Jollyville Plateau Salamander
(*Eurycea tonkawai*)

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Environmental Scientist
Overview

• Background information
• Threats to the species
• Species Status
• Population trends and insights from CMR
Neoteny

neotenic, paedomorphic, perrenibranchiate etc…

“Larval reproduction”

obligate aquatic
aquatic juvenile → eggs → terrestrial adult
aquatic juvenile → eggs → aquatic adult
Prey
Predators

- crayfish
- sunfishes
- giant water bugs (*Lethocerus*)
- damselfly larvae (*Archilesties*)
- cannibalism
Reproduction

- not much known
- “tail-straddle walk” (Plethodontids)
- Male deposits spermatophore which female picks up
- probably lay eggs in subsurface (or biologists are terrible at finding them)
- eggs laid singly (not in clutches)
Reproduction, Life History

- eggs hatch ~ 4 weeks
- sexually mature 1-2 years?
- no metamorphosis (neotenic)
Size class distribution by month

Count

1 2 3 4 5 6 7 8 9 10 11 12

Saddles  ski  mtd/mti  s/mike
Balcones Canyonland Preserve, Franklin Tract
Spicewood Spring
Ribelin Preserve- during drought
Dry stream surface

Fine, compacted sediment

Course gravel with larger interstitial spaces

Water table

8-12”
Testudo Tube (Cedar Park)

Photos: Mark Sanders
Evolutionary Relationships of central Texas spring and cave salamanders

E. tonkawae  
E. naufragia  
E. chisholmensis  
E. rathbuni  
E. robusta  
E. waterlooensis  
E. troglodytes complex  
E. sp. Pedernales  
E. nana  
E. sosorum  
E. neotenes  
E. tridentifera  
E. latitans  
E. pterophila

gray= Austin species

Chippindale et al. 2000; Hillis et al. 2001; Bendik 2006
Some newly discovered sites since 2007
Threats

Summary from USFWS 12-Month Finding (December 2007)

**Water Quality Degradation – Primary Threat**
- Urban Development: Impervious Cover
  - Sediments – transport pollutants, direct habitat alteration
  - Fertilizers – nutrient enrichment (low oxygen), pollutants
  - Pesticides - pollutants
  - Petroleum products - pollutants
  - Sewage spills – nutrient enrichment (low oxygen)

**Direct Habitat Alteration – Minor Threat**
- Human Activities
  - Disturbed vegetation
  - Vandalism
- Feral Hogs
  - Wallowing in spring heads
  - Sedimentation
  - Destroying interstitial spaces in stream bed

**Water Quantity Reduction – degree of threat unknown**
Water Quantity

- Climate Change
- Urban Development
  - Existing
  - Future
- Effect of Drought
  - Many rural sites dry
  - All monitored urban sites continued to flow
- WTP4
City of Austin Population Monitoring

• 1996-1998: Monthly surveys and extensive water quality data collection

• 1999-2006: Variable number of surveys

• 2007: Monthly mark-recapture surveys at three sites

• Present: Biannual mark-recapture and quarterly surveys
Species Status
Impervious Cover and Water Quality
Water quality – may have direct and indirect effects; lethal and non-lethal effects
Population Trends
Population Trends: Methods

- General additive model (GAM) smoothing for each monitored population (mgcv in R)

- Poisson regression on all counts (Bayesian analysis in OpenBUGS):
  - Trend summary by level of impervious cover (low impc sites vs. high impc sites)
  - Impervious cover covariate model: do we tend to see more or less salamanders, independent of population trend?
Impervious Cover < 5%
Poisson regression model

\[
\begin{align*}
\log(\lambda_k) &= \alpha_{\text{site}_k} + \beta_{\text{cover}_k} \cdot (\text{month}_k - \text{fixedmonth}) + \epsilon_k \\
\epsilon_k &\sim \text{dnorm}(0.0, \tau_e) \\
\text{count}_k &\sim \text{dpois}(\lambda_k)
\end{align*}
\]

\[
\left\{ \begin{array}{c}
1 \leq k \leq n\text{counts}
\end{array} \right\}
\]

• Poisson counts, with overdispersion parameter.

• Alpha (intercept) as random effect, varies by site.

• Estimate separate beta (slope), varies by impervious cover category.

• Non-informative priors used.

Trend- geometric mean rate of change

\[
B = \left( \frac{\text{expected}[t]}{\text{expected}[1]} \right)^{1/(t-1)}
\]
Average Population Trend Over Time

<table>
<thead>
<tr>
<th>Imp C</th>
<th>Mean</th>
<th>Lower CI</th>
<th>Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5%</td>
<td>0.54%</td>
<td>0.09</td>
<td>0.99</td>
</tr>
<tr>
<td>&gt; 15%</td>
<td>-0.87%</td>
<td>-1.18</td>
<td>-0.55</td>
</tr>
</tbody>
</table>

n=6
Another Model

- Add impervious cover % as covariate on intercept
- Used average IC % for year-site.
- $\beta_i > 0$, IC positive effect on baseline population size
- $\beta_i < 0$, IC negative
- $\beta_i = 0$, covariate does not affect baseline

\[
\mu(\alpha_j) = \mu_\alpha + \beta^i (i_j - i^*)
\]

RESULTS

<table>
<thead>
<tr>
<th>beta.i</th>
<th>val2.5pc</th>
<th>median</th>
<th>val97.5pc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-18.65</td>
<td>-11.09</td>
<td>-3.521</td>
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</table>
Capture-Mark-Recapture Studies
Capture-Mark-Recapture Studies

• Track individuals over time

• Estimate population parameters

• Using count data as index to population size
  – Assume direct linear relationship between index and population size (i.e. expected value of the count is directly proportional to population size)
  – Assume detection probability is constant over time and space (Bailey et al. 2004)
\[
\begin{align*}
\log(\lambda_k) &= \alpha_{\text{site}_{k}} + \beta_{\text{cover}_{k}} \cdot (\text{month}_k - \text{fixedmonth}) + \epsilon_k \\
\epsilon_k &\sim \text{dnorm}(0.0, \tau_{\epsilon}) \\
\text{count}_k &\sim \text{dpois}(\lambda_k) \\
\tau_{\epsilon} &\sim \text{dgamma}(0.001, 0.001) \\
\sigma_{\epsilon} &= 1/\tau_{\epsilon}^{0.5} \\
\alpha_i &\sim \text{dnorm}(\mu_{\text{site}_i}, \tau_{\text{site}_i}) \quad \{1 \leq i \leq \text{nositess}\} \\
\mu_{\text{site}} &\sim \text{dnorm}(0, 1.0\text{E}-6) \\
\tau_{\text{site}} &\sim \text{dgamma}(0.001, 0.001) \\
\sigma_{\text{site}} &= 1/\tau_{\text{site}}^{0.5} \\
\beta_j &\sim \text{dnorm}(0, 1.0\text{E}-6) \quad \{1 \leq j \leq \text{ncovertypes}\} \\
\log\lambda_{\text{site}_k} &= \alpha_{\text{site}_k} + \beta_{\text{cover}_{k}} \cdot (\text{month}_k - \text{fixedmonth}) \\
\text{fit}_{k} &= e^{\log\lambda_{\text{site}_k} + 0.5 \cdot \sigma_{\epsilon} \cdot \epsilon_k} \\
\mu_{\alpha_1} &= \text{mean}(\alpha_{\text{cover}_{1}}) \\
\mu_{\alpha_2} &= \text{mean}(\alpha_{\text{cover}_{2}}) \\
\text{fitted}_{1,t} &= e^{\mu_{\alpha_1} + \beta_{\text{cover}_{1}} \cdot (t - \text{fixedmonth}) + 0.5 \cdot \sigma_{\epsilon} \cdot \epsilon + 0.5 \cdot \sigma_{\text{site}} \cdot \epsilon_{\text{site}_t}} \\
\text{fitted}_{2,t} &= e^{\mu_{\alpha_2} + \beta_{\text{cover}_{2}} \cdot (t - \text{fixedmonth}) + 0.5 \cdot \sigma_{\epsilon} \cdot \epsilon + 0.5 \cdot \sigma_{\text{site}} \cdot \epsilon_{\text{site}_t}} \\
B_1 &= 100 \cdot ((\text{fitted}_{1,\text{nmonths}}/\text{fitted}_{1,1})^{1/(\text{nmonths}-1)} - 1) \\
B_2 &= 100 \cdot ((\text{fitted}_{2,\text{nmonths}}/\text{fitted}_{2,1})^{1/(\text{nmonths}-1)} - 1)
\end{align*}
\]