Using GIS to Model Common Loon (*Gavia immer)* Habitat in New Hampshire

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Introduction

The common loon (*Gavia immer*) is a water bird that lives throughout northern North America. In New Hampshire, the Loon Preservation Committee (LPC) has monitored loons for over 30 years. This long-term monitoring program has allowed for the analysis of patterns in the loons' distribution. In 2002, Dr. Mark Brennan created a loon habitat model for his dissertation using all the loon field data collected by LPC from 1980 – 2002. This model was used to predict where loon occupancy occurs based on parameters that were determined to be statistically significant. It was then applied to lakes throughout New Hampshire to give an indication as to where to monitor for loon activity on lakes that were not yet occupied. In our project, we used updated occupancy data from 2002 – 2008 to evaluate if this existing model continued to work beyond 2002. In addition, a new model was created using additional parameters that have been collected since 2002. An evaluation was performed to test if this new model improved the prediction of loon habitat. This new model will further aid LPC in determining which lakes to increase their monitoring efforts and which to monitor less in order to make the most efficient use of the field biologists' time.

Background: Common Loons (*Gavia immer*)

Common loons migrate to freshwater lakes in the summertime to breed. In New Hampshire, the common loon was listed as "threatened" by the New Hampshire Fish and Game Department in 2000 under the New Hampshire RSA 212-A, the Endangered Species Conservation Act (Vogel and Taylor, 2006).

Some qualities characteristic of common loons are:

- Long-lived
- Bioindicator species
- Large-bodied
- Piscivorous
- Distinctive features
- Primarily aquatic
- Aesthetically pleasing

Figure 1: Adult Common Loon & Chick

Background: Study Area New Hampshire (NH) & Previous Habitat Model by Brennan (2005)

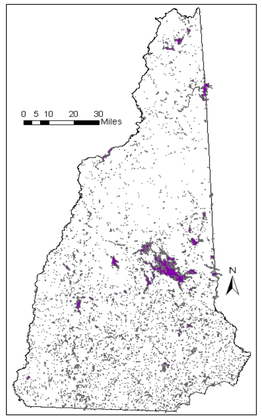


Figure 2: New Hampshire with GRANIT Hydrography GIS layer

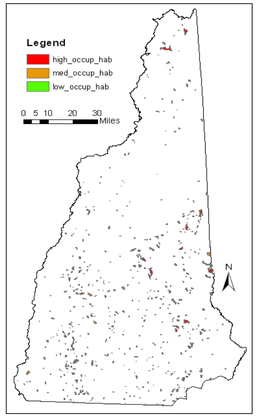


Figure 3: NH with Results layers from Brennan (2005)

Background: Previous Habitat Model

- Model from Brennan (2005):
  p(loon presence) = – 3.4683 + 0.000021(perimeter) + 0.045810(depth) – 0.000096(loon distance) + 0.000936(elevation) + ε
  - Total lakes used to create model: 530
    - Dates used to *create* model: 1980-1996
    - Dates used to *test* model: 1997-2002
  - How model results are broken down:
    - Predicted Probability Values: cutoff at 20%
      - High: 0.5000 – 0.9999
      - Medium: 0.2000 – 0.4999
      - Low: 0.0 – 0.1999

      >20% was considered to be predicted "present"
    - See figure 3 for resulting GIS layers from 3 levels of predicted probability values.

Objectives

- **Overall objective** of this project: to evaluate previous habitat models of common loons and to create a newer model with the most up-to-date field data available.
  - Specific objectives of this project:
    - To evaluate the original habitat model created by Brennan (2005) using field data collected after he completed his project.
    - To combine data from Brennan's habitat model with new factors acquired from different sources to create a new model to improve the process of predicting loon habitat.
    - To statistically compare the models to see which one predicts loon habitat better.

Methods

- To evaluate the previous habitat model, a series of error matrices (Congalton and Green, 2009) were created for each year.
- To create the new model: R statistical open-source software was used to create a logistic regression model from parameters collected from various sources.
  - There were 11 proposed variables for the new model:
    1) Secchi disk depth (measure of water clarity)
    2) Distance to no loon lake (m)
    3) Distance to loon lake (m)
    4) Surface area (hectares)
    5) Lake elevation (m)
    6) Maximum depth (m)
    7) Mean depth (m)
    8) Lake area (acres)
    9) Lake perimeter (m)
    10) Number of Islands
    11) pH

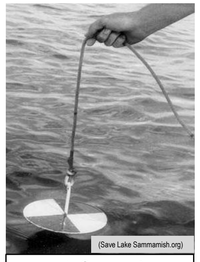
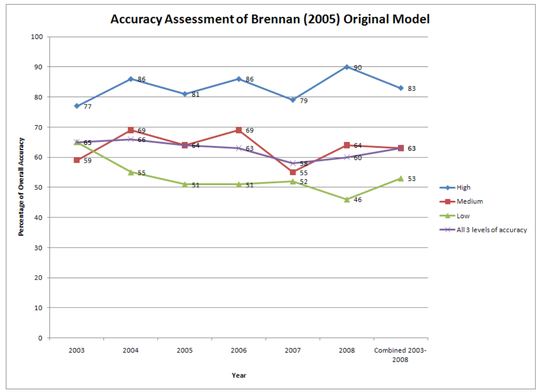


Figure 4: Secchi Disk

Results

- Creation of new model:
  p(loon presence) = 0.2320349 + 0.05770603(secchi) – 0.00003767921(distance to loon) + 0.00001862571(perimeter) – 0.00000000006771735(perimeter^2) + ε
- Accuracy Assessment:
  - Original (Brennan's) Model (see chart below)
    - Overall average accuracy for all three levels of occupancy for combined years 2003-2008: **63%**
      - **high level** of occupancy (years 2003-2008): 83%.
      - **medium level** of occupancy (years 2003-2008): 63%.
      - **low level** of occupancy (years 2003-2008): 53%.
  - New Model
    - Overall Average accuracy (years 2003-2008): **69%**



Discussion

- Parameters for new model:
  - Secchi disk: water clarity is very important to loons because they are visual predators
  - Perimeter of lake + Perimeter of lake^2: suitable shoreline for nesting is critical for reproduction
  - Distance to nearest lake with a loon: loons are territorial and will vocalize to claim territory
- Comparing original Brennan (2005) model to new model:
  - Slightly better, both are useable
  - Differences in accuracy from Brennan (2005) to new accuracy assessment comes from differences in monitoring schemes from 2003 - 2008

Conclusion/Future Plans

- Brennan's model still works with new data
  - Averaged overall accuracy from 2003 – 2008 stayed relatively the same
- Create multiple models
  - 3 largest lakes excluded
    - Winnipesaukee, Squam, Umbagog (>5000 acres)
  - Adding in nest sites suitability model
- Give models to Loon Preservation Committee for decision making
- Add in more lakes to apply model to
  - Through field work
  - Collection of data from various NH sources

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