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

Yellowstone NP

**Rana lessonae**

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

**Bufo periglenes**

Costa Rica

**Atelopus sp.**

- PNAS 105:16988-16993

Salamander Declines & Climate Change

**Bolitoglossa rostrata**

Guatemala

- PNAS 106: 3231-3236

Salamander Declines & Climate Change

Young et al. 2004

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

Physalaemus olfersii
Young et al. 2004

Rana draytonii
Conservation Biology 16:1588-1601

What about the Southern Appalachians?
Conservation Biology 21:159-67
Conservation Biology 7:363-70
9:983-9
Canadian J. Zoology 84:797-807

Salamander Declines & Habitat Loss

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

Amphibian Declines & ROWs

ROWs are being used for wetland mitigation areas
- Reduce maintenance
- Serve as wetland bank areas

Daniel Boone National Forest - KY
- Over 100 constructed in ROWs

Conservation Biology 12:340-52
Yahner et al. 2003
Conservation Biology 21:159-167

Few studies have examined potential effects on salamanders
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

Axelopus zeteki
Nature 439:143-4

Wyoming

Bufo baxteri
Biological Conservation 110:357-65
Amphibian Declines & Diseases

Ranavirus

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

Arizona
GSMNP

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 VADGF
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

4 man-hour
1 man-hour

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

1. Locate 4-toed nests & collect nest parameters

Methods – Nesting Success

Height above water
Type of Moss
Number of eggs

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 – Nesting Success

Determine if nests are joint or single
Female Presence
Measure SVL & TL
Photograph female ventral surface for future identification
Methods – ROW Treatments

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

Annual maintenance mowed every August
Current management mowed every 5 years in August

August 2008
1 year growth

August 2009
2 years of growth
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

- DNA extracted using Qiagen® kit
- DNA quantified using Qubit fluorometer
- 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

Funding:
- Virginia Community College System
- National Science Foundation
- UT Institute of Agriculture
- Tennessee Wildlife Resource Agency

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?