Biotic Community Responses to Flooding from Tropical Storm Lee

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Summer 2011

• Worked with PFBC to document 82 previously unassessed tributaries to Loyalsock Creek

• Worked with volunteers from LCWA

• Collected trout population data, trout weights, trout diets, and Benthic Macroinvertebrate samples

• Recorded baseline data for 82 streams
The Perfect Storm

- Late summer low-flows in Loyalsock Creek
- August 28-29: Local rainfall exceeded 5 inches (H. Irene)
  - Saturated soils
  - Dislodged stable substrates
- Waters receded, but still 3x greater than mean flow
- Sept. 5-8: Over 12 inches of rain fell in the upper Loyalsock Creek drainage (T.S. Lee)
- Peak flows (69,100 cfs) exceeded previous record (55,800 cfs).
Rainfall Data: Loyalsockville, PA

- Peak stage exceeded 20.4 ft, the point at which the gage flooded. Flow estimated to have reached an excess of 69,000 cfs (NOAA).

Daily discharge (cfs) of the USGS stream gage at Loyalsockville, PA from August 28-September 14, 2011.
Tropical Storm Lee

Total precipitation (in) in Pennsylvania from 7:00 am September 5, 2011 to 7:00am September 8, 2011. (NOAA data). Study area outlined in yellow.
Research Opportunity

- Unique opportunity to observe responses of multiple trophic levels to catastrophic flooding
- Pre-flood data recorded less than 3 months prior
- Resampled for trout in early Oct. 2011
  - Lick, Rock, Mill, Streby, and Yellow Runs
  - Extremely low trout densities
  - Streams scoured and redirected
Comparison of Trout Population Estimates

Comparison of trout populations from summer 2011 and our resampling in October 2011 following Tropical Storm Lee.
Brook Trout
*Salvelinus fontinalis*

- Keystone species
- Distribution limited to headwaters
- Sensitive to anthropogenic impacts
Introduction

- Few studies on salmonid population response to catastrophic flooding
- Catastrophic flooding may remove year classes or reduce standing crops causing population crashes (Elwood and Waters 1969)
- Roghair and Dolloff (2005) found brook trout were able to recolonize a reach within 3 years of flooding, and within 5 years population density exceeded pre-flood density
Questions

• How long will it take brook trout to recolonize a reach?

• What will be the primary form of recruitment?

• Have the age structures changed?

• Will population estimates and densities exceed pre-flood levels?
Trout Populations Analysis

- Pulsed DC backpack electrofishing unit
- 100 m study site
- Triple pass collection
  - Zippin population estimates
- Anesthetized in 120 mg·L⁻¹ solution of clove oil
- Total length (mm)
- Weight (g)
Brook Trout Density

Density (m2)

Sampling Year

2010 2011 2012 2013 2014

Density (m2)
Average Brook Trout Density

Density (m²)

Sampling Year

2011
2012
2013
Average Population Estimates

Sampling Year

- Total BK
- YoY BK
- Adult BK
2011 Brook Trout Size Structure

Size distribution and frequency of brook trout from all sites 2011 pre-flood.
Brook Trout Frequency: Age-0 (97), Age-1 (185), Age-2 (124), Ages 3-5 (77)
Size distribution and frequency of brook trout from all sites 2012 post-flood.

Brook Trout Frequency: Age-0 (2153), Age-1 (39), Age-2 (57), Ages 3-5 (100)
Size distribution and frequency of brook trout from all sites 2013 post-flood.
Brook Trout Frequency: Age-0 (1093), Age-1 (757), Age-2 (122), Ages 3-5 (50)
Mill 2011 Brook Trout Size Structure

Size distribution and frequency of brook trout from Mill Run 2011 pre-flood.
Brook Trout Frequency: Age-0 (3), Age-1 (4), Age-2 (9), Ages 3-5 (2)
Size distribution and frequency of brook trout from Mill Run 2012 post-flood. 
Brook Trout Frequency: Age-0 (98), Age-1 (0), Age-2 (1), Ages 3-5 (12)
Size distribution and frequency of brook trout from Mill Run 2013 post-flood. Brook Trout Frequency: Age-0 (105), Age-1 (48), Age-2 (4), Ages 3-5 (7)
Conclusions

• Brook trout populations reduced in all streams
• Age 0-2 year old nearly eliminated
• Small population of adult brook trout (age 3-5) survived and spawned fall 2012
  • Angler harvest
• Compensatory recruitment evident 2012
  • Age-0 class from 2012 recruited into age-1 year class in 2013
• Stable age class distribution returning in 2013
Benthic Macroinvertebrates

- Wide variety of aquatic organisms
- Indicative of water quality
- Variance in functionality
- High biomass
- EPT taxa significance
Ecological Context

- Available data from 12, 18 yr flood intervals (Angradi 1997)
- Must protect diversity of feeder streams to ensure the health of larger systems (Clarke et al. 2008)
- Small streams recover more slowly (Feeley et al. 2012)
- Flushing of free-swimming organisms (Robinson et al. 2004)
- Many studies lack accurate pre-flood samples
- Few headwater studies vs. larger systems (Angradi 1997)
- Flooding as response to climate change

Flood Vulnerability in the US, 2000-2009: Average Number of Extreme High Flow Days and Recorded Floods, by Watershed
Questions and Predictions

- How long will it take for the BMI to rebound?
- Will the results show recovery or resiliency?
- Where are the BMI recolonizing from?
- Does a river recovery model apply to headwaters?
Study Sites: Loyalsock Creek Drainage
BMI Sampling

- Monthly sampling (October 2011-September 2013)
- Collected using 500 µm mesh D-frame kick net
- 6 kick composite (1 m²/kick) from same 100 m reach
- Substrate disturbed for 60 sec to depth of 10 cm
- Samples were preserved in 70% reagent ethanol
BMI Processing

- BMI picked from 14”x 8” tray divided into 28 squares (2x2in.)
- Squares randomly selected
- 200 ± 40 organism sub-sample, 4-square minimum
- Identified to family level
  - Leica MZ6 dissecting scope
- QA/QC verified by certified taxonomist
BMI Responses: Density

• >50% decrease in density ~ 1 month post flood
• BMI density recovered ~ 4 months post flood
• Lick Run (1\textsuperscript{st} order) was exception
BMI Responses: Diversity

- Family richness appears stable ~ 1 year post flood
- Changes in EPT relative abundance
- BMI dissimilarity between July 2011 to July 2012
Conclusions

How long will it take for the BMI to rebound?

• 3-6 months according to literature

• 4 of 5 sample sites recovered within 4 months

• Correlation between stream length/watershed area and recovery time
  • Lick Run (1st order) took longest to recover

• Dependent on flood severity as well as climatic stability following the disturbance (Angradi 1997)
Conclusions

Will the results show recovery or resiliency?

- 98% decline in BMI populations in AZ (Fisher et al. 1982)
- Community structure restored in 2-4 weeks
- Up to one full year for some taxa to return
- Resiliency by specialists, but not for majority
Conclusions

Where do BMI recolonize from?

• Adult migration, Refugium, Downstream Drift

• Relationship between hyporheic zone and immediate recolonization (Angradi 1997)

• Multiple recolonization sources must be employed by taxa

• Recovery led by most resilient/pollution tolerant individuals
Conclusions

Does a river recovery model apply to headwaters?

• Large rivers pool from large, diverse watersheds

  • Smaller watersheds = slower recovery time

  • River watersheds are rarely flooded entirely

• Headwater BMI communities display an incredible ability to recover from even catastrophic disturbances
Future Work

• Generic level ID
  • 1.5-2x taxa richness
  • Functional groups
  • Voltinism differences
• GIS mapping of watersheds
• Flood recurrence interval determination
  • When can we expect another flood?
Thanks for your Support!

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