Modeling the Population Viability and Distribution of Blanding's Turtle, *Emydoidea blandingii*, using a Machine Learning Approach, in Michigan during Mating Season

Figure 1 - A Blanding's Turtle in the Wild
Source: https://www.reconnectwithnature.org/News-Events/The-Buzz/Blandings-turtle-creature-feature

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Category: Physical Sciences and Engineering

Division: Senior

All photos and diagrams taken by researcher unless indicated otherwise

Introduction / Purpose

What are Blanding's Turtles?

- **Freshwater turtles** have distinctive yellow markings on their chin and throat and a dome-like black shell with yellow spots.
- Mating occurs in **spring**; females nest in sandy areas near marshes, with hatchlings emerging in late summer.

Why study Blanding's Turtles?

- Blanding's Turtles are an **indicator** species of the wetland ecosystem that are endangered; there is limited knowledge about the sudden decline of this species.

Goal and Purpose

To model and understand the population viability of Blanding's Turtle population to prevent future decline with the support of Chippewa Nature Center.

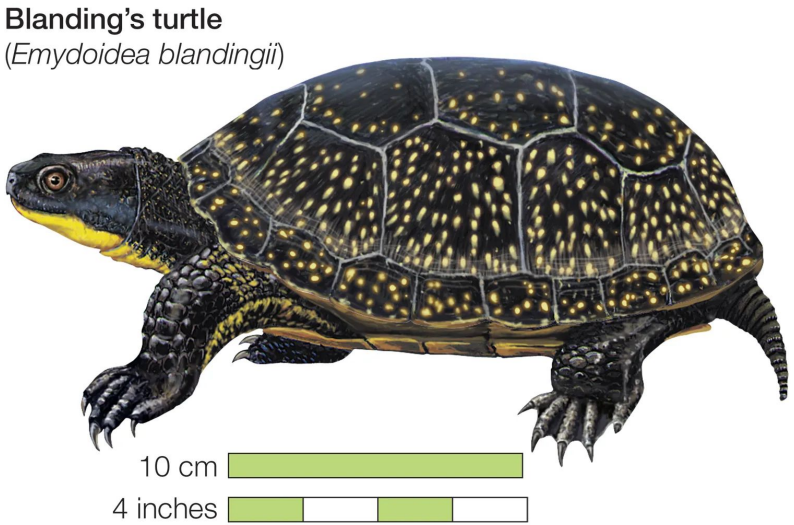
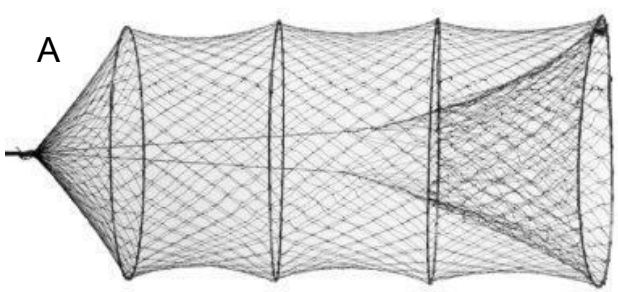


Figure 2 - A diagram of Blanding's Turtle *(Source: https://www.britannica.com/animal/Blandings-turtle)*

Methodology: Data Collection of Blanding's Turtle

Collection Methods

- The following data regarding Blanding's Turtle and other turtle species native to Michigan in mating season was collected by ecologists at Chippewa Nature Center (Midland, MI) and Government Locations (New Buffalo, MI; Dowagiac, MI; and South Bend, IN).
  - Carapace Length
  - Initial and Recaptures of Turtles
    - ➢ Only applicable to *Emydoidea blandingii* (recaptures; Chippewa)
    - ➢ For government data, it applies to all turtles
  - Gender and Age
- The collection period was from April to September.



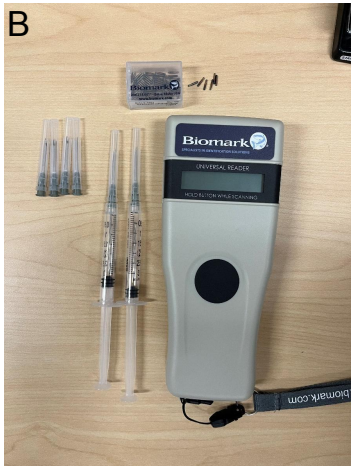


Figure 3-4 Equipment used in data collection: a turtle net (A[1]) and a passive biomarker (B).

Figure 5 - A diagram of the mark-recapture process, where the red diamond is the tag that is inserted into a turtle during the initial encounter. This tag is then used for identification during subsequent captures.

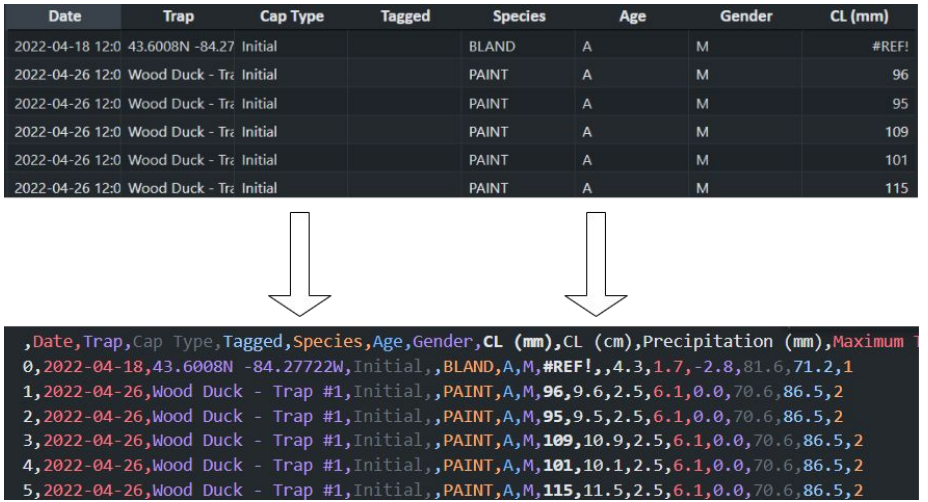
Methodology: Extract, Transform and Load Data

What is Extract, Transform and Load (ETL)?

- A process of extracting data, transforming it (adding additional information) and loading it for future models.

ETL Process:

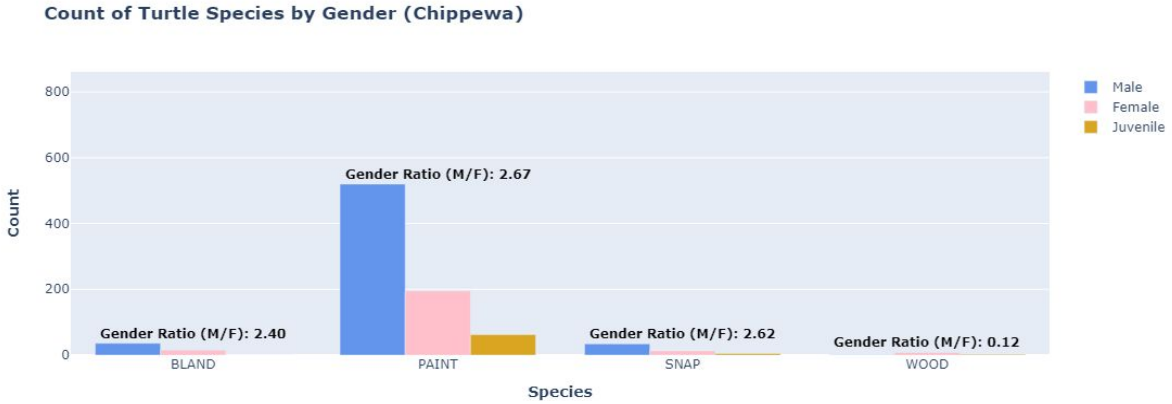
- General formatting (i.e. trailing spaces, unit conversions, or naming conventions)
- Extracting non-turtle data such as:
  - NOAA's Weather Data (Maximum and Minimum Temperature, Precipitation)
  - Visual Crossing Data (Cloud Cover, Humidity, and UV Index)
    - ➢ Ecologists at Chippewa Nature Center recommended these variables
- Transforming such data for turtle datasets.
  - Interpolation for missing temperature dates
- Loading data to a new clean dataset as a CSV file.



Date	Trap	Cap Type	Tagged	Species	Age	Gender	CL (mm)
2022-04-18 12:0	43.6008N -84.27	Initial		BLAND	A	M	#REF!
2022-04-26 12:0	Wood Duck - Tra	Initial		PAINT	A	M	96
2022-04-26 12:0	Wood Duck - Tra	Initial		PAINT	A	M	95
2022-04-26 12:0	Wood Duck - Tra	Initial		PAINT	A	M	109
2022-04-26 12:0	Wood Duck - Tra	Initial		PAINT	A	M	101
2022-04-26 12:0	Wood Duck - Tra	Initial		PAINT	A	M	115

Figure 6 - Before and after the process of ETL for Chippewa Data Center data

Methodology: Exploratory Data Analysis



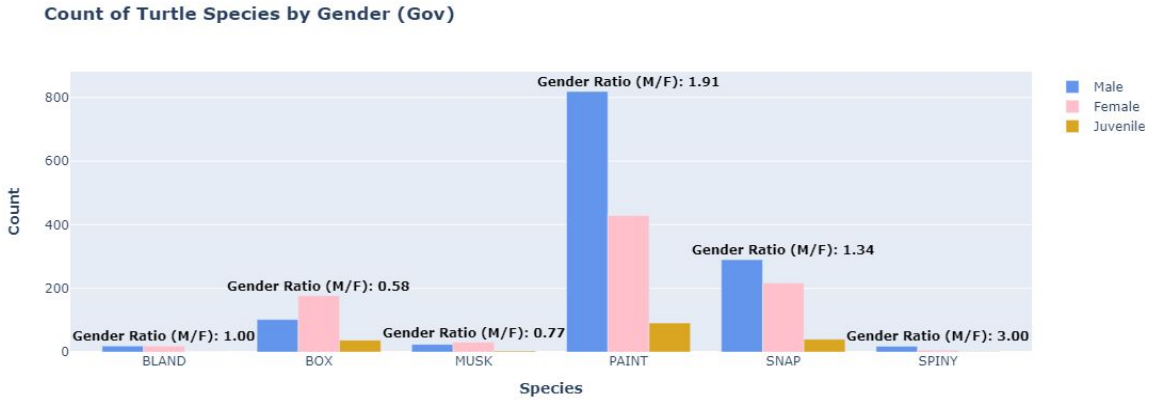
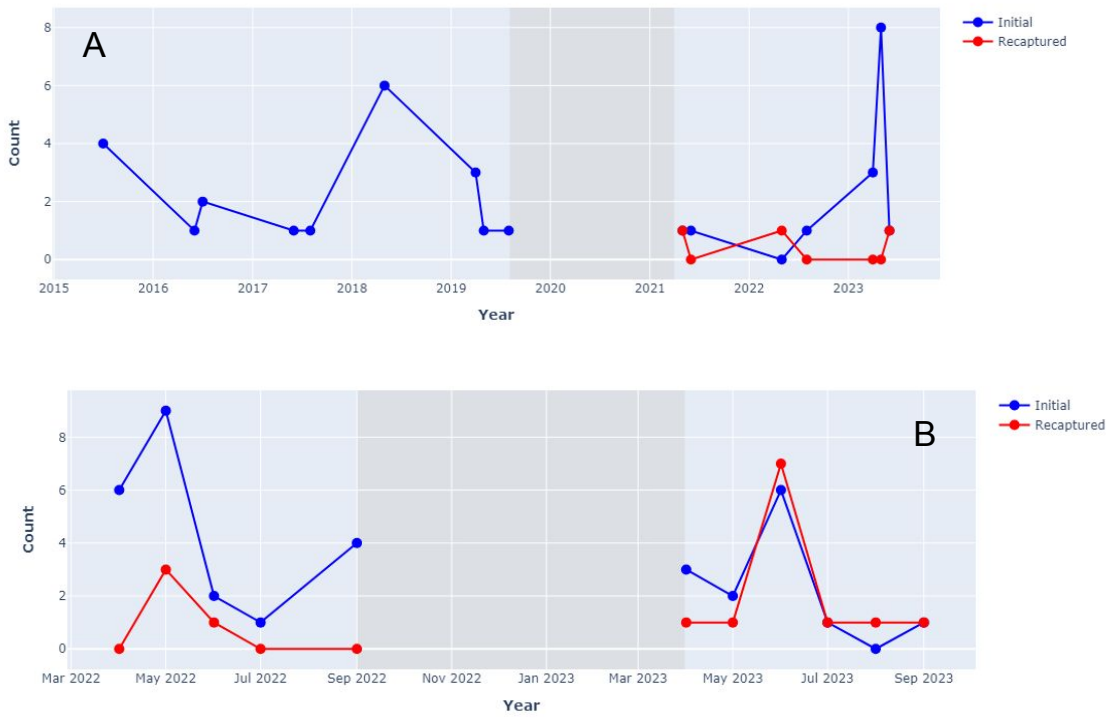


Figure 7-8 - Count of gender of turtle species in the Chippewa Nature Center and Government data

- Exploratory Data Analysis (EDA) is the process of examining the data before modeling to see relationships between variables and is performed in various formats:
  - Univariate Analysis
  - Bivariate Analysis (Species, Capture Type, and Environmental Variables)
- Juveniles cannot accurately be identified as female or male; therefore, they are considered non-gender.

Methodology: Exploratory Data Analysis

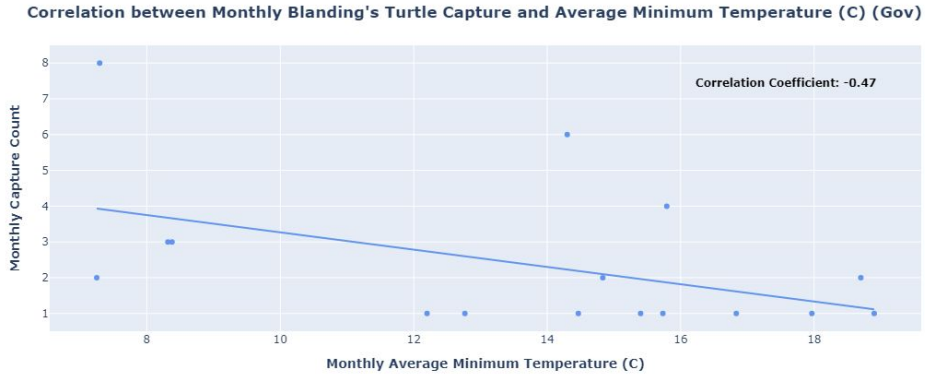


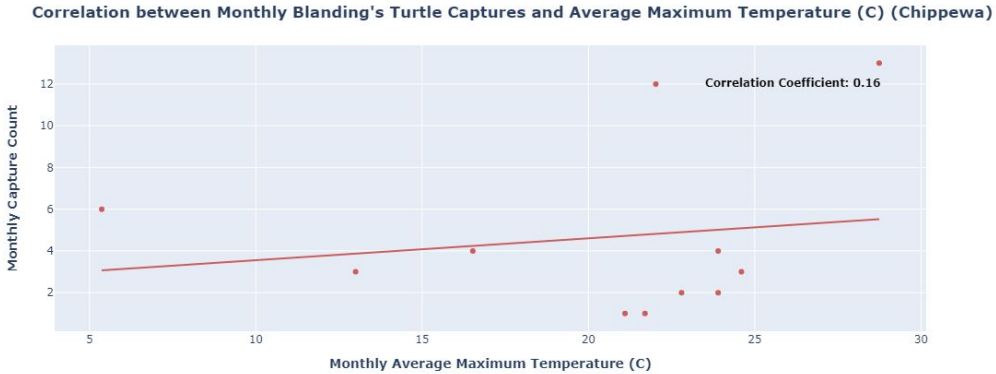
In the government turtle dataset, there is a lack of recaptures of Blanding's Turtles over the capture periods, which could be attributed to the following:

- Trap shyness
  - If caught initially, a turtle may understand the negative connotations of being trapped and become scared.
- Bigger properties
  - With three possible capture sites and more turtles than the Chippewa Nature Center, there is a chance that Blanding's turtles were not active in the trapping areas.

Figure 9-10 - Initial and recaptures of Blanding's Turtle and all turtles (per month). Comparing both the Chippewa Nature Center (A) and Government (B) marked recapture data.

Methodology: Exploratory Data Analysis





Correlation Coefficients for Blanding's Turtles w/ Environmental Variables

	Government	Chippewa
Maximum Temperature	-0.47	0.16
Minimum Temperature	-0.18	0.02
Precipitation	0.31	-0.22
Cloud Cover	0.07	-0.28
Relative Humidity	-0.04	-0.51
UV Index	0.04	-0.01

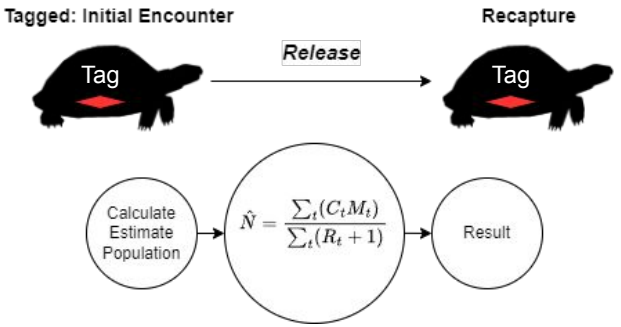
Table 1 - Calculated correlation coefficient of Blanding's Turtle captures per month with environmental variables. A negative correlation coefficient represents a decrease sightings of Blanding's Turtles, and a positive coefficient means an increase in Blanding's Turtles.

Figure 11-12 - Minimum and maximum temperature correlation with Blanding's Turtle Captures (per month). Comparing both the Chippewa Nature Center and Government marked recapture data.

Methodology: Population Estimation Modeling

- In this project two population estimators were used:
  - Schnabel Method
    - ➢ C□ is the total number of individuals caught in sample t.
    - ➢ R□ is the number of individuals already tagged when caught in sample t.
    - ➢ M□ is the total number of individuals marked for the first time and released up to sample t.
  - Cormack Jolly Seber Model (CJS)
    - ➢ p_i: Capture probability
    - ➢ ϕ_i: Survival probability between visits t and t+1
    - ➢ λ: Growth rate
- Both population estimators have assumptions elaborated in their literature.

Schnabel Method



Cormack Jolly Seber Model

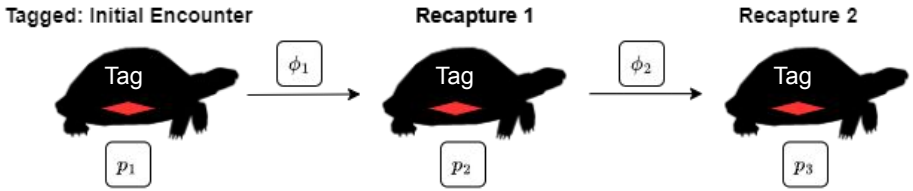
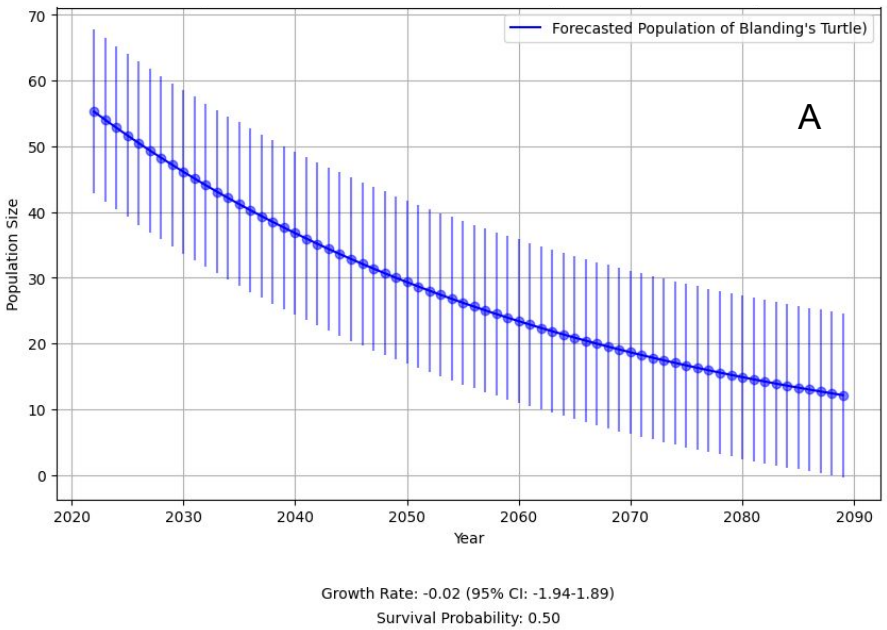


Figure 13-14 - Diagrams of CJS Model and Schnabel Method and how they estimate the turtle population

Methodology: Forecasting and Viability Modeling



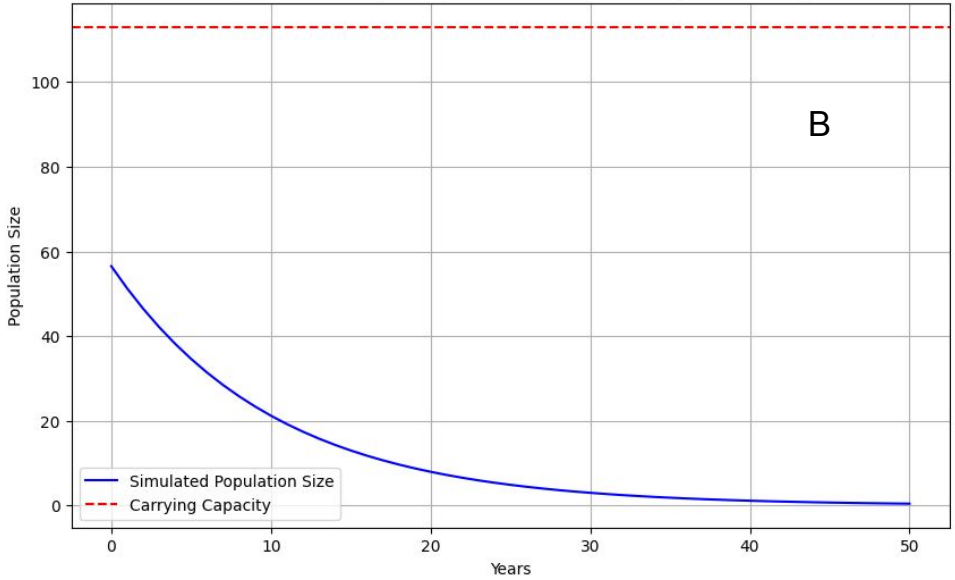


Figure 15-16 - The forecasted population until 2090 (A) and viability analysis (B) of Blanding's Turtle at government locations. The population viability analysis requirements (carrying capacity) are based on King et al.'s 2021 study. The CJS model is used for estimating the population, and population dynamics are employed to make these predictions.

Implications of Modeling Results

- With the **alarming decline** of Blanding's turtles based on the forecasting model and population viability, actions **must be taken to prevent future decline of wetlands**, such as:
  - *Public Knowledge*
    - ➢ Education on the decline of Blanding's Turtles.
    - ➢ Road Signs (where mortalities occur when Blanding's Turtle are searching for a nest location).
  - *New Habitats*
    - ➢ Rehabilitation of fragmented habitats from urbanization.
  - *Communication with Local Nature Centers*
    - ➢ Report any Blanding's Turtle encounter or nest with **Herp Atlas** or nature centers.
  - *Research in the Reproduction of Blanding's Turtles*

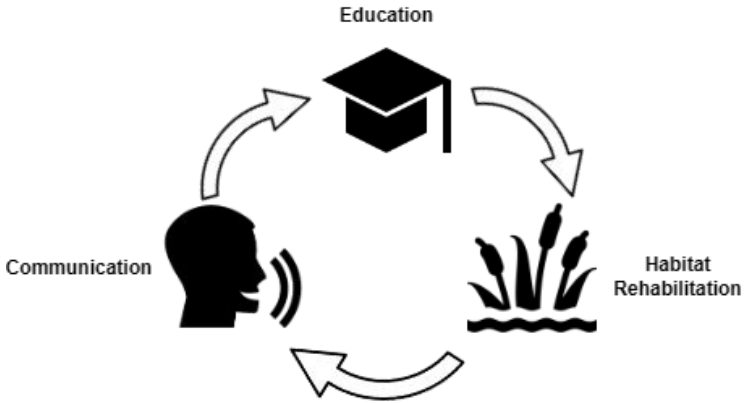


Figure 17 - Future steps to prevent decline of Blanding's Turtles. Chippewa Nature Center's goals for the future align with these recommendations and they hope to achieve them through their collaboration with the researcher.

Conclusion

Overview

The goal was accomplished by creating a model, a population viability analysis of Blanding's Turtle population in Michigan, and a website for other nature centers to get insight regarding Blanding's Turtle population.

- The forecasting model used variables relevant to the model (from Exploratory Data Analysis) and marked recapture data to estimate the population size (CJS model), survival probability, growth rate, and capture probability.
- The population viability model used the results of the CJS Model to provide the population viability, which for Blanding's Turtles is expected to be extinct within 50 years without environmental variables.

Feasibility study: This project is free to replicate and did not use a larger amount of computation power because of its small scale. However, more data regarding Blanding's Turtles will be needed in a larger-scale implementation to make the model more precise.

Avenues for Further Research

1. Examine different population estimators, such as Multistate Models, Generalized Linear Models, and Spatial Cormack Jolly Seber Models.

2. Collaborate with Chippewa Nature Center to create a more extensive dataset of Blanding's Turtle.

3. Consider modeling predation by their primary predators, such as Racoons and Foxes.

Figure 18 - Future Work Possible to Further Build Upon this Study

References

- Diagrams & Graphs Credit to: The Author
- 1 - Turtle Net Photo Source: https://netcollc.com/products/fishing-nets/Turtle-Nets
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