Occupancy Modeling as a Tool to Delineate Invasive Species Distribution in Reservoir Riparian Areas

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Layout

- Invasive Species
- Occupancy Modeling
- Asian Swamp Eels
- Methods
- Results
- Conclusions

Invasive Species

- Reservoirs are more susceptible to the introduction and proliferation of non-native species (Johnson et al. 2008)
- Threaten Native Species
  - Predation
  - Competition
  - Hybridization
  - Loss of Biodiversity
  - Suite of Indirect Ecological Effects

  Davis (2009)

Occupancy Modeling

- Occupancy estimates can be severely biased when species are rare or elusive (McKenzie et al. 2003)
- Account for imperfect species detection through repeat sampling
- Assumptions
  - Site Closure
  - No False Positive Detections
  - No unexplained heterogeneity
  - Survey Independence

Asian Swamp Eels

- Native to tropical and temperate climates of southeast Asia, Indonesia, and Australia
- Obligate Air breathers
- Capable of overland migration
- Cryptic
- Sedentary behavior (Likely high site fidelity)
- 4 known populations introduced into the continental U.S.
- Genetic variation within M. albus equivalent to that observed in some families of fish. (Collins et al. 2002)

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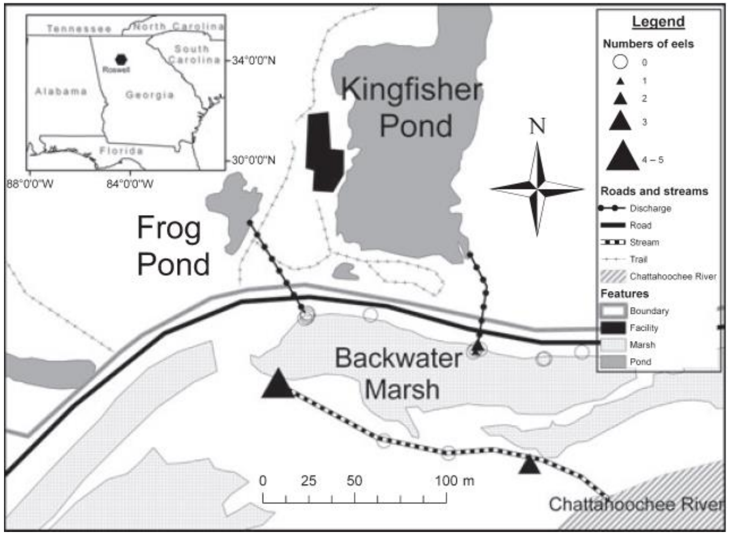
ASEs in Georgia

- GA population has persisted since approximately 1990 (Freeman and Burgess 2000)
- Known to reside in 2 ponds and adjacent marsh area of the Chattahoochee River (Freeman et al. 2005)
- Possibly an undescribed species due to genetic analysis and observed variation in behavior (Collins et al. 2002)



Long and LaFleur (2011)

Research Objective

- Determine current ASE distribution within the Chattahoochee River

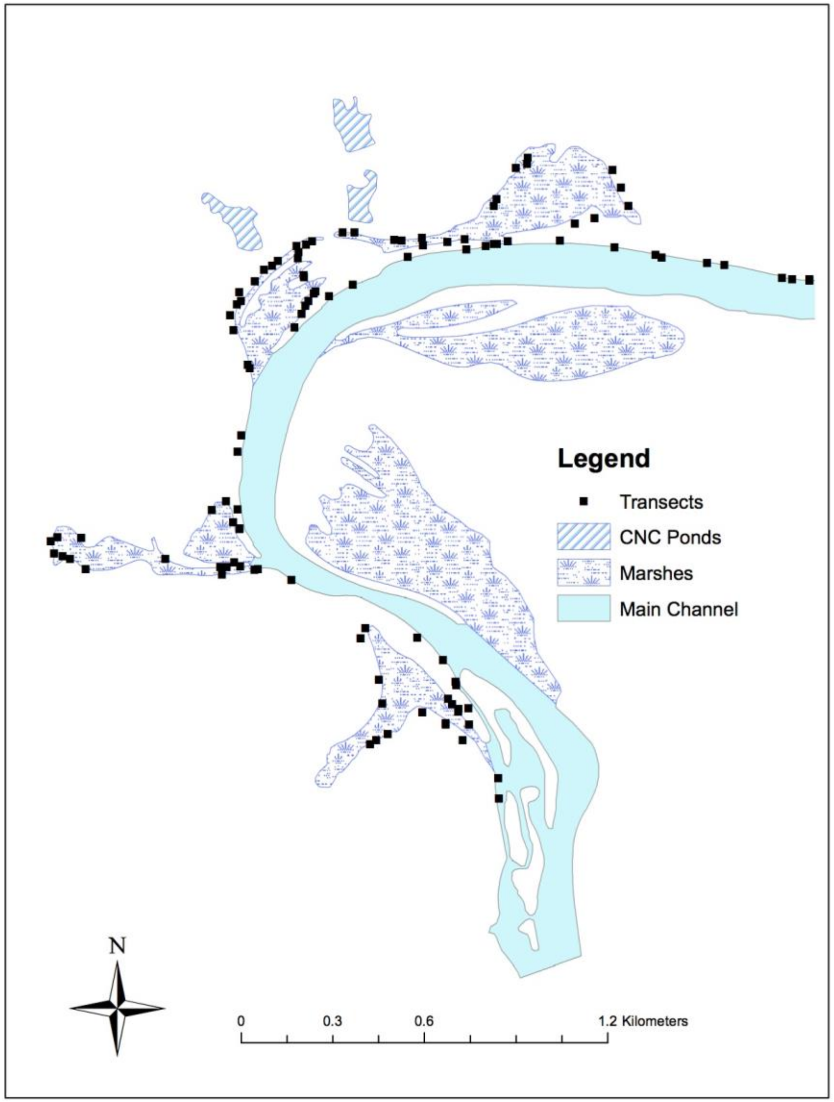
Methods

- 111 Sampling Locations within a 2km radius of known ASE occurrence
  - Sampling locations randomly selected from NHD layer broken into 5 m segments
    - 5 m segments were sampled with a standardized array of leaf litter traps
- Each site visited on 10 occasions from June – August 2015
- Sampling-level covariates collected on every occasion
  - Temperature
  - Depth at each leaf litter trap

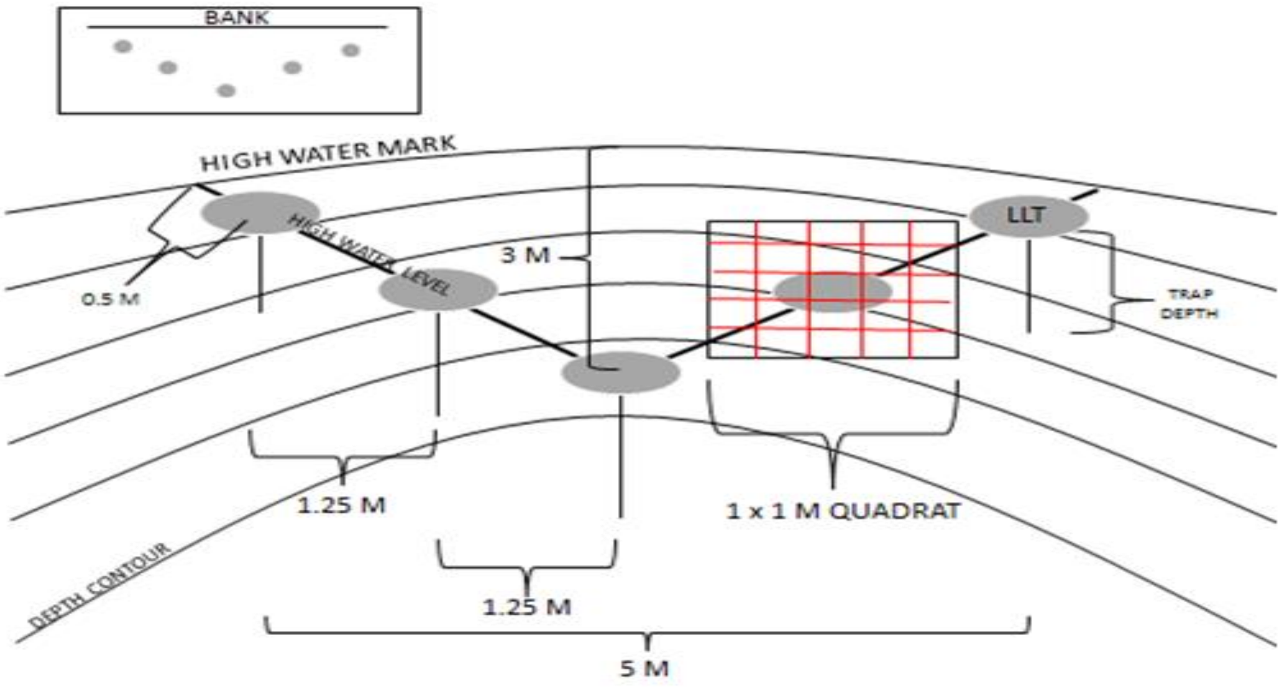
Methods Cont.

- Site-level covariates collected once
  - Aquatic Vegetation (as proportion of area)
  - Silt substrate (as proportion of area)
- Other site-level metrics
  - Distance from proposed invasion point
  - Mean transect depth over sampling season
  - Mean transect temperature over sampling season
  - Temperature variance over sampling season
- Single season models of detection and occupancy
- Interpolate covariate values for locations not sampled
- Apply model averaged estimates of occupancy to entire study area

Study Area


Legend
Transects
CNC Ponds
Marshes
Main Channel
N
0
0.3
0.6
1.2 Kilometers

Transect Layout



Leaf Litter Traps

- Unpublished data on LLT's indicated detection probability is low (11%)
- Alternative capture techniques have shown even lower detection probabilities

Results

- 31 ASEs captured at 14 unique transects

Site ID	Detection History	Total # of Detections
184	0000001000	1
181	0110010000	3
180	1110000101	5
172	0000000001	1
171	0000001000	1
169	0010000000	1
168	0000000001	1
154	0100000000	1
153	0010100001	3
152	0100101011	5
147	0100000000	1
146	0100000000	1
143	1010011010	5
108	1000000000	1

Detection Models

Model	K	AIC	Δ AIC	AIC Weight
psi(.)p(Temp+Mtd)	4	225.06	0	0.89
psi(.)p(Mtd)	3	229.67	4.61	0.08
psi(.)p(.)	2	233.37	8.31	0.01
psi(.)p(Temp)	3	234.77	9.71	< 0.01

Detection Estimate (at mean Temp+Mtd) = 0.174 SE = 0.039

Detection Model Fit

- C-Hat = 1.00
- Likelihood Ratio Test
  - psi(.)p(Temp+Mtd) , psi(.)p(.)
  - x^2 = 12.31 DF = 2 P < 0.01

Occupancy Model Selection

Pearson Correlation Matrix

	Dst	Veg	Slt	Msd	Mst	Tvar
Dst	1.00	**-0.50**	**-0.55**	-0.01	0.01	-0.39
Veg		1.00	**0.53**	-0.31	**0.51**	0.46
Slt			1.00	-0.23	0.05	0.32
Msd				1.00	-0.32	-0.11
Mst					1.00	0.39
Tvar						1.00

- Pearson's Correlation Coefficient (<|0.50|) used to eliminate multicollinearity among site-level covariates

Exploratory model selection approach due to lack of prior research

27 Candidate Models

- All possible non-collinear combinations

psi(Veg)p(Temp+Mtd)
psi(Veg+Tvar)p(Temp+Mtd)
psi(Veg+Msd)p(Temp+Mtd)
psi(Veg+Msd+Tvar)p(Temp+Mtd)
psi(Slt+Msd)p(Temp+Mtd)
psi(Slt+Mst)p(Temp+Mtd)
psi(Slt)p(Temp+Mtd)
psi(Dst+Mst)p(Temp+Mtd)
psi(Dst+Msd)p(Temp+Mtd)
psi(Slt+Msd+Mst)p(Temp+Mtd)
psi(Slt+Msd+Tvar)p(Temp+Mtd)
psi(Tvar)p(Temp+Mtd)
psi(Dst+Msd+Mst)p(Temp+Mtd)
psi(Slt+Mst+Tvar)p(Temp+Mtd)

psi(Slt+Mst+Tvar)p(Temp+Mtd)
psi(Dst+Mst+Tvar)p(Temp+Mtd)
psi(Slt+Msd+Mst+Tvar)p(Temp+Mtd)
psi(Dst+Msd+Tvar)p(Temp+Mtd)
psi(Dst+Msd+Mst+Tvar)p(Temp+Mtd)
psi(Dst)p(Temp+Mtd)
psi(Dst+Tvar)p(Temp+Mtd)
psi(Msd+Tvar)p(Temp+Mtd)
psi(Msd)p(Temp+Mtd)
psi(Tvar)p(Temp+Mtd)
psi(Mst+Tvar)p(Temp+Mtd)
psi(Msd+Mst+Tvar)p(Temp+Mtd)
psi(Msd+Mst)p(Temp+Mtd)
psi(Mst)p(Temp+Mtd)

Models <10ΔAIC

Model	K	AIC	Δ AIC	AIC Weight
psi(Veg)p(Temp+Mtd)	**5**	**201.29**	**0.00**	**0.45**
psi(Veg+Tvar)p(Temp+Mtd)	**6**	**202.96**	**1.67**	**0.19**
psi(Veg+Msd)p(Temp+Mtd)	**6**	**203.01**	**1.72**	**0.19**
psi(Veg+Msd+Tvar)p(Temp+Mtd)	**7**	**204.84**	**3.55**	**0.08**
psi(Slt+Msd)p(Temp+Mtd)	**6**	**207.97**	**6.67**	**0.02**
psi(Slt+Mst)p(Temp+Mtd)	**6**	**208.41**	**7.11**	**0.01**
psi(Slt)p(Temp+Mtd)	**5**	**208.50**	**7.21**	**0.01**
psi(Dst+Mst)p(Temp+Mtd)	**6**	**209.43**	**8.14**	**0.01**
psi(Dst+Msd)p(Temp+Mtd)	**6**	**209.75**	**8.46**	**0.01**
psi(Slt+Msd+Mst)p(Temp+Mtd)	**7**	**209.77**	**8.48**	**0.01**
psi(Slt+Msd+Tvar)p(Temp+Mtd)	**7**	**209.89**	**8.60**	**0.01**
psi(Tvar)p(Temp+Mtd)	**6**	**209.99**	**8.70**	**0.01**

Veg
Tvar
Msd
Slt
Mst

Occupancy Model Fit

- MacKenzie-Bailey Goodness-of-Fit test on two sub-global models of occupancy
- Parametric bootstrap with 10,000 simulations
  - Psi(Slt+Msd+Mst+Tvar)p(Temp+Mtd): c-hat = 0.86 p=0.44
  - Psi(Dst+Msd+Mst+Tvar)p(Temp+Mtd): c-hat =0.63 p=0.42

ASE Distribution

Occupancy Probabilities based on model averages

Warmer Colors = Higher Probability

Conclusions

- ASE’s appear to have a limited distribution within the Chattahoochee river
- Marsh areas have a higher probability of occupancy
- Distribution models can inform future sampling for monitoring, eradication, or suppression efforts

Broader Implications

- Occupancy models provide an informed analysis of species distribution that is robust to imperfect detection
- Detection probability should be incorporated into distribution models when feasible
  - Important for invasive species due to the potential implications of assuming absence
- Able to investigate relationship of covariates to detection and occupancy probabilities
- Occupancy modeling method can be applied to other invasive species and habitats

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Questions?