

## Amphibian Population Declines



*Bufo periglenes*, CR



*Hyla regilla*, OR

**Matthew J. Gray**  
University of Tennessee

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## Outline

- I. Amphibian Declines
- II. Why Amphibians?
- III. Hypotheses for Declines
- IV. Should we Care?

**Required Readings:** Wells (2007): pp. 787-795, 800-803, 850-853

**Supplemental Readings:** Wells (2007): pp. 816-853

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## Worldwide Amphibian Population Declines

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## History of Amphibian Declines

**Prior 1970s:** •Few extinctions; some localized die-offs  
Ohio Journal of Science 49:70-71

**1970-mid-1980s:** •Few extinctions  
•Localized die-offs in temperate areas associated with habitat destruction  
Alberta Naturalist 11:1-4

**Late 80s-Now:** •Increase in extinctions  
•Localized & regional die-offs in temperate and tropical areas; some in “pristine” areas  
1989 First Meeting of the World Congress of Herpetology

Conservation Biology 7:355-362, 8:72-85, 10:406-413, 10:414-425, 12:106-117, 13:117-125; Biotropica 20:230-235; Nature 404:752-755

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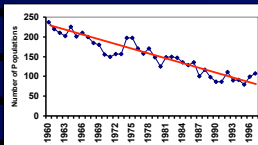
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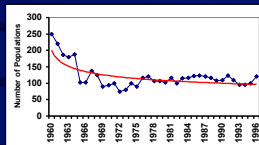
## Global Amphibian Declines

Houlahan et al. 2000, *Nature* 404:752-755

North America



Western Europe




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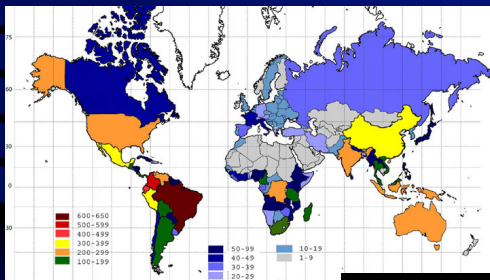
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## Global Amphibian Distributions



Total Number of Amphibian Species per Country  
Map by Tiwari, Gross, Vredenburg and Van der Meijden

**230 US species:**  
•90 anurans;  
•140 urodeles

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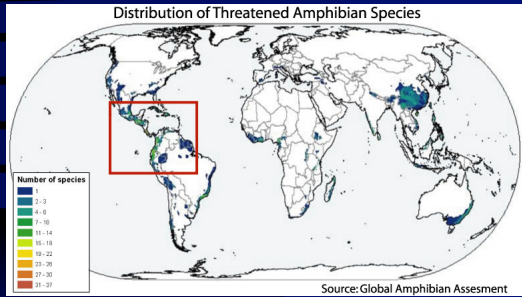
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# Status of Amphibian Populations



In Threat of Extinction: **30%** of amphibian species  
 12% = birds, 23% = mammals  
**40% in decline**

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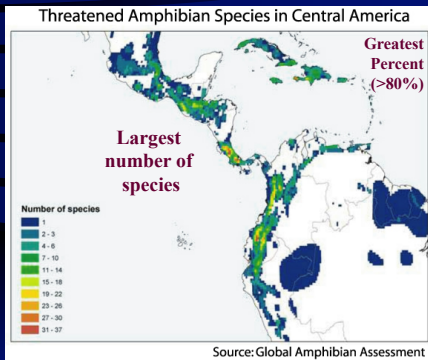
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# Greatest Level of Threat




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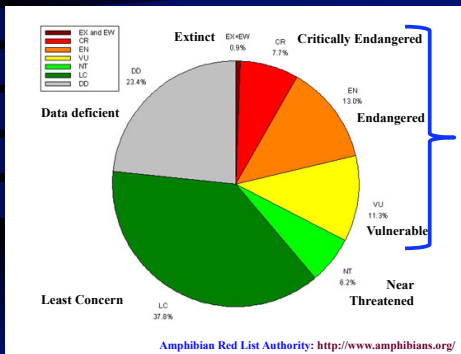
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# Status of Amphibian Populations




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## Status of Amphibian Populations

(as of 2012)

Order	Total	EX	EW	CR	EN	VU	NT	LC	DD	% Threatened or Extinct
Anura Frogs & Toads	5,640	34	2	429	665	561	327	2,178	1,446	29.3
Caudata Salamanders & Newts	557	2	0	79	101	92	62	161	60	48.8
Gymnophiona Caecilians	177	0	0	1	1	4	0	53	118	3.4
Total	5,918	36	1	456	769	671	369	2,236	1,382	30.3

25%

CR, EN, or VU: Anura = 1655 spp  
Caudata = 272 spp  
Gymnophiona = 6 spp

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## Status of U.S. Amphibians



- 2 Species Extinct (*R. fisheri*; *P. ainsworthi*)
- 10 Endangered; 9 Threatened; 5 Awaiting
- CA = 8 Spp.; SW = 6 Spp.; SE = 6 Spp.  
(Chiricahua Leopard Frog, 80%)

Western U.S.

• TN: 1 state-listed; 26 spp (30%)

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## Species Designated Extinct

- 2 Salamanders
  - *Plethodon ainsworthi*- South central Mississippi
  - *Cynops wolterstorffi*- (Newt) Yunnan, China
- 34 Anurans
  - 2 Extinct in the wild- Wyoming toad [7 zoos around the USA], Kinhasi spray toad (Tanzania) [Toledo Zoo]
  - 20 spp. of Rhacophorids- 1 just rediscovered in Sri Lanka after 160 years of no detection (March 5, 2013)
  - 4 spp. Bufonids, 3 Myobatrachids, 2 Craugastorids, and 1 Hylid, Ranid, and Dicroglossid
- 54 species haven't been seen in 5 – 40 yrs, mostly in Latin America



<http://amphibiaweb.org/declines/extinct.html>

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## Commonality of Being Uncommon

Southeastern United States

Federally Listed: *Rana sevosia*, *Ambystoma cingulatum*,  
*Phaenognathus hubrichti*, *Ambystoma bishopi*

**113 Species and 25 Genera Total** 50% U.S.

- 1) Alabama = 14 species (11 genera)
- 2) Arkansas = 25 species (12 genera)
- 3) Florida = 19 species (12 genera)
- 4) Georgia = 22 species (15 genera)
- 5) Kentucky = 22 species (11 genera)
- 6) Louisiana = 15 species (10 genera)
- 7) Mississippi = 18 species (12 genera)
- 8) North Carolina = 41 species (15 genera)
- 9) South Carolina = 19 species (13 genera)
- 10) Tennessee = 26 species (14 genera)




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## Why are Amphibians so Susceptible?



Exothermic vertebrates with a biphasic (in part) life cycle

•Thin, Permeable Skin that must remain Moist

Desiccation  
is a Lifelong  
Struggle

- 1) Respiration
- 2) Osmoregulation

- Long-lived (ca. 10 yr)
- Low Vagility ( $\leq 1$  km)

Absorb  
Compounds  
Readily

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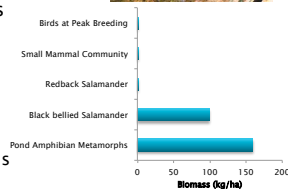
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## Who cares?

### ► Important part of the ecosystem

- Huge amount of biomass
  - Why?
- Move nutrients between ecosystems
- Prey
- Predators
  - Can alter pest populations
  - Change decomposition rates and thus nutrient cycling



References: Peterman et al. 2008; Gibbons et al. 2006; Burton and Likens 1975; Seale 1980; Beard et al. 2002, 2003; Sin et al. 2008; Whiles et al. 2006

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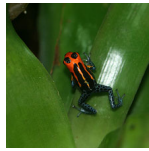
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## Who cares? -cont.



### ▶ **Medicine**

- Skin secretions and toxins– major potential for the development of pharmaceuticals
- Trials in rats show some of them have applications for weight loss, blood pressure regulation, cancer fighting, anti-microbial, anti-fungal, congestive heart failure, drug addiction, pain

### ▶ **Touted as ecological indicators**

- May help assess environmental quality
- Presence of contaminants

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## Hypotheses Related to DIRECT Anthropogenic Effects

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## Habitat Destruction/Degradation Hypothesis

### Obvious:



- Agricultural Practices
- Urban Development
  - Draining & Filling Wetlands
- Deforestation
  - Destroying Terrestrial Habitat (30 yrs)

**54%  
Wetlands  
Loss**

### Not so Obvious:



- Sedimentation
- Altered Hydroperiods
- Wildlife Management
  - Burning, Mowing

**JWM  
64:615-631**

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## Chemical Pollution Hypothesis

**Point Source:** Pollution originating from 1 point.

- **Effluent:** organic or industrial waste
- **Thermal:** electric plants

**Non-point Source:** Pollution originating from multiple points (e.g., field, parking lot).

**Chemicals & Effects:** Relyea (2003, 2004, 2005, 2009)

- **Nitrates & Ammonia:** Direct mortality; Reduce growth
- **Organophosphate Insecticides:** Above plus malformations and altered behavior
- **Atrazine:** herbicide (T. Hayes)
- **Various Oils & Compounds:** Affect respiration

Interactive effects with Natural Stressors

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## Introduced Predators & Competitors Hypothesis

### Predators:

- **Fish** (eat everything)  
 → Sport Fish (e.g. trout, bass)
- **Bullfrogs** (eat everything but adults)
- **Fire Ants** (eat metamorphs)

Copeia 1999:22-23  
Copeia 1991:1-8  
SARI Spec. Pub. 1

### Competitors:

- **Frogs**  
 → *Bufo marinus*, *L. catesbeianus*
- **Bait & Mosquito Fish**
- **Crawfish** (Predator of eggs also)

Conservation Biology 13:613-622  
FROGLOG 15 & 17




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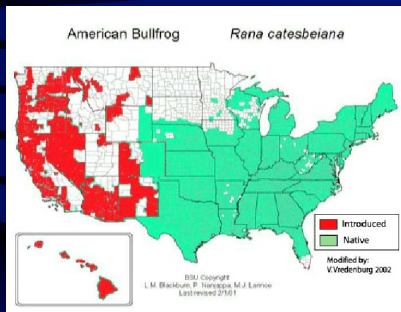
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## American Bullfrog Distribution




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## Commercial Exploitation Hypothesis

Traditionally a Concern in the SE Asia

**Removal:** •200 million exported annually from Asia  
 •70 million exported annually from India  
 → Consumption, Pet Industry

Environmentalist  
10:39-41, 1990

**Release** (Exotics or captive-reared specimens)  
 •2 million from (Rare) biological supply companies in the USA

Bioscience  
21:1027-1034

**Pathogen Pollution**  
 Charles D. Sullivan Co. Inc. Kolby et al. (2014), Schloegel et al. (2009),  
 6685 Holt Road Pico and Collins (2008)  
 Nashville, Tennessee 37211 Cunningham et al. (2003)

USA: 23-72 metric tons bullfrog legs

CAROLINA

Canapés to EXTINCTION

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## Hypotheses Related to INDIRECT Anthropogenic Effects

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## Global Warming Hypothesis

The anthropogenic increase of ambient temperatures via the accumulation of "greenhouse" gases

**Consequences of Greenhouse Effect**

•Severity of Weather  
 •Direct Alteration of Habitat  
*Altitudinal/Latitudinal*  
 → Rare and K-Selected

CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>

atmosphere  
 infrared rays

☀️ sunlight  
 ☁️ water vapor  
 🔴 methane  
 🔴 carbon dioxide

Climate Change  
39:541-561

Catastrophic Events

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## UV-B Radiation Hypothesis

Ozone depletion has resulted in increased incidence of UV-B radiation with the surface of Earth



### Effects on Amphibians

- Direct Mortality
- Decrease Hatching Success\*\*\*
- Malformations

### Most Susceptible Amphibians:

Photochemistry & Photobiology  
64:449-456  
Conservation Biology 10:1398-1402

- Low Photolyase in Eggs
- Eggs Near Surface
- Higher Elevation

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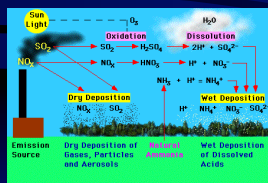
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## Acid Precipitation Hypothesis

The anthropogenic decrease in pH of precipitation via emissions of nitrogen oxides and sulfur dioxide and their oxidation and dissolution to acids

pH < 4



### Effects on Amphibians

- Direct Mortality
- Delayed Hatching
- Reduced Mobility
- Reduced Larval GR & Size



Copeia 1986:454-466

Food Web

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## Pathogenic Hypothesis: Fungi

### Chytrid (*Kl-trid*) Fungus

Non-hyphal, Parasitic Fungus

Phylum: Chytridiomycota

Unicellular

Class: Chytridiomycetes

Most Haploid: Zoospores

Order: Chytridiales

*Batrachochytrium dendrobatidis*

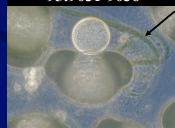
Colonize Keratinized Epidermal Cells

(Mouth & Pelvic Patch)

### Effects on Amphibians

- 50-100% Direct Mortality
- Epidermal Hyperplasia → Sloughing
- Interference w/ Cutaneous Respiration & Osmoregulation

Proc. Natl. Acad. Sci.  
95:9031-9036




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### Pathogenic Hypothesis: Iridovirus

Docherty et al. (2003)      Granoff et al. (1965); Rafferty (1965)      Jancovich et al. (1997)

•dsDNA, 150-280K bp  
•120-300 nm in diameter (3x smaller than bacteria)

Chinchar et al. (2006)

**Family: Iridoviridae**

Genera: *Iridovirus*, *Chloriridovirus*, *Ranavirus*, *Megalocytivirus*, and *Lymphocystivirus*

Invertebrates      Ectothermic Vertebrates

Species (6)

Amphibian Declines

Paracrystalline Array

*Ambystoma tigrinum virus (ATV)*  
*Bohle iridovirus (BIV)*  
*Frog virus 3 (FV3)*

Virion

**Signs:** 1) Dermal ulcerations and edema  
2) Systemic hemorrhages

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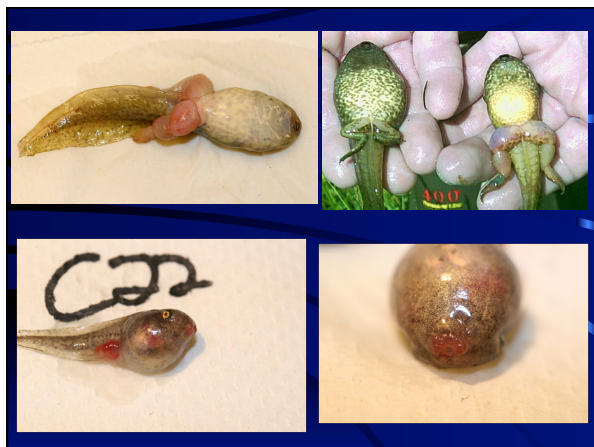
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## Pathogenic Hypothesis: Bacteria

Thought to be Secondary to Viral and Fungal Infections

### *Aeromonas hydrophila*

- Ubiquitous
- Facultatively Anaerobic
- Oxidase-positive
- Gram-negative

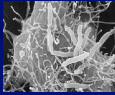
Enters host via Ingestion

Associated w/ "Stress"

**Effects on Humans:** gastroenteritis & septicemia

**Effects on Amphibians:** "Red-Leg"

- 1) Stop Eating
- 2) Septicemia
- 3) Capillary Dilation
- 4) Petechial Hemorrhaging




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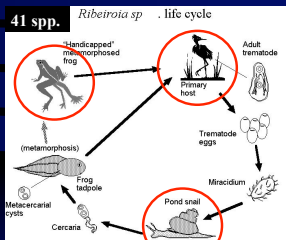
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## Pathogenic Hypothesis: Parasites

### Trematodes

(*Ribeiroia ondatrae*)



### Effects on Amphibians

- 1) Cysts form in and around "limb-buds"
- 2) Limb Development
- 3) Malformations

→ Survival/Reproduction



Science 284:802-804

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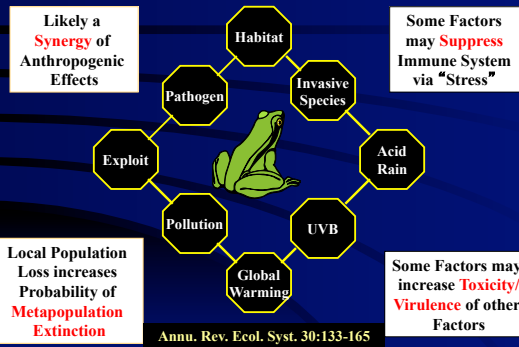
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## The Synergistic Hypothesis




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# Amphibians: The Organism and Community

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## Should we be Concerned??

### ABSOLUTELY!!!

*"The Singularity of Amphibians"*

- Good Ecological Indicators
- Important Components of Ecosystems
- Unknown Medicinal Uses
- Comprise Significant Biomass
- Biological Control: Insects
- Long-lived (10 yrs.)



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## What can you do?

### North American Amphibian Monitoring Program



Participate in Surveys

National: [naamp@usgs.gov](mailto:naamp@usgs.gov)

Tennessee: Bob English; 615-395-4166  
[ENG205@aol.com](mailto:ENG205@aol.com)

**Frog Watch USA**  
Report Malformations  
<http://www.aza.org/frogwatch/>



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