# Wetlands and Microhabitat Used by Nesting Four-toed Salamanders in Maine

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# RESEARCH GOALS

Develop Survey Method and Habitat Models for Rarely-Detected Species:

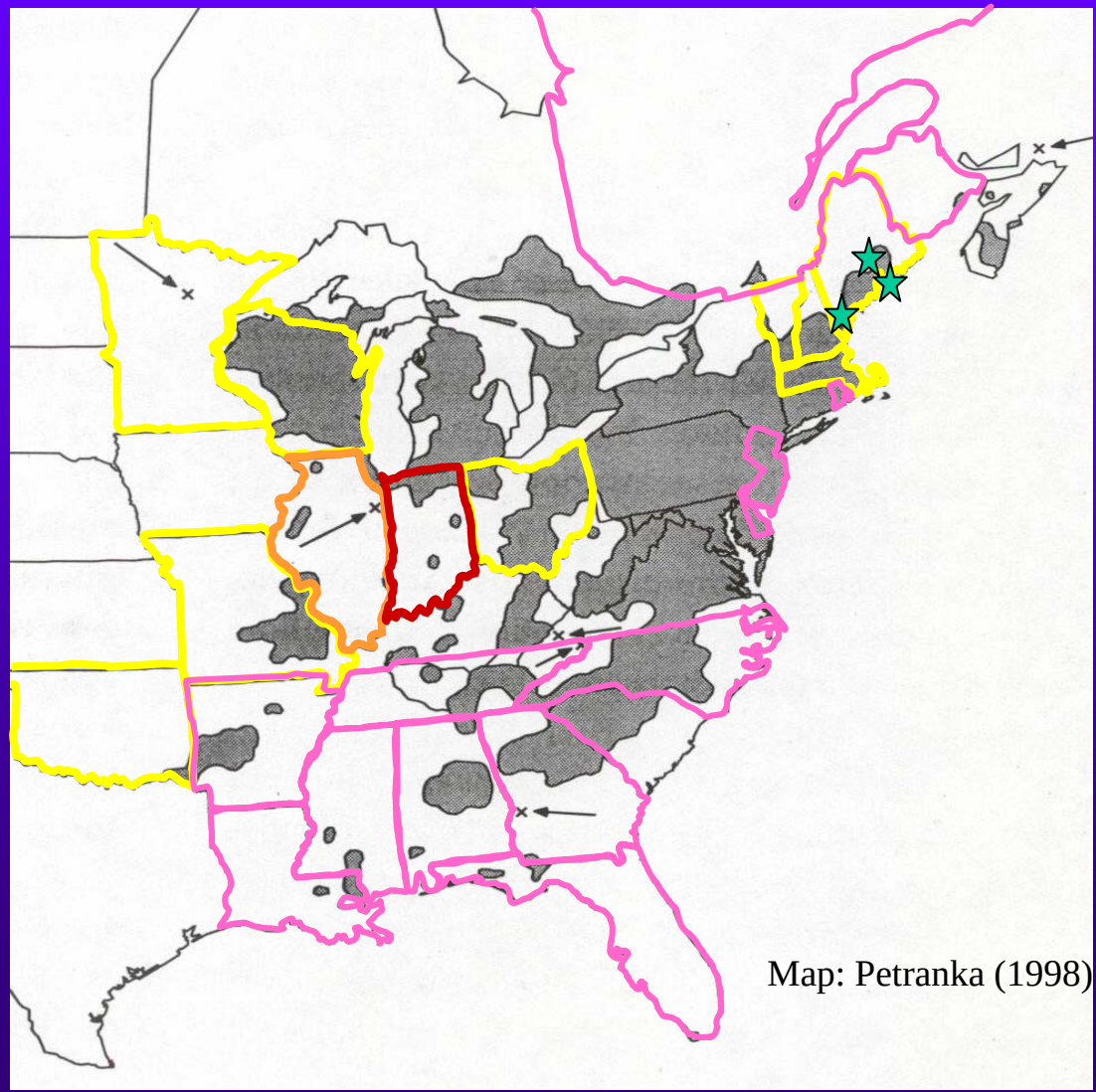
A) Predict wetlands used by four toed salamanders for breeding

B) Predict shoreline microhabitat used by four toed salamanders for nesting

# APPLICATIONS

- Assess health of four-toed salamander populations
- Assess wetland function for providing habitat for four-toed salamander breeding
- Assist management and conservation of four-toed salamander populations

# Range and Conservation Status



Map: Petranka (1998)

# Life History

Adults

Live in forest under leaf litter, woody debris, and underground. Lungless (*Plethodontidae*). Carnivorous.

# Life History

Breeding Adults

Mate in fall.  Females move to wetlands, to lay eggs,  in spring.

# Life History

Embryos

Eggs laid in shoreline above water.  Female attends eggs (2 months).

# Life History

Larvae

Aquatic.  Metamorphose to terrestrial juvenile after 1 month.

# Life History Stages

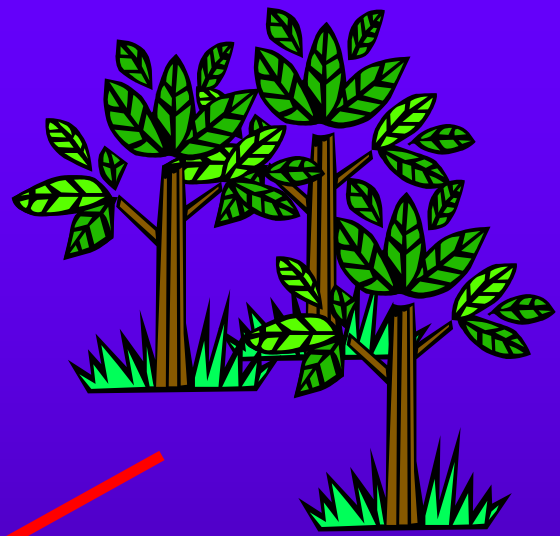
Terrestrial Adult

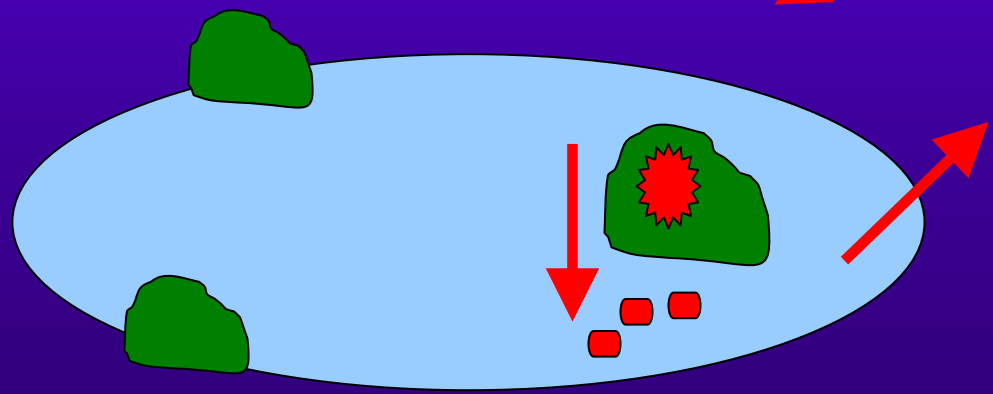
Migrating Female

Nest: Attendant female and eggs

Aquatic larvae

Metamorphose to terrestrial juvenile





# Survey Method

One wetland searched per day

Search entire shore vegetation <30cm water

*N* = 67 wetlands, *N* = 238 nests, *N* = 552 shoreline points

# Three Models Developed

| | |
|---|---|
| Wetlands | Landscape and wetland variables<br>*N* = 35 occupied wetlands<br>*N* = 32 unoccupied wetlands |
| Wetlands | Shoreline microhabitat variables<br>*N* = 258 points in unoccupied wetlands<br>*N* = 294 points in occupied wetlands |
| Shoreline microhabitat | Shoreline microhabitat variables<br>*N* = 294 points in occupied wetlands<br>*N* = 238 nests |

# Model Building Process

Exploratory Analysis  Reduce number of predictor variables based on results of analyses with 25% reserved data (2&3)

Model Building  *A priori* create candidate logistic regression models.  Compare models with Aikake Information Criterion (AIC) for small sample size ($AIC_c$) (1,2&3)

AIC provides strength of evidence comparison within the context of other models examined.  AIC is not a "test" and does not provide "significance".  A benefit of AIC is any new model can be compared to the model previously considered "best" (most parsimonious).  Another benefit is *a priori* false or trivial null hypotheses are avoided.

Model Evaluation  Cross-validation (jackknifing) (1) or testing with 25% reserved data (2&3)

# Wetland/Landscape Variables

| Variable | Data Range |
|---|---|
| pH | 4.0 to 6.7 |
| Specific conductance | 13.3 to 426.7 |
| NWI wetland class | FO1, FO4, FO5, SS, EM, AB, UB, ML[e] |
| Stream | presence, absence |
| Wetland density | 0-100% wetland area in 200m buffer |
| Upland forest | mixed, conifer, deciduous dominant in 200m buffer |

# Shoreline Microhabitat Variables

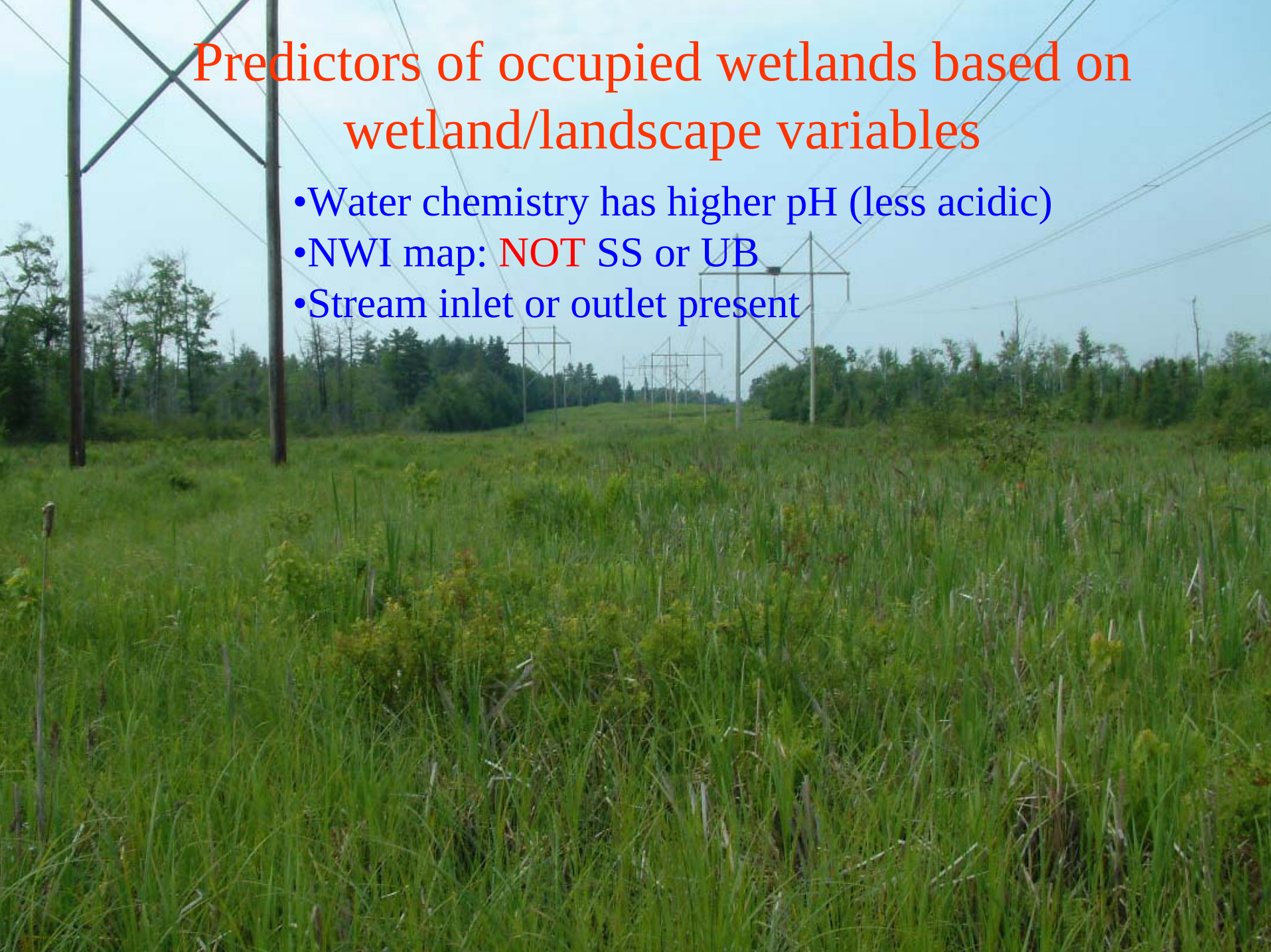
| Variable | Range or Category of Data |
|---|---|
| **Hydrology** | |
| Water depth under nest | 0-110 cm |
| Maximum depth in $4m^2$ | 0-250 cm |
| Slope of basin | 0-90° |
| Water flow | 0, present |
| **Structure** | |
| Substrate | wood, living vegetation, rock, soil |
| Slope from water to shore | 0-90° |
| Depth of nesting vegetation | 0-32 cm |
| Egg attachment | *Sphagnum*, other moss, non-moss |
| **Vegetation** | |
| Plant species in $1m^2$ | 0-10 from 115 total species |
| NWI class in $5m^2$ | FO1[a], FO4, FO5, SS, EM, AB, UB, ML |

# Example of Models Compared With AIC

| No. | Variables in Model | Log ($L$) | $AIC_c$ | $w$ |
|---|---|---|---|---|
| 15 | pH, SS, UB | -32.801 | 76.586 | 0.267 |
| 24 | pH, SS | -34.677 | 77.999 | 0.132 |
| 1 | pH | -35.855 | 78.091 | 0.126 |
| 19 | pH, UB | -34.976 | 78.597 | 0.098 |
| 20 | pH, stream | -35.094 | 78.833 | 0.087 |
| 16 | pH, SS, UB, stream | -32.887 | 79.174 | 0.073 |
| 25 | pH, FO1 | -35.532 | 79.709 | 0.056 |
| 18 | pH, UB, stream | -34.544 | 80.072 | 0.047 |
| 22 | pH, wetland density, stream | -34.553 | 80.090 | 0.046 |
| 26 | pH, mixed upland | -35.816 | 80.277 | 0.042 |
| 21 | pH, EM, stream | -35.092 | 81.168 | 0.027 |
| 13 | stream | -43.093 | 92.567 | 0.000 |
| 23 | SS, UB, stream | -41.304 | 93.592 | 0.000 |
| 6 | UB | -44.416 | 95.213 | 0.000 |
| 8 | AB | -45.047 | 96.475 | 0.000 |
| 2 | specific conductance | -45.168 | 96.717 | 0.000 |
| 11 | deciduous upland | -45.717 | 97.815 | 0.000 |
| 4 | SS | -45.830 | 98.041 | 0.000 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 17 | all variables | -30.063 | 99.538 | 0.000 |

# Predictors of occupied wetlands based on wetland/landscape variables

- Water chemistry has higher pH (less acidic)
- NWI map: NOT SS or UB
- Stream inlet or outlet present



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# Predictors of occupied wetlands based on microhabitat

Wood substrate, Flow, Blue joint reed grass
Sensitive fern, Steeplebush, Meadowsweet, *Sphagnum* spp.
NOT Sheep laurel, Deciduous canopy

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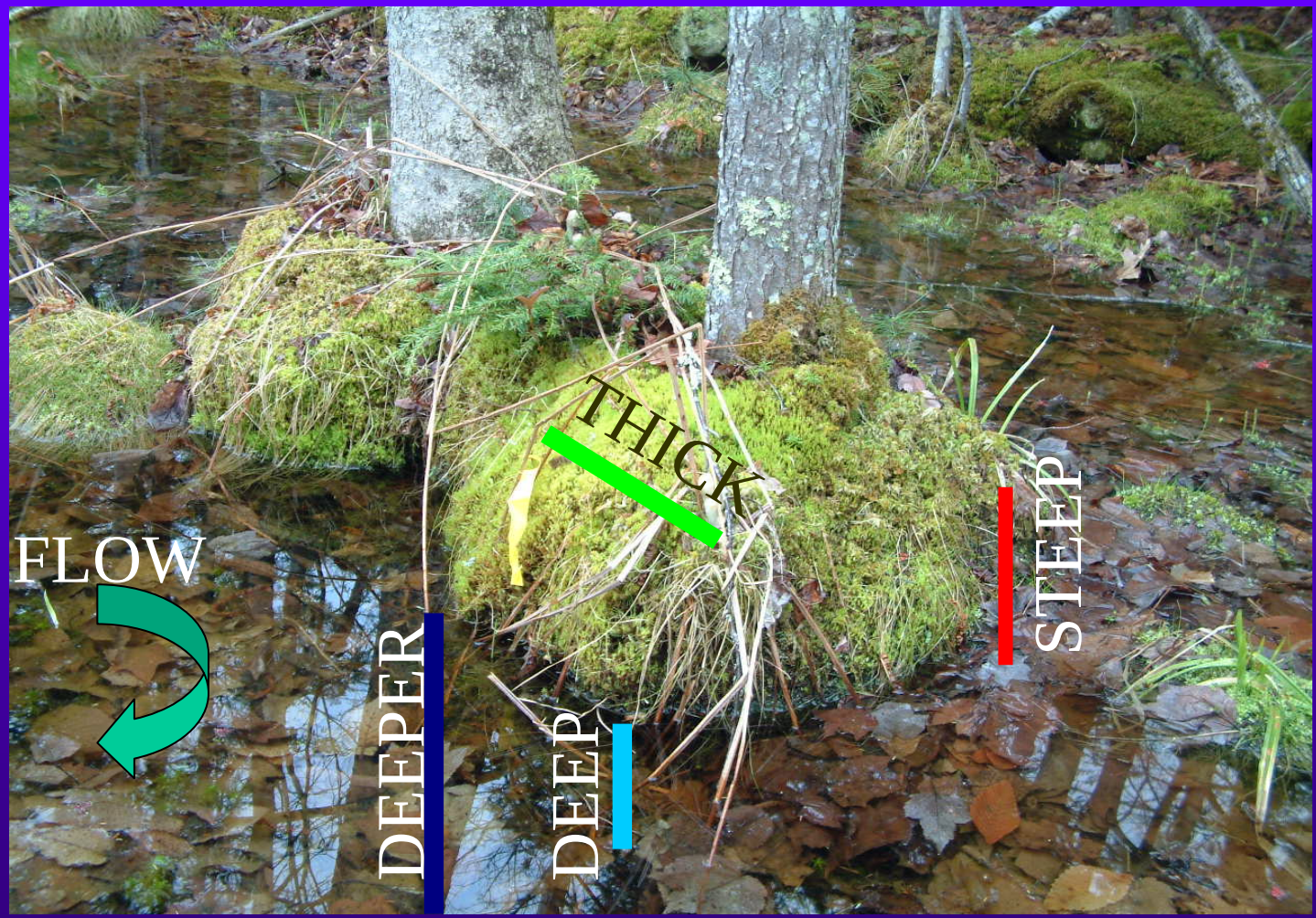


Present: Winterberry, moss spp.

No: Sheep laurel, Meadowsweet, coniferous cover

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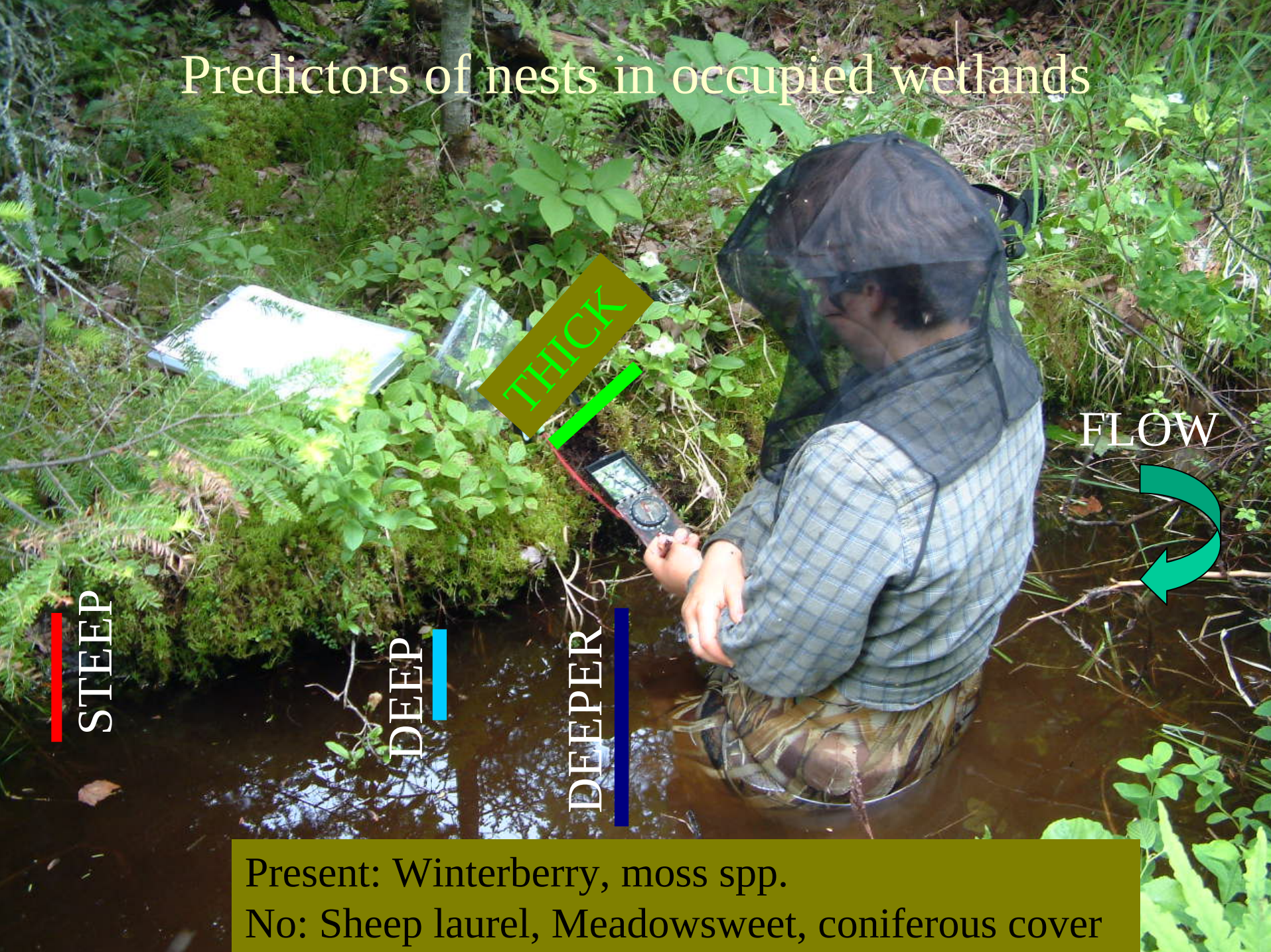


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**Committee:** Cynthia Loftin, Jerry Longcore, Bill Halteman, and Robin Jung
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# For More Information

Chalmers, R. J. and C. S. Loftin 2006. Wetland and microhabitat use by nesting four-toed Salamanders in Maine. *Journal of Herpetology* 40(4):479-486.

Chalmers, R. J. and C. S. Loftin 2006. Four-toed Salamander (*Hemidactylium scutatum*) Morphology/Phenology. *Herpetological Review* 37(1):69-71

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