Resilience of a Pond-Breeding Amphibian Community Following the Mitigation of Introduced Fish

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Introduction:

- **Introduced species constitute a major anthropogenic impact in freshwater ecosystems, and the introduction of predaceous fish is implicated with many amphibian population declines[1].**
- **The adverse effects of fish on native amphibians include the direct effects of predation and indirect effects of fish presence on amphibian breeding distribution[2,3].**
- **Larval amphibians can also use behavioral shifts to respond to the presence of introduced fish[4], but this strategy might compromise various fitness traits.**
- **Although the effects of introduced fish on amphibian communities are well documented, few studies have investigated the response of amphibians to mitigation of introduced fish, and none have examined the community-level responses of amphibians to such mitigation.**

Questions:

1) Is there a change in species diversity within the amphibian community following removal of introduced fish?
2) Is there a shift in smallmouth salamander (*Ambystoma texanum*) larval dynamics following removal of introduced fish?

Methods:

- **This study was conducted at 4 ponds (A, B, C, D) in Warbler Woods Nature Preserve (WWNP; Figure 1).**
- **Black bullhead catfish (*Ameiurus melas*) and centrarchids (*Lepomis* sp.) were introduced into Ponds B and C prior to 1986, and were present when this study commenced in 2001.**
- **Drift-Fences / pitfall traps were constructed around all ponds to census amphibian abundance and species composition (IDNR permit #0946).**
- **Rotenone™, a piscicide used in fish management, was applied to Ponds B and C in the winters of 2001 and 2002 to eradicate all fish.**
- **Ponds were categorized as either mitigated ponds (B and C) or reference ponds (A and D) and the Shannon-Weiner Diversity Index (H') was calculated in both pond types for the two temporal periods (pre- and post-application).**
- **Temporal shifts in species diversity (H') within and between pond types were analyzed using paired t-tests[5].**
- **We quantified smallmouth salamander larval dynamics by measuring size at metamorphosis (snout-vent length; SVL) and duration of the larval period (Julian date of metamorphosis).**
- **Temporal shifts in larval dynamics within and between pond types were analyzed using a 2 x 2 MANOVA.**

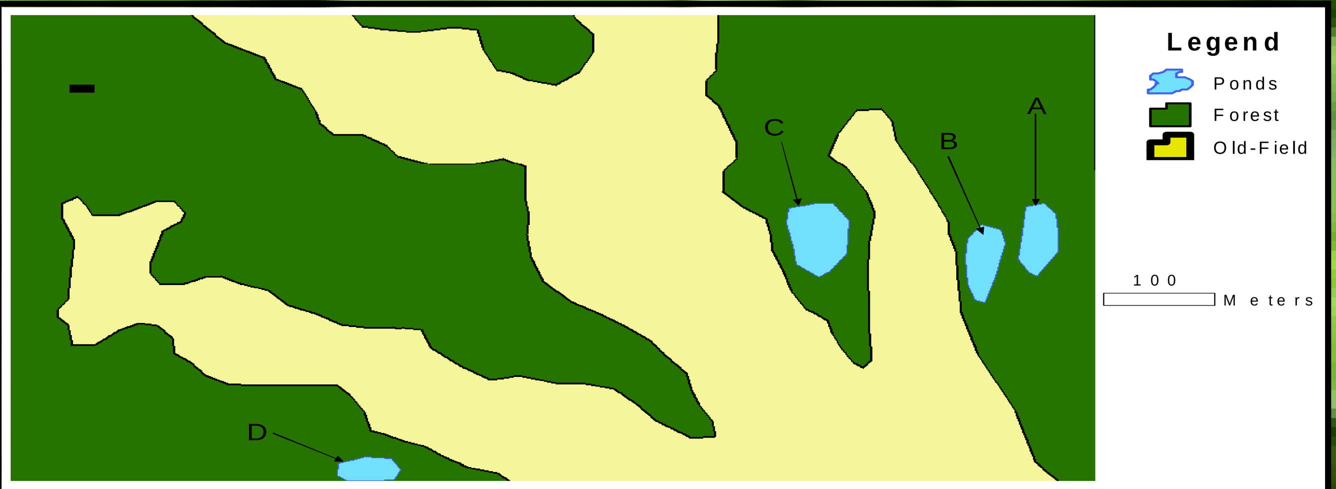

Figure 1. Warbler Woods Nature Preserve (WWNP), Coles County, Illinois, with the location of the 4 experimental ponds and surrounding landscape composition. Fish were introduced into Ponds B & C (mitigated ponds), whereas Ponds A & D (reference ponds) never contained fish.

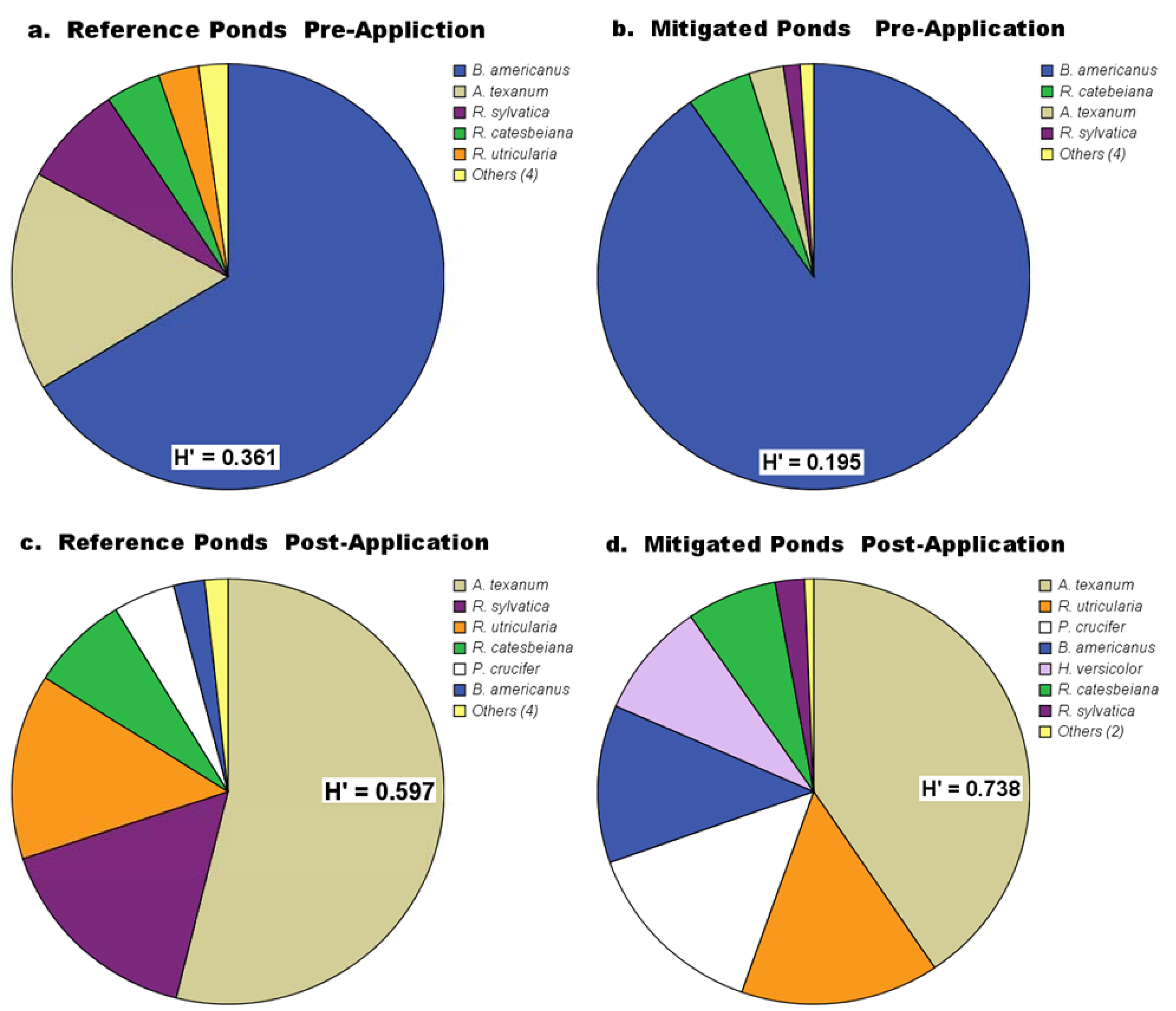

Figure 2. Relative amphibian species abundance and Shannon-Weiner Diversity Index (H') between pond types (mitigated or reference) and temporal periods (pre-application or post-application) at WWNP.

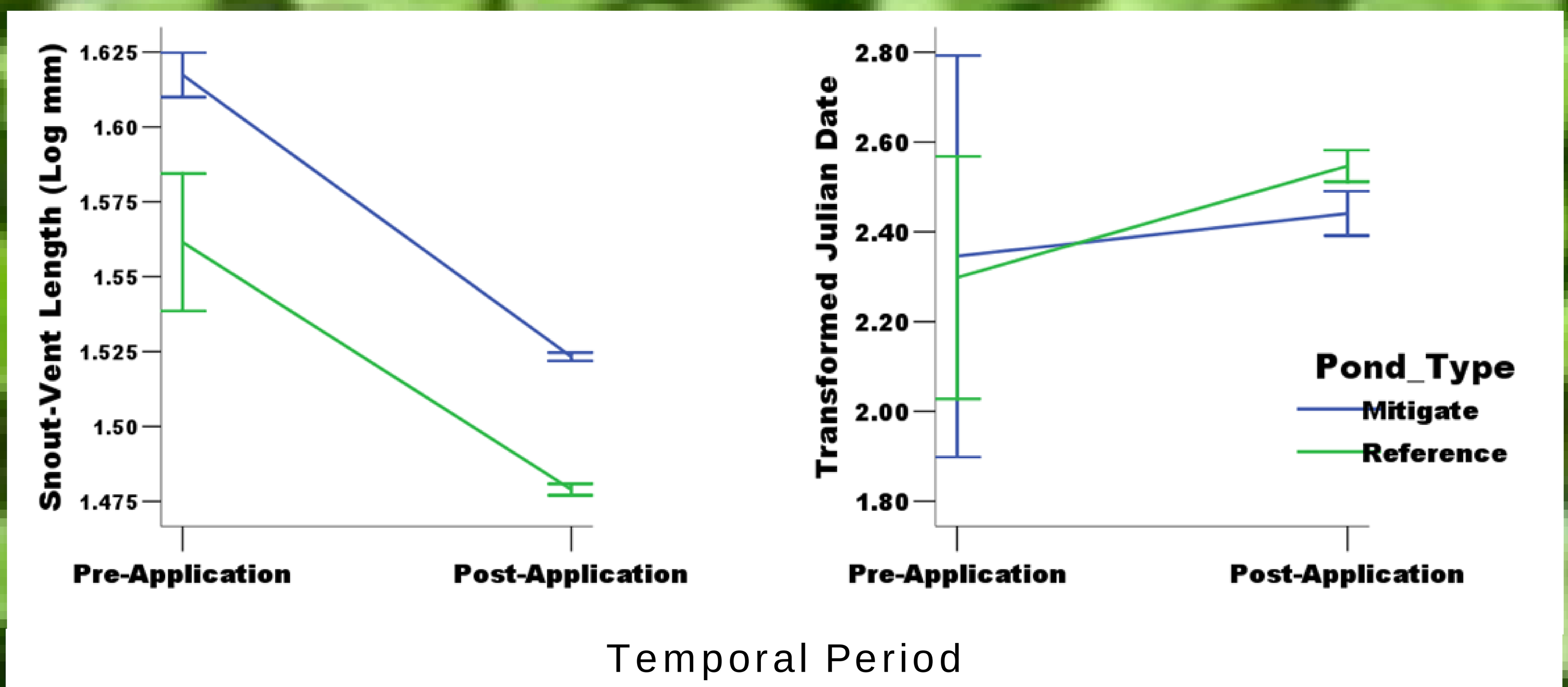

Figure 3. Changes in smallmouth salamander larval growth (size at metamorphosis; SVL) and duration of the larval period (Julian day of metamorphosis) between temporal periods (pre-application or post-application) and pond types (mitigated or reference). All data are presented as means ± 1 SE.

Is there a change in species diversity following Rotenone™ application?

- **Prior to Rotenone™ application, amphibian species diversity was greater in reference ponds than in mitigated ponds ($P < 0.001$; Figure 2a,b).**
- **Following mitigation, species diversity improved in both pond types compared to their pre-mitigation conditions (both pond types, $P < 0.001$; Figure 2).**
- **After mitigation, species diversity was greater in mitigated ponds than in reference ponds ($P < 0.001$; Figure 2c,d).**

Is there a change in smallmouth salamander (*Ambystoma texanum*) larval dynamics following Rotenone™ application?

- **There were significant effects of temporal period ($P < 0.0001$), pond type ($P < 0.0001$), and their interaction ($P = 0.018$) on smallmouth salamander larval growth and duration of the larval period.**
- **Within both pond types, larval growth (size at metamorphosis) decreased following mitigation ($P < 0.0001$; Figure 3).**
- **Duration of the larval period was shorter in mitigated ponds than in reference ponds ($P < 0.0001$), and there is a significant interaction between temporal period and pond type on larval period ($P = 0.011$; Figure 3).**

Discussion:

Community response to fish removal

- **Although species diversity improved within mitigated and reference ponds, mitigated ponds experienced greater improvement compared to reference ponds.**
- **The increase in species diversity within mitigated ponds suggests that pond-breeding amphibian communities are capable of recovery following the removal of introduced fish.**
- **Our results are the first to describe the resilience of a pond-breeding amphibian community following removal of introduced fish.**

Effects of fish on salamander larval dynamics

- **Within mitigated ponds, fewer juvenile smallmouth salamanders were observed prior to fish removal–only 29 were collected while fish were present, whereas 891 were trapped following fish removal.**
- **Fish presence had no effect on smallmouth salamander larval growth – during both temporal periods (pre- and post-mitigation), juveniles emerged at larger sizes from mitigated ponds than from reference ponds.**
- **The interaction between temporal period and pond type indicates that mitigation had an effect on the duration of the larval period, lengthening the duration of the larval period in mitigated ponds by an average of 19.7 days (12.1%).**
- **Other abiotic and biotic factors might have confounded our interpretation of these results, but we found no differences in daily precipitation and temperature (MANCOVA, $P = 0.793$) or adult breeding phenology (ANOVA, $P = 0.232$).**
- **Differences in salamander larval dynamics cannot be explained by climate or adult breeding phenology – shifts in larval dynamics are best attributed to the removal of fish.**

References

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