RESPONSE OF THE BENTHIC MACROINVERTEBRATE COMMUNITY IN THREE PIEDMONT STREAMS IN NORTH CAROLINA TO LAND USE CHANGES OVER A 20 YEAR PERIOD.

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Introduction

- As a watershed develops, the % impervious cover increases
- Storm runoff flow and intensity increase
- Stream channel damage occurs
- Stream bank erosion and channel incision negatively impact fish and benthic macroinvertebrate communities
Introduction

- Majority of studies relating impact of % Impervious Cover (IC) on streams focus on the impact on fish and benthic macroinvertebrate species diversity

- This study examines the influence of land use changes over time on the benthic macroinvertebrate community by:
  - Examining how benthic macroinvertebrate community diversity impacted by changes in % IC
  - Examining how species traits are impacted by changes in % IC

Benthic Macroinvertebrates

- Benthic macroinvertebrates include all organisms that live on or in the stream bottom that are large enough to see without a microscope and do not have a backbone
- The majority of the benthic organisms are aquatic insects
- Other benthic organisms include worms and leeches, clams and mussels, snails, and crayfish
- Benthic macroinvertebrates are useful as biological water quality indicators
Introduction – Species Traits

- Species traits - characteristics unique to each species reflecting their position in the stream ecosystem.

- Species traits have been used to characterize the functional composition of benthic macroinvertebrate communities and have been used to predict changes of both species and species assemblages within a biological community along environmental gradients in terms of traits that are sensitive to local environmental conditions.

- Trait categories include:
  - Life History – rate of development, adult life span
  - Mobility – crawling rate, swimming ability, flying strength
  - Morphology – shape, size, respiration strategy
  - Ecology – feeding, thermal, habit preferences

Study Sites

- 3 stream watersheds that span a gradient of rural (Gar), suburban (Clear), and urban (McMullen) land use
  - Gar Creek – 8.29 mi²
  - Clear Creek – 15.33 mi²
  - McMullen Creek – 15.2 mi²

![Population Density Chart](image.png)
Benthic Macoinvertebrate Sampling Techniques

- Collect benthic macroinvertebrates using Standard Qualitative Method developed by North Carolina Division of Water Resources Biological Assessment Unit
- Identify benthic macroinvertebrates to lowest possible taxa level
- Compare benthic macroinvertebrate function over time using species trait analysis

GIS - Classification Table

<table>
<thead>
<tr>
<th>Reclassified Class</th>
<th>Original Class</th>
<th>Cell Value (Code)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built-up</td>
<td>Developed, open space (21)</td>
<td>No change</td>
</tr>
<tr>
<td></td>
<td>Developed, low intensity (22)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Developed, medium intensity (23)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Developed, high intensity (24)</td>
<td></td>
</tr>
<tr>
<td>Bare</td>
<td>Barren land (31, 32, 33)</td>
<td>3</td>
</tr>
<tr>
<td>Forest</td>
<td>Deciduous forest (41)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Evergreen forest (42)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mixed forest (43)</td>
<td></td>
</tr>
<tr>
<td>Grass</td>
<td>Grassland/herbaceous (71, 72, 73, 74)</td>
<td>5</td>
</tr>
<tr>
<td>Wetlands</td>
<td>Woody wetlands (90, 91)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Herbaceous wetlands (92, 95)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hay pasture (93)</td>
<td></td>
</tr>
<tr>
<td>Planted/Cultivated</td>
<td>Cultivated crops (82, 83, 84, 85)</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Open Water (11)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potential ice/snow (12)</td>
<td></td>
</tr>
</tbody>
</table>

- Organized the data processing steps into ArcGIS workflow,
- Major steps for data processing include:
  - Reclassify land use raster layers based on the categories in the table
  - Re-project the raster data layers to ensure projection consistency between land use raster layers and watershed boundary layer
  - Counting the number of cells for each land use category that fall within corresponding watershed and sub-watershed
  - Calculate land use percentages based on the newly generated table from ArcGIS
Results – Land Use Changes

- Gar Creek % IC changed from 6 to 13.7% from 1994 to 2014
- Clear Creak % IC increased from 9.0 to 24.6%
- McMullen Creek increased from 64.6 to 96.8%
Changes in EPT Taxa Richness Over Time

- Both Gar and Clear Creeks showed declines in EPT taxa richness over time.
- Very little change in EPT taxa richness occurred in the already stressed McMullen Creek.

Response of EPT Taxa Richness to Changes in % Impervious Cover Over Time

- EPT Richness in McMullen Creek greatly impaired at high % IC.
- Clear Creek EPT starting to separate from the Gar Creek EPT as % IC increases in Clear Creek.
Species Trait Response to Changes in % Impervious Cover

- With just 5 species, McMullen Creek began this study in degraded condition
- Gar Creek % IC within range of Good % IC. Multiple points at same % IC indicate some other environmental factor controlling distribution
- Changes in % Trophic Group with changes in % IC seen in Clear Creek

Species Trait Changes Over Time

- Climbers, burrowers fluctuated in % over time in Gar Creek
- Clear Creek lost the burrowing EPTs around 2004 while other Habits fairly consistent
- Only Swimmers and Clingers were found in McMullen Creek
Drought Impact on Gar Creek

- Droughts impacted the flow volume and stream depth in Gar Creek altering the benthic macroinvertebrate community.
- Droughts impacted Clear Creek to lesser degree as the flow and depth not as impacted as seen in Gar Creek (due to larger watershed size).
- McMullen Creek already stressed when droughts hit.
- Drought impacts on Gar Creek masked some of the species trait trends as seen in the Trophic Group slide.

Conclusion

- Overall, there was a decrease in EPT richness in each of these streams over the past 20 years.
- Gar showed the most significant drop in EPT taxa, which has been attributed to two droughts that occurred in the Piedmont between 2002 and 2009.
- Declines in the EPT taxa at Clear were partially due to the drought and partially due to recent development.
- McMullen is a stressed urban stream that showed declines due to urban stresses as well as the droughts.

- Evaluation of species traits can provide information regarding the overall health of the stream ecosystem.
- Data sets covering longer periods of time are important in order to better understand how environmental factors such as land use changes and climate interact with stream health in addition to understanding stream restoration success.
Acknowledgements

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Questions?