

Mechanisms behind the successful invasion of American Bullfrogs (*Rana catesbeiana*) in the Northwest United States

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Invasive Species

Pressing Ecological Question:

What mechanisms allow exotic species to invade and establish in novel environments?



American Beach Grass



Nutria



European Starling



Himalayan Blackberry



New Zealand Mudsnail



Red Swamp Crayfish

Invasive Species

Pressing Ecological Question:

What mechanisms allow exotic species to invade and establish in novel environments?



Sudden Oak Death



Canary



Bullfrog



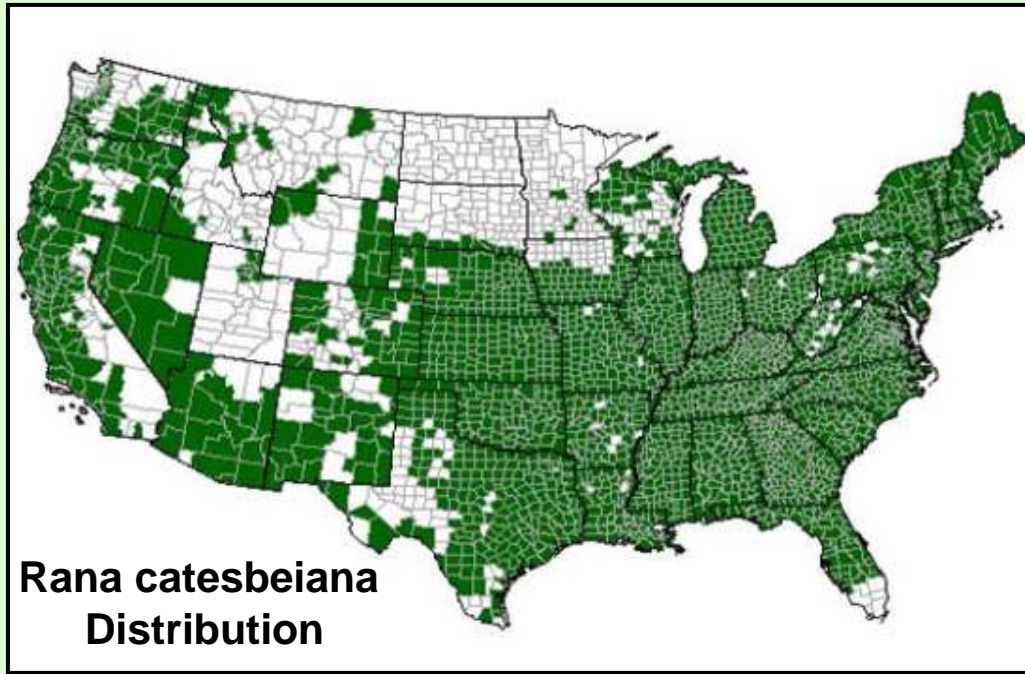
Yellow Star Thistle



European Green Crab

Swamp Crayfish

Bullfrog Background Information



**Native Range:
Eastern North America**

**Invasive Range:
Western North America**

**Mechanism:
Frog farms
Pet release**



<http://co.marion.or.us/>



Photo:L.Morrison



Photo:Corel Inc.

Bullfrog Background Information

Invasion Impacts

- Invasive Bullfrogs can negatively impact native species



Red-legged Frogs

Joseph M. Kiesecker et al. (2001)

- Adult bullfrogs reduce larval Red-legged growth rates and alter microhabitat choice
- Context dependent: respond only when habitats are disturbed



Invasive Synergisms

Mike Adams et al. (2003)

- Invasion of bullfrogs in the PacNW is facilitated by the presence of non-native fish
- Non-native fish reduce predatory macroinvertebrate densities

Bullfrog Background Information

Comparison of Life History Characteristics

	Native Bullfrog Populations	Invasive Bullfrog Populations
Relative Size	Medium	Large
Hydroperiod	Permanent	Ephemeral + Permanent
Larval Period	12-36 mos	3-24 mos
Dispersal Rate	?	>4km/yr

1. Preliminary hydroperiod data
2. Radio tag data

Hypotheses

3 hypotheses for successful establishment

1. Local adaptation to novel environment

- Phenotypic divergence is genetically based
- Invasive population has adapted to local conditions

2. Phenotypic plasticity in response to novel environmental conditions

- Phenotypic divergence is environmentally induced
- Individuals across populations can plastically adjust phenotype

3. Invasive acts as disease reservoir

- Invasive species are carriers of a pathogen
- The introduced disease decreases fitness of natives and facilitates the carrier's invasion

Predictive Model

Question:

Why are bullfrogs successful invaders?

Hypotheses:

Local
Adaptation

Phenotypic
Plasticity

Disease
Reservoir

Lab Predictions:

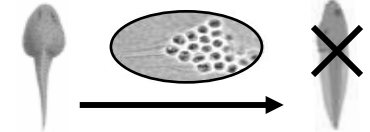
Phenotypic differences
in Common Garden Exp.



No Phenotypic difference
in Common Garden Exp.

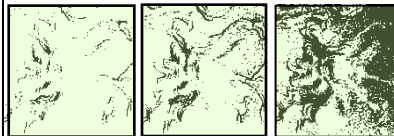


Bullfrogs can infect
native amphibians with Bd



Model Predictions:

Time-lag in population
establishment in
novel habitats

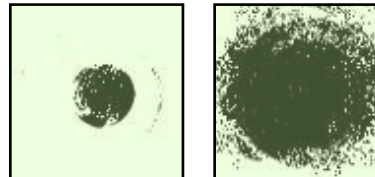


Range @
Time 0

Range @
Time 1

Range @
Time 2

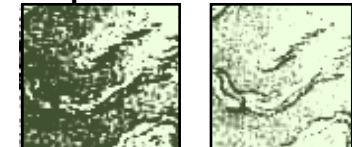
Wide distribution
despite novel habitats



Range @
Time 0

Range @
Time 1

Negative interactions
of (Bd + BF) on native
amphibian distributions



Native
Range

Native+(Bd+BF)
Range

Ground-truthing:

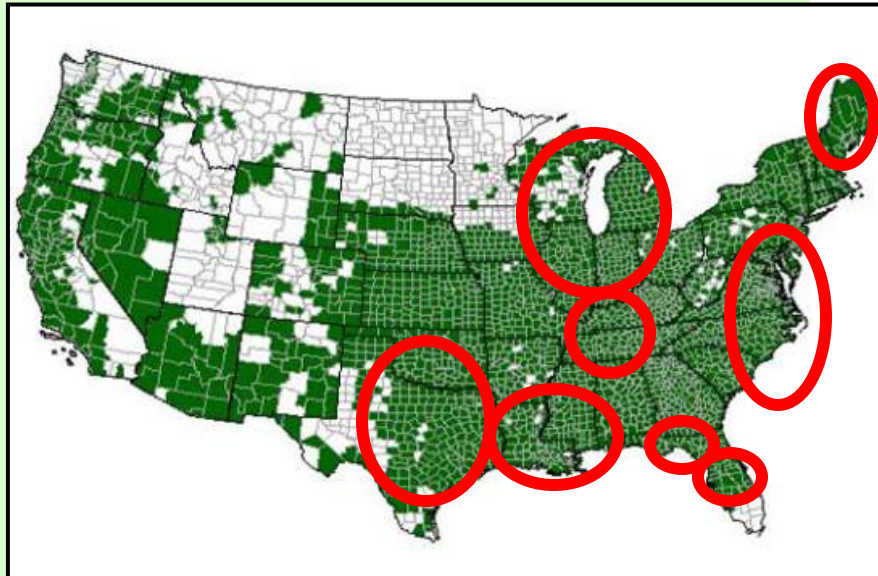
Field Survey

Research Project

Objective 1: Determine the source population(s) of invasive bullfrogs in the Pacific Northwest

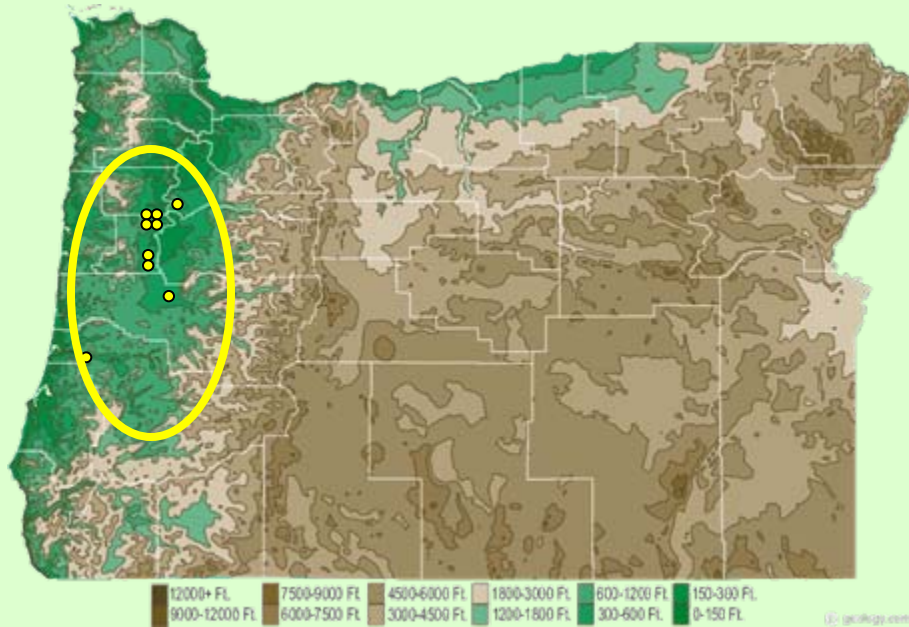
Methods: Use molecular markers to determine the geographic origin of source population(s) within the native range.

- mtDNA markers
- microsatellite markers



Austin et al. 2004

Bullfrog Tissue Collection



Cat tail pond



Turtle Flats

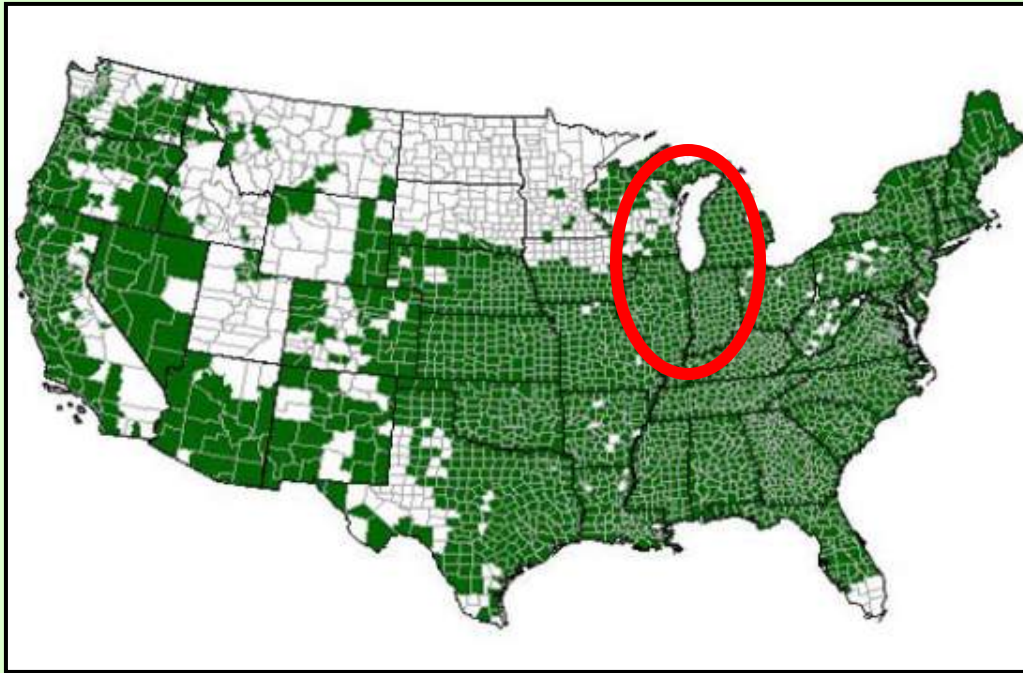


Ankeny NWR



E.E. Wilson Site #4

Results: Objective 1



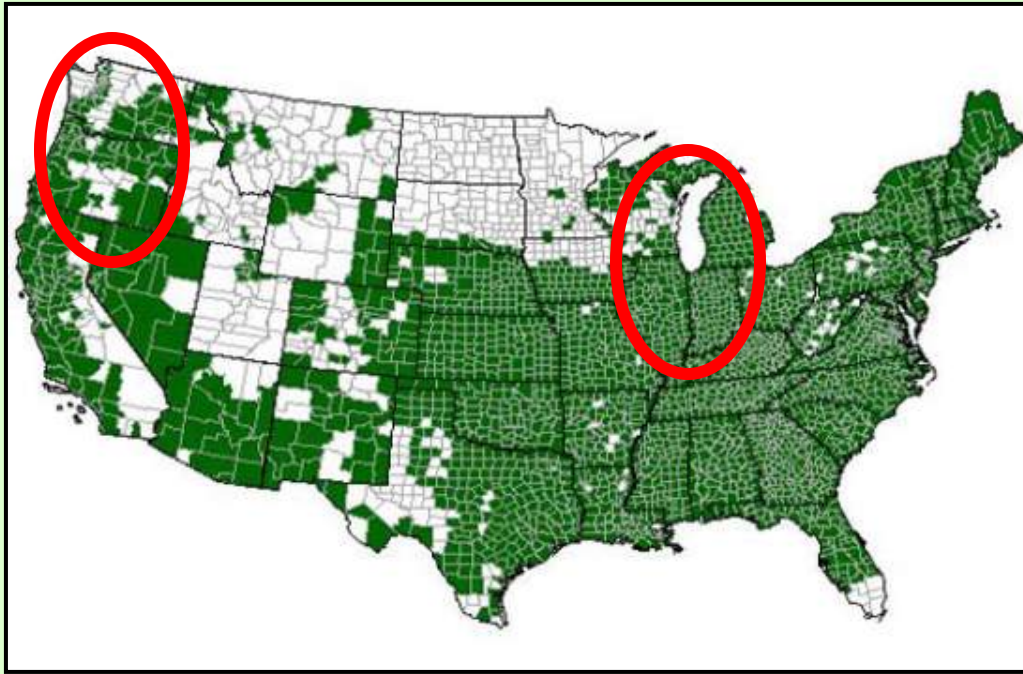
Source Region: Michigan/Indiana/Ohio Haplotype

- mtDNA analysis points to the Great Lakes bullfrog region
- microsatellite data will increase focus to population level

Novel environmental Factors:

- temperature stability
- altered hydrological regimes
- limited temporal overlap w/natives
- facilitation by other invasives

Research Project



Test Invasion Hypotheses:

1. Local Adaptation
 2. Phenotypic Plasticity
 3. Disease Reservoir
- *Batrachochytrium dendrobatidis*
- } Temperature
Hydroperiod

Research Project

Objective 2: Determine whether divergence in larval bullfrog phenotypes is genetically based

Methods: Large-scale Common Garden Experiment

- Temperature (invasive/source)
- Hydroperiod (ephemeral/permanent)



OSU's Center for Disease Research

Quantify Phenotypic Divergence

1. Growth Rate
2. Time till Metamorphosis
3. Morphometrics

Research Project

Objective 3: Test whether bullfrogs can infect native amphibians with *Batrachochytrium dendrobatidis* (Bd)

Methods: Bd Exposure Experiment

1. Expose native individuals to infected bullfrog individuals
2. Quantify mortality
3. Quantify infection using PCR



Significance

How do you stop bullfrog invasions? Depends....

1. Local adaptation

- Delayed expansion into novel environments
- Time to adapt management plans

2. Phenotypic plasticity

- Expansion only limited by dispersal speed
- Run for the hills!

3. Disease reservoir

- Bullfrog invasive range will have little/no overlap with native frogs
- Target the pathogen

Future Coqui?

- Survey range expansion
- Target adult females
- Seasonally drain ponds



Gina Mikel

Send me tissue samples!!!

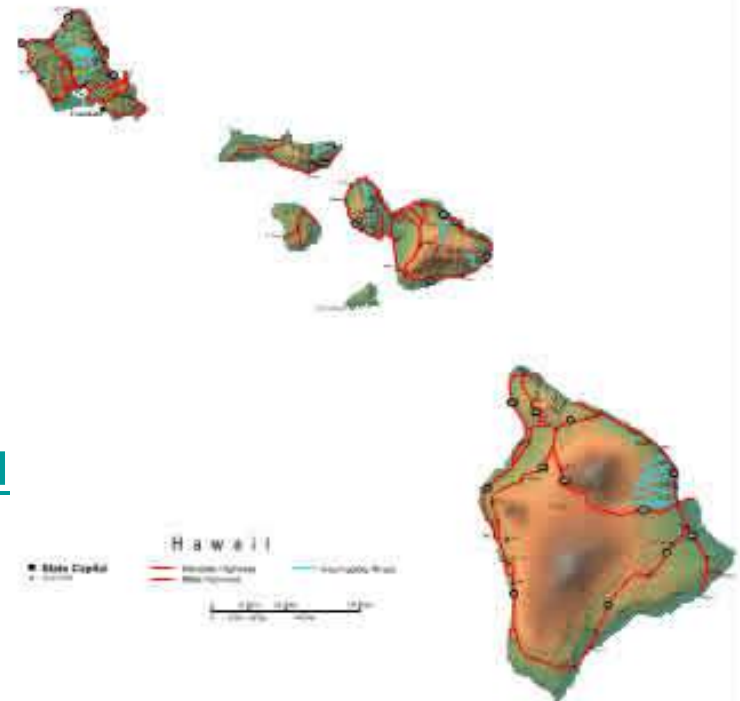
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