Global Amphibian Declines

Bufo periglenes, CR

Hyla regilla, OR

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Outline

I. Amphibian Declines

II. Why Amphibians?

III. Hypotheses for Declines

IV. What can you do?

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

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

Worldwide Amphibian Population Declines


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

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

1989 First Meeting of the World Congress of Herpetology

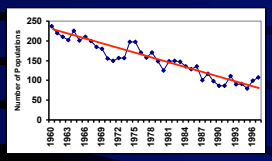
•Localized & regional die-offs in temperate and tropical areas; some in "pristine" areas

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

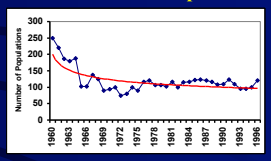
Global Amphibian Declines

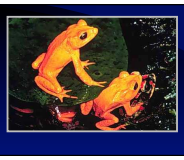
Houlahan et al. 2000, *Nature* 404:752–755

North America

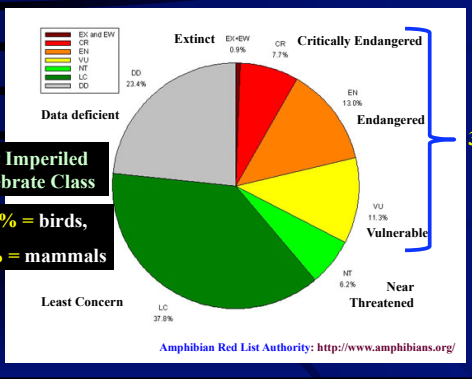


Western Europe





Status of Amphibian Populations

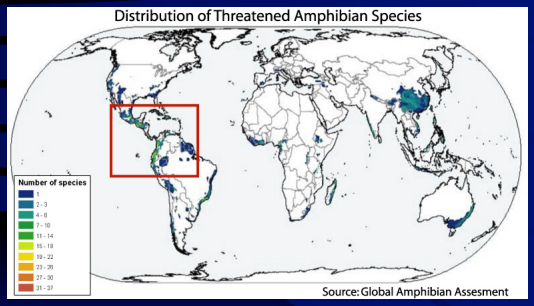


Most Imperiled Vertebrate Class

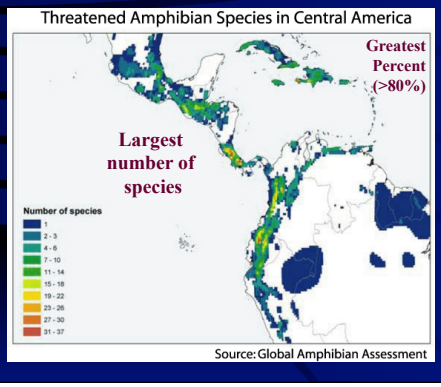
12% = birds,

23% = mammals

Status of Amphibian Populations



Greatest Level of Threat



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

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.
  (Chiracahua Leopard Frog, 80%)

Western U.S.

- TN: 1 state-listed; 26 spp (30%)

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

Commonality of Being Uncommon

Southeastern United States

Federally Listed: *Rana sevosa, Ambystoma cingulatum, Phaeognathus 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)

Why are Amphibians so Susceptible?

Exothermic vertebrates with a biphasic (in part) life cycle

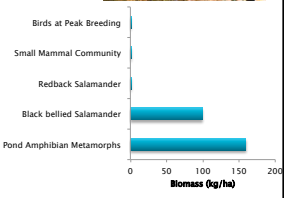
- **Thin, Permeable Skin that must remain Moist**
  - **1) Respiration**
  - **2) Osmoregulation**
- **Low Vagility (≤1 km)**
- **Long-lived (ca. 10 yr)**

Desiccation is a Lifelong Struggle

Absorb Compounds Readily

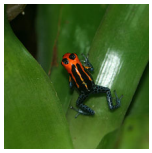
Who cares?

- **Important part of the ecosystem**
  - Huge amount of biomass
  - Prey
  - Predators
    - Pest (insect) populations
  - 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

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 (20X morphine)
- **Ecological indicators**
  - May help assess environmental quality
  - Presence of contaminants

Some Hypotheses for Amphibian Declines

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

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

Introduced Predators & Competitors Hypothesis

Predators:

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

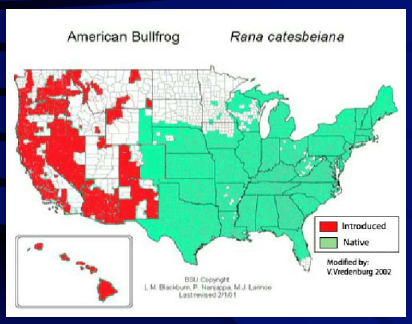
Copeia 1999:22-23
Copeia 1991:1-8
SARI Spec. Pub. 1

Competitors:

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

Conservation Biology 13:613-622
FROGLOG 15 & 17

American Bullfrog Distribution



Commercial Exploitation Hypothesis

Major 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

USA: 23-72 metric tons bullfrog legs

Release (Exotics or captive-reared specimens)

9 million frogs (*Rana*) shipped from biological supply companies in the USA

Bioscience 21:1027-1034

CAROLINA

Charles D. Sullivan Co. Inc.
6685 Holt Road
Nashville, Tennessee 37211

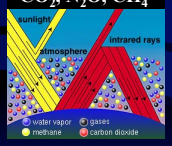
Pathogen Pollution

Kolby et al. (2014), Schloegel et al. (2009), Picco and Collins (2008) Cummingham et al. (2003)

Climate Change Hypothesis

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

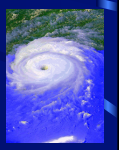
CO_2, N_2O, CH_4



Climate Change 39:541-561

Consequences of Greenhouse Effect

- Severity of Weather
- Direct Alteration of Habitat
  Altitudinal/Latitudinal
- Distribution, Breeding



Catastrophic Events

UV-B Radiation Hypothesis

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

Blaustein

Effects on Amphibians

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

Most Susceptible Amphibians:

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

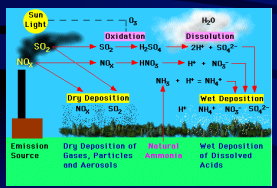
Photochemistry & Photobiology 64:449-456

Conservation Biology 10:1398-1402

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



Copeia 1986:454-466

Effects on Amphibians

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

Food Web

Pathogenic Hypothesis: Fungi

Chytrid *(KI-trid)* Fungus

Non-hyphal, Parasitic Fungus

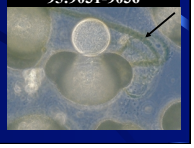
Phylum: Chytridiomycota — Unicellular

Class: Chytridiomycetes — Most Haploid: Zoospores

Order: Chytridiales — *Batrachochytrium dendrobatidis*

Colonize Keratinized Epidermal Cells
(Mouth & Pelvic Patch)

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



Effects on Amphibians

- 50-100% Mortality (adults: tropics)
- Epidermal Hyperplasia → Sloughing
- → Interference w/ Cutaneous Respiration & Osmoregulation

Photos = R. Brenes

Pathogenic Hypothesis: Ranavirus

Granoff et al. (1965); Rafferty (1965)

Docherty et al. (2003)

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

Jancovich et al. (1997)

Chinchar et al. (2006)

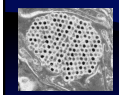
Family: Iridoviridae

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

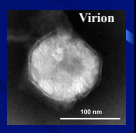
Invertebrates — Ectothermic Vertebrates

Species (6)

Amphibian Declines:
- *Ambystoma tigrinum* virus (ATV)
- Bohle iridovirus (BIV)
- Frog virus 3 (FV3)



Paracrystalline Array



Virion

Signs:
1) Dermal ulcerations and edema
2) Systemic hemorrhages (ebola: cold-blooded vertebrates)

Pathogenic Hypothesis: Bacteria

Thought to be Secondary to Viral and Fungal Infections

Aeromonas hydrophila

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

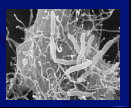
Enters host via Ingestion

Associated w/ "Stress"

Effects on Humans: gastroenteritis & septicemia

Effects on Amphibians: "Red-Leg"

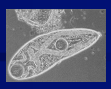
1) Stop Eating
2) Septicemia
3) Capillary Dilation
4) Petechial Hemorraging



Pathogenic Hypothesis: Parasites

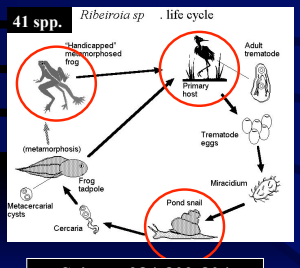
Trematodes

(*Ribeiroia ondatrae*)



41 spp.

Ribeiroia sp . life cycle



Science 284:802-804

Effects on Amphibians

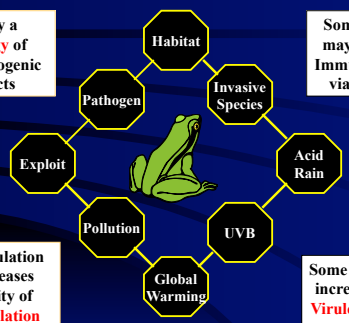
1) Cysts form in and around "limb-buds"
2) Limb Development
3) Malformations
4) High Nitrogen Sites

P. Johnson

The Synergistic Hypothesis

Likely a Synergy of Anthropogenic Effects

Some Factors may Suppress Immune System via "Stress"



Local Population Loss increases Probability of Metapopulation Extinction

Some Factors may increase Toxicity/ Virulence of other Factors

Annu. Rev. Ecol. Syst. 30:133-165

Amphibians:
The Organism and Community

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.)



What can you do?

North American Amphibian Monitoring Program

Participate in Surveys

National: *naamp@usgs.gov*

Tennessee: Bob English; 615-395-4166
ENGC205@aol.com

Frog Watch USA

Citizen-science Surveys

http://www.aza.org/frogwatch/