Nitrogen Retention as an Ecosystem Service is Linked to Land Cover Heterogeneity

James B. McConaghie, Weiqi Zhou, Mary L. Cadenasso

Graduate Group in Ecology, Dept. of Plant Sciences
University of California, Davis
• Built environment is a source of heterogeneity

• Heterogeneity influences ecosystem services

• Retain N to prevent aquatic pollution
structure – function relationship

Nitrate Yield (kg N ha\textsuperscript{-1} yr\textsuperscript{-1})

% Residential Land

\[ r^2 = 0.18 \quad p = 0.40 \]

Groffman et al. 2004

See also:
Brett et al, 2005
Dougherty et al, 2006
Previously published studies often show poor relationship between measures of land use and nitrogen export in urban systems.

Why?

- No relationship
- Misspecified landscape structure
- Mismatch in spatial scale
Land Use vs. Land Cover

Land *Use* : human social or economic activities taking place in a given area

Land *Cover* : a physical pattern created by structural heterogeneity
**HERCULES**

**High Ecological Resolution Classification for Urban Landscapes and Ecological Systems**

- **Elements**
  - Buildings
  - Surfaces
  - Vegetation

- **Features**
  - Buildings: Cover
  - Surfaces:
    - Paved
    - Bare soil
  - Vegetation:
    - Coarse
    - Fine
Scales of Analysis

5,000 km²

80 km²

meters

Brett et al. 2005

Groffman et al, 2004

Vaze and Clausen, 2009
Goals

To identify the contribution of different land cover types to controlling ecosystem services of N retention at fine spatial scales.

1) What are the patterns and dynamics of N export in urban ecosystems?

2) How do relative amounts of land cover types affect N export?
Approach

- Synoptic Sampling
- 8 watersheds, 18 sites monthly for 12 months
- Analyze for NO$_3^-$ using colorimetric methods
- USGS Velocity-Area discharge method
Variables Measured

**Independent**
- % Building
- % Pavement
- % Coarse Veg.
- % Fine Veg.
- % Bare Soil
- Watershed Area

**Dependent**
- N Concentration
- Discharge
High Vegetation Reference Site

Area: 139 ha
Impervious: 0%
Vegetation: 98%
High and Low Impervious Residential Sites

SRS
- Area: 416 ha
- Impervious: 50%
- Vegetation: 50%

SARC
- Area: 438 ha
- Impervious: 26%
- Vegetation: 71%
Decreasing Imperviousness
July 2009 -- July 2010

Discharge (m$^3$ sec$^{-1}$)

- SRS
- NARC
- VCC
- BTC
- CPL
- MNC
- SARC
- DCH

Decreasing Imperviousness
Land cover % are not independent

Need to control for interactions between land cover variables to understand relationships of individual land cover variables to $\text{NO}_3$
Partial Regression holding FV and IS constant

Mean NO3-N (ppm) vs. % Fine Vegetation:
- $R^2 = 0.5727$, $p = 0.0003$

Mean NO3-N (ppm) vs. % Impervious Surface:
- $R^2 = 0.5433$, $p = 0.0004$

Partial NO3,IS vs. % Fine Vegetation:
- $R^2 = 0.279$, $p = 0.017$

Partial NO3,FV vs. % Impervious Surface:
- $R^2 = -0.019$, $p = 0.4185$
Partial Regression Results

Building

+ \rightarrow \text{Coarse Vegetation} \\
\text{Coarse Vegetation} \rightarrow [+ \text{NO}_3] \\

\text{Coarse Vegetation} \rightarrow \text{Fine Vegetation} \\
\text{Fine Vegetation} \rightarrow [+ \text{NO}_3] \\

\text{Impervious} \\
\text{Fine Vegetation} \rightarrow [- \text{NO}_3]
Conclusions

• Impervious surface alone did not correlate with [NO3]

• Building cover correlated with increased [NO3]

• Fine vegetation cover correlated with decreased [NO3]

• System has become fundamentally shifted from ephemeral to perennial stream flow by residential water use
Implications

- Residential landscape management may adversely affect N retention
  - Dry season water use mobilizes N year-round
  - Lawn fertilization increases available N pools
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