Investigating the Influence of Pool and Landscape Features on the Spatial Patterns of Amphibian Breeding in a Vernal Pool Complex in Central New York

Mike Habberfield
Ph.D. Candidate
Dept. of Geography
Ecosystem Restoration IGERT
SUNY at Buffalo
www.erie.buffalo.edu

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Background

- Collaboration with SUNY–ESF: Heiberg Forest in Tully, NY

- Part of broader project on vernal pool ecology and design
Heiberg Forest Site

- 1500+ ha of heterogeneous forest

- 39 pools over ~200 ha
  - 9.2 ha hexagonal plots with varying pool density
Motivation

- Global decline of amphibians
- Ecological value of isolated wetlands and the conservation and restoration of vernal pools
- Maturation of our understanding of the spatial dynamics of amphibian populations
Marsh and Trenham (2001):

1) population dynamics regulated by ponds
2) local extinction and recolonization are frequent
3) local extinctions from stochastic processes
4) pond isolation affects occupancy
Patchy population:
- Local ponds are habitat patches, but no demographic independence
Recent Research


- Populations fluctuate between metapopulation and patchy population structure due to landscape dynamics (e.g. source ponds impacted by drought): Werner et al. 2009

- Pool-specific fidelity may not be high: Petranka and Holbrook 2006, Patrick et al. 2008
What dictates the likelihood and spatial scale of inter-pond switching?
Research Question:

- How do pool- and landscape-level characteristics influence the individual movement histories and spatial breeding patterns of vernal pool obligate species?

  - Wood frogs  
    \((Rana sylvatica)\)

  - Spotted salamanders  
    \((Ambystoma maculatum)\)
1. Local pond quality will determine switching patterns

2. The level of landscape heterogeneity between ponds will determine switching patterns

3. Local pond density on the landscape will determine the switching patterns
Covariates

- **Pool-level**: hydroperiod, canopy cover, presence of predators
- **Landscape-level**: forest types, edge habitat, pool density
Methods:

Sample methods:

- Minnow traps
- Cover boards
- Box sampling
- Some level of drift fence/pitfall trapping
Methods:

- Mark–recapture study design
  - Visual Implant Elastomer (VIE) marks
Methods:

- Mark–recapture study design
  - Capture history: 3 breeding seasons
    101
    110
    011
    001
    100
Methods:

- Mark–recapture study design
  - Classic Cormack–Jolly–Seber (CJS) open–population model:

\[
\begin{align*}
\Pr(101) &= (1 - p_2)\varphi_2 p_3 \\
\Pr(110) &= \varphi_1 p_2 [\varphi_2 (1 - p_3) + (1 - \varphi_2)] \\
\Pr(100) &= (1 - \varphi_1) + [\varphi_1 (1 - p_2)\varphi_2 (1 - p_3)] \\
&\quad + [\varphi_1 (1 - p_2)(1 - \varphi_2)]
\end{align*}
\]
Location is the state variable

Arnason–Schwarz model

CJS:  \( \Pr(101) = (1 - p_2)\varphi_2 p_3 \)

A–S:  \( \Pr(A0A) = S_1^A \left[ \psi_1^{AA} (1 - p_2^A) S_2^A \psi_2^{AA} + \psi_1^{AU} (1 - p_2^U) S_2^U \psi_2^{UA} \right] p_3^A \)
Pollock’s (1982) Robust Design
Analyses

- Program MARK
- M–SURGE

Parameters estimated using **Maximum Likelihood Estimation** methods

\[ L(w|y) = f(y|w) \]
Detect a difference in transition probabilities, e.g.:

\[ \psi^{1,2} = 0.5 \text{ and } \psi^{1,1} = 0.5 \]

VS.

\[ \psi^{1,2} = 0.2 \text{ and } \psi^{1,1} = 0.8 \]
## Power Analysis

<table>
<thead>
<tr>
<th>N</th>
<th>mean ΔAICc</th>
<th>Likelihood Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>1.78</td>
<td>0.410</td>
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<tr>
<td>100</td>
<td>2.76</td>
<td>0.252</td>
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<tr>
<td>250</td>
<td>5.10</td>
<td>0.078</td>
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<tr>
<td>500</td>
<td>11.53</td>
<td>0.003</td>
</tr>
</tbody>
</table>
Unobservable states should be made observable as much as possible

Gather evidence on intra-season switching

Harmonic radar transponder

Fluorescent dye tracking
Expected Results

- Estimates of transition rates between states (locations)
- Frequency distribution of distances between ponds used in successive years
- Identification of covariates that impact these parameters
- Support for metapopulation or patchy population and detailed inference on what dictates the structure for this population
Relevance

- Vernal pool restoration design criteria
  - Spatial arrangement
  - Environmental conditions that facilitate movement between ponds

- Contribution to knowledge on the importance of local vs. landscape focus in amphibian conservation
Thank You

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American toads?