## Top Amphibian Research & Conservation Priorities

**Dr. Deanna H. (Dede) Olson**
*Pacific Northwest Research Station*
*US Forest Service, Corvallis OR*

## Don't we already know the Top Priorities?

" Right, amphibian declines were noted in 1990, 27 yrs ago. And it's not just about amphibians, all species are under similar **threats**. This is old news, isn't it?

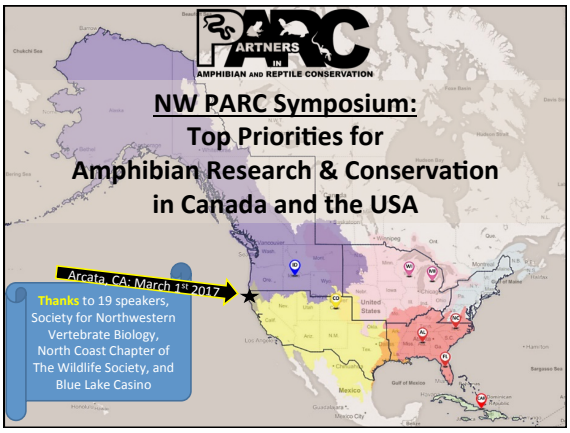
**"Ah, but it's more than identifying threats. Here, I'll show you…**

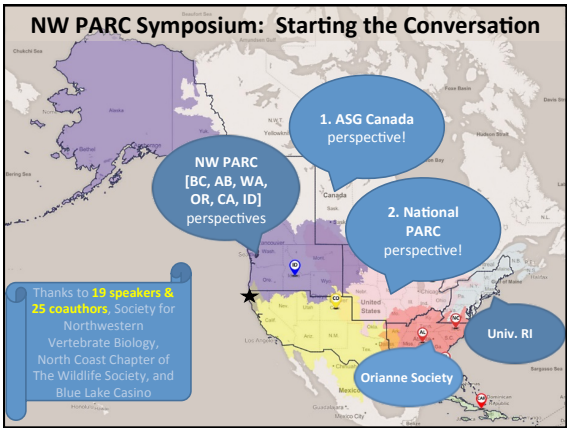
## International Union for the Conservation of Nature (IUCN)

**Time for reflection**:

- How can we increase conservation effectiveness?
- In addition to **Threats**, are there other considerations for amphibian research and conservation priorities?

IUCN SSC
Amphibian Specialist Group


PARC
PARTNERS IN AMPHIBIAN AND REPTILE CONSERVATION
NW PARC Symposium:
Top Priorities for
Amphibian Research & Conservation
in Canada and the USA
Arcata, CA: March 1st 2017
Thanks to 19 speakers, Society for Northwestern Vertebrate Biology, North Coast Chapter of The Wildlife Society, and Blue Lake Casino


NW PARC Symposium: Starting the Conversation
1. ASG Canada perspective!
NW PARC [BC, AB, WA, OR, CA, ID] perspectives
2. National PARC perspective!
Univ. RI
Orianne Society
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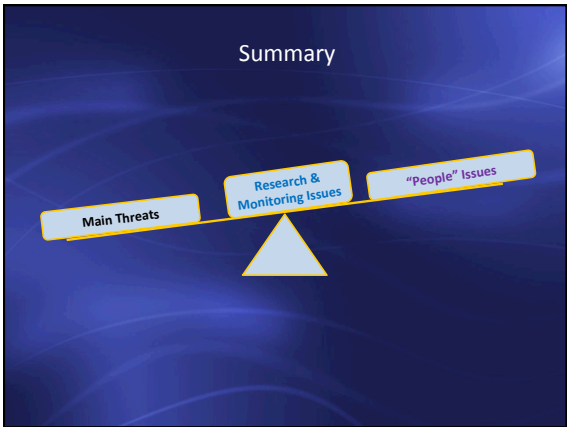

Summary
Main Threats
Research & Monitoring Issues
"People" Issues

# ASG Canada:
## Research & Conservation Priorities for Amphibians in the North

**Kristiina Ovaska[1], Ph.D. & Sara Ashpole[2], Ph.D.**

[1]*Biolinx Environmental Research Ltd., Victoria, BC; ke.ovaska@gmail.com*

[2]*Lawrence University, Canton, NY; sashpole@stlawu.edu*

## Conservation & Research Priorities: ASG Canada's 3 Objectives

1. **Understand causes of amphibian declines in Canada**

K. Ovaska photo

## Summary of Amphibian Threats in Canada

| Threat | Threat Impact |
|---|---|
| Invasive species | Very high –High (≥75% decline) |
| Emerging Diseases | Unknown |
| Transportation & Pollution | High or Medium for majority of amphibians |
| Residential effects, Agriculture effects, & Biological use | High or Medium for some anurans<br>Low for most anurans and salamanders |
| Climate Change | High - Unknown |

[Maintain Diversity]

## Conservation & Research Priorities: ASG Canada's 3 Objectives

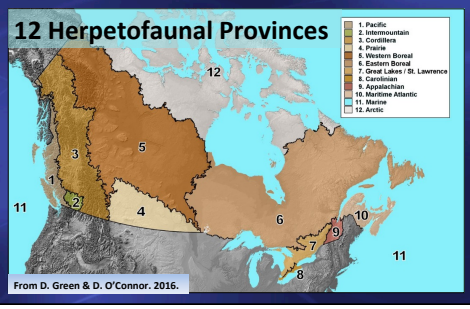
1. Understand causes of amphibian declines in Canada
2. **Continue to document amphibian diversity, and how it is changing**

K. Ovaska photo

**Frogs: 26 species** **Salamanders: 23 species**

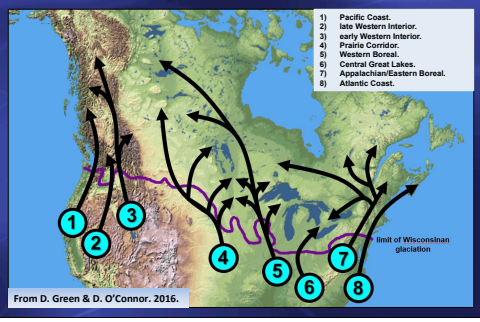
49

### 12 Herpetofaunal Provinces




From D. Green & D. O'Connor. 2016.

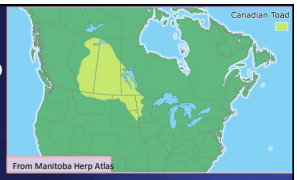
## Putative Post-glacial Range-Expansion Routes




From D. Green & D. O'Connor. 2016.

[Maintain Diversity]

- Conserve Common Spp e.g., Canadian Toad




- Identify Evolutionary Significant Units (ESUs)
  32 spp → 49 ESUs

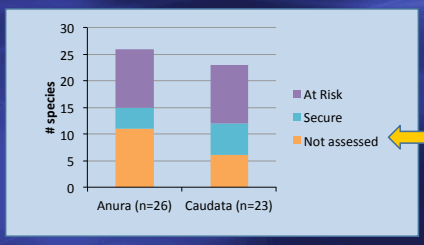

[Track Trends]

- Inventory & Monitor e.g., Citizen Science Atlas Projects

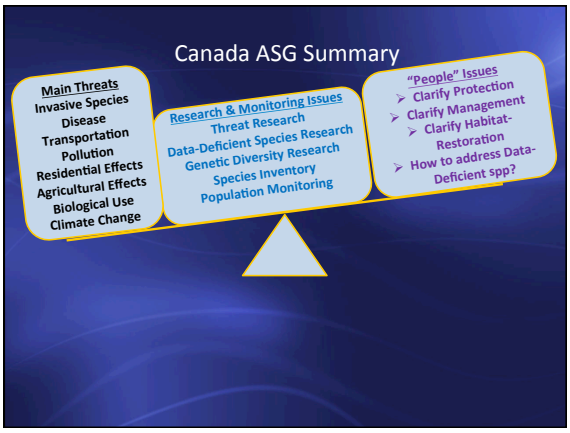
## Conservation & Research Priorities: ASG Canada's 3 Objectives

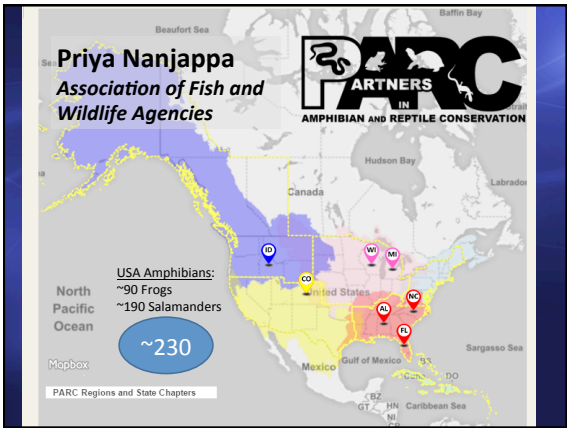
1. Understand causes of amphibian declines in Canada
2. Continue to document amphibian diversity, and how it is changing
3. **Clarify protection, management, & habitat restoration needs (e.g., data deficient species)**


## Species At Risk: COSEWIC Assessment




*46% Canadian amphibian species contain designatable units that are at risk*


Canada ASG Summary
Main Threats
Invasive Species
Disease
Transportation
Pollution
Residential Effects
Agricultural Effects
Biological Use
Climate Change
Research & Monitoring Issues
Threat Research
Data-Deficient Species Research
Genetic Diversity Research
Species Inventory
Population Monitoring
"People" Issues
Clarify Protection
Clarify Management
Clarify Habitat-Restoration
How to address Data-Deficient spp?


Priya Nanjappa
Association of Fish and Wildlife Agencies
PARTNERS IN AMPHIBIAN AND REPTILE CONSERVATION
USA Amphibians:
~90 Frogs
~190 Salamanders
~230
North Pacific Ocean
PARC Regions and State Chapters


VISION
MISSION
VALUES
STRATEGY

## PARC's New Mission Statement

Forging proactive **partnerships**
to conserve amphibians, reptiles,
and the places they live

## Vision

A society where
amphibians and reptiles are **valued**
for their importance in our
**natural and cultural heritage**,
and are
**considered in all conservation and land management decisions**.

## Core Values

1) Inclusivity and Collaboration
2) Proactive, Responsive, and Adaptive Approaches
3) Scientific Integrity
4) Biodiversity
5) Optimism

## Top Ten Challenges


1. Habitat quality [loss, degradation]
2. Habitat connectivity (fragmentation)
3. Metapopulation considerations

## Top Ten Challenges


4. Value in wildlife management agencies
5. Lack of clear and stable funding

## Top Ten Challenges


6. Pathogens and disease

## Top Ten Challenges

7. Land management considerations
8. Pollutants and contamination
9. Climate (and hydrological) changes

## Top Ten Challenges

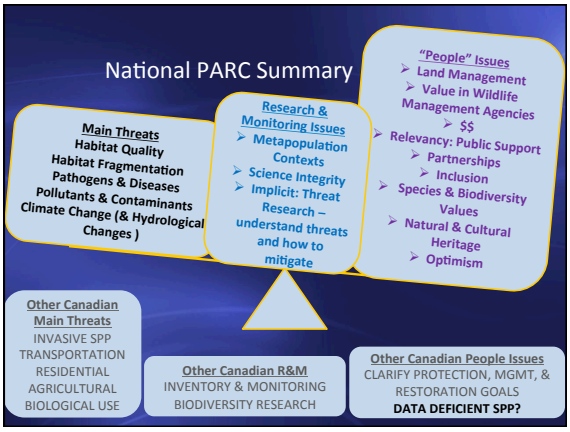
10. Relevancy: Public Support

## National PARC Summary

**Main Threats**
- Habitat Quality
- Habitat Fragmentation
- Pathogens & Diseases
- Pollutants & Contaminants
- Climate Change (& Hydrological Changes )

**Research & Monitoring Issues**
- Metapopulation Contexts
- Science Integrity
- Implicit: Threat Research – understand threats and how to mitigate

**"People" Issues**
- Land Management
- Value in Wildlife Management Agencies
- $$
- Relevancy: Public Support
- Partnerships
- Inclusion
- Species & Biodiversity Values
- Natural & Cultural Heritage
- Optimism


National PARC Summary
Main Threats
Habitat Quality
Habitat Fragmentation
Pathogens & Diseases
Pollutants & Contaminants
Climate Change (& Hydrological Changes )
Research & Monitoring Issues
Metapopulation Contexts
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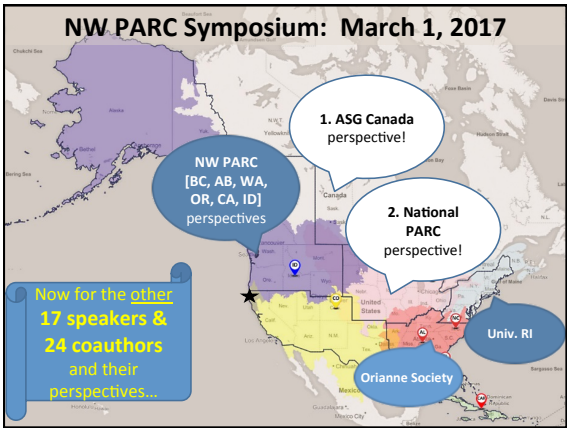
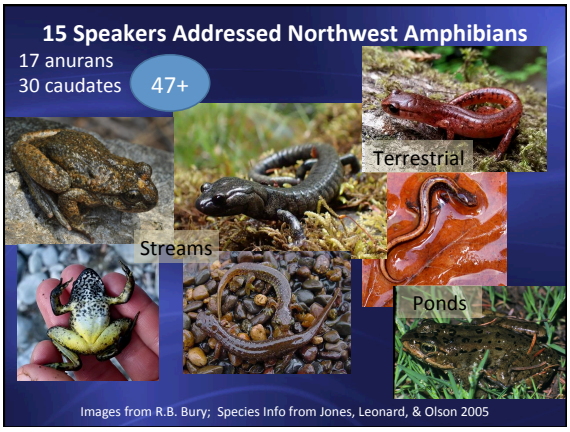
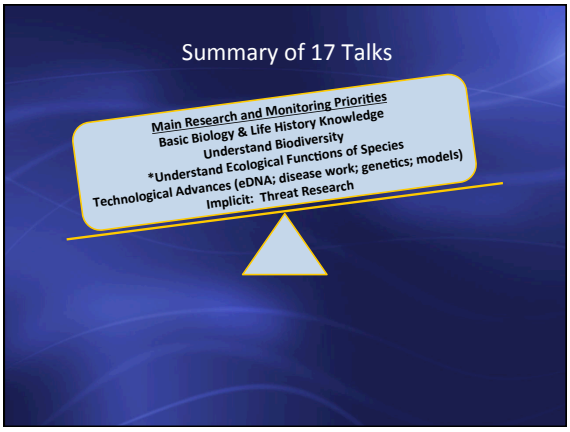
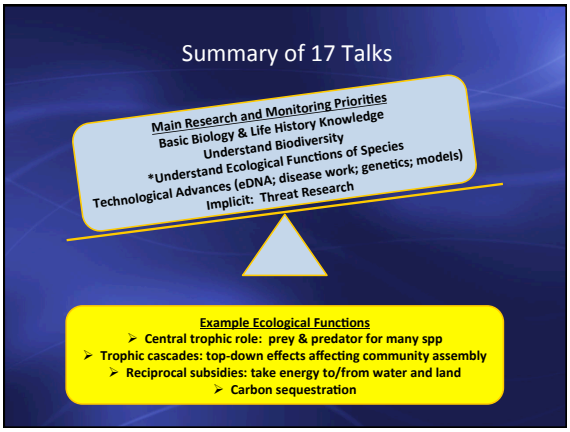
"People" Issues
Land Management
Value in Wildlife Management Agencies
$$
Relevancy: Public Support
Partnerships
Inclusion
Species & Biodiversity Values
Natural & Cultural Heritage
Optimism
Other Canadian Main Threats
INVASIVE SPP
TRANSPORTATION
RESIDENTIAL
AGRICULTURAL
BIOLOGICAL USE
Other Canadian R&M
INVENTORY & MONITORING
BIODIVERSITY RESEARCH
Other Canadian People Issues
CLARIFY PROTECTION, MGMT, & RESTORATION GOALS
DATA DEFICIENT SPP?


NW PARC Symposium: March 1, 2017
1. ASG Canada perspective!
NW PARC [BC, AB, WA, OR, CA, ID] perspectives
2. National PARC perspective!
Now for the other 17 speakers & 24 coauthors and their perspectives…
Univ. RI
Orianne Society


15 Speakers Addressed Northwest Amphibians
17 anurans
30 caudates
47+
Terrestrial
Streams
Ponds
Images from R.B. Bury; Species Info from Jones, Leonard, & Olson 2005


Summary of 17 Talks
Main Research and Monitoring Priorities
Basic Biology & Life History Knowledge
Understand Biodiversity
*Understand Ecological Functions of Species
Technological Advances (eDNA; disease work; genetics; models)
Implicit: Threat Research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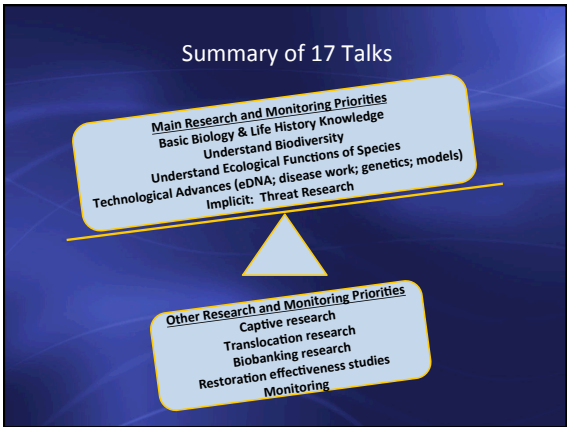
Example Ecological Functions
Central trophic role: prey & predator for many spp
Trophic cascades: top-down effects affecting community assembly
Reciprocal subsidies: take energy to/from water and land
Carbon sequestration


Summary of 17 Talks
Main Research and Monitoring Priorities
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Understand Biodiversity
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Technological Advances (eDNA; disease work; genetics; models)
Implicit: Threat Research
Other Research and Monitoring Priorities
Captive research
Translocation research
Biobanking research
Restoration effectiveness studies
Monitoring

## Summary of 17 Talks

**Main Threats**
Habitat Loss
Habitat Fragmentation
Disease
Invasive Species
Contaminants
Roads
Climate Change

## Summary of 17 Talks

**Main Threats**
Habitat Loss
Habitat Fragmentation
Disease
Invasive Species
Contaminants
Roads
Climate Change

**Other Threats**
Overexploitation
Urban/Rural Development
Forestry, Agriculture
Hydrological changes (dams)
Mining

…but Context Matters!

Photo by Eric Isselée

PARC Partners in Amphibian and Reptile Conservation

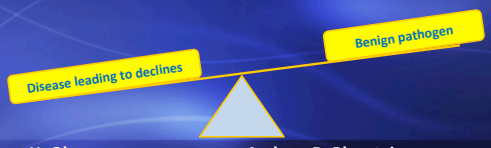
Context…

ALL HABITAT CHALLENGES ARE NOT EQUAL!!

JJ Apodaca
*Warren Wilson College*
*Asheville, NC*

## Context Matters:

### Tipping Points between Amphibian Risks and Threats – Disease Examples of being Benign or Leading to Declines

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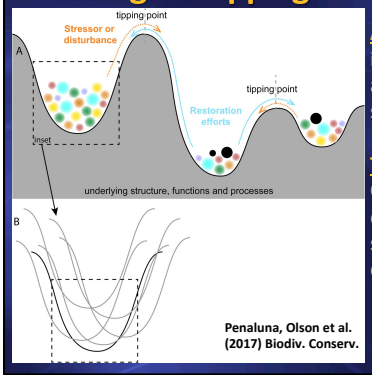
**Andrew R. Blaustein**
*Department of Integrative Biology*
*Oregon State University, Corvallis*

## Ecological Tipping Point Analogy




Penaluna, Olson et al. (2017) Biodiv. Conserv.

A, B: Systems occur in multiple states, and are resilient to some perturbations.

Tipping point: Context* of disturbance moves system to new domain

## Disturbance contexts that matter may include:

1. Magnitude & frequency of disturbance
2. Differential susceptibility of locations
3. Differential vulnerability of life stages or species
4. Synergisms of multiple stressors



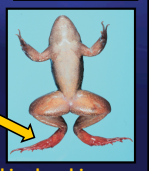
**Amphibian Disease Examples…**

# Amphibian Chytrid Fungus

***Batrachochytrium dendrobatidis* (Bd):** Described in 1999

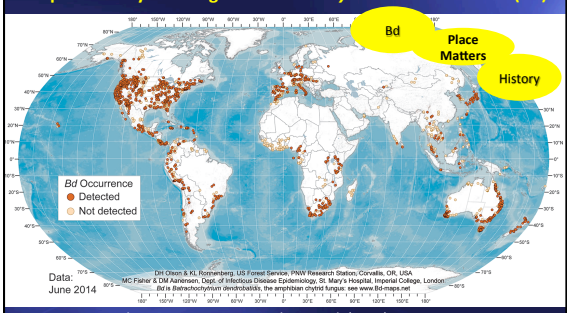
- Infects keratinized mouthparts of larvae (non-lethal)

- Infects skin of metamorphs/adults
  - lethal effects
  - sublethal effects
  - no symptoms



- Symptoms include lethargy, abnormal posture, skin sloughing; Mortality from impaired electrolyte transport then cardiac arrest

## Amphibian Chytrid Fungus: *Batrachochytrium dendrobatidis* (Bd)

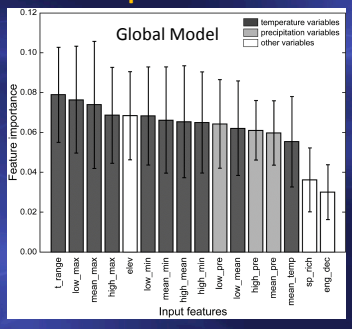



Olson, Aanensen, Ronnenberg et al. (2013) PLoS ONE

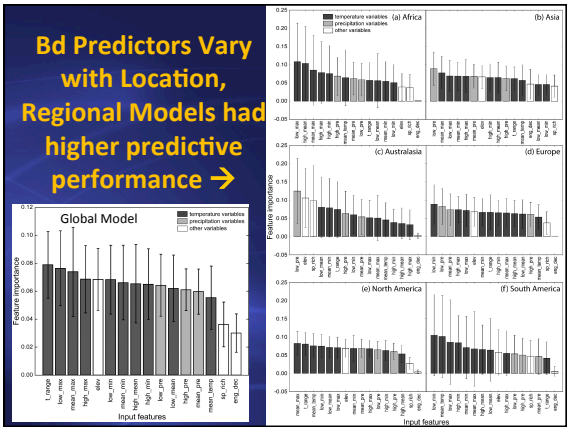
**Global detection = occurrence = host *infection***
***not necessarily *disease* (= *chytriodiomycosis*)***

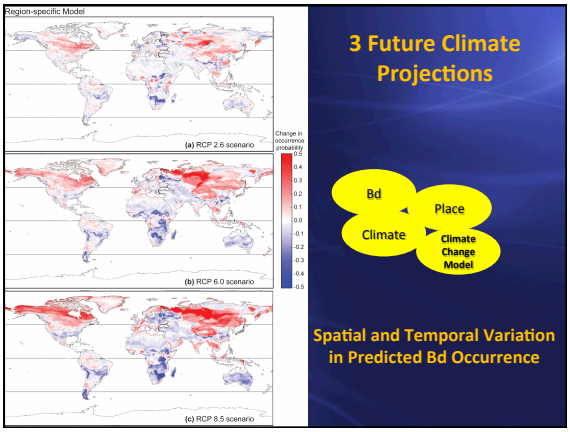
## Bd Landscape-Scale Predictors

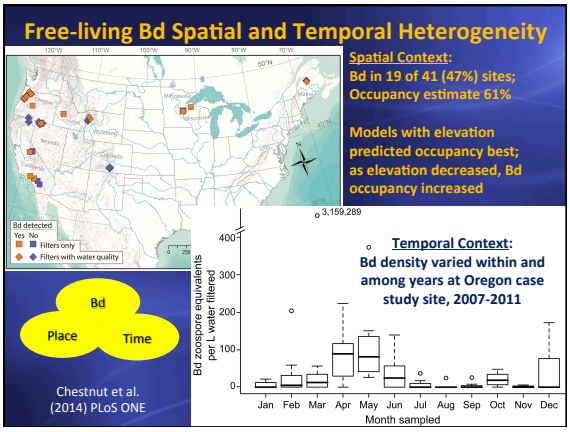
Bd
Climate




Xie, Olson, Blaustein (2016) PLoS ONE


Bd Predictors Vary with Location, Regional Models had higher predictive performance →
Global Model
temperature variables
precipitation variables
other variables
Feature importance
Input features
(a) Africa
(b) Asia
(c) Australasia
(d) Europe
(e) North America
(f) South America


Region-specific Model
(a) RCP 2.6 scenario
(b) RCP 6.0 scenario
(c) RCP 8.5 scenario
Change in occurrence probability
3 Future Climate Projections
Bd
Place
Climate
Climate Change Model
Spatial and Temporal Variation in Predicted Bd Occurrence


Free-living Bd Spatial and Temporal Heterogeneity
Spatial Context:
Bd in 19 of 41 (47%) sites;
Occupancy estimate 61%
Models with elevation predicted occupancy best;
as elevation decreased, Bd occupancy increased
Bd detected
Yes No
Filters only
Filters with water quality
3,159,289
Temporal Context:
Bd density varied within and among years at Oregon case study site, 2007-2011
Bd zoospore equivalents per L water filtered
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month sampled
Bd
Place
Time
Chestnut et al. (2014) PLoS ONE

## Bd Strain Matters

**Support for differential host survival and/or Bd virulence with strain (=isolate)**

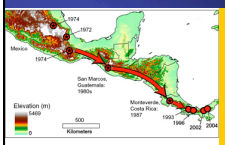
e.g., Johnson & Speare (2003, EID); Berger et al. (2005, DAO); Retallick & Miera (2007, DAO); Fisher et al. (2009, Mol.Ecol.)

**59 Bd isolates from 5 continents compared**

James et al. (2009, PLoS Path.)

**29 focal Bd isolates sequenced, inference to 49 global isolates**

Rosenblum et al. (2013, PNAS)




Cheng et al. 2011

- **Complex genome dynamics with long evolutionary history**
- **Geographic patterns of clades support invasion followed by divergence**
- **Bd endemic in some places, novel elsewhere**
- **THIS MATTERS, naïve hosts may be more vulnerable to chytridiomycosis**

## Bd Infection Intensity May Matter

**Proposed 10,000 zoospore load "rule"**
**Support from Frogs: *Rana muscosa***

Vredenburg et al. (2010)


**Support from Salamanders**

Cheng et al. (2011)

## Host Identity & Life History May Matter

**20-Species Analysis with Life History Traits**

Gervasi et al. (2017) PLoS ONE

**Ranidae: lowest infection intensities**
**Bufonidae: highest mortality**

**Predictors of vulnerability to and intensity of Bd infection:**

- **More ephemeral aquatic habitat use**
- **Larger body size**
- **Larger geographic range**
- **Greater breadth of habitat use**
- **Shorter lifespan**
- **Earlier age at sexual maturity**

Many studies relevant to host-identity matters; Examples:
Bancroft et al. (2011) Biodiv. Conserv.
Blaustein, Romansic, et al. (2005) Conserv. Biol.
Gervasi et al. (2013) PLoS ONE
Searle et al. (2011) Conserv. Biol.
Searle et al. (2013) PLoS ONE

## Host Population May Matter

**10 Wood Frog populations experimentally studied**

Bradley et al. (2015) Conserv. Biol. (Wood Frogs)

Variation among populations in:

- Overall survival
- Mortality rate
- Infection load

May lead to reservoir populations being the source of transmission

See also:
Gervasi et al. (2013) EcoHealth (American Bullfrogs)

## Interactions May Matter

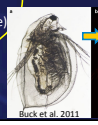

**Co-Infections:**
**Ribeiroia and Bd**
Romansic et al. (2011)

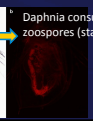
**Ranavirus and Bd**
Hambelek et al. Submitted

**Abiotic Conditions**
**Nitrate and Bd**
Negru et al. Submitted
**Fungicides and Bd**
Chestnut et al. in prep.
**Uv-B and Bd**
Garcia et al.(2006, DAO)

All N + Bd levels lowered *Rana cascadae* survival
Only high N + Bd lowered *P. regilla* Survival.
Also nonlethal combination effects

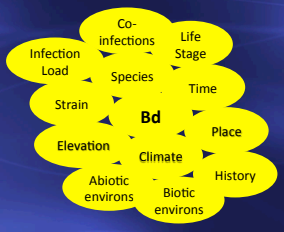
**Aquatic Community**
Buck et al. (2011) Biodiv. Conserv.
Buck et al. (2015) Oecologia
Buck et al. (2016) Freshw. Biol. (+ nutrients)
Groner et al. (2013) Ecol. Appl. (predator exposure)
Han et al. (2015) Ecol. Evol. (host community)



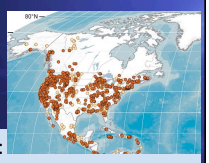
Daphnia consume Bd zoospores (stained red)

## …Yes, Context Matters!




…and scientific experiments & models are critical to understand role of many factors!

## Are there Tipping Points?



Brazil (1980s)
Central America (1980s)
Australia (1990s)
USA (Ranids, 1999-2000s)
Spain (1997)

Some places
~200 spp w/ losses [Skerratt et al. 2007]
Some Bd isolates more virulent
Some zoospore loads lethal
Interactions may matter

Bd in:
71 of 105 countries
~700 of 1400 spp tested
[Olson & Ronnenberg 2014, Froglog]

Benign?

Declines!

Recall: this "CONTEXT MATTERS" concept applies to all the Threats!

## Tipping Points: Benign vs Declines?

Accelerated Pace of Research

Needs

Broadscale Monitoring

Rare & Common Species
$$
So What?

## People Priorities from 17 Talks

Top 18 People-Priorities are....

## PEOPLE PRIORITIES FROM 17 TALKS

ACTIONS
- Create Wonder
- Connect to Nature

Thanks John Applegarth

## 17-PEOPLE PRIORITIES

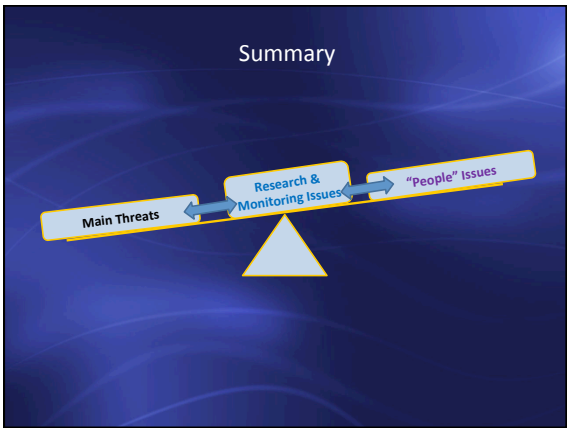
ACTIONS

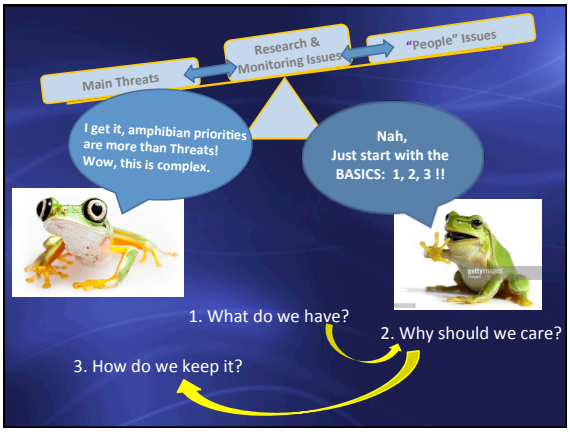
Amphibians are: central to food webs; indicators of environmental health; sources of biomedical advances; teaching tools; totally AWESOME!

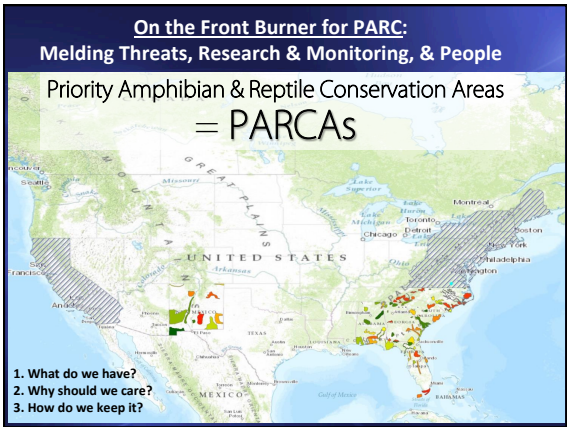
- Explain the "So What?"
- Expand education
- Develop citizen science programs
- Develop partnerships
- Forge the science-management interface
- Stop the piecemeal approach, work across all lands and

## PEOPLE PRIORITIES

ACTIONS
- Develop agricultural stewardship
- Develop stakeholder consensus
- End wetland filling
- Develop shared data web portals
- Green development
- Keep common spp common
- Focus on rare, endemic species
- Restore systems (e.g., Beaver reintroductions)
- Improve conservation capacity
- Improve conservation policy


Summary
Main Threats
Research & Monitoring Issues
"People" Issues


Main Threats
Research & Monitoring Issues
"People" Issues
I get it, amphibian priorities are more than Threats! Wow, this is complex.
Nah, Just start with the BASICS: 1, 2, 3 !!
1. What do we have?
2. Why should we care?
3. How do we keep it?


On the Front Burner for PARC:
Melding Threats, Research & Monitoring, & People
Priority Amphibian & Reptile Conservation Areas
= PARCAs
1. What do we have?
2. Why should we care?
3. How do we keep it?

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