DISEASE THREATS TO AMPHIBIAN POPULATIONS

Evan H Campbell Grant
Northeast Amphibian Research and Monitoring Initiative
US Geological Survey
Patuxent Wildlife Research Center

New England Chapter of the Wildlife Society
Spring Workshop
2015

- Color slides of 5 common lethal infectious diseases of amphibians
- Considerations for surveillance and monitoring of diseases at multiple scales

5 Common Lethal Infectious Diseases of Amphibians

- **Chytrid Fungus**
- **Ranaviruses**
- *Perkinsus*-like organism
- *Ichthyophonus* sp.
- *Ribeiroia ondatrae* (fluke)

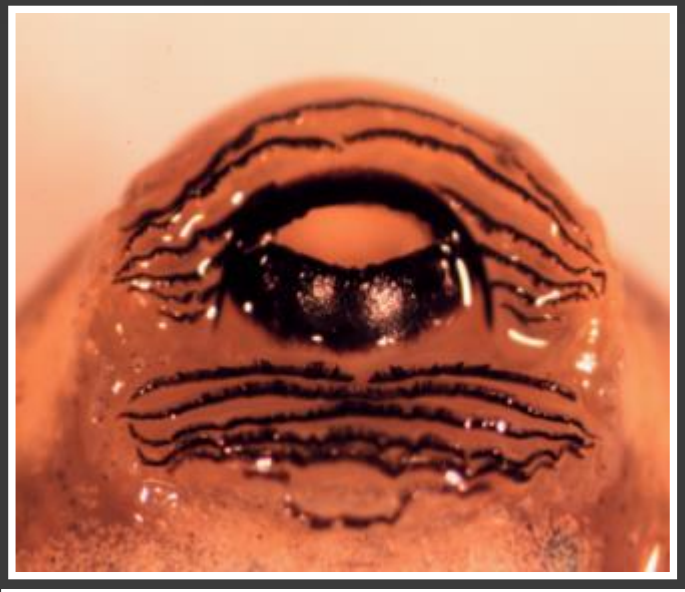
1) Pathogenic Chytrid Fungus:

Batrachochytrium dendrobatidis ("Bd")

- Major cause of amphibian population declines worldwide
- Kills only frogs & toads after metamorphosis; occasionally lethal in adult newts
- Die-offs are insidious; rarely are more than 2 dead frogs or toads found at a site
- Mixed effect of disease on populations in northeastern US

Chytridiomycosis: Gross Findings: Tadpoles

Larvae: non-lethal oral infection of tadpoles



Chytridiomycosis: Gross Findings: Adult Frogs

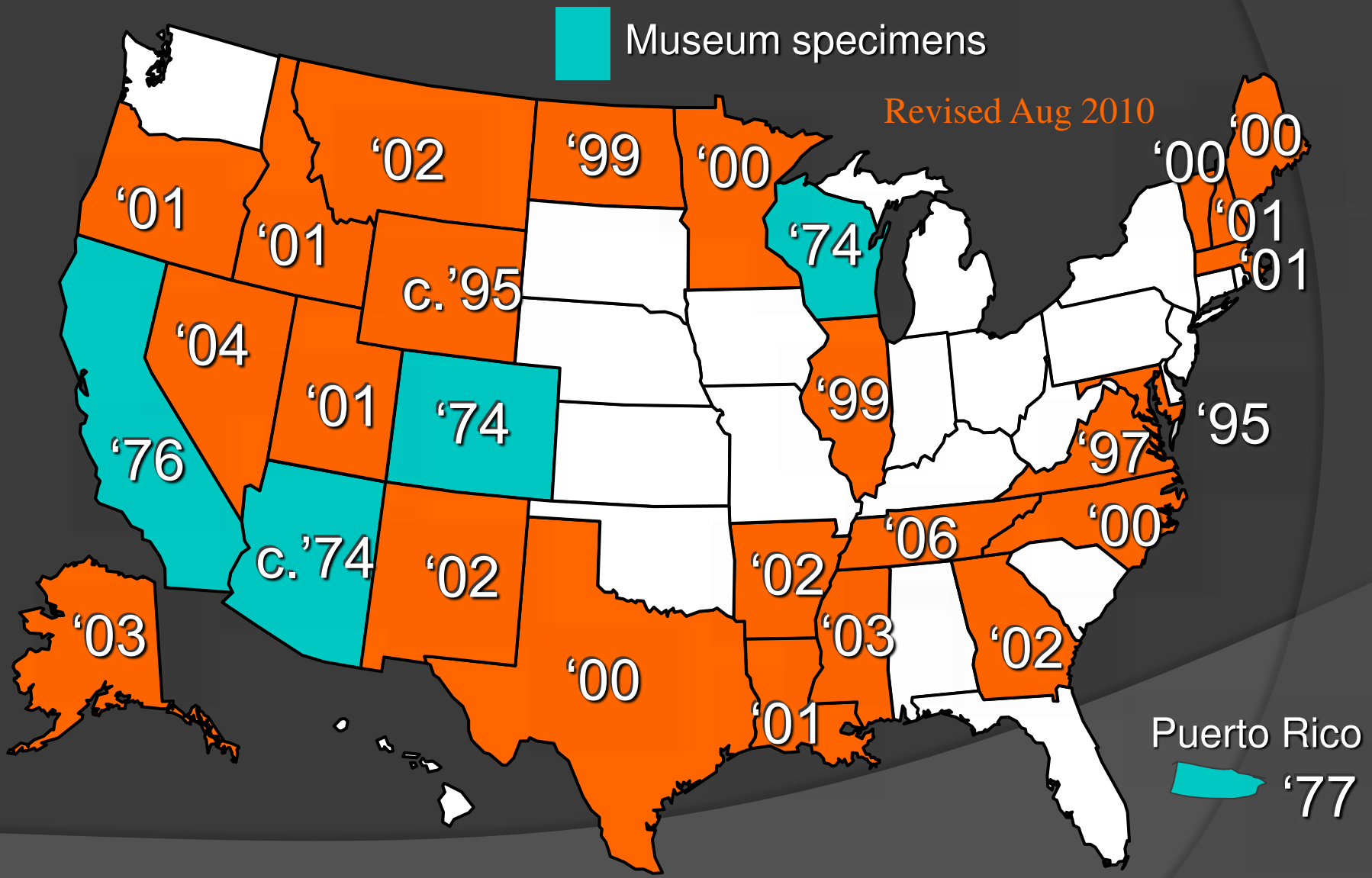
Lethal in majority of spp. within 2-3 wks of end of metamorphosis

Chiricahua leopard frog (*Rana chiricahuensis*)

Bd: Salamanders

- Pathogenicity largely unknown; non-lethal to aquatic life-stages, occasionally lethal to red-spotted newts.
- Susceptibility of terrestrial salamanders is largely unstudied
- Stream salamanders susceptible; no die-offs observed.

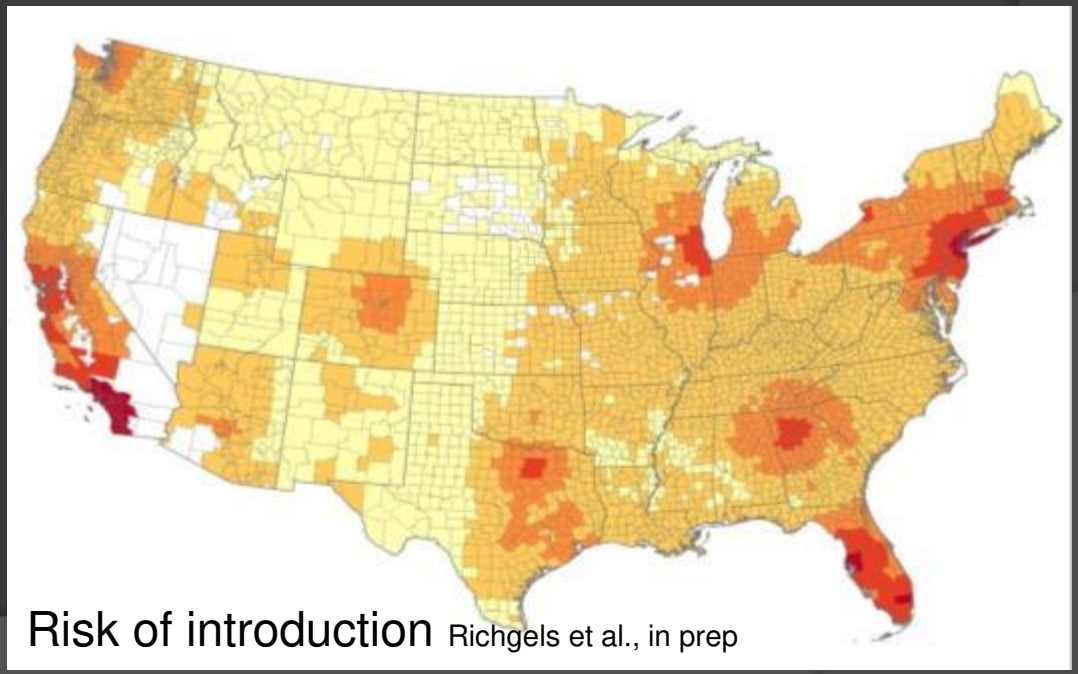
Chytridiomycosis in Amphibians
Year of First Detection



Salamander chytrid fungus

Recent discovery of a second chytrid pathogen, *Batrachochytrium salamandrivorans* sp. nov., that causes lethal skin infections in salamanders, which has resulted in steep declines in salamander populations in northwestern Europe.

Several species of US amphibians (including red-spotted newts in NE) are susceptible.



Risk of introduction Richgels et al., in prep

2) Ranaviruses

Agent: Ranavirus; Family: Iridoviridae

- 5 or 6 distinct strains or species in USA
- Some strains are host-specific, other strains may be panzootic

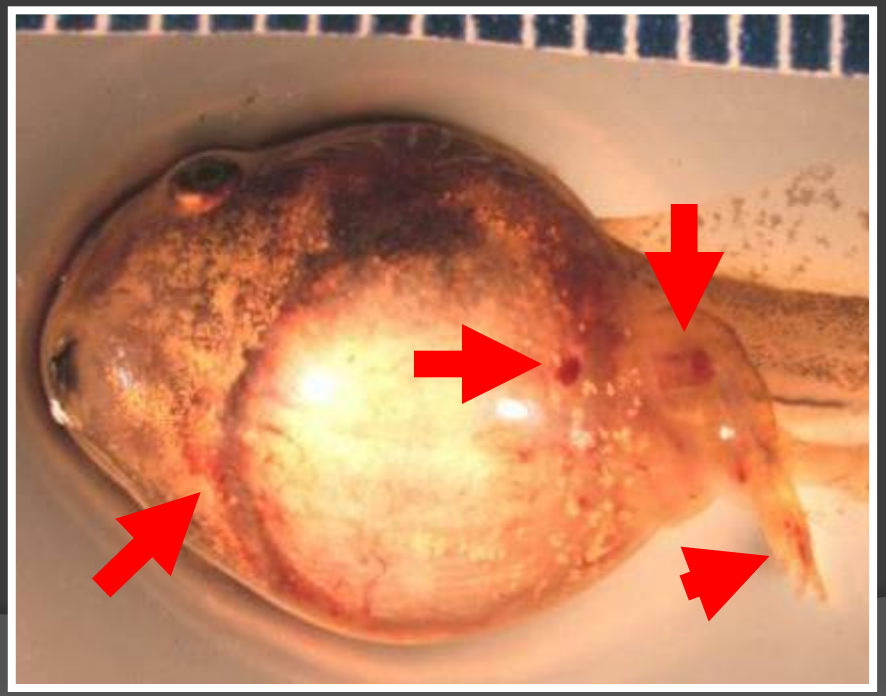
Epizootiology:

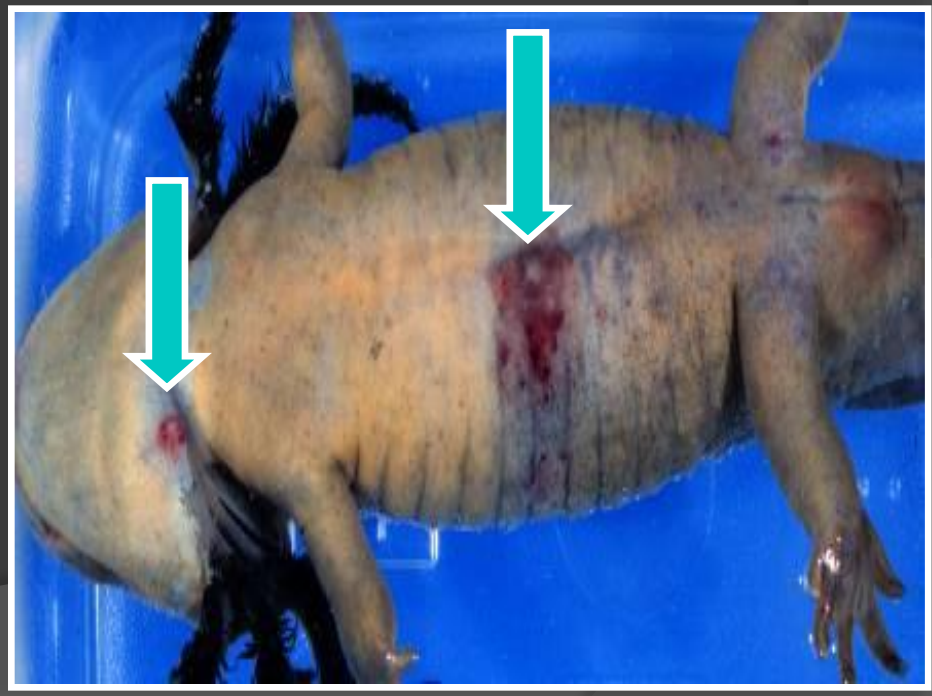
- Kills larvae & larvae in metamorphosis
- Seldom affects adult amphibians in USA
- Onset is sudden (explosive)
- Mortality rate often >95% of larvae

Ranavirus Infection

Gross Findings:

1. Petechia or ulcers in skin

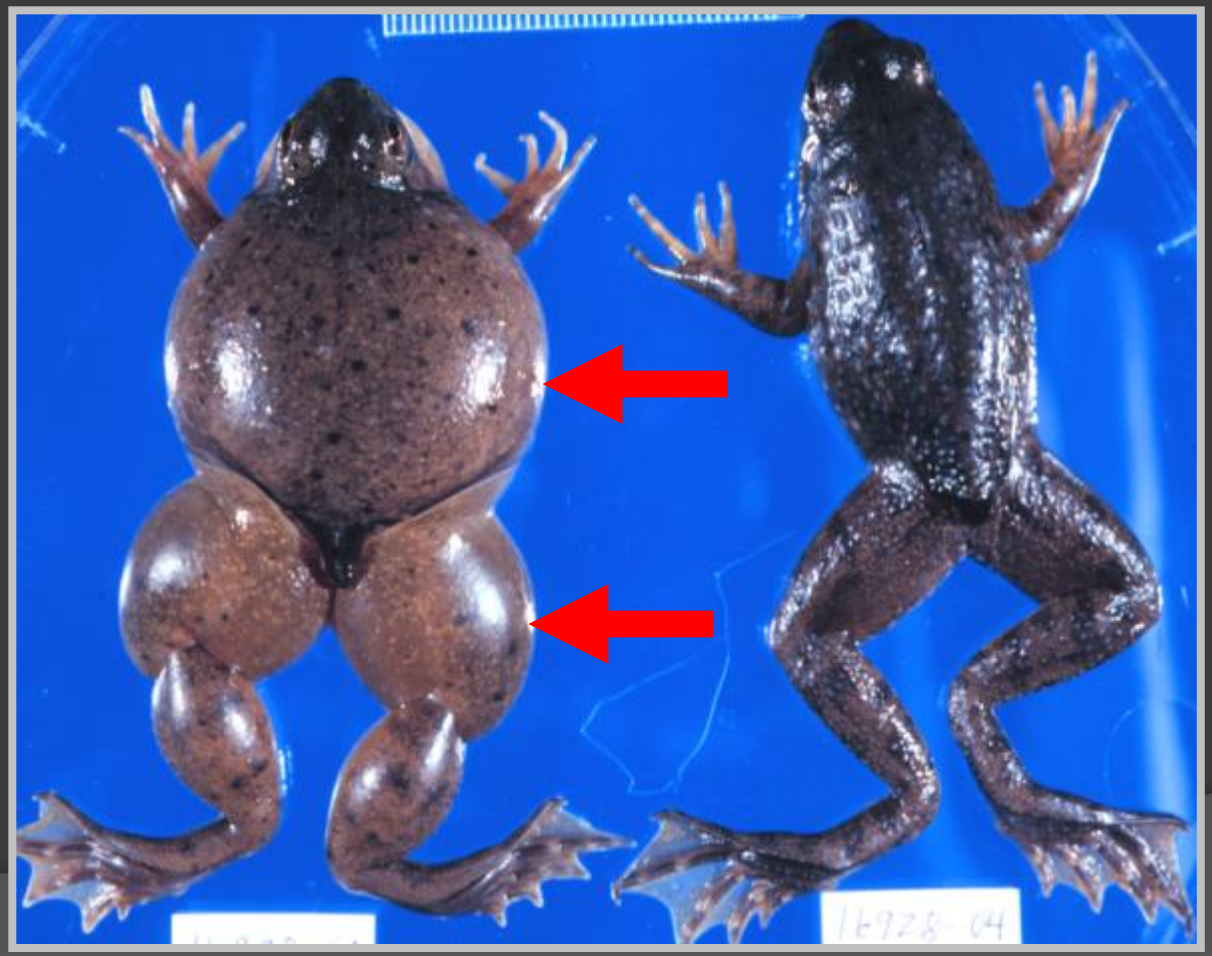




Ranavirus Infection

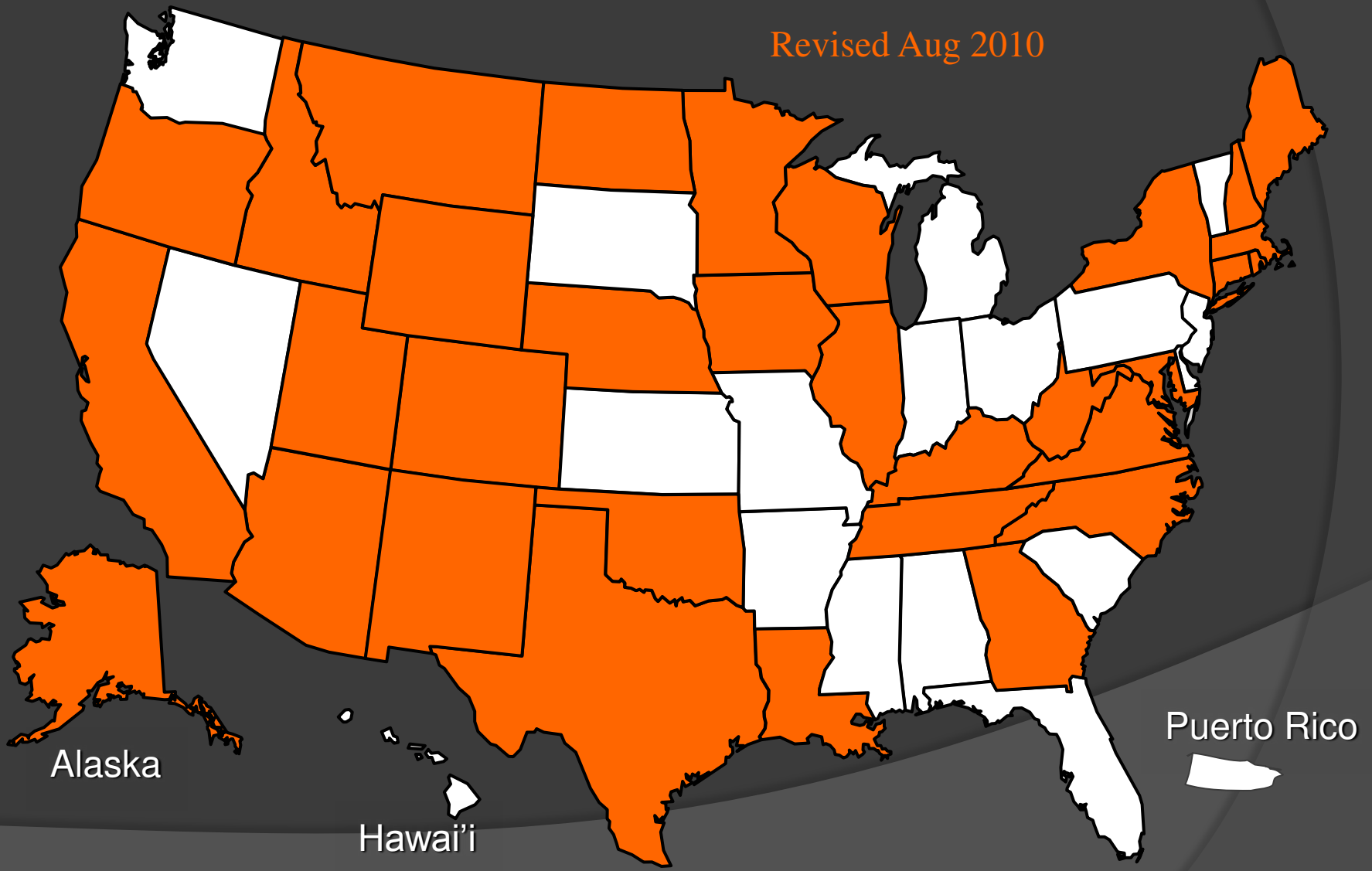
Gross Findings:

2. Effusions under skin and into body cavity

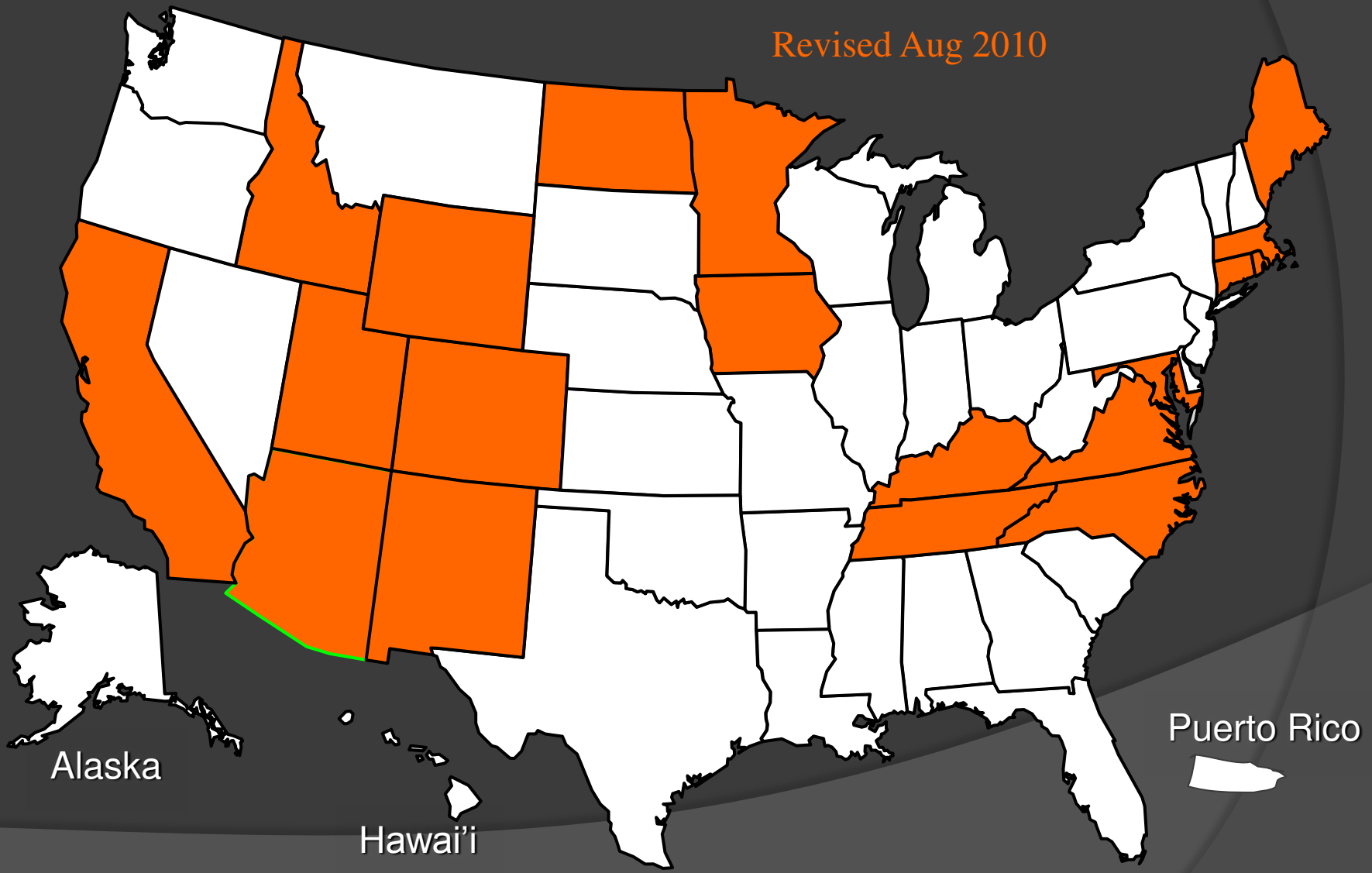


Bunch of dead decaying tadpoles

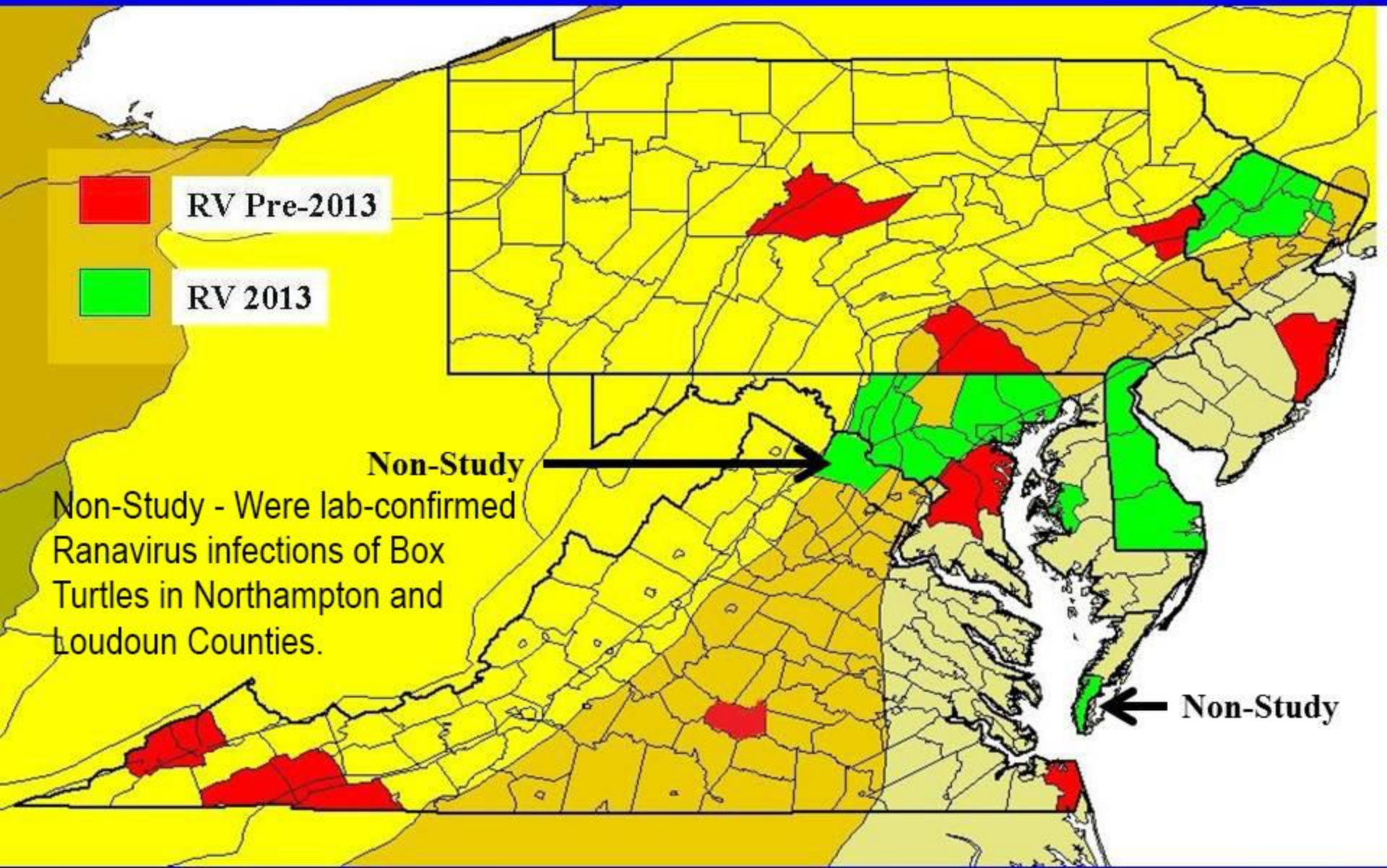
Ranavirus Die-offs: Frogs and Toads (tadpoles)



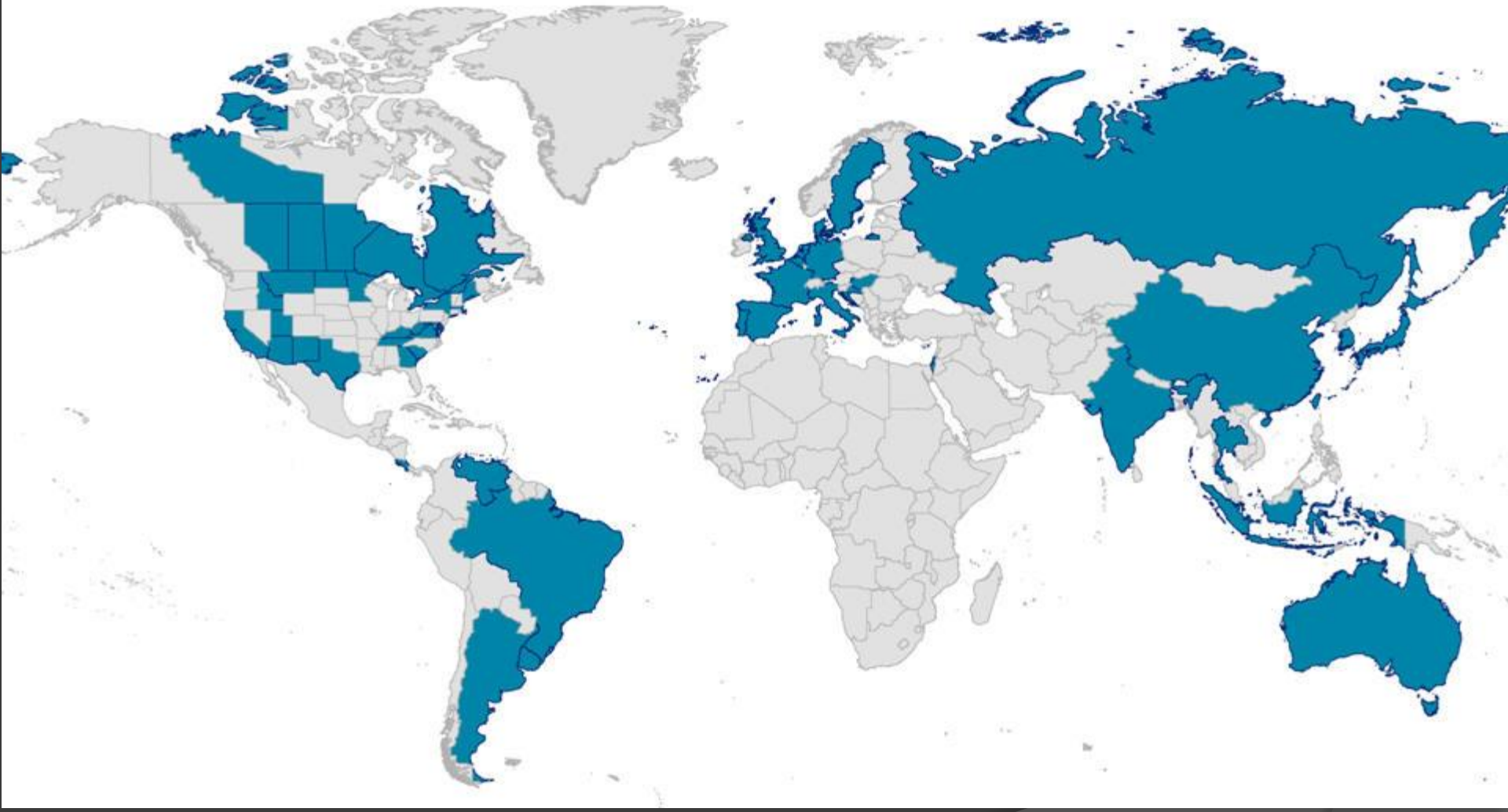
Ranavirus Die-offs: Salamanders (larvae)



Counties of Lab-Confirmed Ranavirus (RV)



Global Distribution of Ranaviruses



Source: Global Ranavirus reporting system (2013)

3) *Perkinsus*-like Organism

- Kills ranid tadpoles only, rarely other spp.
- Die-offs may continue for weeks with bloated weak tadpoles floating on surface
- Often causes >90% mortality of ranid tadpoles in a pond (hence, little recruitment)

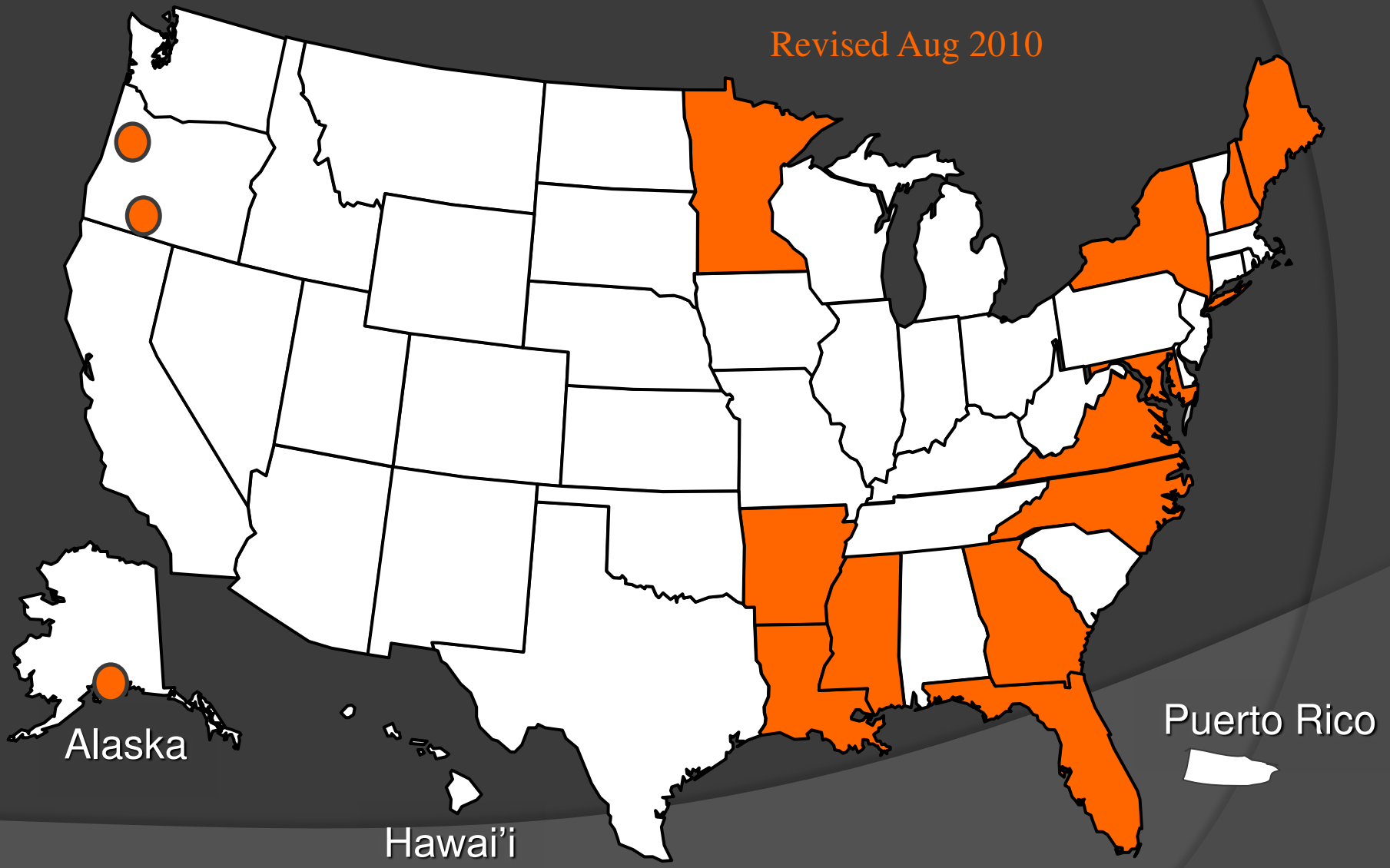
Mississippi gopher frog (*Rana sevosa*)

Perkinsus-like Organism: Gross Findings

- Mildly to massively enlarged light yellow liver, spleen, pronephroi & mesonephroi

- Abdominal distention

Perkinsus-like Organism: Distribution



4) Ichthyophoniasis

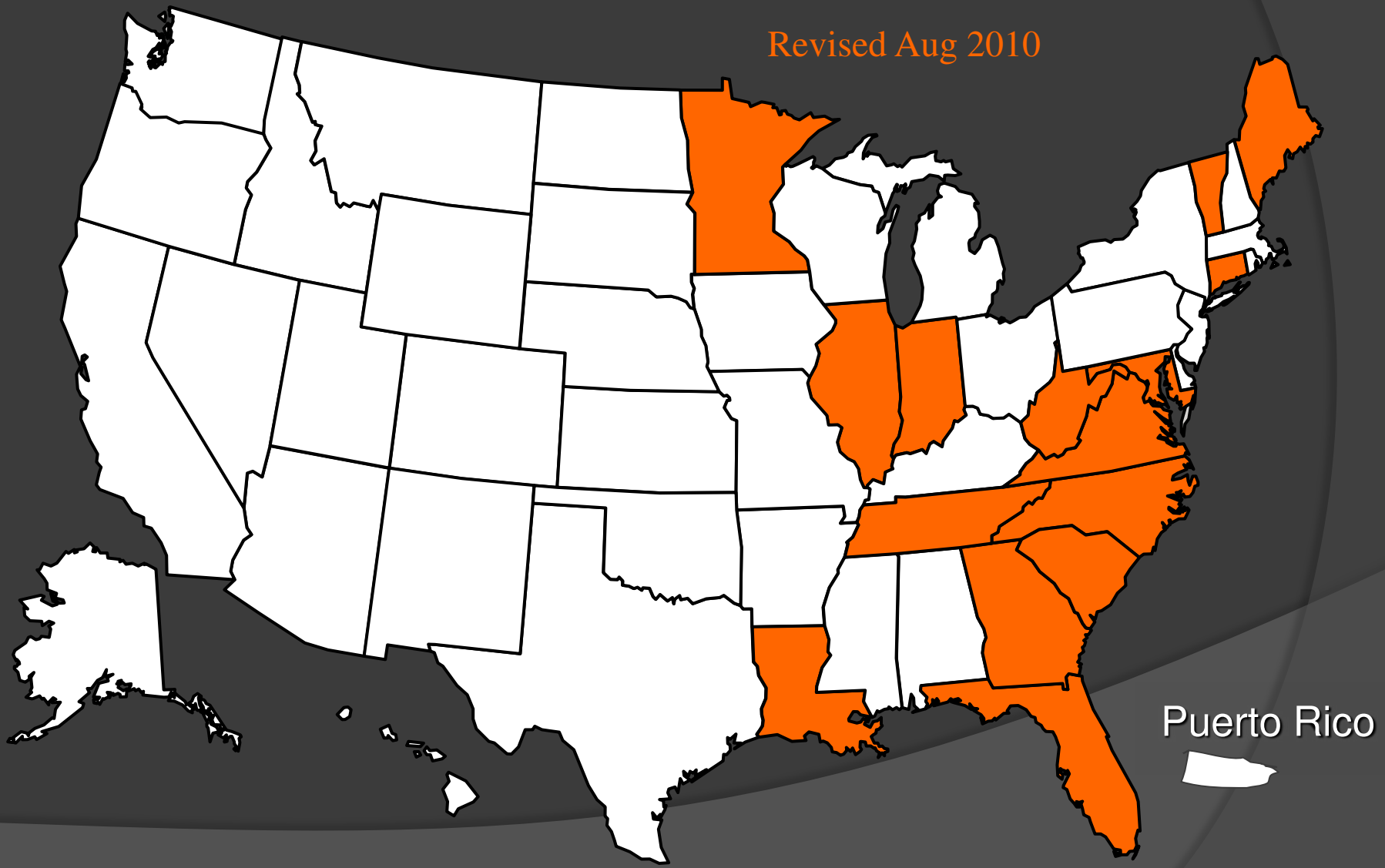
1. Definition: A slight to severe (and lethal) infection of amphibian skeletal muscle

"Swollen rump" in recently metamorphosed frogs

Lethal Infections occur in

Eastern red-spotted newts
Larval *Rana* spp.
Adult Rana spp.

Amphibian Ichthyophoniasis: Distribution



5) *Ribeiroia ondatrae*-induced Malformations:

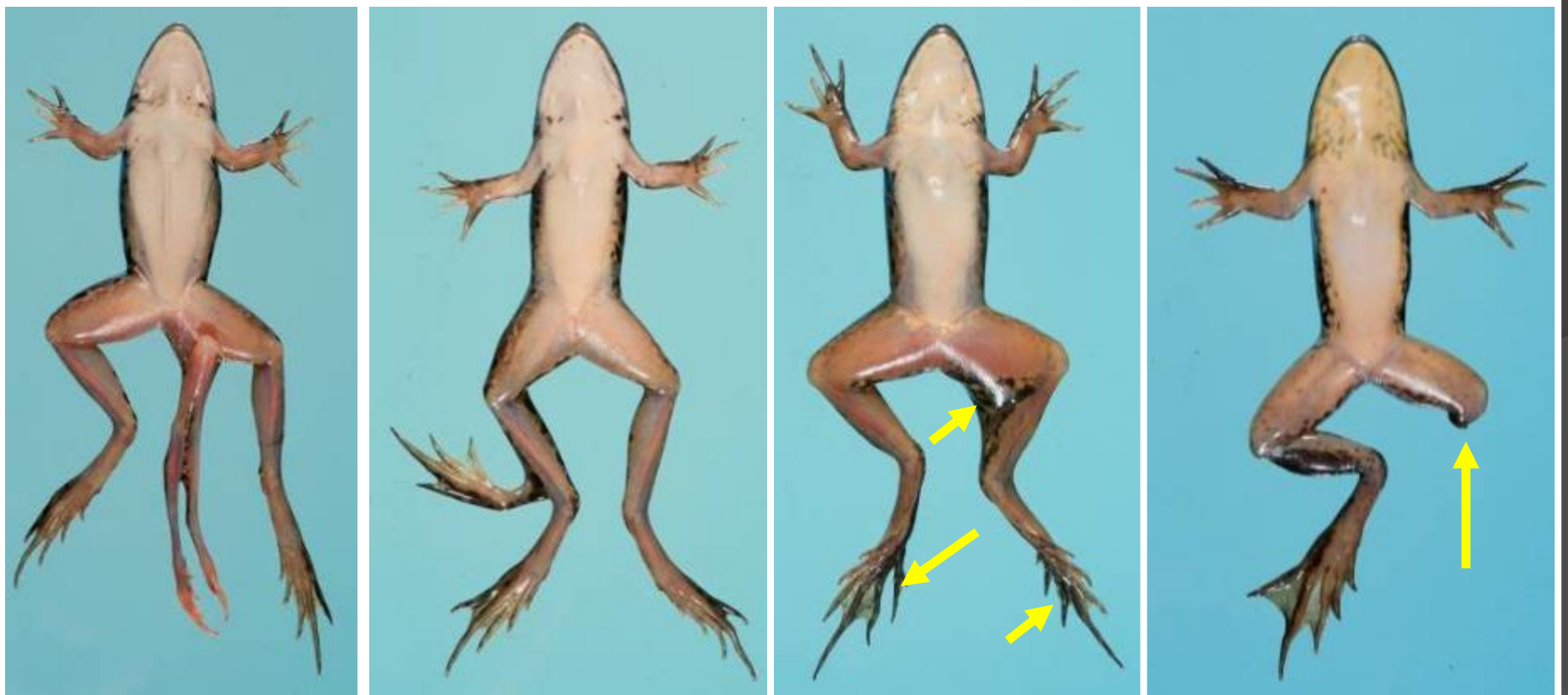
Infection by metacercariae must occur at very specific tadpole ages to induce malformation (Gosner 26-28)

Polymelia

Polypodia

Polydactyly & Skin Web

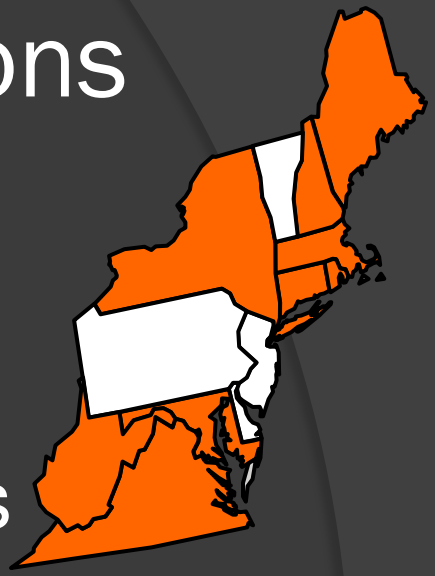
Ectromelia



Now that we know what we're looking for…

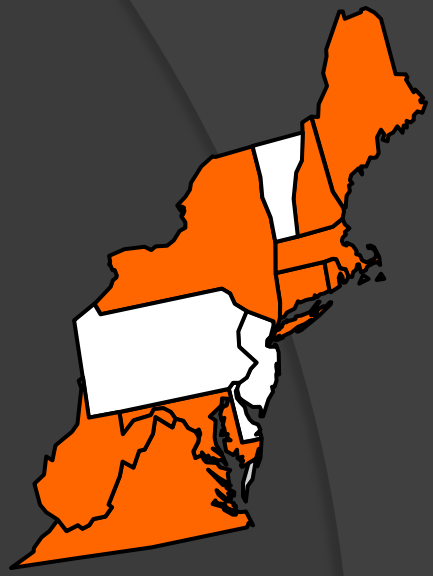
And where it has been found…

Sampling design considerations for amphibian diseases



- Interest in diseases at multiple levels
  - Mapping – detections/dieoffs
  - Number of ponds affected
  - Prevalence at an infected pond
  - Temporal and spatial dynamics
  - Population-level effects

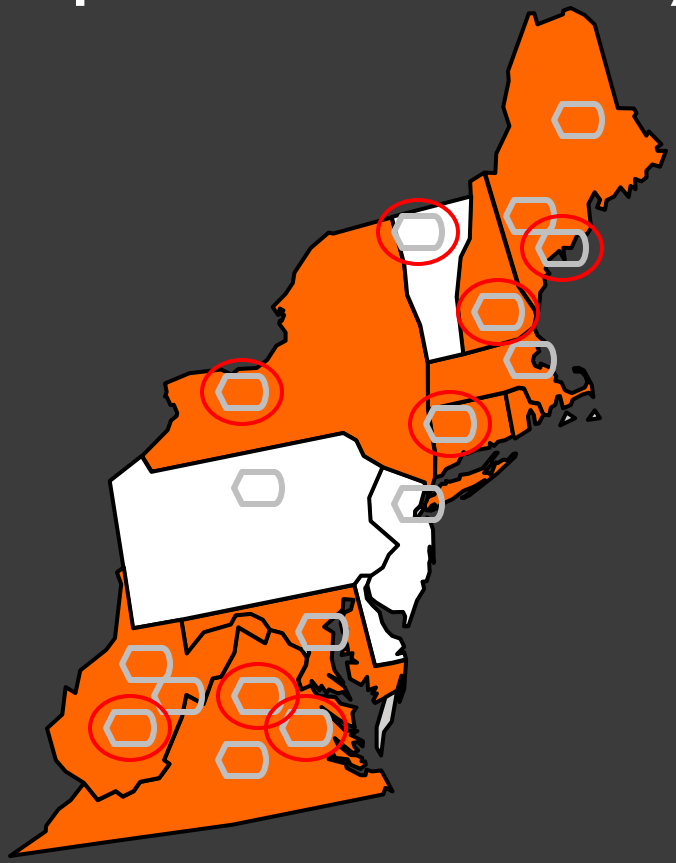
Two primary challenges



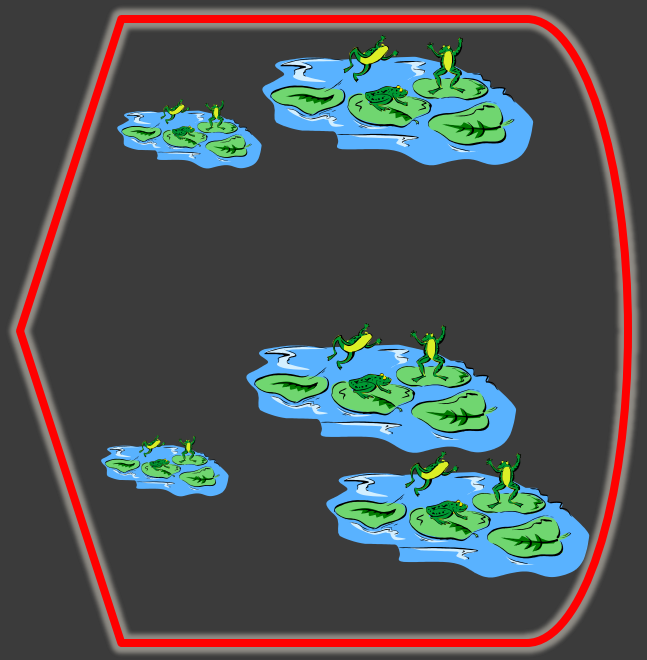
(1) addressing uncertainty with (only partially) observed disease dynamics in the wild

(2) determining how environmental, spatial, and community processes interact to cause outbreaks and disease persistence.

Challenge 1: Uncertainty (False positives and/or negatives)

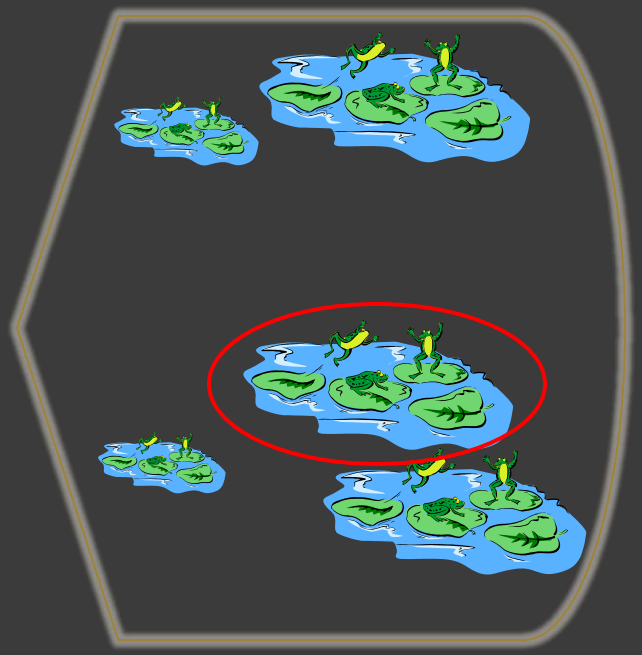


McClintock et al. 2010.
Ecol Lett. 13:659



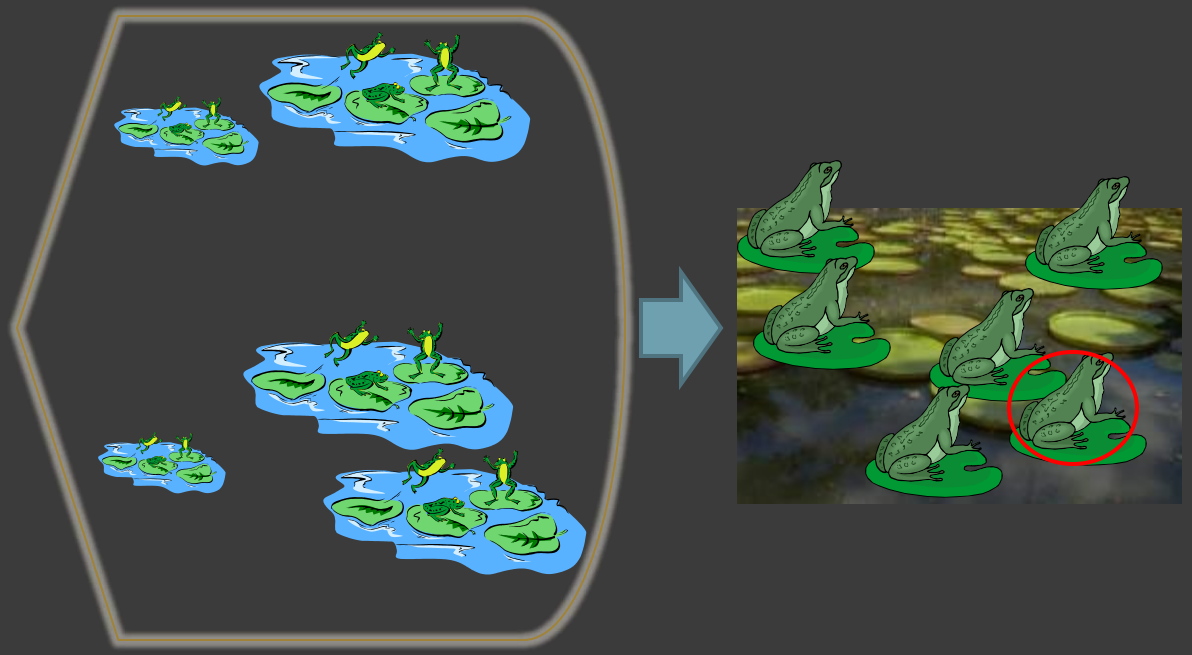
Uncertainty at each level:

Pr(Refuge contains disease)

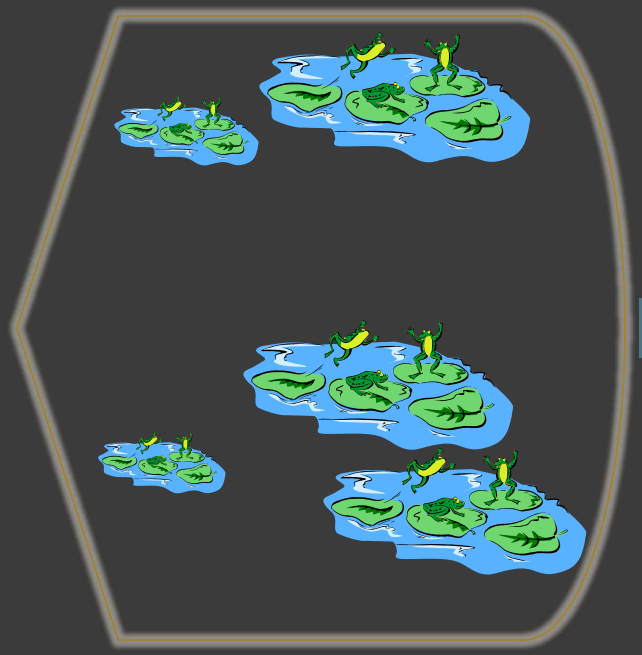


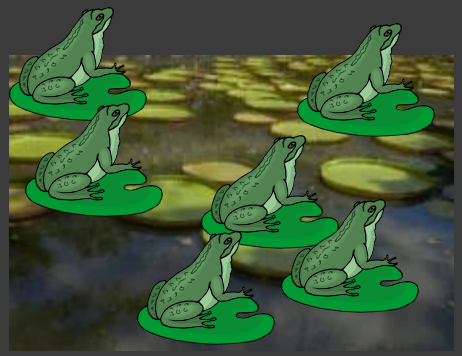
Pr(Refuge contains disease)

Pr(Pond diseased | Refuge diseased)



Pr(Refuge contains disease)
Pr(Pond diseased | Refuge diseased)
Pr(Frog diseased | Pond diseased)





Pr(Refuge contains disease)
Pr(Pond diseased | Refuge diseased)
Pr(Frog diseased | Pond diseased)
Pr(Detect disease | Frog diseased)

Ignoring uncertainty

- False + and/or – errors
  - Results in biased estimates of presence, prevalence and dynamics.

- We need to design methods and apply sampling to efficiently address these sources of uncertainty.
  - Probabilistic choice of sampling units
  - Repeat sampling in space and time
  - How to allocate effort across the hierarchy?

2) Determining causes of outbreaks and disease persistence

- Sampling design considerations (what, when, where)
- Statistical methods which account for imperfect detection
- Combinations of field and laboratory studies

- Research needs:
  - Pathogen ecology
  - Reservoirs/vectors - persistence
  - Mechanism(s) for outbreaks
  - Influence of spatial structure of habitats

Recommendations and challenges

- Consider hierarchical nature of disease question (presence vs. prevalence; scale)?
- Dynamics in presence and prevalence – annual allocation of effort
- Uncertainty in *ecology* of many amphibian diseases.
- Management?
- Developing amphibian disease monitoring program for northeast - ehgrant@usgs.gov