Increased flood frequency and magnitude decreases density of a stream-breeding salamander in urbanized watersheds

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In a nutshell:

- Urbanization has been correlated with the loss of many stream-dwelling species, including salamanders, but mechanisms are not well studied
- We documented a decline in salamander larval density from hatch to metamorphosis in urban streams, relative to reference streams.
- Using data from streams representing a range of abiotic conditions we compared *a priori* models explaining low salamander density in urban streams.
- The model with the most support was characterized by increased impervious surface, which increased flood frequency/magnitude, which then lead to a lower salamander density (Fig. 2).
- We designed an experiment to test the hypothesis that salamander density decreases because larvae are washed from streams. Experiment supported the conclusions from field data described above.

Introduction:

- Urbanization has been correlated with a decline in the abundance or species richness of many organisms or assemblages..
- Effects of urbanization on biota cascade through a series of direct or indirect pathways.
- Identifying mechanisms resulting in species loss may improve ability to identify most problematic aspects of urbanization and facilitate stream restoration for species of concern.
- We studied the response of two-lined salamander larvae to urban development. This species inhabits low-order streams as larvae and resides in adjacent terrestrial habitat and stream margins as adults.

- **Project Goal:** Assess salamander density across several streams subject to land use disturbance. Use data on abiotic stream variables to help explain observed density patterns.
- **Follow up project:** Use an experiment to test the hypothesis generated from field observations.

Methods:

- Selected 12 streams. Categorized as in Fig. 1 from predominant watershed land use.
- Calculated salamander density during spring (pre-metamorphic larvae from the previous year's cohort) and summer (hatchling larvae) for the 2006 and 2007 cohorts.
- At each watershed several abiotic variables assessed (Table 1).
- Created 7 *a priori* models to explain observed density patterns in pre-metamorphic larvae (see Bonus Table).
- Path analysis was used to evaluate individual models and AIC was used to compare among models.

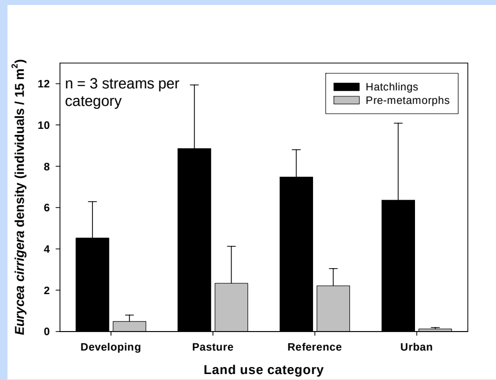

Fig. 1. Density of two-lined salamanders at beginning and end of larval stage across 4 land use categories. Densities were assessed from removal sampling conducted at each of 5 transects per stream.

Table 1. Categories of variables (bold) and predictor variables[1] used to construct path models.

LU/LC	**Hydrology**	**In-stream habitat**	**Physiochemical**
Agriculture	Median Q[2]	Instability	pH
Forest	Max Q	Habitat	Total dissolved solids
	Spate freq.[3]	Width:depth	Total suspended solids
		Bank height	BOM
		In-stream cover	

[1]Subset of all variables assessed. Variables were eliminated in a step-wise procedure based on univariate correlations with response variable (density), and degree of correlation with other predictor variables.

[2]Q = discharge

[3]Spate frequency measured as the number of events that were three times or more greater than the median flow as recorded from June 2003 to June 2004. Spate frequency was highly correlated with spate magnitude.

Results:

- Two-lined salamander density declined in all land use catego but declines were far more evident in urbanized (developing a urban) watersheds (Fig. 1).
- Comparison of candidate models by AIC indicated the pathwa Fig. 2 had the most support.

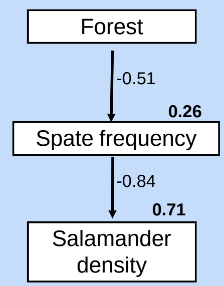

Fig. 2. Path diagram representing a mo describing how land cover change impa salamanders in urban streams. Spate frequency was the top model among th compared by AIC (see Bonus Table). Boldface numbers represent multiple correlation coefficients (analogous to r^2 describing the amount of variance explained by the preceding predictor variables. Numbers adjacent to arrows are standardized path coefficients and represent direct bivariate effects.

Follow up project:

- Manipulate water velocity on substrates common to urban an reference streams to determine larval response (Fig. 3).

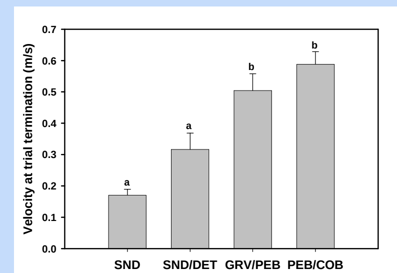

Fig. 3. Mean (± SE) water velocity at salamander washout on one of f different substrates within a constructed flume. Water velocity was slo increased until the salamander was flushed from the channel. Larvae were flushed at significantly lower velocities from sand-based substrat (SND, SND/DET) relative to larvae on rocky-based substrates (GRV/P PEB/COB). Letters represent results from pairwise comparisons.

Conclusions:

- Urban stream degradation and its consequences to biota are numerous. This study highlights the specific biotic conseque of an altered hydrology to salamander larvae.
- Sampling in multiple seasons revealed that adults are reprod in urban streams, but that apparent larval survivorship is low
- For some species extripated from urban streams, stream restoration efforts will require watershed-level efforts, rather in-stream habitat recovery.