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IsoPOPdAnnualEagle Web Interactive: Interactive software to understand how elements in the annual population matrix of Bald Eagle influence the asymptotic population growth rate

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## Overview of the software application

Population matrix models summarize characteristics of a life history into the quantities that describe population-scale dynamics. Although matrix models have been applied to nearly 8,000 species, practitioners often view the interworkings of the matrix mathematics as a black box.

This interactive application allows the user to see how annual vital rates of Bald Eagle combine to form the asymptotic (long-term) growth rate.

This interactive app allows users to:

- 1) Visualize how life history characteristics aggregate into  $p$  and  $q$  superparameters (“important groupings of biological transitions in the life history”), and then how those superparameters aggregate into the population growth rate.
- 2) Visualize the contribution of each life history trait to the characteristic equation,  $\lambda^3 + p\lambda^2 + q\lambda = 0$ .
- 3) Understand how managerial alteration of a life history trait will influence the growth rate.
- 4) Understand how managerial alteration of a life history trait will change the influence of other life history traits on the growth rate.

## Interactive Software User Tutorial

*Preparing the app for use on your computer:*

Step 1: Obtain annual vital rate data for your Bald Eagle population.

Step 2: Download the “IsoPOPdAnnualEagle.R” software code.

Step 3: Install three packages: “shinyBS”, “rgl”, and “rmarkdown”. To install packages, type `install.packages(“shinyBS”)` to the console and hit run. Repeat with the other packages.

Step 4: Open the IsoPOPdAnnualEagle file in R studio.

Step 5: Click “Run All” and begin interacting with the software application.

*Using the IsoPOPdAnnualEagle interactive software app:*

Step 1: Enter all four annual transition rates for your Bald Eagle population. Save your entries by clicking “Save vital rate entries”. This click will activate all the remaining tabs.

Step 2: View the outputs on each tab. The code will produce graphics of a growth rate cube, the  $p$  volume, and the  $q$  volume. Help and interpretation are obtained by clicking the buttons at the bottom of each tab.

*User Inputs:*

The user must input all four transition magnitudes. A transition that begins at one stage and ends in a different stage represents the average probability that a female will survive the time unit and transition to the latter stage. Alternatively, a transition that begins at one stage and ends in the same stage represents the average probability that a female will survive the time unit and remain in that same stage. Transition inputs must be positive real numbers.

For further information on user inputs, please see:

Caswell, H. (2001). - In: *Matrix population models: Construction, analysis, and interpretation*. 2<sup>nd</sup> edition. Sinauer Associates. Sunderland, Massachusetts, USA.

Hanley, B., Dhondt, A., Heylen, D., & Schuler, K. (201X). Population dynamics describing an expanding population of Bald Eagle (*Haliaeetus leucocephalus*) in the Northeast United States.

## Technical details

This app was written under R Studio Version 1.1.463 – © 2009-2018 RStudio, Inc. This code requires three R Shiny packages: “shinyBS”, “rgl”, and “rmarkdown”.

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