The distribution of an exotic and native species of gecko on Nellis Air Force Base, Nevada

2022-23 ESS SUPER Program

Skills for Undergraduate Participation in Ecological Research

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Abstract

In the Southwestern US, exotic species are of significant concern to wildlife management. The exotic gecko *Cyrtopodion scabrum*, also known as the bowfoot gecko, was first detected in Nevada in 2015. Subsequently, *Cyrtopodion scabrum* has been found in other Southwestern states, yet *Cyrtopodion scabrum* and their effects on native geckos in the Southwest have not been studied. This research proposal studies the potential impacts of *Cyrtopodion scabrum* on the native western banded gecko, *Coleonyx variegatus*, on Nellis Air Force Base (NAFB). With predesignated transects, we will conduct population surveys and collect body metrics of these two species. Using spatial analyst tools, we will analyze the geographic distribution of each species on NAFB, and if the species numbers differ in urban and non-urban areas. We expect to see exotic geckos pushing out the native geckos on natural

landscapes. This study could inform management decisions regarding *Cyrtopodion scabrum* regarding its effect on *Coleonyx variegatus*.

Introduction

For as long as humans have traveled around the world, plants and animals have been riding along with them. Introductions of exotic species, whether intentional or accidental, are one of the most impactful drivers of biodiversity loss in ecosystems across the planet.

Studies of how exotic geckos potentially displace native geckos is an emerging concern for wildlife managers. Investigations of interspecific aggression methods between geckos and diet changes in sympatric areas have been done in previous studies (Cooper, 1985; Vaughan, 1996). Little done has been done spatial distribution effects of invasive geckos on natives, which we propose to investigate with this proposal.

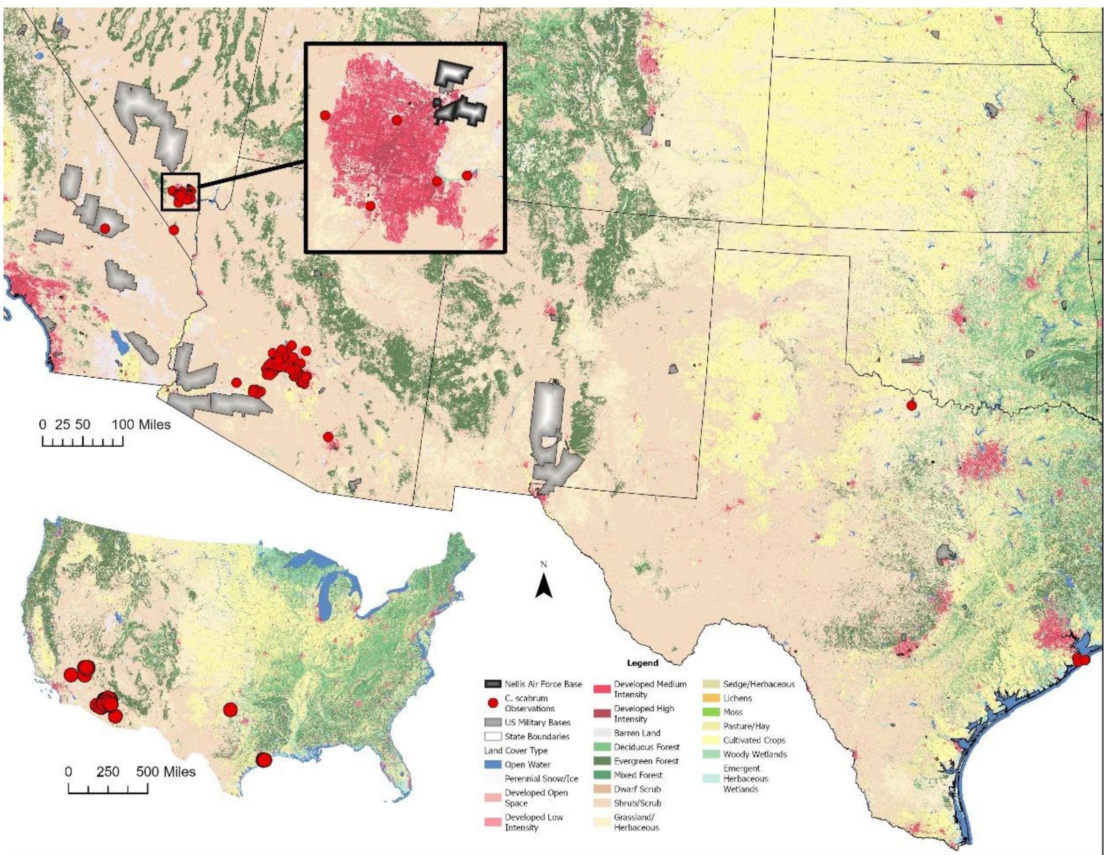

Figure 1: Current Sightings of *Cyrtopodion scabrum* and military bases in the United States (Created by Ashley Martinovich using data via iNaturalist - GBIF Occurrence Download https://doi.org/10.15468/dl.dq3r79)

Nationwide, the Department of Defense (DoD) manages 27 million acres of land, which possesses many protected natural resources (US Fish & Wildlife). The Center for Environmental Management Military Lands (CEMML) assists in natural resource management on many of these installations, including Nellis Air Force Base (NAFB). Monitoring invasive species on NAFB is one of the primary management tasks, including invasive herpetofauna.

The rapid dispersal of *C. scabrum* throughout the Southwestern states. Herpetologists believe this increase of *C. scabrum* was likely precipitated by the US military presence in the Middle East and could have stored away in cargo that passes through the areas (Hansen, 2014). *C. scabrum was* observed in Galveston, Texas as early as 1986 and is most often seen in industrial complexes, cargo, concrete culverts, and other anthropogenically modified areas (Hansen et al., 2014; Hansen et al., 2021). While the population in Galveston seemed to be isolated, recent accounts have found *C. scabrum* at an Air Force airfield in Maricopa County, Arizona in April 2014 (Hansen et al., 2014), near industrial parks in Nevada and identified as far west as Death Valley National Park in California (Hansen et al., 2021). The first sighting of *C. scabrum* on NAFB was in 2015 during herpetofauna surveys (Stocking and Jones, 2017). After its initial discovery, *C. scabrum* was detected on NAFB surveys, which raised concerns about the potential displacement of native species, like *C. variegatus*, in the area.

This invasive species is of great concern and interest of this proposal, due to its rapid dispersal in the United States. Previous studies have shown *C. scabrum* potentially displacing an invasive population of Mediterranean geckos (*Hemidactylus turcicus*) outside of the Port of Galveston, Texas (Klawinski, 1994). *C. scabrum* displaced another invasive (Klawinski 1994), which concludes that *C. scabrum* are likely a very aggressive, adaptable invasive if they can easily displace another well-established invasive population. This leaves more room for questions about this species, especially as it concerns with interactions with native species.


Figure 2 (left): *Cyrtopodion scabrum,* the invasive. Source: iNaturalist

Figure 3 (right): *Coleonyx variegatus,* the native. Source: Wikipedia

The purpose of this proposal, in collaboration with CEMML, is to design a study that elucidates the potential difference between the densities *C. scabrum* (Figure 2) and *C. variegatus* (Figure 3*)* on NAFB. Examining the density of the two species will identify the potential impacts *C. scabrum* has on *C. variegatus.* Additionally, if *C. scabrum* is present in urban areas, then that would be an indicator of their potential vagility through transported cargo, automobiles, and other anthropogenic means. The completion of this study could show what effect, if any, *C. scabrum* has on *C. variegatus* regarding density and distribution on NAFB. As such, this study could inform management actions and incentivize the development of control methods for *C. variegatus*.

Conceptual Diagram

Figure 4: Timeline of the Invasive Gecko study, from the initial life-history research to collection process, and the future potential management decisions after the study is finished.

Research Questions and Hypotheses

Research Question 1:
Do the densities of the *C. variegatus* differ from the densities of the exotic rough tailed gecko *C. scabrum* on Nellis Air Force Base in Las Vegas, Nevada?

Expected Outcome or Alternative Hypothesis:

C. scabrum will occur in a higher density than *C. variegatus*.

Null Hypothesis:

There is no difference between the densities of *C. variegatus* and *C. scabrum*.

Detailed Explanation

In captive trails, *C scabrum* has been documented as displacing two other species, the Mediterranean Gecko (exotic; *Hemidactylus turcicus*) and the Texas Banded Gecko (native; *Coleonyx brevis)* (Klawinski, 1994). If the rough-tailed gecko is outcompeting or displacing native geckos, and even other exotic species, it could also display *C. variegatus*.

Research Question 2
Is there a difference in spatial distributions of *C. scabrum* and *C. variegatus* in two habitat types: natural habitat, Mojave warm desert shrub, and anthropogenically modified habitat, buildings, roads, parks, etc., on Nellis Air Force Base in Las Vegas, Nevada?

Expected Outcome

The rough tailed gecko will spatially dominate more in anthropogenically modified and natural habitats.

Null hypothesis:

There is no difference between the densities of rough-tailed geckos in anthropogenically modified habitat and natural habitats.

Detailed Explanation

In other introduced sites, *C. scabrum* has expanded from an isolated population in Texas in 1987 to a wide distribution throughout the southwest (Hansen et al., 2021). Due to its rapid spread throughout the Southwest, *C. scabrum* is expected to occur in higher spatial distributions than *C. variegatus*. Also, in the native habitat of rough-tailed gecko, they use urban interfaces.

Research Question 3
Does *C. scabrum* occur in or around transported materials on Nellis Air Force Base?

Expected Outcome or Alternative Hypothesis:

C. scabrum occurs on transported materials.

Null Hypothesis:

C. scabrum does not occur in transported materials.

Detailed Explanation:

C. scabrum initial sightings are often found near cargo, ports, and airports. Some believe that their quick distribution is due to transportation via cargo.

Methods

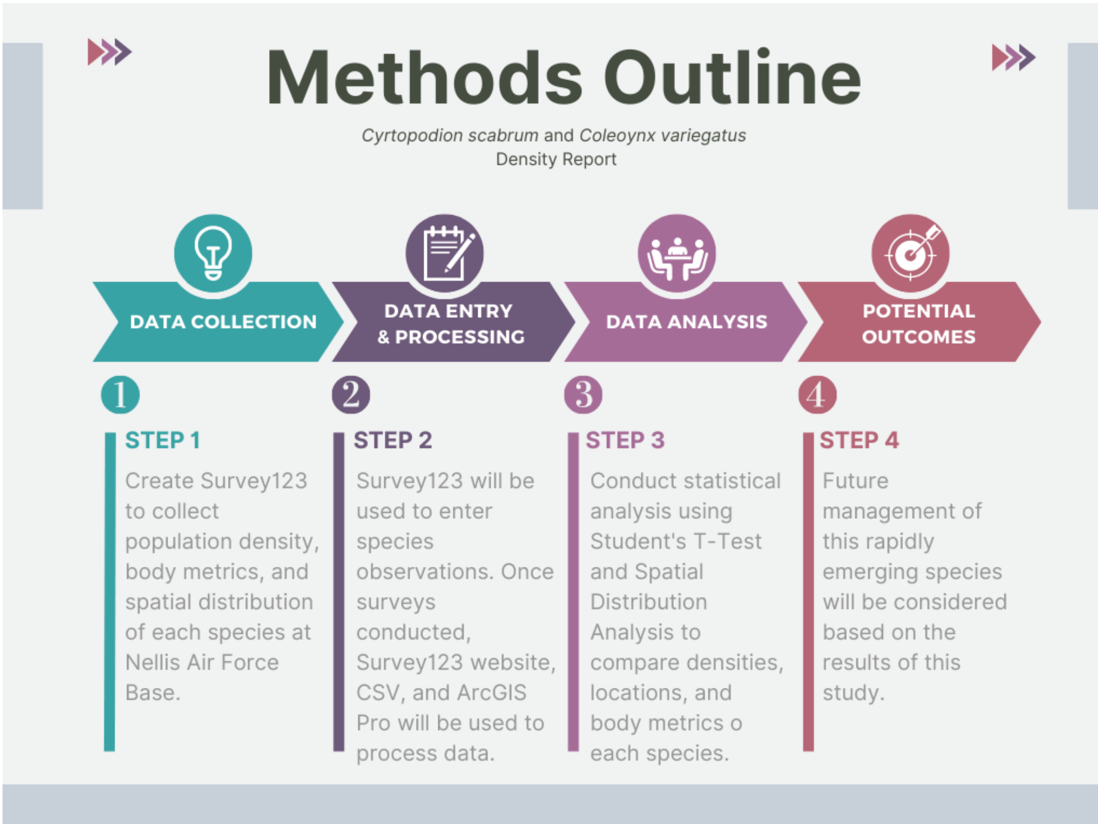

Figure 5 displays the potential method outline for our invasive gecko research. The main portion of our work will be going into the preparation of the data collection and the methods of data analysis.

Study Design Preparation

Literature Review

To ensure proper study protocols, thorough literature review was conducted prior to designing this proposal. This literature review included research concerning the life histories of both *C. scabrum* and *C. variegatus*, proper collection techniques for geckos, invasive species management techniques, and an overview of statistical protocols for post-collection analysis.

Transects

Transects 14, equally distributed transects were randomly chosen to survey, which are transects split between natural Mojave Desert habitat and anthropogenically modified habitat. The proposed transects are displayed below in Figure 6 with details of the anthropogenically modified transects in Table 1.

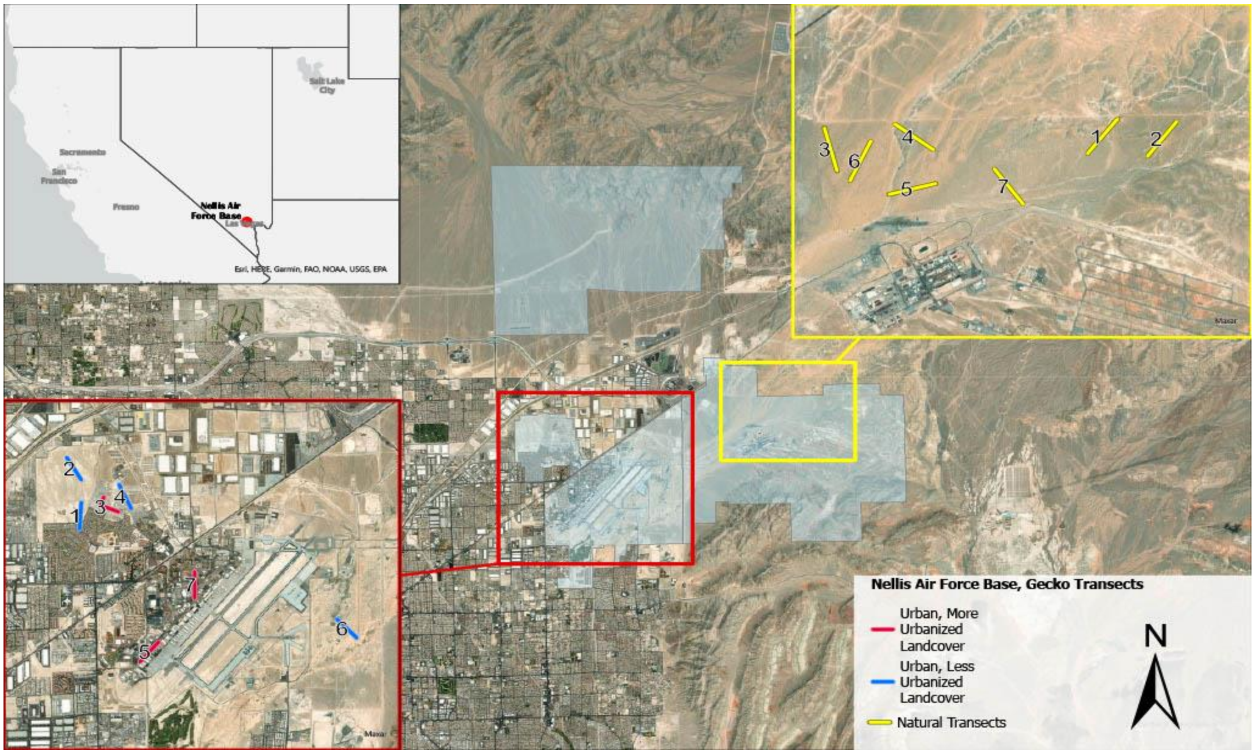

Figure 6: Study Area, Nellis Air Force Base, of the Proposed Invasive Gecko Survey with transects. Displays urban (red & blue) and natural (yellow) transects.

Table 1 displays the nearby areas of each anthropogenically modified transect from *Figure 6.* Important notes about the specific urban transects are detailed.

Anthropogenic Transect Number	Important Notes
1	Residential area
2	Protected natural area, industrial buildings nearby outside of NAFB boundary
3	Outside of an In-boundary hospital
4	Near solar fields
5	Along Tyndall Ave Road
6	Close to landing strip, but not an issue
7	Along Ellsworth Ave Road

Seven natural habitat transects were already established for herpetofauna surveys via randomly selected transects created in ArcGIS Pro, in the northern section of NAFB. Seven additional randomly distributed urban transects were created by Ashley and Ashlee from the building's shapefile in ArcGIS Pro. The urban transects include transects near roads, between buildings, in residential areas, and in a protected area that is located near a distribution center.

Capture Methods

An important aspect of this study design concerns collecting body metrics of captured geckos. To accurately collect this data, gecko captures use a variety of techniques.

One capture method for lizards is simply catching them with bare hands. To facilitate hand capture, biologists can spray them with a water bottle and then capture the animal. Cold water slows down their circulatory system, which makes them move slowly and they become easier to capture. Another method involves using a laser to draw the geckos towards the surveyor. It is suspected that the gecko thinks the laser is an insect and will chase the light. This method was historically used on tree geckos, but potentially will be helpful with geckos found on buildings.

Data Collection

Morphological and geographic data will be collected on both species using Survey123 in the field, titled IGS_BodyMetrics_2 (see Appendix B). Surveyors will collect individual metrics of captured geckos along the transects. The survey is broken into two parts – geography and body metrics.

Part one is for the spatial data of geckos, which includes data and time input, GPS location of the individual captured, and transect number the individual is collected on. In case the individual is found outside of a transect line, such as on an unmarked building or while traveling between transects, the sighting will be reported as incidental.

Part two is the body metrics for the geckos. Snout-vent length, tail length, and weight are typical measurements taken on captured lizards, which will be measured in millimeters and grams. These measurements help determine gecko's body condition, and health. Sex and breeding condition are also important body metrics to collect. These data will show if female geckos are gravid and will help determine how the two species' populations are growing. Additional information collected will be estimated age category (hatchling, juvenile, adult, or unknown) and tag information, if the individual has been previously tagged.

Data Entry and Processing

Data entry will be collected through a survey via Survey123 – IGS_BodyMetrics_2. With the help of Survey123, data processing time is cut down as we can export our data directly into a CSV, ArcGIS Online, or through Survey123's website. The attribute table will include data such as surveyor initials, species captured, GPS location and dates, and body metrics of the species. For more information on the survey that will be conducted, visit Appendix B.

To process our information, we will be using ArcGIS Pro to create a map of the spatial distribution of the two species. We will also utilize Survey123's website to further analyze the data collected through graphs and other visual means.

Data Analysis

Basic comparison statistics will be used to analyze density and distribution metrics of the exotic species the native species. The survey will be used to create an ArcGIS Map to identify the exotic and native population distributions. For further analysis, an R code script was created to clean up the Survey123 data and create statistical tests; which compare the habitat type to species of gecko. The code also creates visual figures of body metrics and breeding conditions.

This was created before data collection, to streamline data analysis. To see the code, visit Appendix C.

Assuming our analysis demonstrates that the exotic geckos are displacing the native geckos, then we have the evidence to create an incentive to potentially create a management plan for CEMML to recommend. Additionally, if data shows that exotic geckos are near buildings & cargo, it will strengthen the premise that *C. scabrum* moves via anthropogenic means.

Expected Results

We expect data analyses to be completed by August 2023. Prior to data collection, our team delivered a comprehensive study design outlining transect information, species identification information, proper capture methods, and body metrics background information. Ashley created a Survey123 form to aid in data collection, and Ashlee created an R script to aid in post-collection statistical analysis, along with creating randomly distributed urban transects in ArcGIS Pro.

The results of our research will be yet to be determined before the presentation of our report; however, we expect a few outcomes once the study design is conducted, and data analyzed. This includes:

- The density of *C. variegatus* is lower when in the presence of *C. scabrum* density is higher in both habitat types
- *C. scabrum* density is highest in anthropogenically modified habitats, especially near cargo and building materials

Discussion

Interpretation of Expected Results

By the end of this study, we expect to have two main results: a.) the density of *C. variegatus* is lower when in the presence of *C. scabrum*, and *C. scabrum* is found more frequently in both habitat types, b.) the invasive density is highest in anthropogenically modified habitats, especially near cargo and building materials.

Our most important expected result could be that the native's density is lower than the exotic when the exotic is in the same place as the native. If our study suggests this outcome, this could indicate that *C. scabrum* species are expanding into *C. variegatus* range. Invasive species tend to adapt to new areas quickly and do not require specific resources to survive, and previous literature has shown that *C. scabrum* potentially displace other invasive species in Texas (Klawinski, 1994). If our study shows a higher density of *C. scabrum*, more studies will have to occur to determine if there is a potential for displacement of the *C. variegatus.*

Another expected result is there are indications that *C. scabrum* density is highest in anthropogenically modified structures and cargo. This could help solidify hypotheses on the expansion of *C. scabrum* throughout the Southwest. Previous studies have hypothesized that the dispersal of *C. scabrum* occurred by accident and through means of Air Force cargo traveling between the Middle East and United States bases (Hansen et al 2014; Hansen et al 2021). This could also indicate that *C. scabrum* may expand outside of NAFB through the same ways that it encroached the Air Force. This could be a more urgent issue due to the industrial buildings that lie outside of the NAFB boundaries, which transport goods all over the United States.

Importance and Potential Implications

Potential implications for these results range from management implications on Nellis Air Force Base to potential habitat health in the areas that this invasive occurs in. Future implications for this result could include wildlife managers suggesting stricter monitoring of cargo spaces before departure or after landing of aircraft. Implications of this result could also mean that *C. scabrum* occurs in many habitat types and could spread further, putting more native species at danger.

Limitations of Study

There are a few limitations to our proposal, including the location of our study, limitations on data that will be collected, and the timeframe of the study.

First, this is a proposal and we have not conducted research on the study site yet. Due to this, we are not aware of the terrain or study site until we collect the data. Without properly knowing the location of the study site, future problems could arise that we cannot predict until we are in the field.

Second, our study is based on densities of each species only. In a scientific sense, it is good practice to have less parameters of study so that a study is not convoluted or over-saturated.

However, since we are only collected density of each species and body metrics, our study is limited to other conclusions that we can draw from this study.

Third, due to this class and internship, we cannot conduct a full-sized study within this class's timeframe. If given more time, we may have been able to collect data on the two species prior to the CURC Symposium and report accurate data on the two species in question. Further analysis, figures, and conclusions on data could have been assessed if more time were available.

Conclusions

Invasive species are a threat to native biodiversity in all habitats. Learning more about how invasive geckos may impact native gecko species in the Mojave Desert will aid in the lack of studies being conducted on this matter in the Southwest States. With the finalization of this study, CEMML and NAFB will have a better understanding of the densities of *C. scabrum* and *C. variegatus* in both anthropogenically modified habitat and natural Mojave Desert habitat. If the outcome of the study results in lower densities of *C. variegatus* when in the same space as *C. scabrum*, further studies should be done concerning behavioral competition of these two species. If the outcome of the study results in the highest density of *C. scabrum* near cargo and transported material because they reside more in urban landcover, CEMML and NAFB may consider stricter rules regarding storage of materials or daily checks for invasive species.

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Appendix A: Methods Outline

1. Data Collection

- By us:
  - A) Creating a Survey123 for collection (Ashley Martinovich)
    - This will be used in the field to collect density & body metric data for the species. Info may include species, GPS coordinate, which transect, etc.
  - B) Designing a collection protocol (Ashlee Ducharme)
    - This document will describe each measurement and how to properly measure to remove human bias. Additionally, it will give steps in case something goes wrong in the field, and what the next steps are.
  - C) Designing an observational study where we collect densities of each species by surveying 3 wild and 3 urban transects (Ashley Martinovich & Ashlee Ducharme)
    - Collecting data such as SVL, tail length, sex, body weight, and breeding condition.
    - Breeding condition: if there are eggs visible on the body
    - Marking the geckos already counted reduces recount & bias of our study. We will have an option on Survey123 to record that you have already seen the gecko before.
  - D) Habitat plots: 10m radius sampling plots characterized by habitat
    - Random plot along each transect to identify plant census, land cover, & any indicators of geckos present.
- By others:
  - o We are using previous gecko surveys from CEMML that we are designing our study on (Mojave fringed toed lizard, Species Report)

2. Data Entry and Processing

- A. GIS Maps (TBD)
  - o Maps provided of NAFB
  - o Map of previous transects on densities of Mojave fringed toed lizard
  - o Creating maps from transects & field data
- B. Data Entry from field collection should be streamlined due to Survey123 (CEMML)
  - o A well thought-out Survey123 format should subdue any data cleaning.

3. Data Analysis

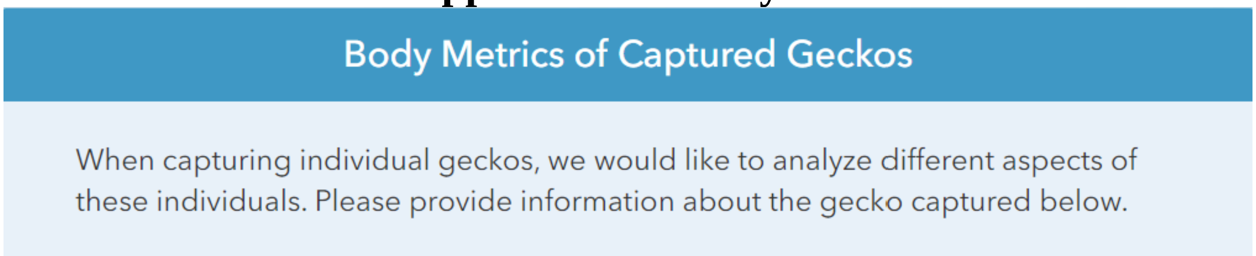
- A. Our spreadsheet will help us create our GIS map, which will help us analyze distribution.
- B. The type of cover from transects & the species identified on the plots will help with analysis on the transportation of the geckos.
  - So far, we have not explored on what kind of statistical analysis we will need, but it may be T-tests or ANOVA

4. Data Interpretation

- A. Assuming our analysis demonstrates that the exotic geckos are displacing the native geckos, then we have the evidence to prove that & to create incentive to create an eradication plan

B. If our analysis displays that the exotic geckos are near buildings & cargo, it solidifies our incentive to create an eradication plan.

Appendix B: Survey123


Body Metrics of Captured Geckos

When capturing individual geckos, we would like to analyze different aspects of these individuals. Please provide information about the gecko captured below.

Link to the Survey123 form.

Appendix C: Code Analysis

```
geckocsv <- read.csv("test_survey.csv")

CYSC <- geckocsv %>%
  filter (Species == "CYSC")

COVA <- geckocsv %>%
  filter (Species == "COVA")
CYSC_plot <-ggplot(CYSC, aes(x = Snout.Vent.Length..SVL.)) + #If you want to
change the SVL to other metrics, replace the x variable
   geom_histogram(binwidth = 2, color = "black", fill = "darkorchid") +
  ggtitle(expression("SVL of C. Scabrum")) +
  xlab("Snout Vent Length (mm)") +
  ylab("Frequency (n)")

#Create a graph for COVA body metrics
 COVA_plot <- ggplot(COVA, aes(x = Snout.Vent.Length..SVL.)) +
  geom_histogram(binwidth = 2, color = "black", fill = "olivedrab") +
  ggtitle(expression("SVL of C. variegatus")) +
  xlab("Snout Vent Length (mm)") +
  ylab("Frequency (n)")

grid.arrange(CYSC_plot, COVA_plot, nrow = 1)

geckocsv$Breeding.Condition[geckocsv$Breeding.Condition == "G,B"] <- "B,G"

geckocsv$Breeding.Condition[geckocsv$Breeding.Condition == "NG,B"] <- "B,NG"
CYSC_female <- nrow(filter(CYSC, Sex == "F"))
 CYSC_gravid <- nrow(filter(CYSC, Breeding.Condition == "B,G"))

CYSC_percent <- (CYSC_gravid / CYSC_female) * 100

print(paste0("There are ", CYSC_gravid, " C. scabrum female geckos that are
gravid. That makes up ", CYSC_percent, "% of the C. scabrum females"))
## [1] "There are 1 C. scabrum female geckos that are gravid. That makes up
25% of the C. scabrum females"
COVA_female <- nrow(filter(COVA, Sex == "F"))
 COVA_gravid <- nrow(filter(COVA, Breeding.Condition == "B,G"))

COVA_percent <- (COVA_gravid / COVA_female) * 100

print(paste0("There are ", COVA_gravid, " C. variegatus female geckos that
are gravid. That makes up ", COVA_percent, "% of the C. variegatus females"))
## [1] "There are 1 C. variegatus female geckos that are gravid. That makes
up 100% of the C. variegatus females"

gravid_table <- table(geckocsv$Species, geckocsv$Breeding.Condition)
 chisq.test(gravid_table)
```

```
## Warning in chisq.test(gravid_table): Chi-squared approximation may be
incorrect
##
##  Pearson's Chi-squared test
 ##
## data:  gravid_table
 ## X-squared = 2.3111, df = 3, p-value = 0.5104

geckocsv %>%
  filter(Sex == "F") %>%
  count(Species, Breeding.Condition) %>%
  ggplot(aes(x = Species, y = n))+
   geom_col(aes(fill = Breeding.Condition))+
   labs(fill = "Breeding Condition", y = "Frequency (n)")+
   theme_minimal()
geckocsv <-view(mutate(geckocsv, transect_group = if_else(str_detect(
   Transect.Number, "A"), "Anthropogenic", if_else(str_detect(
     Transect.Number, "N"), "Natural", ""))))
 #The code above is required for the chi squared test, the rest is to show
statistical numbers.

gecko_natural <- nrow(filter(geckocsv, transect_group == "Natural"))
 gecko_anth <- nrow(filter(geckocsv, transect_group == "Anthropogenic"))
 gecko_total <- nrow(geckocsv)

#percentages
 anth_percent <- (gecko_anth / gecko_total) * 100
 nat_percent <- (gecko_natural / gecko_total) * 100
 #Percentage of those found incidental
 incidental_percent <-((gecko_total - (gecko_natural + gecko_anth))
/gecko_total) * 100

print(paste0( anth_percent, "% of geckos were found in the anthropogenic
landcover transects. ", nat_percent, "% of geckos were found in the natural
landcover. ", incidental_percent, "% of geckos were found incidentally"))
## [1] "50% of geckos were found in the anthropogenic landcover transects.
37.5% of geckos were found in the natural landcover. 12.5% of geckos were
found incidentally"

landcover_table <- table(geckocsv$Species, geckocsv$transect_group)
 chisq.test(landcover_table)
## Warning in chisq.test(landcover_table): Chi-squared approximation may be
 ## incorrect
##
##  Pearson's Chi-squared test
 ##
## data:  landcover_table
 ## X-squared = 0.88889, df = 2, p-value = 0.6412
```