Vernal Pool Amphibian Monitoring as part of the NE ARMI Program

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VERNAL POOLS ARE…

- Non-tidal ephemeral wetlands
- Supplied by precipitation or ground water
- Typically not mapped or protected
- Lacking in predatory fish populations
- Critical breeding habitat for fairy shrimp, wood frogs, marbled & spotted salamanders

What do Vernal Pools look like?

Upland Isolated

Floodplain &
Wetland Complexes

Roadside Ditch

4/2/2002

4/29/2002

Finding Vernal Pools

Aerial Photos or Color Infrared DOQQs

Ground-truthing

Wood frog (*Rana sylvatica*)

"…egg-mass counts may be an effective means to monitor wood frog populations, as it is a relatively accurate and precise survey technique." (Crouch & Paton 2000)

Spotted salamander (*Ambystoma maculatum*)

"Because the spotted salamander is so widespread and well studied, it would make an excellent focal species for use in long-term amphibian monitoring programs." (Petranka 1998)

Breed February-May

Eggs for 1-4 week window

1 egg mass per female

Eggs often laid in communal rafts

Attached to vegetation

Near water surface

Breed March-June

Eggs for 4-7 week window

2-4 egg masses per female

Eggs laid individually or in communal aggregates

Attached to vegetation

Typically deeper in water

Goals of Vernal Pool Study

To estimate wood frog & spotted salamander abundance using egg mass counts & presence using a proportion of area occupied (PAO) approach for the purpose of drawing inferences about variation over time (population trends) & space (relationships with landscape & environmental variables).

In This Talk…

- Spatial sampling and detectability issues
- Describe double-observer dependent egg mass estimation technique

PRELIMINARY ANALYSES

- Examine covariates that might influence detectability and abundance of wood frog & spotted salamander egg masses
- Examine covariates that might influence site occupancy and detectability of wood frogs and spotted salamanders

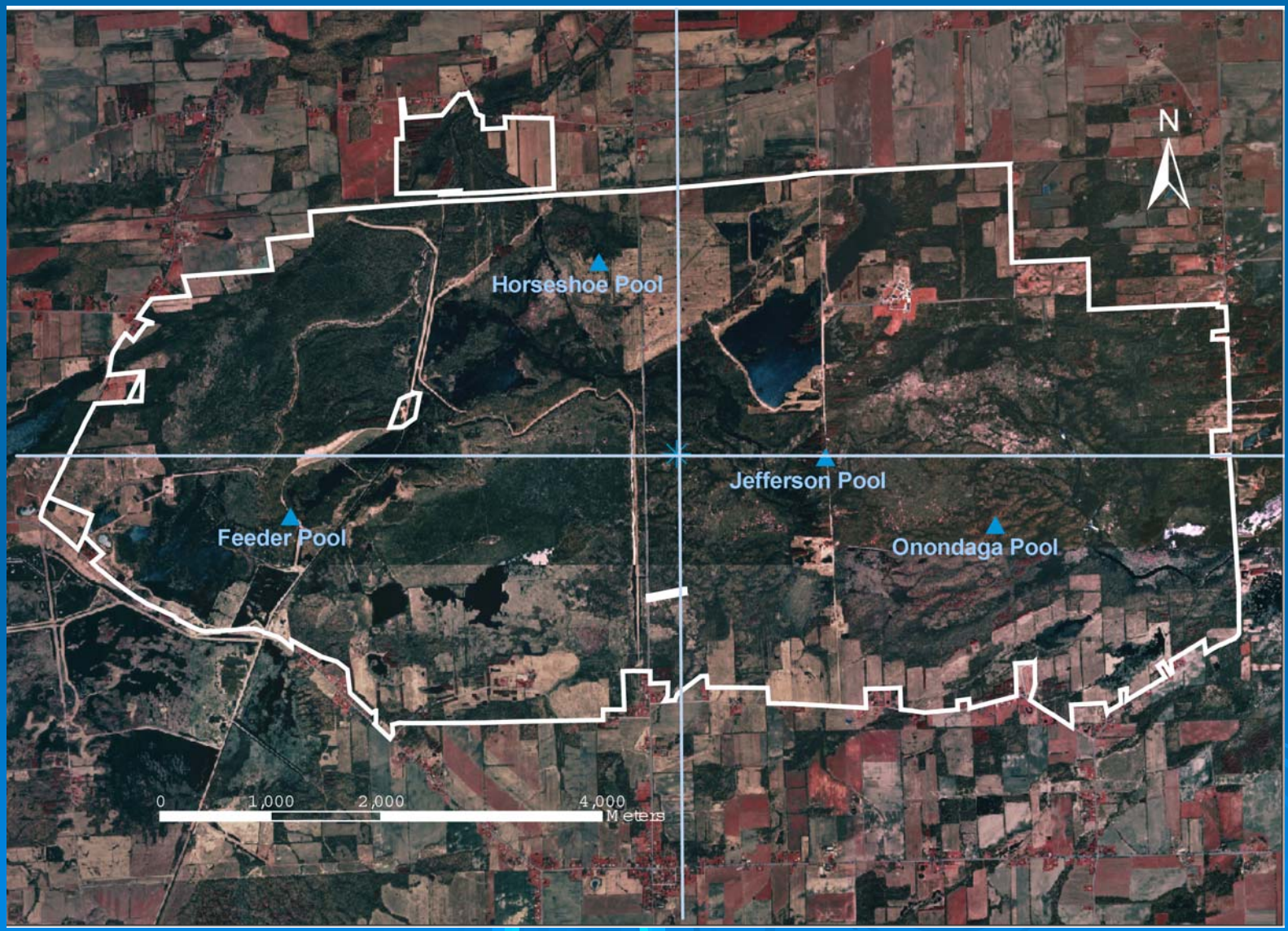
Spatial Sampling: DOI Lands in the NE US

15 National Wildlife Refuges
4 National Parks
1 State Park

Double-observer egg mass counts at 4 Focal Pools per DOI land (stratified selection by quadrant & proximity to road)

PAO at Focal Pools & Transect Pools found off 250 m transects in cardinal directions from Focal Pools

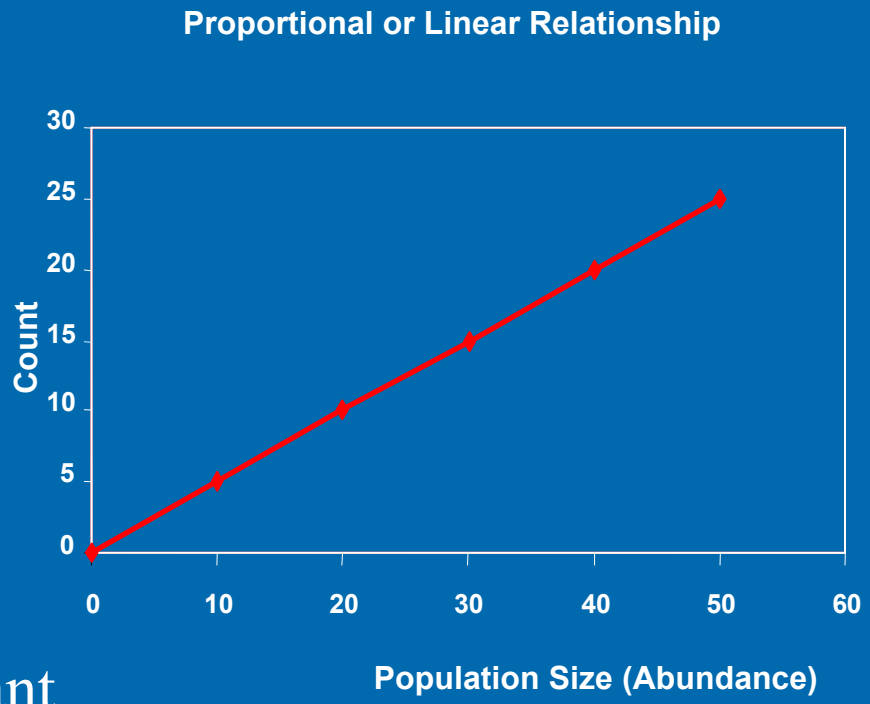
Iroquois National Wildlife Refuge



Estimation of N Requires Estimation of Detectability

$$E(C) = Np$$

With unadjusted count data, one assumes a linear relationship between C and N and that p is constant



C = Count statistic (what we collect)

N = True abundance (population size unknown)

p = Detection probability (probability that a member of N appears in C)

Double-Observer Dependent Egg Mass Estimation Technique

- Two Observers (Obs) survey pool together
- Obs 1 points out egg mass areas & numbers of egg masses per area to Obs 2
- Obs 2 records Obs 1's counts & records any other areas & egg masses that Obs 1missed
- Observers switch halfway around pool

Each pool surveyed at least twice during peak breeding season to obtain estimates of maximum abundance

Double-Observer Dependent
(Nichols *et al.* 2000)

Enter Data into Program DOBSERV
http://www.mbr-wrc.usgs.gov/software/dobserv.html

Observers: Sally Mander = 1, Woody Frog = 2

Obs #, Species, # eggs Obs 1, # additional eggs detected by Obs 2

1,Spotted salamander,35,0
1,Spotted salamander,14,2
2,Spotted salamander,0,1
2,Spotted salamander,4,3

Egg Mass Detection Probabilities (p)…

were high and did not differ between wood frogs & spotted salamanders

mean ± SE (n)

Wood frog

0.96 ± 0.02 (16)

Spotted salamander

0.92 ± 0.01 (12)

Site Covariates

that could influence detectability & site occupancy

Collected at Focal and Transect Pools

Pool Area (maximum length x width; m^2)

Maximum Pool Depth (cm)

Collected at Focal Pools

% Land Use (e.g., woodland) around pools

Distance to Road

In-Pool Vegetation

Water Chemistry (pH, ANC)

Sampling Covariates
that could influence detectability

Air & Water Temperatures

Precipitation within previous 24 hours

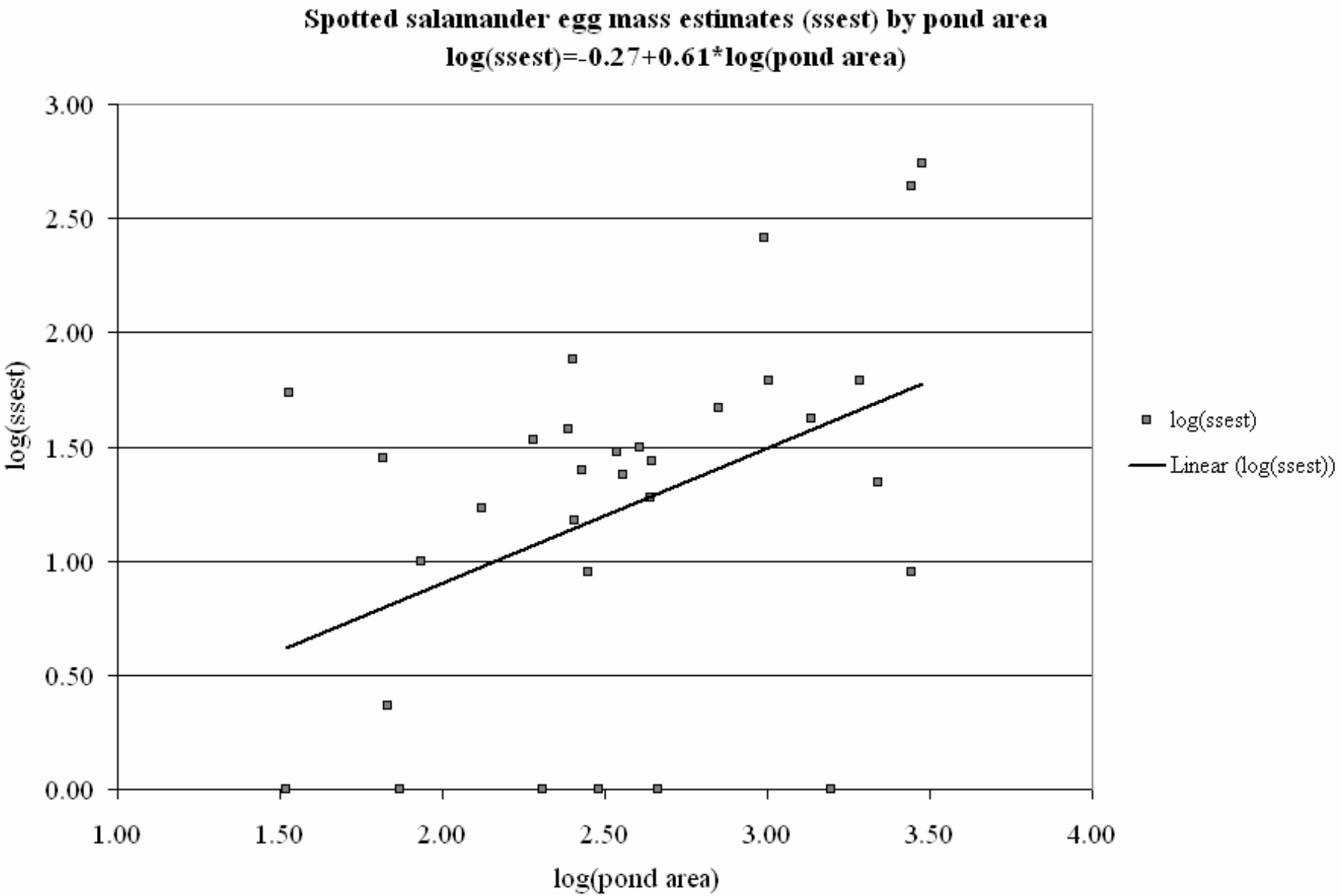
Visibility

Sampling Occasion

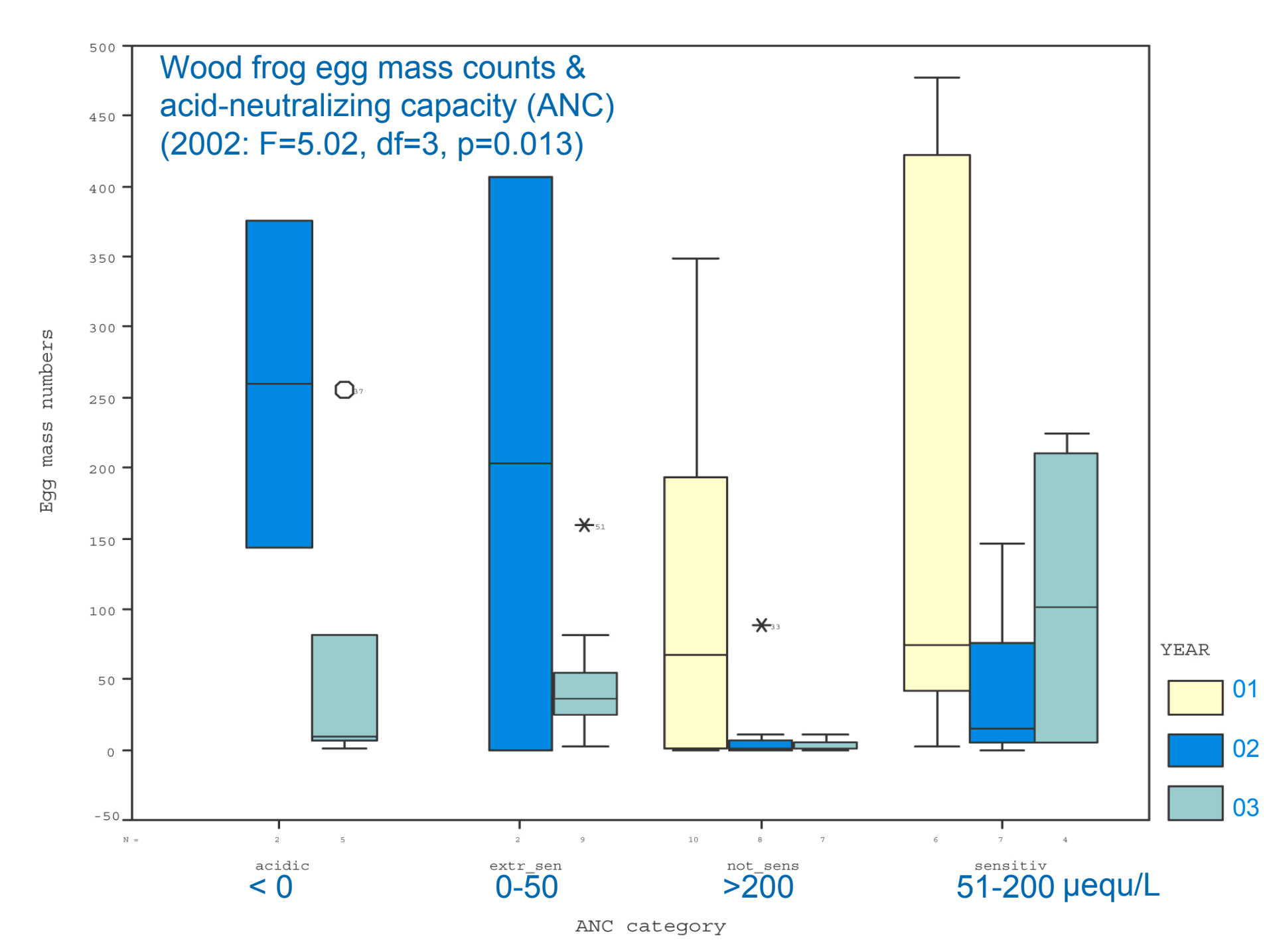
Do Egg Mass Detection Probabilities (p) Vary by:

Best Model Results for Parks & Refuges Based on AIC_c Values from SURVIV

p(.)	1
p(species)	2
p(observer)	1
p(pool)	2
p(observer x pool)	1
p(pool area)	1
p(max depth)	4
p(vegetation)	2
p(egg mass)	1



Multiple regression: Wood frog & spotted salamander egg mass estimates related to % forest, distance to road, pool area, maximum depth, water temperature (only significant variable entered was pond area for spotted salamanders)

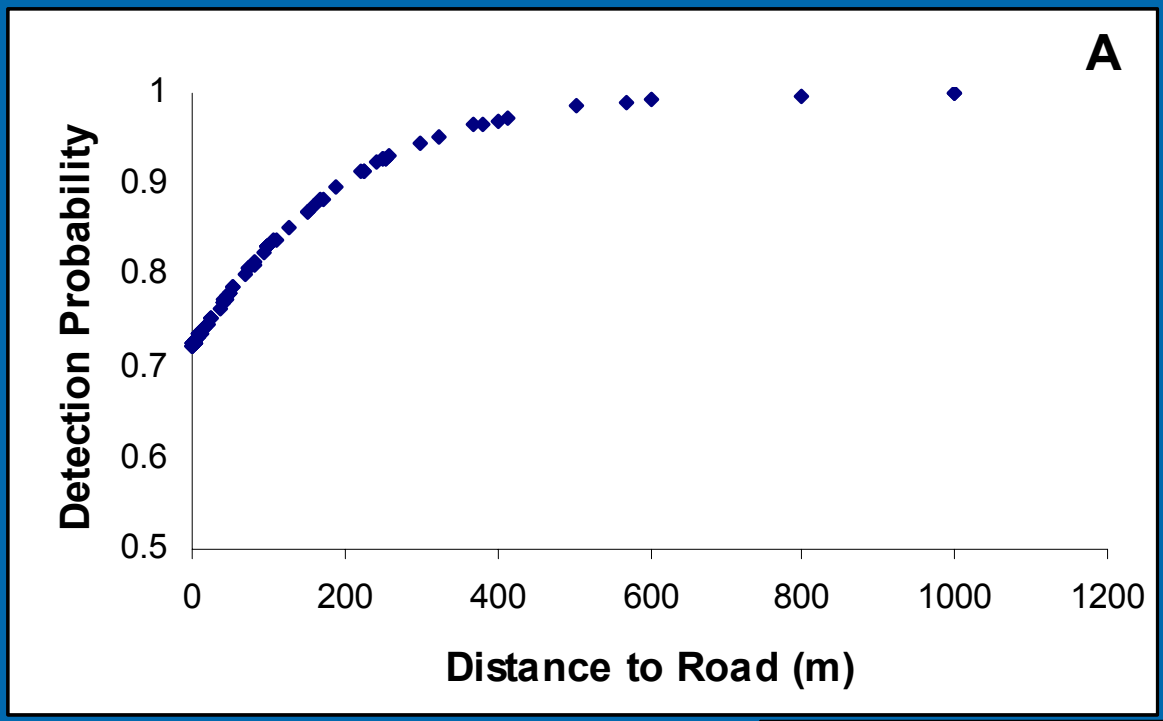

Wood frog egg mass counts &
acid-neutralizing capacity (ANC)
(2002: F=5.02, df=3, p=0.013)
Egg mass numbers
500
450
400
350
300
250
200
150
100
50
0
-50
N =
2
5
2
9
10
8
7
6
7
4
acidic
< 0
extr_sen
0-50
not_sens
>200
sensitiv
51-200 µequ/L
ANC category
YEAR
01
02
03

Focal pool PAO analyses for wood frogs (n = 90)

Models	-2Log(L)'	K	QAICc	ΔQAICc	QAICc wts
Ψ(.) *p*(time)	**271.626**	**6**	**192.555**	**0.000**	**0.324**
Ψ(.) *p*(.)	**286.304**	**2**	**194.311**	**1.756**	**0.134**
Ψ(distance road) *p*(.)	284.089	3	194.839	2.284	0.103
Ψ(.) *p*(distance road)	284.462	3	195.087	2.532	0.091
Ψ(.) *p*(water temp)	284.923	3	195.393	2.838	0.078
Ψ(woodland) *p*(.)	285.330	3	195.664	3.109	0.068
*Ψ(distance road, pond area, woodland) *p*(t)	268.133	9	196.232	3.678	0.051
Ψ(.) *p*(woodland)	286.269	3	196.288	3.733	0.050
Ψ(.) *p*(pond area)	286.281	3	196.296	3.741	0.050
Ψ(pond area) *p*(.)	286.289	3	196.301	3.746	0.050
***c(hat)**	**1.504**				

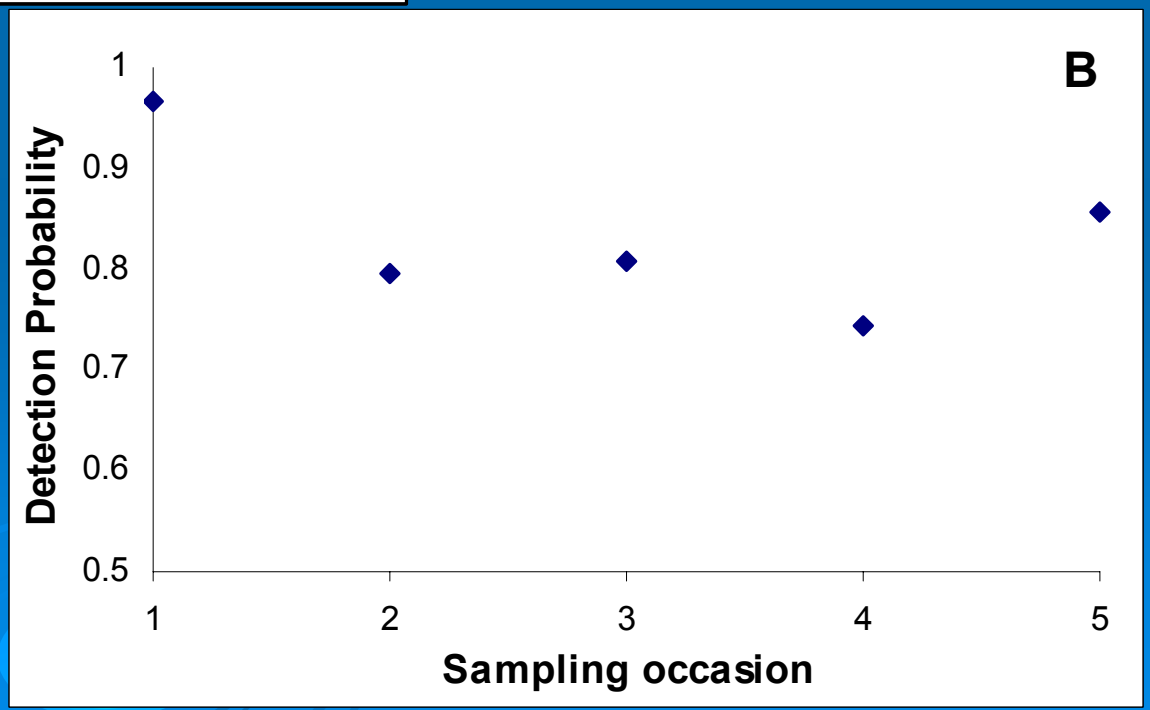
Focal pool PAO analyses for spotted salamanders (n = 90)

Models	*-2Log(L)'*	K	QAICc	ΔQAICc	QAICc weights
Ψ(.) *p*(distance road)	**270.034**	**3**	**119.655**	**0.000**	**0.468**
Ψ(.) *p*(.)	281.448	2	122.460	2.804	0.115
Ψ(woodland) *p*(.)	277.048	3	122.607	2.952	0.107
Ψ(.) *p*(pond area)	277.843	3	122.942	3.287	0.091
Ψ(.) *p*(water temp)	279.423	3	123.607	3.952	0.065
Ψ(.) *p*(woodland)	280.285	3	123.970	4.315	0.054
Ψ(distance road) *p*(.)	280.874	3	124.218	4.563	0.048
Ψ(pond area) *p*(.)	281.392	3	124.436	4.781	0.043
Ψ(.) *p*(t)	275.064	6	127.773	8.117	0.008
* Ψ(distance road, pond area, woodland) *p*(t)	269.946	9	131.619	11.963	0.001
***c(hat)**	**2.3759**				



A. Spotted salamander detection probability increases with distance from a road

B. Wood frog detection probability varies by sampling occasion



PAO models for wood frogs & spotted salamanders at Focal & Transect Pools (n = 234)

Wood frog models	*-2Log(L)'*	K	QAIC	ΔQAIC	QAIC weights
Ψ(.) *p*(time)	**793.69**	**5**	**143.498**	**0.000**	**0.791**
Ψ(.) *p*(.)	845.44	2	148.332	4.835	0.071
Ψ(pool depth) *p*(.)	845.71	3	148.378	4.881	0.069
Ψ(pool area) *p*(.)	847.60	3	148.701	5.203	0.059
*Ψ(pool area, pool depth) *p*(.)	843.88	4	152.066	8.568	0.011
***c(hat)**	**5.86**				

Spotted salamander models	*-2Log(L)'*	K	QAIC	ΔQAIC	QAIC weights
***Ψ(pool area, pool depth) p(.)**	**640.36**	**4**	**176.800**	**0.000**	**0.698**
Ψ(pool depth) *p*(.)	665.95	3	179.546	2.746	0.177
Ψ(pool area) *p*(.)	672.83	3	181.359	4.559	0.071
Ψ(.) *p*(.)	675.00	2	181.931	5.131	0.054
Ψ(.) *p*(time)	721.48	5	198.184	21.383	0.000
***c(hat)**	**3.79**				

CONCLUSIONS

- Estimation of egg mass numbers in pools essential because detection probabilities (*p*'s) vary spatially (and perhaps temporally)
- More spotted salamander egg masses at larger vernal pools; wood frog egg mass counts differed at pools differing in acid-neutralizing capacity
- Spotted salamander detectability higher at pools further from a road and site occupancy influenced by pool area and pool depth
- Wood frog detectability higher earlier in season
- Coming Soon: GIS landscape analyses

SPECIAL THANKS TO
Larissa Bailey
Jim Nichols
NE ARMI Field Technicians
Partners in USFWS, NPS,
State Parks & Universities