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Commonalities in Species Distribution, an Advanced Search for the Elusive Arizona elegans

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COMMONALITIES IN SPECIES DISTRIBUTION, AN ADVANCED SEARCH FOR THE ELUSIVE *ARIZONA ELEGANS*

By

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The purpose of this study was to identify ecological parameters which could serve as a basis to more accurately predict the population distribution of the species *A. elegans*. Population numbers of *A. elegans* in Nebraska are low, and limited a range distribution has been estimated throughout the state. Due to the elusive nature and limited numbers of this animal, accurately identifying its range in Nebraska is of concern to biologists. Analysis of multiple ecological variables throughout selected counties of Nebraska were used in an attempt to account for current distribution and possible extensions of its known range. Ecological information was collected at the county level, charted and statistically analyzed in order to examine any correlations to snake habitation. Analysis provided few statistically significant correlations between *A. elegans* habitation and the variables studied at the county level, however, annual rainfall and soil pH had a significant correlation. These results do not necessarily suggest a causal relationship and further study is needed to determine if these variables are a suitable metric with which to determine habitation. Used in tandem with multiple variables, as well as more advanced modeling techniques such as GIS, these results may play a role in furthering our understanding of the population distribution of *A. elegans* in the state of Nebraska.

Introduction

Arizona elegans, or the Kansas Glossy Snake, is a colubrid snake and the only member of the genus *Arizona*, of which there are many subspecies. This reclusive reptile is primarily nocturnal, feeding on small mammals, lizards and bird eggs (Powell et al 2016). *A. elegans* can characteristically be found in open, dry prairie habitats and prefers sandy loam soils for burrowing during the day (Fogell 2010). This species inhabits the southeastern portion of the United States as well as Mexico.

In Nebraska this species has been recorded in only five counties. The three southwestern most counties include Chase, Dundy and Hitchcock, and more recently a few individuals of this species has been observed in the central-state counties of Thomas and Hooker, where a small, but known breeding population has been established (Ferraro 2017). These two disjunct geographical populations share certain environmental characteristics with each other and the land which separates them. By understanding the variations in habitat between both populations, we can learn how to more effectively manage the species and the land it inhabits in the state of Nebraska.

Gap analysis is a proactive conservation mapping technique that can be used to spatially analyze species richness as well as land cover, and management criteria (Ecological 2017). According to Michael Jennings, in his paper on gap analysis published in *Landscape Ecology*, by using multiple datasets such as vertebrate species distributions, land use, soil type and climate variables, scientists are able to create spatial maps of larger ecosystem functions. This technique allows for a greater understanding of biodiversity overall, and can inform the scientific community of the need for often overlooked conservation efforts (Jennings 2000). The Center for Advanced Land Management Information Technologies, (CALMIT), at the University of Nebraska have been utilizing gap analysis across the state, and released a comprehensive project in 2005. Their objectives included mapping land cover, predicting animal distributions and species richness, and comparing that data with existing land management goals in order to provide a basis for a statewide biodiversity strategy (CALMIT 2005).

Arizona elegans being a somewhat elusive and nocturnal creature, may have a population distribution which has been underrepresented by the observational data currently on record. Although *A. elegans* is not listed as a threatened species, they are listed as a species of concern in

Nebraska due to their rarity and limited distribution (Fogell 2010). The glossy snake plays an important role in its ecosystem and being that a large part of its diet consists of rodents, it may be an important contributor in areas such as pest control. Snakes also act as bio-indicator species, meaning they can provide information as to the status of the environment around them (Bauerle et al 1975).

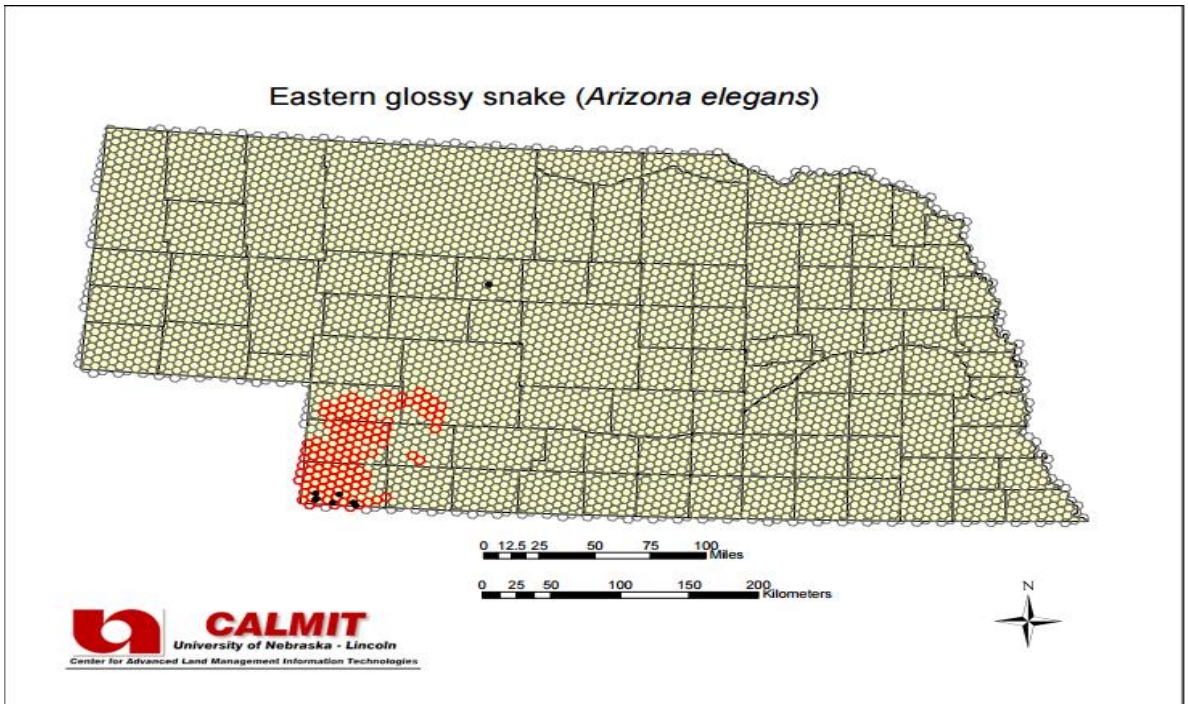
According to Rodriguez-Robles et al, nearly fifty percent of the glossy snake's diet consists of small lizards and forty four percent consists of mammals. In Nebraska, due to the relative size and location of the prey in the region, the Prairie Lizard, *Sceloperus undulata*, is a major food source for the glossy snake (Rodriguez-Robles et al 1999). The prairie lizard inhabits much of the same sandy, open prairie habitats as the glossy snake (Powell et al.). Rodents in the region include one species which is small enough to be preyed upon by the glossy snake, *Perognathus flavus*, or the Silky Pocket Mouse (Jones 1964).

In this project I will use the gap analysis data provided by CALMIT, along with additional metrics and data collected since the study released in 2005 in the hopes of providing a broader perspective on the distribution of *A. elegans* in the state of Nebraska. The amount of data available for the glossy snake in Nebraska is quite small, however there is a large pool of available data for *A. elegans* collected outside the state. I will analyze additional factors and reference them with the observational data collected in the respective counties the glossy snake has been found, as well as the counties which separate their two disjunct populations.

The CALMIT gap analysis released for *A. elegans* was limited to two applicable variables, soil and land cover. In this project I attempt to account for alternative variables including land use, crop land cover, native vegetation, soil texture, annual precipitation, pH levels and prey populations. Datasets used include "Terrestrial Natural Communities of Nebraska" published in 2010 by Gerry Steinauer and Steve Rolfsmeier, the NRCS Soil Survey data, USDA National Agricultural Statistics Service as well as field data collected by Professor Dennis Ferraro of the UNL Herpetology department.

Currently the CALMIT gap analysis lists *A. elegans* as possibly reaching its range limit in the southeast corner of Nebraska, however, if their distribution were underrepresented this may have an impact on their overall assessment. I hypothesize that this is the case, due to the fact that after this analysis was released, an established breeding population has been found in

Hooker County. According to the CALMIT range projection, there is not suitable habitat for the glossy snake in Thomas and Hooker counties.



Thomas County is the central state county with a black dot represented a known find, Hooker is the county to the left of it. As you can see the suitable range habitat (red) does not extend in to either county.

If, as demonstrated by SNR at UNL through Professor Ferraro's research there is a breeding habitat of *A. elegans* in the central state counties of Thomas and Hooker, then perhaps there was once a continuous population that spanned through the counties between these populations. These counties include: Arthur, Hayes, Keith, Logan, Lincoln, Mcpherson and Perkins. Why or why should we not expect to find *A. elegans* in these counties? By interpreting multiple variables on a county by county basis, there may be additional information to add to the CALMIT data and other organizations as well.

By analyzing soil type through each county I will attempt to find soils that would support a population of *A. elegans.* Counties with a suitable amount of sandy loam soils may contain habitat available for the glossy snake. I hypothesize that the counties in which the glossy snake is already found will already have suitably large sandy loam soil habitats, and hope to find counties between the two disjunct populations which also support these characteristics.

By analyzing land cover data I will attempt to find land that would support a population of *A. elegans*. The land which is closest to native vegetation may harbor the most positive environment for glossy snake habitation. Lands with less farmed acres, or larger grazing habitat may also support them. I hypothesize that the counties in which the glossy snake is already found will already have suitable amounts of native vegetation and grazing habitat, and hope to find counties between the two disjunct populations which also support these characteristics.

By analyzing average annual precipitation data I will attempt to find precipitation averages that support the glossy snake. Counties which have low annual rainfall may harbor the most positive environment for glossy snake habitat. I hypothesize that the counties in which the glossy snake is already found will have suitably dry habitats, and hope to find counties between the two disjunct populations which also support these characteristics.

By analyzing soil pH data I will attempt to find soil reactivity averages which support glossy snake habitation. There is no literature available which directly associates *Arizona elegans* with a certain pH, however, because the glossy snake interacts so frequently with the soil and burrows in it regularly, there may be a correlation with snake habitation and pH whether directly or indirectly.

By analyzing prey population overlap I will attempt to find prey population distributions which would support *A. elegans* habitation. Areas with populations of *Sceloperus consobrinus* and *Perognathus flavus* may provide a necessary food source for the glossy snake. I hypothesize that the counties in which the glossy snake is already found will have suitable populations of these to prey items, and hope to find counties between the two disjunct populations which also support these characteristics.

There is a lack of literature available to directly quantify ideal levels of all ecological parameters being used in this study. Because of this, a baseline metric outside of the literature must be established with which to compare each county. Because the largest known population density of Glossy snake in Nebraska is found in Dundy County, the variables associated with Dundy county data will serve as the baseline metric to compare all other counties.

Materials and Methods

The aim of this research is to analyze basic ecological variables which may or may not account for the species *Arizona elegans*' current distribution in Nebraska. The variables analyzed were as follows: land use, crop land cover, native vegetation, soil texture, annual precipitation, pH level and prey populations. These ecological parameters were compared with a baseline metric provided by the data associated with Dundy County, in which the majority of glossy snakes are found. The metrics provided by Dundy County were regarded as having a 100% positive presumed effect on habitable area. All other counties were compared against this data.

Data was collected on a county by county basis. Similarities between the counties Chase, Dundy and Hitchcock, referred to as "Population A" were cross referenced with counties Thomas and Hooker, referred to as "Population B." Any similarities found between these two independent populations were cross referenced with "Zone X" (Fig. 1). T-distribution tests were performed on crop land cover, annual precipitation, and pH data. In each case, the null hypothesis was calculated at three levels. The first test was performed with the null set as the value of Dundy County. The second test was performed with the null hypothesis as the average of the three southwest counties Chase, Dundy and Hitchcock, and the third test was performed with the null hypothesis as the average of the two central state counties, Thomas and Hooker.

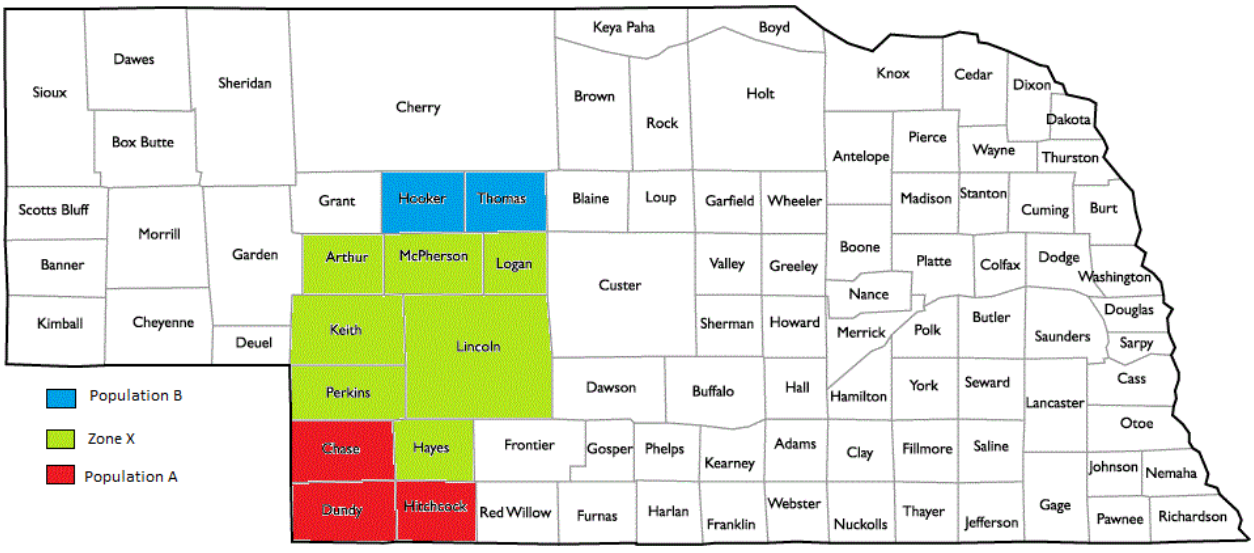


Figure 1

Soil Type: Statewide county data was collected from the NRCS soil survey database and used to account for soil texture. Soil texture is an important component in glossy snake

habitation due to the fact that the soil must provide the snake the ability to burrow. Metrics were created from the literature to include sand, loamy sand and sandy loam soils as a 2, Sandy clay loam, medium loam, and silty loam as a 1, and all other soil textures as a zero. Using NRCS soil surveys the majority soil types were analyzed and their according textures were averaged. Soils were compared individually and compared and contrasted as groups. The data were represented as percentages of Dundy County which was set as the 100 percent mark.

Land Use: Crop Land cover was collected from the USDA's National Agricultural Statistics Service. The counties were surveyed using CropScape- Cropland Data Layer (NASS) in order to estimate a cropland acreage total for the county. The total acreage of all farmland in each county was divided by the county's total acreage to produce a ratio. Crop variables that were included in the analysis were: corn, sorghum, soybeans, sunflowers, pop corn, barley, winter wheat, double crop winter wheat/soybeans, rye, oats, millet, speltz, alfalfa, other hay/non alfalfa, dry beans, potatoes, peas, sod/grass seed, fallow, grapes, triticale, double crop winter wheat/corn, and double crop winter wheat sorghum. My hypothesis was that the more land area used for crops, the less we would expect to find breeding populations of glossy snakes

The cropland acreage data were represented as percentages of Dundy County which was set as the 100 percent mark. A T-distribution replicate measurement test was performed in order to determine statistical significance using the null value of Dundy county, Population A average, and Population B average. Hypotheses were assumed as $H_{0:}\ \mu_D=0$ and H_1: $\mu_D\neq0$. The formula used is as listed: $Tcalculated = \left(\frac{|x1-x2|}{Spooled}\right) X\ square\ root(\frac{n1n2}{n1+n2})$. The T value given was then compared to a t-table in order to determine significance at a 99 percent confidence interval.

Terrestrial ecosystem data: Terrestrial ecosystem data was collected for each county from "Terrestrial Ecological Systems and Natural Communities of Nebraska" published by the Nebraska Game and Parks Commission. Communities were ranked based on overall vegetative density of the natural ecosystem. Open areas are preferred by *A. elegans* and its prey, prairie lizards, which use the less dense underbrush to hunt, and for thermoregulation. Each ecosystem was analyzed for its habitability using the following metrics: Any ecosystem which was described with moderate to low vegetative density, and appropriate soil formation was recorded as a 2, any ecosystem which was described with moderate to high vegetative density and/or undesirable soil formation were recorded as a 1, and finally, any ecosystem which was described

as a wetland and/or completely undesirable soil formation was recorded as a zero. The terrestrial ecosystem data were represented as percentages of Dundy County which was set as the 100 percent mark.

The counties were analyzed by tallying up the native communities found within them using an excel table:

	Chase	Dundy	Hitchcock	Hooker	Thomas	Arthur	Hayes	Keith	Logan	Lincoln	Mcpherso	Perkins
Western Great Plains Closed Depression Wetland	x	x						x				x
Central Mixed-Grass Prairie			x				x			x		
Sandsage Prairie	x	x	x				x					x
Threadleaf Sedge western mixed grass prairie	x	x	x				x	x				
Western great plains mixed grass prairie			x				x					
Loess Mixed Grass Prairie			x				x			x		
Wheatgrass Playa Grassland												x
Green Ash				x	x							
Sandhills Dune Prairie						x		x		x		
Eastern Sand Prairie						x			x			
Rocky Mountain Juniper Woodland								x				
Great Plains Gravel/Cobble Prairie								x				
Riverine Gravel Flats								x		x		
Sandhills Hardstem Bullrush Marsh									x			
Sandhills Mesic-Tallgrass Prairie									x			
Cottonwood Riparian Woodland										x		

The terrestrial communities were listed on the y axis and the counties were listed on the x axis. The communities highlighted red were recorded as a "-", or very undesirable for the habitation of *A. elegans*. The communities highlighted yellow were recorded as a "+" or neutral for habitation, and the communities highlighted green were recorded as "++" or beneficial for habitation by *A. elegans*. These results were then tallied to produce a final rating. For example, Chase county had two green communities and one red community listed, one green and red cancel each other out, leaving us with one green tally, giving Chase county a score of "+" These data were represented graphically against the results for Dundy county, being expressed as a percentage of the Dundy average.

Average Annual Rainfall: Data was collected from NRCS Soil Survey database by county. Average annual rainfall data were graphed as a percentage of Dundy County. A T-distribution replicate measurement test was performed in order to determine statistical significance using the null value of Dundy county, Population A average, and Population B average. Hypotheses were assumed as H_0: $\mu_D=0$ and H_1: $\mu_D\neq0$. The formula used is as listed: $Tcalculated = \left(\frac{|x1-x2|}{Spooled}\right) X\ square\ root(\frac{n1n2}{n1+n2})$. The T value given was then compared to a t-table in order to determine significance at a 99 percent confidence interval.

pH: Soil reactivity data was collected from NRCS Soil Surveys by county. The pH for all counties were graphed against Dundy County, being expressed as a percentage of the Dundy average. A T-distribution replicate measurement test was performed in order to determine statistical significance using the null value of Dundy county, Population A average, and Population B average. Hypotheses were assumed as $H_{0:}\ \mu_D=0$ and H_1: $\mu_D\neq0$. The formula used is as listed: $Tcalculated = \left(\frac{|x1-x2|}{Spooled}\right) X\ square\ root(\frac{n1n2}{n1+n2})$. The T value given was then compared to a t-table in order to determine significance at a 99 percent confidence interval.

Data for *Sceloperus consobrinus* was drawn from range maps provided by The School of Natural Resources at UNL for Reptiles and Amphibians. The lizard was recorded as present or not present in the counties being studied. Counties with the presence of *Sceloperus consobrinus* populations were recorded as 100% and counties without a population presence were recorded as 0% (Ferraro 2017).

Data for *Perognathus flavus* was drawn from range maps in the "Distribution and Taxonomy of Mammals of Nebraska" and recorded as present or not present in the counties being studied. Counties with the presence of *Perognathus flavus* were recorded as 100% and counties without a population presence were recorded as 0% (Jones 1964).

Results

Soil Type: Figure 2 shows soil texture ranked as a percentage of Dundy. The counties of Chase, Hitchcock, Keith and Perkins all had beneficial soil texture equal to that of Dundy County, while Hooker, Thomas, Arthur, Hayes, Logan, Lincoln and Mcpherson counties had greater amounts of beneficial soil texture according to the NRCS County Soil maps.

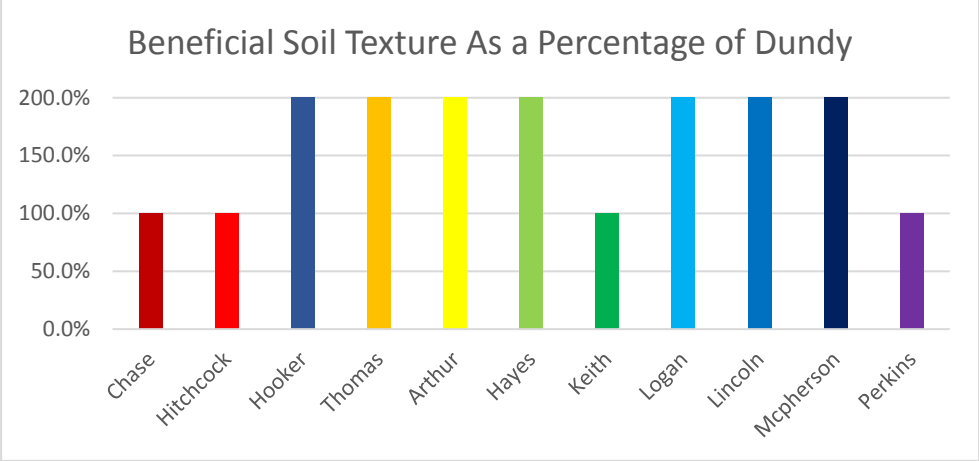


Fig. 2

Land Use: When ranking crop land over, there was a wide variation in cover over all twelve counties studied. Hooker County, with 0.31% crop land cover had the lowest amount, while Perkins County had the highest at 77.14% crop land cover. Figure 3 shows crop land cover ranked as a percentage of Dundy. As we can see, crop land cover varies greatly between the counties of Chase, Hitchcock, Dundy, Hooker and Thomas in which the Glossy Snake is found.

According to statistical analysis, crop land cover was not found to be significant in all three scenarios at a 99% confidence interval. Neither Dundy County itself, Population A nor Population B proved to be statistically different, with a T-value of 1.26, 1.19 and 1.44 respectively. We fail to reject our null hypothesis that $H_{0:}\ \mu_D=0$.

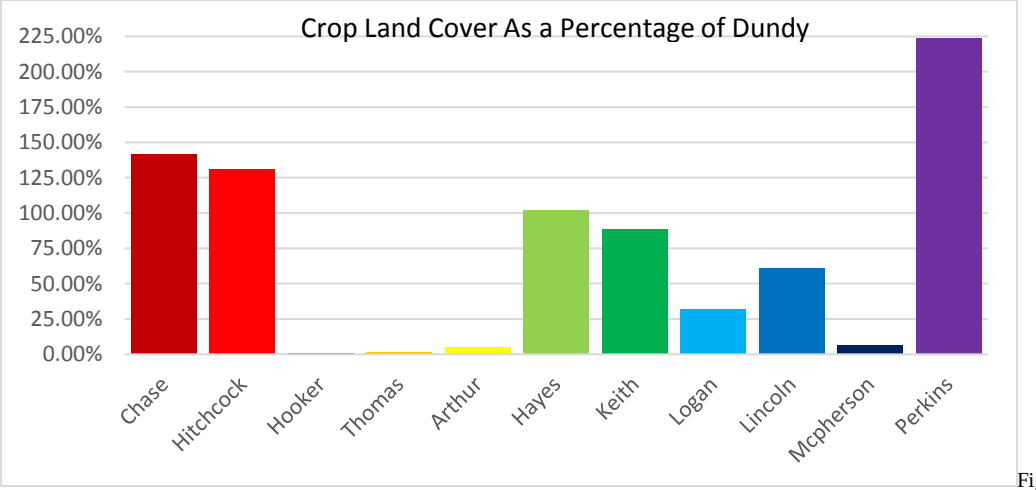


Fig. 3

Terrestrial Ecosystems: When ranking beneficial land cover habitat, little variation was recorded due to the scale of measurement. The counties of Chase, Hitchcock, Arthur, Hayes and Mcpherson all ranked at the same level of beneficial terrestrial ecosystem habitation as Dundy. Hooker, Thomas, Keith, Logan and Lincoln counties ranked at 50% of beneficial terrestrial ecosystem habitat. Data for Perkins County was not included in the *Terrestrial Natural Communities of Nebraska* literature and so was not reported here. Beneficial Land Cover is ranked as a percentage of Dundy County in figure 4 below.

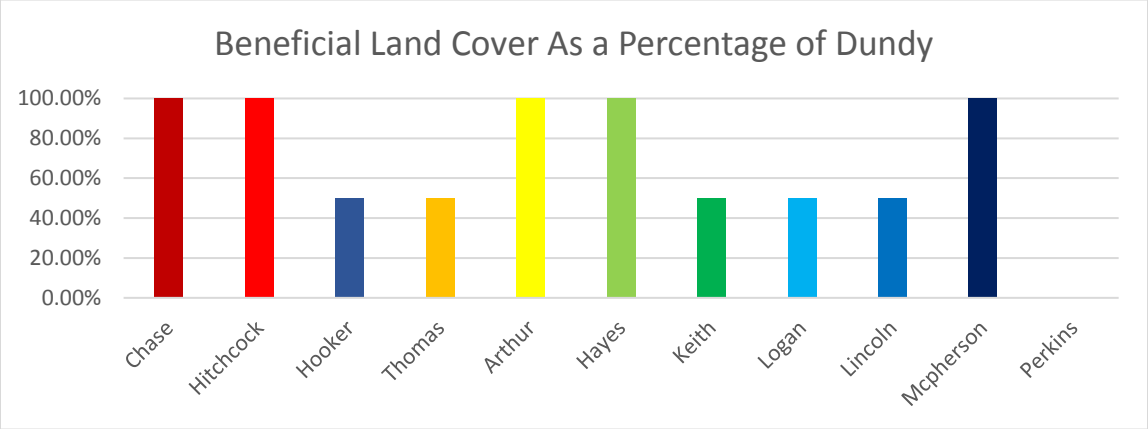


Fig. 4

Average Annual Rainfall: Annual rainfall averages by county are listed as a percentage of Dundy County in figure 5 below. There was little variation in the means of all twelve counties, with a range spanning from 17.92 inches in Keith County, to 20.70 inches in Logan County. According to statistical analysis, annual precipitation was significant at a 99% confidence interval in Dundy County, with a T-value of 3.26. Thus, we can reject our null

hypothesis that $H_{0:}\ \mu_D=0$, and conclude that the annual precipitation found in Dundy county is statistically different from the mean, with an average of 18.44" vs 19.25". The annual precipitation for Population A, the southwest counties of Chase, Dundy and Hooker were also significant at a 99% confidence interval with a T-value of 38.943. We can reject our null hypothesis that $H_{0:}\ \mu_D=0$, and conclude that the annual precipitation average of Population A is statistically different from the mean, with an average of 19.183" vs 19.25". The T-value for Population B, was 0.68 and so was not significant, and we fail to reject our null hypothesis.

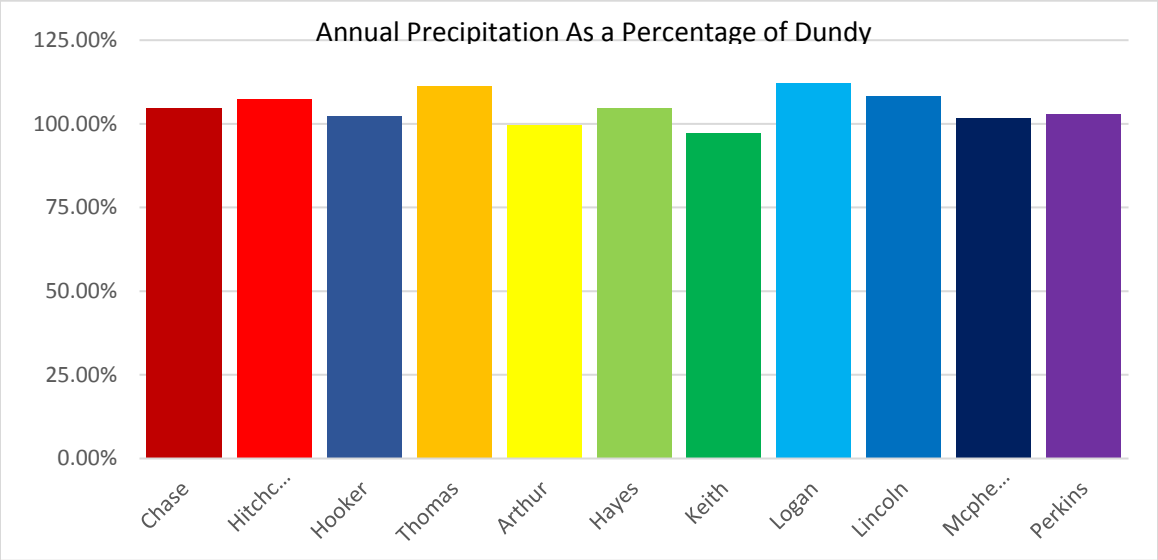


Fig. 5

pH: pH averages by county were expressed in figure 6 below as a percentage of Dundy county. The pH values varied from 7.25 in Hayes County to 8.55 in Dundy County. Dundy had the highest average pH of all twelve counties. Additionally, the Dundy County average was statistically significant, with a T-value of 7.08. We can conclude at a 99% confidence level that the Dundy pH value was statistically different from the mean value, with an average of 8.55 vs 7.71. We reject the null hypothesis that $H_{0:}\ \mu_D=0$. The T-values for Population A and B were 0.88 and 1.04 respectively and are not significant at a 99% confidence interval, so we fail to reject the null hypothesis that $H_{0:}\ \mu_D=0$.

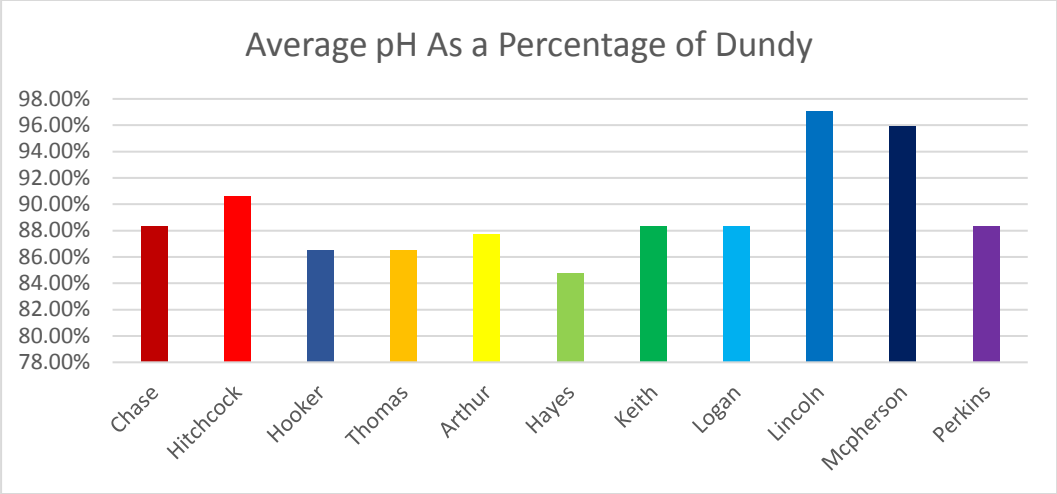


Fig. 6

Prey Items: Data for *Sceloperus consobrinus*, the Prairie Lizard, and *Perognathus flavus*, the Silky Pocket Mouse are shown in Figures 7 & 8 below. These prey items were found in all twelve counties studied.

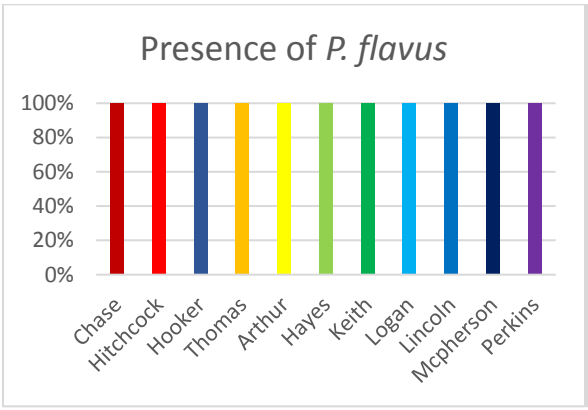


Fig. 7

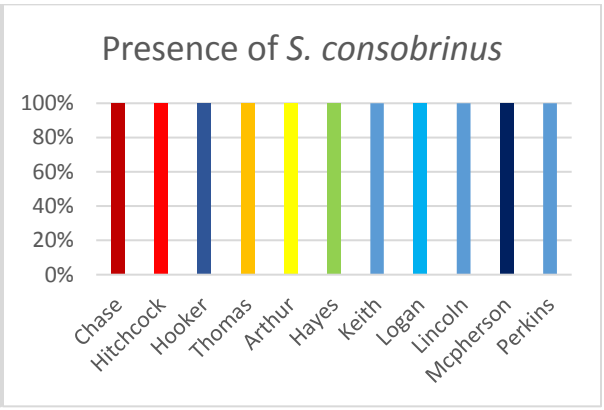


Fig. 8

Discussion

The analysis of multiple ecological variables to account for the presence of *A. elegans* proved to show little to no correlation between either population group and zone x. Statistical analysis did provide some insight into which variables were significantly different, however, the majority of these variables seem to be correlative and the literature does not suggest a causal link. Utilizing Dundy as a baseline with which to compare other counties allowed for good comparative results.

When ranking soil texture data, all counties researched had a suitably large amount of habitable soil textures. Sandy loam soils were ubiquitous in the region studied. The results suggest that soil texture should not be a barrier for the habitation of *A. elegans* at the county level in this area in particular. In fact, many of the counties where the glossy snake is not known to be found were observed to have higher amounts of suitable soil habitat than the counties in which the snake has been found.

Crop land cover was shown to be extremely varied throughout all twelve counties. None of the three population groups studied proved to be statistically significant, and I did not find a correlation between established *A. elegans* populations and crop cover. I hypothesized that with less farmland and more native habitat, there would be a benefit for habitation by *A. elegans*, but the findings fail to support this hypothesis. Population B, the counties of Thomas and Hooker, had the lowest amount of cropland, but the counties of Population A, Chase, Dundy and Hitchcock counties had the most amount of crop land cover with the exception of Perkins County.

Precipitation analysis showed a fairly homogenous rainfall throughout the twelve counties. The difference in rainfall between the highest and lowest counties was only 2.6 inches. While this is a relatively small difference in precipitation, Dundy County was recognized as having the third lowest amount of precipitation of the twelve counties. This data was statistically significant, and is in accordance with the literature. Precipitation was also statistically significant in Population A.

It is possible that this could be a causal relationship, and the glossy snake may be sensitive to small differences in precipitation. The counties of Hayes, Logan and Lincoln all have higher rainfall averages than Population A, and this would suggest a lowered advantage for habitation in these counties. It may also suggest that the counties of Arthur, Keith, Mcphereson and Perkins would be beneficial for habitation of *A. elegans*. Further study is needed, and an analysis of the precipitation in specific months of the year when the Glossy snake becomes active could provide more understanding.

Soil pH data were significant, with Dundy having the highest pH of all counties. The literature does not suggest a causal link between *A. elegans* and soil pH. Future studies may provide an insight as to whether *A. elegans* has a preference for higher pH soils, or if there is an

external variable which is affected by pH, such as a prey item etc. Both *Sceloperus consobrinus* and *Perognathus flavus* were found to be present in all counties studied. This data does not provide any insight into new interpretations of the population distribution of *Arizona elegans.*

The main significance in the results of this study have to do with precipitation and pH levels. While both are significant, they do not lend strong support to the hypothesis that the Glossy Snake inhabits the counties which separate its two known breeding populations. However, this study does rule out crop land cover, soil texture and prey populations from being significant at the county level.

Previous assessments of the species' distribution including the CALMIT report require attention, however, my data does not clearly define a single ecological variable which would serve as a basis to conduct further research. Multiple variables should be analysed in tandem in order to gain a more accurate picture of *A. elegans'* distribution. If further research is done to confirm a causal relationship, the addition of pH and precipitation variables, along with the up to date field findings into the CALMIT projection may produce a more accurate projection.

Conclusion

This investigation was conducted in order to try and gain a more accurate picture of the population distribution of *A. elegans.* Accurate vertebrate species modeling is an important tool for farmers and contractors especially in these rural areas, especially when dealing with a species which is threatened in numbers. Unfortunately this study did not identify major variables which would help us gain more insight.

According to the data analyzed there is little evidence to support the hypothesis that the population distribution of *A. elegans* extends outside its currently known range. The statistically significant results, including precipitation and soil pH suggest a correlative relationship. According to the literature available, small differences annual rainfall may suggest a causal relationship for habitation; this would need to be confirmed through further study. In future work, a GIS analysis which accounted for multiple variables at once would benefit field researchers.

By using mostly countywide averages in this study, there is a significant chance that compounding factors may have been missed in a single spot. Consider an area in a predominantly wet, clay, agricultural county. In such a county there may in fact exist a suitably sized area of land which contains two or more positive variables including dry, sandy, native vegetation habitats. If this study were to be performed again it would be ideal to use a smaller scale and more precise measurements, and analyze these measurements on a habitat scale with local ecosystems. In the future, utilizing GIS software would more effectively allow one to narrow down these compounding factors. As we continue to learn more about the habitation preferences of the Glossy Snake, we will understand which ecological variables to consider before undertaking projects which may threaten it. Hopefully research will continue that will enable future populations of *Arizona elegans* to flourish.

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