Effects of Agricultural Land Use on Water Quality at the Watershed Scale

Julia D. Friedmann, Charnsmorn R. Hwang, Jon E. Schoonover, Karl W.J. Williard

Department of Forestry
Southern Illinois University Carbondale
Outline

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- Objectives
- Past Research
- Importance of Research
- Study Area
- Methods
- Results
- Conclusions
- Future Research
- Acknowledgements
Introduction

- 45% of streams are impaired (US EPA 2007)
- Agricultural activities top cause of impairment
- Non-point source (NPS) pollution
- Water quality issues not contained to a field scale, Gulf of Mexico Hypoxia

Photo by J. Friedmann
Objectives

- Determine how agricultural land cover affects baseflow and stormflow:
  - Total Suspended Solids (TSS)
  - Nutrients (orthophosphate and nitrate)
  - *Escherichia coli*

- Determine how percent canopy cover within a 10, 30, and 50 m buffer affects baseflow and stormflow:
  - Total Suspended Solids (TSS)
  - Nutrients (orthophosphate and nitrate)
  - *E. coli*
Past Research

- **Landscape influence (Johnson et al. 1997)**
  - Seasonal difference (TN, ammonium, nitrate, phosphate)
  - Row crop dominant landscape factor explaining variability

- **Landscape metrics % Ag and % Forest (Jones et al. 2001)**
  - Consistently explained variation (nitrogen, phosphorus, and sediment)
  - Riparian forest most important for phosphorus

- **Watershed land cover and size (King et al. 2005)**
  - % cropland positively correlated with nitrate-n
  - % forest negatively correlated with nitrate-n
Importance of Research

- Past research at field scale
- Best management at watershed scale
- Assess multiple landscape characteristics
- Better understanding of water quality impairments, NPS pollution TMDLs

Photo by J. Friedmann
Study Area

Lower Kaskaskia River Watershed
Agriculture
Land Cover
- 19 watersheds
Rural Community

- 21 watersheds

Photo by J. Friedmann
Urban

- 4 watersheds

Photo by C. Hwang

Upper Richland Creek Watershed Land Cover O'Fallon, Illinois
Total Monthly Precipitation (Scott Airforce Base-Belleville)

Month

Jan Feb March April May June July Aug Sept Oct Nov Dec

Total Precipitation (in)

30 Year Average

2008
Field Methods

- Twice a month (January-July)
- Once a month (August-September)
Field Methods

Photo by J. Schoonover
Lab Methods

- Water Quality Lab Analysis
  - Vacuum Filtration
    - Total Suspended Solids
  - Ion chromatography (filtered)
    - Nitrate
    - Sulfate
    - Chloride
  - Spectrophotometer (filtered)
    - Orthophosphate
    - Ammonium
  - IDEXX and mFC Agar
    - Total coliform-IDEXX
    - Fecal coliform-mFC
    - *E. coli*-IDEXX
GIS Methods
## GIS Results

### Percent Canopy Cover

<table>
<thead>
<tr>
<th>Descriptive Statistics</th>
<th>10 m Buffer (%)</th>
<th>30 m Buffer (%)</th>
<th>50 m Buffer (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min.</td>
<td>11.21</td>
<td>9.74</td>
<td>6.99</td>
</tr>
<tr>
<td>Max.</td>
<td>93.27</td>
<td>82.79</td>
<td>77.46</td>
</tr>
<tr>
<td>Mean.</td>
<td>58.78</td>
<td>46.28</td>
<td>37.59</td>
</tr>
<tr>
<td>S.E.</td>
<td>3.19</td>
<td>2.97</td>
<td>2.69</td>
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## Spearman’s Correlation Matrix

<table>
<thead>
<tr>
<th>Parameter</th>
<th>10 m Buffer</th>
<th>30 m Buffer</th>
<th>50 m Buffer</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO3</td>
<td>$r = 0.267$</td>
<td>$r = 0.205$</td>
<td>$r = 0.135$</td>
</tr>
<tr>
<td></td>
<td>$p = 0.284$</td>
<td>$p = 0.414$</td>
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<tr>
<td>PO4</td>
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<td>$r = -0.224$</td>
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<tr>
<td></td>
<td>$p = 0.669$</td>
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<tr>
<td>TSS</td>
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<tr>
<td></td>
<td>$p = 0.272$</td>
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<tr>
<td>E. Coli</td>
<td>$r = -0.309$</td>
<td>$r = -0.312$</td>
<td>$r = -0.315$</td>
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<tr>
<td></td>
<td>$p = 0.213$</td>
<td>$p = 0.210$</td>
<td>$p = 0.203$</td>
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<tr>
<td>NO3</td>
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<td>$r = -0.115$</td>
<td>$r = -0.172$</td>
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<tr>
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<td>$p = 0.785$</td>
<td>$p = 0.651$</td>
<td>$p = 0.494$</td>
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<tr>
<td>PO4</td>
<td>$r = 0.090$</td>
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<td>$p = 0.723$</td>
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<td>TSS</td>
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<td>$p = .887$</td>
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<td>$p = 0.130$</td>
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* Significant at 0.10
<table>
<thead>
<tr>
<th>Rural Community</th>
<th>Parameter</th>
<th>10 m Buffer</th>
<th>30 m Buffer</th>
<th>50 m Buffer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseflow</strong></td>
<td>NO$_3$-N</td>
<td>$r = 0.205$</td>
<td>$r = 0.072$</td>
<td>$r = -0.010$</td>
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<tr>
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<td></td>
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<td>$p = 0.969$</td>
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<tr>
<td></td>
<td>PO$_4$</td>
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<td>$r = -0.073$</td>
<td>$r = 0.017$</td>
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<tr>
<td></td>
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<td>$p = 0.754$</td>
<td>$p = 0.942$</td>
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<tr>
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<td>$p = 0.289$</td>
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<td><strong>Stormflow</strong></td>
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<td>$r = -0.084$</td>
<td>$r = -0.149$</td>
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<td>$p = 0.758$</td>
<td>$p = 0.716$</td>
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<tr>
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<td>PO$_4$</td>
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<td>$r = -0.126$</td>
<td>$r = -0.068$</td>
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<tr>
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<td>$p = 0.040$</td>
<td>$p = 0.414$</td>
<td>$p = 0.771$</td>
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<tr>
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<td>TSS</td>
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<tr>
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<td>$p = 0.076$</td>
<td>$p = 0.028$</td>
<td>$p = 0.014$</td>
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<tr>
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<td>E. Coli</td>
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<td>$r = -0.256$</td>
<td>$r = -0.169$</td>
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<tr>
<td></td>
<td></td>
<td>$p = 0.109$</td>
<td>$p = 0.263$</td>
<td>$p = 0.464$</td>
</tr>
</tbody>
</table>

* Significant at 0.10
NHD Streams and Flow Accumulation Lines

Legend

- Stream Layer

Flow Accumulation Value

- 0 - 200
- 200,000 - 2,499,435
- 2,499,436 - 2,499,435
Results

Nitrate-N

Concentration (mg L⁻¹)

Dominant Land Cover

Agriculture  Rural  Community  Urban

Baseflow  Stormflow
Orthophosphate

Concentration (mg L⁻¹)

Dominant Land Cover

Agriculture Rural Community Urban

Baseflow Stormflow
**E. Coli**

Most probable number (MPN)

<table>
<thead>
<tr>
<th>Dominant Land Cover</th>
<th>Baseflow</th>
<th>Stormflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Rural Community</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Graph showing the comparison of E. Coli levels in different land covers under baseflow and stormflow conditions.
Conclusions

- Nitrate levels low
  - No difference among sites
- Orthophosphate levels high
  - Septic systems, fertilizer leaching
  - Slightly negative relationship between % canopy cover
- TSS from urban and rural communities possibly coming from channel scouring
- E. coli levels high during stormflow
  - Slight negative relationship between % canopy cover

Photo by J. Friedmann
Future Research

- Continue data collection
- Enhanced stream layer
- Landscape metrics (gap length, gap frequency, 1st vs. 2nd order streams)
- Tile drainage information
- Stormwater sampling
- Further analysis of correlations (season, % agriculture, etc.)
Acknowledgements

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