Discussing and Understanding Animal Welfare Challenges in Research and Education on Wildlife, Non-Model Species and Biodiversity

Session 3: Wild Animal Population Concerns

Part 2: How the emergence of a wildlife disease led to the evolution of biosecurity efforts in the field & lab (m*ove this slide to where part 2 begins*)

Dr. Karen R. Lips
University of Maryland

Dr. Vance Vredenburg
San Francisco State University

Problem statement

(1) Wildlife pathogens/parasites and frequency of outbreaks are increasing in the wild (Emerging Infectious Diseases or EIDs)

(2) Most IACUC policies and guidelines are not designed for use with wildlife or their pathogens/parasites

(3) Research is necessary to understand challenges of EIDs, but doing so involves risk to researchers, study organisms, and their environments

(4) Need to develop policies to ensure human safety, support wildlife research, and reduce environmental health risks related to EIDs and invasive organisms

Talk outline:

(1) Background: Biodiversity conservation

(2) Early biosecurity & precautions in the **field** (eg, gloves & bleach; vehicles

(3) Conservation of wild populations; surveys, manipulations, collecting; (over)collecting)

(4) Who is Responsible for oversight/approvals & Who needs to know? (enforcement, regulation, tracking; communication between lab & field)

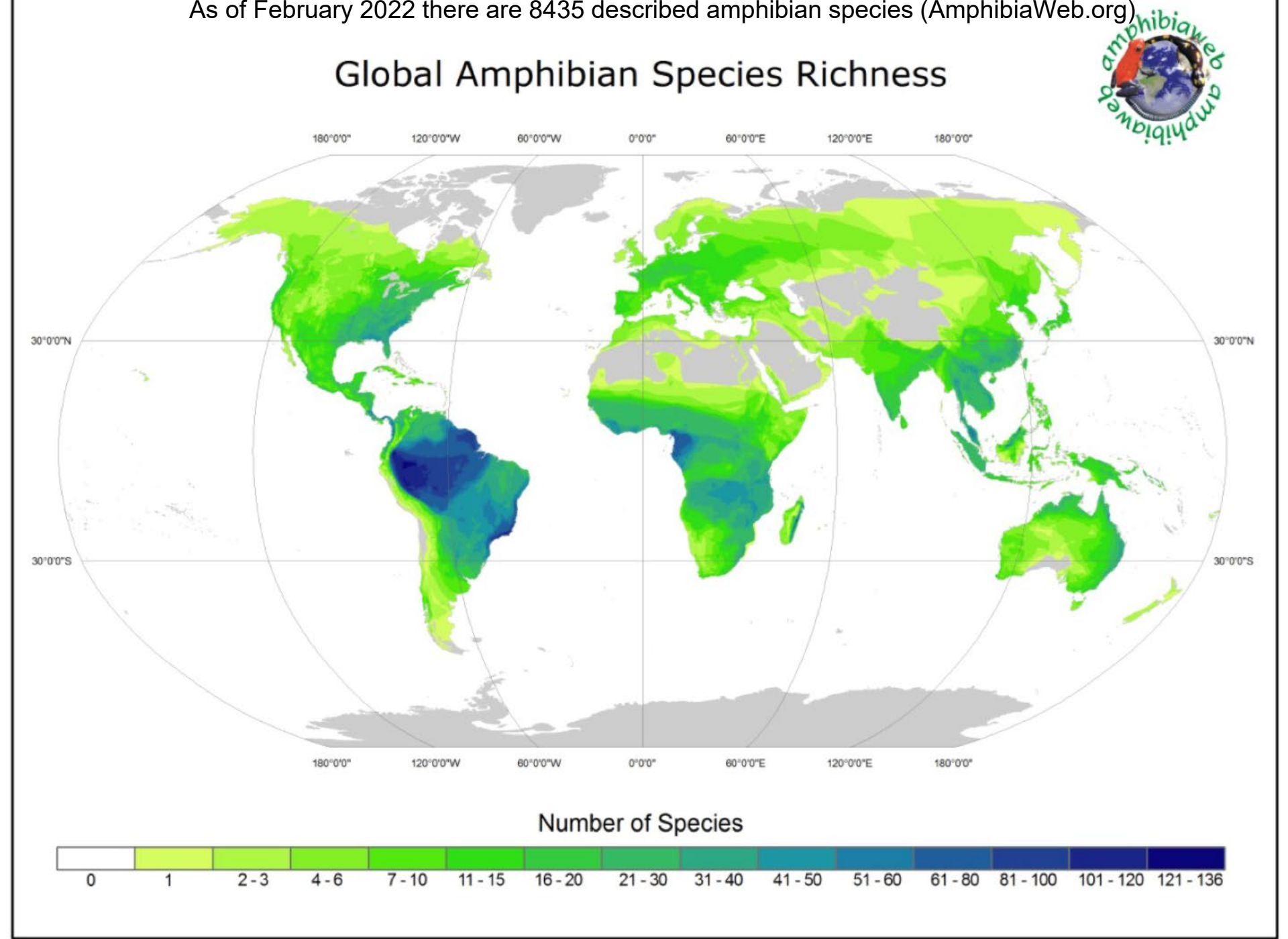
(5) Biosecurity & precautions in the lab (lab escapes, Bsal; shipping cultures and animals)

(6) Experimental manipulations (genetics, microbes) & field-Lab exchanges: (Re)Introducing captive/exposed/modified animals into field sites

(7) Future concerns (crisper, bioengineering)

(8) Recommendations

As of February 2022 there are 8435 described amphibian species (AmphibiaWeb.org)

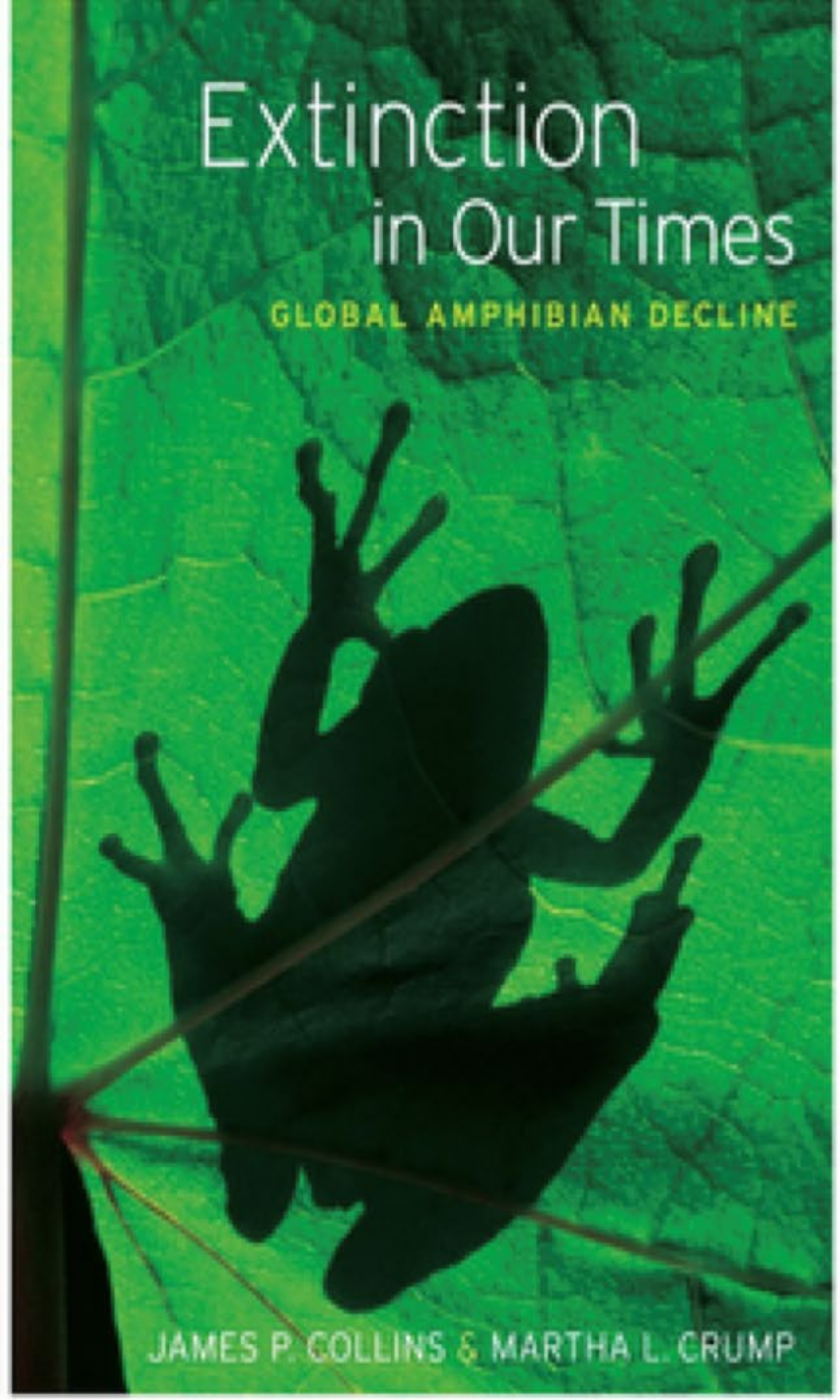


Amphibians: ~390 Million Years of Evolution

“wolverine frog”

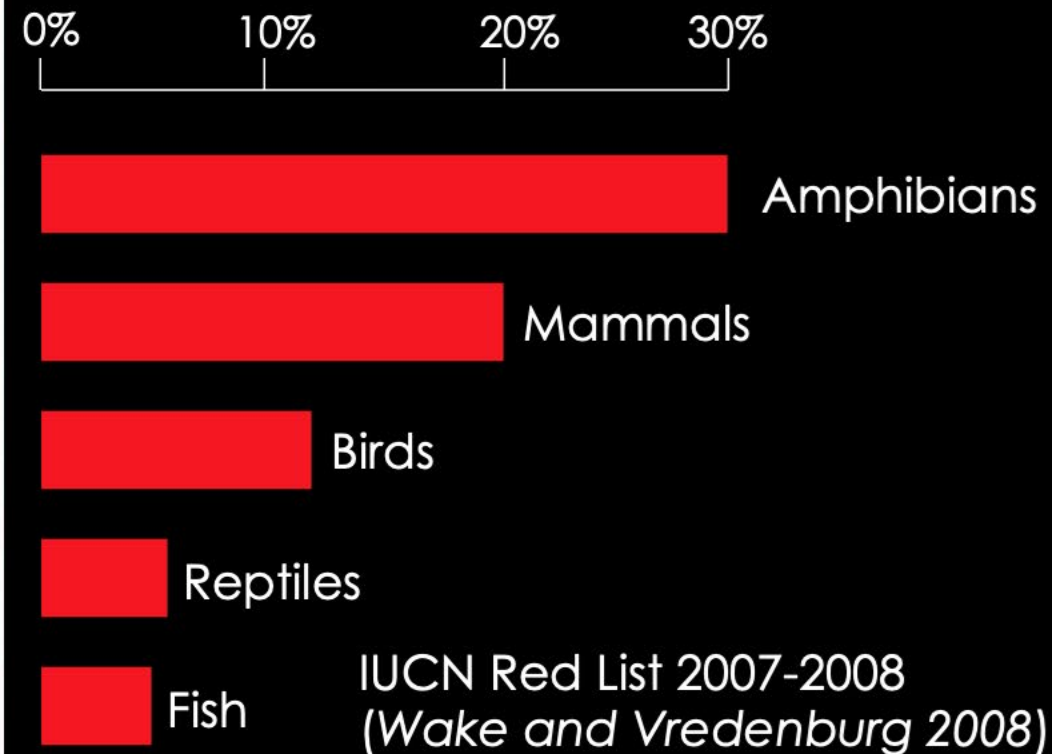
Gastric brooding frog

Chinese Giant salamander

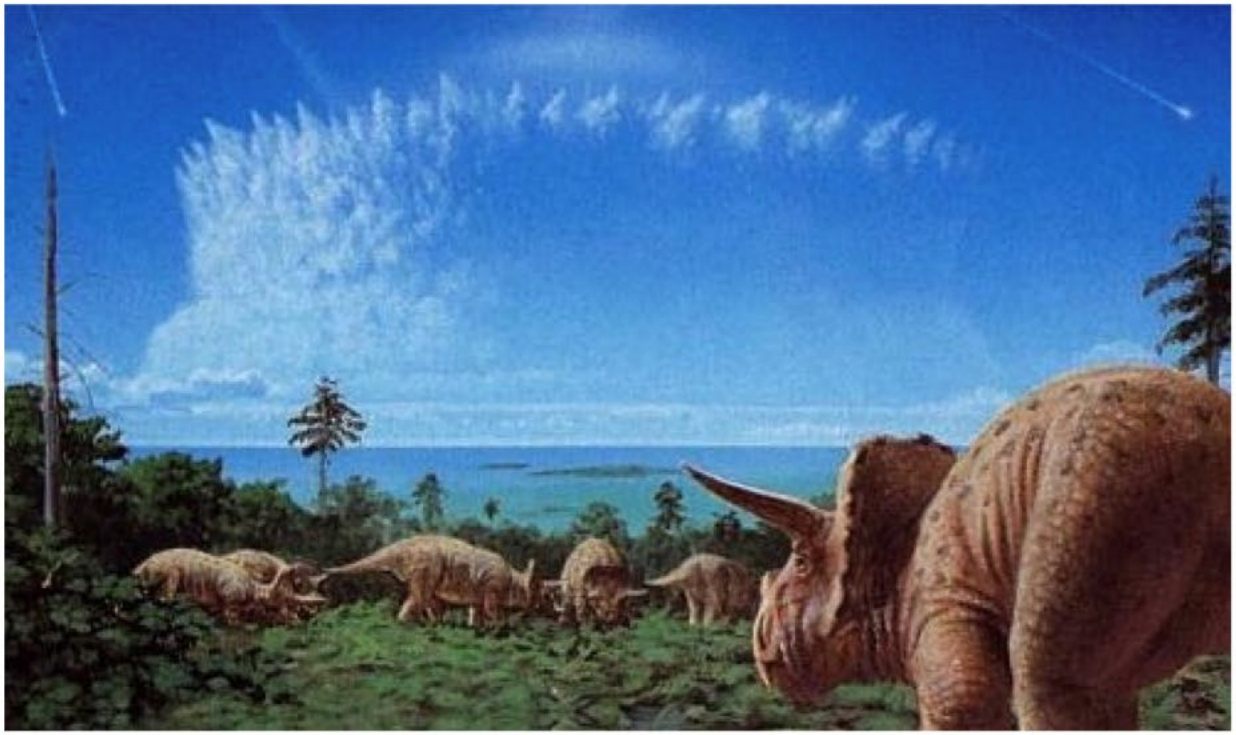


8435 described Amphibian Species

- 41% declining
- 30% threatened with extinction



IUCN Red List 2007-2008
(*Wake and Vredenburg 2008*)



PNAS

Are we in the midst of the sixth mass extinction? A view from the world of amphibians

David B. Wake*† and Vance T. Vredenburg*‡

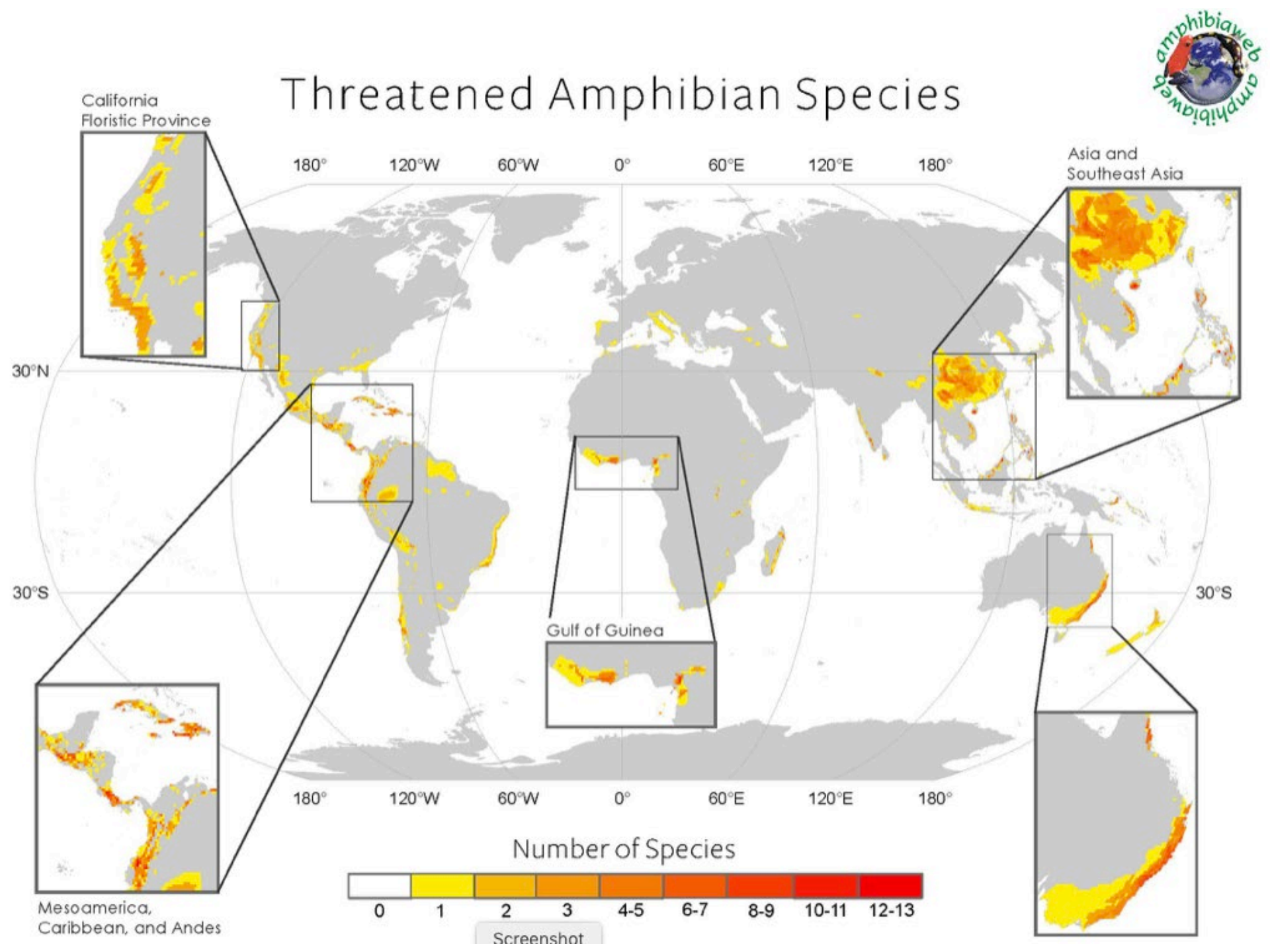
*Museum of Vertebrate Zoology and Department of Integrative Biology, University of California, Berkeley, CA 94720-3160; and ‡Department of Biology, San Francisco State University, San Francisco, CA 94132-1722

Many scientists argue that we are either entering or in the midst of the sixth great mass extinction. Intense human pressure, both direct and indirect, is having profound effects on natural environments. The amphibians—frogs, salamanders, and caecilians—may

families and nearly 60% of the genera of marine organisms were lost (1, 2). Contributing factors were great fluctuations in sea level, which resulted from extensive glaciations, followed by a period of great global warming. Terrestrial vertebrates had not

(Wake and **Vredenburg** 2008; *PNAS*)

Threatened Amphibian Species



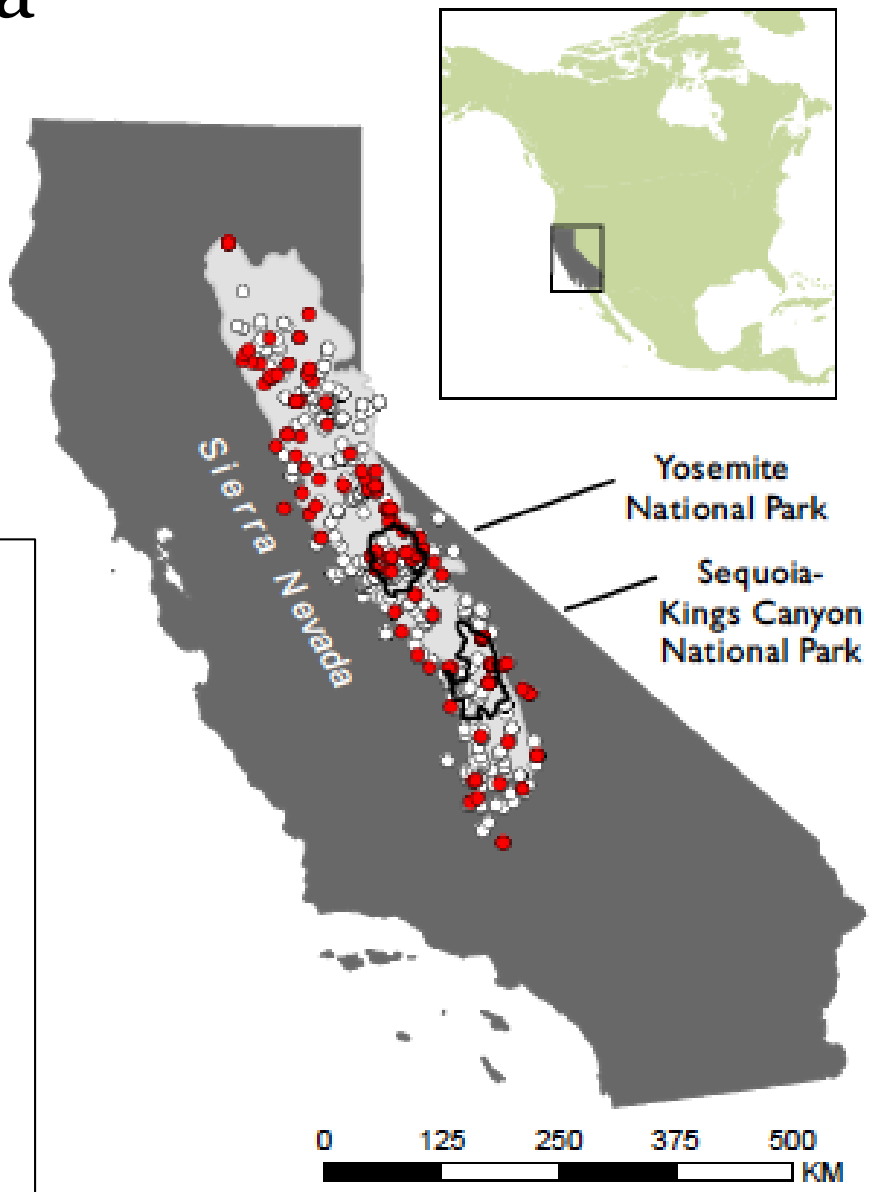
Screenshot

Sierra Nevada of California
A protected landscape

Why are so many species in decline?

High elevation amphibians (> 1,500 m)

- *Hydromantes platycephalus*
- *Hydromantes spp.*
- ***Ambystoma macrodactylum***
- *Hyliola regilla*
- ***Anaxyrus boreas***
- ***Anaxyrus canorus***
- ***Rana muscosa***
- ***Rana sierrae***



Sierra Nevada landscape:
1000-3400 m elevation
>15,000 lakes 90% have introduced trout

Emerging Infectious Disease

Disease: Chytridiomycosis
Described: Longcore et al. 1999

Pathogen: *Batrachochytrium dendrobatidis* (*"Bd"*)

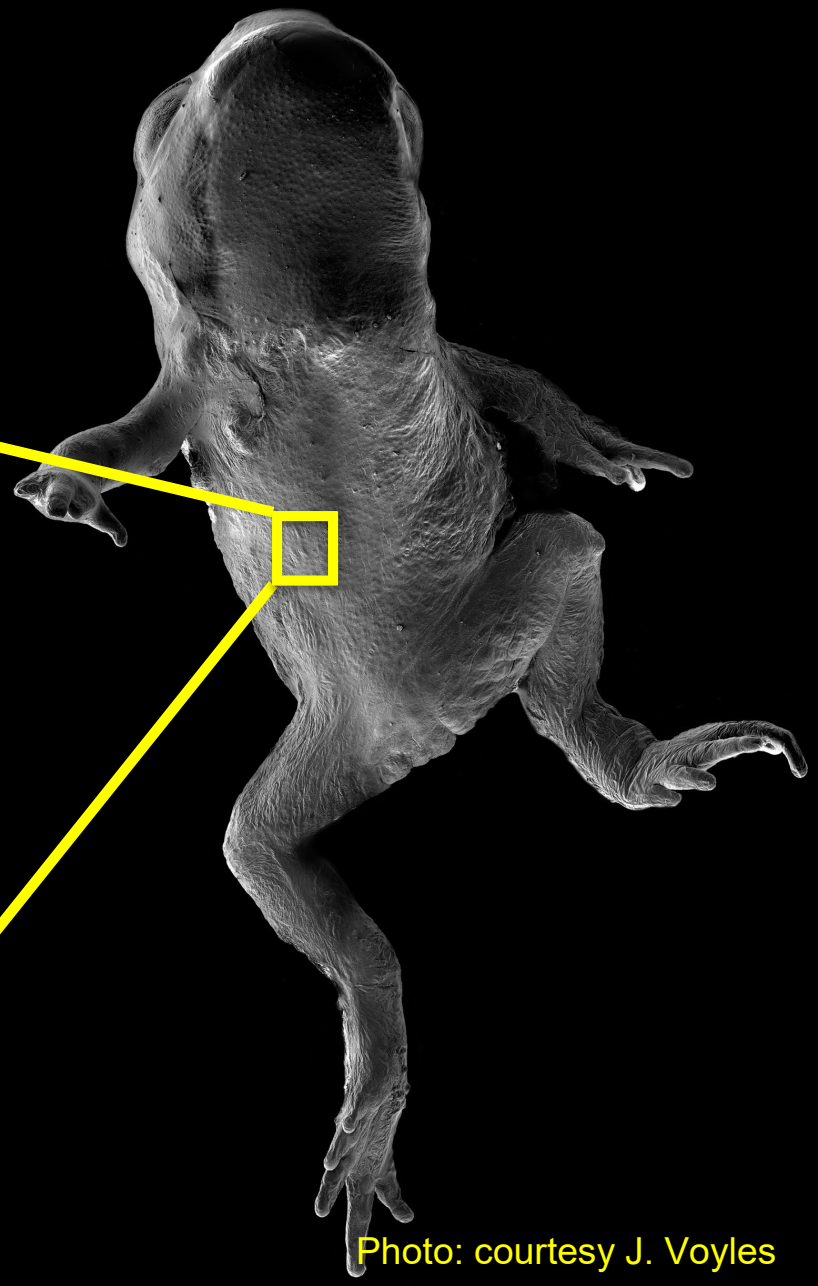


Photo: courtesy J. Voyles

Bd reproduces asexually on the skin of the frog host and spreads rapidly within and between hosts

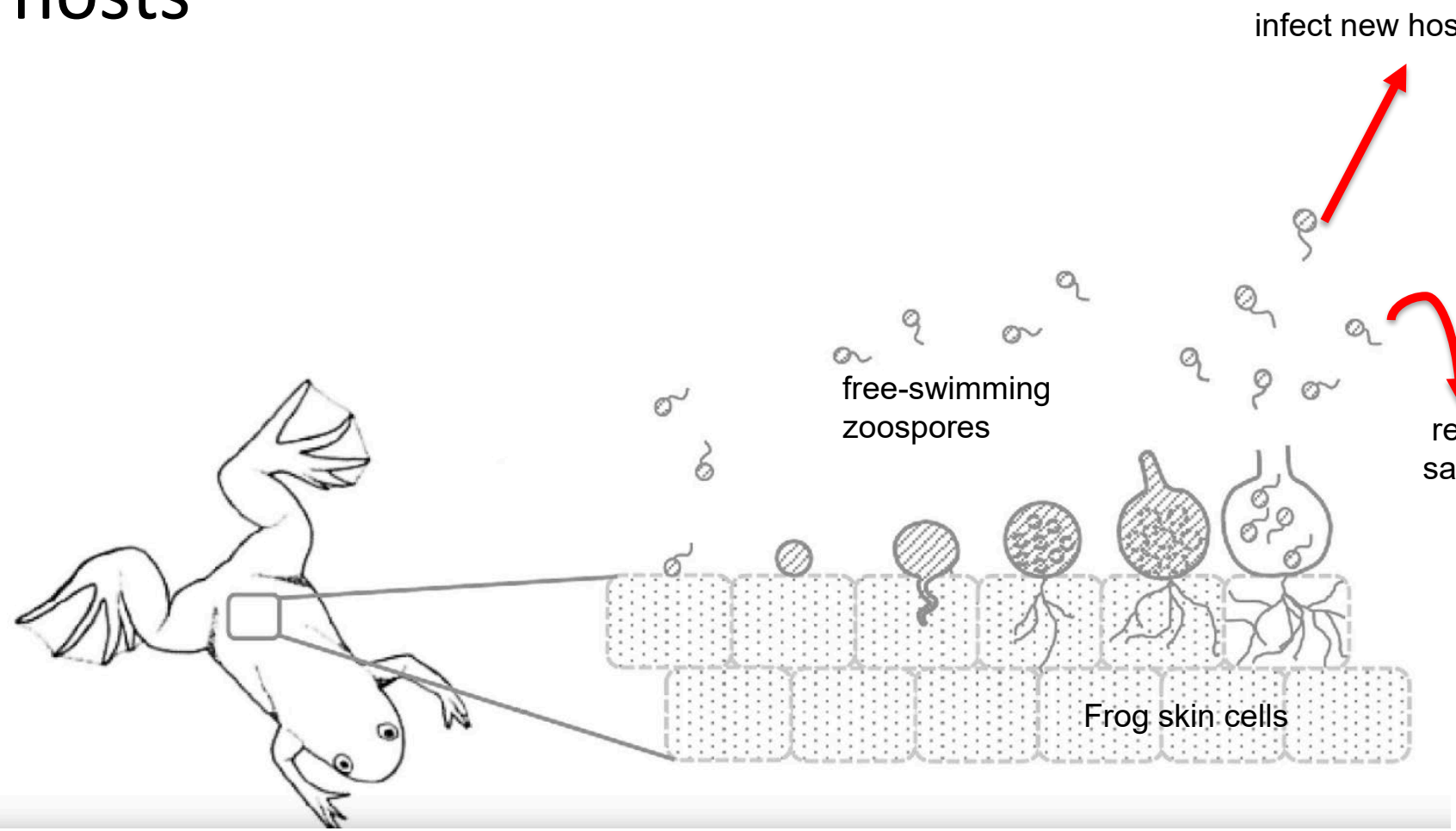
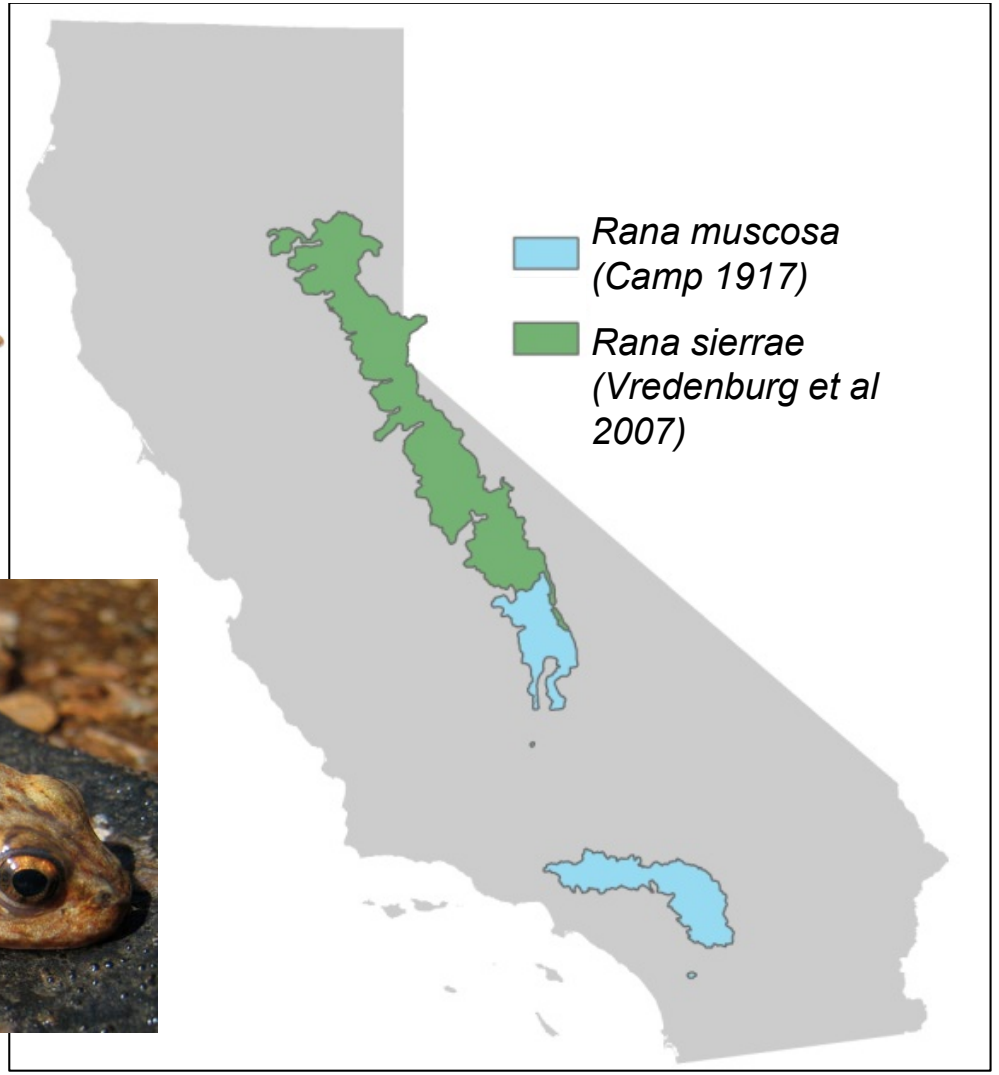


Figure adapted from Van Rooj, Housebrouk, and Pasmans 2015

NSF-NIH funded research:
Repeated visual population counts (>900; 1996–2008)
Skin swabs for pathogen assays (> 6,000; 2004-2008)

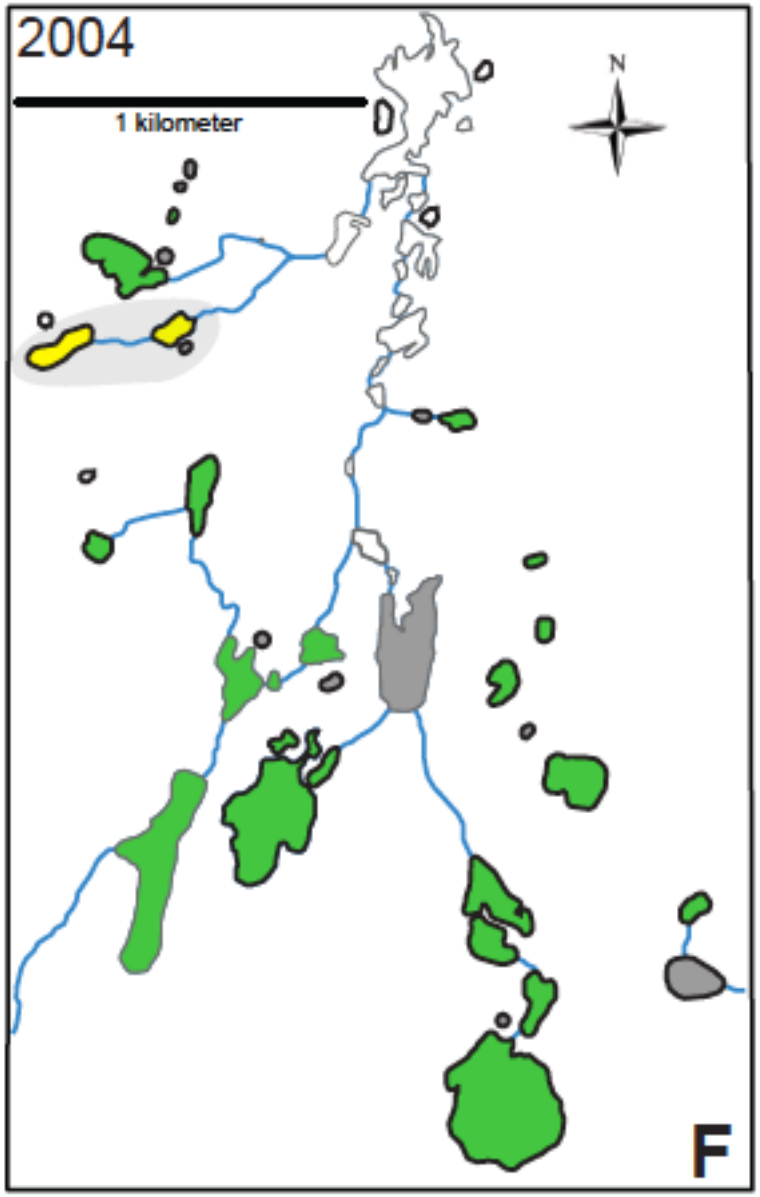
Mountain yellow-legged frogs and *Bd*

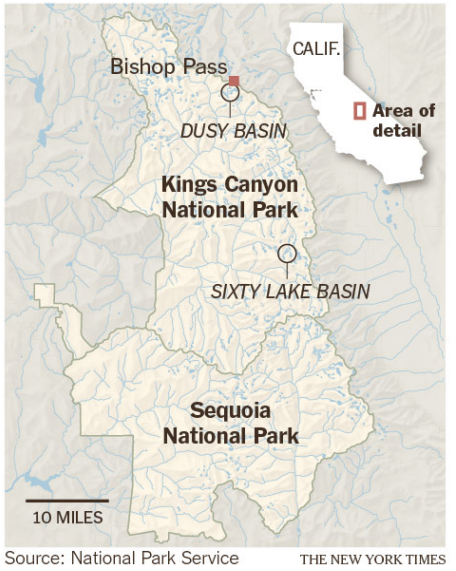


Vredenburg et al. 2007 Journal of Zoology

Key:

- Uninfected frog pop.
- Infected frog pop.
- Extirpated frog pop.
- No data





(**Vredenburg**, et al. 2010; *PNAS*)

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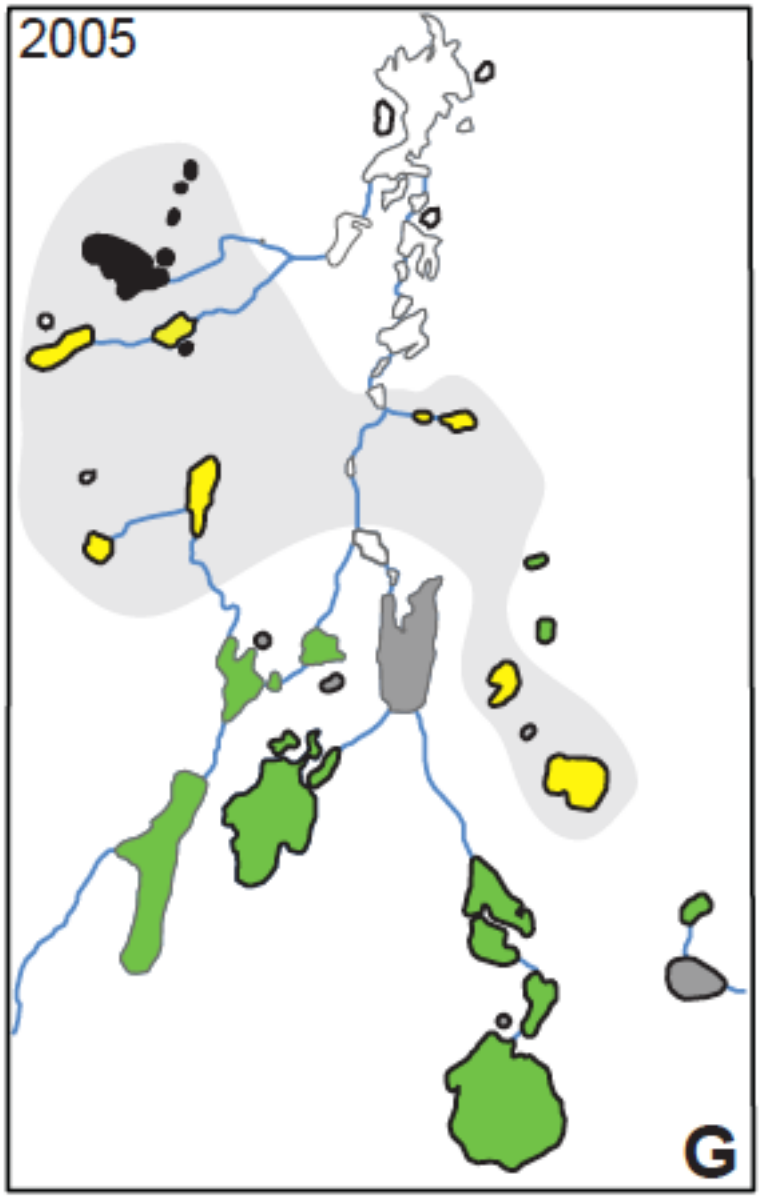

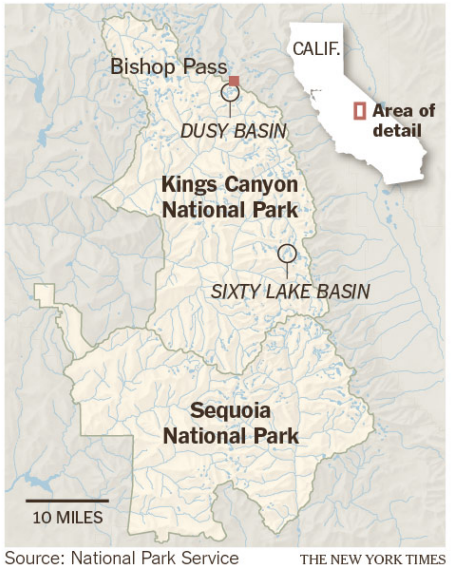

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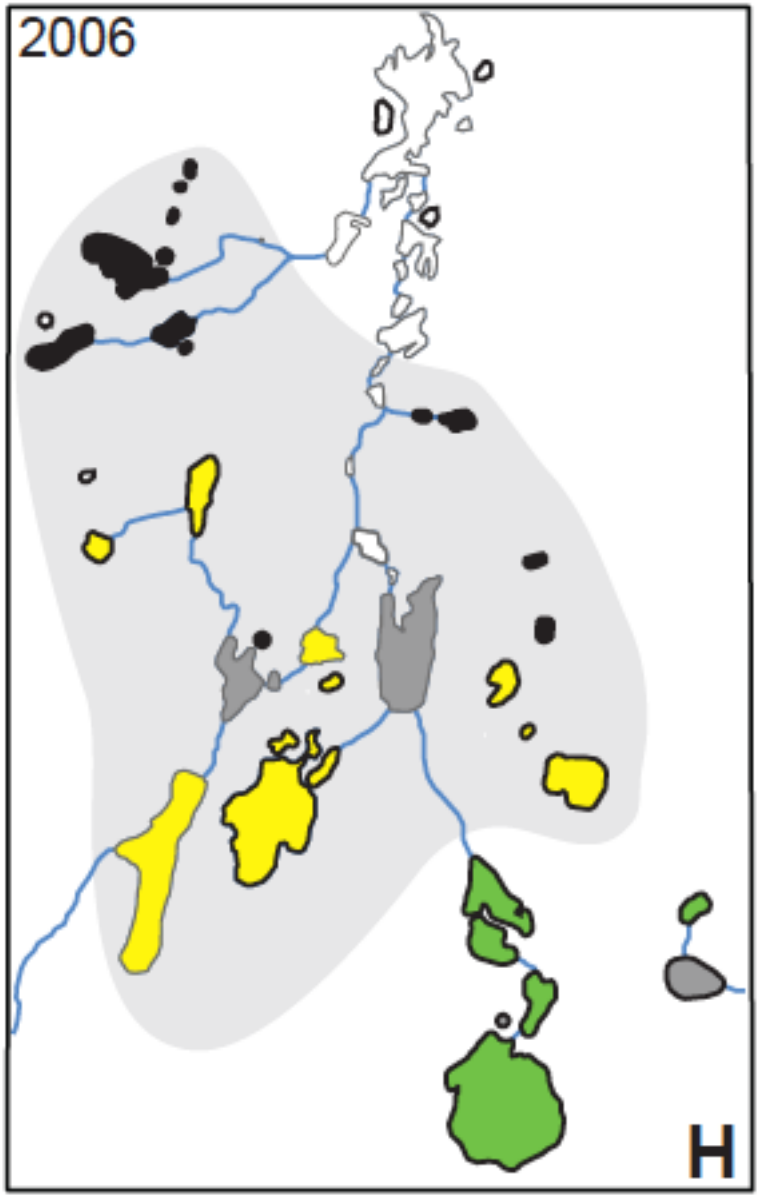

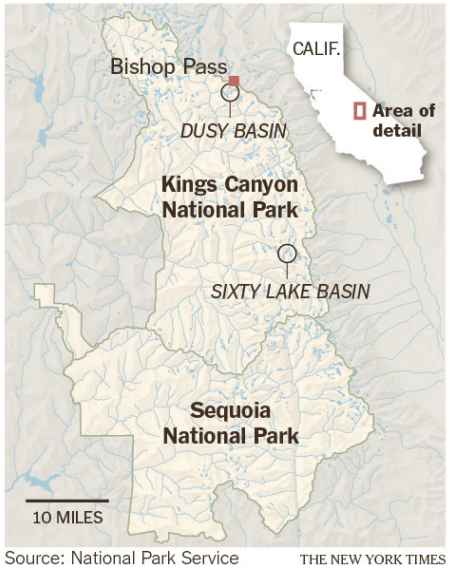

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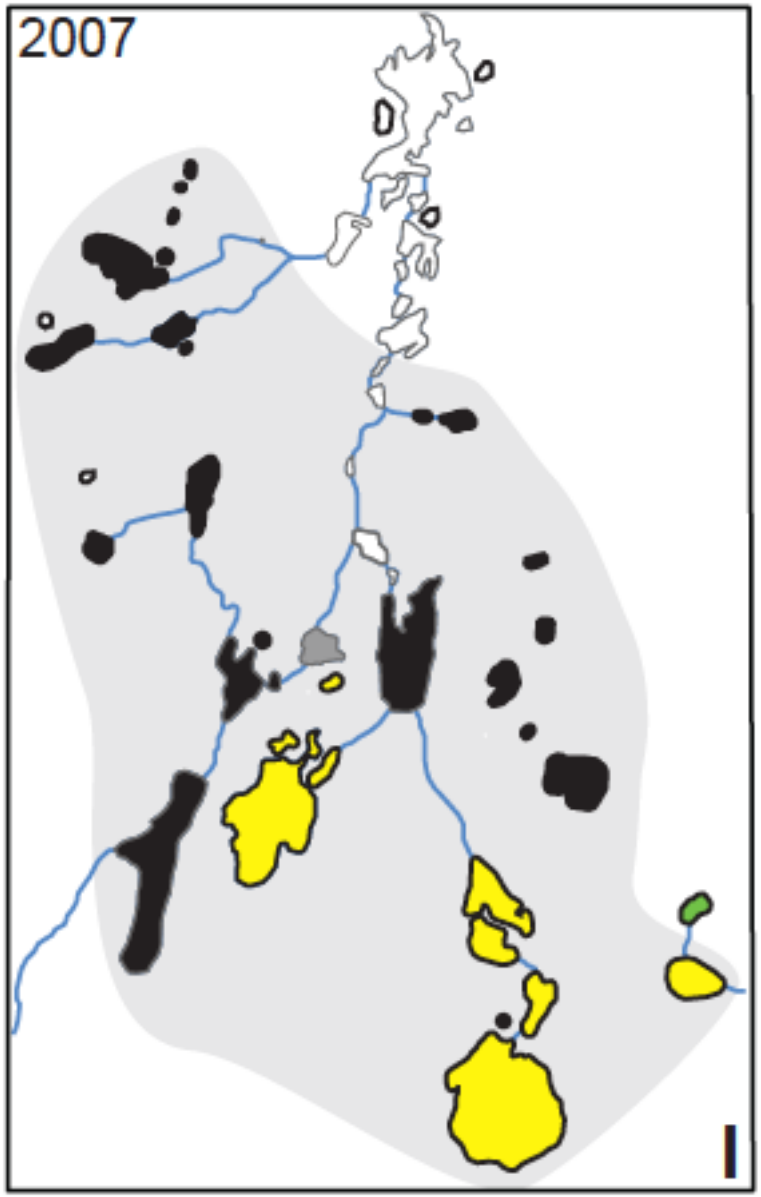

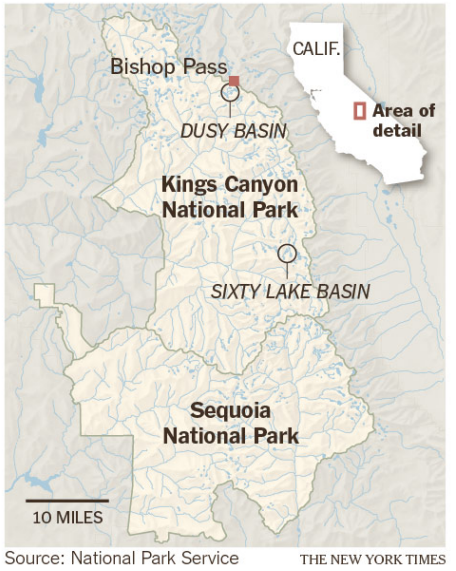

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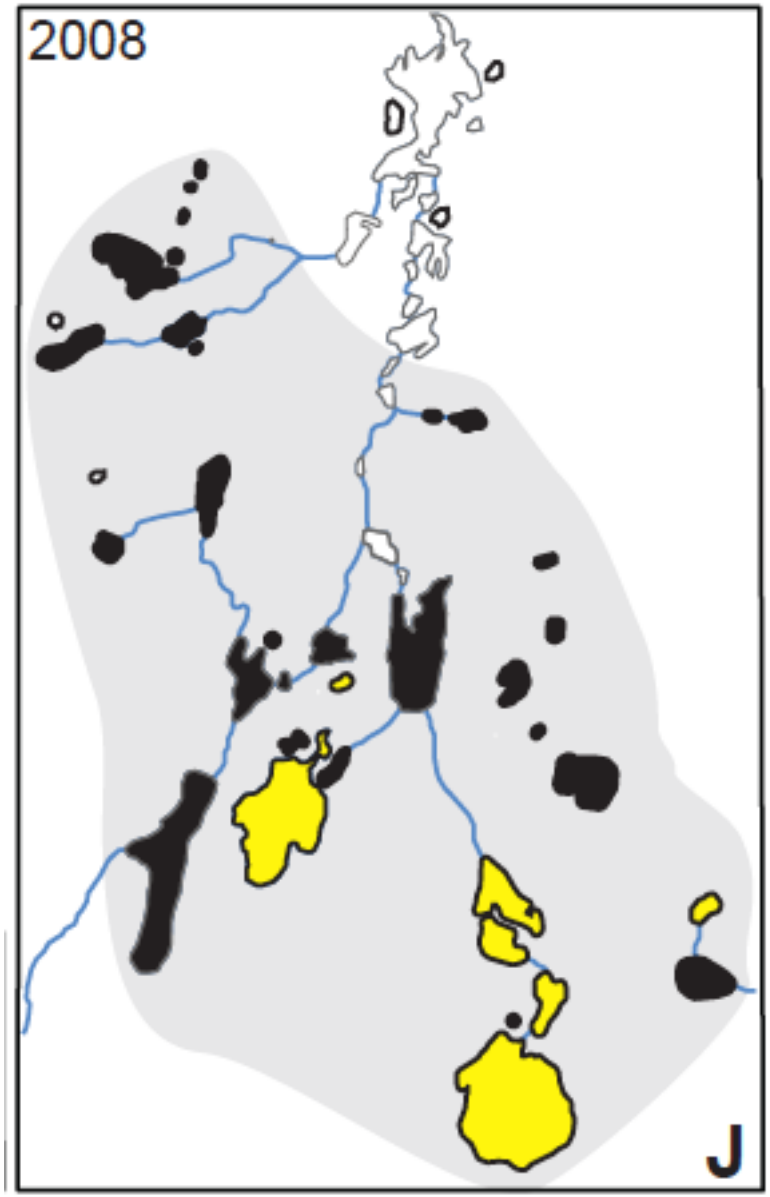
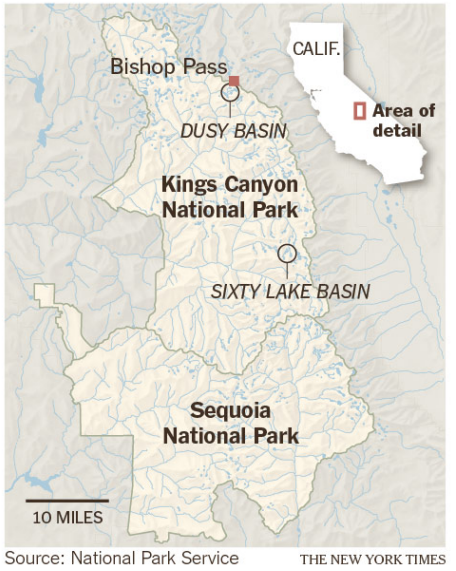
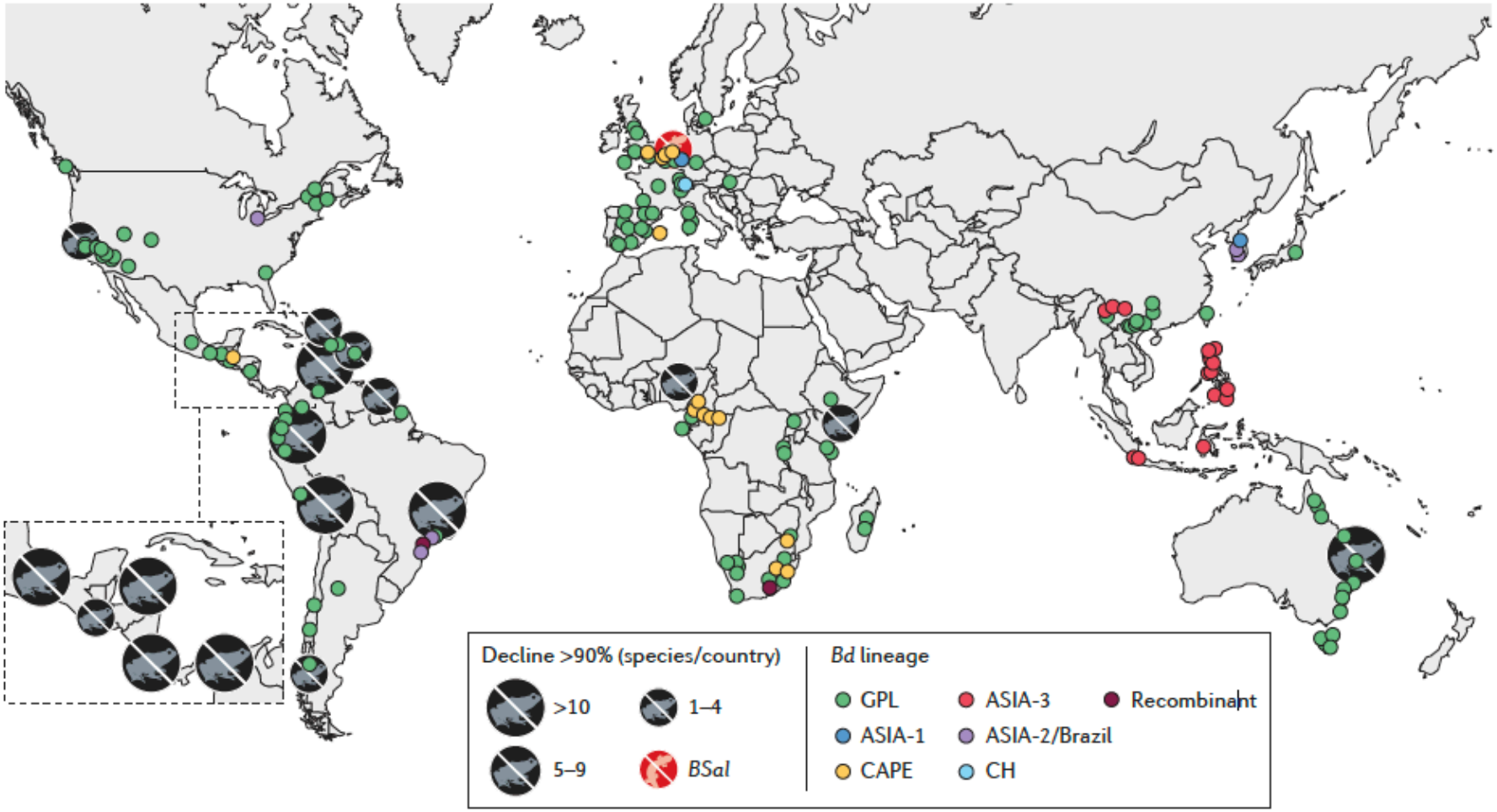




(**Vredenburg**, et al. 2010; *PNAS*)

Chytridiomycosis: over 500 species affected

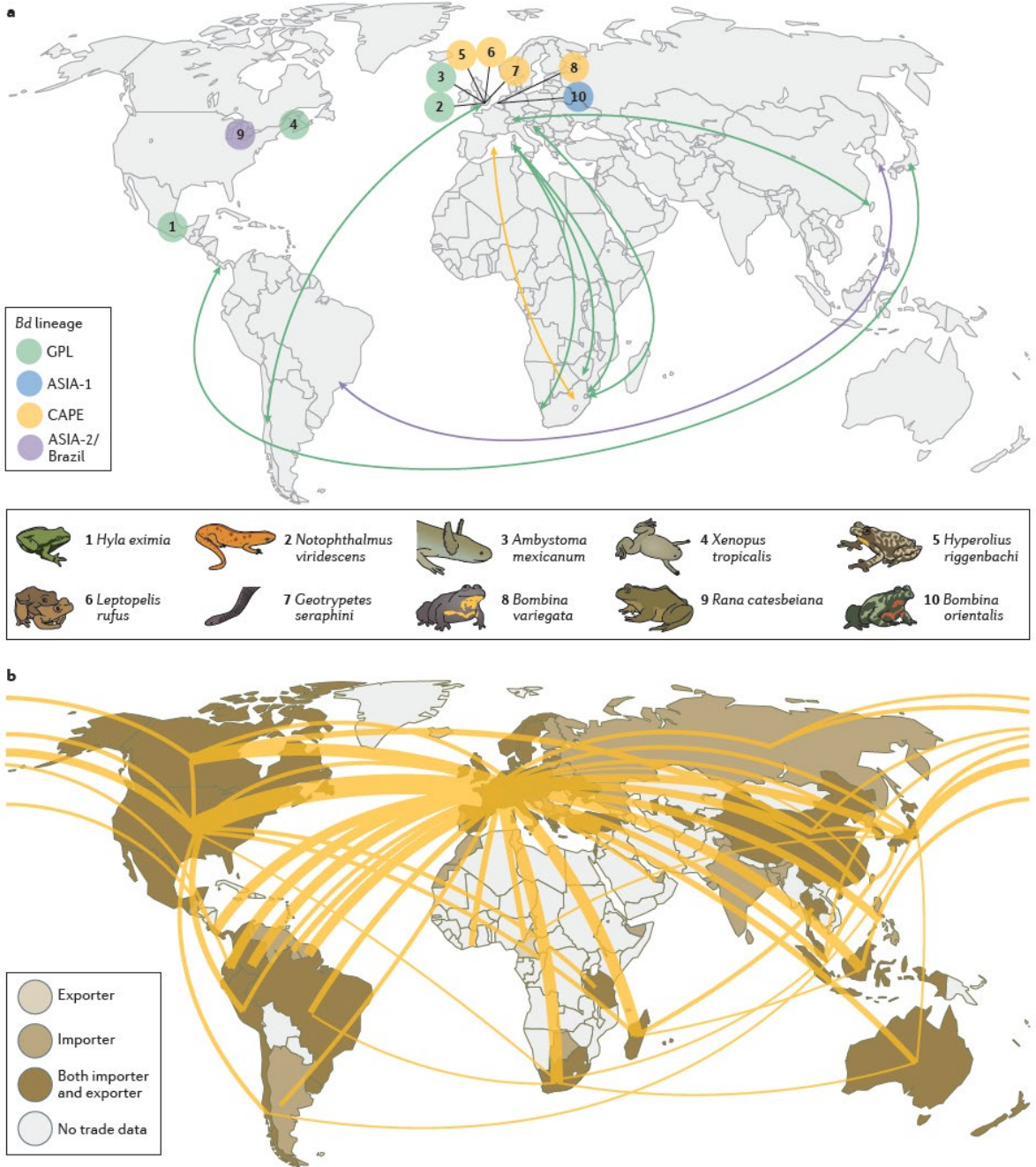
Figure 1



Fisher and Garner 2021

Figure 2

Global trade in live amphibians spreads fungal pathogen



Fisher and Garner 2021

Expect more pathogen invasions!

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Averting a North American biodiversity crisis

Tiffany A. Yap[1,2,3], Michelle S. Koo[2], Richard F. Ambrose[1,4], David B. Wake[2,5], Vance T. Vredenburg[2,3,*]

+ Author Affiliations

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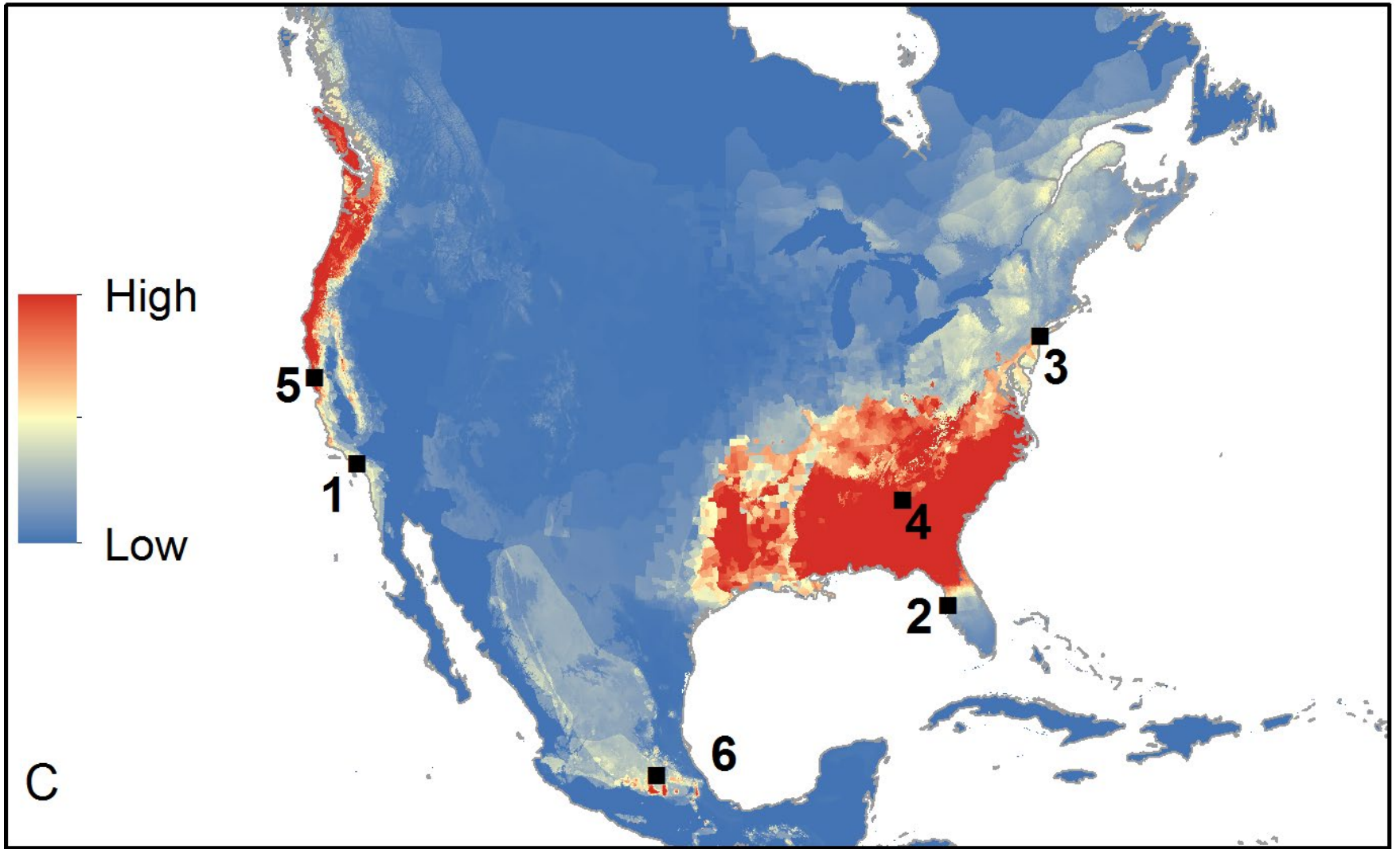
Science 31 Jul 2015:
Vol. 349, Issue 6247, pp. 481-482
DOI: 10.1126/science.aab1052

Bsal Salamander Vulnerability Model



Yap, Koo, Ambrose, Wake & Vredenburg, 2015, *Science*

Biosecurity in the lab

What species are susceptible??

(5) Biosecurity & precautions in the lab

(lab escapes, *Bsal*; shipping cultures and animals)

There are laboratories that are testing pathogenicity of different pathogens.

How do we let the research continue but in a safe way?

BIOLOGICAL CONSERVATION 138 (2007) 390–398

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/biocon

Symbiotic bacteria contribute to innate immune defenses of the threatened mountain yellow-legged frog, *Rana muscosa*

Douglas C. Woodhams[a,*], Vance T. Vredenburg[b], Mary-Alice Simon[c], Dean Billheimer[d], Bashar Shakhtour[d], Yu Shyr[d], Cheryl J. Briggs[b], Louise A. Rollins-Smith[a], Reid N. Harris[c]

The *Bd* pathogen invasion:
>200 species extinctions, >500 species infected.
What can we do?

1. NextGen sequencing: skin microbiome and metagenomics for pathogen discovery

2. Identify bacterial cultures as bioaugmentation tools to protect against fungal infection

3. Use Zoos to help re-introduction experiments

Local Conservation Efforts

The care of wildlife extends far beyond the Zoo's gates. Learn more about our leading roles in conserving western pond turtles and Mountain yellow-legged frogs.

Western Pond Turtle (WPT) Project

A partnership between the San Francisco Zoo, the Oakland Zoo, and Sonoma State University. Project goals are to determine the critical temperature and timing of sex determination in WPT to optimize male-female sex ratios for ex-situ incubation and to establish a WPT head starting program at San Francisco and Oakland Zoos. These goals are essential to the immediate conservation and ultimate recovery of the turtle.

Watch this video about the project

More information

Mountain Yellow-legged Frogs

Mountain yellow-legged frogs are facing down an extinction threat throughout the Sierra Nevadas in California. The San Francisco Zoo and its partners are working together to keep these amazing frogs in their high mountain habitat by head-starting the most critically threatened populations and trying different techniques to boost numbers throughout the frog's range. Learn more about our newest project in Sequoia-Kings Canyon National Park.

More information

Conservation Programs
Animal Wellness
Local Conservation Efforts
Restoring Native Habitat
Working Green
Conservation Community

(6) Experimental manipulations & field-Lab exchanges

1. (Re)Introductions captive/exposed/modified animals into field sites animals infected with disease, or microbes.
2. experimental manipulations (genetics, microbes; multiple pathogens)
3. Add/remove disease or diseased animals at sites that could affect disease dynamics.
4. Can we inoculate animals and then reintroduce them?
5. Adding healthy animals could provide additional host resources that could produce additional disease epidemics, or increase environmental disease load (propagule pressure).
6. Bd, Bsal, ranavirus, snake fungal disease

Zoo animals and captive populations and the ethics of reintroductions

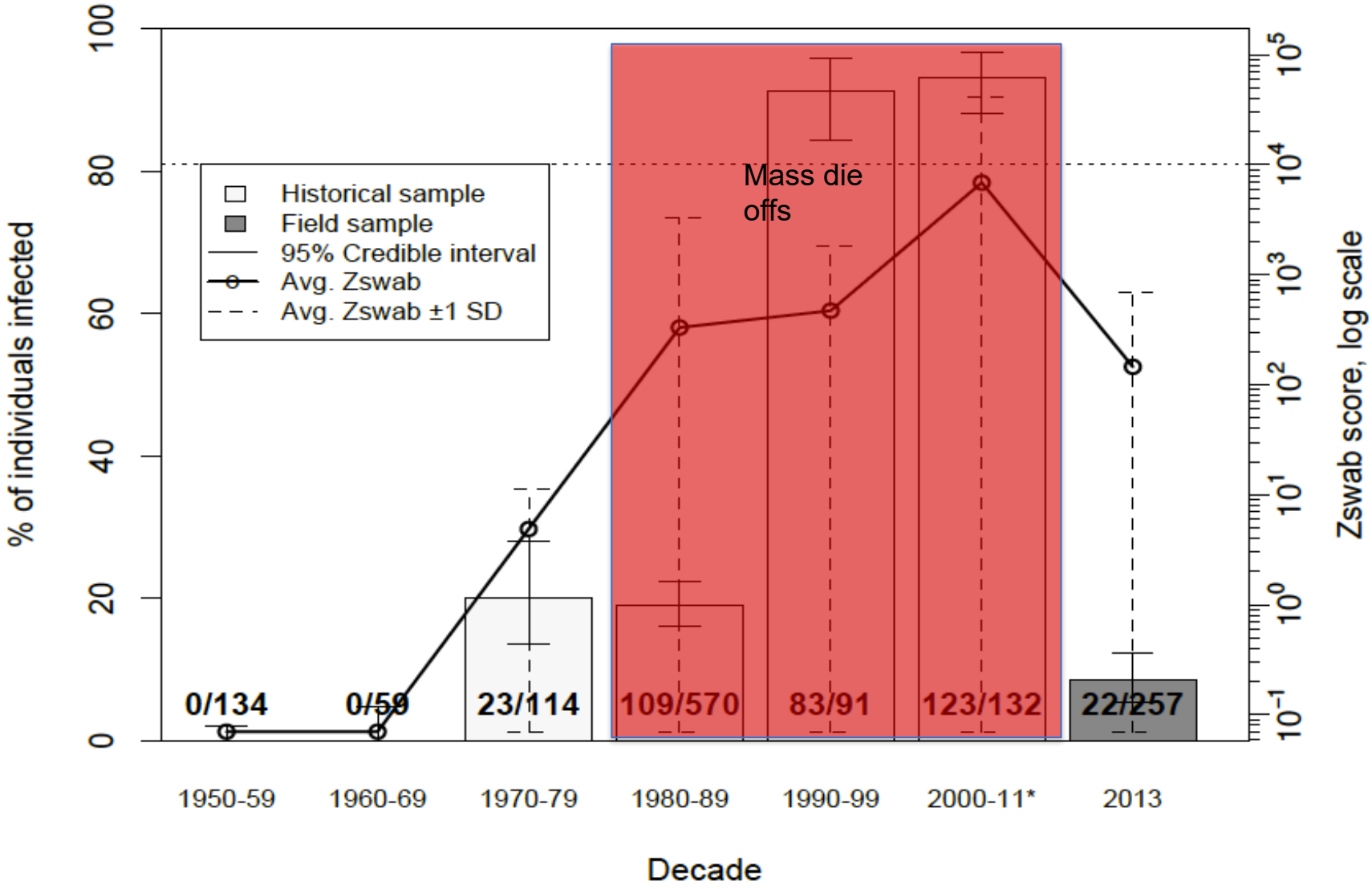
AArk estimates ~ 600 species require captive "Rescue" programs, but only ~ 80 are in such programs now

amphibian ark

Timeline of proposed Bd epidemics in the Andes

(Lips *et al.* 2008, *PLoS Biology)*

Bd emergence in Ecuador declines began in early 1980s

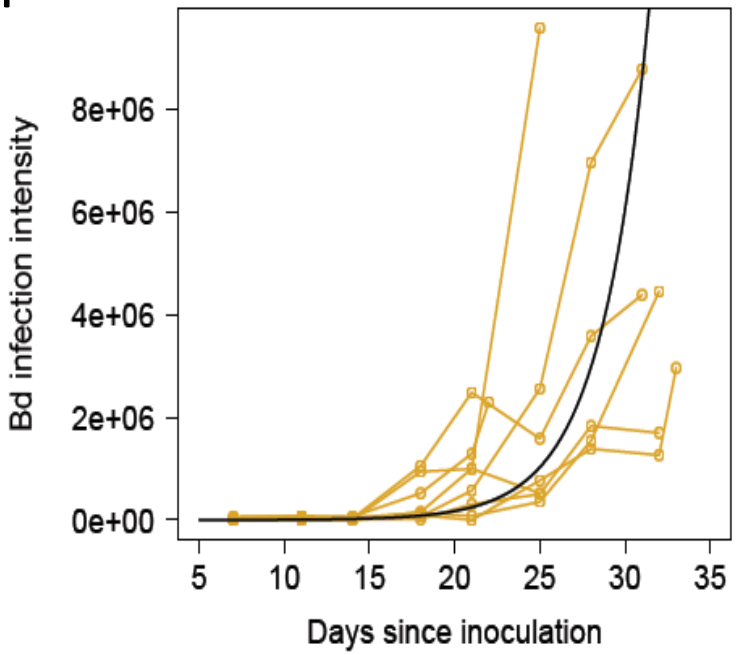


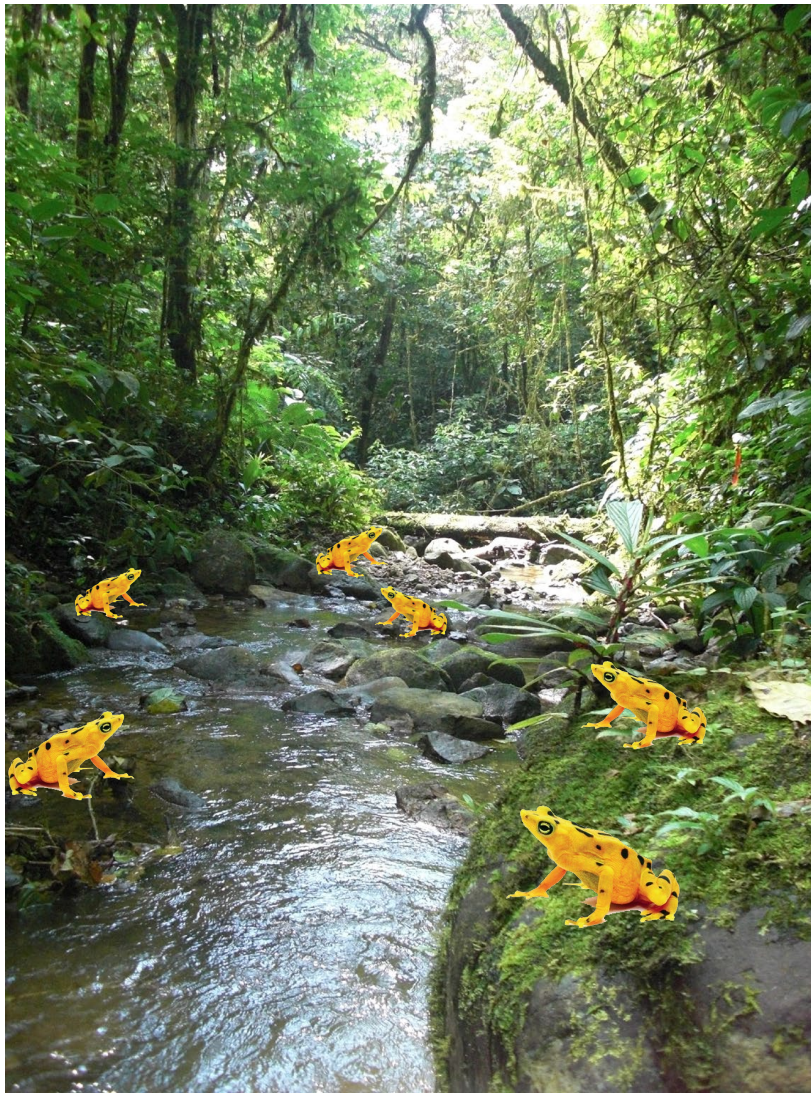
Ecuador has 666 amphibian species

(Manzano, Catenazzi, and **Vredenburg** in prep)

What will happen if we reintroduce *Atelopus?*

- Easily infected, produce 6 million zoospores a day ("super spreaders")
- Active, but ineffective immune response
- Will reintroductions promote new epizootics?





7.) Future concerns: Bioengineering, etc.

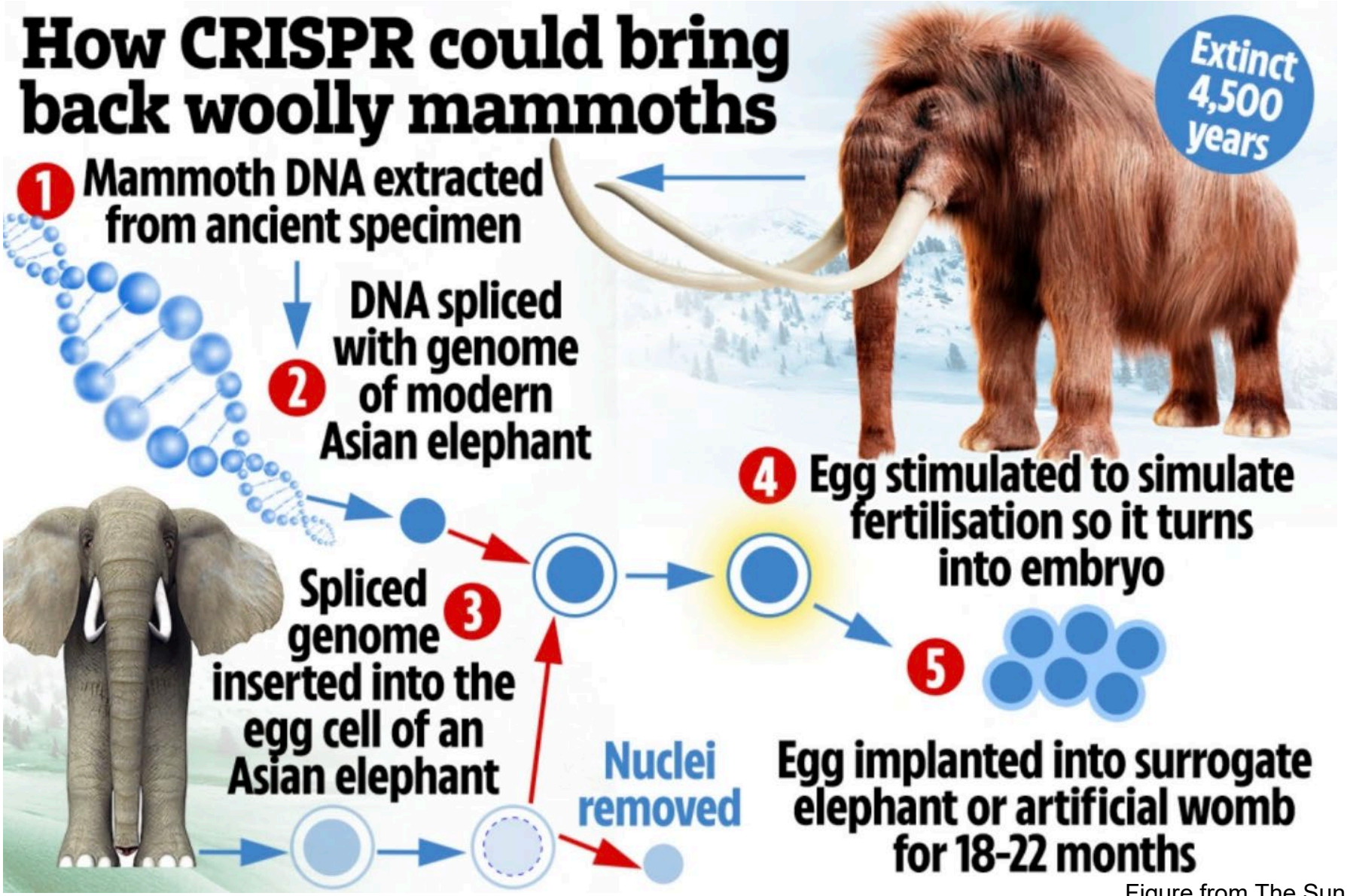


Figure from The Sun

National Academies of Sciences, Engineering, and Medicine. 2016. *Gene Drives on the Horizon: Advancing Science, Navigating Uncertainty, and Aligning Research with Public Values*. Washington, DC: The National Academies Press.https://doi.org/10.17226/23405

What do we recommend?

Success!! USFWS black-footed ferret, by calling it experimental population allowed some flexibility to explore new conservation options and has increased genetic diversity of surviving individuals

We don't want to close down our options.

We need to allow controlled exploratory science that could assist species that are in trouble: we are experiencing a global biodiversity emergency!

Doing the science will inform conservation actions or plans, and will help resolve when we need to step in and do something

We can't just not do anything because of biosecurity concerns.

How do we intervene? Where do we intervene?

Who needs to be involved in this conversation? IACUC? Scientists? Land managers? How do we bring them together?

Getting good data to help us do what we need to do AND being safe about it.

(8) Specific recommendations

IACUC committees should support research in the field, not to impede research

1. People are safe: people understand the dangers to people, and take precaution, & have a plan
2. Organisms are safe: and not impacted significantly
   a. numbers collected or impacted should be biologically relevant - consider IUCN redlist criteria? or the IACUC levels (reduce numbers, lower taxonomic level, online?)
   b. unintended consequences: all field researchers (not just herpetologists) should follow decontamination procedures (boots, vehicles, nets) when moving site to site; site based washes/showers (boat ramps)

What do we hope to achieve?

IACUC & Biosecurity regulations should support research in the field, so that

1. People are safe: researchers understand the dangers to people, take precautions, & have a biosafety and biosecurity plan
2. Organisms are safe: research does not significantly reduce or impact wild populations
    a. Field IACUC supports conservation goals
        a. numbers collected or impacted should be biologically relevant - consider IUCN redlist criteria? or the IACUC levels (reduce numbers, lower taxonomic level, online?)

    b. Field and Lab biosecurity procedures support conservation goals
        a. unintended consequences: all field researchers (not just herpetologists) should follow decontamination procedures (boots, vehicles, nets) when moving site to site; site based washes/showers (boat ramps); Labs need to be especially careful

3. Ethical considerations
4. Sharing information & communication

Thank you!

SAEM & Workshop organizers

Find out more:
AmphibiaWeb.org