

## Amphibian Population Declines and Malformations



*Bufo periglenes*, CR



*Hyla regilla*, OR

**Matthew J. Gray**  
University of Tennessee

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## Worldwide Amphibian Population Declines

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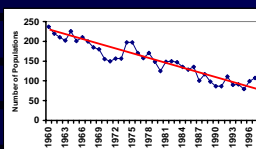
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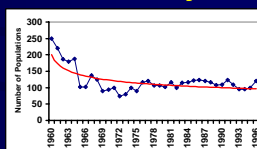
## Global Amphibian Declines

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

**North America**



**Western Europe**



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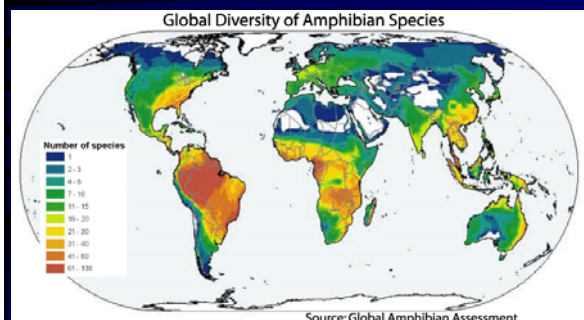
## History of Amphibian Declines

- 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  
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

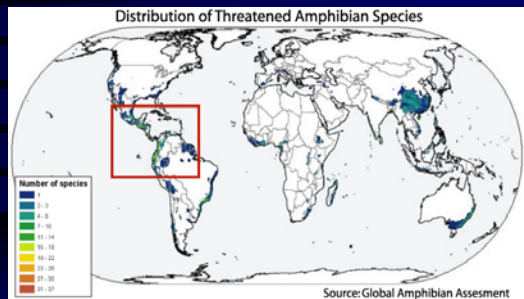
## Status of Amphibian Populations

- United States:** •1 Species Extinct (*Rana fisheri*) Western U.S.  
•10 Endangered; 7 Threatened; 8 Awaiting  
•CA = 6 Spp.; SE = 5 Spp.; Wyoming = 1 spp  
•SW = 6 Spp. (Chiricahua Leopard Frog, 80%)
- Puerto Rico:** •3 Spp. Extinct (*Golden*, mottled, web-footed Coquis)  
24 spp. (16 coquis)  
61% spp. in Caribbean
- Australia:** •1 Spp. of Toad; 2 Spp. Coquis  
•8 Spp. Extinct; 6 Spp. in Serious Decline  
→ Gastric-brooding Frogs  
(Discovered in '70s)
- Costa Rica:** •1 Spp. Extinct (Golden toad)  
•Multiple in Decline
- Elevation*  
*Pristine*

## Global Amphibian Distributions



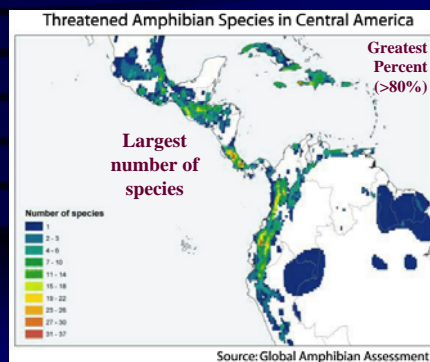
## Status of Amphibian Populations



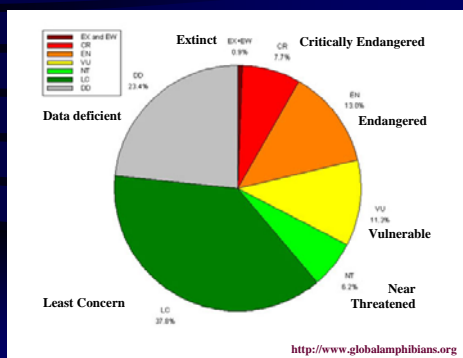
1/3 of amphibian species  
12% = birds, 23% = mammals

43% in  
decline

## Status of Amphibian Populations



## Status of Amphibian Populations



## Status of Amphibian Populations

Order	Total	EX	EW	CR	EN	VU	NT	LC	DD	% Threatened or Extinct
Anura Frogs & Toads	5,211	32	1	401	659	582	311	2,028	1,197	32.1
Caudata Salamanders & Newts	535	2	0	54	109	86	58	155	71	46.9
Gymnophiona Caecilians	172	0	0	1	1	3	0	53	114	2.9
Total	5,918	34	1	456	769	671	369	2,236	1,382	32.9

23%

CR, EN, or VU: Anura = 1642 spp  
Caudata = 249 spp  
Gymnophiona = 5 spp

## Amphibian Conservation Entities

### Declining Amphibian Populations Task Force (DAPTF)

•Established in 1991 after 1989 First World Congress of Herpetology

IUCN

•3000 Scientists, 90 Countries •Partnership, Research, FROGLOG

To determine the nature, extent, and cause of worldwide amphibian declines, and promote efforts to reverse current population trends

### North American Amphibian Monitoring Program

To determine the current population status on NA amphibians

#### 5 Prongs:

Voluntary

- Call Surveys\*\*\*
- Terrestrial Salamander
- Aquatic Surveys
- Atlassing
- Western Surveys

USGS  
1995

Working Groups

## Basic Amphibian Biology

Paleozoic Era  
(350 m. yrs.)

Water is a  
Necessity



Behaviorally  
Hydroregulate

Aestivation

Exothermic vertebrates with a biphasic (in part) life cycle

•Thin, Permeable Skin that must remain Moist

Desiccation  
a Lifelong  
Struggle


- 1) Respiration
- 2) Osmoregulation

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

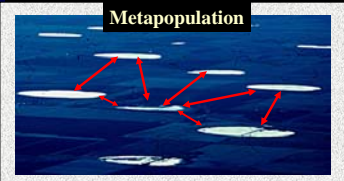
Absorb  
Compounds  
Readily

## Amphibian Population Structure


Species-Specific Vagility



**Metapopulation**



Landscape Physiognomy & Connectivity



**Isolated Demes (Subpopulations)**  
 Population Demography is Influenced by Interdemic Movements (Dispersal)

- Genetically:** Increasing Individual Heterozygosity
- Numerically:** Reducing Susceptibility of Demes to Demographic or Environmental Stochasticities

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## Hypotheses Related to DIRECT Anthropogenic Effects

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## Habitat Destruction/Degradation Hypothesis

**#1 Cause of Amphibian Declines** W1


Seemingly, Obvious:



- Logging Practices
- Agricultural Practices
- Cultivation, Grazing
- Urban Development & Roads

**54% Wetlands Loss**

Not so Seemingly, Obvious:



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

**Ray Semlitsch**  
 JWM  
 64:615-631

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## Chemical Pollution Hypothesis

L3

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

Harfenist et al. 1989;  
Blaustein and Wake 1990

•**Effluent:** organic or industrial waste

•**Thermal:** electric plants

**Repositories**

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

**Chemicals & Effects:**

**Tolerance**

USFWS Res. Pub. 60

**Sub-Lethal**

•Nitrates & Ammonia: Direct mortality; Reduce growth

•Organophosphate Insecticides: Above plus malformations and altered behavior; **bioconcentration**

•Various Oils & Compounds: Affect respiration

**Food Web**

## Introduced Predators & Competitors Hypothesis

L2

**Predators:**

•Fish (eat everything)



Sport Fish (e.g. trout, bass)

Copeia 1999:22-23

Copeia 1991:1-8

SARI Spec. Pub. 1

•Bullfrogs (eat everything but adults)

•Fire Ants (eat metamorphs)

**Competitors:**

•Frogs



*Bufo marinus*, *Rana catesbeiana*

Conservation  
Biology 13:613-622

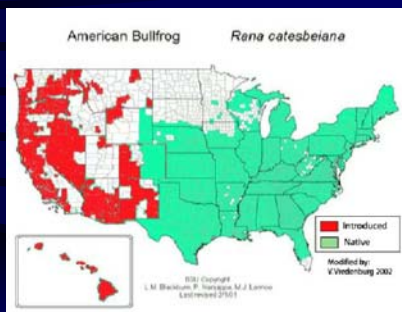
FROGLOG  
15 & 17

•Bait & Mosquito Fish

•Crawfish (*Predator of  
eggs also*)



## American Bullfrog Distribution



## Commercial Exploitation Hypothesis

Traditionally a Concern in the Orient L3

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

**Release:** (Exotics or captive-reared specimens)  
 → Science

**Reintroduction:** •Pathogens  
 •Regional Genetic Structure

**Environmentalism**  
 10:39-41, 1990

**Bioscience**  
 21:1027-1034

**USA:** 23-72 metric tons bullfrog legs

**Conservation Biology** 8:60-71

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## Hypotheses Related to INDIRECT Anthropogenic Effects

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## Global Warming Hypothesis W3

The anthropogenic increase of ambient temperatures via the accumulation of “greenhouse” gases

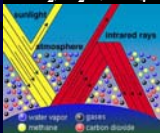
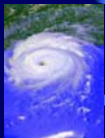

**Consequences of Greenhouse Effect**

•Severity of Weather  
 •Direct Alteration of Habitat  
 Altitudinal/Latitudinal  
 → Specialist (K-Selected)

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

**Climate Change**  
 39:541-561

**Catastrophic Events**


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## UV-B Radiation Hypothesis

W1

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

Synergy

Blaustein



### 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

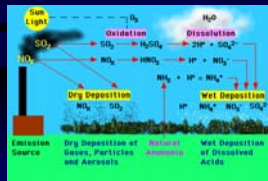
Vegetation

## Acid Precipitation Hypothesis

W3

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

Synergy

## Pathogenic Hypothesis: Fungi

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

LI

Circumpolar

Non-hyphal, Parasitic Fungus

Phylum: Chytridiomycota

Unicellular

Class: Chytridiomycetes

Most Haploid: Zoospores

Order: Chytridiales

*Batrachochytrium dendrobatidis*

Colonize Keratinized Epidermal Cells

(Mouth & Pelvic Patch)

Introduced?

### Effects on Amphibians

- 50-100% Direct Mortality

Epidermal Hyperplasia → Sloughing

→ Interference w/ Cutaneous Respiration & Osmoregulation

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





## Pathogenic Hypothesis: Fungi

### Chytrid Distribution

**L1**

Global Distribution of Chytrid fungus

● = number of species with chytrid - reported in wild populations  
 ● = number of species with chytrid - reported in captive populations

Copyright © M. J. Ryan, November 2004

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## Pathogenic Hypothesis: Iridovirus

**L1**

- dsDNA, 150-280K bp
- 120-300 nm in diameter (3x smaller than bacteria)
- Icosahedral Shape (20)

Crystal Packing Gives Infected Cells **Blue Iridescence**

Australia, USA, CR

**Family:** Iridoviridae  
**Genus:** Ranavirus & **Species:** FV3

**Symptoms:**

- 1) Dermal ulcerations and edema
- 2) Systemic hemorrhages

Phil. Trans. R. Soc. Lond. 351:1539-1557

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## Pathogenic Hypothesis: Bacteria

**L2**

Generally Secondary to Viral and Fungal Infections

*Aeromonas hydrophila*

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

Neg. Corr. w/ WBC

Found in Fresh and Saltwater  
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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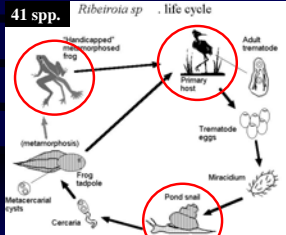
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## Pathogenic Hypothesis: Parasites

### Trematodes

(*Ribeiroia ondatrae*)

L2



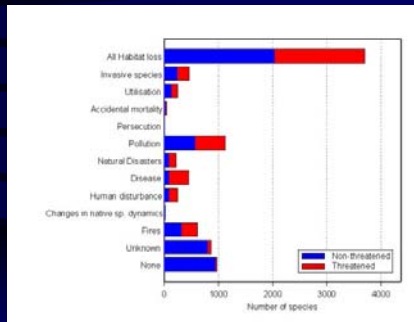
### Effects on Amphibians

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

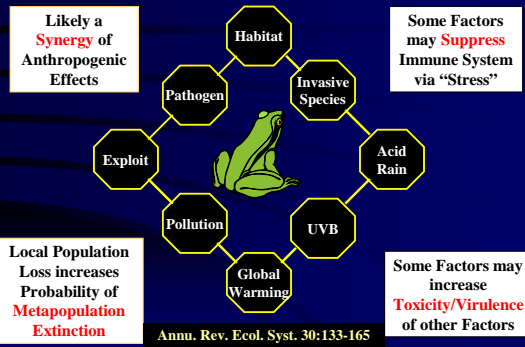


Science 284:802-804

## Attributed Mechanisms for Known Declines



## The Synergistic Hypothesis



## Amphibian Malformations

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### History of Amphibian Malformations



New County Middle School  
LeSueur, MN  
August 1995  
Cindy Reinitz

Turn-road bordered by  
corn and soybean field

**50% Deformed**

July 1996  
175 Reports, 2/3 Counties in MN

Similar Reports emerged,  
especially in WI and Western States



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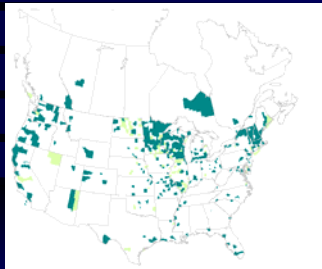
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### Locations of Confirmed Malformations in North America



Brewster, Burleson,  
Liberty, and Harris

Gray & Smith: 1) 1999: 1.5% JUV; 3% AD  
2) 2000: ??? (ca. 25% w/ TGSL)

Hale, Crosby,  
Floyd, Castro

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## Examination of Malformation Hypotheses



Stanley K. Sessions, Ph.D.  
Department of Biology  
Hartwick College, Oneonta, NY



Science 284:800-802; Science 284:802-804  
Journal of Experimental Zoology 254:38-47

[http://www.hartwick.edu/biology/def\\_frogs/](http://www.hartwick.edu/biology/def_frogs/)

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## Chemical Pollution Hypothesis

### Retinoids

No

Family of biochemicals (including vitamin A)  
that are important in embryonic development

Excess → Teratogen

Methoprene  
IGH

#### Why not Retinoids?

- 1) Lack of geographic correlation
- 2) Exogenous RA have to be excessively high (30 mg/l, 2d)
- 3) Affects all organisms equally
- 5) Affects limbs equally (hind)
- 6) Symmetrical Deformities
- 7) Bony Triangle




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## UV-B Radiation Hypothesis

No



Less than ambient UV (~70%) at  
constant exposure can cause deformities

#### Why not UV-B?

- 1) Bilateral and Symmetrical Deformities
- 2) Presence of Cartilaginous Spike




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## Eukaryotic Parasite Hypothesis



### Trematodes

(*Ribeiroia ondatrae*)

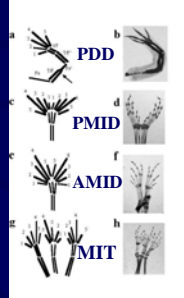
Yes

#### Why Trematodes?

- 1) Cause all classes of deformities  
PDD, PMID, AMID, MIT
- 2) Cause bony triangles & cutaneous fusions
- 3) Empirical FIELD and LAB evidence



Mechanical and Chemical Inhibition




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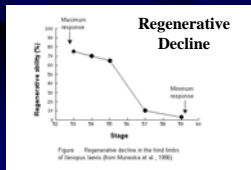
## Predation/Cannibalism Hypothesis

Yes

Dave Pfennig



Animal Behaviour  
46: 87-94



Associated with missing limbs and limb parts

Asymmetrical Limb Truncation

After Regenerative Decline

Abnormality

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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
- Comprise Significant Biomass
- Important Components of Ecosystems
- Very Efficient (95%)
- Unknown Medicinal Uses
- Long-lived (10 yrs.)



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## What can you do?

### Amphibian Population Declines

Participate in Surveys

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

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



### Amphibian Malformations

Report Malformations

**Form:** <http://frogweb.nbii.gov/narcam/>

**Email:** [narcam@usgs.gov](mailto:narcam@usgs.gov)



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