

Amphibian Population Declines



Gavi Night Frog- 1 of 12 newly discovered frogs in India (Nyctibatrachidae)

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Outline

- I. Why does it matter?
- II. Amphibian Declines: History and Current State
- III. Why Amphibians?
- IV. Hypotheses for Declines

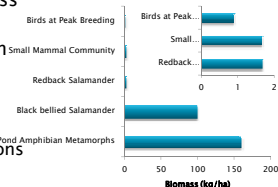
Required Readings: Wells (2007): pp. 787-795, 800-803, 850-853

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

Who cares?

► Important part of the ecosystem

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



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
- ▶ Touted as ecological indicators
 - May help assess environmental quality
 - Presence of contaminants

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:

1989 First Meeting of the World Congress of Herpetology

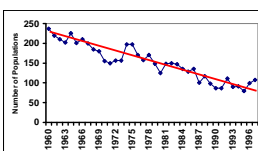
- Increase in extinctions
- Localized & regional die-offs in temperate and tropical areas; some in "pristine" areas

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

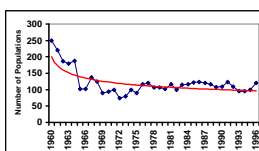
Global Amphibian Declines

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

North America



Western Europe

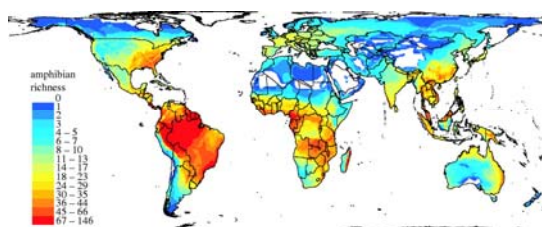


Golden Toad: Amphibian Decline Poster Child

- ▶ *Bufo periglenes*
- ▶ Discovered in 1966 in Costa Rica in the cloud forests
- ▶ ~15,000 were seen for the next 17 years
- ▶ 1988: 10 individuals
- ▶ 1989: 1 individual
- ▶ None seen since
- ▶ Monteverde Cloud Forest Preserve- very well protected

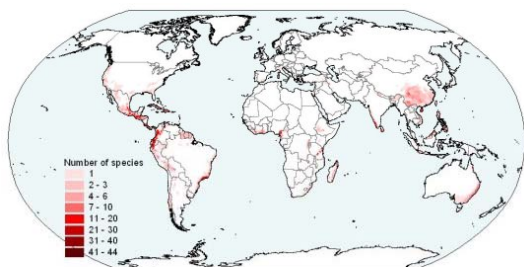


Locations of Amphibian Diversity



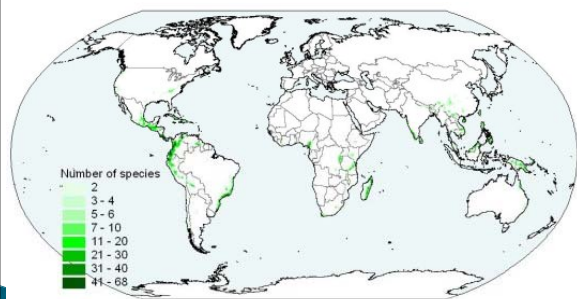
In Threat of Extinction (2012 data):
 30% of amphibian species
 13% = birds, 21% = mammals
 21% = reptiles, 20% bony fish

Global Distribution of Threatened Amphibians

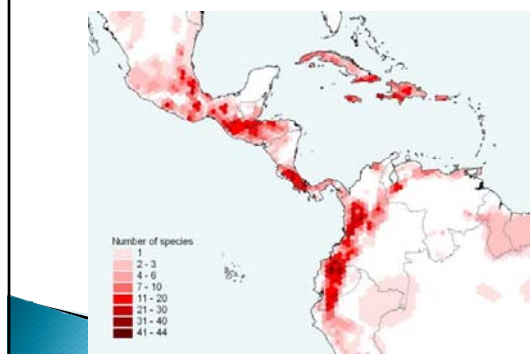


From the Global Amphibian Assessment, 2004

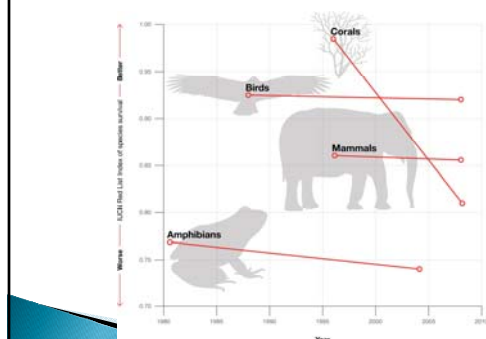
Distribution of Endemic Amphibians



Highest Level of Threat



Change in Status over Time



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	32	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	6,374	34	2	509	767	657	389	2,392	1,624	30.3

CR, EN, or VU: Anura = 1,655 spp
Caudata = 272 spp
Gymnophiona = 6 spp

25%

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
- Plus 54 species that haven't been seen in 5–40yrs, mostly in Latin America: see the MIA section
<http://amphibiaweb.org/declines/extinct.html>



Status of U.S. Amphibians



- 2 Species Extinct (*R. fisheri*; *P. ainsworthi*)
- 10 Endangered (+3 subspp, 3 pop.); 9 Threatened (+1 pop.); 5 spp and 2 pop. Awaiting
- Of the E,T: 4 in Puerto Rico, 8 in CA, 6 in SW, 6 in SE, 1 in MO and 1 in WY

Western U.S.

•TN: 1 state-listed out of 26 spp (30%)

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 (≤ 1 km)

Absorb
Compounds
Readily

Hypotheses Related to DIRECT Anthropogenic Effects

Habitat Destruction/Degradation Hypothesis

Obvious:



•Agricultural Practices

•Urban Development

•Draining, Filling, Altering Wetlands

•Barriers between

aquatic and

terrestrial habitat

•Fragmentation

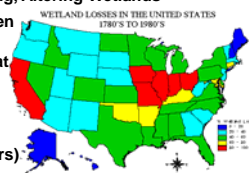
•Deforestation (R. Semlitsch, LEAP)

Destroying Terrestrial Habitat (30 yrs)

-Plethodontids especially vulnerable

- Some debate about how much direct mortality, evacuation, underground (Petrunka)

54%
Wetlands
Loss



Habitat Destruction/Degradation Hypothesis

Not so Obvious: •**Sedimentation** (deforestation, urban development, agriculture, roads)



-Fill in interstitial spaces, inhibit O₂ uptake

•**Altered Hydroperiods**

-Can occur from changes in vegetation nearby, or changes in groundwater

•**Wildlife Management**

•**Burning**- Still not much known about controlled burns- direct mortality, reduced leaf litter, microclimate

•**Mowing**

•**Soil Compaction** –burrow use

JWM
64:615-631

Chemical Pollution Hypothesis

Point Source: Pollution originating from 1 point.

•**Effluent:** organic or industrial waste

•**Thermal:** electric plants

Sublethal

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

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

•**Nitrates & Ammonia:** Direct mortality; Reduce growth

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

•**Atrazine:** Most widely used herbicide in the world. Endocrine disruption, eggs in testes, at very low doses (Tyron 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)

• Intentionally stocked all over the world. In montane regions, often by airplane. In western USA- 60% of montane and 90% of large lakes.

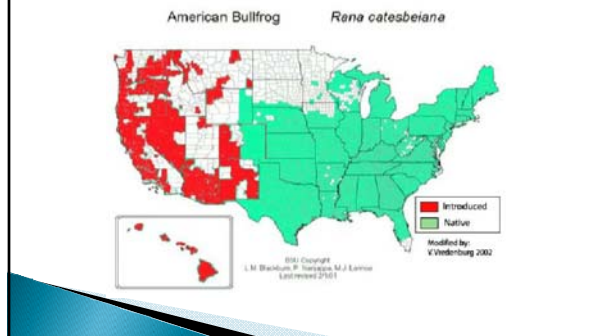
•**Bullfrogs** (eat everything but adults) – Introduced S. America, Europe, and Asia. Also, concern that they spread disease.

•**Fire Ants** (eat metamorphs)



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

American Bullfrog Distribution



Introduced Competitors Hypothesis

- **Frogs** – competitors in the aquatic stage. *B. marinus* also is toxic in all stages- not very good prey...

➡ ***Bufo marinus*, *L. catesbeianus***

- **Bait & Mosquito Fish** – New research show they can attack ranids, causing prolific injuries
- **Crawfish** (Predator of eggs also) - Also alter habitat quality by shredding aquatic vegetation.

Other Invaders: -Primarily plants. Can contain toxic compounds that leach into ponds. Alter terrestrial habitat structure

-Earthworms (NE USA): accelerate leaf decomposition, depriving salamanders of moisture and cover

Conservation
Biology 13:613-
622
FROGLOG
15 & 17



Commercial Exploitation Hypothesis

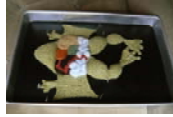
- ▶ **Food** –Mainly for frog legs, but also *Andrias*
 - **Domestic Consumption:** SE Asia, Latin America
 - **Major importers:** EU (Belgium, France) 4.6 thousand tons/yr (about 10–100millions frogs/yr), USA 4.3 thousand tons/yr, Japan
 - **Major exporter:** Indonesia (84% of EU's consumption), China/Taiwan (81% of USA's bullfrog imports), Mexico (43% of USA's other frog imports, mostly wild caught)
 - These data are up to date. Historically, most amphibian imports came from India and Bangladesh, but a ban went into effect in 1987 and 1989.



Resource: "Canape's to Extinction: The International Trade in Frog's Legs and its Ecological Impact" 2011, report by the Defender's of Wildlife

Commercial Exploitation cont.

- ▶ **Pets:** Wild caught primarily consist of W. Dwarf African clawed frogs (2.4 million), Chinese Fire Belly Newt (1.6 mil), Oriental Fire Belly Toad (1 mil), stats are imported to USA from 1998–2002 [Bioscience 55(3): 256–264, 2005]
- ▶ **Bait:** ex. tiger salamanders and *Desmognathus* in the USA
 - Used by up to 73% of anglers in the SW
 - Spread Chytridiomycosis [Cons. Bio. 22(6): 1582–9]
- ▶ **Research/Teaching**– biological supply companies
 - Primarily bullfrogs, n. leopard frogs, and mudpuppies
 - As of 2003, only 1 of 14 companies sold only farm–raised
- ▶ **Lots of data challenges, also indirect effects– release, disease spread**



Hypotheses Related to INDIRECT Anthropogenic Effects

Global Warming Hypothesis

- The anthropogenic increase of ambient temperatures via the accumulation of “greenhouse” gases.
- Expected to increase temperatures (1.5–5.8°C) by 2100, increase weather severity, generally change weather patterns.

Consequences of Greenhouse Effect

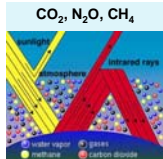
- Decreased/alterd hydroperiods

- Some amphibians may have a lower ability to shift their ranges with the climate due to low dispersal ability

- High altitude/latitude

- Ectotherms

- A LOT OF UNCERTAINTY



Climate Change
39:541-561



Catastrophic
Events

UV-B Radiation Hypothesis

- Ozone depletion has resulted in increased incidence of UV-B radiation with the surface of Earth.
- Damages DNA and other cellular processes
- Higher amounts of melanin (dark pigment) is protective.

Blaustein



Effects on Amphibians

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

Photochemistry & Photobiology 64:449-456

Conservation Biology 10:1398-1402

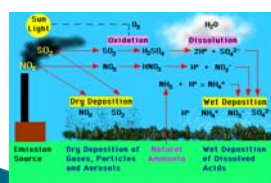
Most Susceptible Amphibians:

- Low Photolyase in Eggs (DNA repair)
- Eggs Near Surface
- Higher Elevation

Vegetation

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.
- Disrupts ion balance, also associated with high concentrations of dissolved heavy metals, e.g. Al



Effects on Amphibians

pH < 4

- Direct mortality
- Delayed hatching
- Reduced mobility
- Reduced larval growth rate & size



Copeia 1986:454-466

Food Web

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
- Biggest problem in Central America, Australia

Epidermal Hyperplasia → Sloughing

→ Interference w/ Cutaneous Respiration & Osmoregulation

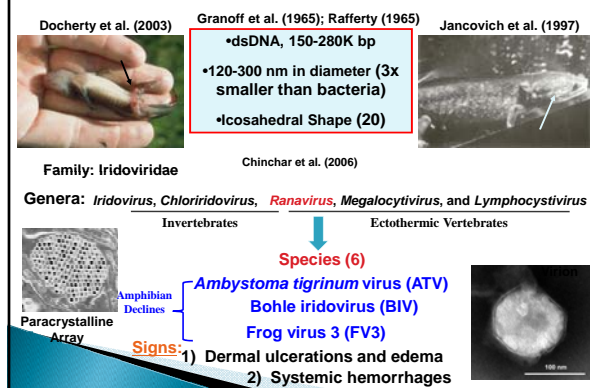
Proc. Natl. Acad. Sci. 95:9031-9036



Chytrid in the USA



Pathogenic Hypothesis: Iridovirus



Pathogenic Hypothesis: Bacteria

Thought to be Secondary to Viral and Fungal Infections

Aeromonas hydrophila

"Red-Leg"

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

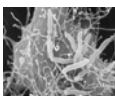
Enters host via Ingestion

Effects on Humans: gastroenteritis & septicemia

Associated w/ "Stress"

Effects on Amphibians:

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



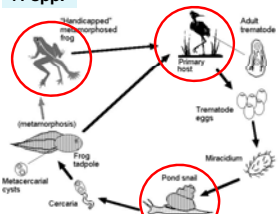
Pathogenic Hypothesis: Parasites

Trematodes

(*Ribeiroia ondatrae*)



41 spp. *Ribeiroia sp.* life cycle



Effects on Amphibians

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

Survival/Reproduction



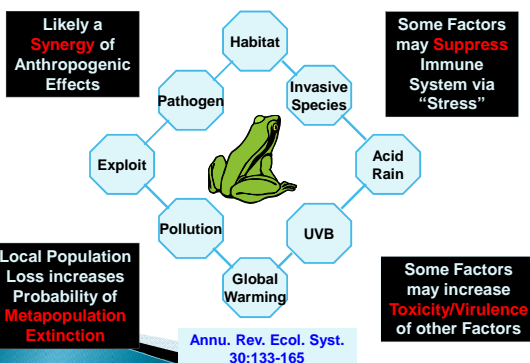
Science 284:802-804

Something to keep in mind...

- ▶ Many of these go together
- ▶ For example-
 - Deforestation can lead to stream sedimentation, increased UV light getting through, changes in hydroperiod, encroachment by invasive species
 - Agriculture can increase chemical loads, sedimentation, parasite loads, invasive species
 - All of which can be further complicated by disease, acid rain and global warming
- ▶ These effects can be additive (can predict) or interactive (much harder to predict)



The Synergistic Hypothesis



What can you do?

Amphibian Population Declines



Participate in Surveys

National: *naamp@usgs.gov*

Tennessee: Bob English; 615-395-4166
ENG205@aol.com

Other Activities

- Use good practices around your home and encourage others as well
http://www.fws.gov/contaminants/Documents/Homeowners_Guide_Frogs.pdf
- Don't release pets or bait into the wild
- Lots of other ideas:



In Conclusion

It's not
easy being
GREEN