CLIMATIC SCALING EFFECTS OF FOUNDATION PLANT SPECIES INTERACTIONS WITH VERTEBRATE SPECIES IN CALIFORNIAN DRYLANDS

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THIS THESIS IS SUBMITTED TO THE FACULTY OF GRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

GRADUATE PROGRAM IN BIOLOGY

YORK UNIVERSITY

TORONTO, CANADA

JULY 2020

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*“After all, only the desert remains.”*

- Zhu

**Acknowledgements**

I would like to thank my advisor and mentor Dr. Christopher Lortie for all his guidance throughout the last two years. Thank you for helping me with my experimental design and the countless challenges that accompany scientific work. Most importantly, thank you for inspiring me each and every day to do just a little better than I did the day before. Additionally, thank you to Dr. Suzanne MacDonald for the constructive feedback and advice throughout this entire project, always given with the utmost kindness.

Thank you to my parents for all the sacrifices they have made, so that I have the opportunity to do what I love. Mom, dad, I simply cannot express how grateful I am to have you as my parents. Thank you for making me believe that the work that I do is valuable- I am forever indebted to you for the experiences and opportunities that have made me who I am.

I would like to thank my best friends Nadiya, Sanaz, Rojin, Matina, and Niki for allowing me to talk about how amazing deserts are for hours on end. As strong, intelligent women, your words of encouragement mean a lot.

Thank you to all the members of Ecoblender for helping me brainstorm ideas and providing me with input on a number of drafts. Special thanks to Mario Zuliani for changing flat tires and hammering countless stakes into ground. Thank you to Jenna Braun and Stephanie Haas for imparting your statistical wisdom upon me. Thank you to Malory Owen for the great selection of music during field season and always being a good sport when thing did not go as planned. Additional thanks to everyone that has helped me process data: Sharan Johal, Parableen Saini, Shaleena Rajabali, and Fatma Alrubeye.

Lastly, I’d like to thank the folks at the Bureau of Land Management (BLM) for allowing me to conduct research in their land. Thank you especially to Dr. Michael Westphal for his hospitality and his guidance on the region. Thank you to Emmelia Nix for handling equipment storage at the end of field season, checking-up on my plots, and always coming to the rescue when help was needed.

**Abstract**

Shrub are known to be structural agents of facilitation, providing benefit to animals that take refuge under their canopy. In spite of this, much of the literature has focused on plant-plant interactions, leaving a gap for animal-plants interactions to be further examined. The central theme of this thesis is to test how shrubs influence their microclimate and how they compare to artificial shelters and the open. We first conducted a literature review of the field, specifically looking at camera traps and their use in wildlife studies as a technique. We wanted to look at number of photos to test for reported sampling effort. We then tested the effects of UV permeable artificial shelters on how they influence temperature and sunlight intensity experienced under the canopy. We tested two shapes (square and triangle) at three different blockage intensities (15%, 50%, and 90%) and contrasted those against the dominant shrub *Ephedra californica* and the open using temperature and light sensor loggers. Shelters offered more stable temperatures and shade from direct sunlight compared to the open. They also functioned analogous to *E. californica*. Triangular shelters at 90% in general was best at reducing sunlight and temperature. This thesis contributes to the better understanding of climatic stressors in the context of facilitation research, in addition to providing a viable, temporary strategy for conservation and management.

**General Introduction**

The study of interactions has fascinated the field of ecology for centuries. Competition, for the most part, dominated the field during the previous century; however, following the introduction of Bertness and Callaway’s Stress Gradient Hypothesis (SGH), the focus has been shifted to facilitation as a fundamental interaction in many communities (Bertness and Callaway 1994; Bruno, Stachowicz, and Bertness 2003). Facilitation is defined as a positive interaction where one interacting species benefits, whilst none are harmed (Bertness and Leonard 1997). The SGH in particular proposes a shift from competition to facilitation with increasing stressful environmental conditions (Bertness and Callaway 1994). Due to this, many studies of positive interactions have focused on harsh environments, including arid ecosystems (Lu et al. 2018; Synodinos, Tietjen, and Jeltsch 2015; Maestre et al. 2009). Thus, positive interactions are studied relatively well when discussing stress, though it’s almost paradoxical that many studies fail to report stress effectively. Climate in particular is a stressor not typically explored, not reported. Hence, to ideally advance the relative importance in stress with global change, we need to introduce climate into the equation when measuring interactions.

Foundational plant species are a vital component of facilitation research (Filazzola and Lortie 2014). Foundational plants can include shrubs, nurse plants, perennials, trees, and cushion plants (Gómez-Aparicio et al. 2004). These vegetation have the ability to facilitate other taxa through mechanistic pathways that include, but are not limited to, seed trapping, abiotic stress amelioration, herbivore protection, magnet pollination, facilitation-mediated secondary seed dispersal, and soil modification (Filazzola and Lortie 2014; Lortie, Filazzola, and Sotomayor 2016). Facilitation by shrubs is an established mechanism, able to repair and maintain semiarid ecosystems even post extensive damage (Lortie et al. 2018). Foundational plants have crucial impacts on the entire community dynamic, however much of the research has focused solely on plant-plant interactions (Gómez-Aparicio et al. 2004; Castro et al. 2004; Flores and Jurado 2003), while the interaction with other taxa such as vertebrates is less-explored. There are a total of 63,000 documented species of vertebrates worldwide (Brown 2018). The south-western region of the United States is home to a variety of vertebrate species, including some of the first to be listed as endangered (Tazik and Martin 2002). Shrubs fulfill a critical role as agents of structural facilitation by offering an environment where animals can thermoregulate, reproduce, and take refuge (Lortie, Filazzola, and Sotomayor 2016; Filazzola et al. 2017). In order to advance the theory of facilitation, an emphasis also needs to be placed on examining direct and indirect shrub-animal interactions, as they may be key to arid region management and restoration.

The state of California is home to a diverse array of vegetation including *Ephedra California. E. califronica* is an ecologically dominant or co-dominant foundational shrub, wide-spread in hot deserts (Sawyer, Keeler-Wolf, and Evens 2009). In recent years however, climate change and extensive land-use has imposed severe stress on arid ecosystems, resulting in rapid degradation that may be difficult to reverse (Verwijmeren et al. 2013). In the south-western region of the United States, anthropogenic disturbances and land-use have reduced the available terrestrial habitat, in turn decreasing biodiversity (Germano et al. 2011). The well-being and function of foundation plants species such as shrubs may depend on factors such as temperature, variability in precipitation, extended drought periods, and radiation (Tattini et al. 2006; Kogan and Guo 2015; MacDonald 2007). Shrubs can be expanding in cover in some arid system, whilst declining in others. Given that landscape recovery post disturbance can be slow, it is simply unrealistic to merely rely on management efforts to encourage the growth of new shrubs. Shrubs help augment structural diversity; thus, the availability of viable mimics as a temporary solution, alongside conservation efforts, can enhance management outcomes.

Arid region expansion and desertification are important global change challenges (Asner and Heidebrecht 2005). Anthropogenic climate change significantly modifies physical and biological systems in all continents (Rosenzweig et al. 2008). It’s important to understand that difference between macro and micro-climate. Micro-climate or weather can be defined as short-term (minutes to months) changes in atmospheric conditions in one small study site, while climate is the long-term weather pattern of a particular region (NASA 2005). By the year 2100, different micro-climatic parameters in California may vary; however, the overall temperature is predicted to increase by 5.6º-8.8º, which indirectly augments the frequency of extreme wildfires, and the average area burned statewide could increase by 77% (California’s Fourth Climate Change Assessment 2019). Therefore it’s important to have data at both levels. Climate change can encourage shifts in species distributions and promote novel interactions between species (Parmesan and Yohe 2003). Climate envelope models are common tools to understand how species respond to change and environmental drivers, though one cannot ignore the interactions that buffer their tolerances.

The objective of this thesis is to examine the role of climate in vertebrate-shrub interactions and to contrast shrubs as a form of structural facilitation against artificial shelters. In the first chapter I provide a detailed literature review of the field focusing on the published literature. Specifically, I discuss what we know to date, the different research methods, and where the gaps fall within the literature. In the second chapter, I focus on the methodologies of UV Permeable Shade Cloth Shelters- a simple and cost-effective artificial canopy not examined previously. The goal of this chapter is not merely to describe how these shelters are built, or how they’re different from other prototypes discussed in the literature, but instead to understand their effects on canopy microclimate, including temperature and light intensity, relative to the open and the foundational shrub *E. californica.* Additionally, I explain how shape and permeability influence the above parameters. I confirm that shelters act similar to vegetation and increase the thermal heterogeneity within a given environment, and that they are different from coarser-scale climate. Additionally I demonstrate that there are significant differences between different permeabilities and shapes. In the general synthesis and conclusions, I provide insight into future studies, linking the ideas examined in this thesis to questions that have yet to be answered. The concepts discussed in this thesis are valuable because globally no system is exempt from the impacts of climate change. The key ideas discussed can be used as tools for stakeholders in various restoration strategies, in conjunction with other conservation and management practices.

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