Effects of Urban Hydrology on Amphibian Decline in King County

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Watershed and Ecological Assessment Team
Science and Technical Support Section
No Net Loss Of Wetlands

  - “no-net-overall-loss” and “long-term net-gain” in quality and quantity of nation’s wetland resources.
- King County’s Comprehensive Plan & Sensitive Areas Ordinance (Acreage & Function)
- Providing Amphibian Breeding Habitat is a Critical Wetland Function
Scientific Methods

Two Approaches

1) Survey Approach
2) Experimental Approach
Survey Approach
Wetland Locations

Map of studied wetlands within King County, Washington State
Egg Mass Surveys
At inflows, channels and outflow channels of creeks & streams to wetlands I measured current velocity along a gradient where eggs masses were missing and where egg masses first appeared.

Also measured velocities at egg masses and within wetland channels.
Measuring Water Depths & Depths Below the Surface at Egg Masses of Indicator Species
Identifying Plant Species, Plant Health & Measuring Stem Diameters
Collecting “Grab” Water Samples
Laboratory Water Quality Analysis
Results
No Relationship Between Amphibian Species Richness and Wetland Size
The Richness of Amphibians is Unrelated to the Number of Vegetation Classes
Amphibian Richness is Lower When Water Level Fluctuation is > 0.2 meters.
Fewer Amphibian Species in Wetlands Within Highly Urbanized Watersheds

N = 5.559 - 0.033 (% Urbanization)

r^2 = 0.394, p = 0.004
Watersheds With Greater than 10% Impervious Area Have Fewer Species
Developed an Oviposition Hypothesis for Northwestern Salamander as a Hierarchical Model
Amphibian Breeding and Spawning Habitat Model

Hydrology → Vegetation Structure → Water Quality

Unsuitable Habitat
Ambystoma Gracile Breeding and Spawning Habitat Model

Vegetation Structure

From Hydrology

Yes

≥0.2 cm
≤0.9 cm

To Water Quality

Unsuitable Habitat

No

<0.2 cm
>0.9 cm
Ambystoma Gracile Breeding and Spawning Habitat Model

Water Quality

- Suspended Sediment
- Conductivity
- Turbidity
- Petroleum Hydrocarbons
- Metals
- Pesticides
- Other

No
No
No
No
Yes
No
No
No
No

Unsuitable Habitat
Experimental Approach
Instillation of Surrogate Plants
Measuring Water Level Fluctuation with the Richter “3000”
Measuring Depth to Egg Masses
Results
## Aspect as a Determinant of Spawning in *Ambystoma gracile*: North - South Transition

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Total Number of Dowels</th>
<th>Number of Spawn</th>
<th>Percent of Total Spawn</th>
<th>Mean Spawn per 100 Dowels</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>120</td>
<td>45</td>
<td>98</td>
<td>37</td>
</tr>
<tr>
<td>South</td>
<td>84</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>204</td>
<td>46</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Results:
- 98% of Total Spawn along North Shore
- 2% of Total Spawn Along South Shore
- 37 Spawn per 100 Dowels Along West Shore
- 1 Spawn per 100 Dowels Along East Shore
Aspect as Determinant of Spawning in *Ambystoma gracile*:
East - West Transition

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Total Number of Dowels</th>
<th>Number of Spawn</th>
<th>Percent of Total Spawn</th>
<th>Mean Spawn per 100 Dowels</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>60</td>
<td>13</td>
<td>29</td>
<td>22</td>
</tr>
<tr>
<td>West</td>
<td>60</td>
<td>32</td>
<td>71</td>
<td>53</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>45</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

* Total Dowels Deletes Southern Exposure Replicates.

Results:
- 71% of Total Spawn along West Shore
- 29% of Total Spawn Along East Shore
- 53 Spawn per 100 Dowels Along West Shore
- 22 Spawn per 100 Dowels Along East Shore
## Water Depth as a Determinant of *Ambystoma gracile* Spawning

<table>
<thead>
<tr>
<th>Depth Category (cm)</th>
<th>Total Number of Dowels</th>
<th>Number of Spawn</th>
<th>Percent of Total Spawn</th>
<th>Mean Spawn per 100 Dowels at Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>30</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
<td>13</td>
<td>29</td>
<td>43</td>
</tr>
<tr>
<td>40</td>
<td>30</td>
<td>31</td>
<td>69</td>
<td>103</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>45</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

*Total Dowels = 3 Dowels/Replicate, 10 Replicates on North Shore Only. Deleted 1 clutch on LPS9 South Shore.*
## Dowel Diameter as a Determinant of *Ambystoma gracile* Spawning

<table>
<thead>
<tr>
<th>Dowel Diameter (mm)</th>
<th>Total Number of Dowels</th>
<th>Number of Spawn</th>
<th>Percent of Total Spawn</th>
<th>Mean Spawn per 100 Dowels at Diameter Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>40</td>
<td>30</td>
<td>67</td>
<td>75</td>
</tr>
<tr>
<td>6</td>
<td>40</td>
<td>11</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td>9</td>
<td>40</td>
<td>4</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>45</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
Logistic Regression Results

Estimated Probability of Finding Northwestern Salamander Spawn at Three Wetland Habitat Conditions

- **Stalk Size**
  - Large (9 cm)
  - Medium (6 cm)
  - Small (3 cm)

- **Probability of Use**
  - 91-100%
  - 71-90%
  - 1-71%
  - 0%

*These three habitat conditions correctly explain an overall 90% of spawning sites.
Desiccating Egg Masses as Storm Water Levels Drop
Frozen Egg Mass
Northwestern Wetland Breeding Amphibian Spawning Sites

Depth in Centimeters

Long-toed Salamander

Northwestern Salamander

Red-legged Frog
Northern Red Legged Frog Eggs at Northwest Quadrant Stranded at Identical Water Depths & Retreating Shoreline
Probable Hydrologic Mechanism for Amphibian Declines in Urbanizing Areas
Significance of Watershed Forests
Fig. 1. One year of simulated streamflow for a 13-km² drainage basin under differing land uses, simulated with the Hydrologic Simulation Program Fortran (HSPF). Parameters characterize existing (1985) land cover (6 percent effective impervious area [EIA]) and projected future land cover (29 percent EIA).
Simulated Increase in 5-Year Storms Associated with Urbanization

- Soosette Basin (13 km²)
- Upper Soos Basin (47 km²)
- Soos Creek Basin (170 km²)

1985 Land Use
Future Land Use

Booth, 1991
Cause-and-Effect Relationship between Watershed Urbanization and Decreasing Amphibian Richness in King County Wetlands

- Watershed urbanization
- % impervious surfaces in the watershed
- Water depth and fluctuation
- Optimum spawning sites
- Decreasing individual species
- Decreasing overall amphibian richness
Significance of Wetland Outlet Configuration
Significance of Watershed Area Relative to Wetland Area