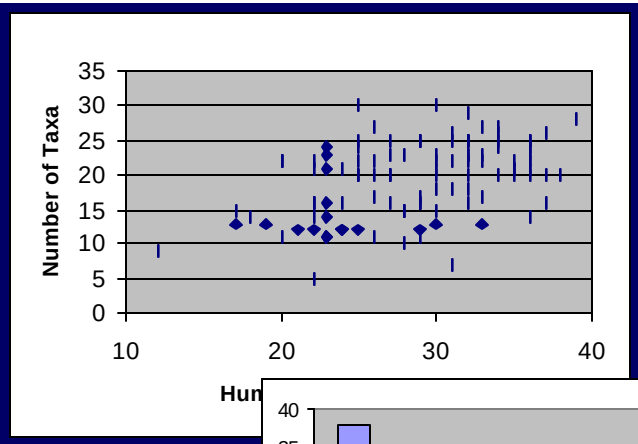
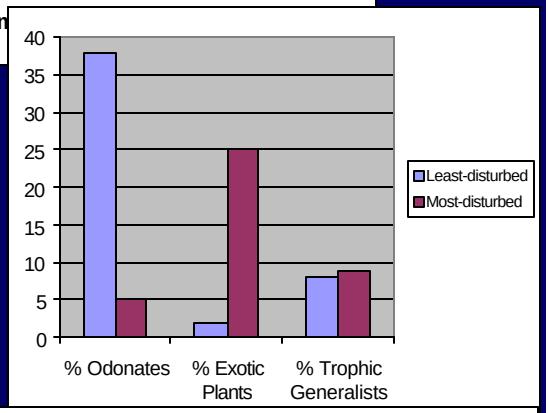
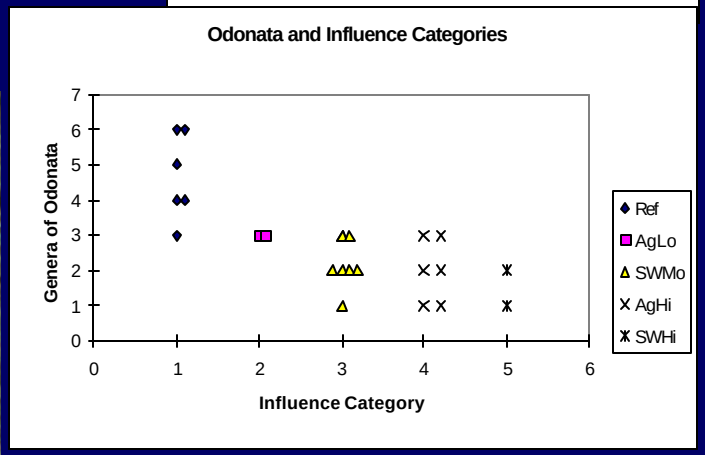
The Mechanics of Metrics and Index of Biological Integrity: Developing Metrics and IBIs





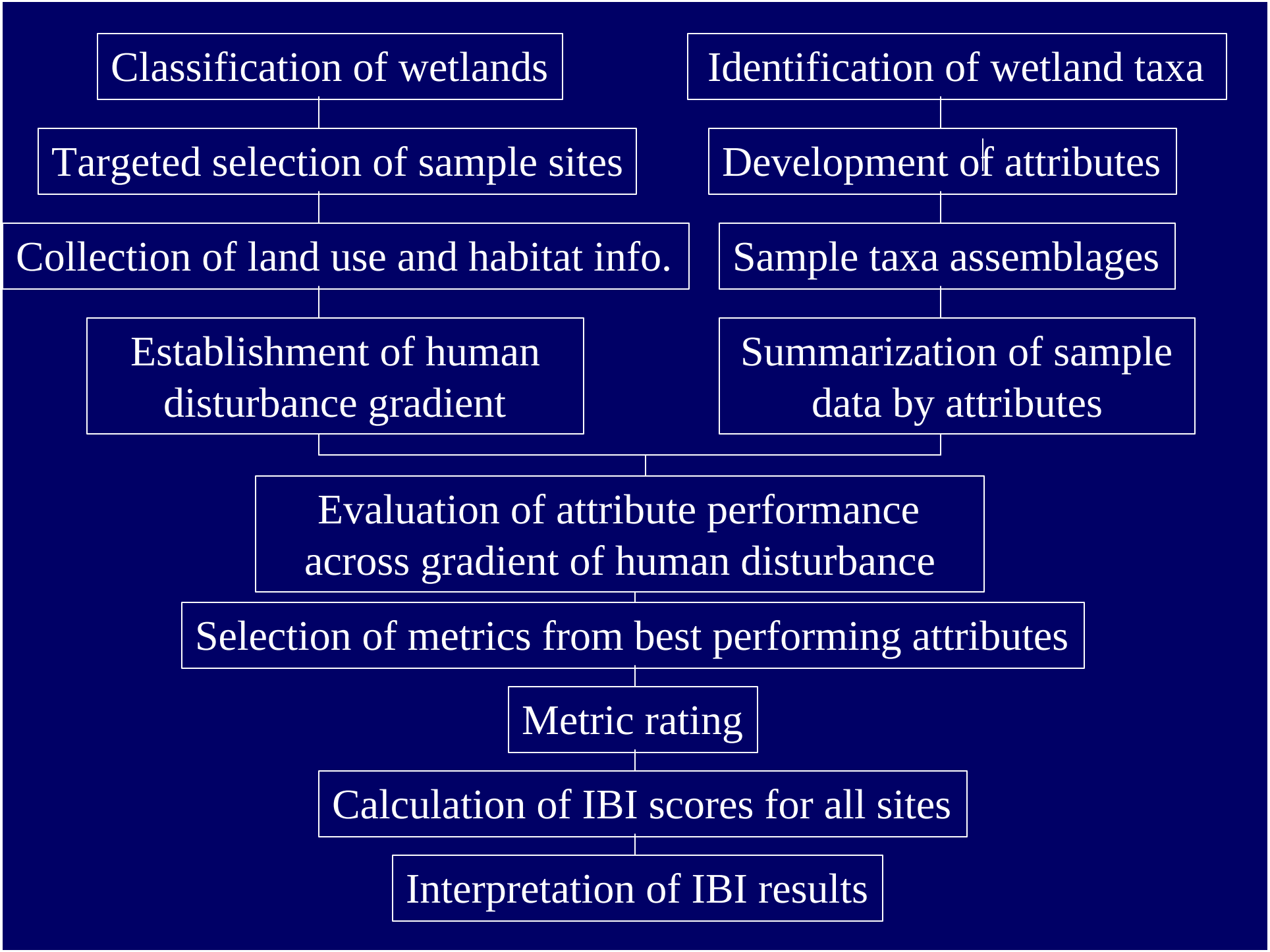


Multimetric indexes: Integrate several biological metrics to indicate a site's condition.

Attributes: Measurable components of a biological system.

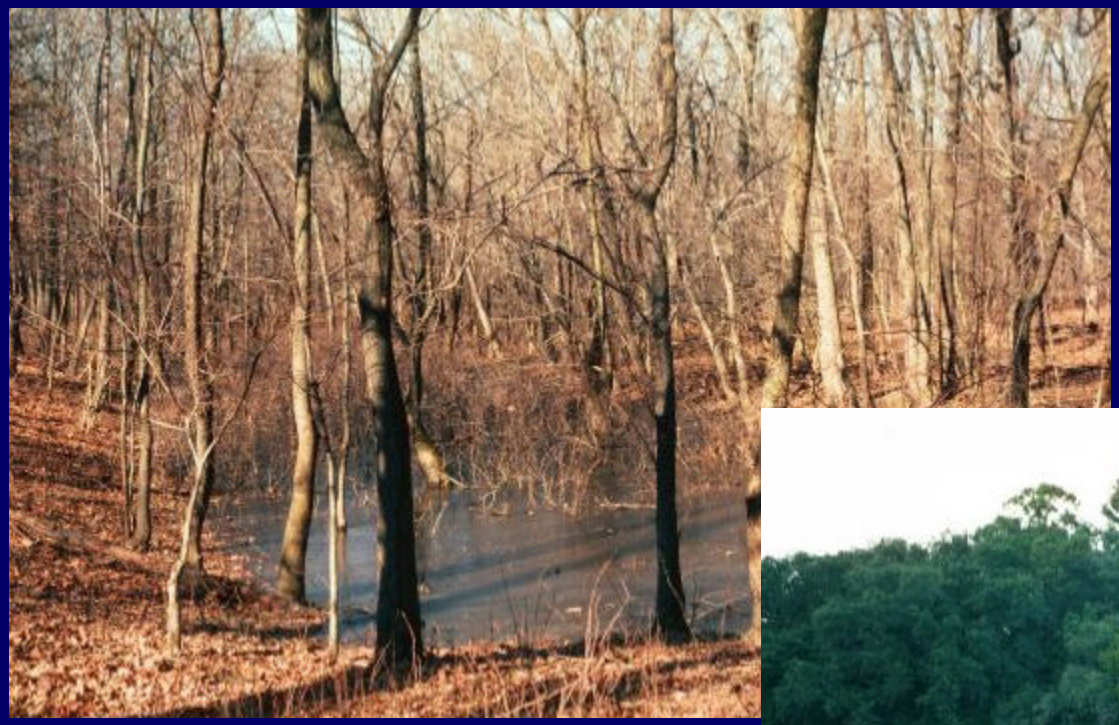
Metrics: Attributes empirically shown to change in value along a gradient of human influence.

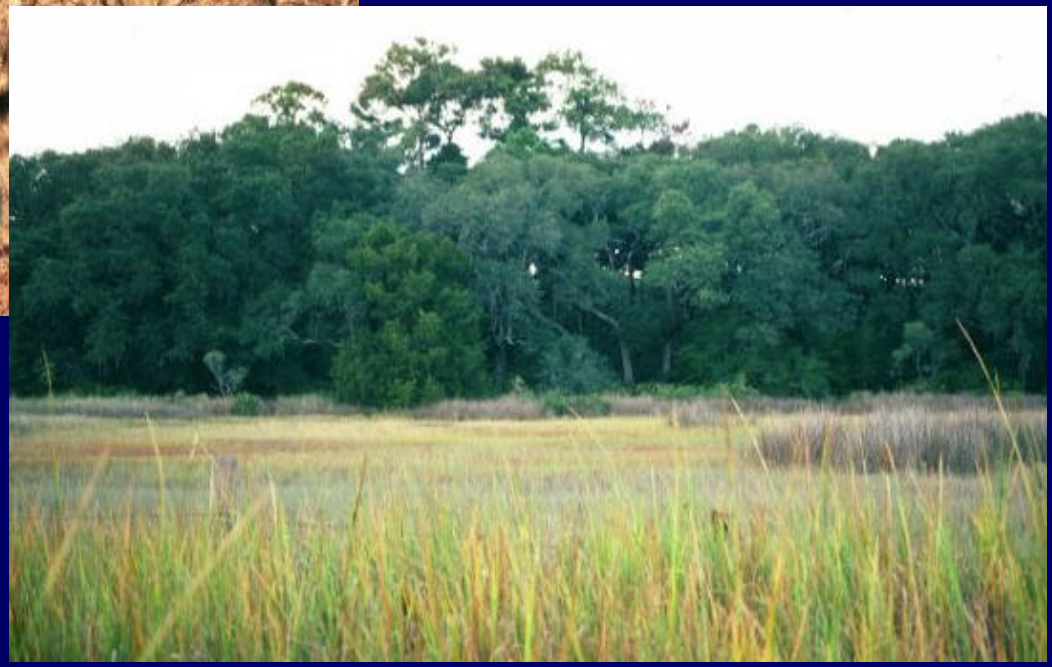
* The need to test and validate biological responses of metrics across degrees of human influence is a core assumption of the IBI (Karr and Chu 1997).


Classification of wetlands
Identification of wetland taxa
Targeted selection of sample sites
Development of attributes
Collection of land use and habitat info.
Sample taxa assemblages
Establishment of human disturbance gradient
Summarization of sample data by attributes
Evaluation of attribute performance across gradient of human disturbance
Selection of metrics from best performing attributes
Metric rating
Calculation of IBI scores for all sites
Interpretation of IBI results

Wetland Classification

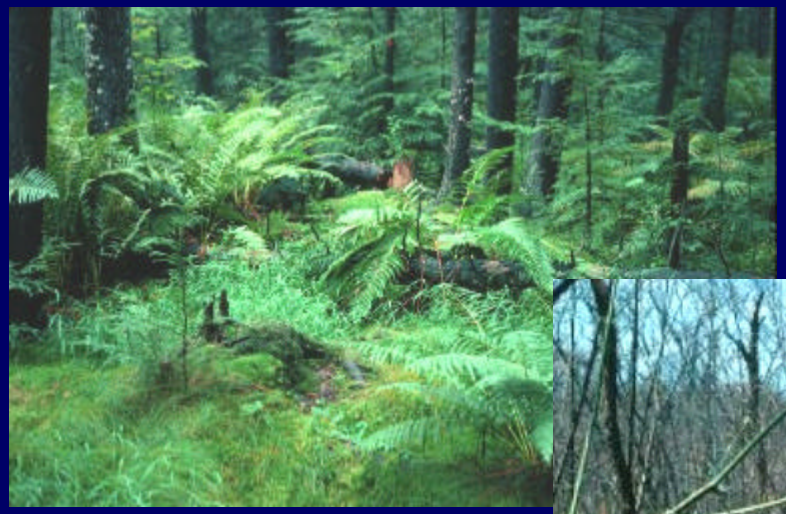
Classification into an appropriate wetland class.

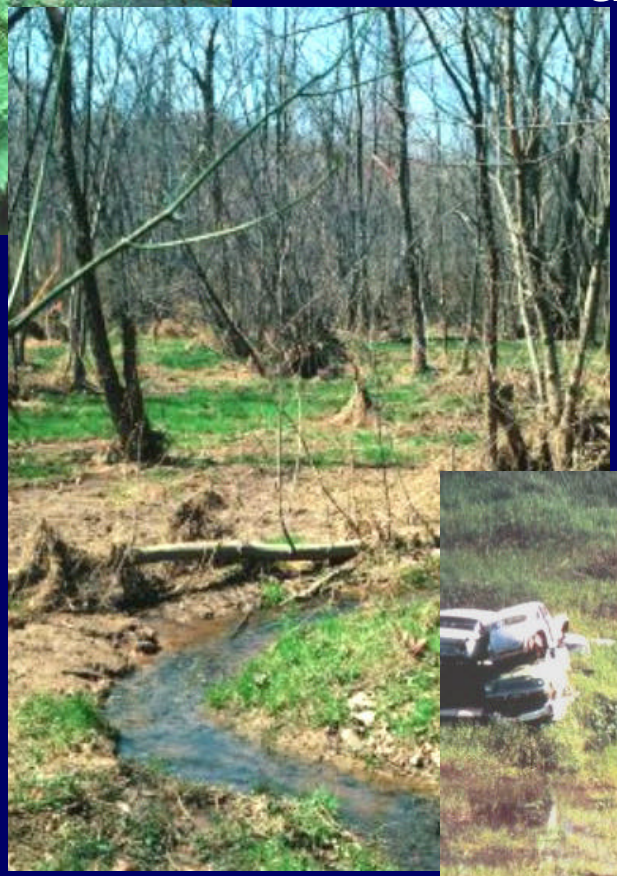




Objective: Compare apples to apples and oranges to oranges.

Targeted selection of sample sites





Objective: Establish a gradient of human influence from least- to most-disturbed within a wetland class.

Collect landuse and habitat information -- Primary purpose: Data on which to base gradient of human influence.

Landscape level disturbances (outside the wetland)

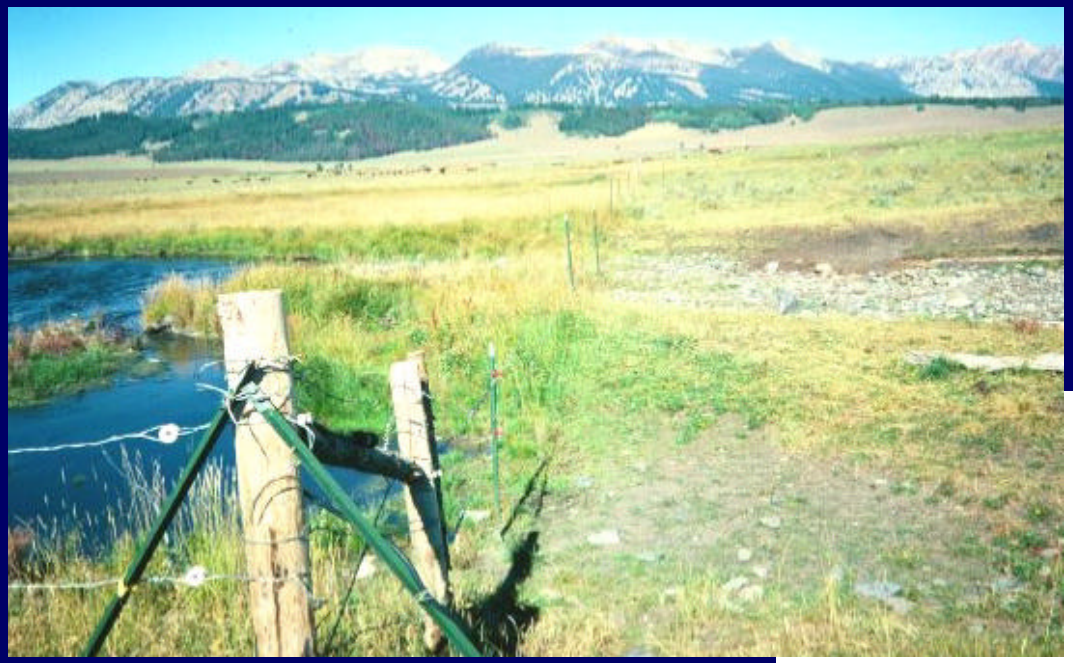
- % watershed in disturbing land uses (cropland, urban land, etc.)
- presence, condition, and width of wetland buffer
- proximity of wetland to other natural habitats
- amounts of natural habitats in close proximity

Local disturbances (within the wetland)

- alterations of the flow, circulation, or reach of water
- removal of vegetation (logging, grazing, mowing)
- loss of wetland microtopography
- persistent disturbance (e.g., tillage, trampling)
- loss of shoreline sinuosity

Establish Gradient of Human Influence:

Gradient can be based on a single variable that incorporates one or more human influences, for example:

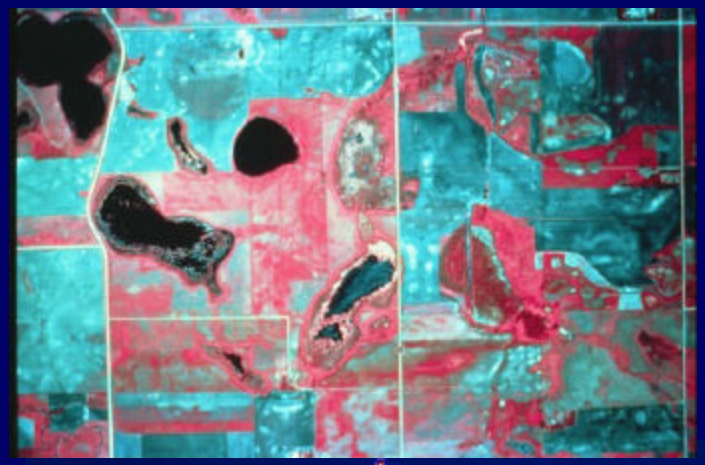


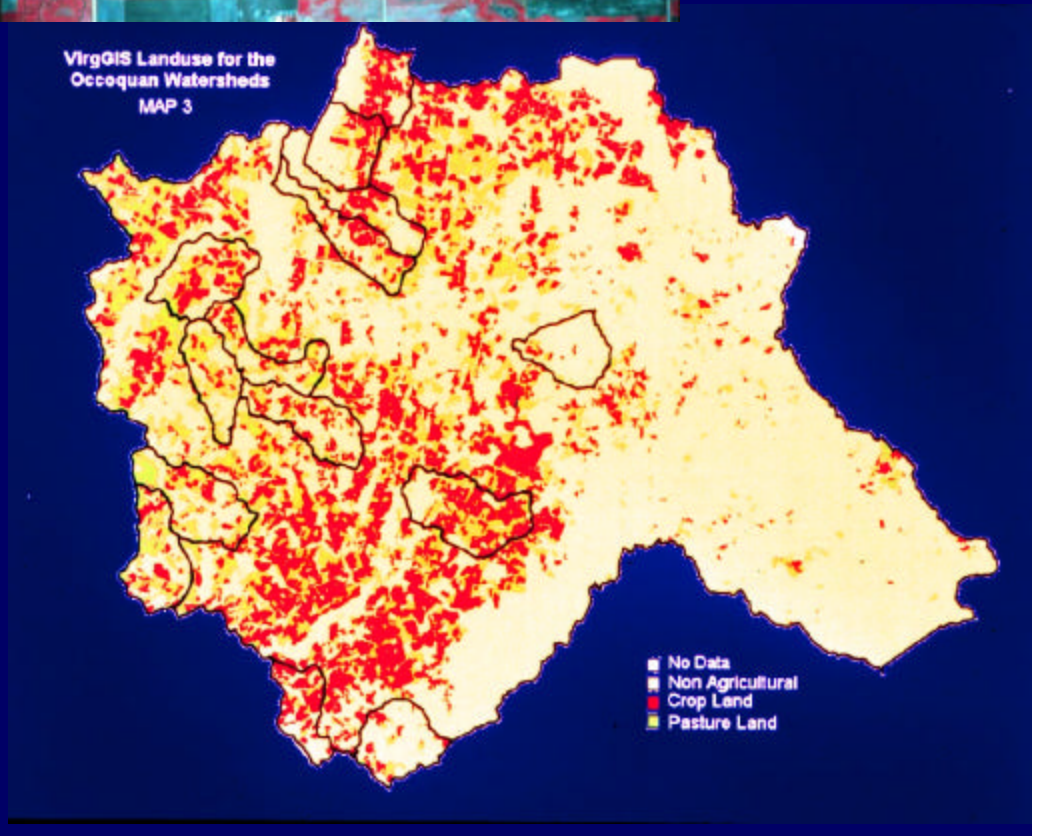
Grazing

Cultivation

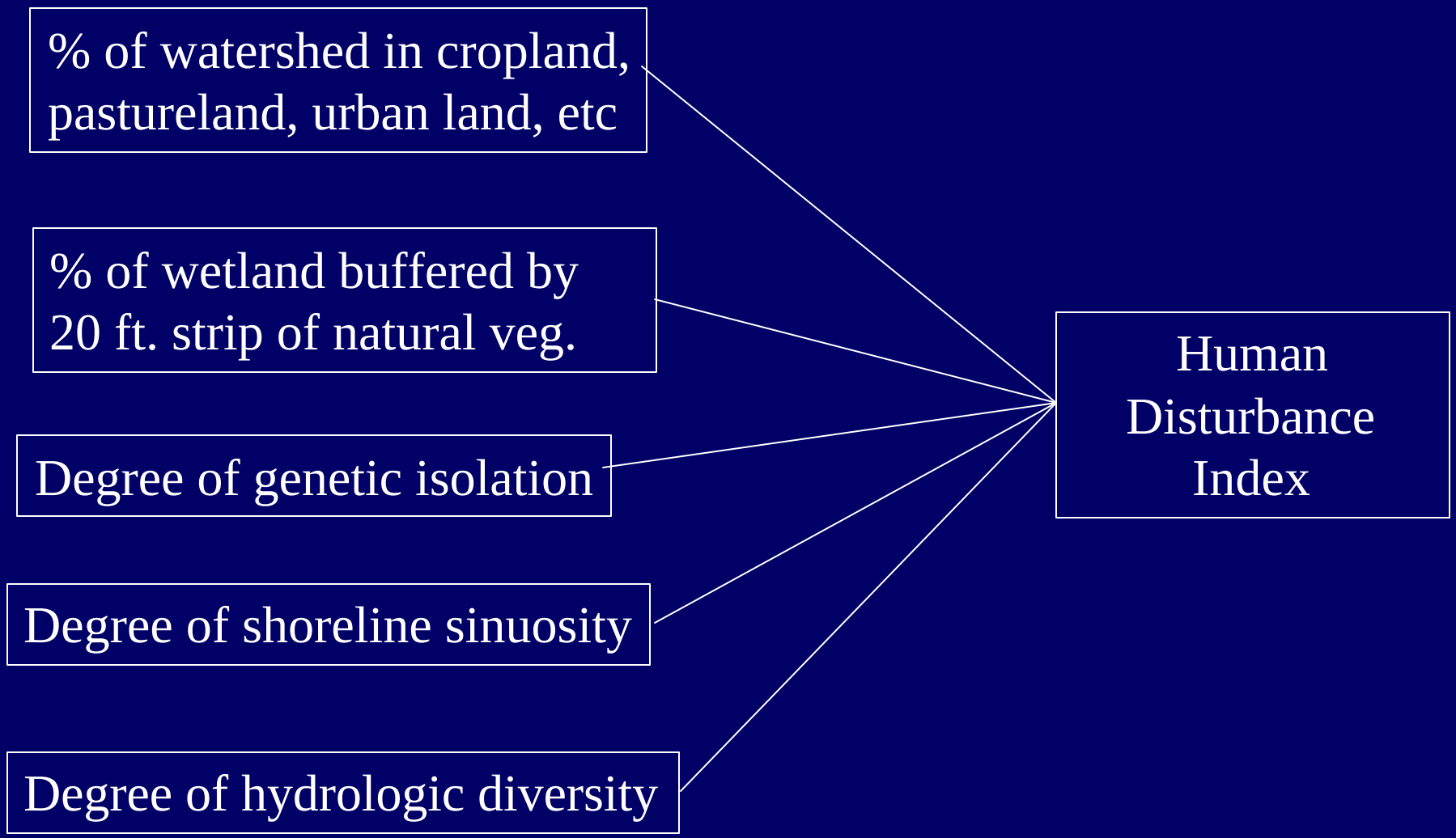
Or, gradient can be based upon several variables that incorporate multiple human influences.

If the gradient is based based upon multiple influences, then a composite index can be constructed from on-site and off-site assessment information.





Index should combine and properly weight individual components.



Identification of wetland taxa:

Most states are developing wetland IBIs that are based on IBIs developed for streams

Presumed effects of environmental degradation on biological assemblages in streams (Hughes and Oberdorff 1999)

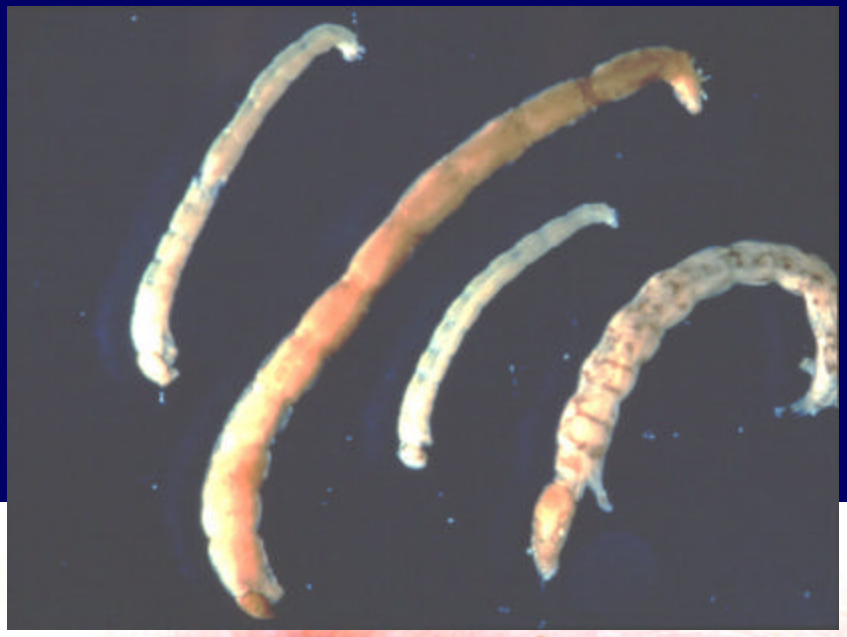
Number of native species or specialized taxa declines
Number of sensitive species declines
Percent of trophic and habitat specialists declines
Total number of individuals declines
Percent of large individuals and number of size classes decrease
Percent of alien or non-native species or individuals increases
Percent of tolerant individuals increases
Percent of trophic and habitat generalists increases
Percent individuals with anomalies increases

Development of biological attributes:
A number of assemblages have potential for wetlands bioassessment

Within assemblages, certain taxa may be expected to respond to influence gradient better than others.

Some may work in certain wetlands, while not in others.

Attributes should be grouped in a way that you would expect a distinct response to the gradient of human influence.



Examples of invertebrate attributes used for freshwater wetlands in Minnesota, with projected disturbance responses (Helgen 2001).

Attribute	Response
Species Richness and Composition	
Total # of invertebrate taxa	decrease
# mayfly and caddisfly taxa	decrease
# dragonfly and damselfly taxa	decrease
Tolerance/Intolerance	
Percent dominance of 1-3 taxa	increase
Leech *Erpobdella* proportion	increase
# intolerant taxa	decrease
Trophic	
Percent filterers	decrease
Percent macrophyte consumers	decrease
Percent predators	decrease

Considerations for developing attributes:

- Explicitly define attributes.
- Develop attributes to represent responses to an array of impairments.
- Be careful in using measures of abundance.
- Be careful in over-relying on metrics developed for other regions or ecosystems.
- Avoid combining attributes.
- Use ends of the tolerance scale for assigning tol. and in intol. taxa.
- Use # of intolerant taxa; % tolerant individuals.
- Don’t evaluate too few attributes.

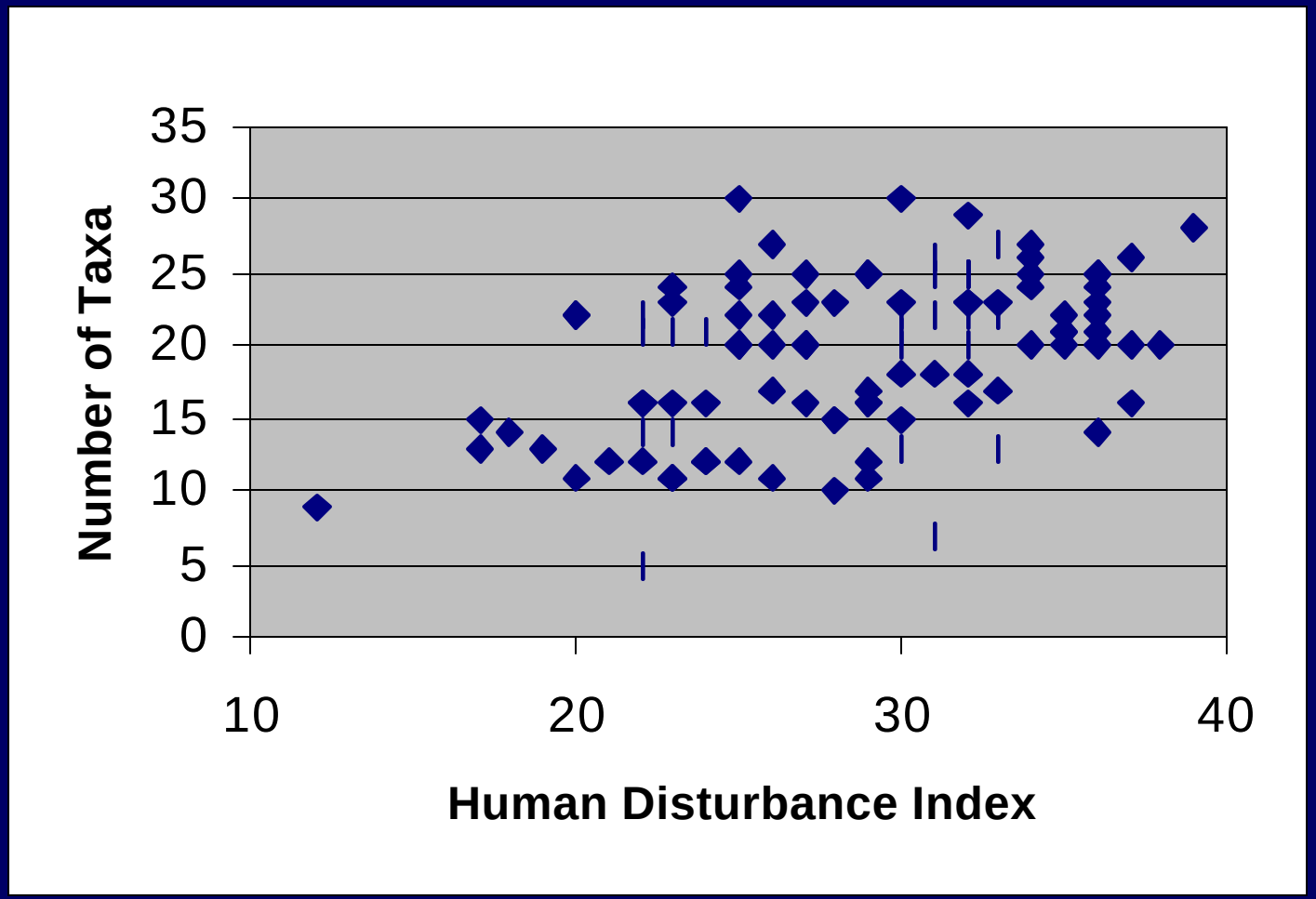
Sampling taxa assemblages:

A basic premise of the IBI is that the biota is sampled in its true and relative abundance without bias toward taxa or size (Karr et al. 1986).

Collection of physical and chemical data

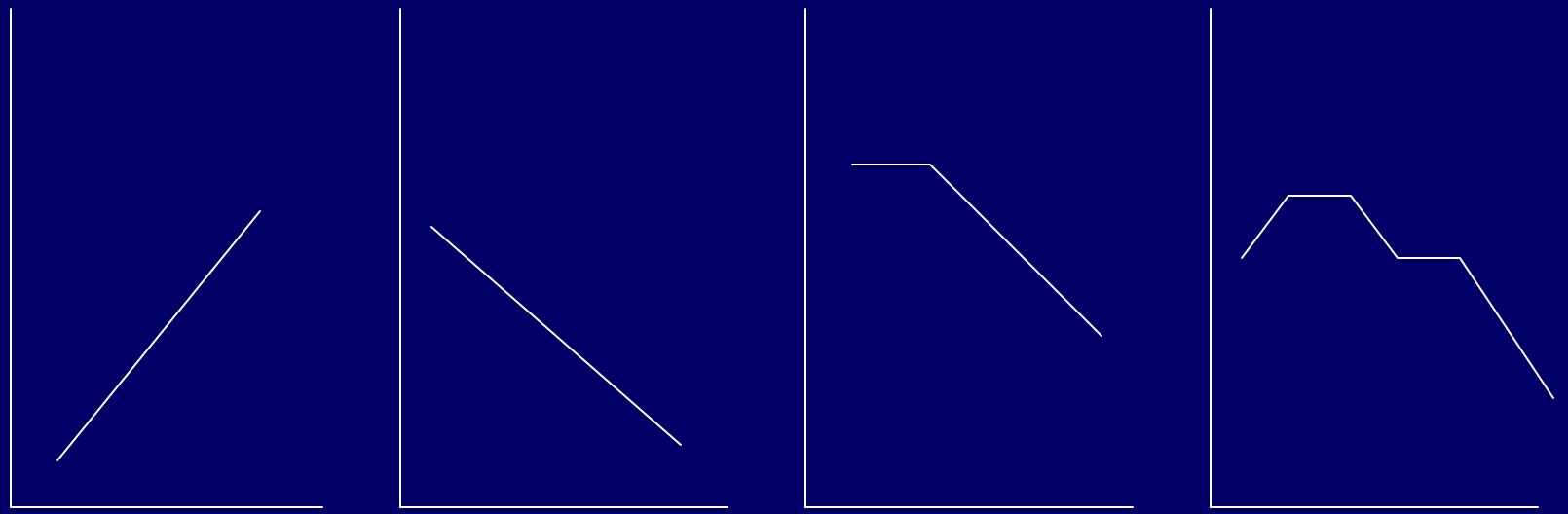
Evaluate attribute performance across a gradient of human influence.

Human Disturbance serves as the gradient along the X-axis to which biological attribute data along the Y-axis are compared.



Metrics should:

- be easy to measure and interpret
- increase or decrease as human influence increases
- be sensitive to a range of biological disturbances (not narrow)
- discriminate human influences from background noise



Metric Selection:

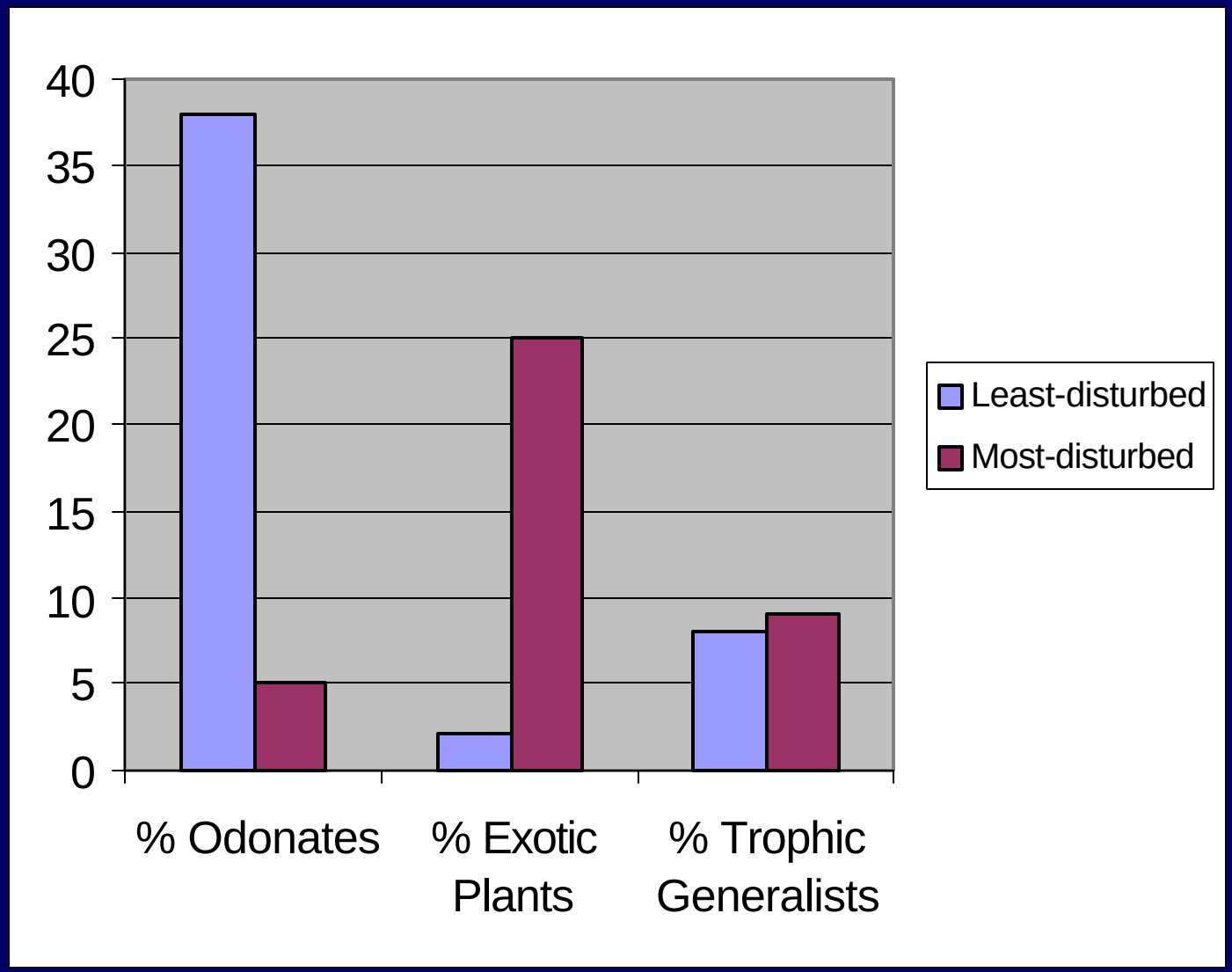
Process of metric evaluation and selection involves testing each attribute to determine how well it:

- separates least- from most-impaired sites
- correlates to the disturbance gradient
- provides similar values for similarly impaired sites
- provides a unique (non-redundant) response

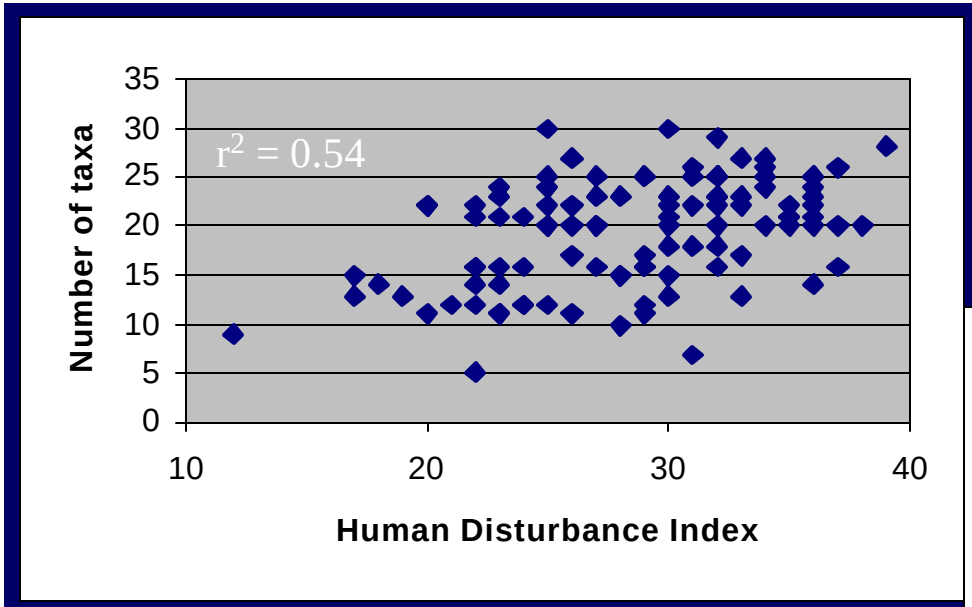
Process should cull attributes down to those 8-12 that are most sensitive collectively to form the IBI.

Various tests can be performed, either graphical or statistical, to examine attribute performance.

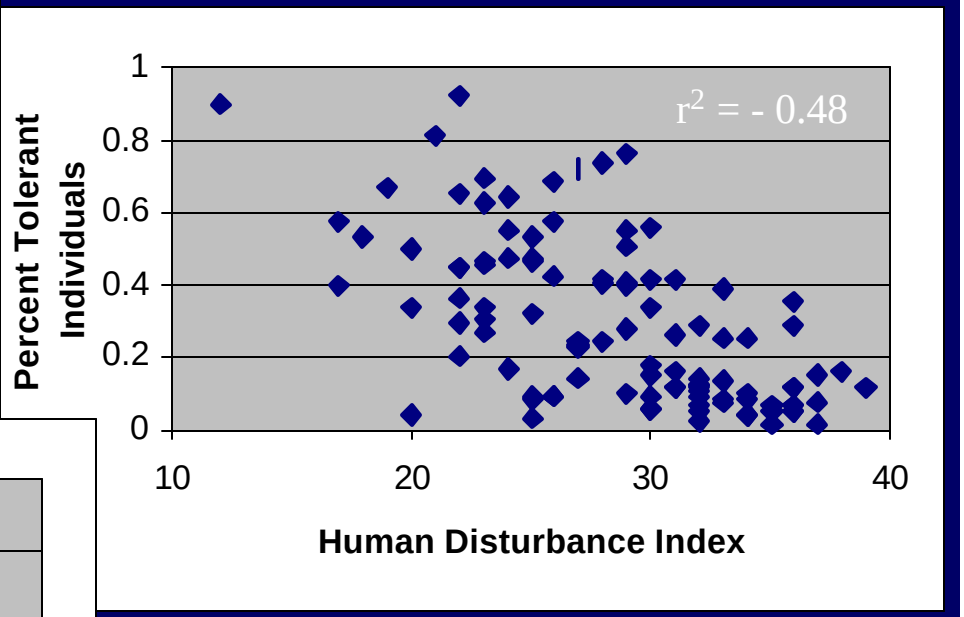
Separation of least- from most-impaired sites.



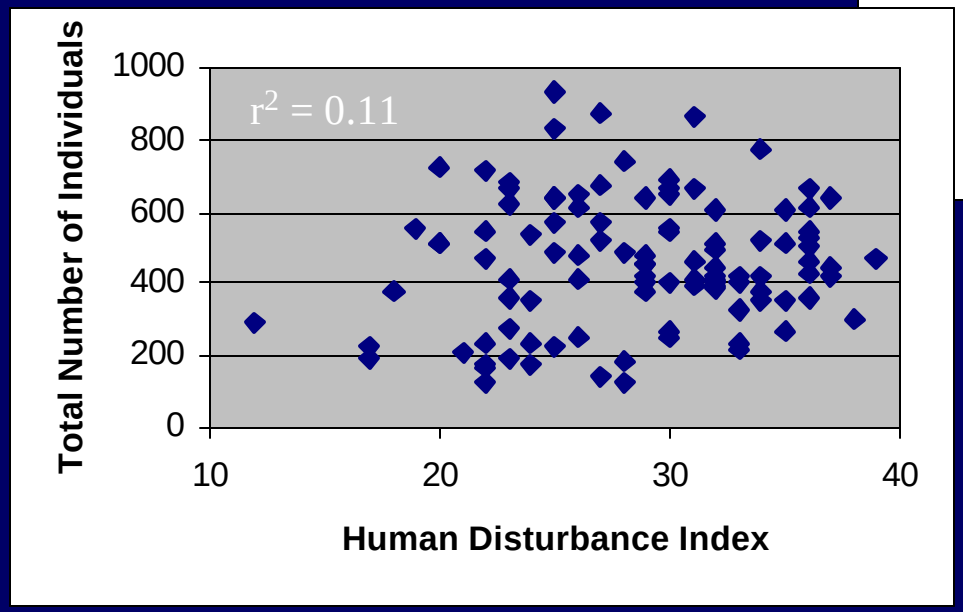
Correlation to the disturbance gradient



Positive

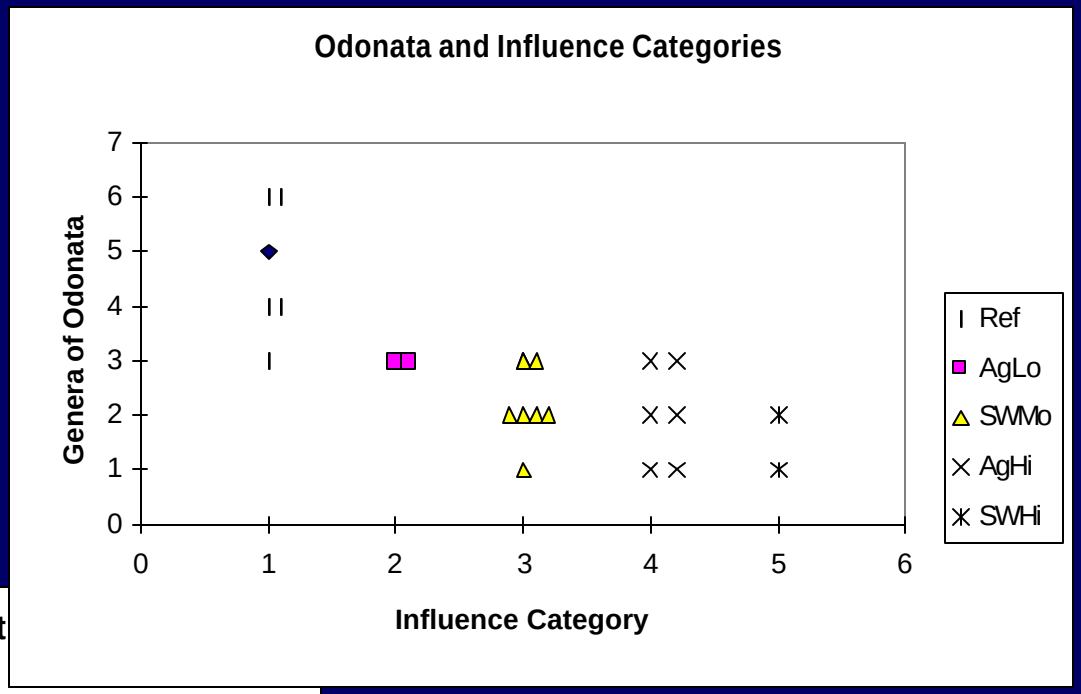


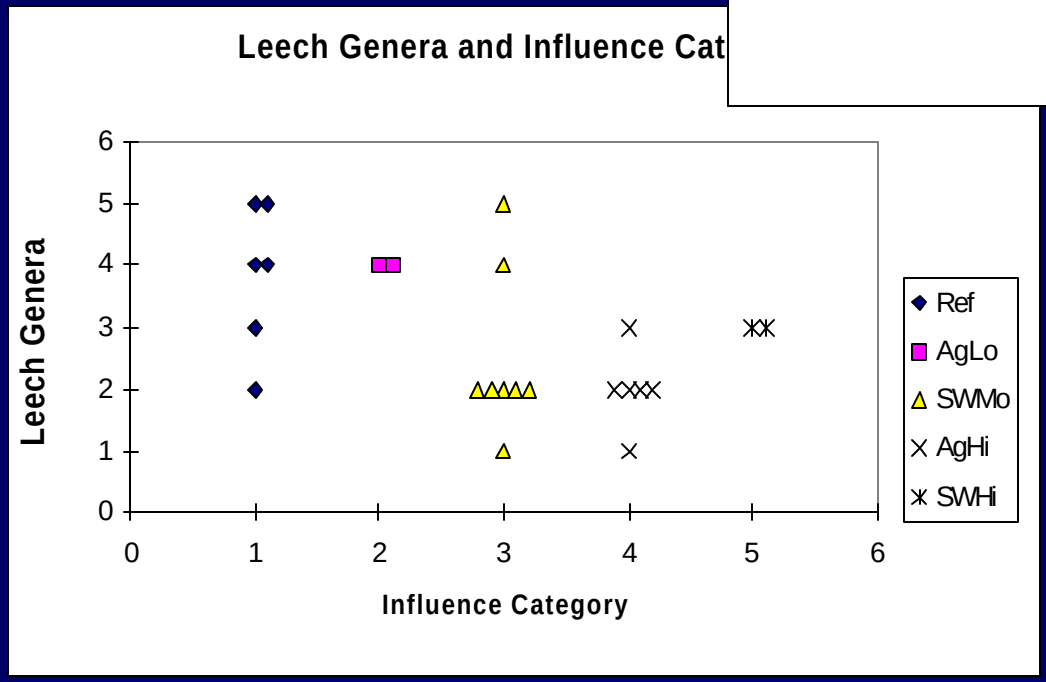
Negative



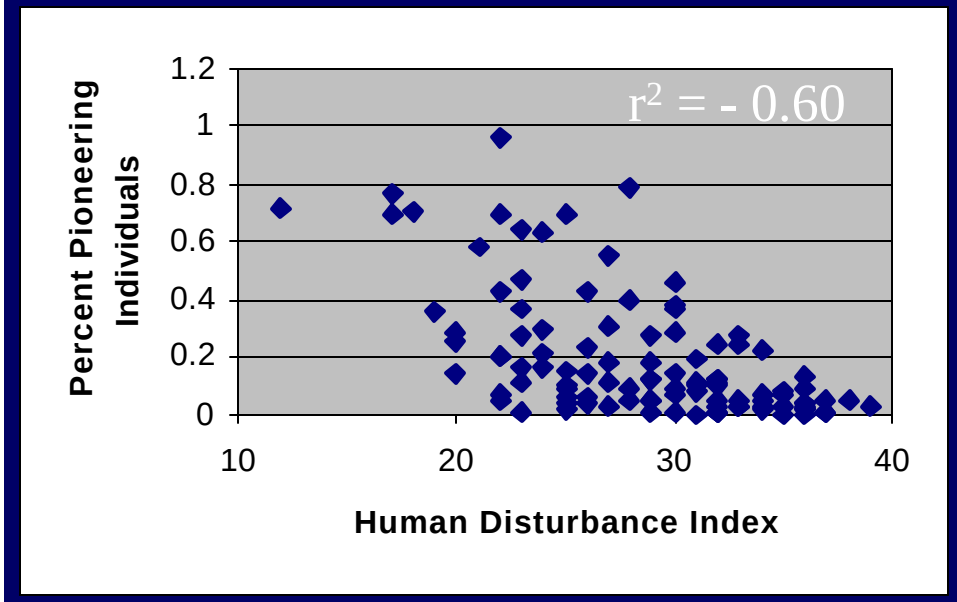
Little if any

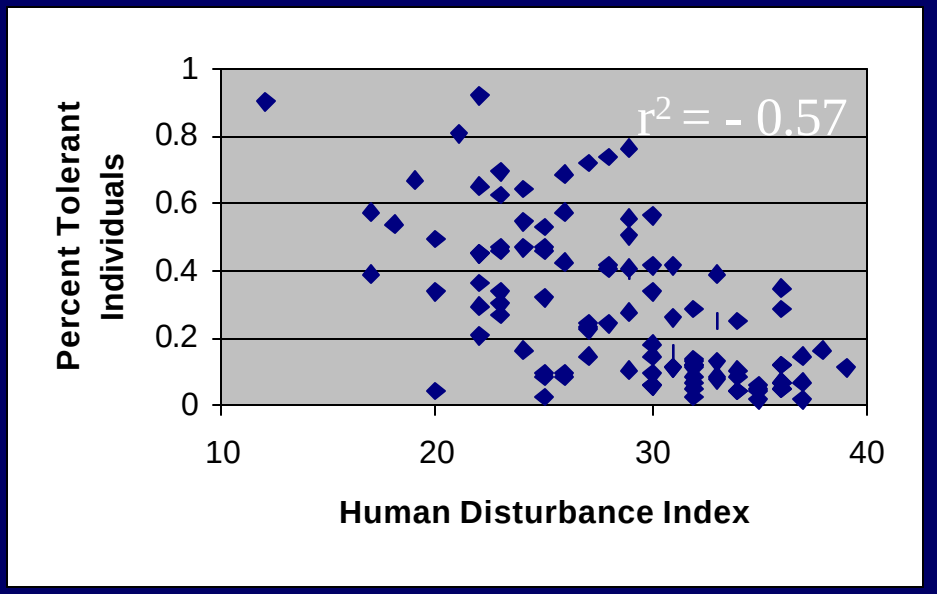
Similar values for similar impairments (Gernes and Helgen 1999)

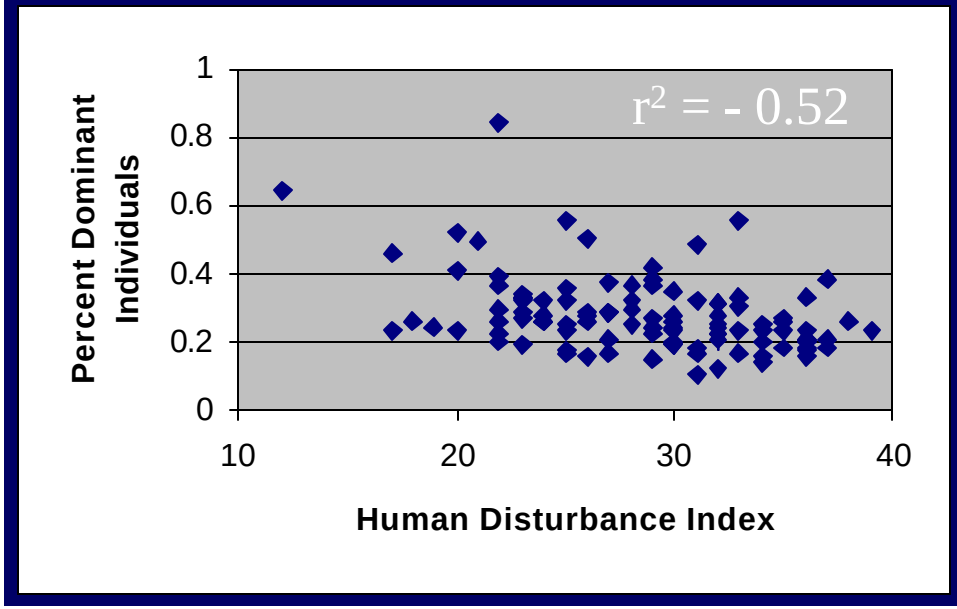


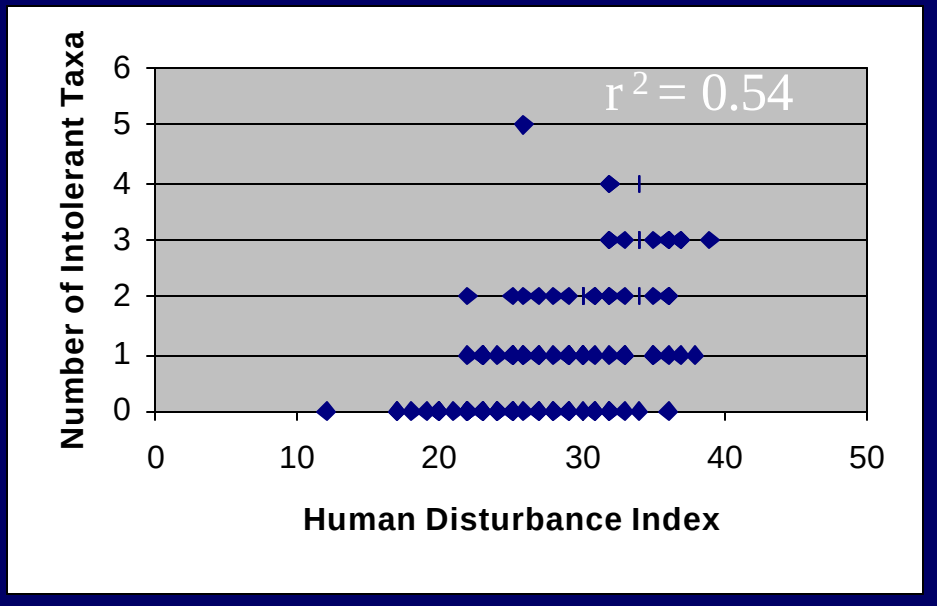


Check for redundancy: There may be no need to adopt a metric if it duplicates another's response.









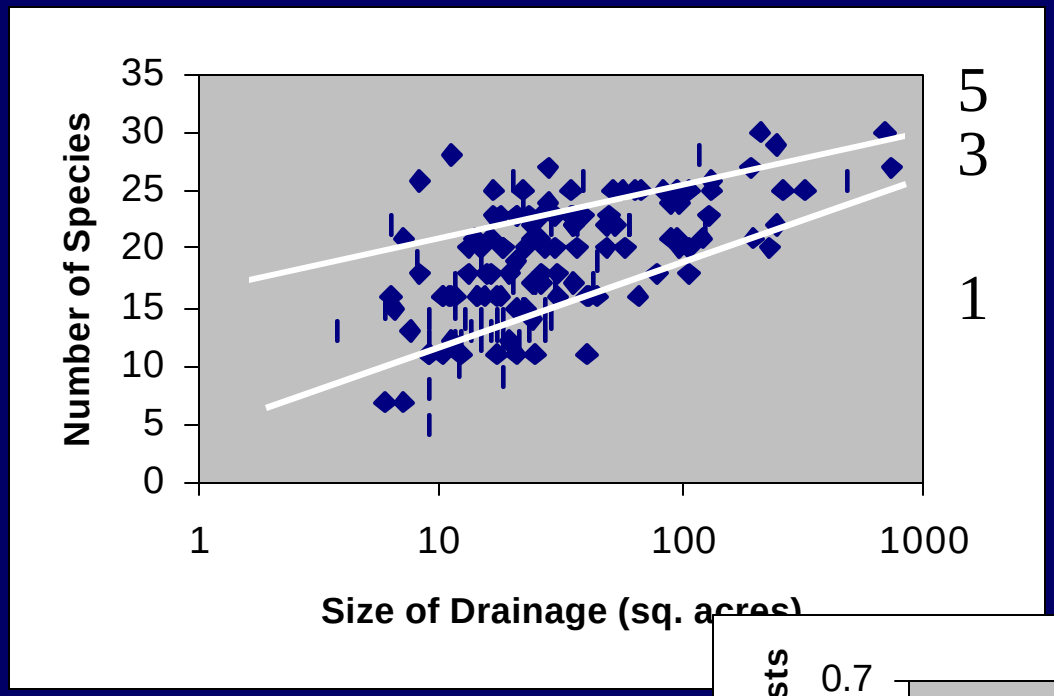
Tables or matrixes can be developed to help select those 8-12 metrics that perform best to form the IBI.

Attribute	Separates least-from most-impaired sites	Correlates to disturbance gradient ($r^2 = 0.35$)	Provides unique response	Metric
Taxa Richness				
Attribute 1	x	x	x	x
Attribute 2	x	x	x	x
Attribute 3	x	o	x	o
Tolerance				
Attribute 4	x	x	x	x
Attribute 5	o	o	o	o
Attribute 6	x	o	o	o
Trophic				
Attribute 7	o	o	o	o
Attribute 8	x	x	x	x

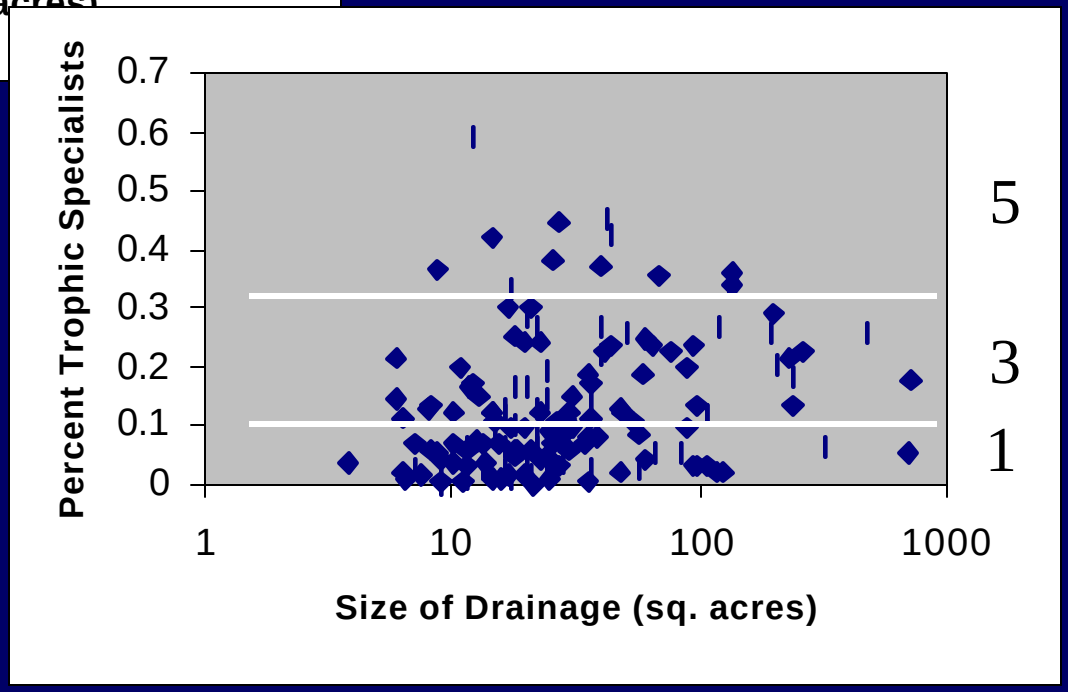
Scoring: Based on dividing the range in metric values into equal thirds (Helgen and Gernes 1999).

Metric	Score 1	3	5
Species Richness and Composition			
Total # of invertebrate taxa	0 - 13	12 - 25	26 - 38
# dragonfly and damselfly taxa	0 - 2	3 - 4	5 - 7
Tolerance/Intolerance			
Percent dominance of 1-3 taxa	72 - 90	54 - 71	35 - 53
Leech *Erpobdella* proportion	22 - 33	11 - 21	0 - 10
# intolerant taxa	0 - 2	3 - 4	5 - 7

Tri-section scoring technique



Natural variables, such as size or age of wetland may influence response; scoring should account for the influence of these variables



Calculation of total IBI score for all sites.

Site scores and condition classes for invertebrate metrics (Helgen and Gernes 1999)

Site	Ch	Od	Co%	Le	ETSD	Er%	Tot	In	Do%	Sn	Type	IBI	Con
1	5	5	5	5	5	5	5	5	5	5	Ref	50	Ex
2	5	5	5	5	5	5	3	5	5	5	Ref	48	Ex
3	3	3	5	5	5	5	5	5	3	5	Ref	44	Ex
4	3	5	3	5	5	5	5	3	5	5	Ref	44	Ex
5	5	5	5	3	5	5	3	5	5	1	Ref	44	Ex
6	3	3	5	5	3	3	1	1	5	5	Ag	34	Mo
7	1	3	5	5	3	5	5	1	3	1	SW	32	Mo
8	3	1	1	3	3	3	3	1	3	5	Ag	26	Mo
9	3	1	3	3	1	5	3	1	1	3	Ag	24	Mo
10	3	1	3	3	1	3	5	1	1	1	SW	22	Po
11	1	3	1	1	1	1	3	1	3	3	Ag	18	Po
12	1	1	1	3	1	1	3	1	1	3	SW	16	Po

Interpretation of IBI and Reporting of Data.

Total IBI scores, integrity classes and their attributes, modified from Karr et al. 1986.

Total IBI score (sum for 12 metric ratings)	Integrity class	Attributes
50-60	Excellent	Comparable to the best situations in the regional subclass without human disturbance; contains all species expected for the region, including the most intolerant forms; exhibits balanced trophic structure and reproductive success.
40-49	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundances; trophic structure and reproduction shows some sign of stress. Presence of some invasive or non-native species.
30-39	Fair	Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure (e.g., increasing frequency of omnivores or tolerant species); older age classes or top predators may be rare.
20-29	Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; reproductive and condition factors commonly depressed; hybrids or diseased individuals often present. Invasive or non-native species abundant.
10-20	Very Poor	Dominated by highly tolerant forms or invasive species; hybrids may be common; disease, lesions, parasites, and other anomalies may be regular. Complete absence of less tolerant forms.