Ghazian Thesis Proposal

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**Effects of weather on vertebrate interaction with foundational plant species: Implications for anthropogenic climate change in arid ecosystems.**

**Examination Committee:**

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**Table 1. Summary** of each thesis chapter, alongside methods, progress, and timeline goal.

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| --- | --- | --- | --- | --- |
| Chapter | Title | Methods | Progress | Timeline |
| 1 | **A systematic review of camera trap papers to generate rarefaction curves from extracted data.** | Extract data for number of pictures taken, number of species seen, and location from a literature database. | -Have many papers compiled  -Try to finish all the readings by the end of December 2018 | -Analyse data in January 2019 and have the manuscript by end of February 2019 |
| 2 | **Animal-plant interaction versus long-term weather data:**  **A look at correlation.** | -Camera trap incidents of an animal near shrub for both 2017 and 2018 data in the Carrizo National Monument at 2 different sites shrub and open  -Obtain long term weather data of each region (at least for those two years)  -confirm behaviour with shrub using camera trap video data | -Imagery data all processed  -Long-term weather data for **precipitation, air temperature, soil temperature, relative humidity, and solar radiation**  -Videos are half way processed | -Match data to weather February-April 2018  -Do stats May 2018  - Have a manuscript ready by Sep. 2019 |
| 3 | **Plexiglas shelters paired with camera traps to manipulate weather parameters and observe animal interactions: A look at causation.** | -Have 2 sites in Carrizo for the experiment  - microsite: open, shrub, shelter open, control, shelter temperature and soil, shelter radiation  -Measure growth of plants, take soils samples before and after  -camera trap set at a few | -Field season 2019 Spring-Summer | -Have a manuscript ready by January 2020  -Wrap-up thesis by September 2020 |

**Background**

For decades, individualistic and competition theories were the topics most favoured by plant ecologists. However, Bertness and Callaway’s (1994) ‘stress-gradient-hypothesis’ (SGH) of competition to facilitation switch under stressful environmental conditions, sparked the interest of many for the topic. Since, many studies have focused on facilitation in harsh environments such as alpine (Batllori et al. 2009; Wang et al. 2008) and arid ecosystems (Maestre et al. 2009; Michalet et. 2014). Facilitation is defined as an interaction where one member to multiple members benefit, whilst none are harmed (Bertness and Leonard 1997). Although most facilitation research have focused on plant-plant interactions (Lortie, Filazzola, and Sotomayor 2016), the emergence of studies focusing on animal-shrub/plant has become more prevalent in recent years (Dalsgaard et al. 2011; Watson 2016). At the centre of facilitation research lies the concept of foundational plant species or nurse plants, which are usually shrubs, perennials, trees or cushion plants that benefit other plant or taxa (Gómez-Aparicio et al. 2004) through various mechanistic pathways such as seed trapping, abiotic stress amelioration, soil modification, and pollinator visitation (Filazzola and Lortie 2014). In particular, shrub canopy is thought to be the most important agent of structural facilitation for animals through direct and indirect shelter and refuge effects (Bråthen and Lortie 2016; Lortie et al. 2018). Hence, foundational plants serve as a great focal point for a variety of studies hoping to examine plant-plant, plant-animal, plant-plant-animal, or plant-animal-animal facilitation in a given ecosystem.

As previously mentioned, numerous facilitation studies have focused on arid ecosystems (Maestre et al. 2009; Michalet et. 2014) since global desertification and arid region expansion continue to be a growing issue (Asner and Heidebrecht 2005). Temperature, variability in precipitation, extended drought periods, and radiation are probable factors affecting the function of foundation species (Kogan and Guo 2015; MacDonald 2007; Tattini et al. 2006). The changes in the above weather parameters are mainly due to anthropogenic climate change (Gibelin and Déqué 2003), which significantly alters physical and biological systems in all continents (Rosenzweig et al. 2008). Despite the interest in effects of climate change on physiology and biology, few of the published literature has focused on effects of anthropogenic factors on animal behaviour and in turn the conservation of biodiversity (Berger-Tal et al. 2016). Thus, closing this research gap by examining behavioural-ecological domains such as movement and spatial pattern, forging and vigilance, social organization, and reproductive behaviour (Berger-Tal et al. 2011) against the landscape can provide crucial knowledge for conservation paradigms and frameworks to be developed. Weather-driven behavioural plasticity can promote shift in habitat so behavioural regimes can continue to function despite changes in climate (Noonan et al. 2018). Knowing the importance of foundational species, I propose that weather patterns can encourage changes in vertebrate behaviour, in turn promoting more interactions with foundational species as deserts continue to grow hotter and arid regions continue to expand.

Carrizo Plain National Monument (35.1914° N, 119.7929° W) is the largest remnant ecosystem of the San Joaquin Desert, located in the south-eastern San Louis Obispo Country (Noble et al. 2016). The shrub species of the region are important as they are beneficial to many animals living in the region (Lortie et al. 2016). The dominant shrub species are *Ephedra californica*, commonly known as Mormon tea, and *Atriplex polycarpa*, known as saltbush (Stout et al. 2014). The species *E. californica* is a slow-growing shrub which spreads colonially in hot deserts. It is well-adapted to alluvial substrate and shifting sand, generally growing in elevations of 200-1200 m. Although severe fires can kill the plant (Anderson 2004), it is fairly resistant to moderate fires with the ability to sprout. Ephedra’s high abundance and resilience in this ecosystem makes it the perfect plant to study positive plant-animal interactions.

Open-top Chambers (OTC) are relatively inexpensive and provide a great way to study plants when wanting to manipulate parameters such as CO2, temperature, soil temperature, solar radiation, humidity and etc. (Chiba and Terao 2014; Welshofer et al. 2018). However, a cheaper alternative can be Plexiglas car shelters which not only raise the temperature, but can be used to change sun radiation intensity and alter UV permeability. To the extent of my knowledge no experiment has ever paired Plexiglas shelter designs with camera traps in order to examine the impact of manipulations of the above parameters on animal behaviour. Cam(era) trapping allows researcher to obtain wildlife data with relatively little to no human disturbance (O’Connell et al. 2011; Trolliet et al. 2014). Previous studies have explored the use of cam traps to estimate population size (Karanth 1995), examine wildlife behaviour (Dupuis-Desormeaux et al. 2015), and explore activity patterns and habitat use (Bowkett, Rovero, and Marshall 2008). Although cam traps have been used to look at animal interactions with plants, seldom have they been used as a direct method in facilitation research. Additionally, despite previous literature’s focus on closing the gaps that exists in photographic rates as an index of density (Carbone et al. 2001; Rovero and Marshall 2009), to my knowledge no single study to this date has been published that concentrates on generating refraction curves of number images versus species richness compiled from previous research data.

**Chapter 1: A systematic review of camera traps to generate species rarefaction curves**

**Purpose:** Identify the relevant literature in which camera traps were a study method to gather information on number of pictures taken and the number of species spotted. The data will then be used to generate rarefaction curves and provide estimates for the duration of cam trapping and quantity of photos/samples need to accurately estimate species richness of a cam trapped area.

**Questions:** How often are camera traps used as a research method? In which ecosystems is camera trapping most often used? What was the duration of sampling? How many pictures were taken? How many had animals in them? What were the animals (species)? How many species in reality settle in that habitat (GBIF)?

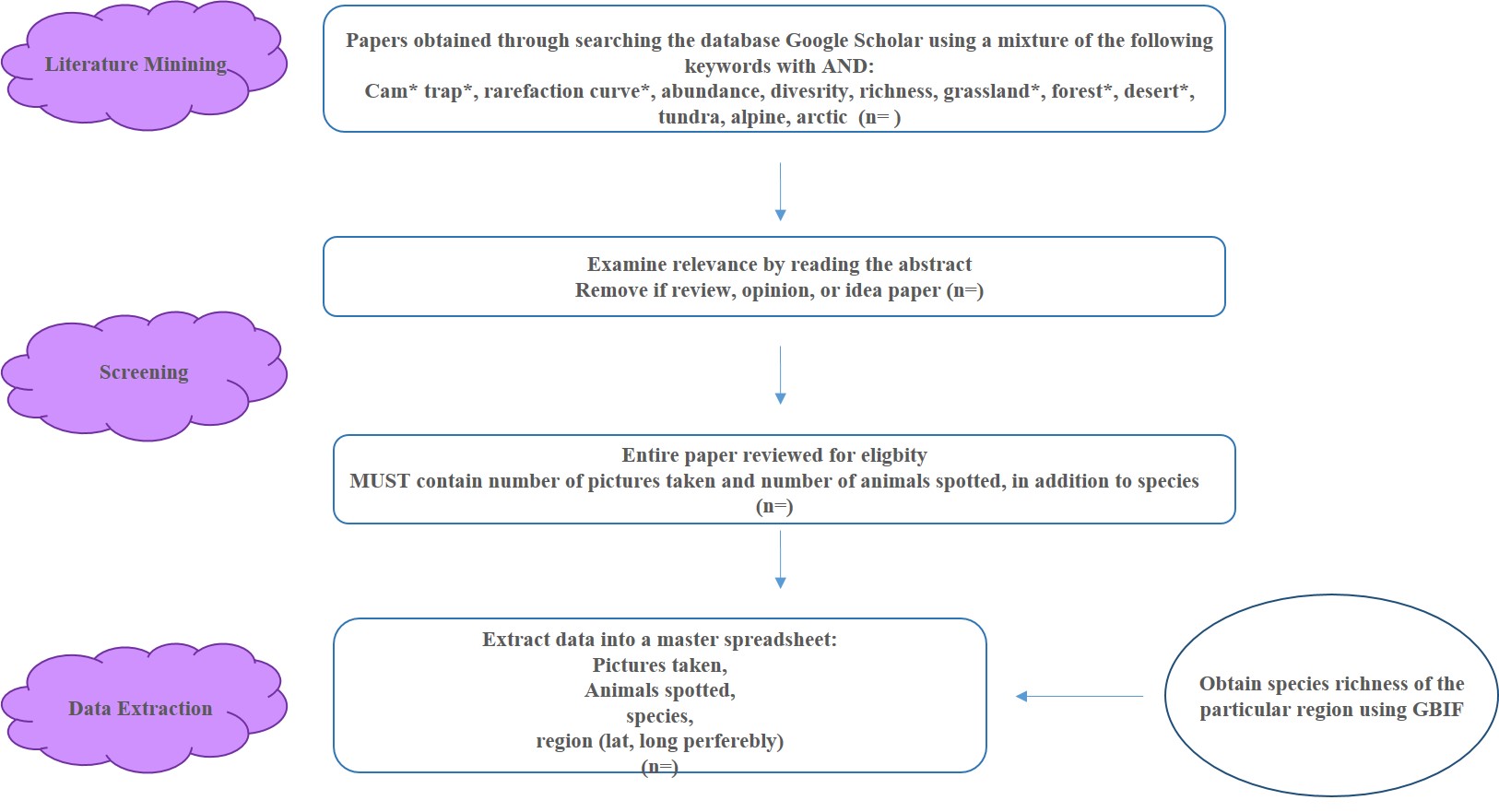
**Hypothesis:** There a few studies exploring photogenic rate as an index of density, though there is a lack of literature which has created rarefaction curves from previously published literature data-a research gap that needs more attention.

**Predictions:**

* Many studies using camera traps will focus on one type of animal
* Studies generally only report how many photos were captured/processed and how many different species were seen
* Very few will focus on minimizing repeat visits
* Widely used in studies in grassland and forests

**Methods:** Figure 1 represents the workflow for extracting relevant data. Literature will be obtained through keyword searches in Google Scholar. Species richness data will be obtained via GBIF.

**Preliminary Results:** May need to look deeper than the abstract to assess relevance. May also have to divide of data by regions and generate a curve for each region.



**Figure 1:** Workflow used to select the relevant literature for generating rarefaction curves from cam trap literature.

**Chapter 2: Animal-shrub interaction versus long-term weather data: A look at correlation.**

**Purpose:** To use camera trap imagery data in order to examine whether the incidence of animal captured in the vicinity of a shrub correlates with the following weather parameters: precipitation, air temperature, soil temperature, relative humidity, and solar radiation.

**Questions:** Does temperature, precipitation, solar radiation, and humidity correlate with the number of incidents a vertebrate is found near a foundational plant? If yes, what are these animals doing?

**Hypotheses and predictions:**

1. As temperature, drought, and the intensity of the sun increases, vertebrates are likely to interact more often with shrubs since foundational species provide many benefits to through various mechanistic pathways.
2. Vertebrates can be found forging, mating, resting, and cooling near shrubs, benefiting from the canopy coverage and shelter and refuge effects provided by the foundational plant.

**Methods:**

**Cam trapping**

Camera trapping has been done in the Spring-Summer of 2017 in the Carrizo National Monument at 2 different sites: the same sites were re-sampled in 2018. Cameras were moved around to maximize incidents of associational observation. Each camera was deployed facing a shrubs with their respective open microsite facing the back to serve as control.

**Processing**

Images collected were saved as Join Photographic Expert Group (JPEG) format. These dataframes were then manually examined for the presence of animals. A datasheet was created where every row corresponded to a unique image. Additionally, data was recorded for the year, region, calendar date, microsite, rep, photo rep, and week number. If a vertebrate was present in the photo, further info on the type of vertebrate, time block, actual time, temperature, and additional observations were also recorded. Images from cameras were clear enough during both day and night (low light condition) to distinguish between animals. An animal was classified as present if as little as a section of a body part (i.e. tail) made it into the captured image. Because the dates and timestamps are generally wrong on these traps, dates must be manually corrected manually or in R. Behavioural data are to be obtained from video traps as a collaborative effort with Mario. For the most part the same parameters as above are to be recorded alongside behaviour.

**Weather Data**

Carrizo data for weather parameters of interest for both 2017 and 2018 were obtained from the following website:

http://ipm.ucanr.edu/calludt.cgi/WXSTATIONDATA?MAP=&STN=BLACKWLL.A

**Stats**

Point-biseral correlation analyses are to be performed examining the relationship between the continuous weather variable and the binary variable presence/absence of animal (Gupta 1960). Effects of covariates may be studied through an ANCOVA. Effects of multiple weather parameters may be explored through Principle Component Analysis (PCA) (Bryant and Yarnold 1995).

**Chapter 3: OTC field experiment to manipulate weather parameters: a look at causation.**

**Purpose:** To physically manipulate temperature and solar radiation intensity using open top chamber designs (or a variation) paired with camera traps to examine whether the increase/decrease in in the above parameters significantly affects shrub visitation instances.

**Hypotheses and predictions:**

1. Incidents of animal capture will be significantly different between shrub versus open microsites because foundational plant species are beneficial to many vertebrates.
2. High increase in temperature will slow plants growth and visitation rates; hence, decreasing the diversity of the soil microbiota, whilst a small increase may promote visitation.
3. Decrease in solar radiation intensity, depending on the extent, may or may not promote plants growth.
4. Temperature manuplated shrubs *may* show significantly higher instances of visitation compared with unaltered shrub microsites.

**Methods:**

Car shelter chambers will be built in the field using the design similar to figure 2 design. Shelters will be built from Plexiglas glued together. Each chamber will be high enough to account for the height of the individual shrub; however, chosen shrubs will generally be of the same volume and stature to minimize treatment differences. A hole will allow for the entrance and exit of animals. The presence of the shelter will result in an increase in temperature which will be measured by temperature loggers. Soil temperature and relative humidity will also be recorded via loggers. Shelters also have the ability to increase CO2 concentrations without altering the air; thus, carbon dioxide meters will be used to record the change in the concentration of this gas. Solar radiation intensity can be manipulated by Plexiglas of different darkness intensity that either UV permeable or impermeable. Soil microbiota samples will be taken once before the start of the study and once when the study is completed, and analyzed to reveal possible microbial differences. Shelter sites would be paired with simple open and shrub microsites. Furthermore, a mesh shelter that does not manipulate any weather parameters will be used as control. Shrub height, length, and width (x, y, and z) dimensions will also be recorded once before and after the study is finished for both shelter and non-shelter microsites. The study will take place in site 3 and 4 of Carrizo. Table 2 summarizes the treatments and replications. Cam traps will be paired with 4 sets of shrubs, 4 sets of open, and 4 sets of shelters (2 sets in each site).

**Table 2.**  **Replication** breakdown for open-shrub microsites and open-top-chambers.

|  |  |  |  |
| --- | --- | --- | --- |
| **Microsite** | **OTC** | **Replication** | **Total** |
| **2** | **4** | **X 8:**  **X4 in site 3**  **X4 in site 4** | **64** |
| Shrub | Control (no shrub) |
| Open | Temperature |
|  | Radiation intensity |
| Mesh shelter (control) |  | |

**Stats**

Statistical analyses will focus on examining the differences between and within groups for different parameters and to see whether correlation, in fact translates to causation.



**Figure 2:** Similar to the shelter design to be built in the field. Walls will be built out of Plexiglas of various colours depending on the treatment group. Length, Width, and height will depend on the given shrub. A ‘door’ will allow animals to enter or exit. (Picture courtesy of Google Images)

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