Conceptual Methods for Defining Mammalian Functional Traits in Urban Landscapes

Katherine C. B. Weiss[1,2], Courtenay A. Ray[1], Jan Schipper[2], and Sharon J. Hall[1]

[1]School of Life Sciences, Arizona State University, [2]Arizona Center for Nature Conservation, Phoenix Zoo

Central Arizona-Phoenix Long-Term Ecological Research CAP LTER

Arizona State University

Background

Cities have been described as novel ecosystems that support unique assemblages of wildlife[1,2]. Yet undefined are mechanisms for how species filter into cities to form communities[2]. Functional traits that respond to people and the environment have been postulated as likely mechanisms for urban community assembly[2]. However, significant disagreement exists on how to measure and compare functional traits across taxa[3]. Other approaches instead categorize species by their ability to avoid, utilize, or dwell within cities[4]. However, classifications fail to account for how species change across space and time[5].

How do methods for the classification of species in cities differ, and how might we synthesize approaches to support the creation of more useful datasets?

We present a novel functional trait framework to be applied across terrestrial mammals within CAP LTER. We predict mammals closer to urban elements share physiological, behavioral, and cultural functional traits.

Challenges with Functional Traits

Many use functional traits to quantify species distributions in cities[6,7,8]. Despite efforts to untangle how traits correspond with feedbacks between organisms and their environment:

- Functional trait studies often do not select traits based on the research question or community assembly processes
- Definitions remain unaligned (Table 1), limiting the comparability of current work across contexts[3]

Table 1. Example "functional trait" definitions in foundational functional ecology literature. Citations were determined on Google Scholar (https://scholar.google.com/) on November 5, 2018. Adapted from Weiss and Ray (In Review)[3].

Publication	Defines functional traits as	Citations
Tilman (2001)[9]	"... organismal **traits that influence one or more aspects of the functioning of an ecosystem**"	547
Díaz and Cabido (2001)[10]	"... **the characteristics of an organism ... relevant to its response to the environment and/or its effects on ecosystem functioning**"	2169
Lavorel and Garnier (2002)[11]	"... **Response groups and effect groups** ... Physiological, harder traits at the individual level are more commonly used for effect groups ... Whereas response groups are identified through community-level studies of changes in soft, morphological or behavioural traits in response to abiotic or biotic factors"	2025
McGill et al. (2006)[12]	"... **a well-defined, measurable property of organisms**, usually measured at the individual level and used comparatively across species ... **that strongly influences organismal performance**"	2451
Petchey and Gaston (2006)[13]	"... components of an organism's **phenotype that influence ecosystem level processes**"	1401
Violle et al. (2007)[14]	"**Any trait which impacts fitness indirectly** via its effects on growth, reproduction and survival"	1881

Limitations of Other Methods

An alternative to using functional traits is categorizing species as urban avoiders, utilizers, or dwellers[5]. However, categorizations have recently been called into question, as they fail to account for how species change over space, through time, and across heterogeneous environments[4] (Fig. 1).

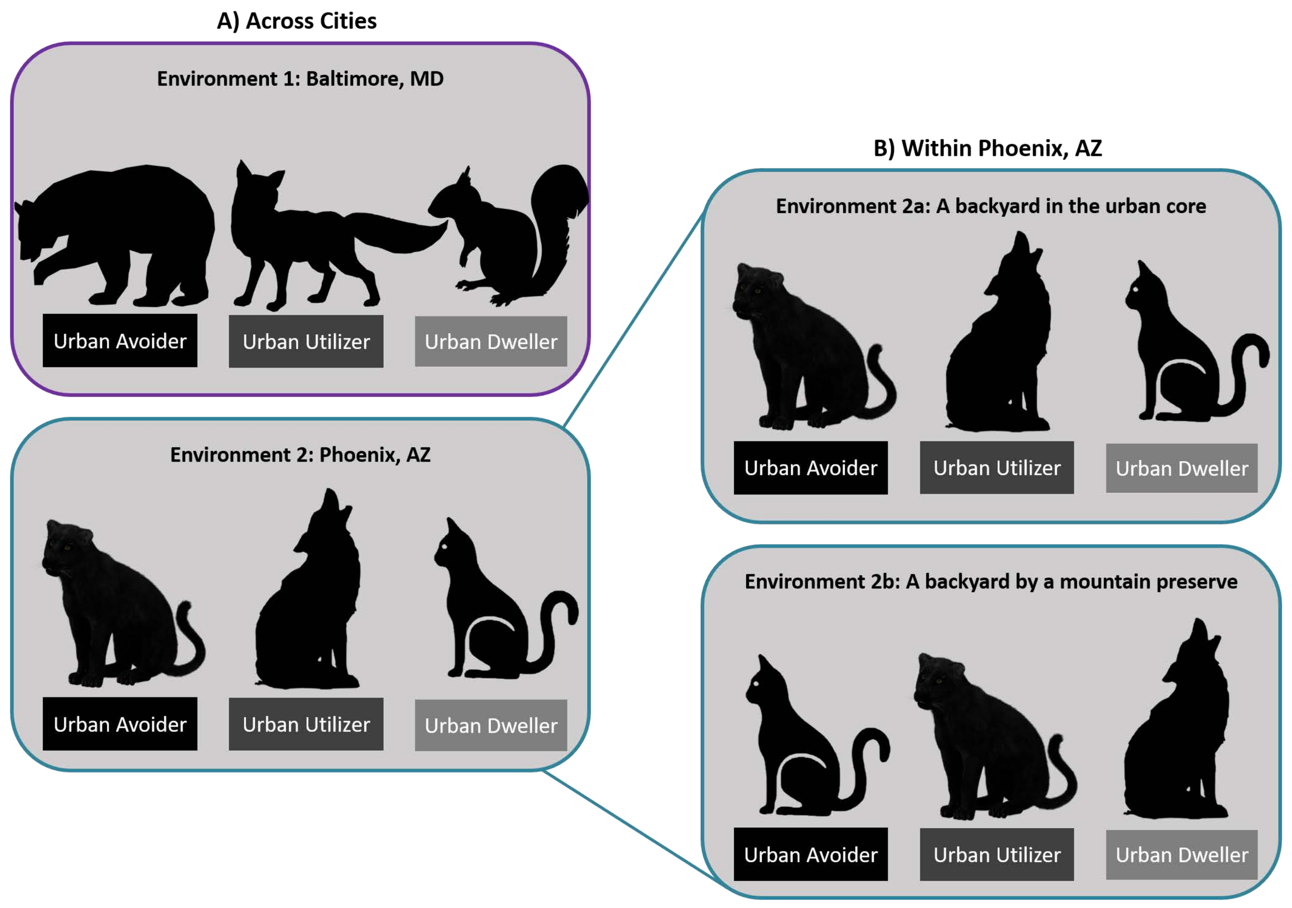

Figure 1. Illustrating the limitations of current categorizations of urban wildlife. Many classify species as urban avoiders, utilizers, or dwellers[4,5]. However, **(A)** categorizations may differ across cities depending upon regional species pools, and **(B)** the role a species plays within a city depends upon local landscape characteristics, and so may not be consistent[5].

Unifying Approaches

We provide a unified definition of functional traits to support application across contexts and along urban gradients (Fig. 2). By focusing on aspects of an organism's physiology and behavior that correspond with fitness, we can ascertain longer-term trends in community assembly.

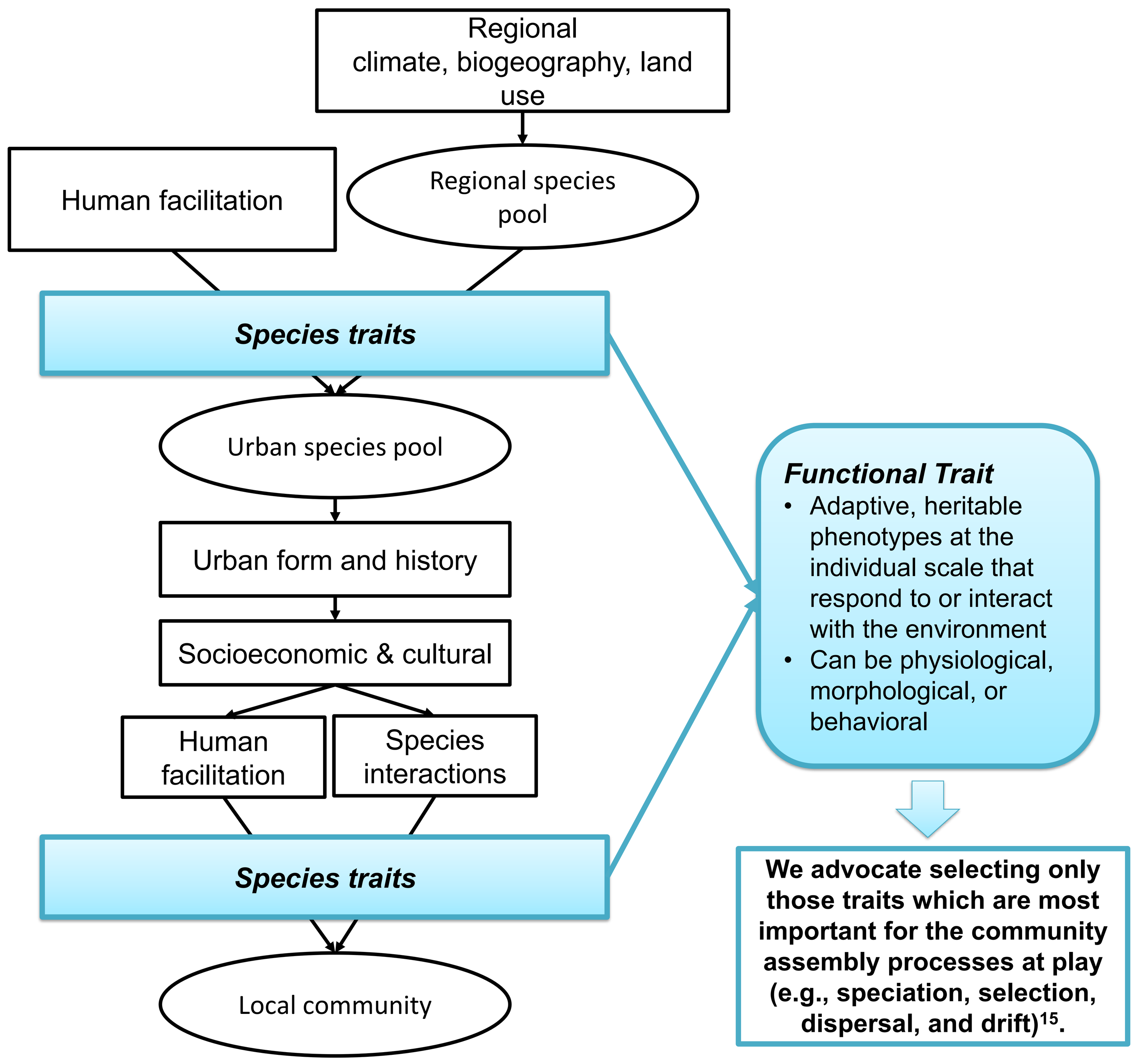

Figure 2. Unifying framework of functional traits for urban ecological communities. On the left side is an adaptation of the hierarchical filtering framework from Aronson et al. (2016)[2], where urban species pools are determined by socio-ecological interactions that filter through species traits (blue boxes). On the right, functional traits are defined and the kinds of traits to select are described (Adapted from Weiss and Ray In Review)[3].

In applying our framework to terrestrial mammals in CAP LTER (Table 2), we advocate using traits that:

- Are resilient to genetic drift
- Have selective advantages for urban exploitation
- Support dispersal into the urban matrix
- May be selected for or against by human decision-making at the local scale

Mammal Traits for CAP LTER

Table 2. Mammalian functional traits of interest in CAP LTER. Presented traits are those expected to be important for community assembly processes and human preferences along urban gradients.

Trait	Corresponds with	Predicted Trends with Urbanization
Activity pattern	Behavioral thermoregulation and human avoidance	Increased nocturnality[16]
Body size	Heat dissipation, human avoidance, and the increase of mesopredators in cities[17]	Small to moderate body sizes
Dentition and nutritional physiology	Urban resource use	Generalized dentition with few dietary restrictions
Home range plasticity	Adaptability to changing patch sizes	Higher home range plasticity
Behavioral plasticity	Acclimation to humans and increased species densities in urban areas[18]	Greater behavioral plasticity
Social structure	Population size and whether or not individuals collect in groups or individually	Solitary social behavior
Facial structure and dentition	Human perception of wildlife as "cute"[19] and non-threatening	Human preferred facial features (e.g., small and round)

Conclusions & Future Directions

- As our work considers both adaptations and socio-ecological interactions, we believe our approach may support better predictions for how species assemble in heterogeneous landscapes
- We will use our framework in CAP LTER to identify how urbanization influences wildlife in Phoenix, AZ
- Our research will test a novel functional trait approach for the assessment and conservation of urban ecological communities across the U.S.

References

[1]Grimm, N., et al. 2008. Science 319(5846): 756-760.
[2]Aronson, M., et al. 2016. Ecology 87(11): 2952-2963.
[3]Weiss, K.C.B., and C. A. Ray. In Review. Ecography.
[4]Fisher, J.D., et al. 2015. Conservation Biology 29(4): 1246-1248.
[5]Soulsbury, C., and P. White. 2015. Wildlife Research 42(7): 541-553.
[6]Devictor, V., et al. 2007. Conservation Biology 21:741–751.
[7]Vandewalle, M., et al. 2010. Biodiversity and Conservation 19:2921–2947.
[8]Santini, L., et al. 2018. Ecology Letters:1–12.
[9]Tilman, D. 2001. Encyclopedia of Biodiversity, pgs. 109-120.
[10]Díaz, S., and M. Cabido. 2001. Trend in Ecology & Evolution 16(11): 646-655.
[11]Lavorel, S., and E. Garnier. 2002. Functional Ecology 16:545–556.
[12]McGill, B.J., et al. 2006. Trends in Ecology & Evolution 21(4): 178-185.
[13]Petchey, O.L. and Gaston, K.J. 2006. Ecology Letters. 9: 741–758.
[14]Violle, C., et al. 2007. Oikos 116(5): 882-892.
[15]Vellend, M. 2016. The theory of ecological communities. Princeton University.
[16]Gaynor, K.M. et al. 2018. Science. 360: 1232–1235.
[17]Crooks, K.R., and M.E. Soulé. 1999. Nature 400:563–566
[18]Shochat, E., et al. 2006. Trends in Ecology & Evolution 21:186–191.
[19]Borgi, M., et al. 2014. Frontiers in Psychology. 5: Article 411.

: @MammalKate

Acknowledgements: We would like to acknowledge support from the Central Arizona-Phoenix LTER Graduate Grant program.

: kcweiss@asu.edu