Developing relations among human activities, stressors, and stream ecosystem responses for integrated regional, multi-stressor models

R. Jan Stevenson[1], M. J. Wiley[2]
D. Hyndman[1], B. Pijanowski[3], P. Seelbach[2]
[1]Michigan State Univ., East Lansing, MI
[2]Univ. Michigan, Ann Arbor, MI
[3]Purdue University, West Lafayette, IN
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Goals

- relate patterns of human landscape activity to commonly co–varying stressors (nutrients, temperature, sediment load, DO, and hydrology)
- relate those stressors to valued fisheries capital and ecological integrity of stream ecosystems.

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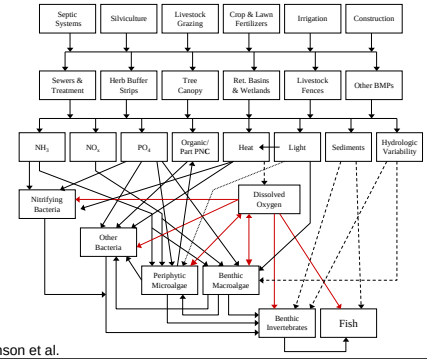
Natural Ecosystems Are Complex



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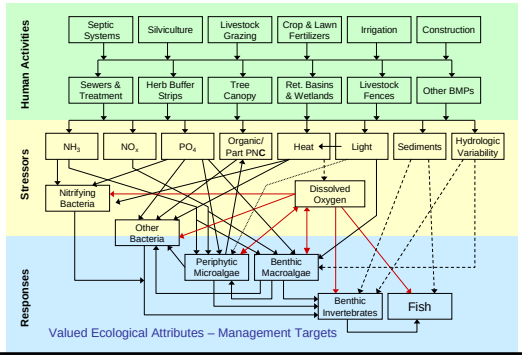
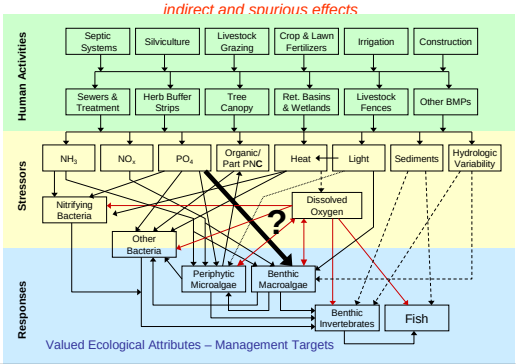
Natural Ecosystems Are Complex but can be Organized for Management



Refining Relationships

thresholds, contingencies, interactions, indirect and spurious effects



Complicating Issues

- Non-linearity and thresholds: graded responses may be rare in complex systems and thresholds make management choices critical.
- Complex causation: multiple actions results in a cascade of effects which ultimately simultaneously shape biological responses; most importantly-issues of direct and indirect causation (effects)
- Scale and dynamics: Potential stressors operate at different spatial and dynamic scales, as do different ecosystem components. Scale hierarchies complicate the diagnosis of stressor-response relationships because they can obscure causal dependencies through time lags, ghosts of past events, and misidentification of natural spatial/temporal variability.

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Approach

- Building on prior and current regional Assessment and modeling work of this team (Michigan Indiana, Kentucky, Ohio, Illinois, Wisconsin)
- Blending causal (mechanistic) with empirical (statistical) modeling integrated in an modeling system (linked Landcover-surface water-groundwater-loading framework)
- Emphasizing regional (wide ranging) analysis to capture ranges of variation
- Emphasizing intensive site sampling to address specific mechanisms and parameterize models

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Where we are working

Muskegon River Watershed, Mi
Grand River Watershed, Mi
Crane Creek Watershed, Oh

Focal systems:

- Cedar Creek (high Ag loadings, high Slope, high GW)
- Brooks Creek (high Ag loadings, mod Slope, mod GW)
- Looking Glass River (high Ag loadings, mod Slope, mod GW)
- Red Cedar River (Ag and Urban loadings, mod Slope, mod GW)
- Crane Creek (highly impacted by Ag, very lo Slope, very lo GW)
- Upper Grand and Upper Muskegon (wetland dominated, mod Slope, GW variable)

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2003 Progress report

- Late start last year, 2004 first extensive field year
- Pilot Nitrification study completed in Grand River tribs
- Integration anad re-analysis of existing data sets well underway
- Linked surface water-ground water model (Hec-HMS/MODFLOW/GWLF) running for Muskegon tribs [see http://www.mwrp.net]
- Stream gauging and nutrient sampling underway in Crane Creek
- Summer assessment sampling in July-Aug 2004&2005

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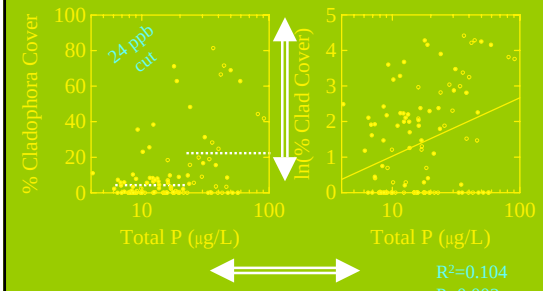
2003 highlights…
detecting thresholds & refining relationships

Peak Cladophora Biomass

Can a noisy ***Threshold response***
to Phosphate be by resolved by biologically averaging the nutrient signal?



R^2=0.104
P=0.002

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Distinguishing Differences Among Assemblages

Sensitive Taxa

Tolerant Taxa

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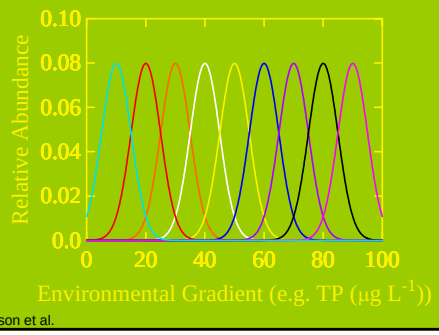
Species Abundances Along Environmental Gradient



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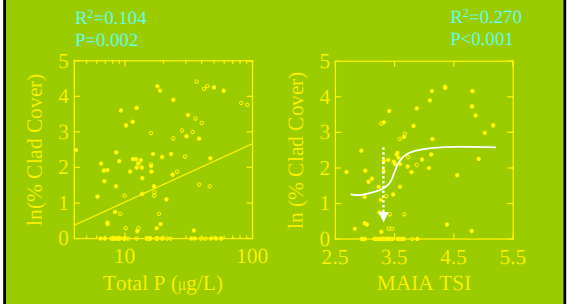
Cladophora/Nutrient Model Improves with Diatom Inferred TSI



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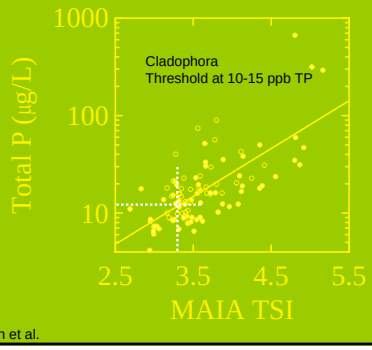
Translating TSI to Nutrient Criterion



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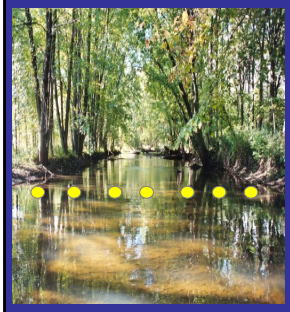
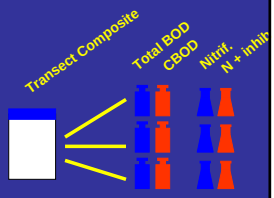
2003 highlights…Nitrification Pilot

Methods:

- How variable is Nitrification demand on oxygen?
- NBOD Parameterization for the DO modeling





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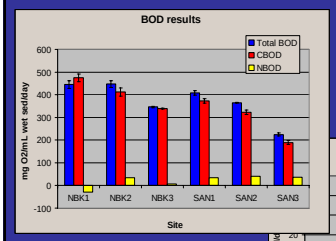
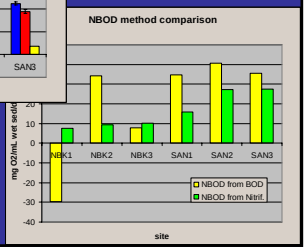
2003 highlights…Nitrification Pilot

Results from 3 transect trials





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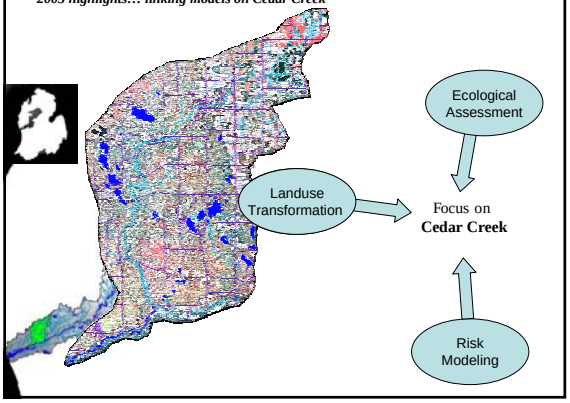
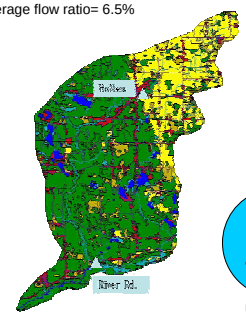
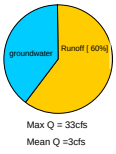
2003 highlights… linking models on Cedar Creek

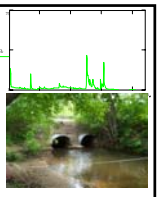


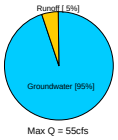
Holten to River Rd. Ratios
Catchment area ratio= 26%
Typical storm peak ratio = 25%
Average flow ratio= 6.5%



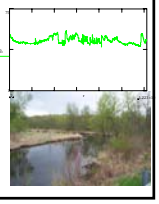


Max Q = 33cfs
Mean Q =3cfs

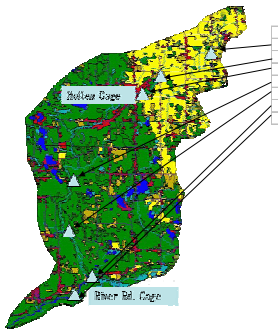




Max Q = 55cfs
Mean Q =46cfs

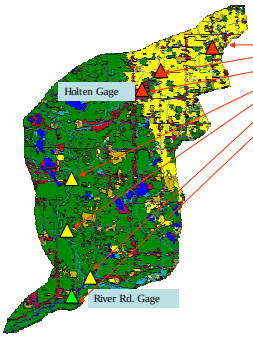


2003 highlights… linking models on Cedar Creek



Q(cfs)	Conductivity (uS)	NOx-N (pbb)	TP (pbb)
0.0	824	101	120
1.0	670	102	90
1.1	521	522	121
15.9	278	197	53
18.4	293	209	43
24.4	293	156	48
24.5	300	150	10

2003 highlights… linking models on Cedar Creek



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Basic Water Quality

- Poor
- Below expectation
- Acceptable
- Excellent

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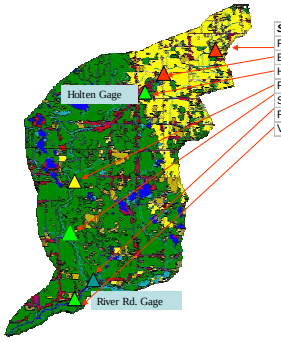


Observed/Expected diversity

Site Name	*Fish score*	*EPT score*	*Average*
Reeman Road	0.00	0.00	0.00
Brickyard N	0.29	0.00	0.14
Holten	1.00	0.93	0.96
Ryerson Road	0.50	0.93	0.71
Sweeter Road	0.83	1.00	0.92
River Road	1.67	0.50	1.08
Valley Site	0.58	0.55	0.57

Biological Quality

- Poor
- Below expectation
- Acceptable
- Excellent

2003 highlights… linking models on Cedar Creek

Linked models evaluate effects of future landuse changes

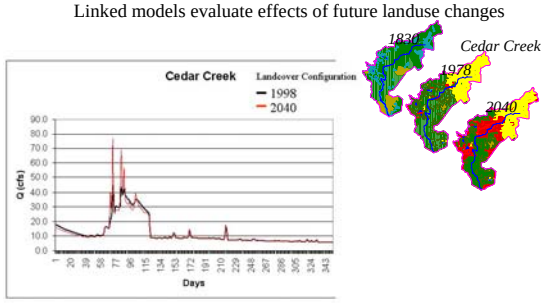


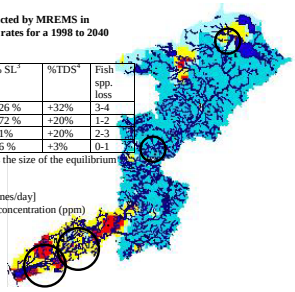
Figure 6 - Modeled hydrographs for Cedar Creek using observed 1998 and LTM projected 2040 landcover scenarios. Precipitation and temperature patterns, and all other variables held constant. Days are arbitrary simulation dates.

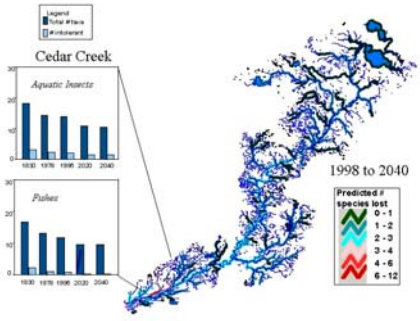
2003 highlights… linking models on Cedar Creek

Table 2 - Example of multiple ecological responses predicted by MREMS in preliminary runs for a "Fast Growth" scenario. Change rates for a 1998 to 2040 time frame comparison.

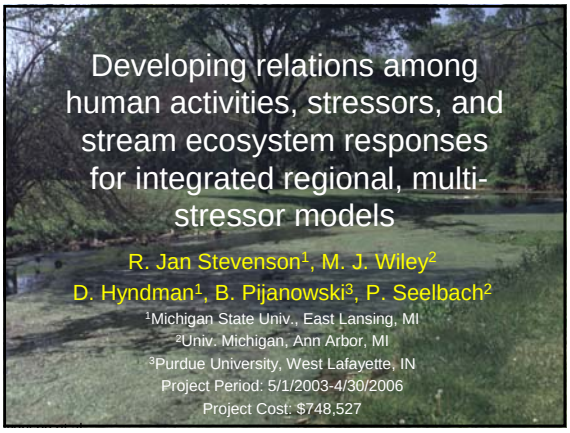
Site	% DD[1]	Channel[2] Response	% SL[3]	%TDS[4]	Fish spp. loss
Cedar Creek	-13 %	aggrade	+26 %	+32%	3-4
Brooks Creek	-22 %	aggrade	+72 %	+20%	1-2
Main River @ Evart	0 %	No change	+1%	+20%	2-3
Main River @ Reedsburg	0 %	No change	+6 %	+3%	0-1

[1] %DQ: Percent change in Dominant Discharge (determines the size of the equilibrium channel)
[2] Channel response: expected response based on %DD
[3] %SL: Percent increase in average daily sediment load [tonnes/day]
[4] %TDS: Percent change in median Total Dissolved Solids concentration (ppm)





Mega-Model Runs target the entire watershed and provide a time-dependent context for understanding our Current conditions, identifying risks that lie ahead, and a testing ground for alternate Management Scenarios.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