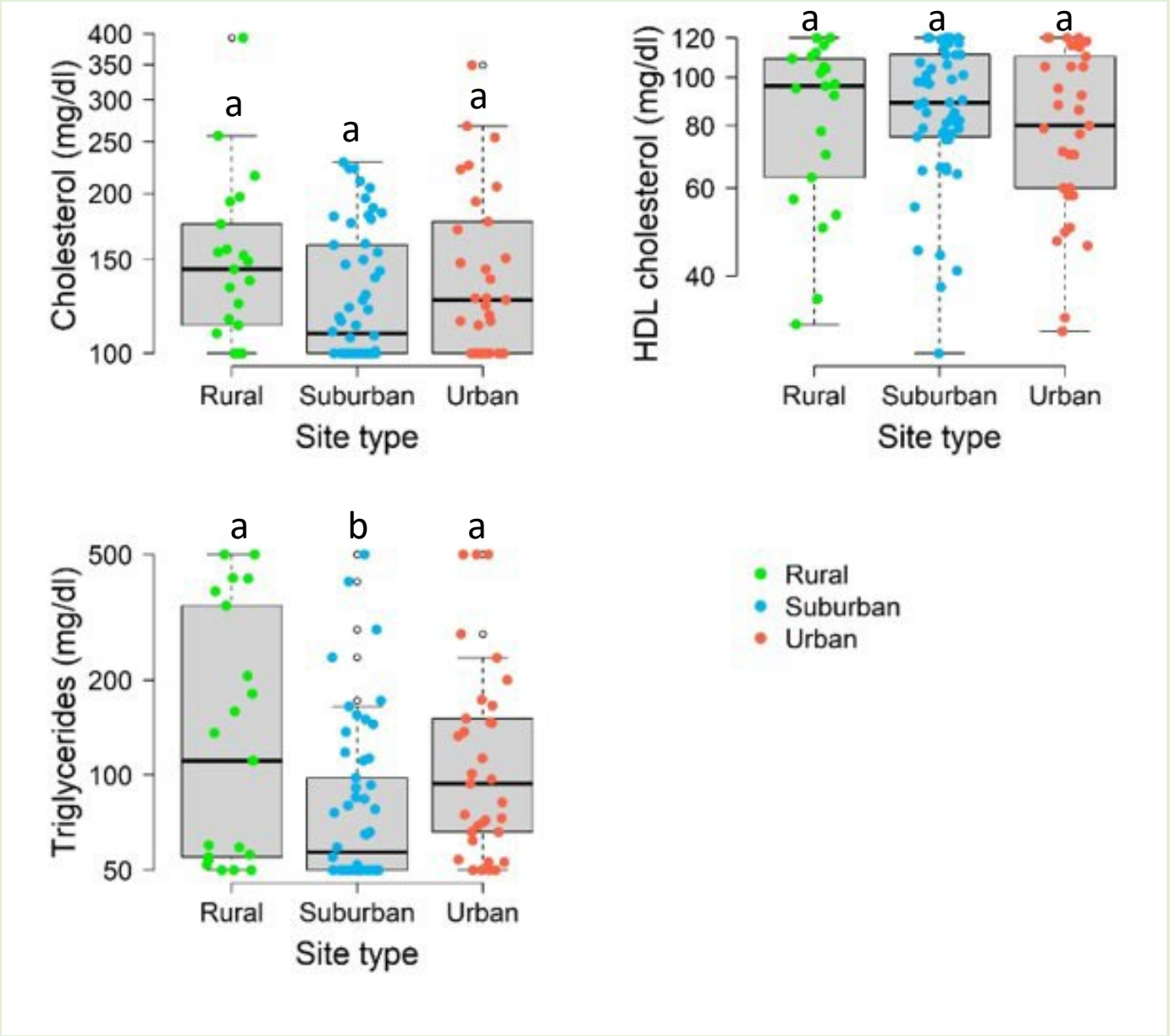
White-footed mice (*P. leucopus*)



Body mass and total length of white-footed mice (*P. leucopus*): Model $R^2 = 0.448$ (omnibus ANOVA $F_{5,401} = 66.8$, $P < 0.01$) (Silhouette: E. Price).

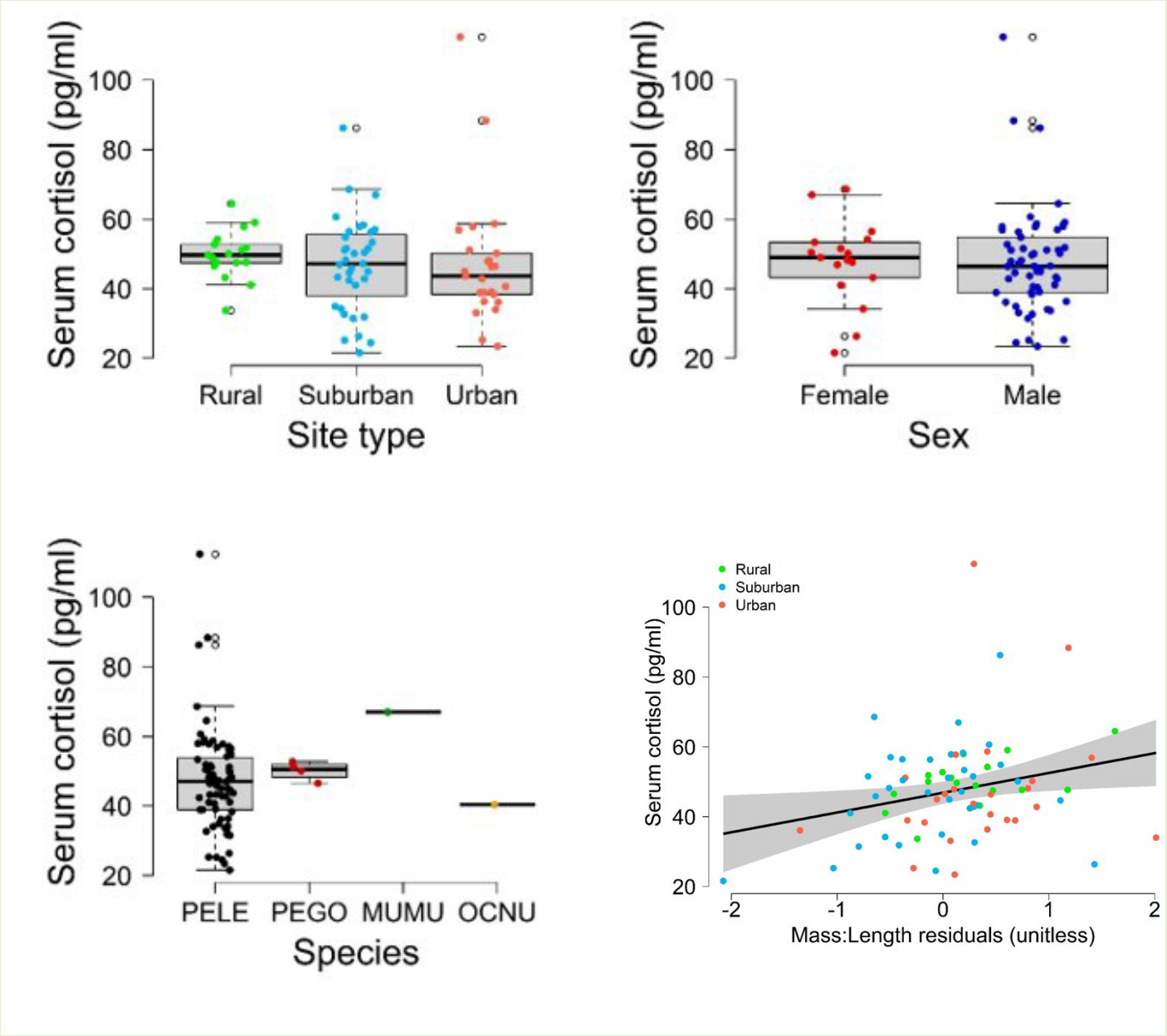
Results: Body condition

- 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).



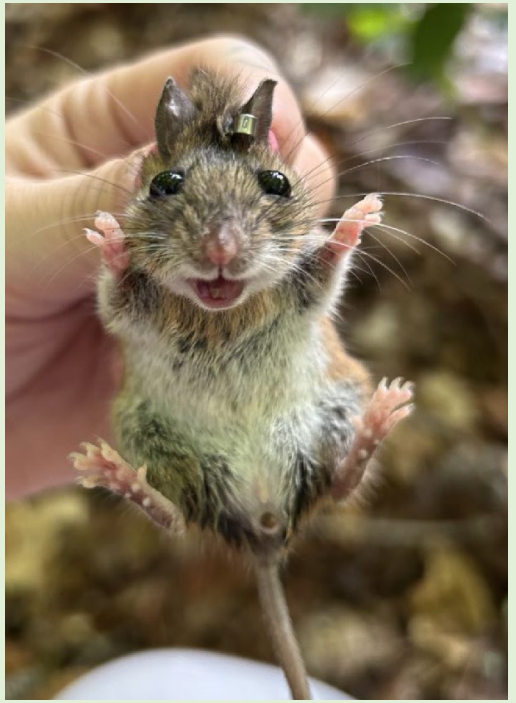
Results: Cortisol levels

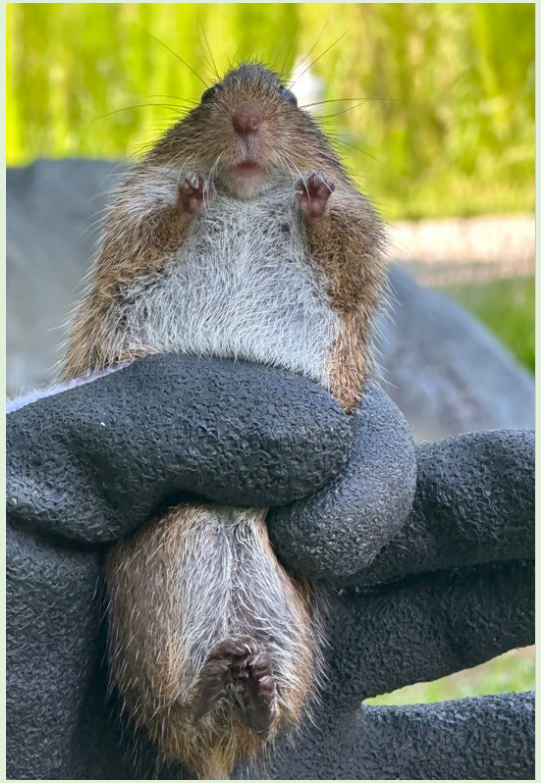
- Small mammal serum cortisol (CORT) was not affected by urbanization, species, or sex.
- CORT was weakly related to body size (mass:length residuals) ($F_{1,75}$ = 5.414, P = **0.022**, R^2 = 0.055).



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





Acknowledgements

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- U.S. Army Corps of Engineers
- Cobb County Parks Department
- Georgia Power at Plant Bowen
- Frazer Forest
- Fernbank Museum of Natural History
- Atlanta Expo Center
- The Conservation Fund

Thank you!

Green Quantitative Ecology

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