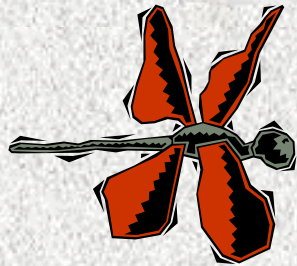


**Development of Biological
Criteria for Macroinvertebrates
for Streams of the
Western Corn Belt Plains
Ecoregion**



by

Shannon Donley



Special Thanks to my committee

Len Ferrington
Don Huggins
Jerry deNoyelles

and to my
wonderful family and friends

Degradation of United States Rivers and Their Floodplains

- ✦ **Of 3.2 million miles of rivers in the U.S., only 2 % are healthy enough to be considered high quality.**
- ✦ **Of medium-sized rivers, only 42 studied in the National Rivers Inventory have not been dammed.**
- ✦ **Sixty to eighty percent of riparian corridors have been destroyed throughout the U.S.**
- ✦ **More than 70% of the floodplain forests in the U.S. have been converted to urban and agricultural use.**

Modified from Karr, J. R. 1995. In W.S. Davis and T.P. Simon (eds.), *Biological Assessment and Criteria*.

Clean Water Act of 1972

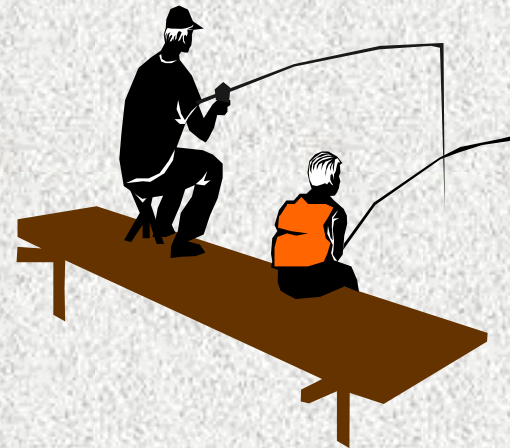
Provided, for the first time, legislation that commanded regulatory agencies.....

“To restore and maintain the chemical, physical and biological integrity of the Nation’s waters”



Biological Criteria

...numerical values or narrative expressions that describe the resident aquatic community inhabiting a regional reference condition.



Watershed Score =

$$(H1+H2+...Hn) + (LU/LC1+LU/LC2+...LU/LCn) + (WQ1+WQ2+...WQn)$$

Habitat Parameters (H):

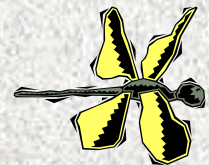
e.g. %CPOM, %FPOM, vegetative overhang, HDI, riparian width...

Land use/Land cover parameters (LU/LC):

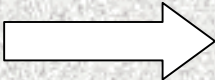
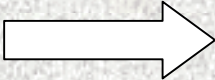
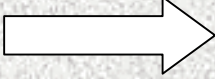
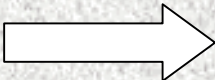
e.g. % grassland, % cropland, % woodland, % conservation cropland...

Water Chemistry parameters (WQ):

e.g. turbidity, dissolved oxygen, organic nitrogen, inorganic nitrogen, ammonia...



Habitat Development Index (HDI)

Watershed	Score		
North Elm	17.254		
Cedar	11.614		3
French	10.963		
Wolf	10.197		
Straight	9.379		
Silver	8.189		
Rock	7.55		2
Beemis	7.408		
Walnut (S)	7.354		
Bear	7.317		1
Four Mile	6.954		
Powell	6.855		
Buck	6.378		
Walnut (J)	6.228		0
Seven Mile	6.038		
Three Mile	5.788		

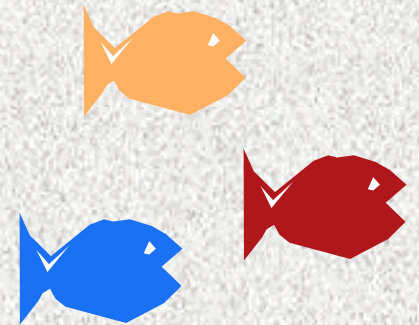
Watershed Rankings		Watershed Rankings		Total Taxa Richness	
WQ + H + LU/LC		Habitat/2 + LU/LC		(family level)	
French	73	French	26.5	French	69
Straight	71	Straight	22	Straight	62
Three Mile	56	North Elm	19.5	North Elm	62
North Elm	53	Three Mile	19.5	Cedar	62
Walnut (Story)	48	Wolf	17.5	Wolf	61
Cedar	46	Cedar	16.5	Walnut (Story)	57
Walnut (Jasper)	45	Buck	16.5	Beemis	57
Wolf	44	Walnut (Jasper)	14.5	Bear	55
Rock	43	Rock	14.5	Three Mile	53
Buck	43	Walnut (Story)	14	Rock	53
Powell	42	Beemis	11.5	Buck	53
Beemis	41	Four Mile	11	Silver	52
Four Mile	37	Powell	11	Four Mile	51
Seven Mile	34	Bear	9	Walnut (Jasper)	49
Bear	28	Seven Mile	8	Powell	45
Silver	23	Silver	7.5	Seven Mile	44

Sampling Methodology

- ↓ Macroinvertebrates were collected using a timed one minute kick sample.
- ↓ Sixteen streams; two sites per stream; three macrohabitats sampled within a site. Total 96 samples.
- ↓ While a multi-habitat approach was implemented during macroinvertebrate collection, single habitat analyses (runs only) were performed on all macroinvertebrate data.
- ↓ All insects were identified to genus.

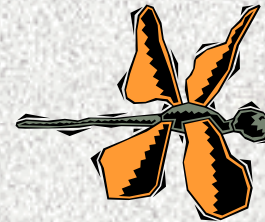
Metric

...a characteristic of the biota that changes in some predictable way with increased human influence.



Macroinvertebrate

...animals without backbones
of a size large enough to be seen
by the unaided eye

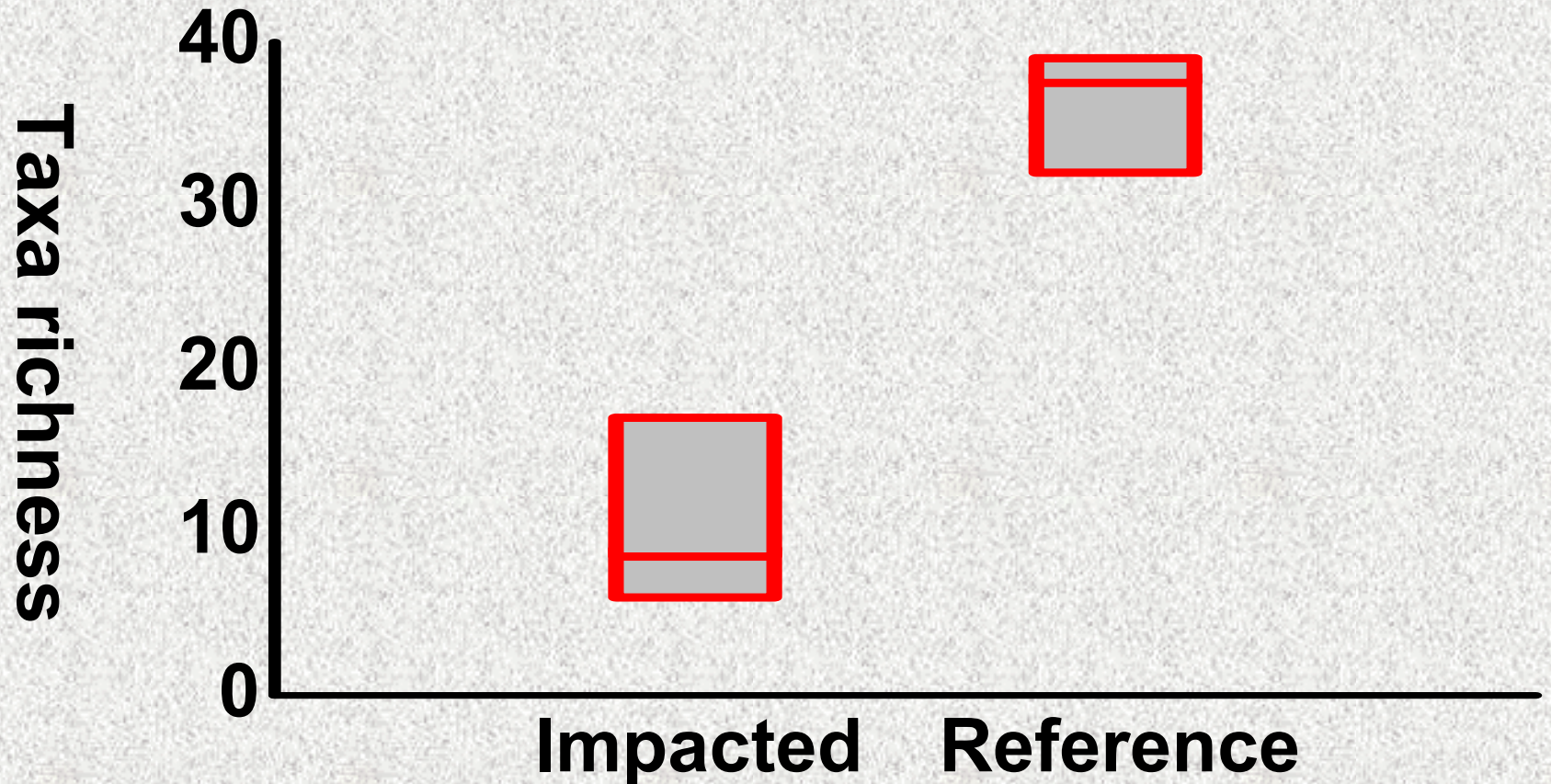


Why use macroinvertebrates for biological monitoring?

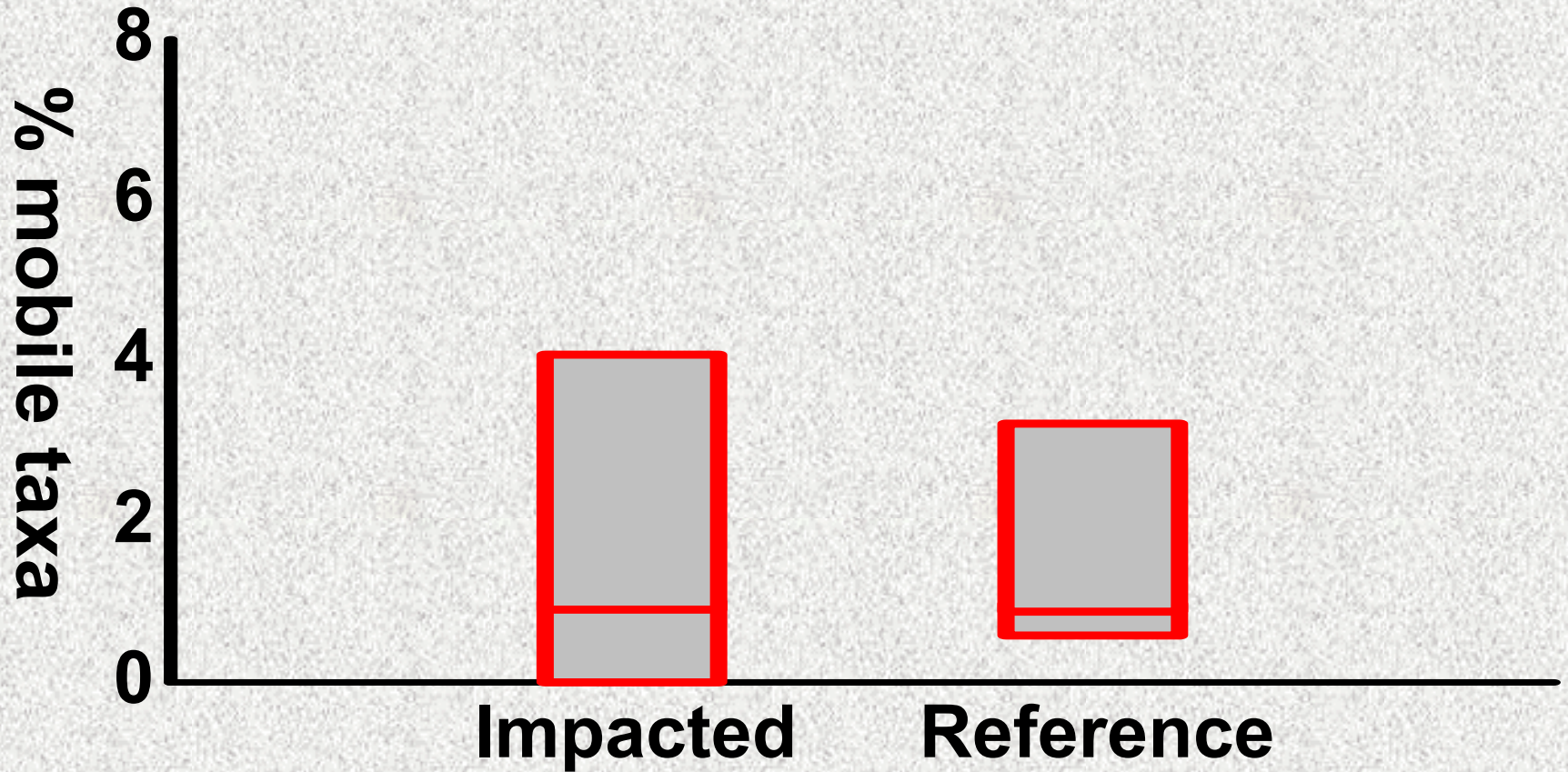
- ↓ **Being ubiquitous, they are affected by perturbations in all types of waters and habitats.**
- ↓ **Large numbers of species offer a spectrum of responses to perturbations.**
- ↓ **Their long life cycles allows effects of regular or intermittent perturbations, variable concentrations etc. to be examined temporally.**
- ↓ **Responses of many common species to different types of pollution have been established.**

Modified from Resh, V. H. 1995. In W.S. Davis and T.P. Simon (eds.), *Biological Assessment and Criteria*.

Box plots comparing taxa richness of reference and impacted streams from the Western Corn Belt Plains ecoregion, spring 1992.



Box plots comparing % mobile taxa of reference and impacted streams from the Western Corn Belt Plains ecoregion, spring 1992.



Additional analysis of potential macroinvertebrate and chironomid metrics

- ↓ Box plot results were supported by the Kruskal-Wallis anova ($p < 0.05$) for all potential metrics.**
- ↓ Metrics were inspected for variability using the coefficient of variation. A metric representative of the reference condition must exhibit consistency and low variability so that anthropogenic disturbance is easier to detect.**
- ↓ Correlation analysis was used to check for redundancy of information within each candidate metric. Metrics highly correlated with each other contribute similar information, and therefore, one can be substituted for another.**

Candidate metrics	Potential problem with metric
Taxa richness	Correlated with Margelef's diversity
Sensitive taxa	
Diptera richness	
Mayfly richness	Low values
EPT richness	Low values
Total insect abundance	High variability
Total EPT abundance	High variability
Gleason's diversity	Correlated with Margelef's, Brilliou'n's
Margelef's diversity	Correlated with taxa richness, Gleason's, Brilliou'n's
Shannon's diversity	Correlated with Brilliou'n's
Brilliou'n's diversity	Correlated with Margelef's, Gleason's and Shannon's

Candidate metrics	Potential problem with metric
Chironomid richness	
Sensitive chironomid taxa	
% dominant chironomid	
% tribe tanytarsini	Low values
Gleason's chironomid diversity	Correlated with Margelef's and Shannon's
Margelef's chironomid diversity	Correlated with Brilliouin's and Gleason's
Shannon's chironomid diversity	Correlated with Brilliouin's and Gleason's
Brilliouin's chironomid diversity	Correlated with Margelef's and Shannon's

Significant ($p < 0.05$) Spearman's correlation coefficients using candidate macroinvertebrate metrics

	Avg. HDI	Total N	Inorg N	Total P
Taxa rich.	0.82**	-0.48**	-0.49**	0.47**
Sensitive taxa	0.76**	-0.69**	-0.70**	0.49**
Diptera rich.	0.71**	ns	ns	0.60**
Mayfly rich.	ns	-0.43**	-0.47**	0.22*
EPT rich.	ns	-0.51**	-0.54**	ns
Insect abun.	0.72**	-0.36**	-0.38**	0.47**
EPT abun.	0.36**	-0.42**	-0.44**	ns
Gleason's	0.79**	-0.45**	-0.44**	0.50**
Margelef's	0.81**	-0.44**	-0.43**	0.52**
Shannon's	0.66**	-0.54**	-0.54**	0.45**
Brillioun's	0.77**	-0.57**	-0.61**	0.51**

* $p < 0.05$

** $p < 0.001$

Significant ($p < 0.05$) Spearman's correlation coefficients using candidate chironomid metrics

	Avg. HDI	Total N	Inorg. N	Total P
Chironomid richness	0.64**	-0.57**	-0.54**	0.61**
Sensitive chironomid	0.76**	-0.37**	-0.37**	0.47**
% Dominant chir.	-0.54**	0.41**	0.42**	ns
% Tanytarsini	0.68**	-0.34*	-0.70**	0.51**
Gleason's chironomid	0.50**	-0.59**	-0.58**	ns
Margelef's chironomid	0.57**	-0.66**	-0.66**	0.27*
Shannon's chironomid	0.50**	-0.60**	-0.60**	ns
Brillioun's chironomid	0.56**	-0.65**	-0.64**	ns

* $p < 0.05$

** $p < 0.001$

Conclusions

↓ Reference Condition

A reference condition has been identified within the WCBP ecoregion.

↓ Tools

Eleven macroinvertebrate and eight chironomid metrics were identified that exhibited sensitivity to perturbation.

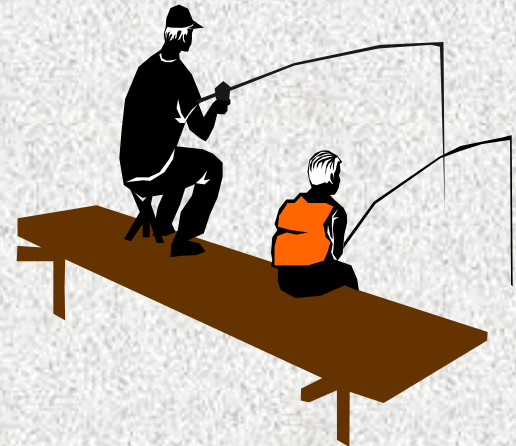
↓ Causes of impairment

The quality of in-stream habitat appears to be the major factor influencing stream biota. Stream channelization is most likely the cause of habitat homogeneity.

Determining a Reference Condition in the Agricultural Midwest

by

Shannon Donley



Study Watersheds

- ↓ **Each watershed's location was within the WCBP ecoregion.**
 - ↓ **Each watershed exhibited perennial flow yet had a limited drainage area less than 100 square kilometers.**
 - ↓ **No urban development**
 - ↓ **Potential study watersheds could not possess anomalous features such as impoundments, large feedlots or unusual geologic features.**
 - ↓ **Selected watersheds had to exhibit variations in general basin land use.**
-

Rankings of streams within the WCBP ecoregion.
Based on scores derived from the invertebrate index.

Very Good

French

Straight

North Elm

Good

Wolf

Cedar

Poor

Bear

Buck

Very Poor

Three Mile

Four Mile

Seven Mile

Walnut Story

Powell

Rock

Silver

Walnut Jasper

Beemis

Invertebrate Index

Taxa richness

Number of sensitive taxa

Diptera richness

EPT abundance

Insect abundance

Shannon's diversity

EPT richness

Rankings of streams within the WCBP ecoregion.
Based on scores derived from the chironomid index.

Very Good

French

Straight

North Elm

Good

Bear

Cedar

Poor

Very Poor

Three Mile

Four Mile

Seven Mile

Walnut Story

Powell

Rock

Silver

Walnut Jasper

Beemis

Buck

Wolf

Chironomid Index

Sensitive chironomid taxa

Chironomid richness

% dominant chironomid

% Tanytarsini

Gleason's diversity index

Ordinal rating scale for the macroinvertebrate index with quadrisection of scoring ranges

Macroinvertebrate Index (7 metrics)

Very Good

Good

35 34 33 32 31 30 29 / 28 27 26 25 24 23 22

Poor

Very Poor

/ 21 20 19 18 17 16 15 / 14 13 12 11 10 9 8 7

Ordinal rating scale for the chironomid index with quadrisection of scoring ranges

Chironomid Index (5 metrics)

Very Good

Good

25 24 23 22 21 / 20 19 18 17 16 /

Poor

Very Poor

15 14 13 12 11 / 10 9 8 7 6 5

