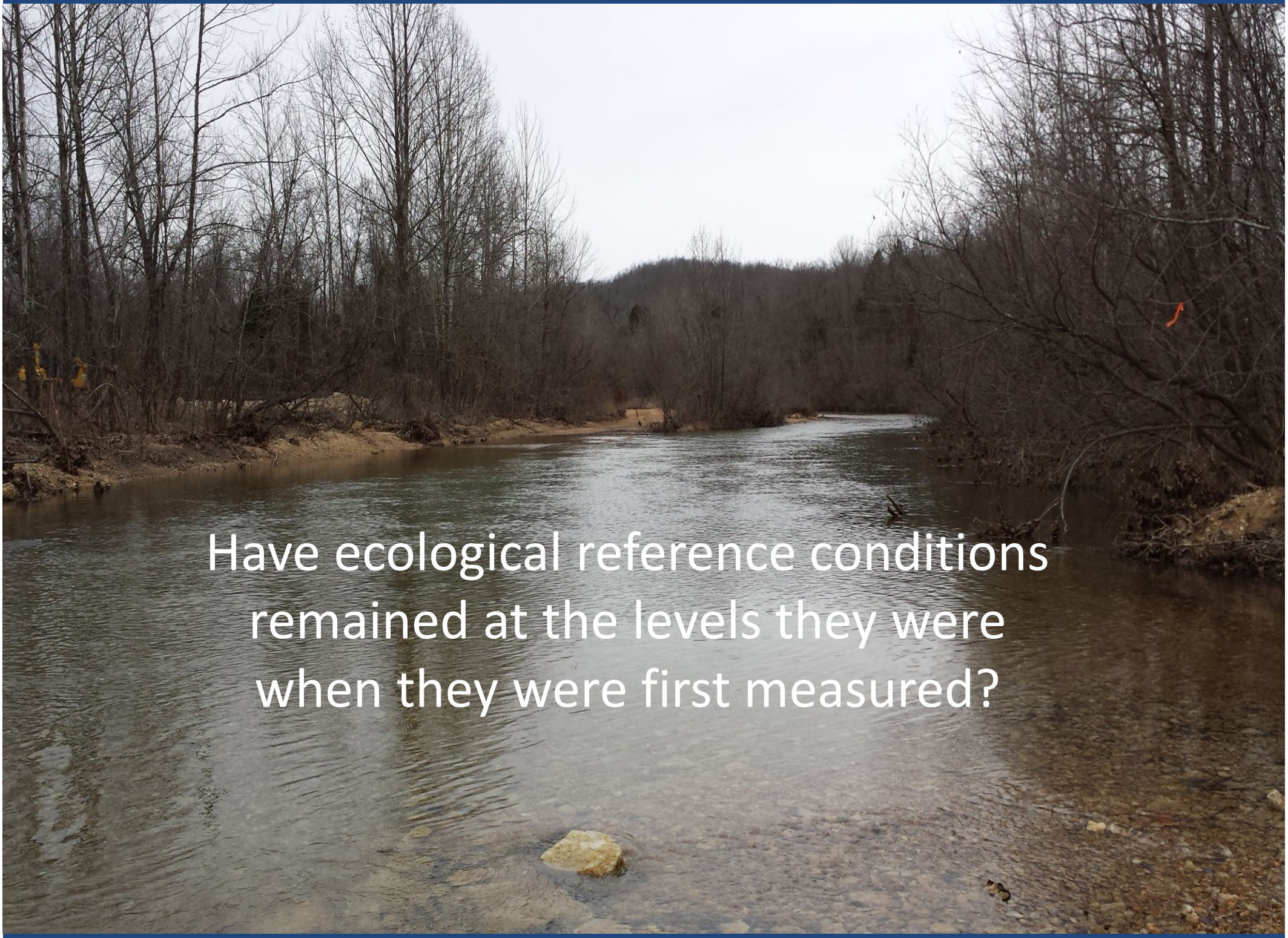
Persistence of environmental reference conditions: a case study in the central US

Casey Scott and Sam McCord


Have ecological reference conditions remained at the levels they were when they were first measured?

Reasons for degradation (general)

- Changes in land use/land cover – data available for study area
- Climate change – data not available

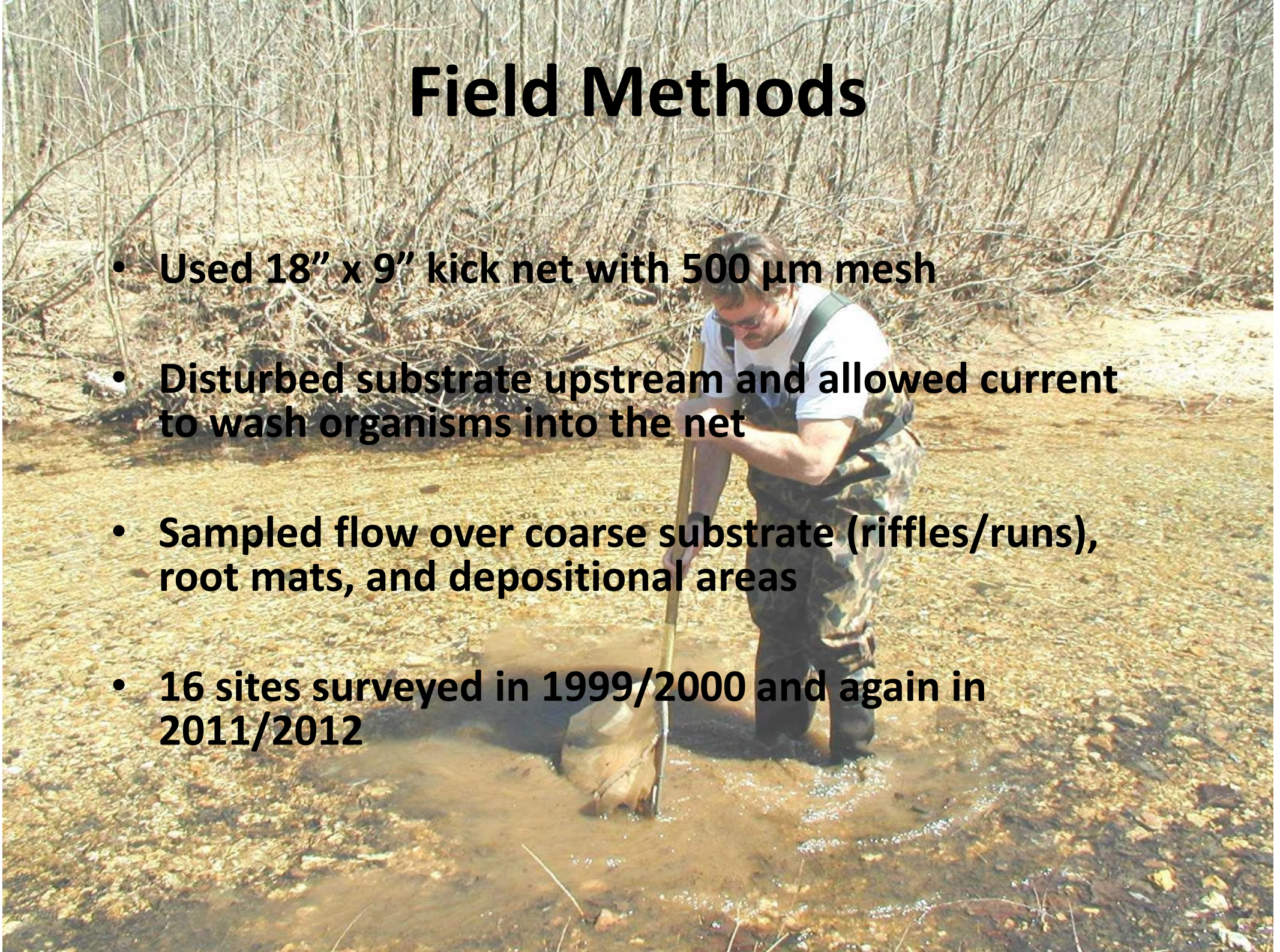
Reasons for degradation (specific)

- Increased summer temperatures from canopy removal
- Increased sedimentation from clearance of riparian and other watershed areas
- Reduced base flow/greater flashiness
- Reduced water quality from pollutants e.g., road salt, pesticides, wastewater, excess nutrients

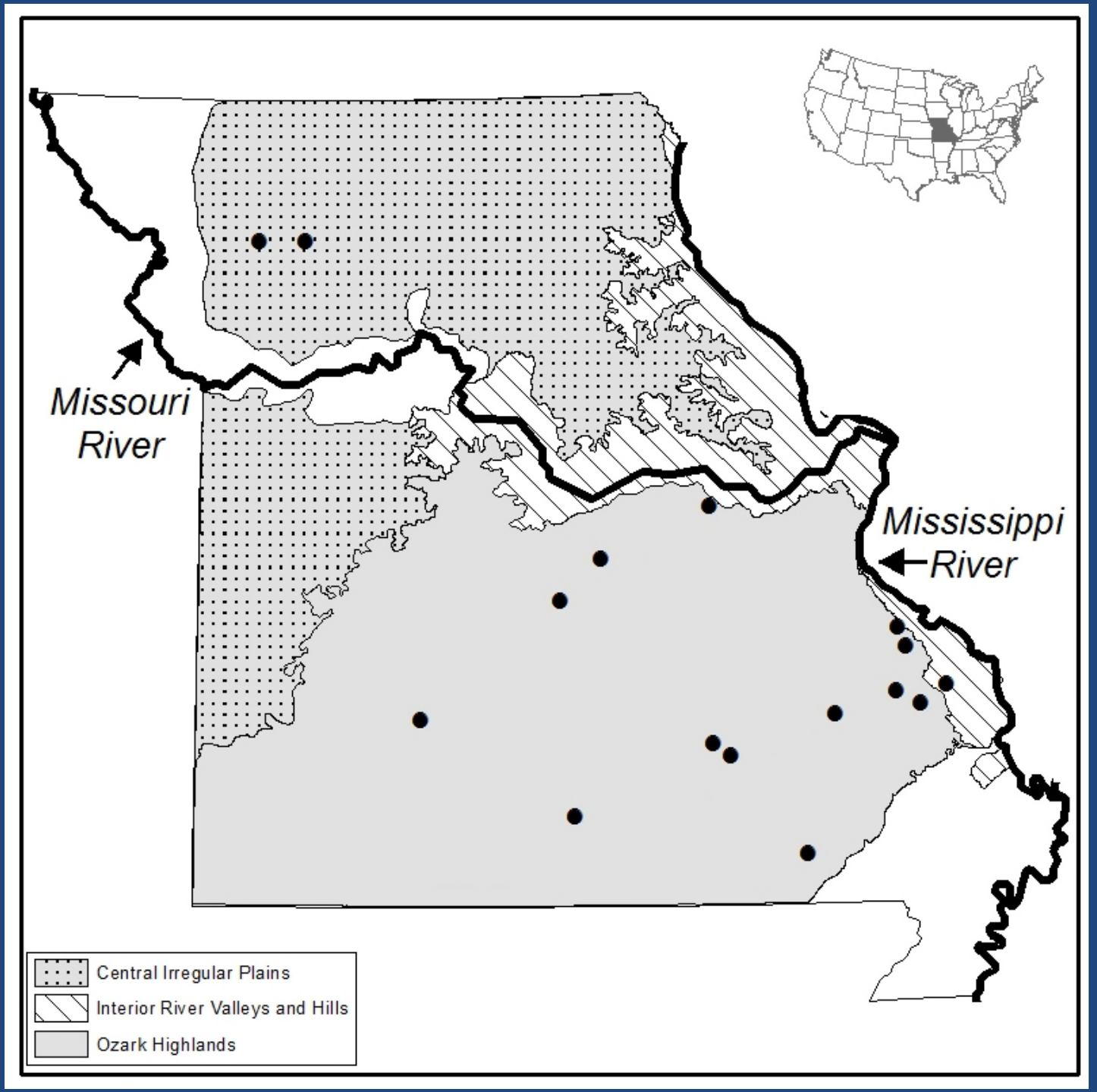
Other studies that have addressed this issue with either invertebrates or fish

- Durance and Ormerod (2009) Freshwater Biology 54:388-405
- Gido et al. (2010) JNABS 29:970-987
- Jacquemin and Pyron (2011) Hydrobiologia 665:39-50
- Johnson et al. (1994) JNABS 13:496-510
- Woodward et al. (2002) Freshwater Biology 47:1419-1435

Field Methods



- Used 18” x 9” kick net with 500 µm mesh
- Disturbed substrate upstream and allowed current to wash organisms into the net
- Sampled flow over coarse substrate (riffles/runs), root mats, and depositional areas
- 16 sites surveyed in 1999/2000 and again in 2011/2012

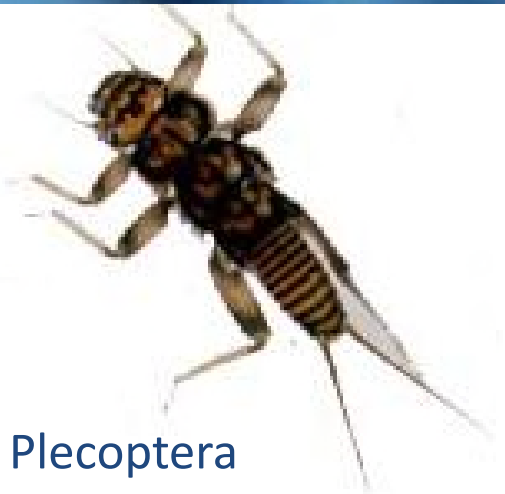

Missouri River
Mississippi River
Central Irregular Plains
Interior River Valleys and Hills
Ozark Highlands

Comparison of abiotic variables by sub-region.

	n	Drainage area (km^2)	Elevation (m)	Distance to MO/MS (km)	%Forest	%Grassland	%Cropland	
Eastern Ozarks	4	116.8	192.3	700.8	90.2	5.7	0.0	Far from MO/MS; high %Forest and low %Cropland & %Grassland
outlier - Castor River	1	98	208	143	73.4	20.5	1.4	
"Interior River Valleys/Hills"	4	135.3	143.3	36.8	56.1	33.4	6.1	Close to MO/MS; intermediate re %Forest and %Cropland
outlier - Little Whitewater River	1	70	167	90	53.1	39.6	2.2	
Central/Western Ozarks	4	171.0	257.0	352.3	52.6	42.1	0.3	Intermediate re all variables
Central Irregular Plains	2	168.0	236.5	176.0	13.2	49.6	30.0	Low %Forest; high %Cropland


Chironomidae


Trichoptera


Plecoptera


Ephemeroptera

Community variables

Richness of:

- All taxa (total richness)
- EPT taxa
- Chironomidae
- Non-insects
- Other insect orders
- Sensitive (TV ≤ 3) taxa

Relative abundance of:

- EPT taxa
- Chironomidae
- Non-insects
- Other insects
- Sensitive taxa

Abiotic variables

- Drainage area
- Elevation
- Distance to ultimate (HUC-2) receiving stream (Missouri River or Mississippi River)
- % Forest land cover (including woodland)
- % Grassland cover (including pasture)
- % Cropland cover

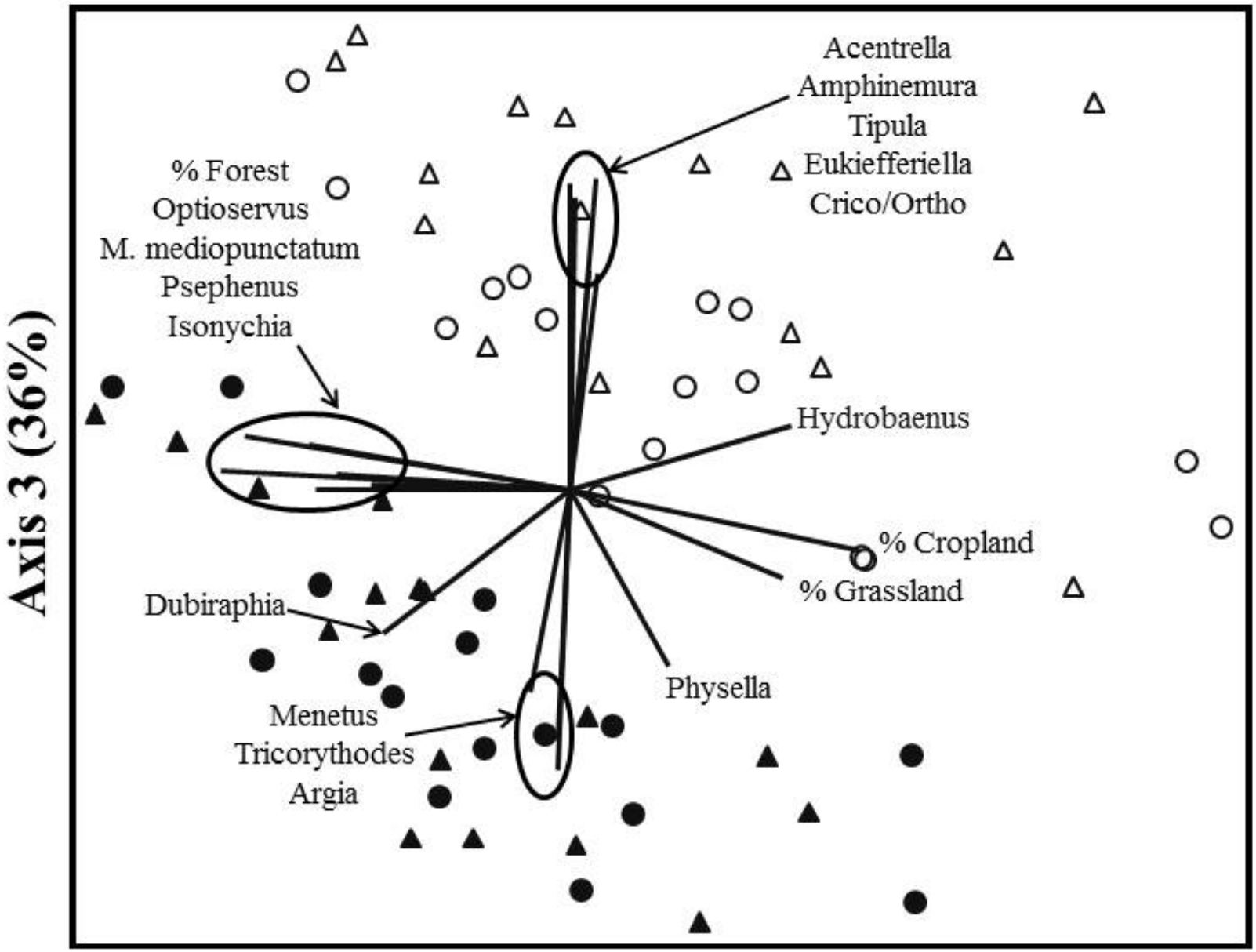
Tests

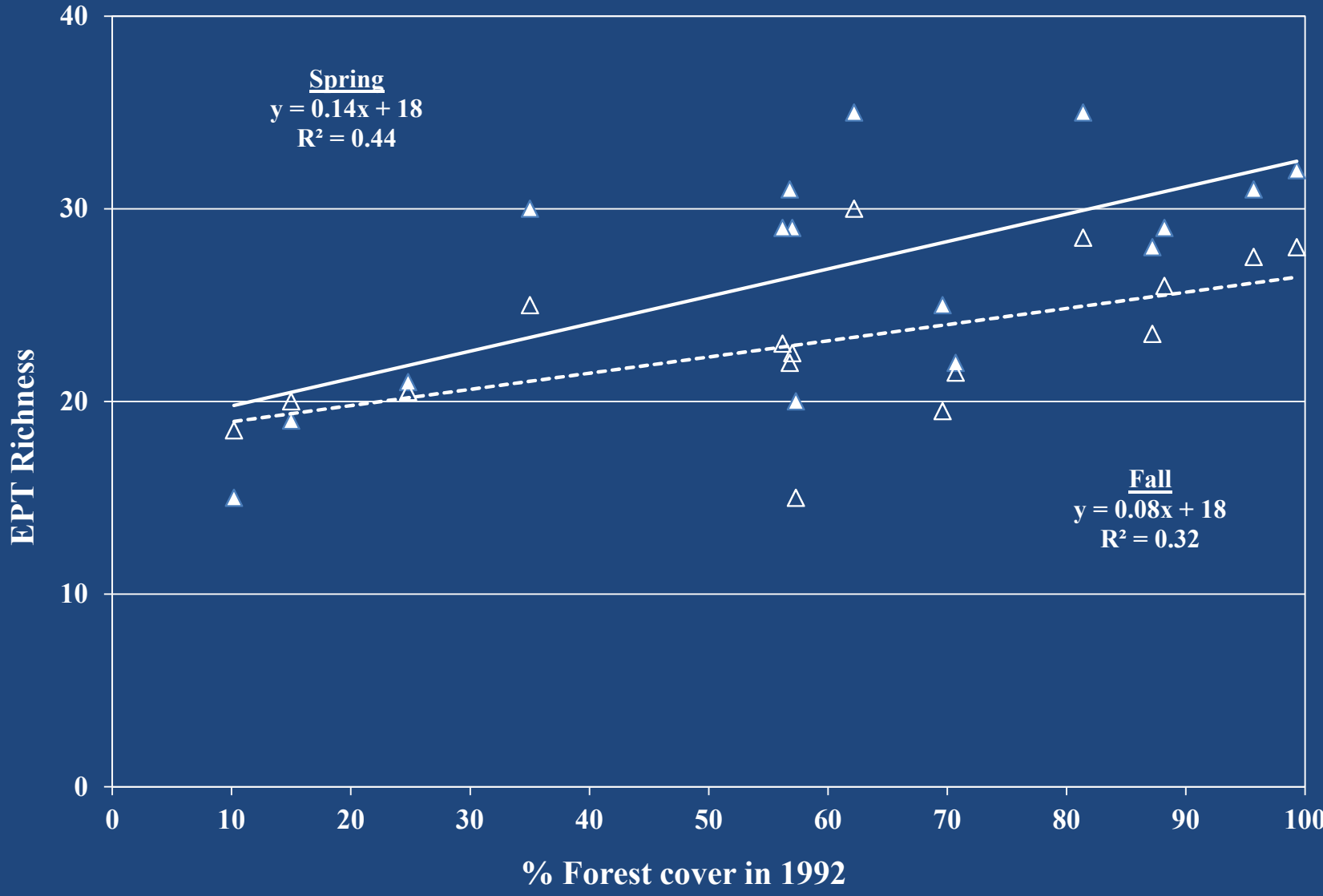
- 2-way ANOVA (year, season, year*season) on community characteristics
- NMS ordination using abundance data to examine compositional similarity among samples
  1. Excluded rare taxa
  2. First matrix – macroinvertebrate data
  3. Second matrix – macroinvert and abiotic data
- Linear regression using total richness and EPT richness and abiotic variables


RESULTS

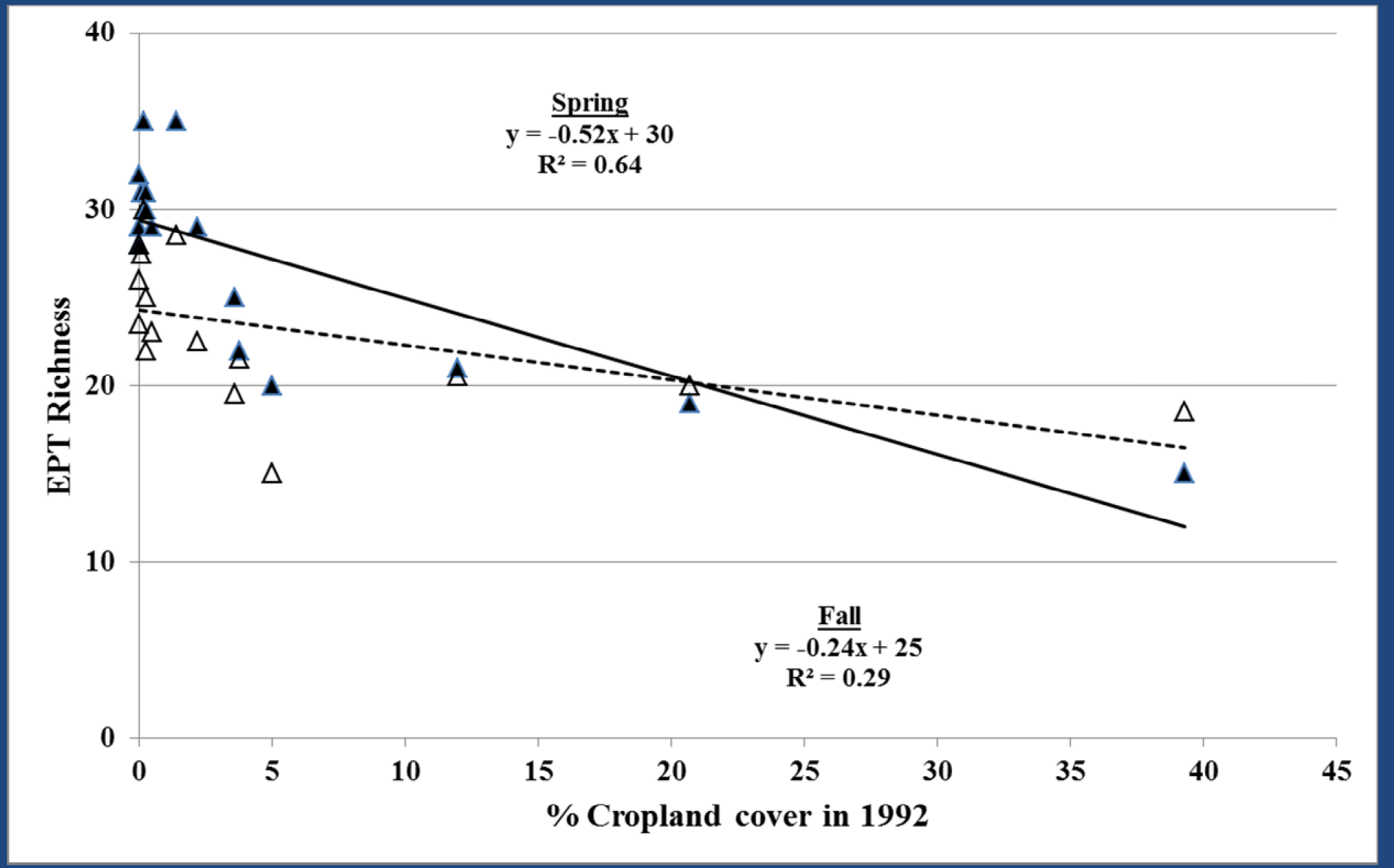
Table 3. Means of macroinvertebrate community characteristics in spring and fall samples from 1999 and and 2011 study periods. Asterisks indicate significant difference in 2-way analysis of variance. Effect of period*season interaction is represented by F-value and p-value of the 2-way ANOVA.

	Year		Season		Interaction	
Variable	1999	2011	Spring	Fall	F-value	p
Total richness	86.8	92.8*	93.1*	86.5	1.94	0.168
EPT richness	23.9	25.9	26.6*	23.2	0.10	0.754
Chironomidae richness	28.3	30.5*	31.4**	27.4	2.40	0.126
Other insects richness	23.0	23.3	22.6	23.8	0.07	0.791
Non-insects richness	11.7	13.2	12.6	12.2	2.45	0.123
Percent EPT	39.2	41.6	34.9	45.9**	5.07*	0.028
Percent Chironomidae	36.4**	24.9	40.8**	20.5	9.20**	0.004
Percent Other insects	13.5	20.5**	15.4	18.4	1.01	0.320
Percent Non-insects	11.0	13.1	8.9	15.2**	0.00	0.992
Sensitive taxa richness	14.3	16.1	16.7	13.6	1.21	0.275
Percent Sensitive taxa	12.6	16.1	14.8	13.9	3.39	0.070
* significant at $p < 0.05$						
** significant at $p < 0.01$						


Acentrella
Amphinemura
Tipula
Eukiefferiella
Crico/Ortho
% Forest
Optioservus
M. mediopunctatum
Psephenus
Isonychia
Hydrobaenus
% Cropland
% Grassland
Dubiraphia
Physella
Menetus
Tricorythodes
Argia
Axis 3 (36%)
Axis 1 (36%)
1999 Spring
1999 Fall
2011 Spring
2011 Fall



Regression relationship between EPT richness (mean of 1999 and 2011 levels) and forest land cover in HUC-12 watershed. Spring – solid triangles and line; fall - open triangles and dashed line.



Regression relationship between EPT richness (mean of 1999 and 2011 levels) and cropland cover in HUC-12 watershed. Spring – solid triangles and line; fall - open triangles and dashed line.

Conclusions (1)

- Differences between the 1999 and 2011 periods included similar or greater richness for all groups, and greater relative abundance of Chironomidae in 1999.
- Richness and relative abundance levels of sensitive taxa did not differ between periods.
- Seasonal variation was generally stronger than that between 1999 and 2011, with generally greater richness in the spring, greater Chironomid (relative) abundance in the spring, and greater EPT taxa abundance in the fall.
- Relative abundance patterns for the community as a whole were driven by the much greater collection of Chironomidae in the spring of 1999, as evidenced by the highly significant interaction F-value in the ANOVA.

- No degradation of the quality of the macroinvertebrate communities at statewide reference sites was indicated by the data.

Conclusions (2)

- Land cover differences were strongly related to differences in macroinvertebrate community characteristics.
- Greater community quality (as estimated by EPT Richness was associated with greater forest land cover, and was inversely related to the amount of cropland.
- These patterns were primarily evident on a spatial gradient. Land cover changes were generally small between the 1992 and 2006 data sets.
- The time-frame of the study may have been too short to reveal effects of land cover conversion from forest to cropland/grassland.
- Urban land cover increased at all 16 reference sites, from a mean of 0.5% of the HUC-12 in 1992 to 3.8% in 2006.

Acknowledgements

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Questions?