

Stream biota- in a nutshell

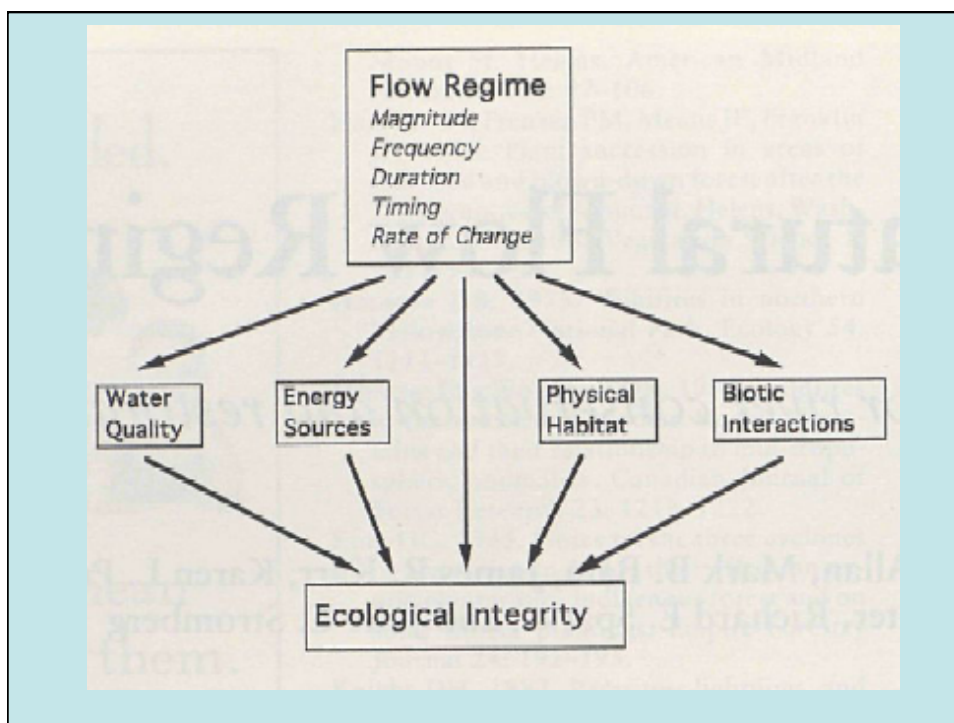
Brian Helms

*Assistant Research Professor
AU Natural History Museum
Dept of Biological Sciences
Auburn University, Alabama*



“current is the most significant characteristic of running water, and it is in their adaptations to constantly flowing water that many stream animals differ from their still-water relatives”

H.B.N. Hynes (1970), *The Ecology of Running Waters*



What is 'ecological integrity'

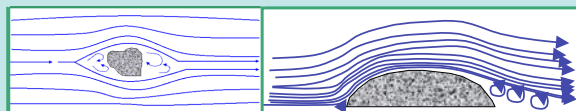
- the structure, composition, and function of an ecosystem operating within the bounds of natural or historic range of variation (NatureServe)
 - Hydrologic regime
 - Geomorphology
 - Physicochemical conditions
 - Biotic composition
 - Energy flow
 - Ecosystem function

- Exist in a state of non-equilibrium
- Changes are irreversible



Stream Biota

- Effects of flow on animals
 - Morphology
 - Flattening
 - Streamlining
 - Suckers, hooks
 - Reduction of swim bladder
 - Behavior
 - Body position in relation to current
 - Drift



Basic questions for studying stream communities

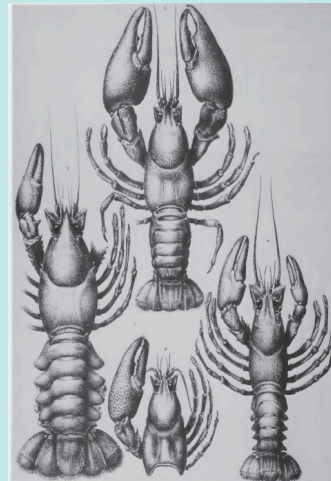
- WHO is there?
 - Community composition
- WHERE is there?
 - Spatial variation
- WHEN are they there?
 - Temporal variation
- WHAT are they doing?
 - Biotic processes and interactions
- HOW is it occurring?
 - Mechanisms



Stream ecology questions

- Who is there?

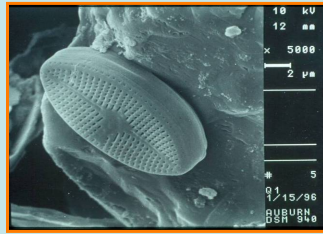
- Natural history studies
 - Basic biological information
 - Fish, many insects
- Targeted inventories
 - Conservation/remediation
 - Species or species-group
- Community composition
 - Local (α) diversity
 - Baseline info



Stream biota

- Basal resources

- Fungi & bacteria
- Algae (diatoms)
- Protists
- Macrophytes



Stream biota

- Invertebrates

- Aquatic insects
 - EPT's, Odonates, Diptera, etc.
- Crustaceans
 - Crayfish, copepods, isopods
- Mollusks
 - Mussels, snails



Stream biota - Vertebrates

- Fish
 - Cyprinids, centrarchids
- Amphibians
 - Plethodontids
- Reptiles
 - Snakes, turtles
- Birds & mammals
 - Rodents, kingfishers, herons

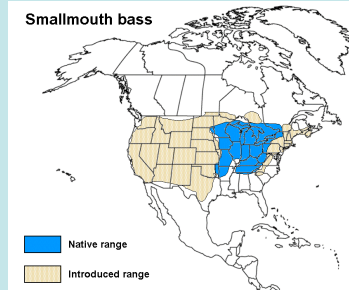


Stream ecology questions - Where are they?

- Local
 - Habitat-specificity
 - Diversity reflects life history adaptations
- Regional
 - Landscape influence, dispersal, species' range
 - Diversity reflects species' function



Smallmouth bass





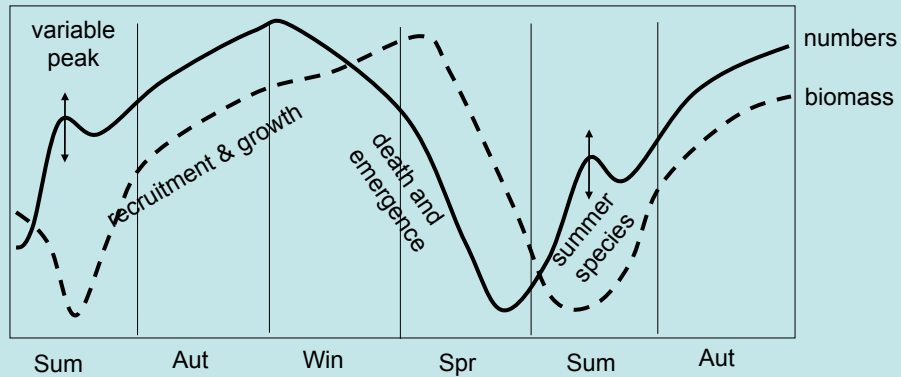


Stream ecology questions

- When are they there?

- Seasonal variation
 - Voltinism (inverts)
 - Migrations (fish)
 - Environmental influence
- Annual variation
 - Recruitment
 - Dispersal
 - Disturbance

Insect seasonal fluctuation



Modified from Hynes (1970)

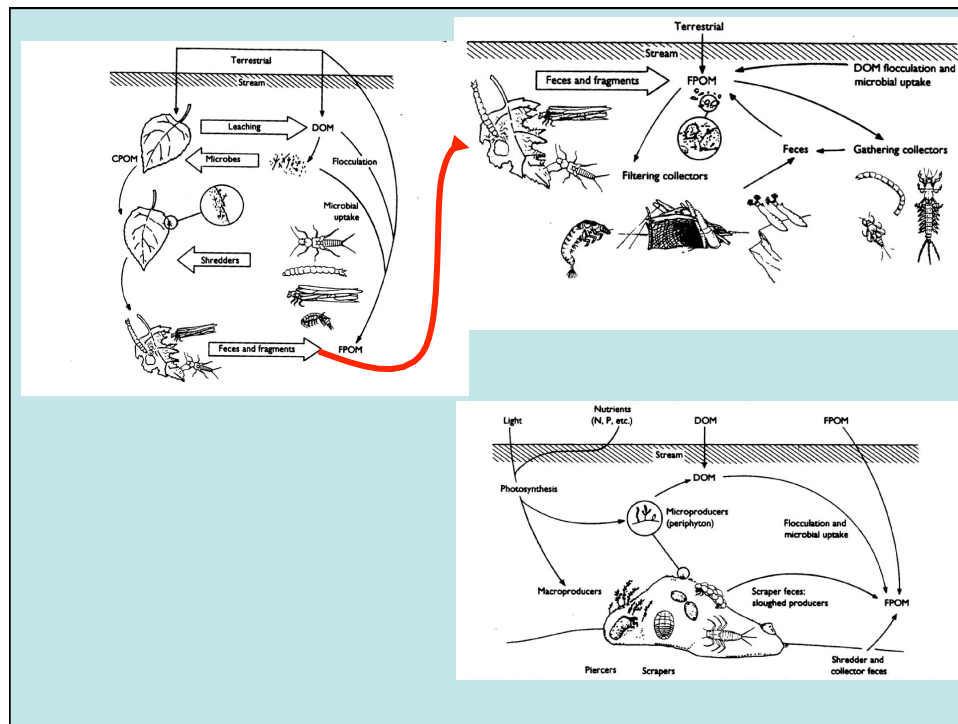
Stream ecology questions

- What are they doing?

- Invert feeding groups

- Shredder
- Filterer
- Collector-gatherer
- Grazer
- Predator
- 'Omnivore'



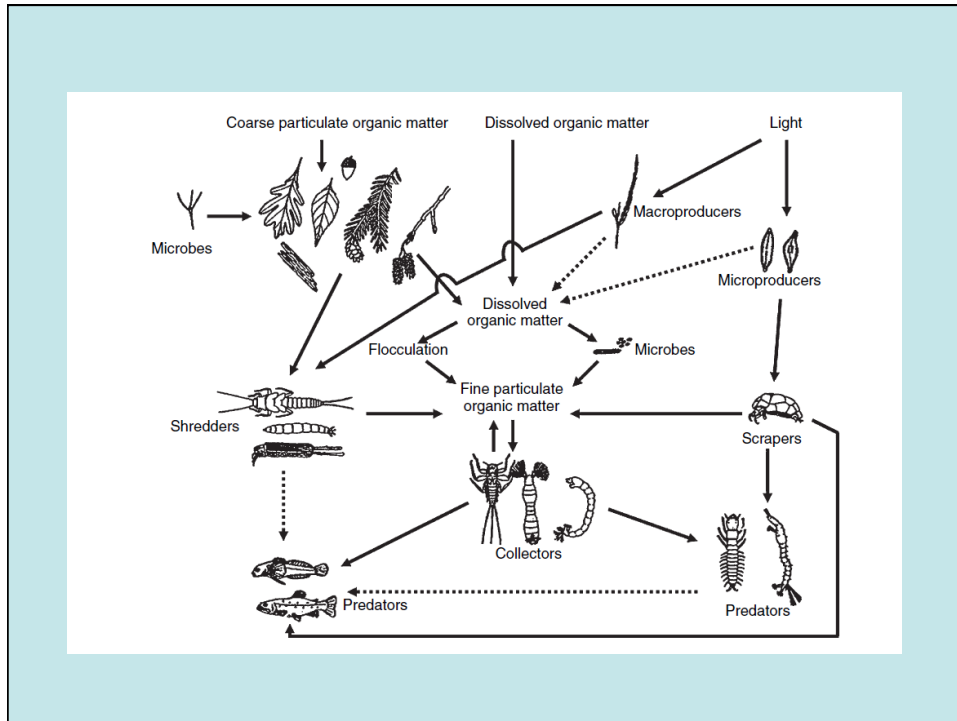


Stream ecology questions

- What are they doing?

- Fish feeding guilds
 - Piscivore
 - Benthic invert feeder
 - Surface/column feeder
 - Invertivore
 - Planktivore
 - Herbivore
 - Omnivore
 - Parasite

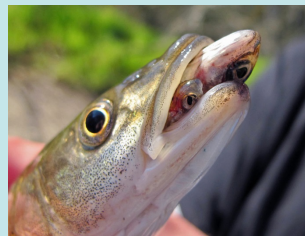




Stream ecology questions

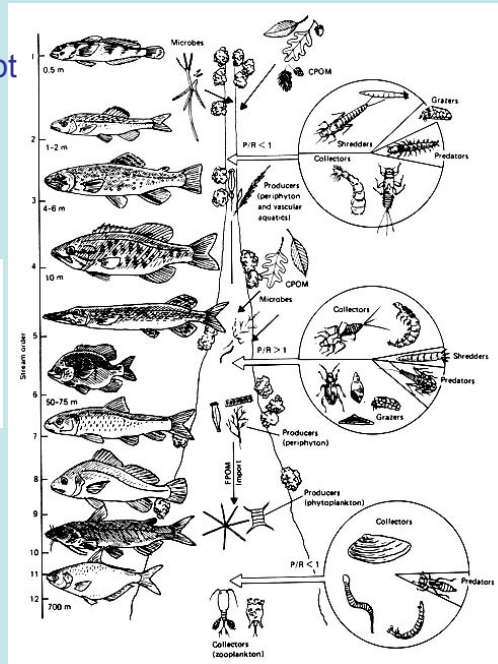
- How is it happening?

- Species interactions
 - Predation, herbivory, competition
- Patch dynamics
 - Habitat specificity
- Disturbance
 - Ultimate abiotic control
- River continuum
 - ‘Longview’ of stream processes
- Ecological filters
 - Series of environmental criteria of various SCALE



The River Continuum Concept Vannote et al. 1980

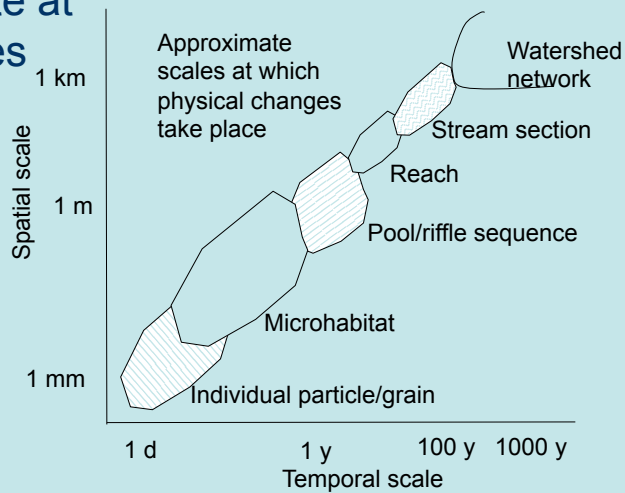
Basically, the concept proposes that understanding of the biological strategies and dynamics of river systems requires consideration of the gradient of physical factors formed by the drainage network. Thus energy input, and organic matter transport, storage, and use by macroinvertebrate functional feeding groups may be regulated largely by fluvial geomorphic processes.



Hierarchical scales

Frissell et al. 1986.

- Things operate at different scales
 - Spatial
 - Temporal
 - Abiotic
 - Biotic

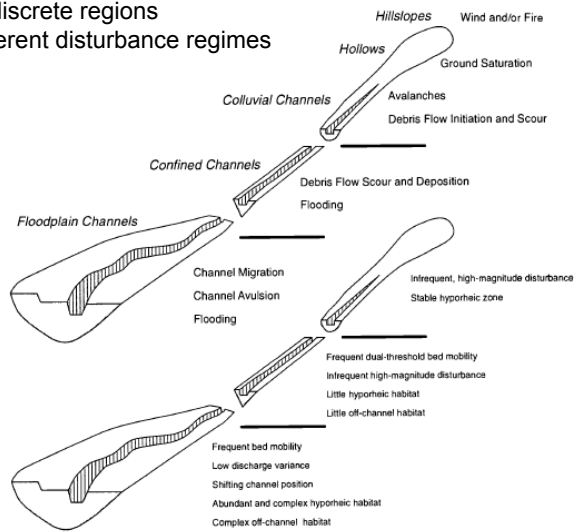


relative significance of factors driving physicochemistry and biology change with scale!

Process domains

Montgomery 1999

- Regions can be characterized by geomorphic processes
- River networks divided into discrete regions
- Communities respond to different disturbance regimes



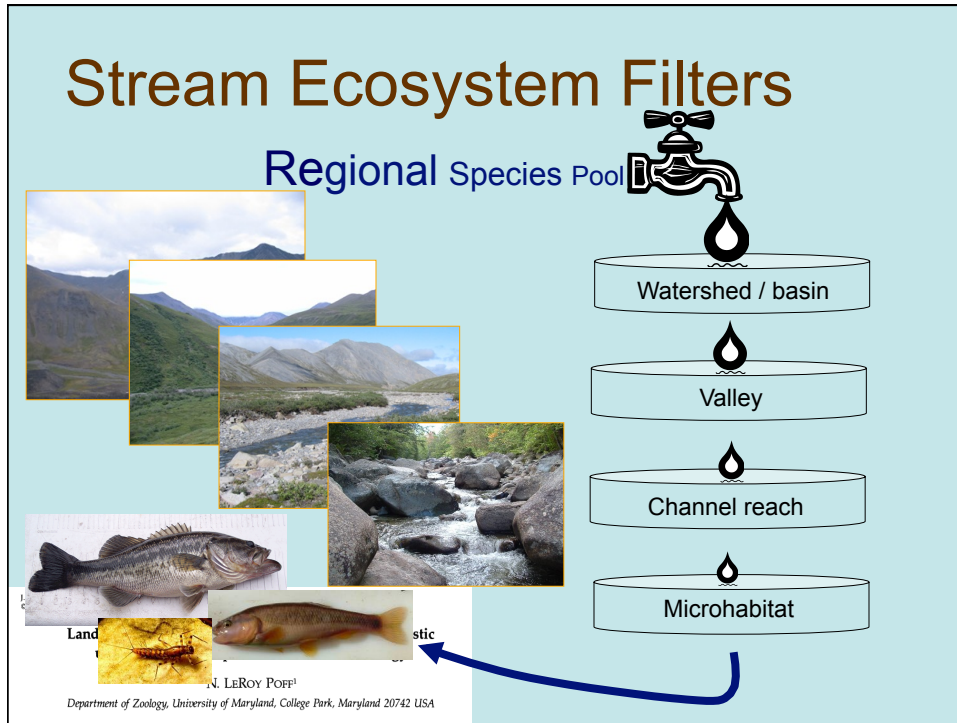
Stream Ecosystem Filters

J. N. Am. Benthol. Soc., 1997, 16(2):391-409
 © 1997 by The North American Benthological Society

Landscape filters and species traits: towards mechanistic understanding and prediction in stream ecology

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Bioindicators as a tool

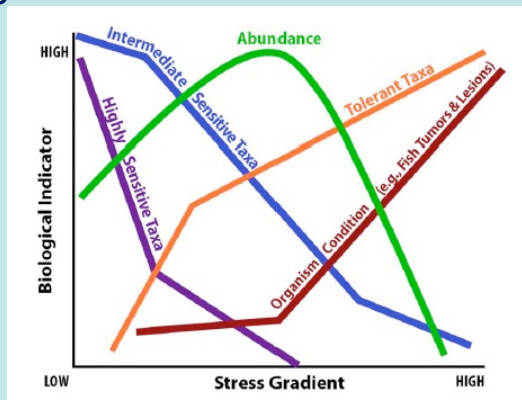
- Organisms used to assess environmental condition
 - Microbes
 - Algae
 - Invertebrates
 - Fish and amphibians
- Why??
 - Time-integrated response
 - Scale comprehensive



Mechanics

- Total abundance
- Taxonomic diversity
- Indicator species
- Condition
- Multimetrics

Based on region-specific reference condition



Environmental Protection Division
A Division of the Georgia Department of Natural Resources

Technical Guidance
[Macroinvertebrate Bioassessment Standard Operating Procedures \(SOP\) and Metric Spreadsheets](#)
[Guidelines for Using Third Party Biological Data For 305\(b\)/303\(d\) Purposes \(Revised August 2010\)](#)

Ecoregion Metric Spreadsheets
 The MS Excel spreadsheets and associated documents are compressed into a separate ZIP file for each subecoregion.

Ecoregion 45-Piedmont
[45a-Southern Inner Piedmont \[09/2008\]](#)
[45b-Southern Outer Piedmont \[11/2007\]](#)
 45c-Carolina Slate Belt "Coming Soon"
[45d-Taladega Upland \[11/2007\]](#)
 45f-Six Mountain Ridges "Coming Soon"

Ecoregion 65-Southeastern Plains
[65a-Sand Hills \[11/2011\]](#)
[65b-Southern Hills/Gulf Coastal Plain \[11/2007\]](#)
[65c-Douglasville Plain \[02/2010\]](#)
[65d-Tifton Upland \[11/2007\]](#)
[65e-Coastal Plain Red Uplands \[11/2007\]](#)
[65f-Atlantic Southern Loam Plains \[12/2011\]](#)
 65o-Tallahassee Hills/Valdosta Limestone "Coming Soon"

Ecoregion 66-Blue Ridge

GADNR/EPD MACROINVERTEBRATE MULTI-METRIC INDICES
 PIEDMONT ECOREGION (45)
 Southern Outer Piedmont (45b) Metric Index

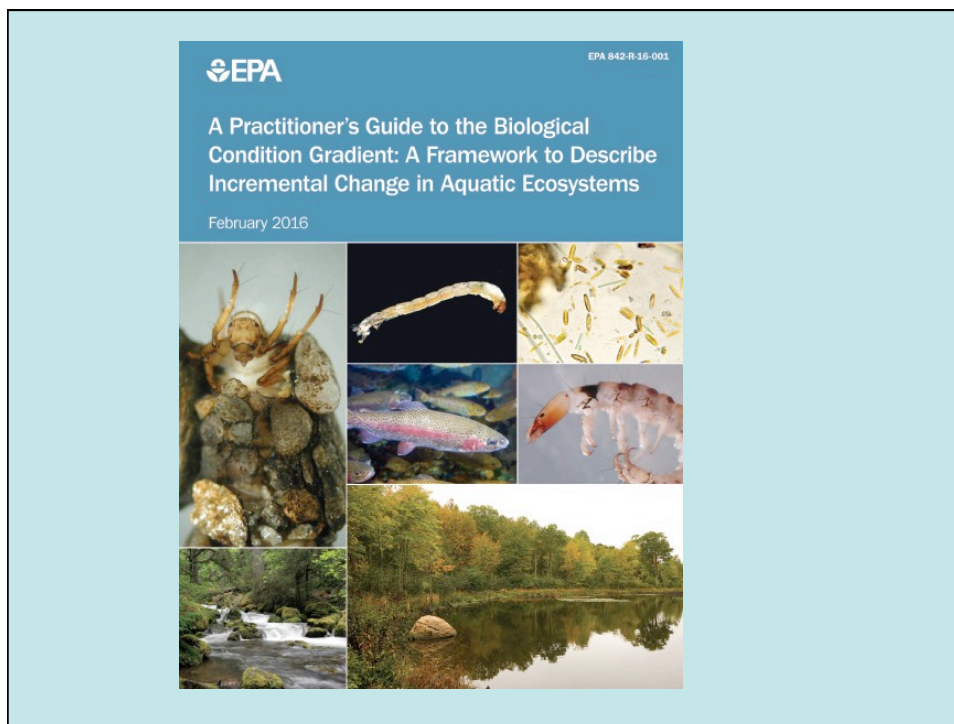
(45) PIEDMONT ECOREGION	
45b Metric Index - Southern Outer Piedmont	
Metric	Metric Category
Coleoptera Taxa	Richness
% Oligochaeta	Composition
% Plecoptera	Functional Feeding Group
Shredder Taxa	
Scraper Taxa	
Swimmer Taxa	Habit

GADNR/EPD MACROINVERTEBRATE MULTI-METRIC INDICES
 (67) RIDGE AND VALLEY
 Southern Inner Piedmont/Dominic Valleys & Low Rolling Hills and Southern Dissected Ridges & Knobs (676k) Metric Index

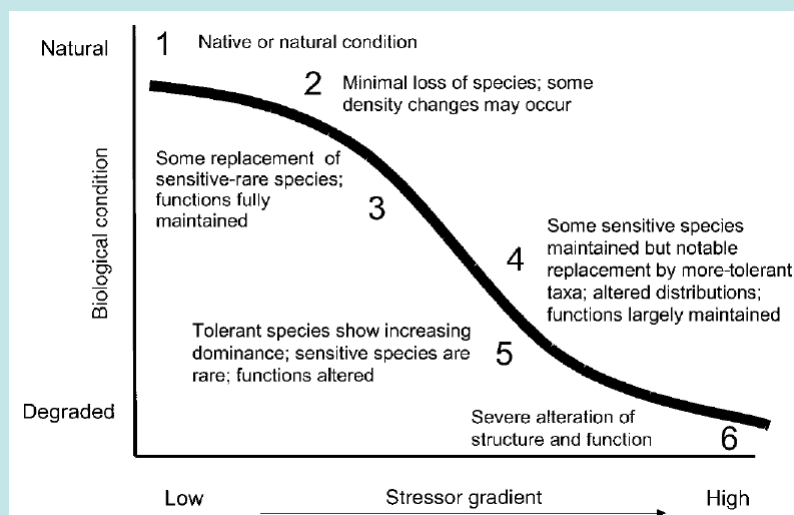
(67) RIDGE AND VALLEY	
Metric Index - 676k	
Metric	Metric Category
EPT Taxa	Richness
Plecoptera Taxa	Composition
% EPT	
% NCRH	Tolerance
Scraper Taxa	Functional Feeding Group
% Cinger	

GADNR/EPD MACROINVERTEBRATE MULTI-METRIC INDICES
 SOUTHEASTERN PLAINS (65)
 Coastal Plain Red Uplands (65k) Metric Index

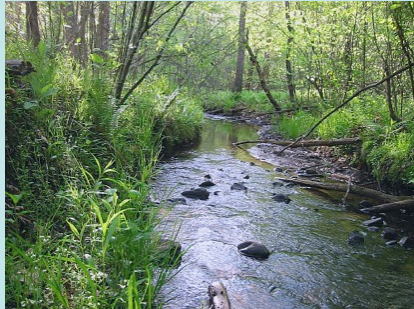
(65) SOUTHEASTERN PLAINS	
65k Metric Index - Coastal Plain Red Uplands	
Metric	Metric Category
% Gastropoda	Composition
% Orthocladinae/Total Chironomidae	
% Coleoptera	
% Hydropsychidae/Total Trichoptera	
% Filterer	Functional Feeding Group
% Collector	



Biological Condition Gradient



LU/LC change and stream morphology

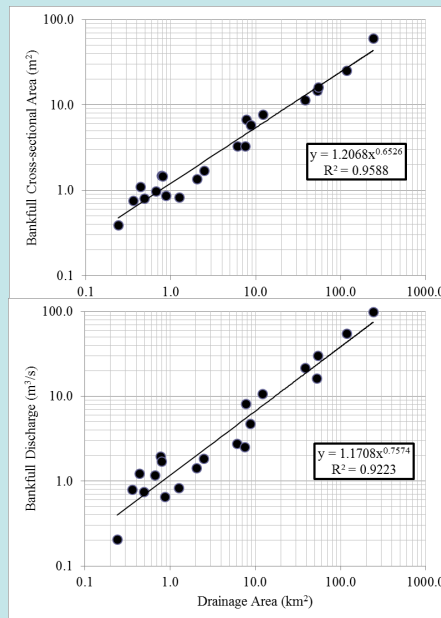
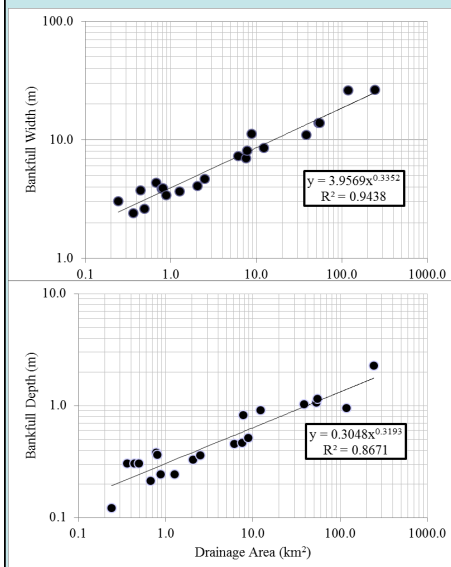


- ‘Natural’ flows
- Stable banks
- Unconfined channel
- Connection

- Increased flows
- Unstable banks
- Confined channel
- Incision



Regional curves



Ecological endpoint development

- Physical/biological integration
- Backpack electroshocker
 - Fish and crayfish
- Surber sample
 - Macroinvertebrates
- Fit log-log plots using biota and drainage area
 - Taxonomic and functional responses

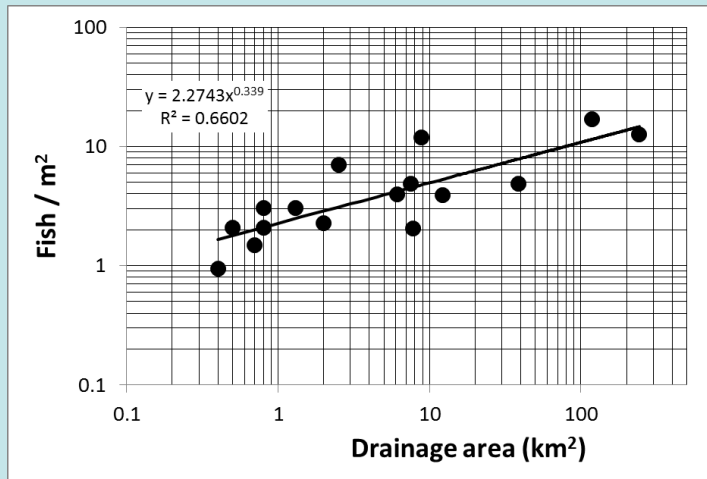


Species encountered and scale of response

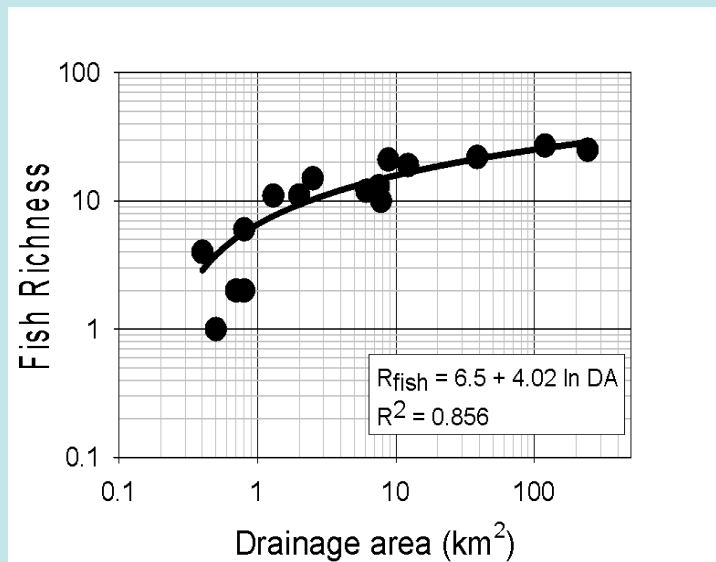
- Fish
 - 8000+ individuals
 - 51 species
 - Broad scale
- Crayfish
 - 1400+ individuals
 - 10 species
 - Intermediate scale
- Macroinvertebrates
 - >150k individuals
 - 60+ families, ~150 genera
 - Fine scale



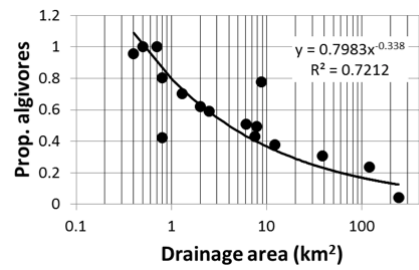
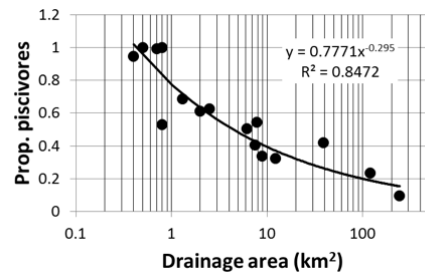
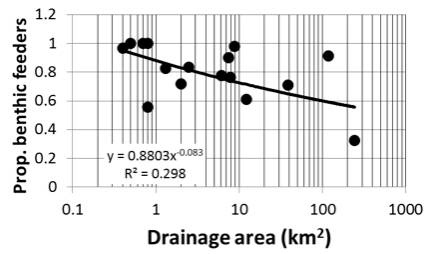
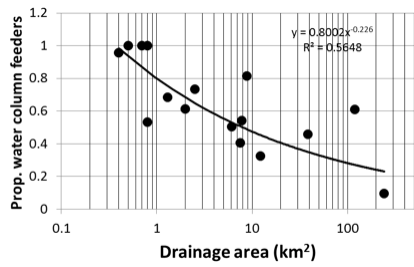
Fish Abundance Curve



Fish Taxonomic Curves



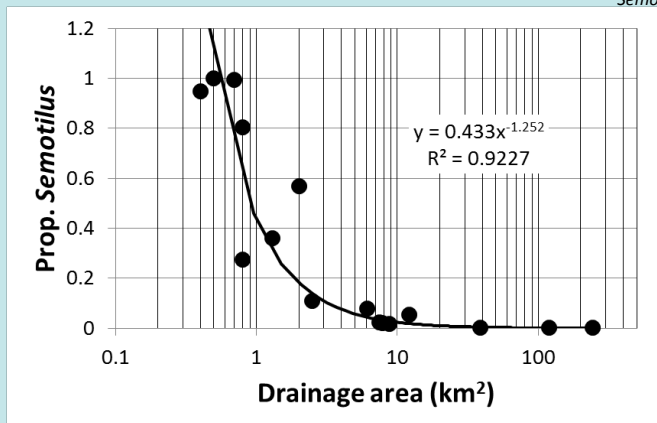
Fish Functional Curves



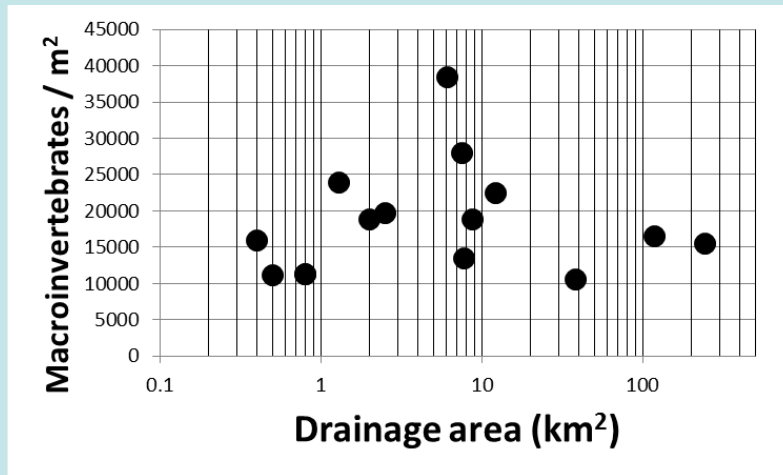
Fish Taxon Curve



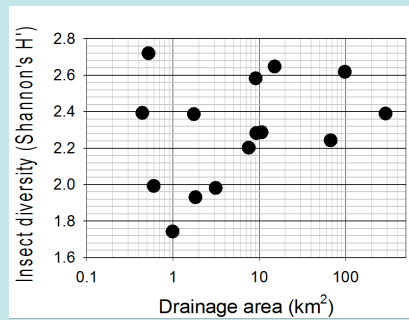
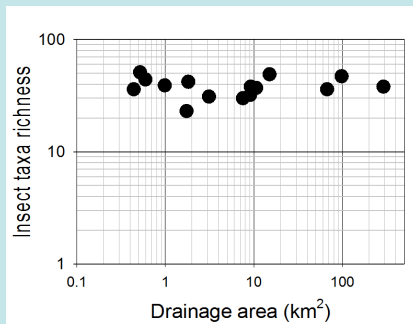
Semotilus atromaculatus



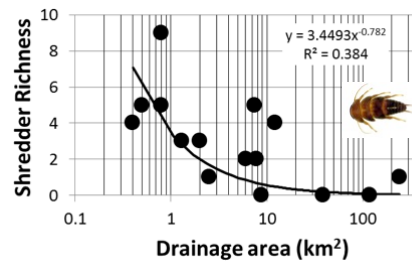
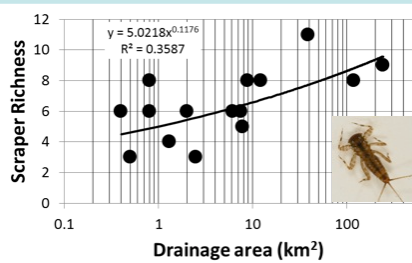
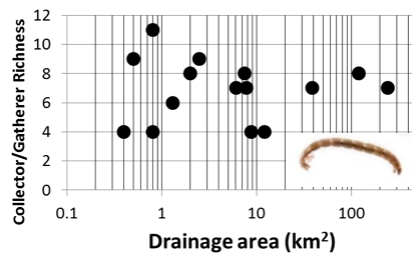
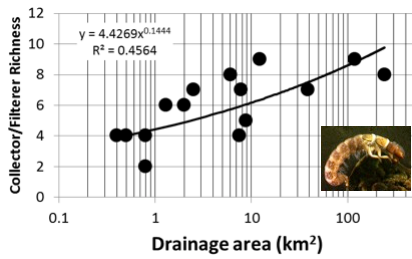
Bug abundance curve



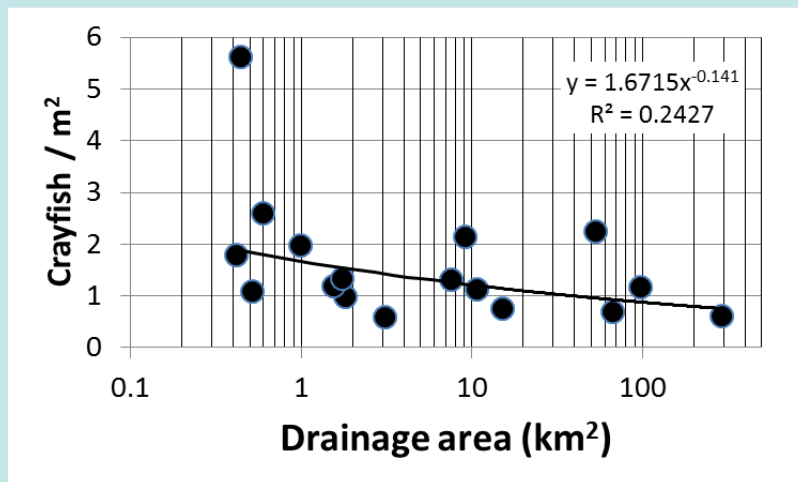
Bug taxonomic curves



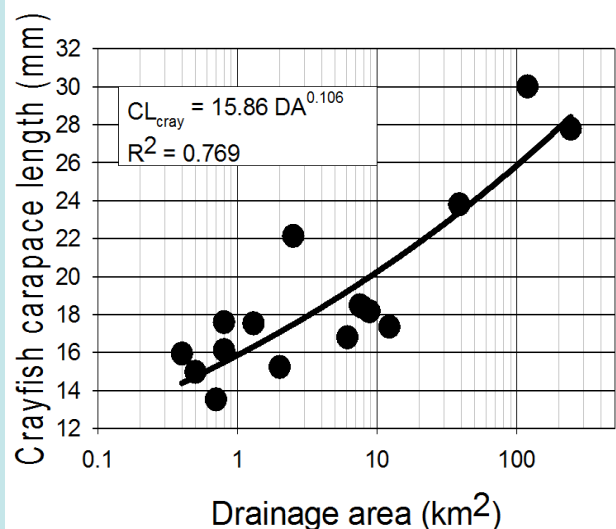
Bug functional curves



Crayfish Abundance Curve



Crayfish Endpoint Curves



Ecological endpoints



- Predictable, biological “ceiling”
- Considerable variation in some metrics
- Taxonomic measures only part of story
- Conditions are the outcomes of nested hierarchy
 - Restoration efforts will respond accordingly
 - Biology gets messy, but predictable

Important restoration questions

- Measurement of need?
 - Physical degradation = biological degradation?
 - Biologically meaningful goals
- Do efforts address needs?
 - Scale of work = scale of processes
 - Function may not follow form
- Measurement of success?
 - Species of concern
 - Taxonomic / functional diversity
 - Scale of success measure = scale of need?
 - Do physical improvements = biological improvements?



Important stream ecology themes

- Streams are physically dynamic and harsh
 - Understand component parts
- Environmental conditions are primary selective force on biota
 - Physical/behavioral adaptations
 - Reduced influence of biotic interactions
- Consideration of scale is critical
 - Temporal and spatial

“Despite massive efforts by engineers, in league with agronomists and power companies, water still manages to run downhill with remarkable frequency.”

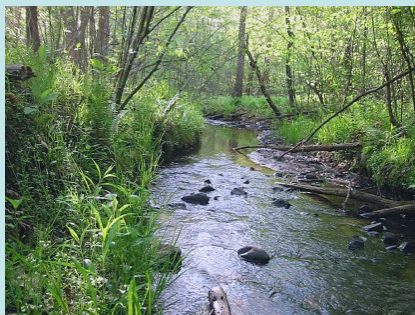
Ken Cummins (1971), review of
The Ecology of Running Waters

Acknowledgements

- AL Dept. of Conservation and Natural Resources 
- AL Dept. of Environmental Management 
- US Forest Service 
- US Fish and Wildlife Service 
- US Environmental Protection Agency 
- National Science Foundation 
- Auburn University 



LU/LC change and stream morphology



- 'Natural' flows
- Stable banks
- Unconfined channel
- Connection

- Increased flows
- Unstable banks
- Confined channel
- Incision



Bank stability assessment

- Bank erodibility hazard index (BEHI, Rosgen 2001)
 - Bank height:bankfull height, root depth:bank height, bank angle, root density, surface protection
 - Erodibility hazard scored 5 - 50
- No biological component
 - Physical = ecological integrity?



Physical/biological integration

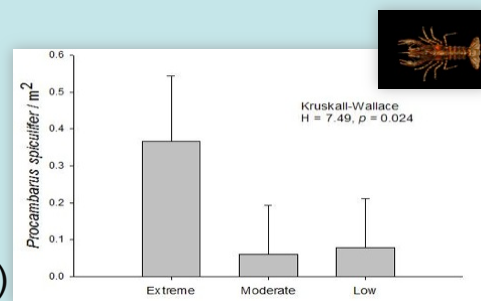
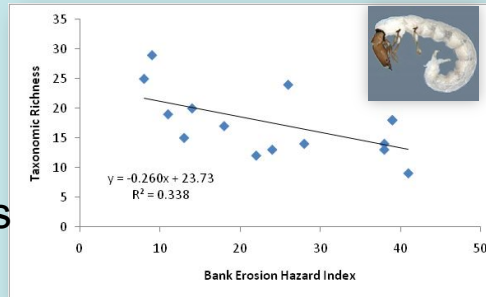
- AL Piedmont stream
 - 15 banks/reaches
 - Varied in condition
 - Control for inter-stream biotic variation
- Quantify bank condition
 - BEHI
- Quantify biotic assemblages
 - Near-bank composition
 - Macroinvertebrates and crayfish



Simpson et al. 2014 Ecological Indicators

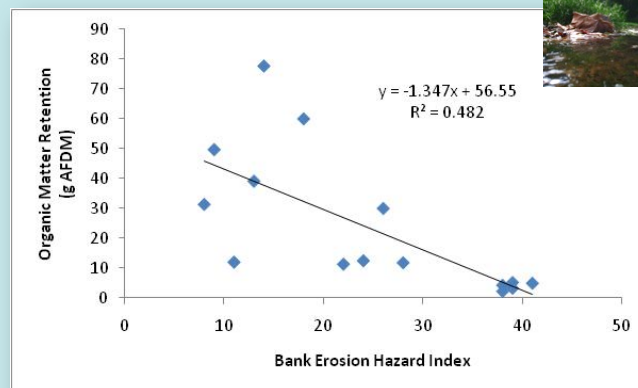
BEHI and biota

- Range of BEHI scores
 - 8 – 41
 - 5 Extreme, 4 Mod, 6 Low
- With increasing BEHI
 - Reduced invertebrate richness
 - Increased crayfish abundance (generalist)



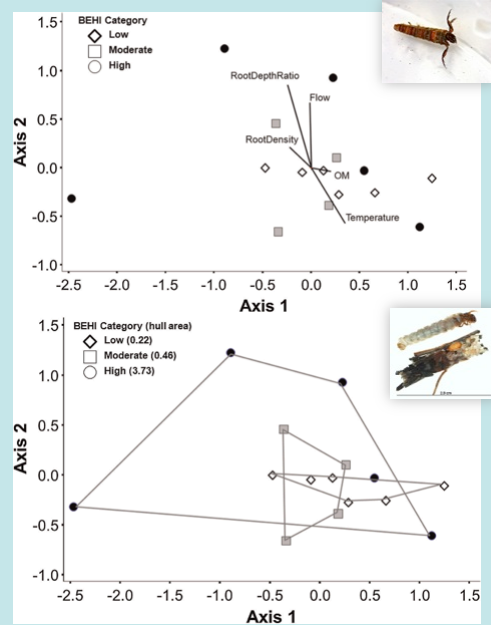
BEHI and habitat

- With increasing BEHI
 - Decrease in OM retention



BEHI and assemblages

- Substantial spatial variation
- Environmental correlates
 - Flow, temperature, OM
- Increased faunal similarity / predictability / stability with lower BEHI



What does it mean?

- Congruence between physical measures and biological condition
- Manifest in assemblage structure
- May require more than diversity/richness measures to determine biological effects

