Predictive Models for the Occurrence of Green Frogs (*Lithobates clamitans*) and Wood Frogs (*Lithobates sylvaticus*) Using In-Pond Characteristics and Geographic Wetland Isolation

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INTRODUCTION

We compared the relative importance of in-pond characteristics vs geographic wetland isolation when predicting the occurrence of pond-breeding amphibians in the Stone Valley Forest (Centre County, PA). Larger ponds with long hydroperiods can accommodate the larval periods of more species, but they can harbor predators such as fish (Heyer et al. 1975, Hayes and Jennings 1986). Surrounding landscapes of wetlands can have a strong effect on amphibian species that conduct seasonal migrations and display metapopulation dynamics (Regosin et al. 2003, Semlitsch and Bodie 2003), with occurrence and recolonization rates being heavily influenced by wetland isolation (Sjögren 1994). In 2013, we surveyed amphibian communities at 44 ponds throughout the 7,000 acres of the Stone Valley Forest. We expected the occurrence of wood frogs (*Lithobates sylvaticus*) would be better predicted by measures of isolation than green frogs (*Lithobates clamitans*) which are less likely to establish metapopulations.

STUDY OBJECTIVES:

- ❑ Determine if green frog and/or wood frog occurrence is influenced by wetland size, isolation, or fish presence.
- ❑ Determine if wood frog occurrence was influenced by the proximity of green frog breeding habitats.
- ❑ Compare in-pond vs. wetland isolation variables for predicting occurrence.

METHODS

- ❑ 44 breeding ponds were identified. At each pond:
  - ▪ Conducted ≥ 2 amphibian surveys from March to July
  - ▪ Species presence was determined by the detection of egg or larval stages
  - ▪ Pond perimeters were mapped with GPS
- ❑ A GIS was built to quantify:
  - ▪ In-Pond Variables such as:
    - ➢ Individual pond area (**Size**), fish presence (**Fish**), and green frog present (**Gfrog**)
  - ▪ Wetland Isolation Variables:
    - ➢ Within 400 meters of each pond we calculated:
      - ▪ Number of amphibian breeding ponds (#**Ponds**)
      - ▪ Number of ponds with green frogs (#**GFpond**),
      - ▪ Total breeding pond area (**PondArea**)
    - ➢ Distance to nearest pond (**Nearpond**)
    - ➢ Distance to nearest green frog pond (**NearGfrog**)

STATISTICAL MODELING

- ❑ 29 sites were used to create logistic regression models for wood frog and green frog occurrence
- ❑ Five pre-selected models were created for each species
  - ▪ Models used **"In-Pond**" predictors, **"Landscape"** predictors, or both **"In-Pond and Landscape"** predictors **(Table 1 and 2)**
  - ▪ Akaike Information Criteria (AIC) was used determine the most parsimonious model
- ❑ We used logistic regression models to:
  - ▪ Assess significant predictors of species occurrence
  - ▪ Estimate each species probability of occurrence at each breeding pond
  - ▪ Predicted presence /absence of species at each pond
  - ▪ Compared predicted to observed presence to calculate correct classification rates for:
    - ➢ 11 validation ponds
    - ➢ All 44 ponds in study

Table 1. Green frog logistic regression models

Statistical Model	Predictors	Model P-Value	Predictor P < 0.05	AIC	Correct Classification	
					Validation Ponds (n=11)	All Ponds (n=44)
In-Pond (1)	**Size + Fish**	**0.001**	**Size(+)**	**26.55**	**90.9%**	**90.9%**
Landscape (2)	#Ponds + Nearpond	0.435	-	30.56	100%	81.8%
Alternate Landscape (3)	PondArea + Nearpond	0.52	-	36.47	100%	81.8%
In-Pond and Landscape (4)	Size + Fish + #Ponds + Nearpond	0.006	Size(+)	30.09	90.9%	90.9%
In-Pond and Alternate Landscape (5)	Size + Fish + PondArea + Nearpond	0.007	Size(+)	30.32	90.9%	90.9%

Table 2. Wood frog logistic regression models

Statistical Model	Predictors	Model P-Value	Predictor P < 0.05	AIC	Correct Classification	
					Validation Ponds (n=11)	All Ponds (n=44)
In-Pond (1)	Size + Fish + Gfrog	0.133	-	45.88	55%	68%
Landscape (2)	#Ponds + Nearpond + NearGfrog	0.858	-	50.71	64%	59%
Alternate Landscape (3)	PondArea + Nearpond + NearGfrog	0.431	-	48.71	82%	66%
In-Pond and Landscape (4)	Size + Fish + Gfrog + #Ponds + Nearpond + NearGfrog	0.172	-	48.44	73%	73%
In-Pond and Alternate Landscape (5)	**Size + Fish + Gfrog + PondArea + Nearpond + NearGfrog**	**0.164**	**-**	**48.29**	**73%**	**75%**

RESULTS

- ❑ **Green Frogs: More likely to be found in large ponds**
  - ▪ **Model 1(Size+ Fish)** was the best predictive model
    - ➢ Model P-value of 0.001
    - ➢ Pond size was the only significant predictor
      - ▪ 18 times more likely to occur in ponds with each tenfold increase in pond size **(Figure 1)**
    - ➢ 90.9% correct classification rates for validation ponds and all ponds
    - ➢ Most parsimonious model in predicting occurrence
  - ▪ **Observed Results**
    - ➢ Occur in 33% of ponds that contain fish **(Table3)**
    - ➢ Only occur in 14% of fishless ponds
- ❑ **Wood Frogs: More likely to be in fishless ponds and ponds without green frogs**
  - ▪ **Model 5 (Size+ Fish+Gfrog+PondArea+Nearpond +NearGfrog)** was the best predictive model
    - ➢ 73% correct classification rates for validation ponds and 75% for all ponds
    - ➢ Not most parsimonious model
  - ▪ **Observed Results**
    - ➢ Occur in 50% of fishless ponds, but only 33% of ponds with fish
    - ➢ Occur in 47% of ponds without green frogs, but only 25% of ponds that contain green frogs
    - ➢ Ponds with wood frogs were closer to green frog ponds (679 ± 160m) than ponds where wood frogs are absent (1055 ± 213)

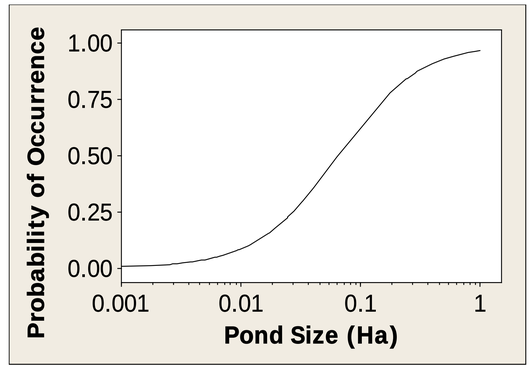

Figure 1. Influence of pond size on the occurrence of green frogs..

Table 3. Observed occurrence patterns for green frogs and wood frogs.

	Fish Present	Fish Absent
Green frog present	33.3%	14.3%
Wood frog present	22.2%	48.6%
	Green frog Present	**Green frog Absent**
Wood frog present	25%	47.2%

CONCLUSIONS

- ❑ Models with only in-pond variables performed best at predicting green frog occurrence, with pond size having a positive influence on green frog occurrence.
  - ▪ Larger ponds typically have longer hydroperiods, and were ideal for their larvae which overwinter in ponds.
- ❑ Models that combined wetland isolation and in-pond variables performed best in predicting wood frog occurrence
- ❑ Although not statistically significant, wetlands that contained wood frogs were relatively small, fishless, and lacked green frogs, yet they were relatively close to wetlands containing green frogs.
- ❑ Future studies will examine the relationship between disease occurrence in wood frogs populations and their proximity to infected green frog populations.

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