Impacts of Climate Change and Human Land Use on Southern Appalachian Salamanders



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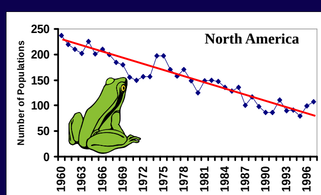
Amphibian Declines

Science
306:1783-1786

IUCN
2008

Science
253:860



32.5% of Amphibians and **46%** of salamanders are threatened globally

Why are Amphibian Declining?

- Climate Change
- Habitat Loss
- Diseases & Pathogens
- Pesticides
- Invasive Species
- Overexploitation

Amphibian Declines & Climate Change

Rana luteiventris

Bufo periglenes

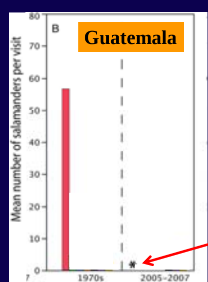
Atelopus sp.

PNAS 105:16988-16993

Nature 427:107-109
Nature 439:161-167

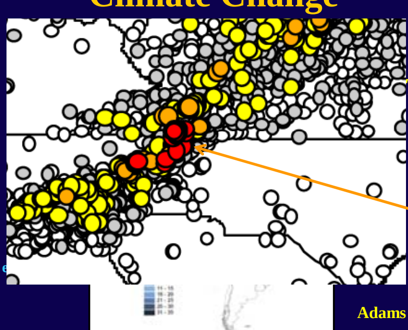
Salamander Declines & Climate Change

PNAS 106: 3231-3236



Bolitoglossa rostrata

Salamander Declines & Climate Change



Young

Adams 2008

Unique Study Animals

Plethodon welleri

Desmognathus wrighti

Unique Study Animals

Plethodon yonahlossee

Spatial Distributions of Southern Appalachian Salamanders

Previous Research

Dr. James Organ, City College – NY

- Mount Rogers National Recreation Area - VA
- Sampled 1957 - 59 and 1990 - 1991
- Established 14 transects (2950'- 5700')
- No distributional comparisons have been made
- Sites have not been surveyed since 1991

Objectives – Distribution Changes

1) Document if salamander distribution changes have occurred since 1950s and 1990s to 2008-10
2) Relate potential changes to long term climate change
3) Model future spatial shifts due to climate change scenarios

Amphibian Declines & Habitat Loss

Brazil

Physalaemus olfersii

Young et al. 2004

California

Rana draytonii

Conservation Biology 16:1588-1601

Salamander Declines & Habitat Loss

What about the South

Conservation Biology 16:1324-32
Canadian J. Zoology 84:797-807

Conservation Biology 7:363-70
9:983-9
Conservation Biology 21:159-67

Loss of 14 million salamanders in NC annually due to clear-cutting

Recovery times of at least 14 years
Forest Ecology and Management 114:245-52

Amphibian Declines & Habitat Loss (Right-of-Ways)

- 2.8 million hectares of ROWs maintained each year
- Mechanical mowing is the most common maintenance method
- Negative impacts to other species of herpetofauna

Gopherus polyphemus

Amphibian Declines & Habitat Loss (Right-of-Ways)

Few studies have examined potential effects on salamanders

Conservation Biology 12:340-52
Yahner et al. 2001
Conservation Biology 21:159-167

Amphibian Declines & ROWs

ROWs are being used for wetland mitigation areas

- Reduce maintenance
- Serve as wetland bank areas

Daniel Boone National Forest - KY
- Over 160 constructed in ROWs

Unique Study Animal

Hemidactylium scutatum

"In Need of Management"

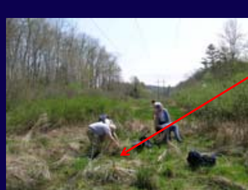
(Redmond & Scott 1996)

Unique Study Animal

Shallow moss lined temporary pools

Pool breeding is uncommon for Plethodontid salamanders

4-toed nesting in ROWs



ROW pools with little shade

Forest pools with canopy cover

Current ROW management

ROW is mowed every 5 years

Do pool temperatures exceed larval thermal limits?

33 - 34°C
Wells 2007

Objectives – ROW management

1) Test for differences in larval survival and growth between forest and ROWs pools
2) Test the effect of pool distance from the forest edge on larval survival and growth
3) Test for differences in larval survival and growth between annual and 5-year mowed ROWs

Amphibian Declines & Diseases

Panama

Atelopus zeteki

Nature 439:143-4

Wyoming

Bufo baxteri

Biological Conservation 110:357-65

Amphibian Declines & Diseases

Ranavirus

Arizona

Ambystoma mavortium

GSMNP

Rana sylvatica

Gray et al. 2009
- Plethodontids are infected
- 81% Prevalence across 10 spp

Gray (unpublished data)
- Ranavirus is pathogenic to Plethodontids

Amphibian Declines - Ranavirus

Gray et al 2009

- Aquatic species have higher infection rates than terrestrial species
- Ranavirus prevalence decreased with elevation
  - o Temperature variation
  - o UVB
  - o Downward stream flow
  - o Aquatic transmission

Dr. Organ specimens are housed at Univ. of Michigan Museum of Zoology

Objectives – Disease Sampling

1) Compare ranavirus prevalence among elevations and species
2) Test if distance from stream affects the likelihood of salamander infection
3) Determine if ranavirus prevalence has changed since the 1950s

Methods
Climate Change Effects

Study Area
Mount Rogers National Recreation Area

Highest 2 Mountains in Virginia
- Mt. Rogers – 5,729'
- Whitetop Mt – 5,525'
- Beech Mt - 4,960'
- Bluff Mt - 4,840'

Grayson, Smyth, & Washington Counties , Virginia

Study Area
Mount Rogers National Recreation Area

17 salamander species

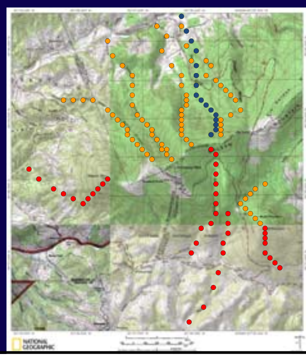
6 Listed as Special Concern by VADGIF

Methods -Transect Sampling

- Resurvey 10 transects (2008: n=1, 2009: n=5, 2010:n=4)

Red = Southern aspect

Orange/Blue = Northern aspect



2008: Bluff Mt. North
2009: Byars Creek
Whitetop Creek
Dells Branch
Beech Mt.
Daves Ridge
2010: Bills Ridge
Pennington Branch
Bluff Mt. South
Big Branch

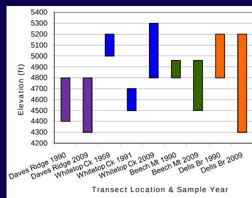
Methods - Transect Sampling

Location

Methods - Transect Sampling

- HOBO Data Loggers every 100’
- Record Temperature and RH every 15 min. from June 1 – Dec 31, 2009

Occupancy Modeling



- **Estimate probability of detection among years and sites**
- **Estimate the likelihood of occurrence using species-specific detection probabilities**
- **Compare occurrence likelihoods between historic and current surveys using logistic analysis**

Climate Modeling

Historic and Current Climate Variables will be compared

Regional Weather Stations can provide historical data:

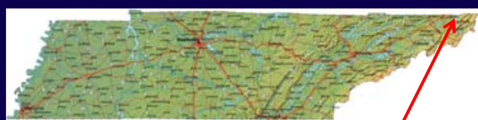
- **Precipitation**
- **Temperature**
- **Relative humidity**
- **Drought index**

Ecological Niche Models:

Relate changes in species occurrence to climate variables
Predict future shifts given climate change scenarios

Methods
ROW Management

Study Area
South Holston Dam



Methods – Nesting Success

1. Locate 4-toed nests & collect nest parameters

Number of eggs

Type of Moss

Height above water

Methods – Nesting Success

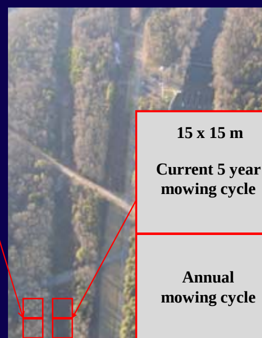
Additional Nest Parameters

- Nest aspect
- Slope of bank below the nest
- Maximum depth of the pool

Female Presence

- Determine if nests are joint or single
- Measure SVL & TL
- Photograph female ventral surface for future identification

Methods – ROW Treatments



15 x 15 m Forest	15 x 15 m Current 5 year mowing cycle
Forest	Annual mowing cycle

Methods – ROW Treatments

Annual maintenance mowed every August

Current management mowed every 5 years in August

Methods – ROW Treatments

August 2008
1 year growth

August 2009
2 years of growth

Methods – ROW Treatments

n=56

Methods – ROW Treatments

Place 1-L buckets below nests to catch all hatchlings

Methods – ROW Treatments

Added to the pool
- 10 larvae
- 100g leaf litter
- 2g rabbit chow

Pools searched weekly to determine percent survival

At metamorphosis larvae are collected, weighed, measured (SVL & TL)

Methods – ROW Treatments

Water temperatures and light levels are measured with HOBO data loggers

33 - 34°C

Pool Productivity

- Quantify phytoplankton and periphyton
- Monitor DO levels for 24 hr periods

Data Collection & Analysis

Response variables

- Growth Rate
- Percent Survival
- Time to Metamorphosis
- Pool Productivity

Effects

- Treatment
  - Annual Mow
  - 5-year Mow
  - Forest
- Distance from the edge

Analysis

- ANOVA

Methods
Disease Sampling

Methods – Disease Sampling

Univ. of Michigan Museum of Zoology

- DNA extracted using Qiagen® kit
- DNA quantified using Qubit flourometer
- Infection tested using conventional and real-time PCR

Data Collection & Analysis

Response variables

- Ranavirus Prevalence

Effects

- Year
- Elevation
- Distance from stream
- Species

Analysis

- Logistic Regression

Special Thanks

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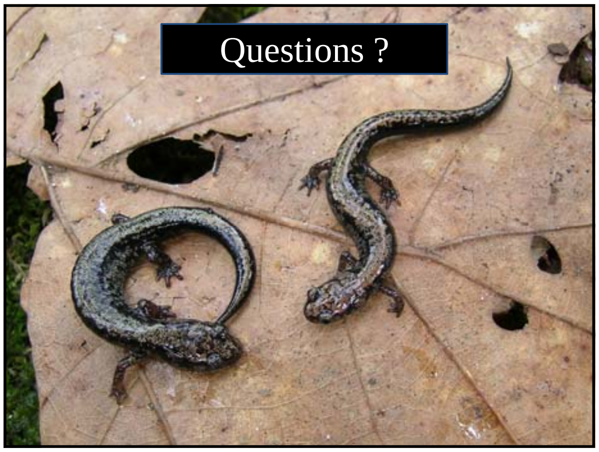
Logistics & Field Work:

- Dr. James Organ
- Mrs. Della Organ
- Gary Poe
- VHCC General Biology Students
- Mt. Rogers National Recreation Area
- VA Dept of Game & Inland Fisheries
- Tennessee Valley Authority


Questions ?