Urban Heat Island Effect and Rodent Body Condition

Brittany D. Allen[1], Heather L. Bateman[1], Marianne S. Moore[1], and David M. Hondula[2].
[1]College of Integrative Sciences and Arts, Arizona State University, and [2]College of Liberal Arts and Sciences, School of Geographical Sciences and Urban Planning, Arizona State University

ARIZONA STATE UNIVERSITY

NSF — **Central Arizona-Phoenix Long-Term Ecological Research** — **CAP LTER**

Introduction and Objective

- Human-made surfaces and structures increase radiant heat exchange in urban areas by several degrees hotter compared to non-urban areas (Chow et al. 2012). Studies have shown negative affects of heat on human health (Petitti et al. 2016), however no studies have focused on the response of wildlife to urban heat.

- Studies compare quantitative magnetic resonance (QMR) scans to carcass analysis and indicate QMR as an accurate measure of fat, lean mass, and water content of rodents (Nixon et al. 2010).

- Animal body condition is storage of resources such as fat, which are important for survival and reproduction (Young 1976).

- The objective of our research is to evaluate rodent body condition living in three levels of urban heat. We tested the hypotheses that percent body fat, lean mass, and water varies in animals from three levels of urban heat.

Methods

- Selected sites of three levels of temperature based on mean daily summer surface temperatures (A: 47.0 - 49.0° C, B: 50.0 - 52.0° C, and C: 53.0 - 55.0° C).

- We captured 37 adult nocturnal rodents (Merriam's kangaroo rats, *Dipodomys merriami,* and pocket mice, *Chaetodipus spp.*) using baited Sherman live traps from mid-July through early September in urban parks and open spaces.

- QMR machine used to measure fat, lean mass, and water content of live rodents.

- Fat mass (g) was averaged over 12 runs per individual animals' mass from the QMR and then was divided by the animals' measured mass (g).

- Statistical analyses preformed using R Version 3.5.2 to evaluate differences in means across temperature levels using an ANOVA (alpha at $P = 0.10$) and post-hoc comparisons with Tukey test.
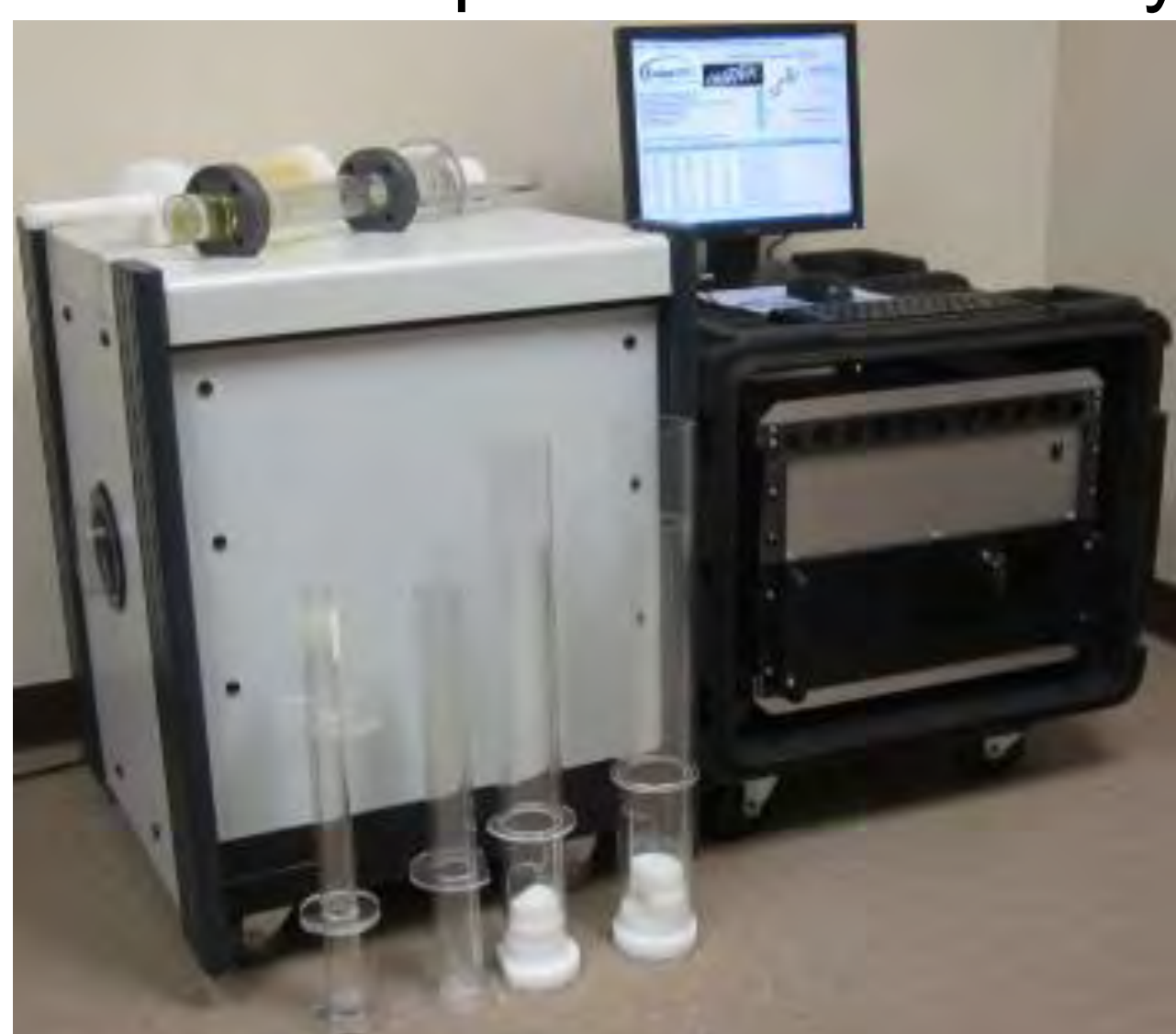

Figure 1. EchoMRI™ Mobile Body Composition Analyzer. Image obtained from echomri.com.

Figure 2. *Chaetodipus spp.* rodent on scrub, McDowell Sonoran Preserve.

Study Area

Daily Avg. °C
- 47.0 - 49.0
- 50.0 - 52.0
- 53.0 - 55.0
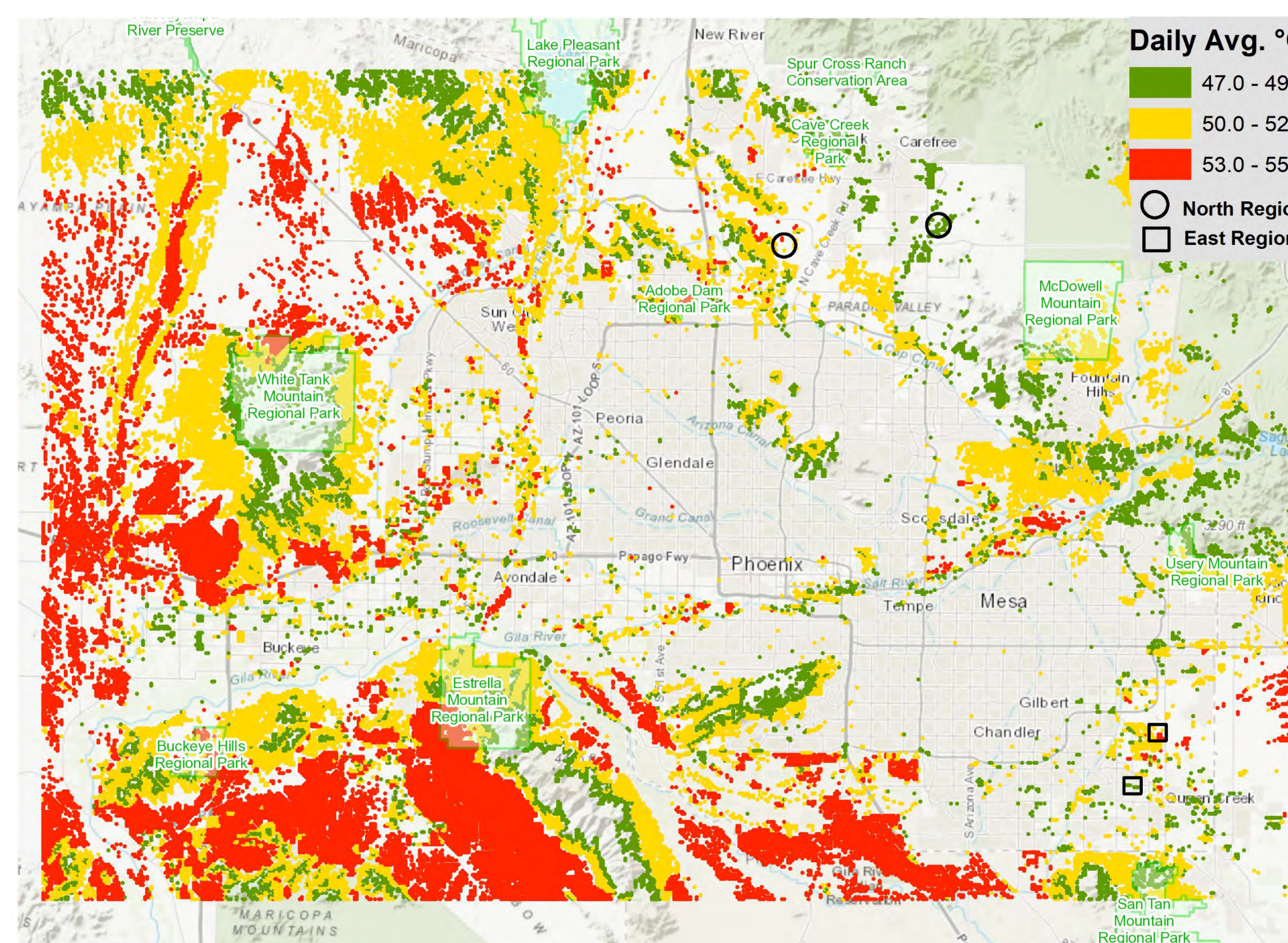- ○ North Region
- □ East Region

Figure 3. Temperature levels and site locations in two regions across Phoenix, Arizona. Map creation using ArcMap 10.6.1 based on the variation of temperature variations across a heat gradient using the 2010, 15-meter land use and land cover classification data (available from Central-Arizona Phoenix, Long Term Ecological Research program, CAP LTER; Li 2015).

- The data for site selection and map production is in collaboration with Dr. Hondula.

- Temperature levels (colored areas) represent 400m plots of open area to sample animals from similar habitats.

Results

Pocket Mice (Chaetodipus spp.) Body Condition and Temperature

Average of Mean Fat %

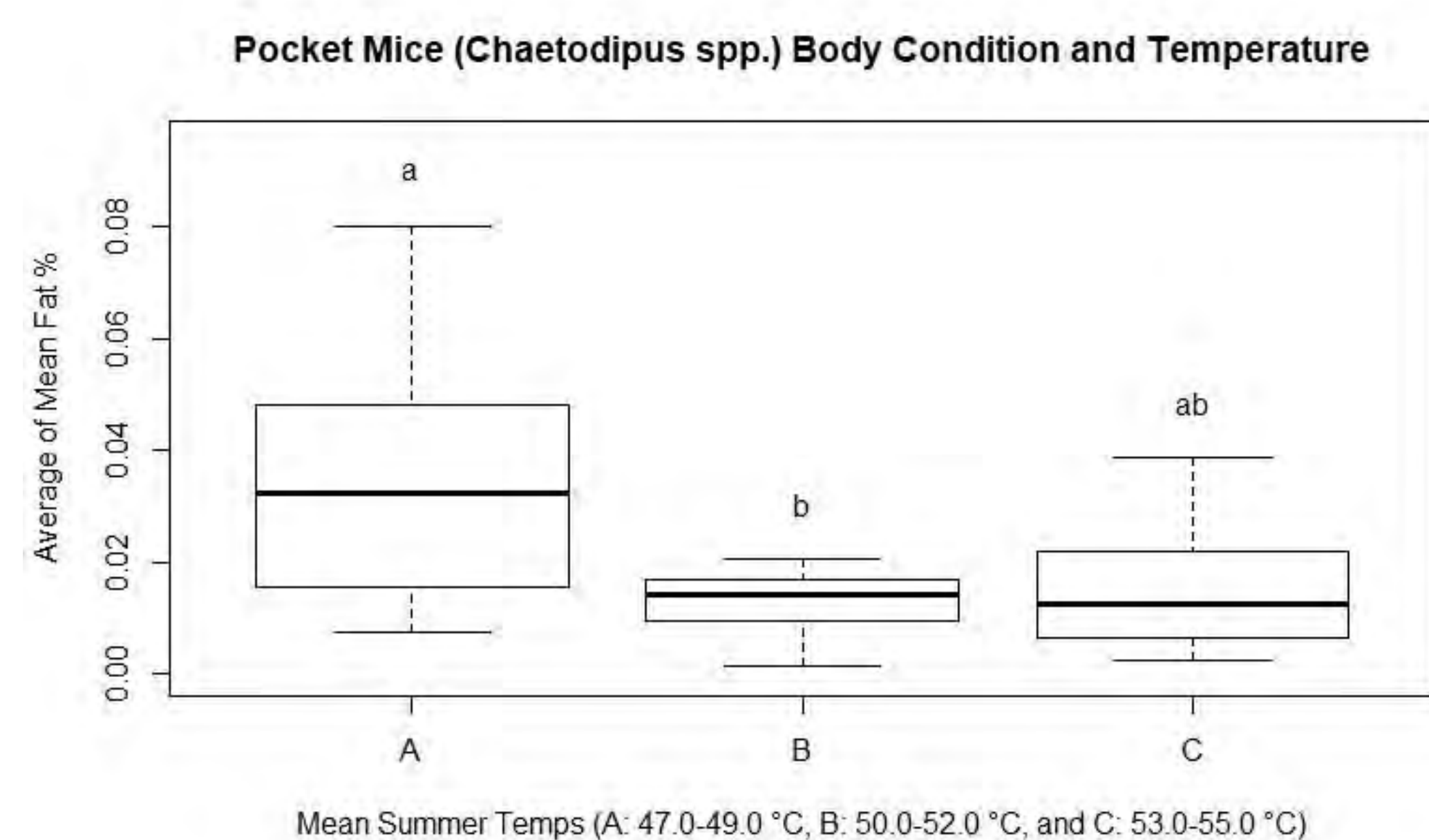Mean Summer Temps (A: 47.0-49.0 °C, B: 50.0-52.0 °C, and C: 53.0-55.0 °C)

Figure 4. Average of mean fat % of each temperature level for *Chaetodipus spp.,* letters above bar graph symbolize Tukey test results with different letters indicating groups that are significantly different.

Merriam's Kangaroo Rats (Dipodomys merriami) Body Condition and Temperature

Average of Mean Fat %

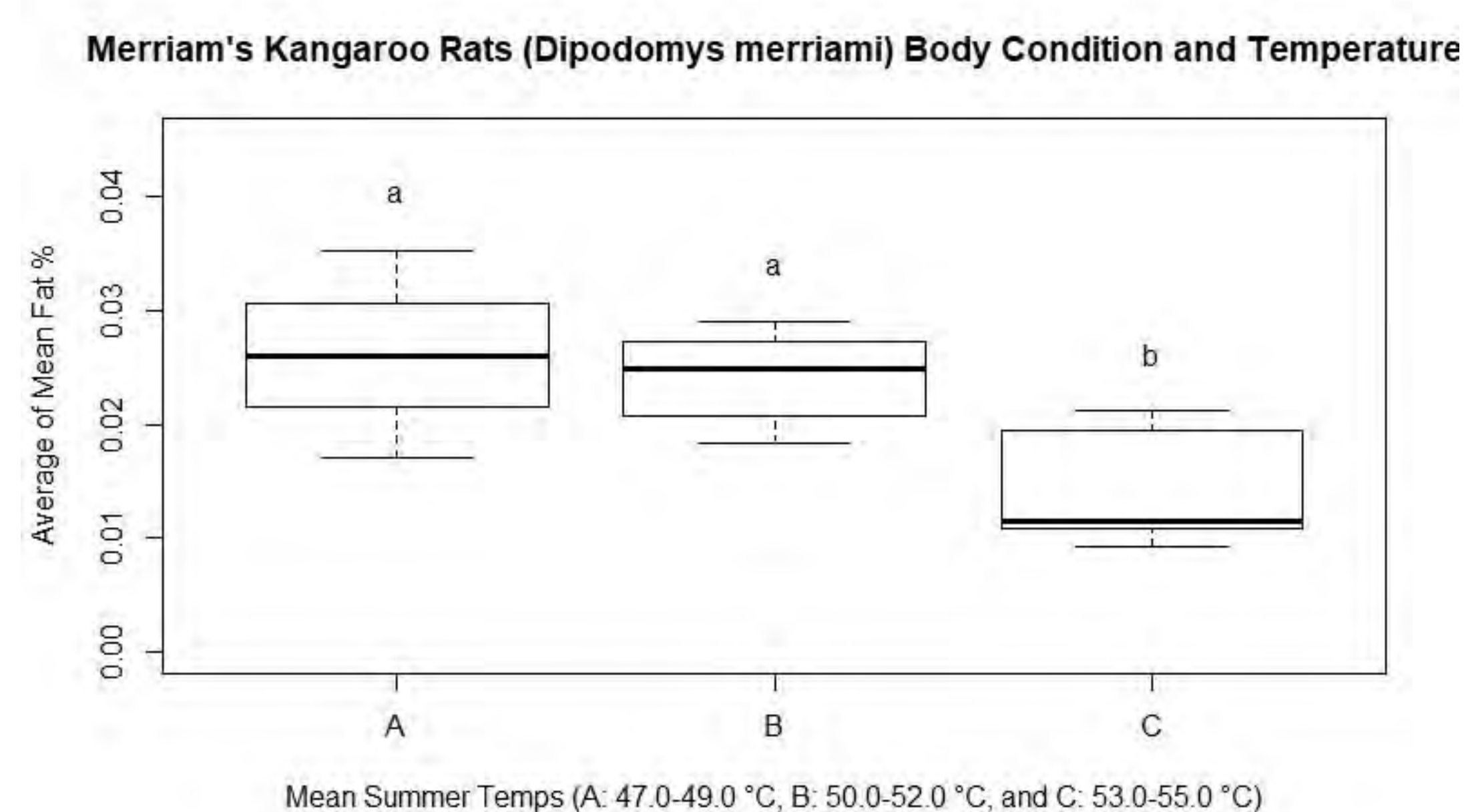Mean Summer Temps (A: 47.0-49.0 °C, B: 50.0-52.0 °C, and C: 53.0-55.0 °C)

Figure 5. Average of mean fat % of each temperature level for *Dipodomys sp.,* letters above bar graph symbolize Tukey test results with different letters indicating groups that are significantly different.

- The average of mean fat percent is significantly different between the different temperature levels for *Chaetodipus spp.* (ANOVA: $F_{2, 21} = 4.0$, $P = 0.0341$, figure 4). The A-B groups ($P = 0.0478$) showed they differed significantly from each other.

- The average of mean fat percent is significantly different between the different temperature levels for *Dipodomys sp.* (ANOVA: $F_{2, 10} = 4.7$, $P = 0.0369$, figure 5). The A-C ($P = 0.0576$) and B-C ($P = 0.0722$) groups showed they differed significantly from each other.

- Lean mass and water content show no significant difference between levels of urban heat.

Conclusions

- Our preliminary results show pocket mice and Merriam's kangaroo rats captured from cooler summer temperature regimes had more fat than rodents captured from hotter summer regimes.

- Our results will contribute to understanding the effects of extreme heat on urban wildlife body condition and health.

- Implications for management include a better understanding of how wildlife are affected by extreme heat in urbanized areas. We hope this research brings attention to the need to mitigate the effects of extreme heat on urban wildlife and humans.

Summer 2020

To further investigate the preliminary findings, we plan to:

- Sample additional animals across regions surrounding Phoenix, Arizona

- Expand predictor variable to include vegetation cover, soil type, and land use/land cover

Acknowledgements

Citations

Chow, W.T., D. Brennan, and A.J. Brazel. 2012. Urban heat island research in Phoenix, Arizona: Theoretical contributions and policy applications. Bulletin of the American Meteorological Society 93(4): 517-530.

Li, X. 2015. Land use and land cover (LULC) classification of the CAP LTER study area using 2010 Landsat imagery. https://sustainability.asu.edu/caplter/data/view/knb-lter-cap.619.1/

Nixon, J.P., M. Zhang, C. Wang, M. Kuskowski, C.M. Novak, J.A. Levine, C.J. Billington, and C.M. Kotz. 2010. Evaluation of a quantitative magnetic resonance imaging system for whole body composition analysis in rodents. Obesity 18(8): 1652-1659.

Petitti, D.B., D.M. Hondula, S. Yang, S.L. Harlan, and G. Chowell. 2016. Multiple trigger points for quantifying heat-health impacts: New evidence from a hot climate. Environmental Health Perspectives.124(2): 176-183.

Young, R.A. 1976. Fat, Energy and Mammalian Survival. American Zoology. 16: 699-710.