Ecological Sustainability in Rapidly Urbanizing Watersheds: Evaluating Strategies Designed to Mitigate Impacts on Stream Ecosystems

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Collaborative Science and Technology Network for Sustainability
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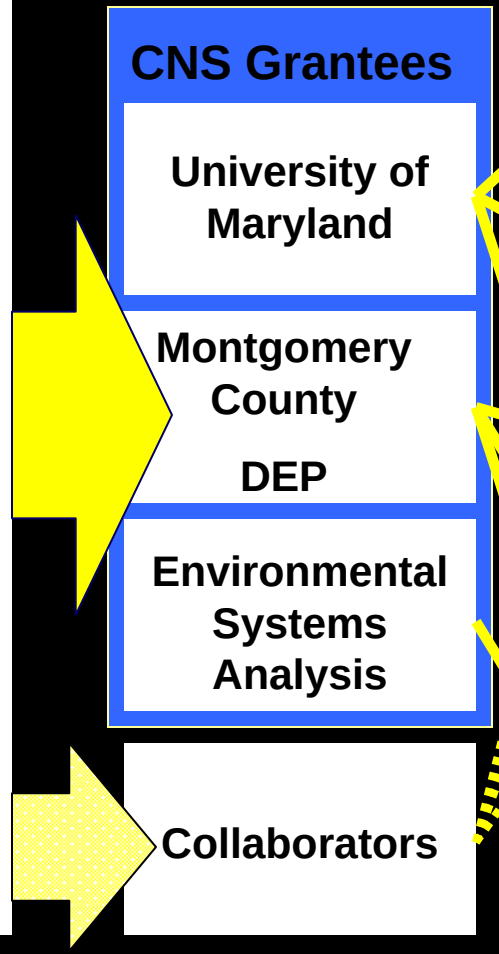
Environmental Systems Analysis

Questions:

When compared to pre-2K SWM strategies, are post-2K strategies better at mitigating the effects of urbanization on stream ecosystems?

How does watershed development affect receiving streams?



Selected Metrics

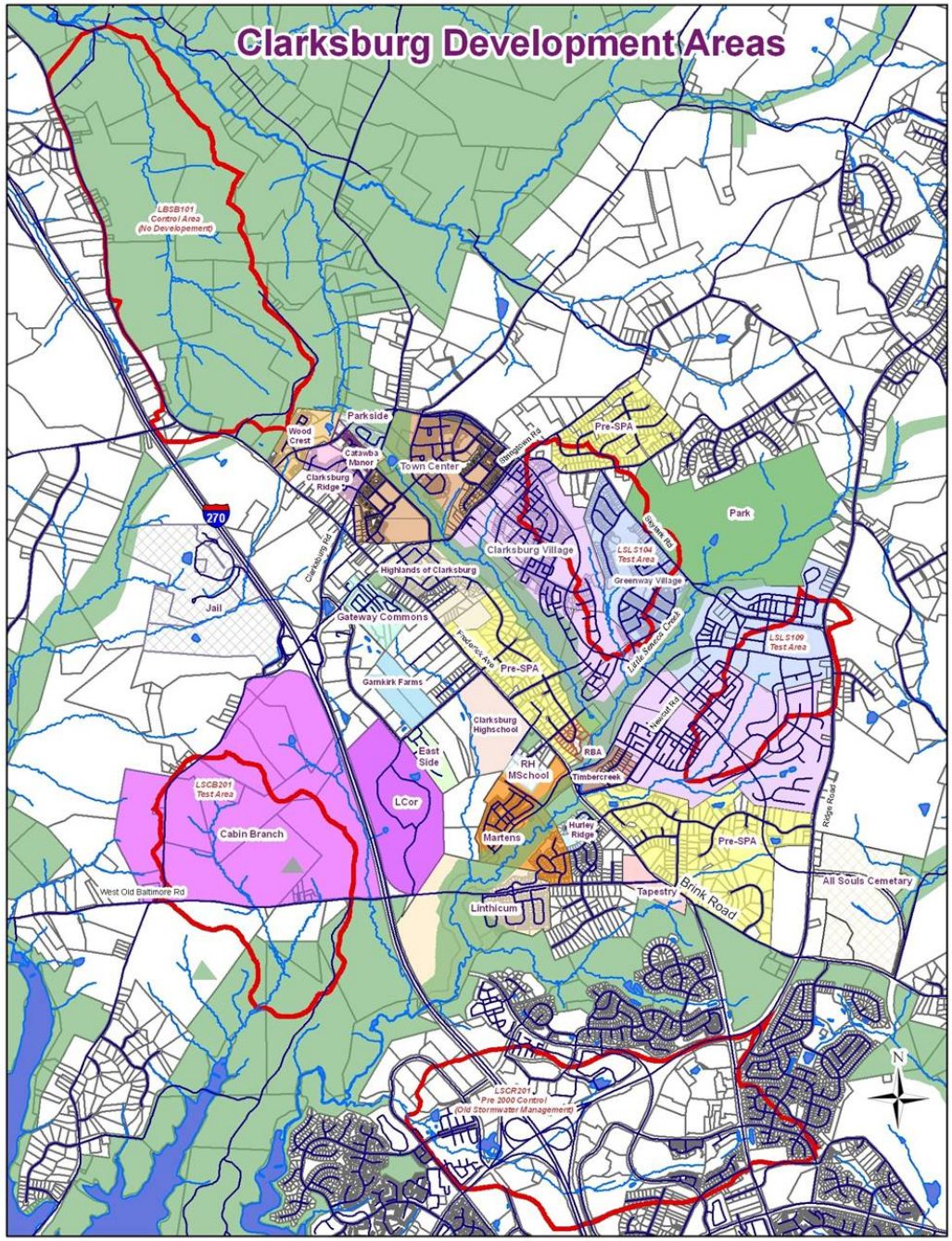
Ecosystem Function	*N removal & retention* *Stream metabolism*
Water Quality	*Carbon availability* *Nutrient concentrations*
Hydrology	*Peak Q* *Baseflow Q* *Rainfall:Runoff*
Geomorphology	*Channel morphology* *Particle size distribution*
Community Ecology	*Biodiversity*

Study System:

- 1 pre-2K control watershed
- 1 forested watershed
- 3 post-2K watersheds

Valuable Tools:

- 5 USGS stream gages
- 2 rain gages
- LiDAR imagery

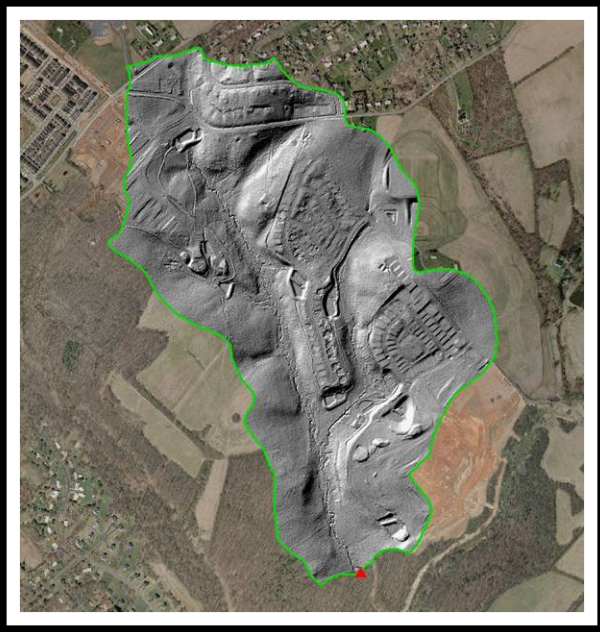


BACI Approach

2 Control drainages
3 Test areas

5 USGS stream gages
2 rain gages

LiDAR overflights



Meeting the needs of environmental decision-making for sustainability

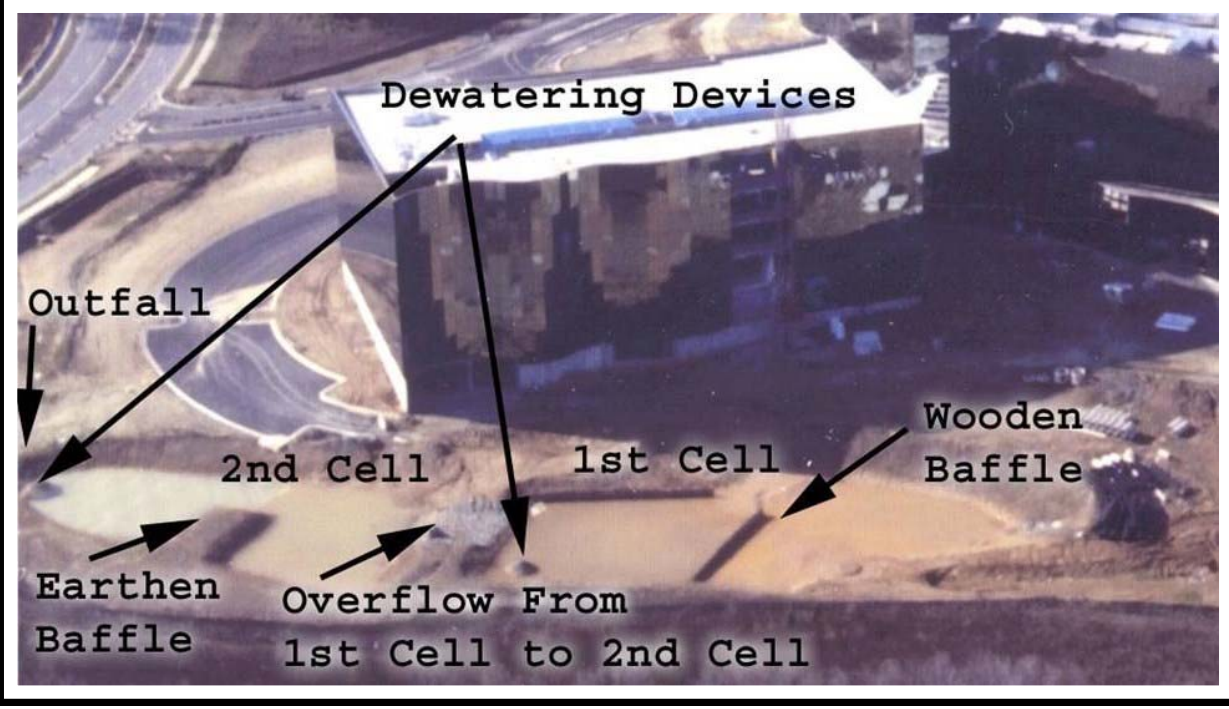
- Documenting ecosystem response/recovery to long term and significant landscape changes
- Documenting effectiveness of sediment and erosion control and SWM best management practices
- Providing feedback to decision-makers regarding development and SWM design
- Devising more focused research questions based on the needs of managers and decision-makers

"Lessons Learned"

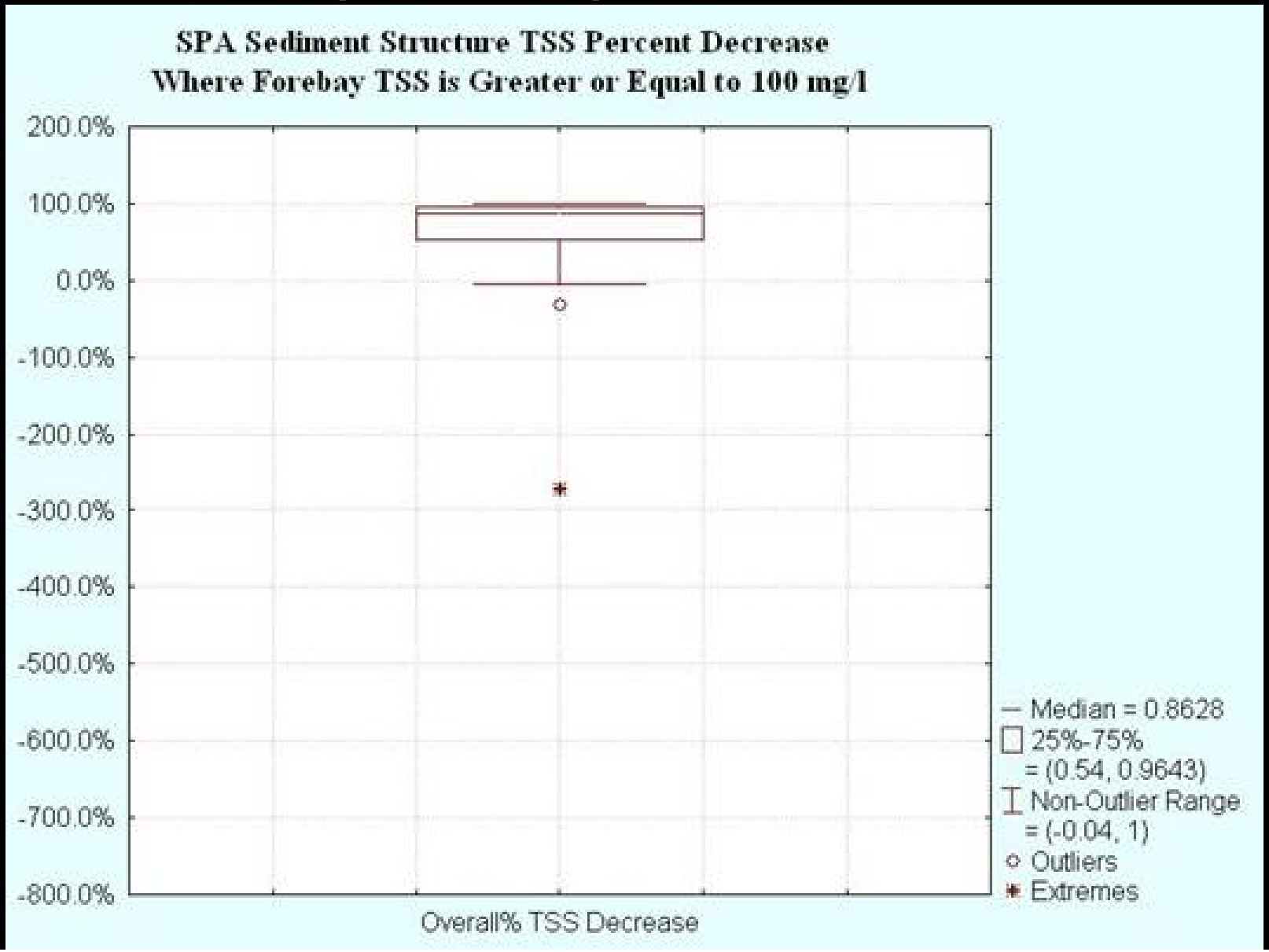
Questions and methods must be adaptable when studying large-scale treatments that you cannot control

- Conversion of sediment control to SWM has been slower than expected
  - Building moratorium imposed on study area
  - Conversion can only occur when 100% of drainage area is controlled
- Speed of development has slowed over the course of the study
  - Slow down of housing market
- "Treatment" effects may be masked by larger local effects
  - Cut and fill
  - Loss of natural drainage patterns
  - Influence of local geology and physiography

The Long Construction Phase



Sediment and erosion control devices are, at best, 86% efficient



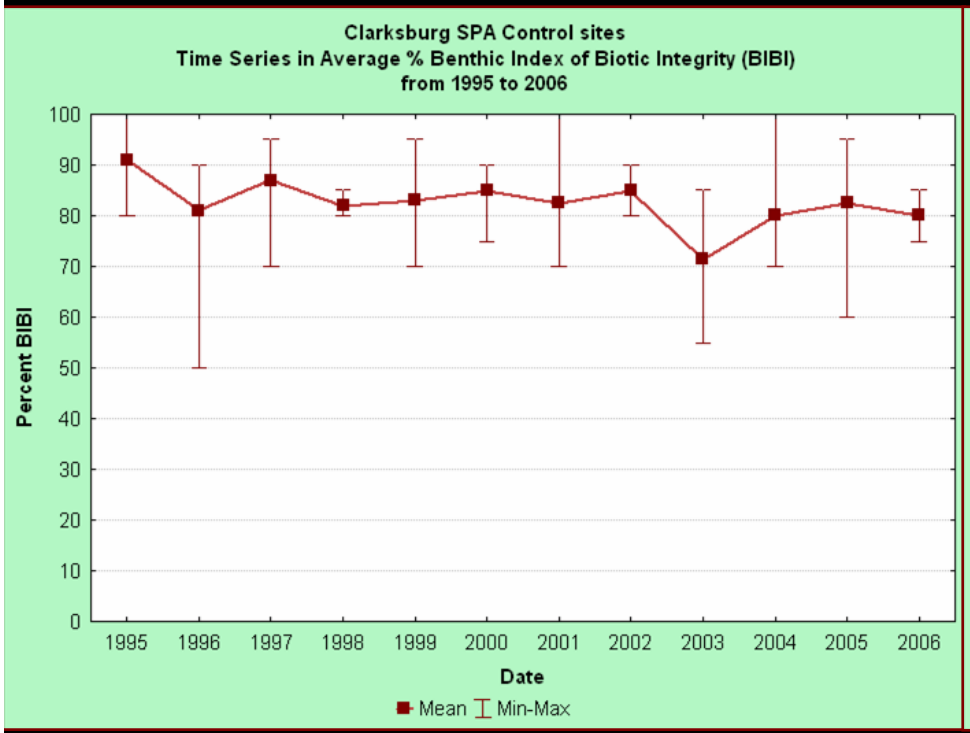
Development results in changes to in-stream habitat

2002

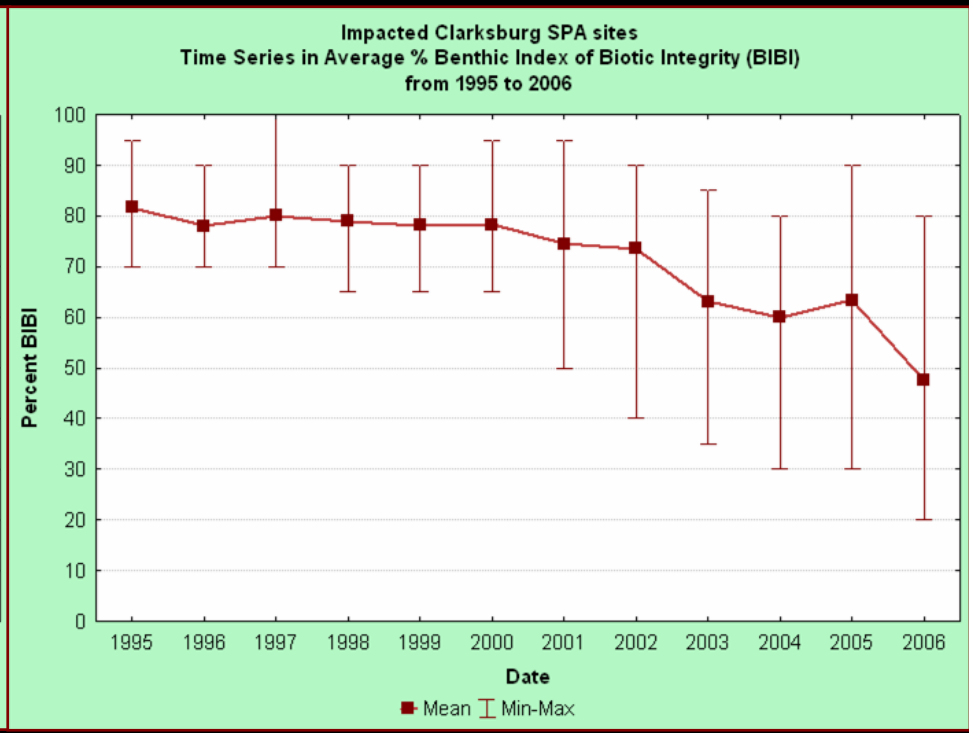
2005

Construction phase profoundly changes benthic macroinvertebrate community composition

Benthic Macroinvertebrate IBI Scores



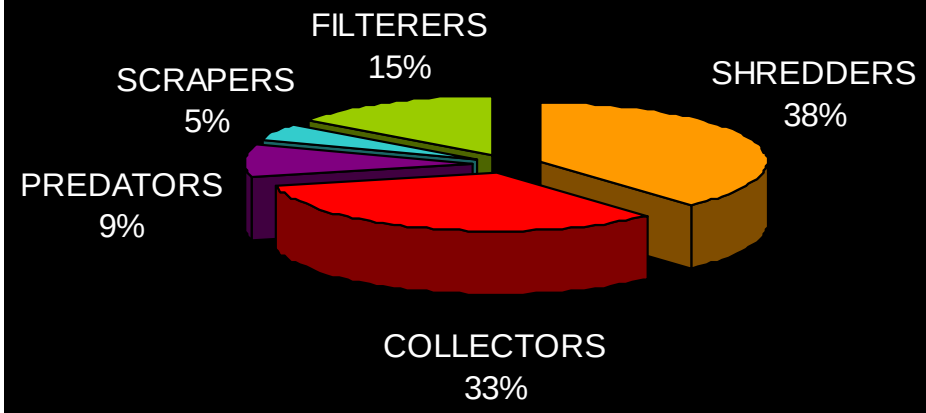
Control Sites



Impacted Sites

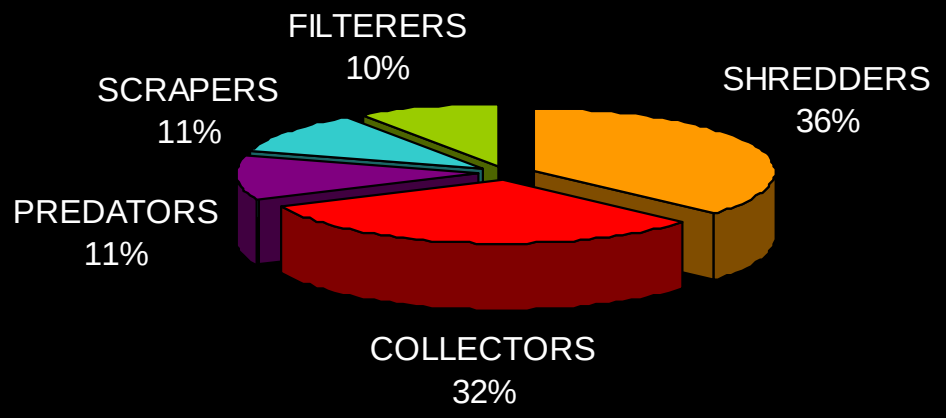
Changes in Benthic Macroinvertebrate Community Composition (Control Sites)

1996-2000



Dominant Taxa:
Amphinemura= 33% Shredder
Chironomidae= 21% Collector
N= 24, Total # of Stations = 7

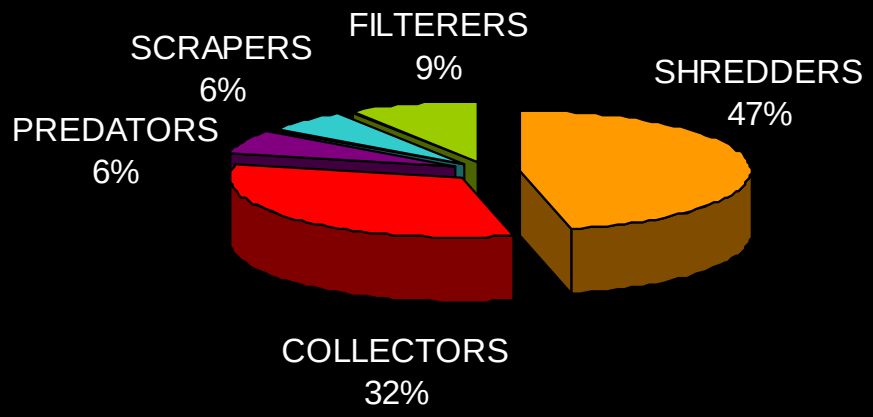
2003-2006



Dominant Taxa:
Amphinemura = 34% Shredder
Orthocladiinae= 13% Collector
N = 17, Total # of Stations = 7

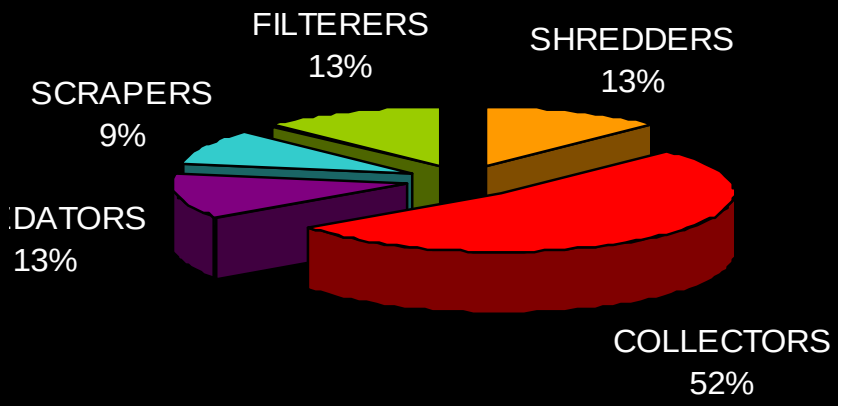
Changes in Benthic Macroinvertebrate Community Composition (Impacted Sites)

1996-2000



Dominant Taxa:
Amphinemura= 43% Shredder
Chironomidae= 20% Collector
N= 35, Total # of Stations = 9

2003-2006



Dominant Taxa
Orthocladiinae = 24% Collector
Chironimini= 13% Collector
N = 31, Total # of Stations = 9

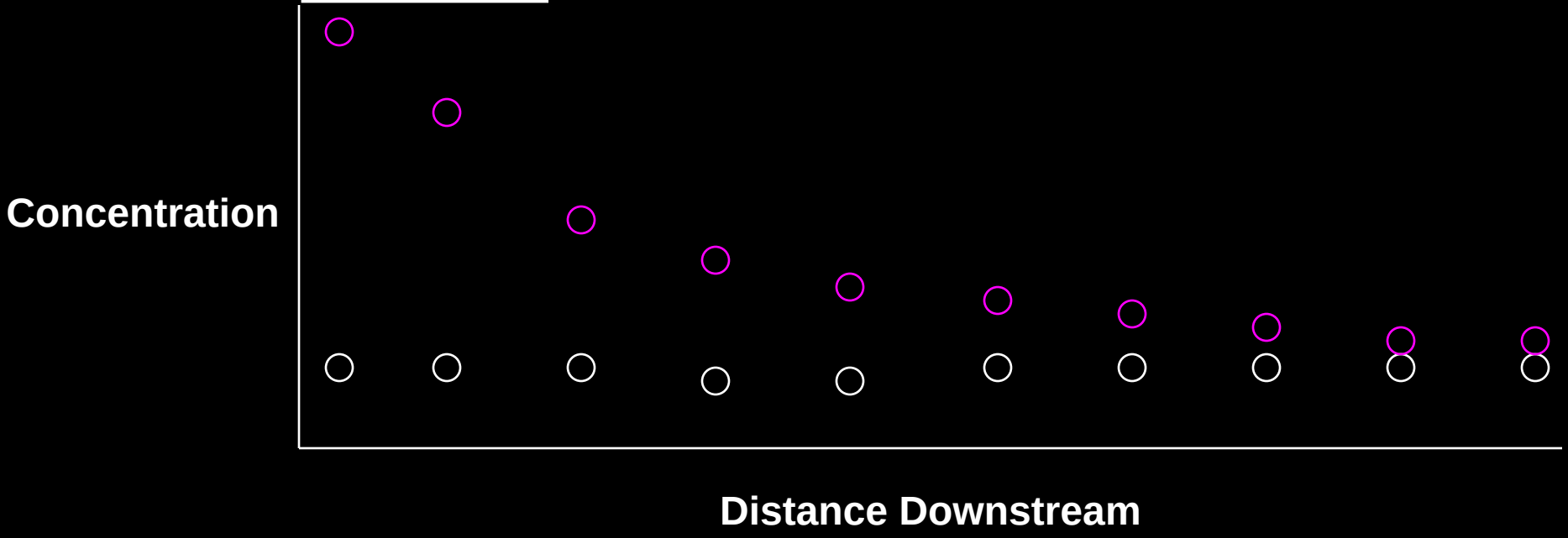
In-stream NO_3^- uptake cannot be detected in Clarksburg study watersheds

Measured NO_3^- uptake at each site:

Summer and Fall 2005

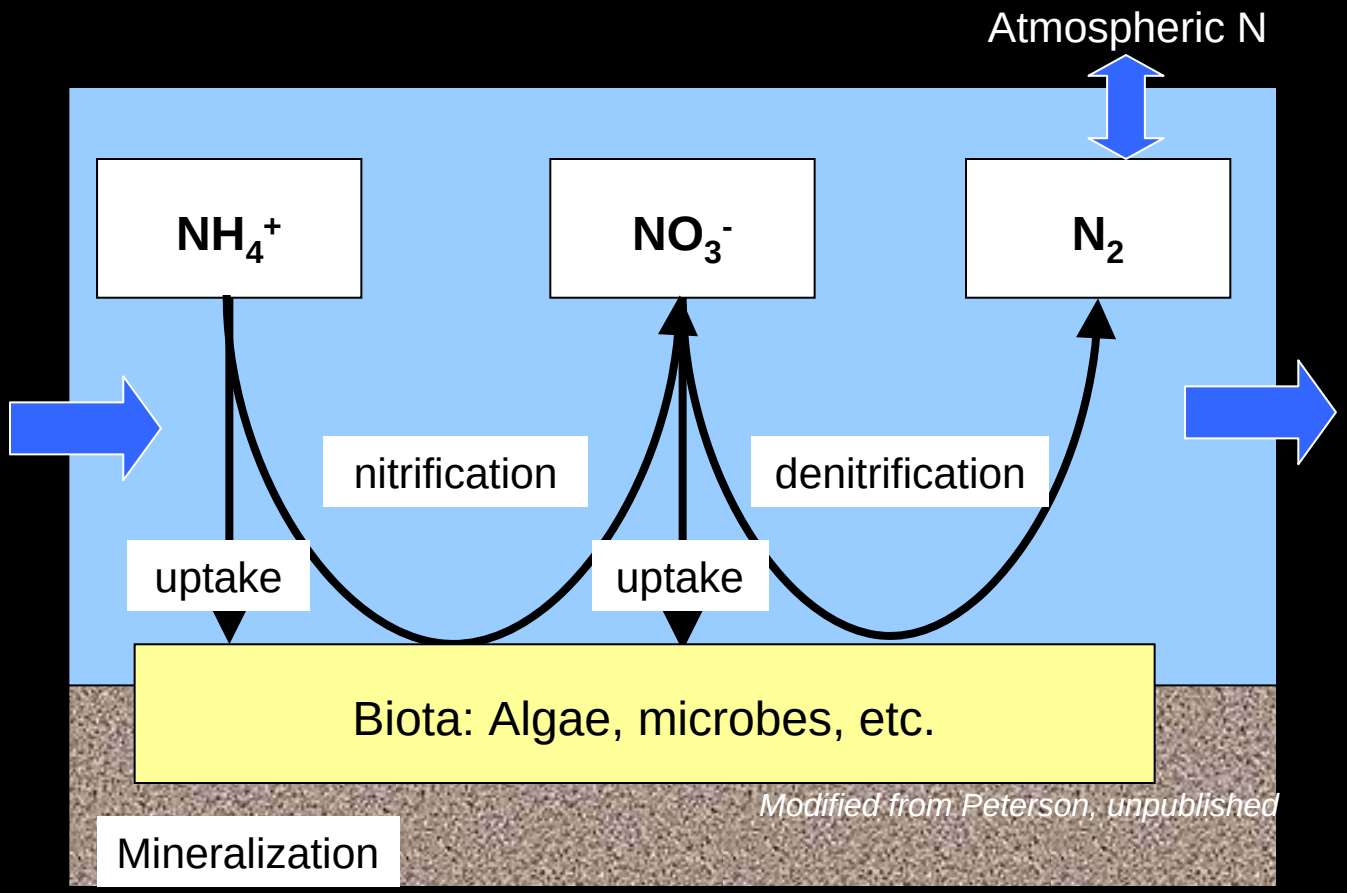
Spring, Summer, and Fall 2006

Summer 2007



Nutrient concentrations do not change with distance downstream!

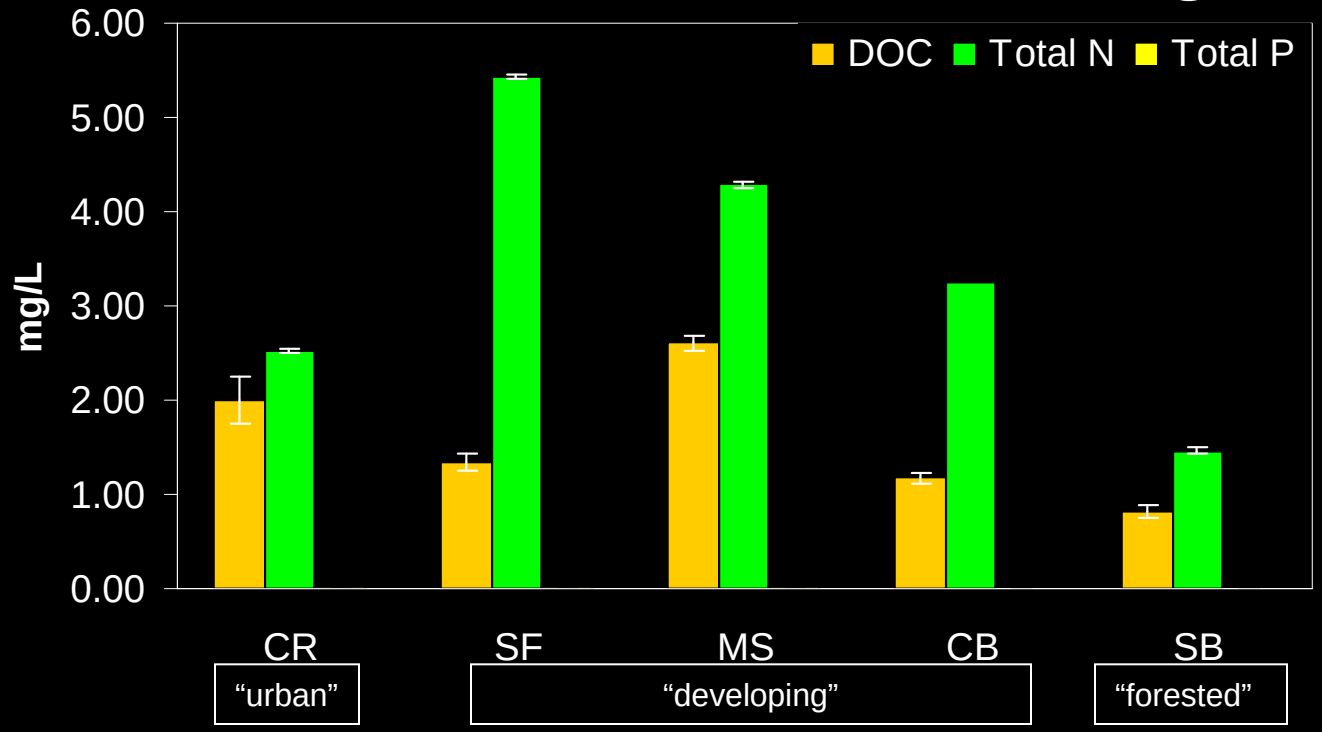
Why can't we measure NO_3^- uptake in Clarksburg??

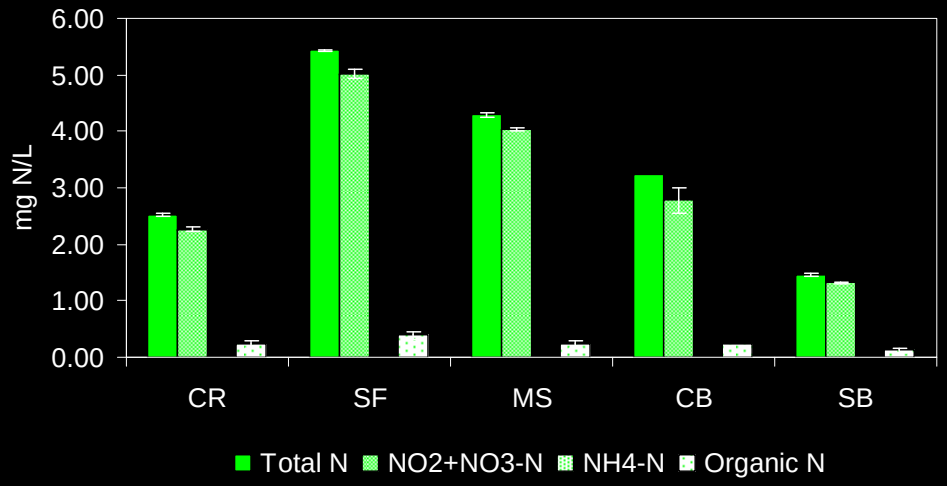


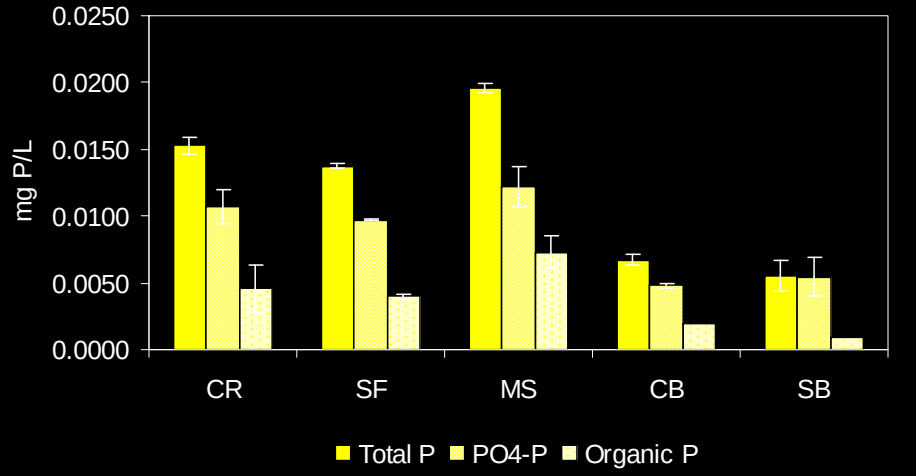
Streams are N saturated / Other nutrients are limiting

Nitrification is producing NO_3^- (masking effects of removal)

Are streams N saturated?
Are other nutrients limiting?

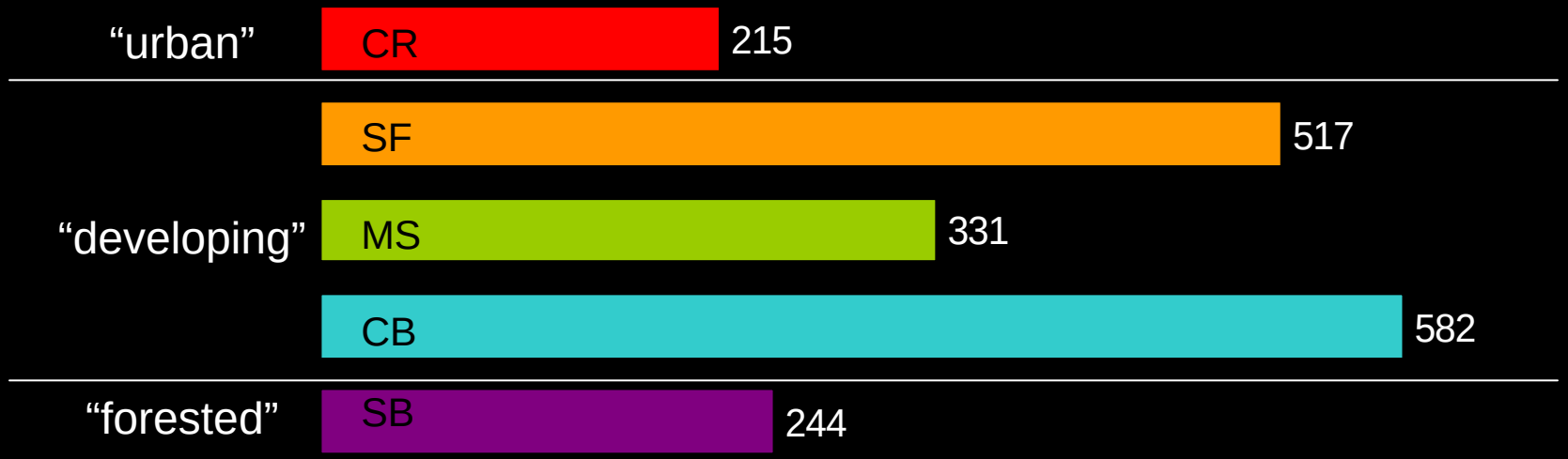






Are streams N saturated?
Are other nutrients limiting?

DIN:SRP is a strong predictor of N saturation (Earl *et al.* 2006)



Study streams appear N saturated

C and P may be limiting uptake by benthos

Local conditions "mask" treatment effects!

Ways the CNS Funding & Program have Helped Us

- Creation/recognition of the Clarksburg Integrated Ecological Study Partnership has increased the number contacts from potential collaborators
- Helped leverage funding and in-kind services
- Provided a level of “legitimacy” to the county’s efforts to understand effects of land use change to receiving streams and biota
- Networking has provided increased access to information, people, and equipment
- Research funded by CNS has led to new and interesting research questions regarding the effects of land use on stream ecosystems.

Update on Collaborators and Partners

S. Taylor Jarnagin, EPA-EPIC

Mapping landscape change and channel morphology using LiDAR

Dianna Hogan, USGS-Reston

Direct measurement of SWM BMP effectiveness

John W. Jones, USGS-Reston

Land use change and climate

Yusuf M. Mohamoud, EPA-NERL

Modeling urban development with HSPF

Kaye Brubaker, Vince Gardina, University of Maryland

Accuracy of LiDAR in different canopy densities

Gary Fisher, WRD, USGS

Collaborator on 5 USGS stream gages

M-NCPPC Park Managers and Ecologists

Response to feedback from partners, CNS grantees, and others

Expanded partnerships with collaborators and the generation of additional data related to our original questions.

- Multi-year LiDAR coverage captures landscape and stream changes (Jarnagin)
- Accuracy assessment of LiDAR (Jarnagin)
- Creation of ARCMAP coverages (Hogan)
- Creation of BMP database (Hogan)

Discussions with other grantees at last year's meeting provided insight regarding data and inspired follow-up experiments

Motivated the upgrade of the USGS gauge at our urban site to "real-time" allowing for public access

The Future of "Ecological Sustainability in Rapidly Urbanizing Watersheds"

Continued monitoring to gain a long-term understanding of the effects of land use change and SWM on geomorphological and ecological metrics as funding allows

Continued collaborative efforts

Pursue interesting "spin-off" questions

Publication of results (DEP releases and peer-reviewed journals)

Questions?

Comments?

Feedback?