Effect of Artificial Light at Night on Wood Frog Development in Natural, Restored, and Created Vernal Pools

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Grant Category: Macro-ecology: spatial distribution of animals and light

Background Information

Artificial light at night (ALAN) has been connected to unusual mating behavior, decreased metamorphic duration, and smaller size in various amphibian species (Longcore and Rich 2004, Dananay and Benard 2018, Underhill and Höbel 2018). However, the precise effects of ALAN are still largely unknown, especially to amphibians in vernal pools, which provide crucial habitat for 56% of amphibians in northeastern North America. I propose an experiment to quantify the impact of ALAN on wood frog growth and development by simulating both skyglow and vehicular artificial light at levels comparable to those at previously monitored vernal pool field sites (Fig. 1).

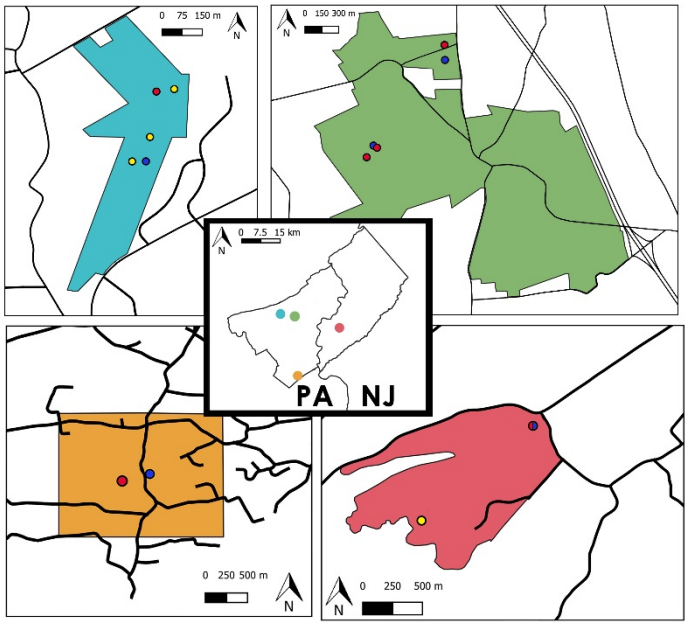

Figure 1. Several vernal pool restoration (yellow points) and creation attempts (red points) across four locations in PA and NJ have been paired with conservation of natural pools (blue points), providing a valuable research opportunity to compare amphibian habitat quality among pool types. The 15 vernal pools vary in their skyglow exposure and proximity to roads (45m to >1000m).

Prediction and Hypothesis

I established that skyglow at the vernal pools (Fig. 1) ranges from 0.02 – 0.043 lux, corresponding to a moderate amount of light pollution (i.e., a very dark sky would measure ~0.00001 lux). Three of the vernal pools are also within 45 m of paved roads and exposed to regular vehicular light pollution. Based on these preliminary observations and results of previous studies (e.g., Dananay and Benard 2018), I predict that skyglow and vehicular light pollution are additional environmental variables governing amphibian success at these pools. I hypothesize that, if I expose developing wood frogs to levels of ALAN comparable to those measured at our field sites, then metamorphic duration and size of wood frogs will decrease with increasing exposure to ALAN.

Methods

Experiments will include four manipulation types: no ALAN (control), simulated vehicular light pollution, simulated skyglow, and combined simulated vehicular light pollution and skyglow. Each treatment will consist of three replicates. To obtain individuals for this experiment, we will collect 2 egg masses from one of our natural pools which will enable us to begin with ~80 eggs in each of our twelve 38 L treatment tanks and a density of ~2 larvae L^{-1}, which is comparable to our most successful vernal pools and to previous studies. Percent survival, metamorphic duration, snout to vent length, and mass will be used as dependent variables. Skyglow and vehicular light pollution will be measured at each pool and used to inform experimental treatments. ALAN measurements at each of the study vernal pools will also be included as environmental variables in our multivariate analysis to investigate potential environmental predictors of amphibian success in vernal pools.

Anticipated Analyses and Findings

ANOVA and Tukey's test will be used to compare dependent variables among experimental treatments. Non-metric Multidimensional Scaling (NMDS) will continue to be used to investigate environmental predictors of amphibian success in vernal pools (Fig. 2), but our dataset will now include measures of ALAN. Because the pools included in our study represent a variety of habitat characteristics, including differing intensities of ALAN, our results will provide practitioners with additional information to guide future projects and inform adaptive management of vernal pools.

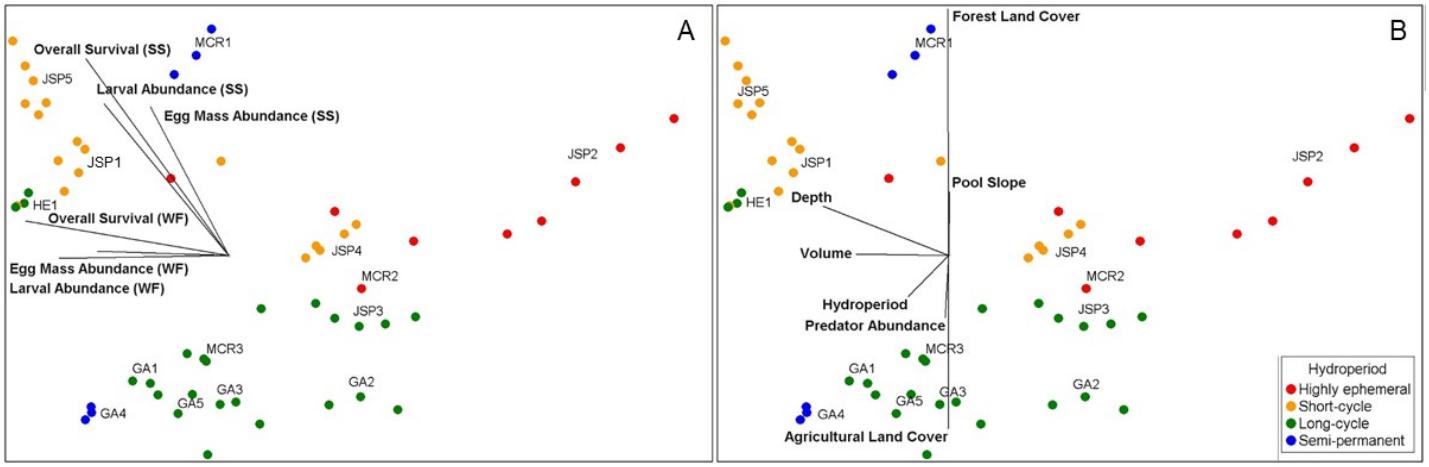

Figure 2. NMDS is used to establish differences in amphibian success by vernal pool hydroperiod category. Each point on the diagram represents biotic parameters from a given pool and year. Relative distance between points reflects similarity or differences in biotic parameters. Pools that are most successful as indicated by vectors representing biotic parameters in panel A (WF = wood frog; SS = spotted salamander) correlate positively with pool depth, volume, and forest land cover and negatively with predator abundance and agriculture in panel B.

Ethical Statement of Animal Research

Methods for wood frog egg collection, larval maintenance and care were approved by the Institutional Animal Care and Use Committee at Lafayette College in February 2019. Research collection permits have been obtained from Pennsylvania Department of Conservation and Natural Resources.

Literature Cited

Dananay, K. L., and M. F. Benard. 2018. Artificial light at night decreases metamorphic duration and juvenile growth in a widespread amphibian. *Proceedings of the Royal Society B: Biological Sciences* 285:2–7.

Longcore, T., and C. Rich. 2004. Ecological light pollution. *Frontiers in Ecology and the Environment* 2:191–198.

Underhill, V. A., and G. Höbel. 2018. Moonlighting? - Consequences of lunar cues on anuran reproductive activity. *Acta Oecologica* 87:20–28.