



ENVIRONMENTAL
LAW • INSTITUTE®

2015 Invasive Species Webinar Series

Non-native Wildlife Disease: Prevention, Rapid Response, and Containment

Thursday, October 15, 2015
1:00pm-3:00pm Eastern Time
(speaking will begin at 1:03)

Co-hosted by the Environmental Law Institute &
The National Invasive Species Council

This webinar is made possible by the generous support of the Turner Foundation.

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Thursday, October 15, 2015 • 1:00pm-3:00pm ET

NOW SPEAKING:

Read Porter

Director, Invasive Species Program,
Environmental Law Institute



Read Porter is Director of the Invasive Species Program and a senior attorney with the Environmental Law Institute. Mr. Porter has published widely on a range of invasive species topics, including state law, federalism, and bioenergy; as well as on fisheries, aquaculture, natural resources law enforcement, third-party certification, and regulation of emerging technologies. Prior to joining ELI in 2006, Mr. Porter served as a law clerk for the Honorable Julia Smith Gibbons on the United States Court of Appeals for the Sixth Circuit and was Editor-in-Chief of the Harvard Environmental Law Review. Mr. Porter holds a J.D. from Harvard Law School and a B.A. in geology from Amherst College.



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INTRODUCING:

Camille Harris

US Geological Survey

Dr. Camille Harris is the Fish and Wildlife Disease Coordinator in the USGS Office of Ecosystems. She serves as the primary USGS staff member for national coordination of fish and wildlife disease policies, plans and programs. Camille recently received her PhD in wildlife disease ecology at Virginia Tech. Camille obtained a DVM and MS at Mississippi State University through a dual-degree program with the Veterinary College and Department of Wildlife, Fisheries & Aquaculture and received an undergraduate degree in Biology at Cornell University where she gained aquatic research experience studying walleye dermal sarcoma. She conducted feral swine disease monitoring; received zoological medicine training at Smithsonian's National Zoo; and completed two wildlife medicine internships (one in South Africa and the other at the Wildlife Center of Virginia). Camille, a US Army Veterinary Corps veteran, cared for military working dogs overseas and participated in the food safety and public health missions. She has a great interest in considering the role of invasive species, anthropogenic stressors (climate change, contaminants), biosecurity and One Health in wildlife disease dynamics.



Invasion Biology & Disease

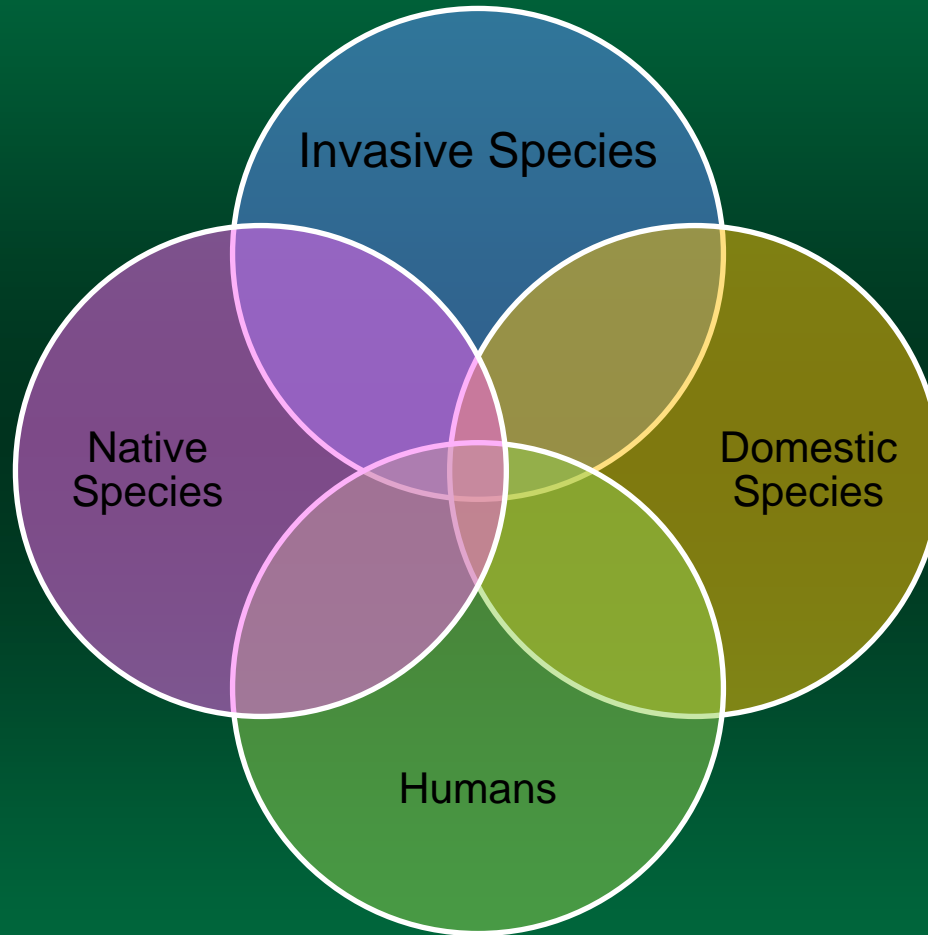
M. Camille Harris DVM, MS, PhD

Wildlife Disease Coordinator, US Geological Survey

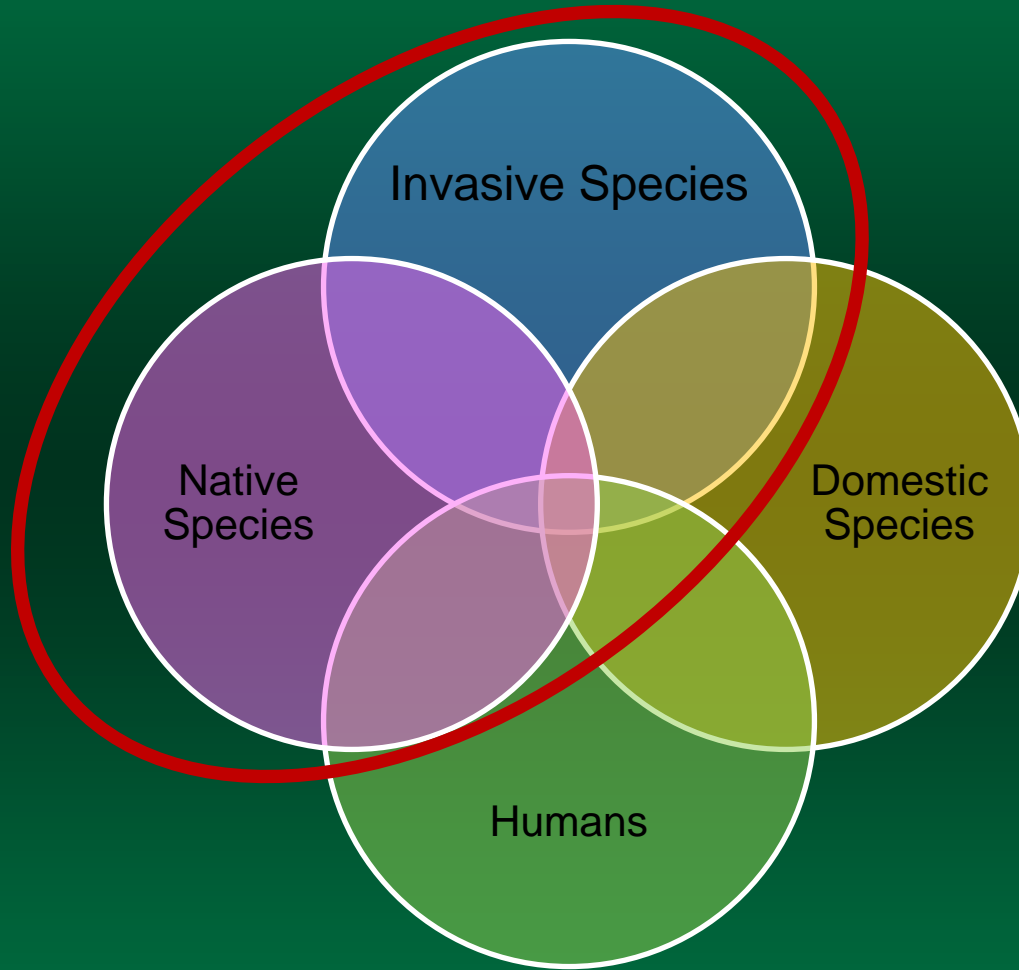
Chair, Animal Pathogens Subcommittee, Federal Interagency Committee on Invasive
Terrestrial Animals and Pathogens (ITAP)

October 15, 2015

Invasive Species At the Disease Interface



Invasive Species At the Disease Interface



Invasive Species – Native Species Disease Interface

- **Invasion Success and Disease**
 - Enemy Release
 - Biotic Resistance
 - Indirect Disease Amplification
- **Invasive Species Management and Disease**
 - Risk Assessment for Biological Threat²
 - Biocontrol
- **Invasive pathogens with an unknown source**



USGS Science to Support Invasive Microbe Management





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INTRODUCING:

Deb Iwanowicz

USGS Leetown Science Center



Dr. Deborah Iwanowicz serves as a multidisciplinary research biologist at the Leetown Science Center, National Fish Health Research Laboratory (NFHRL) in Kearneysville, WV. Her research principally involves that pertaining to next-generation sequencing incorporated within and beyond the infectious and non-infectious diseases of fish and invasive species. She is a Principle Investigator for a number of studies that address regional, national and sometimes international fish and wildlife health and disease issues. Her primary interests and expertise include that of the effects of contaminants on fish health, the spread of diseases with invasive species, investigating complex microbial communities and protocol/assay development. Her research includes that of molecular microbiology (parasitology, bacteriology, virology on fishes, amphibians, sea turtles, marine mammals, insects, plants, aquatic and terrestrial gastropods), and environmental health assessments. She leads efforts in the NFHRL for method development and the adoption and application of new technologies to assist her research and that of others.

Pathogen detection and invasion genetics within Florida populations of the Giant African land snail (*Lissachatina fulica*)

Deborah Iwanowicz and Cheryl Morrison

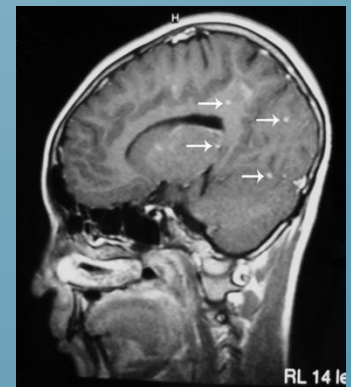
USGS, Leetown Science Center, National Fish Health Research Laboratory



Giant African land snails (GALs)



- Introduction thru the pet trade and Santeria
- Potential vector of pathogens that infect both humans and native wildlife
 - Rat lungworm (*Angiostrongylus cantonensis* – eosinophilic meningoencephalitis)
 - *Aeromonas hydrophila*
 - *Salmonella* sp.
- Infection can occur by eating raw or undercooked snail meat, contaminated vegetables, handling animals and contacting mucous membranes of the eyes, nose or mouth



GALs (*Lissachatina fulica*)

- Consume over 500 plant species – severe agricultural pests
- One of the most damaging snails in the world
 - Regulated by USDA APHIS
- Found in Indiana, Wisconsin, Michigan, Ohio, Florida, California, Hawaii
- Can hibernate up to a year
- Out competes native snails
- Economic damage
- Eradication efforts by Florida Dept. of Ag and Consumer Services
 - Diatomaceous earth
 - Molluscicides (metaldehydes)
 - Negatively impact soil, plants and other beneficial organisms
 - Ground beetles, earthworms, native species of snails
 - Iron sulfate
 - Education methods

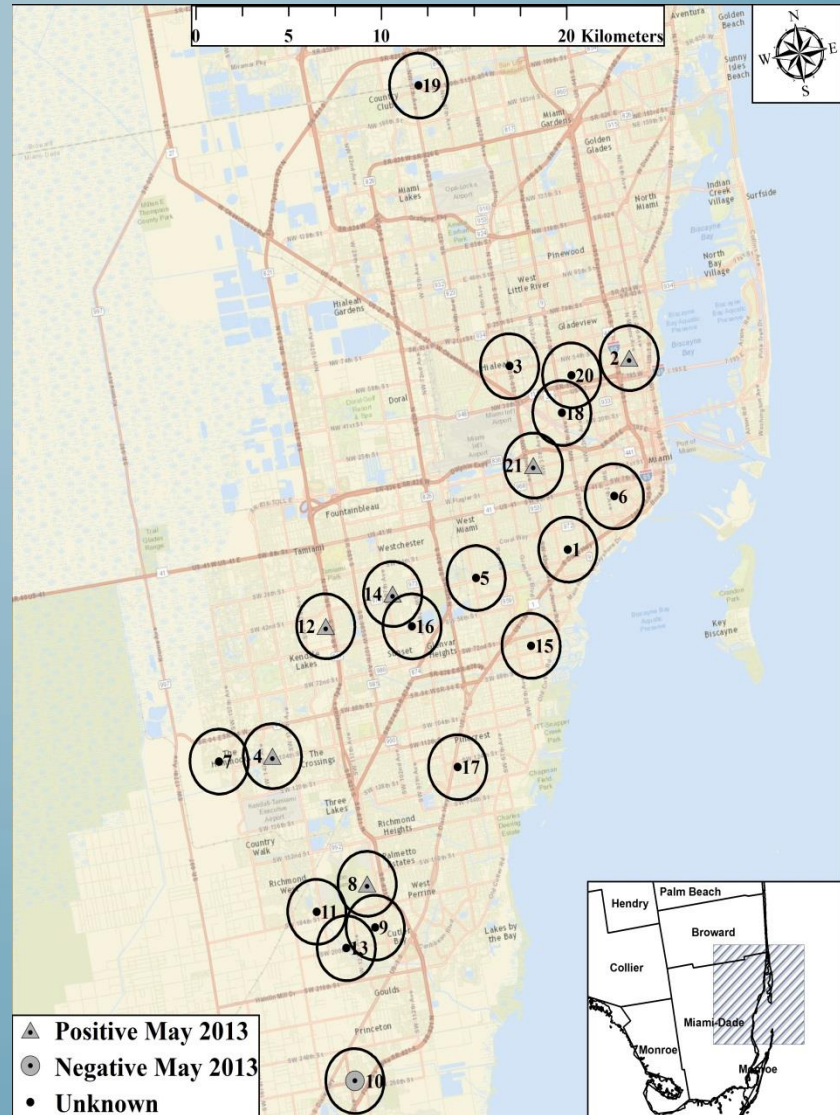


GALs (*Lissachatina fulica*)

- Objectives
 - Identify pathogens associated within the land snail that poses a significant risk to humans or other animals
 - To evaluate the genetic structure and estimate the number of invasion events within Miami/Dade County, FL



Sample sites



Methods

- 50 snails collected in Miami/Dade County, May 2013
- Individually bagged, labeled, weighed and measured
- Killed by decapitation within 5 hours of collection
- Mucus swabs were collected in TE buffer
- Hemolymph was aseptically extracted and flash frozen
- Foot muscle, digestive system and gonads were collected and put into z-fix for histopathology or 97% EtOH for molecular work
- Molecular work:
 - DNA was extracted from all samples using the DNeasy blood and tissue kit (Qiagen)
 - Multiple extractions were made from all muscle tissues collected
 - DNA was eluted with 100 μ L NF-water

Genetics

- Quantitative PCR on parasitic nematode, *Angiostrongylus cantonensis*
 - Iwanowicz et al. (2015) *Journal of Wildlife Diseases*
- 16S metagenomics performed on all tissue samples to look for pathogenic bacteria
- Constructed amplicon libraries for pathogen detection on both the Ion Torrent and Illumina MiSeq:
 - Fungal, bacterial, protozoan and trematode
- Developed 10 microsatellite loci on the Ion Torrent
 - Ion Torrent next-generation sequencing
 - Morrison et al. (2015) *Conservation Genetics Resources*

Results

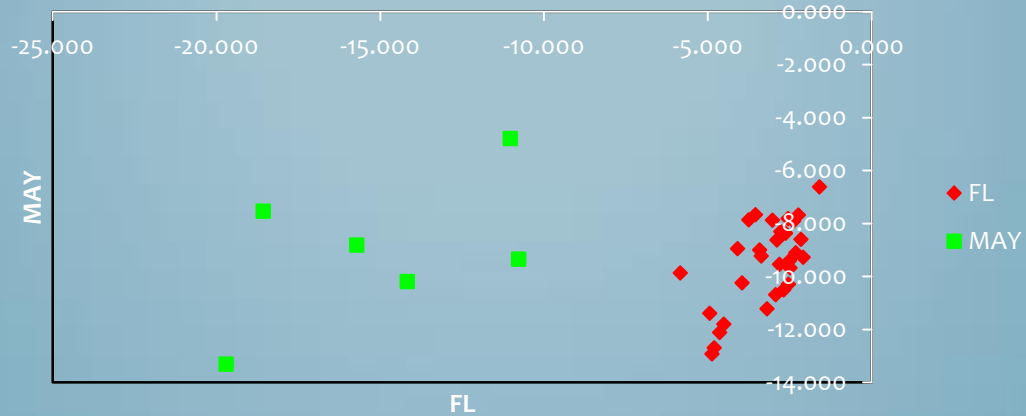
- Histopathological examination was normal
- *Angiostrongylus cantonensis* found in 18 snails
 - Larger range than previously detected
 - Increased tissue sample = increased positives
- Next generation sequencing found multiple bacteria genera that contain species pathogenic to wildlife
 - *Aeromonas* sp., *Legionella* sp., *Staphylococcus* sp., *Geobacillus* sp., *Pseudomonas* sp., and *Citrobacter* sp.
- Some species have been verified with Sanger cycle-sequencing
 - *Citrobacter freundii*
 - *Proteus penneri*
- Markers diagnostic for Miami/Dade County *L. fulica* populations

Invasion Genetics of *L. fulica* in Florida

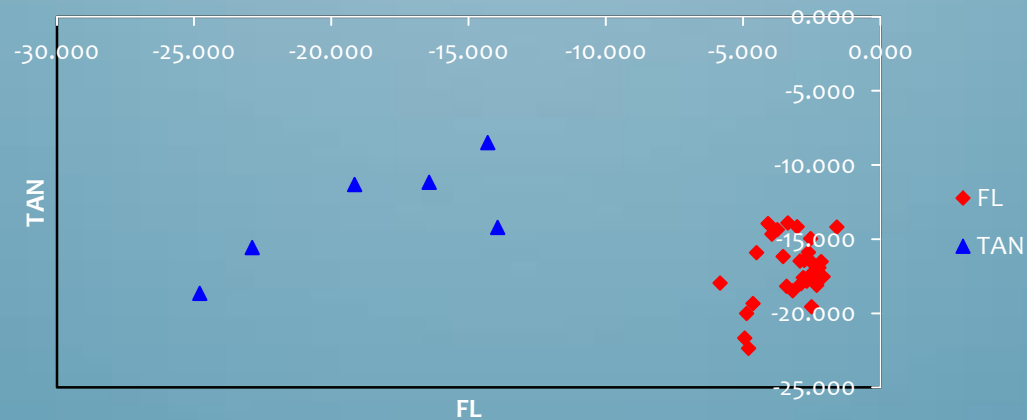
- Obtained samples from potential source populations worldwide:
 - Tanzania, Kenya, Japan, Philippines, Singapore, Nepal, Mayotte, New Caledonia, Thailand, Moorea, Borneo, Burma/Myanmar
- Currently genotyping samples to determine:
 - Origins of invasions to Florida
 - Levels of genetic diversity
 - Fine-scale spatial structuring
 - Track the spread of invasions
 - Prevent additional invasions through similar pathways

Florida population differentiated from Tanzania and Mayotte

Population Assignment for FL vs. MAYOTTE



Population Assignment for FL vs. TANZANIA



Conclusions

- Method development needs to be refined for larger snail species (e.g. amount of tissue collected for diagnosis)
- *Angiostrongylus cantonensis* has a larger range in Florida than previously determined
- There are at least two invasion events within Miami/Dade County, FL
- Further examination of tissues from other countries is necessary for determining all possible pathways for entering the U.S.A.



Acknowledgments

- USGS Wildlife Program
- Dr. Chris Wade, U of Nottingham
- Florida, Department of Agriculture and Consumer Services
- Dr. Mary Yong Cong
- Dr. Kay Marano Briggs





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Rebecca Cole

USGS National Wildlife Health Center

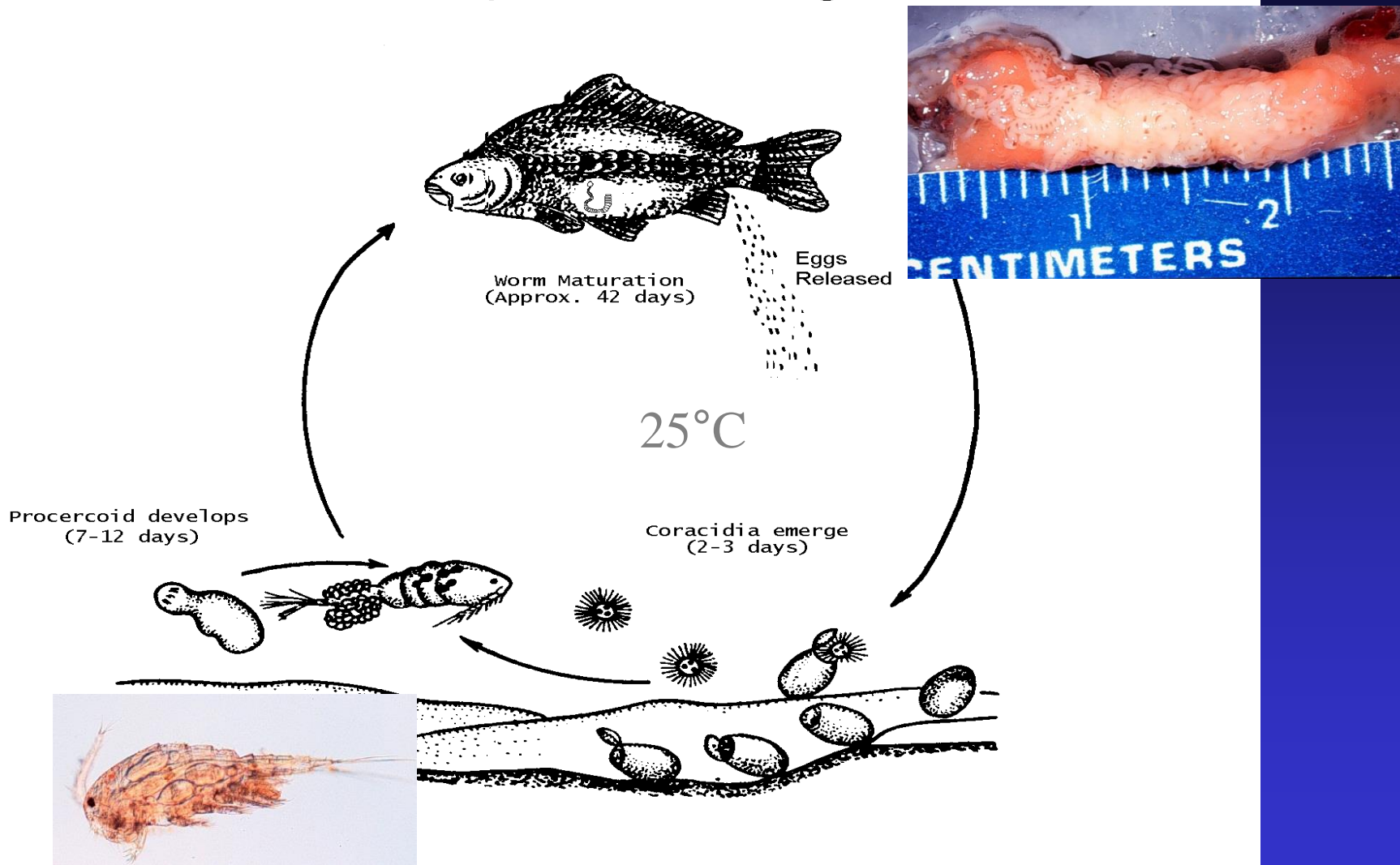


Rebecca Cole is a research zoologist with the U.S. Geological Survey National Wildlife Health Center in Madison, WI. She supervises the parasitology diagnostic laboratory and conducts research on wildlife parasites. Her research has most recently focused on invasive species and their associated parasites. She is currently studying introduced eels (*Monopterus* spp) both from market sources and introduced populations in GA, FL and NJ to document what parasites might be established in the introduced wild populations. She has also conducted field and laboratory research on the Asian fish tapeworm in native and introduced fish in the Colorado River.

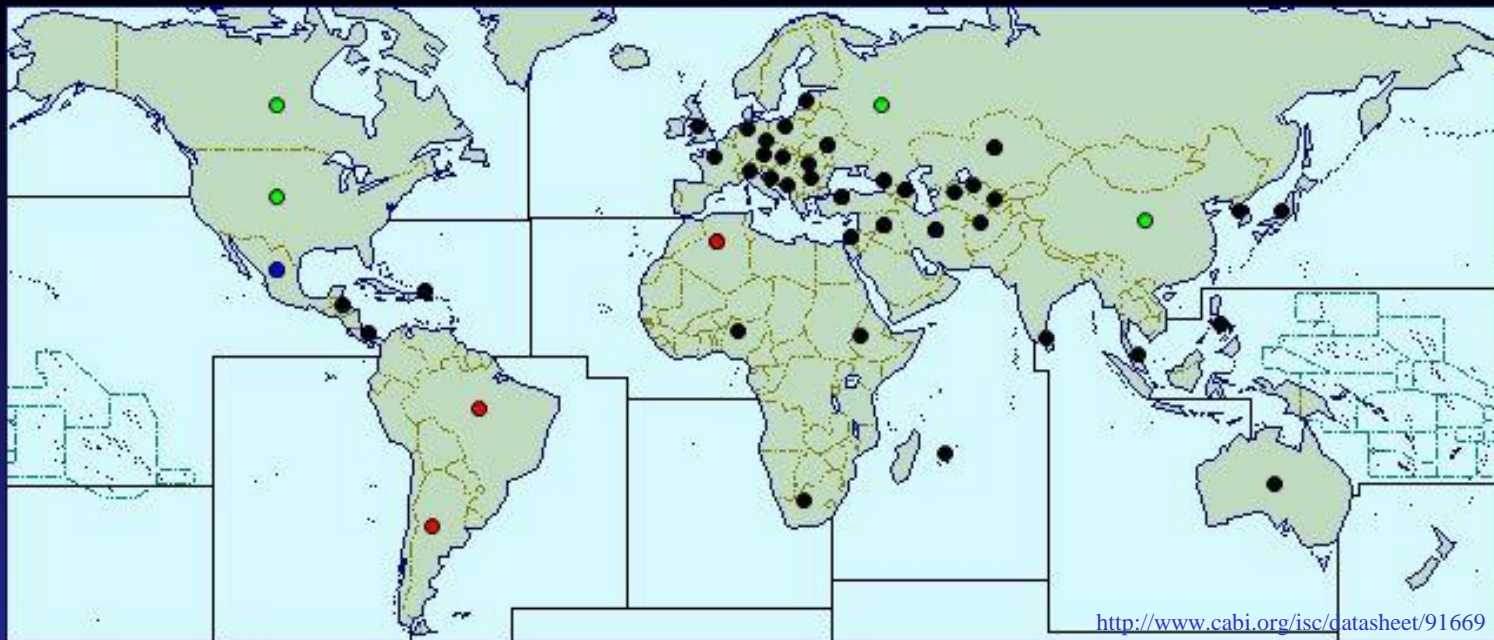
Asian fish tapeworm
(Bothriocephalus acheilognathi)

Rebecca A. Cole, PhD
USGS National Wildlife Health Center,
Madison, WI

Life cycle *B. acheilognathi*



Also, postcyclic transmission



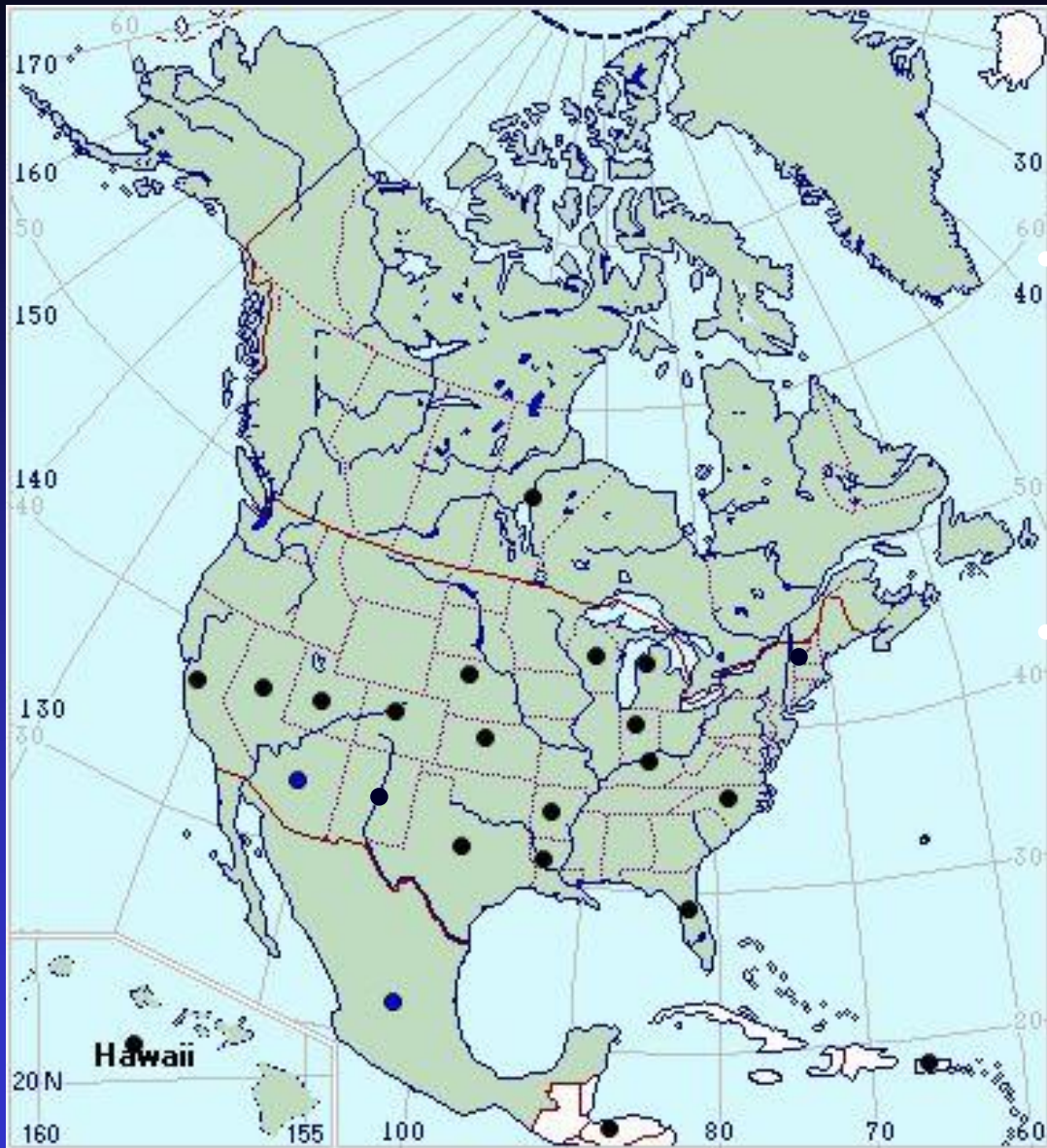
● Various distribution

○ Present, no further details

● Localized

● Widespread

- Native to East Asia has been introduced via human activity to all continents except Antarctica. First report in USA in 1975 presumably from introductions of grass carp in 1960's
- Estimated to infect 200 species of freshwater fish but mainly reported from cultured & wild carp



• **19 States report the presence of the Asian fish tapeworm. (KY, NH, AR & CO hatchery only)**

• **Listed as a Pathogen of Regional Importance in the West & Southwest (U.S. Fish and Wildlife Service, 2015).**

Species of Concern in US

Threatened Species	Conservation Status	Citation
<i>Gila cypha</i> (Humpback chub)	IUCN red list: Endangered	Choudhury & Cole, 2012 ; Hoffnagle et al., 2006 ; Stone et al., 2007
<i>Gila elegans</i> (Bonytail chub)	IUCN red list: Critically endangered	Hansen et al., 2006
<i>Gila robusta</i> (Roundtail chub)	IUCN red list: Near threatened	Brouder, 1999
<i>Notropis Topeka</i> (Topeka shiner)	USA ESA listing Endangered	Koehle & Adelman, 2007
<i>Plagopterus argentissimus</i> (Woundfin)	IUCN red list: Endangered	Heckmann, 2000 ; Heckmann, 2009
<i>Siphateles bicolor mohavensis</i> (Mojave Tui Chub)	USA ESA listing: Endangered	Archdeacon et al., 2008

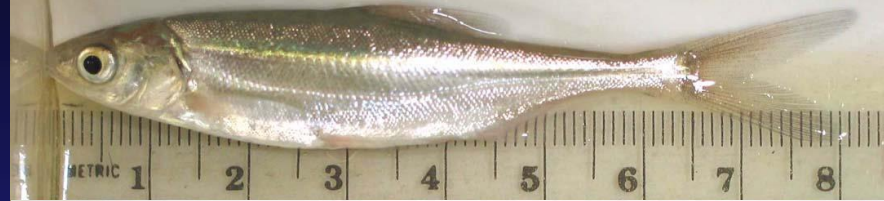
Bothriocephalus acheilognathi

Pathology

- Extensive mortality in hatchery-reared juvenile carp usually from intestinal lesions and perforations or impactions.
- Free-living: Impaired growth in roundtail & humpback chub & Topeka shiner. Reduced condition factor in red shiner. Contributed to population decline of humpback chub.
- Experimental infection of bonytail chub caused 8% reduction in growth, a decrease in health indices & accelerated mortality with lowered food ration. Reduction of hematocrit and erythrocyte counts.
- Not reported as a human pathogen

- **Loss of energy stores as reflected in fat reduction**
- **Parasite accelerates & increases mortality under conditions of food restriction**

Control

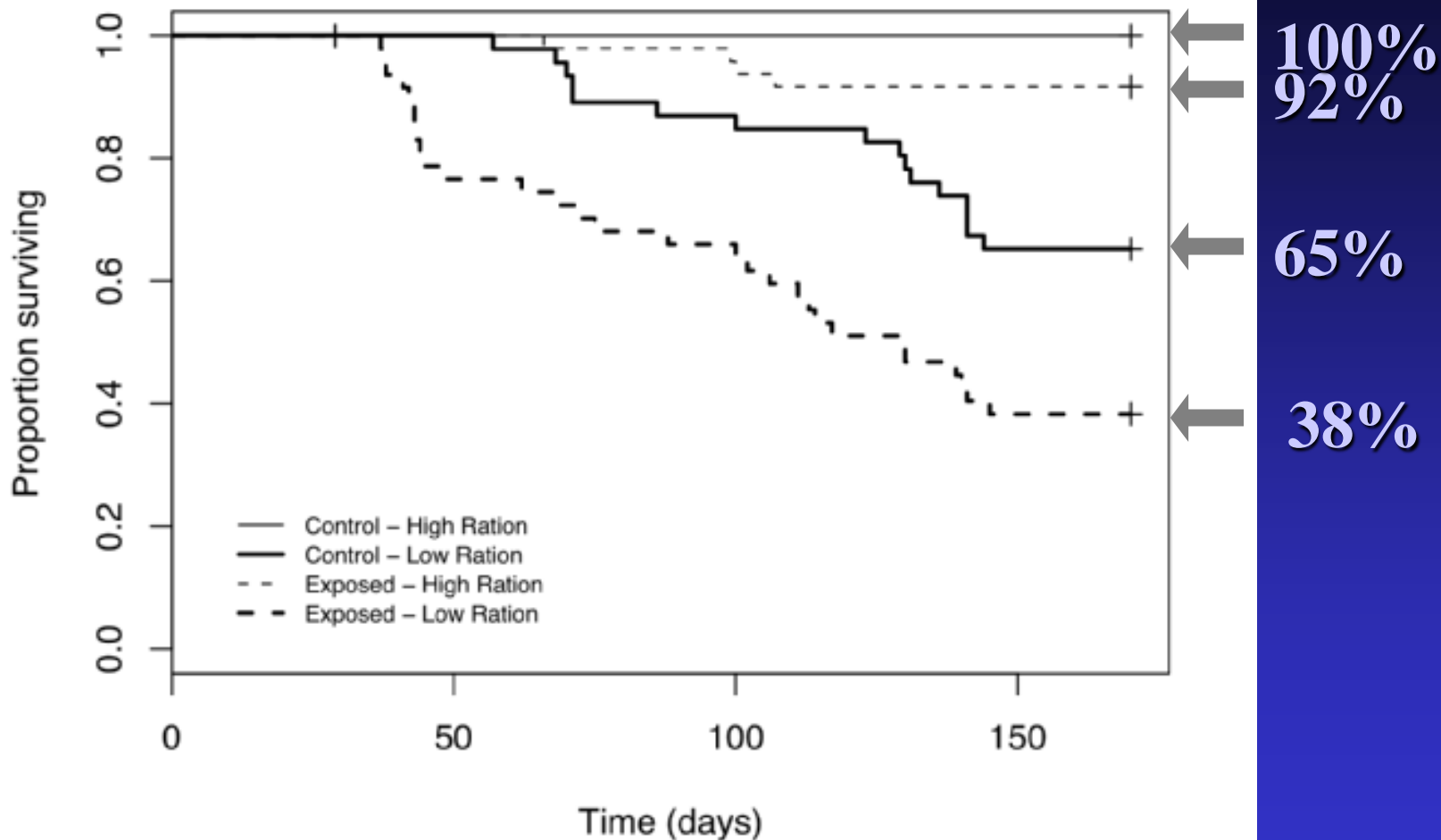


Infected



Infected, low ration





Low ration infected began dying 20 days earlier than control low ration with only 38% survival compared to 65%

Excellent Invader

- Simple 2 –host life cycle
- Can infect a broad range of fish species & sustain life cycle without original infected host species present*
- Uses several genera of copepods that are common around the world as an intermediate host
- Worm eggs and infected copepods in water or on vegetation can facilitate introductions

* Except in Australia

Control

- Wild fish relocated within Grand Canyon system treated with praziquantel to prevent spread amongst tributaries.
- In most settings no practical control

Future Research

- Understanding the impact on wild populations of protected fish species
- Spread of *Bothriocephalus acheilognathi* with climate change and resulting water temperature changes
- Development of environmental assay for detection of DNA of *Bothriocephalus acheilognathi*

- <http://www.cabi.org/isc/datasheet/91669>



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INTRODUCING:

Priya Nanjappa

Association of Fish & Wildlife Agencies



Priya Nanjappa leads the amphibian and reptile conservation program and policy efforts for the Association of Fish & Wildlife Agencies (AFWA), based in Washington, DC. In this role, she serves as the National State Agencies Coordinator for Partners in Amphibian and Reptile Conservation (PARC), and staffs the AFWA Amphibian & Reptile Subcommittee. She has worked in these roles since 2005, and before that, she was a field technician in the Northeast Amphibian Research and Monitoring Initiative (ARMI) at the USGS Patuxent Wildlife Research Center in Laurel, MD, since 2001. She received her M.Sc. in 2000 working with Dr. Michael Lannoo. Along with her herpetofaunal portfolio (2/3 of her time), Priya has also led invasive species policy and management issues for AFWA since 2009 (1/3 of her time, including all species from quagga mussels to cheatgrass), and staffs their Invasive Species Committee. Priya, her husband, and 3 year-old daughter live in Colorado.

The **Bsal** fungal pathogen: Emerging perils, partnerships, and policies

Priya Nanjappa



*What is Bsal?

***Batrachochytrium salamandrivorans* sp. nov. causes lethal chytridiomycosis in amphibians**

An Martel^{a,1}, Annemarieke Spitzen-van der Sluijs^b, Mark Blooi^a, Wim Bert^c, Richard Ducatelle^a, Matthew C. Fisher^d, Antonius Woeltjes^b, Wilbert Bosman^b, Koen Chiers^a, Franky Bossuyt^e, and Frank Pasmans^a



- Described in 2013
- Asian origin
- Salamander specialist
- Causes chytridiomycosis

*What do we know?

* Caused 96% wild mortality in Netherlands

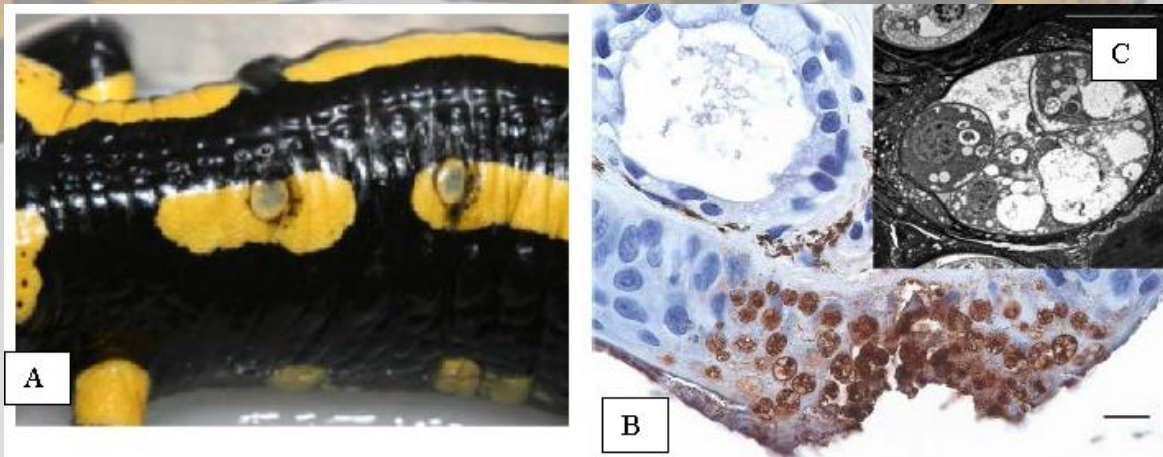
* Present in:

* wild salamanders in Asia (Vietnam, Thailand, Japan)

* museum records in Asia >150 yrs

* trade & captivity

Frank Pasmans

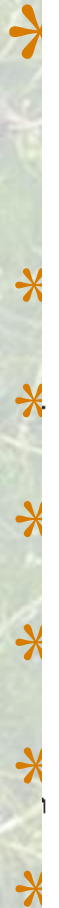
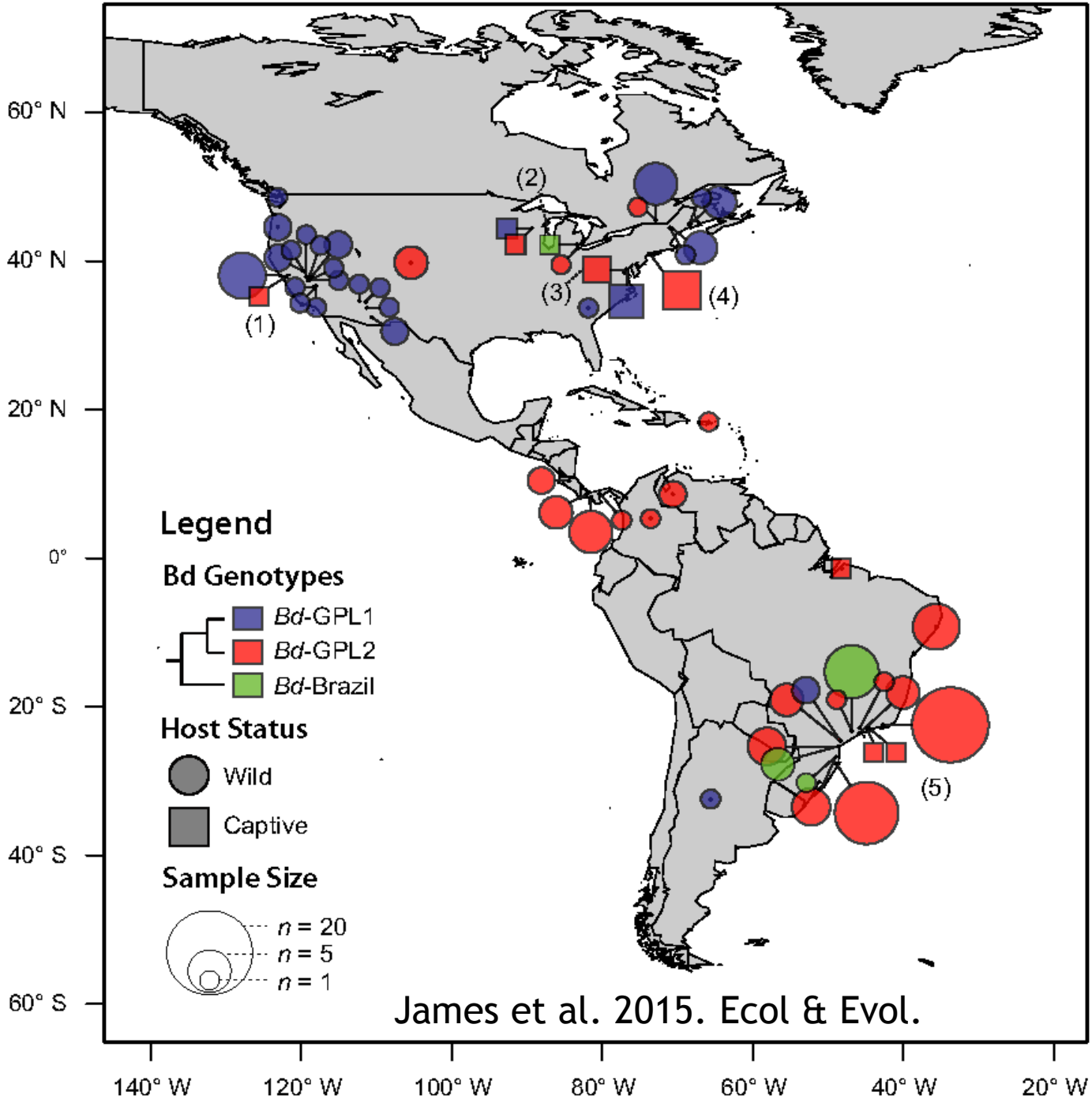


Martel et al. 2013, PNAS;
Martel et al. 2014. Science;
Blooi et al. 2015. Scientific Reports;
Pereira. 2015. SEPARC Info Sheet

*What do we know?

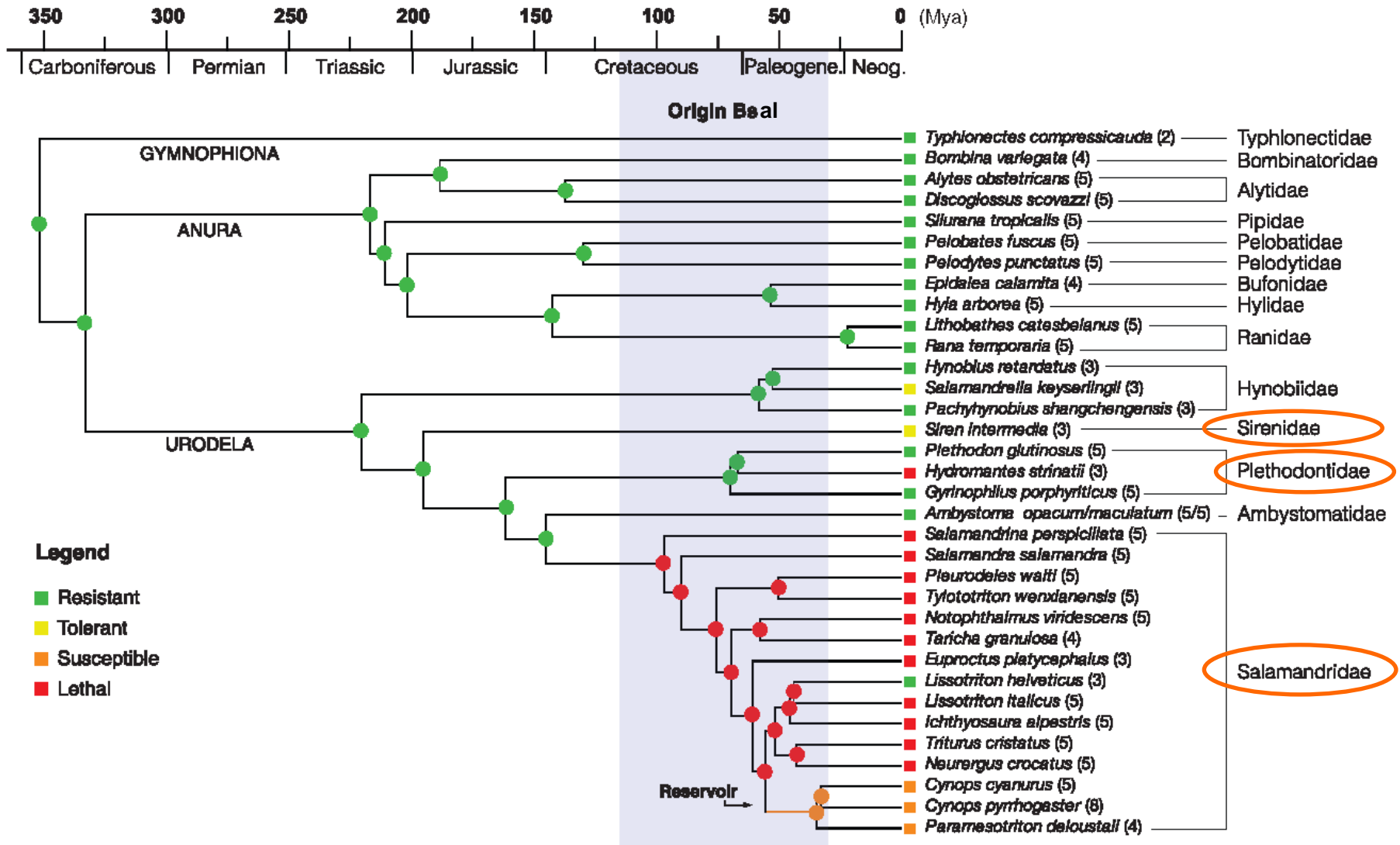
- * Related to *B. dendrobatidis* (Bd)





©

* Why is Bsal a threat?

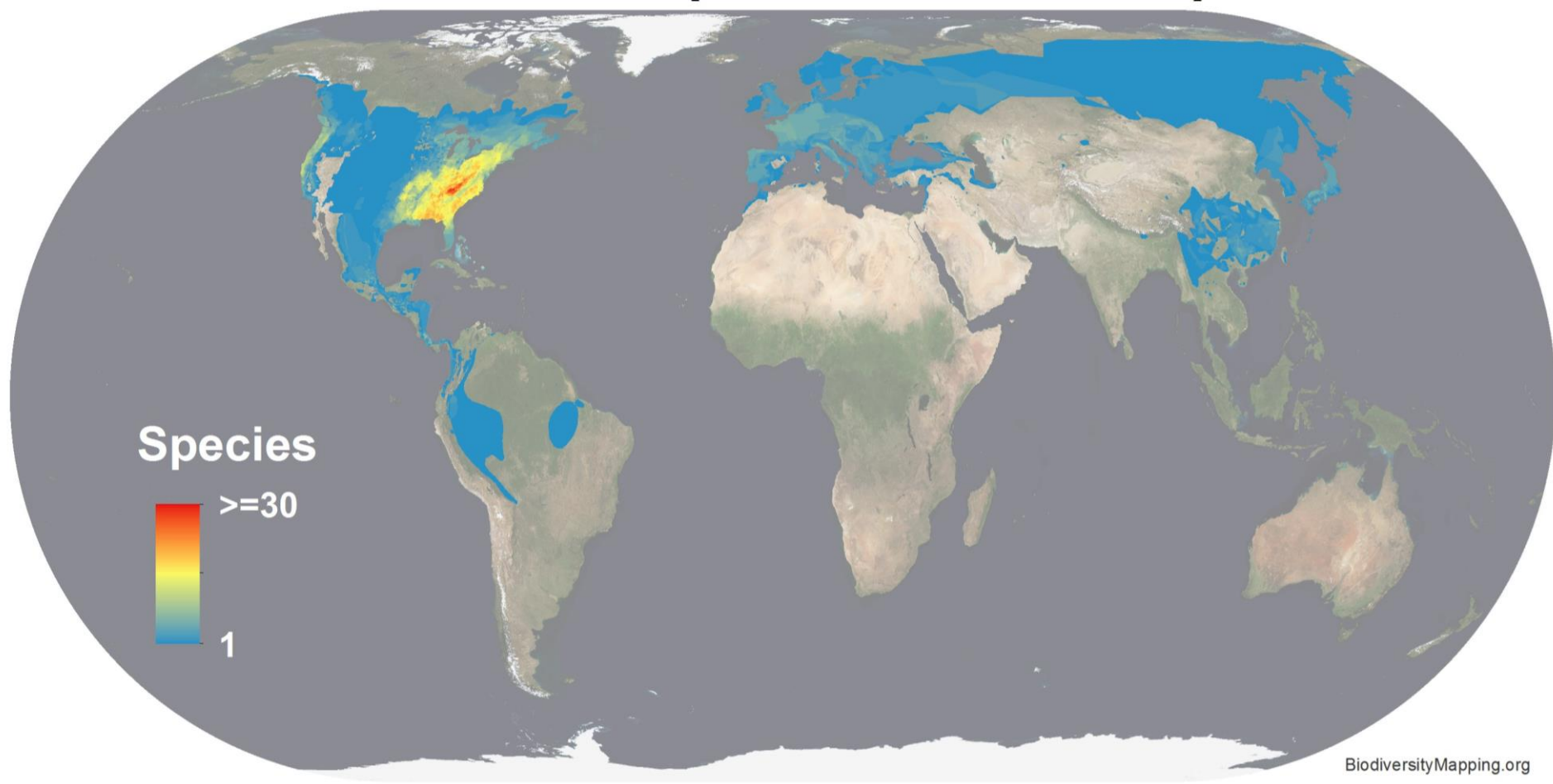


* Why is Bsal a threat?

- * 100,000+ *annual* salamander imports to US
- * primarily Asian newt species
- * North American species are susceptible

Martel et al. 2014. *Science*
Yap et al. 2015. *Science*

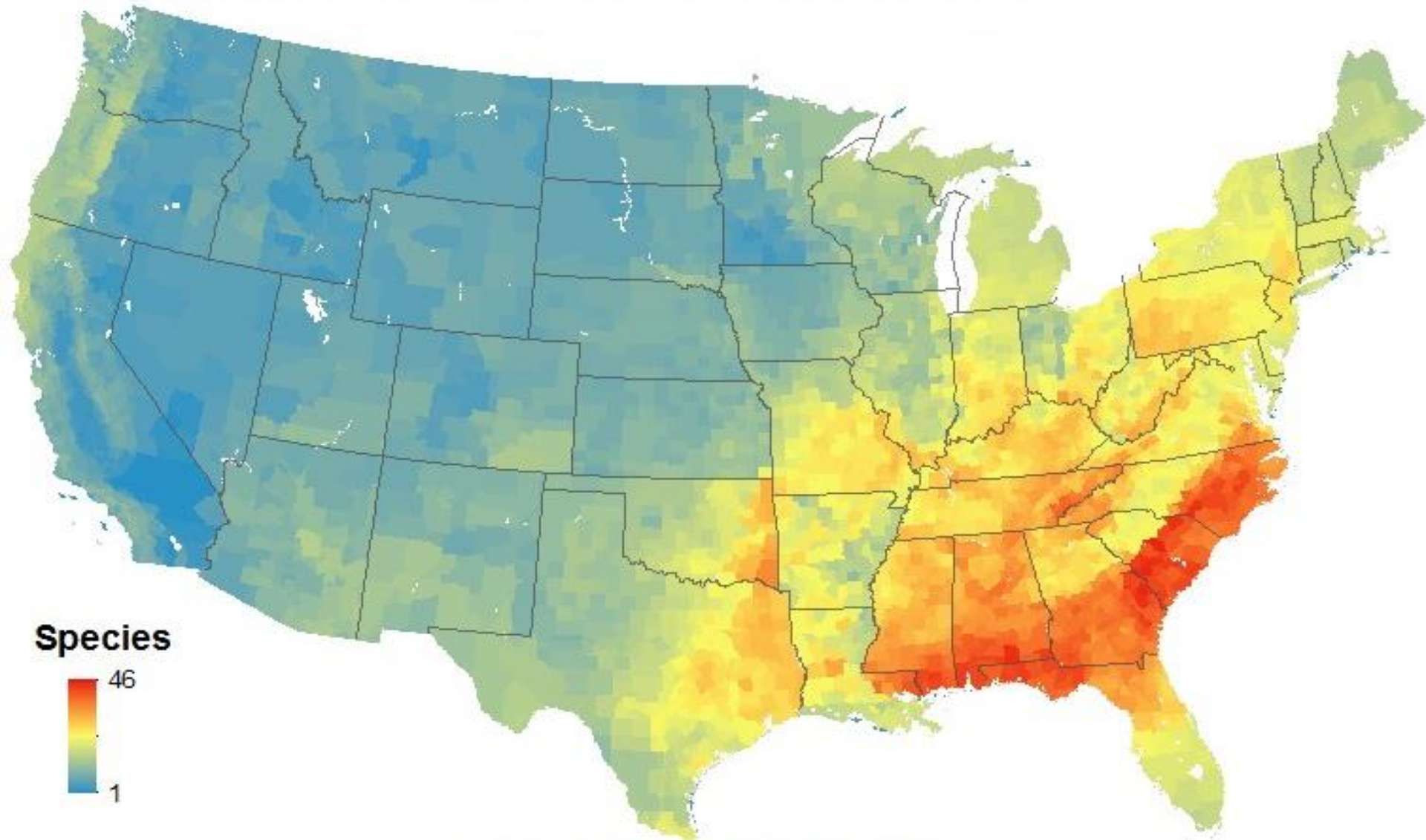
* Why is Bsal a threat?



Jenkins et al. 2013. PNAS.

<http://www.biodiversitymapping.org/amphibians.htm>

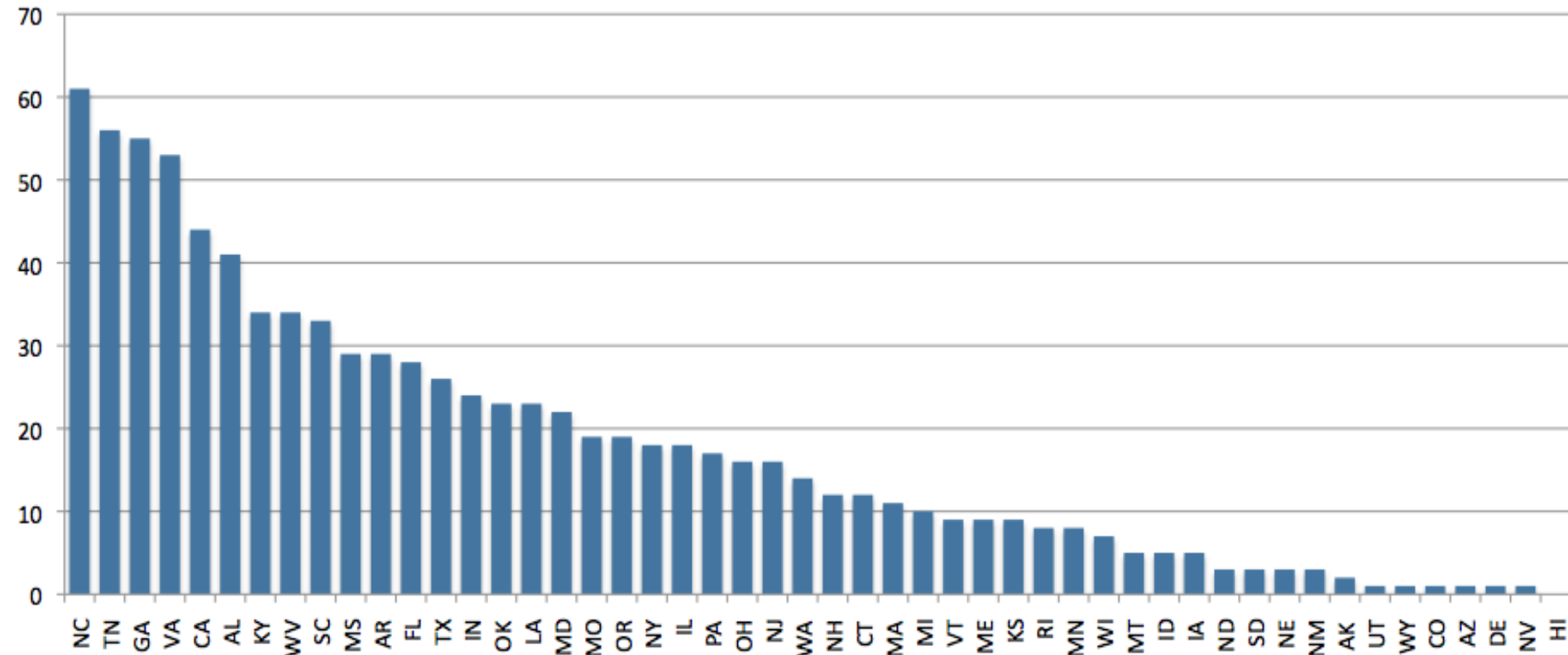
* Why is Bsal a threat?



Amphibian richness, 270 spp, 190 salamanders

*Why is Bsal a threat?

#salamander species by state





ASSOCIATION of
FISH & WILDLIFE
AGENCIES

November 21, 2014

Mr. Dan Ashe
Director
U.S. Fish and Wildlife Service
Department of the Interior
1849 C Street, NW
Washington, DC 20240

Dear Director Ashe:

On behalf of the Association of Fish and Wildlife Agencies (Association), I am writing to express our concerns and desire for prompt action by the US Fish and Wildlife Service (USFWS) regarding the looming threat of the salamander fungus, *Batrachochytrium salamandrivorans* (*Bsal*). The October 31 publication in the journal *Science* (Martel et al., 2014) and subsequent media underscore the matter: a) we have strong information to suggest that this disease is not yet present in the United States, b) we have more salamander species than any other country in the world, and c) we have insights into what could happen to our salamanders based on impacts to wild salamanders in Europe, and impacts of the previously known amphibian fungus, *B. dendrobatidis* (*Bd*), worldwide.

As you know, the Association represents the interests of the state fish and wildlife agencies, who have primary authority over the management of salamanders in the United States (and shared authority with the USFWS for currently listed salamander species). Action now by the USFWS can greatly facilitate our ability to manage our native salamander populations. Conversely, a lack of action resulting in the introduction of this disease will most certainly have a potentially devastating impact on conservation of native salamanders. It will also create a shift in priorities for state and federal wildlife agency staffs and habitat-based conservation work to more time spent addressing or responding to the impact of petitions for listing under the Endangered Species Act. We have petitioned for listing of several population crashes due to *Bd* in the US.

THE PARTNERSHIPS

... + it?

The voice of fish and wildlife agencies

Hall of the States
444 North Capitol Street, NW
Suite 725 • Washington, D.C. 20001
Phone: 202-624-7890
Fax: 202-624-7891
E-mail: info@fishwildlife.org
www.fishwildlife.org

*What are we doing about it?



Disease Task Team

USGS *Bsal* Workshop

June 23-25, 2015

THE PARTNERSHIPS

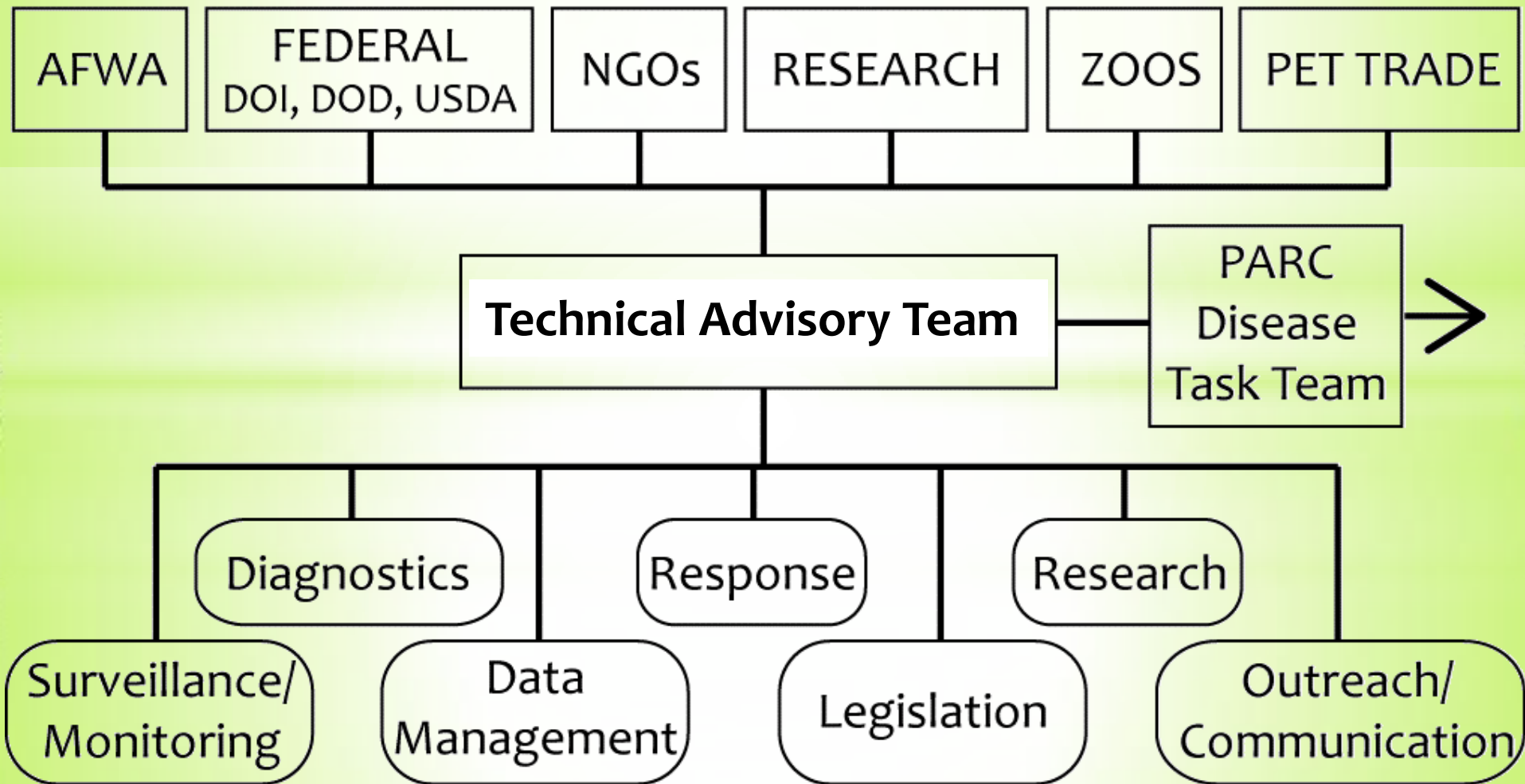
Participants:

- Federal (13)
- International (4, 3 countries)
- State (1, AFWA)
- Academia (8)
- Zoos (1)



Bsal National Task Force

Executive Oversight Group



* Post-Workshop Products & Actions

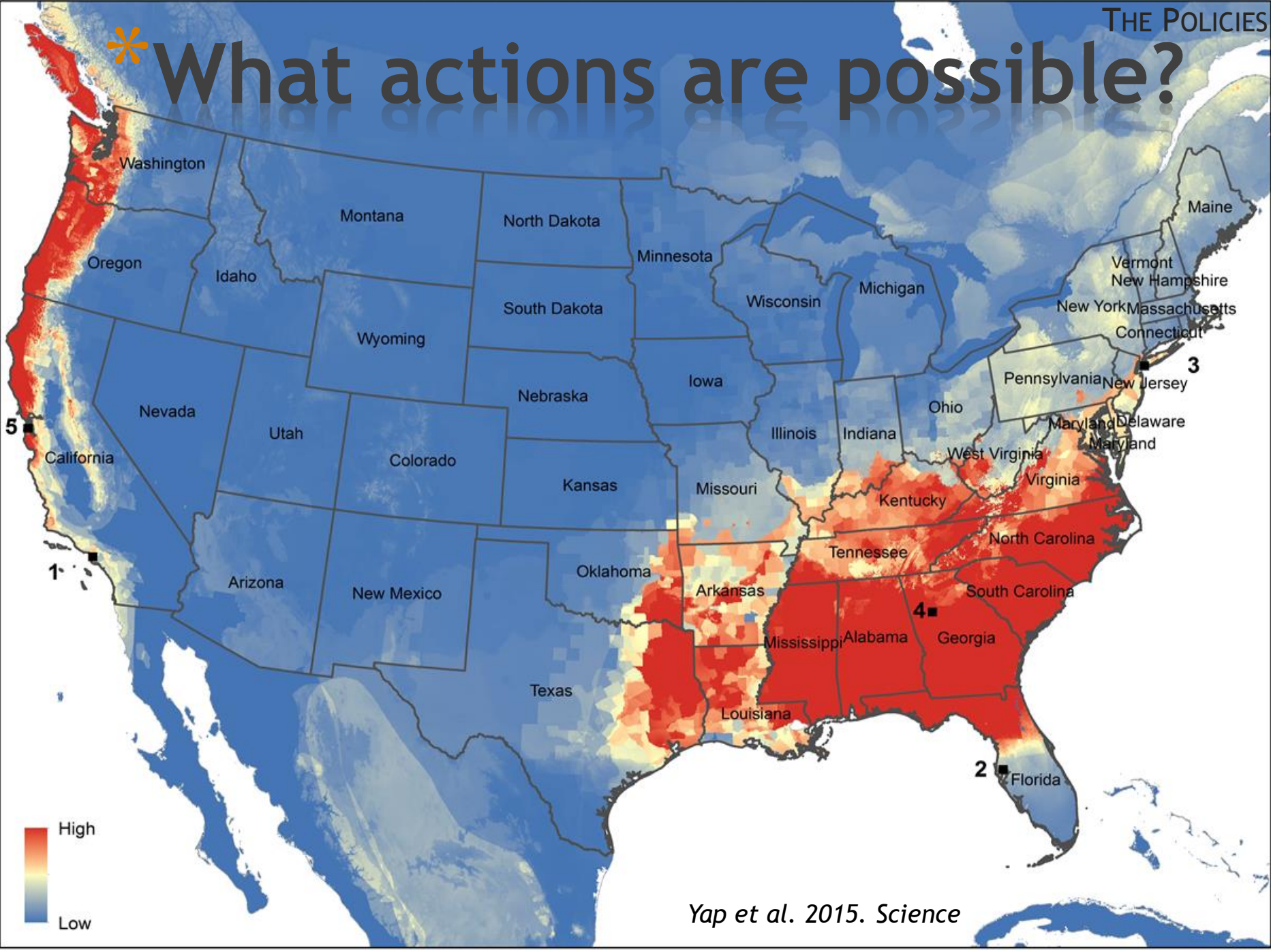
1. ARMI-led targeted surveillance and monitoring of salamanders for *Bsal*
2. NWHC-led coordination of diagnostic laboratory network
3. AFWA-led Completion of Rapid Response Plan



* Post-Workshop Products & Actions

1. ARMI-led targeted surveillance and monitoring of salamanders for *Bsal*
2. NWHC-led coordination of diagnostic laboratory network
3. **AFWA-led Completion of Rapid Response Plan**
4. ARMI-led *Bsal* Decision model
5. USGS-led *Bsal* Database
6. Public-Private Partnership: Research Needs White Paper
Standardized laboratory and field procedures
7. Modified risk model as more information becomes available
8. Website for information exchange and outreach, **coming soon!**

* What actions are possible?



*What actions are possible?



*What actions are possible?



* Summary:

- * Need comprehensive law for wildlife diseases
 - * controls based on pathogens, not hosts
- * State laws increasingly important
 - * import restrictions/veterinary health certifications
- * Partnerships are key in proactive disease mgmt
- * Communications and outreach are essential
 - * EDRR and containment

* Acknowledgements:

ELI

NISC

PARC

AFWA

Matt Gray

Camille Harris

Jake Kerby

Karen Lips

An Martel

Frank Pasmans

Kenzie Pereira



THANK YOU!

Priya Nanjappa
pnanjappa@fishwildlife.org

* Questions?



Priya Nanjappa
pnanjappa@fishwildlife.org



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NOW SPEAKING:

Peter Jenkins


Center for Invasive Species Prevention



Peter Jenkins, President of the Center for Invasive Species Prevention, has 24 years of experience, both national and international, in invasive species policy and management as a policy analyst, attorney, advocate, lobbyist, consultant, manager, author and speaker. He was a co-founder of the National Environmental Coalition on Invasive Species (NECIS), an original member of the IUCN Invasive Species Specialist Group and co-chaired the Society for Conservation Biology's Biological Security Task Force. Mr. Jenkins has a J.D. degree (University of Puget Sound Law School, 1983) and a Masters in Environmental Studies (Yale School of Forestry and Environmental Studies, 1990)

Improving Federal Policy on Wildlife Disease Prevention

[*www.cisp.us*](http://www.cisp.us)

 <p>CENTER FOR INVASIVE SPECIES PREVENTION</p>	<p>Peter T. Jenkins, Executive Director PO Box 42241 Washington, DC 20015 USA Tel: 301.500.4383 Email: jenkinsbiopolicy@gmail.com Skype: petertjenkins</p>
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NEEDED QUALITIES

- - PRECAUTIONARY; PREVENTION-FOCUSED
- - PROACTIVE
- - RAPID AND FLEXIBLE
- - SCIENCE-BASED BUT PRACTICAL
- - STAKEHOLDER SUPPORT
- - COOPERATIVE WITH STATES AND INTERNATIONAL PARTNERS
- - COST-EFFECTIVE
- - ADEQUATE FUNDING

*** FEW OF THESE QUALITIES IN U.S. LAW NOW**

GOLD STANDARDS?

- USDA REGULATION OF FARM ANIMAL AND CROP PLANT PATHOGENS
- CDC REGULATION OF HUMAN PATHOGENS

Defenders of Wildlife Report - 2007

Broken Screens: the Regulation of Live Animal Imports in the United States

www.defenders.org/publications/

[broken_screens_report.pdf](http://www.defenders.org/publications/broken_screens_report.pdf)



One Solution:

HR 996/ S.1153 – 113th Congress

Invasive Fish and Wildlife Prevention Act

- Not reintroduced in this Congress yet

Proposed Elements of a Wildlife Health Bill

National Environmental Coalition on Invasive Species

Center for Invasive Species Prevention

National Wildlife Federation

Natural Areas Association

The Wildlife Society

www.necis.net

1. Purpose: to protect the health of terrestrial and aquatic species in the United States by improving the national system of preventing the importation and spread of any pathogens and parasites that are likely to cause harmful disease outbreaks in wildlife populations.

Bill Elements

- 2. Scope and Coverage
- 3. Improvement of Authority: Secretary of the Interior via U.S. Fish and Wildlife Service
- 4. Consultation and Coordination

Bill Elements

- 5. Emergency Authority – like USDA and CDC
- 6. Response Coordination
- 7. No Effect on Other Agency or State Authority
- 8. Prohibited Actions

ENGAGE ON BILL ADVANCEMENT?

- contact:

jenkinsbiopolicy@gmail.com



Peter T. Jenkins, Executive Director

PO Box 42241 | Washington, DC 20015 USA | Tel: 301.500.4383

Email: jenkinsbiopolicy@gmail.com | Skype: [petertjenkins](https://www.skype.com/en/people/petertjenkins)



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Q & A Session

Questions for the panelists? Submit via the “Questions” box or raise your hand by clicking on the hand icon.

Please visit the event page (<http://tinyurl.com/wildlifedisease>) for background materials and resources.

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