Montana Prairie Streams: IBI Development and Assessment of Condition

Tom Johnson, Karl Hermann, Tony Selle, Peter Ismert
U. S. EPA-Region 8

Ted Angradi, Billy Schweiger
USEPA-ORD

Robert Bramblett
Montana State University

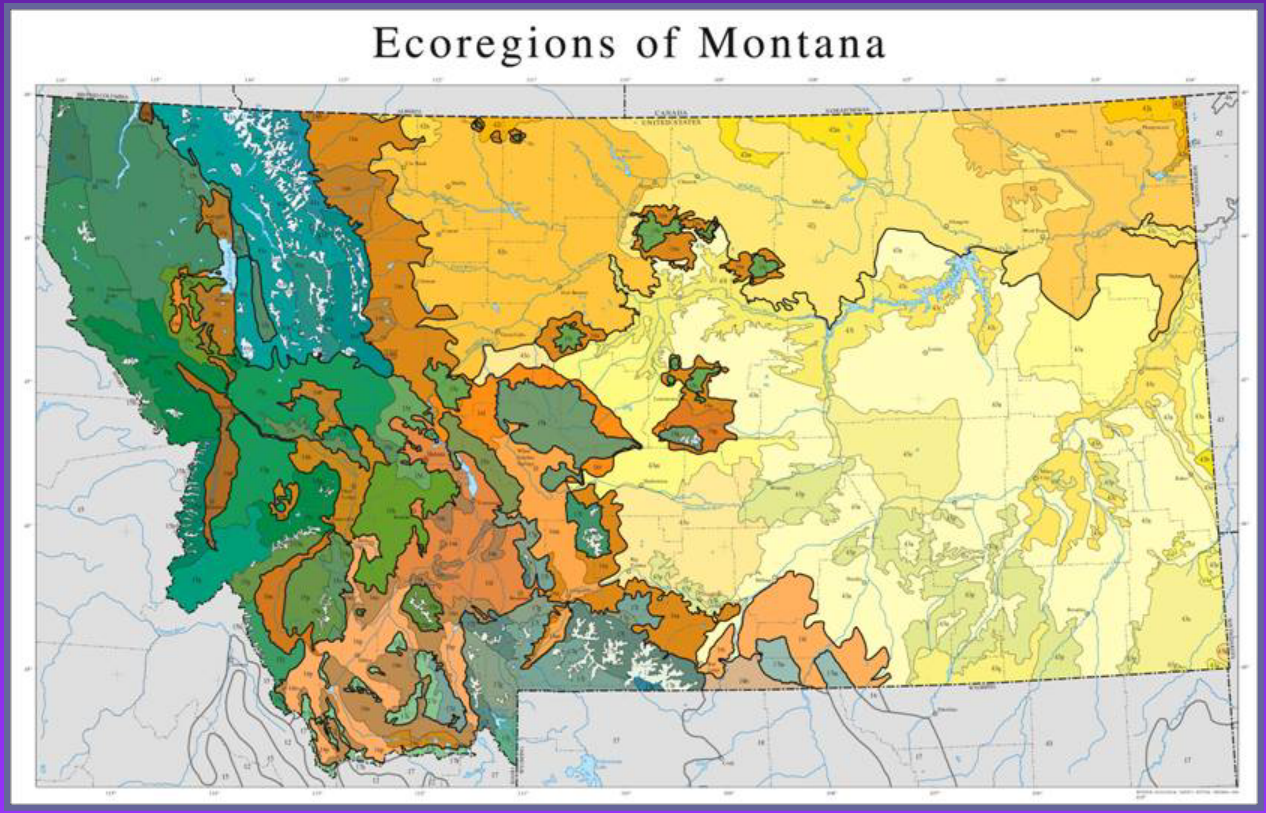
Sarah Spaulding
U. S. Geological Survey

6/29/2003

Study Area

Eastern Montana within the Northwestern Glaciated Plains and Northwestern Great Plains Ecoregions

Land use - primarily grazing and dryland agriculture



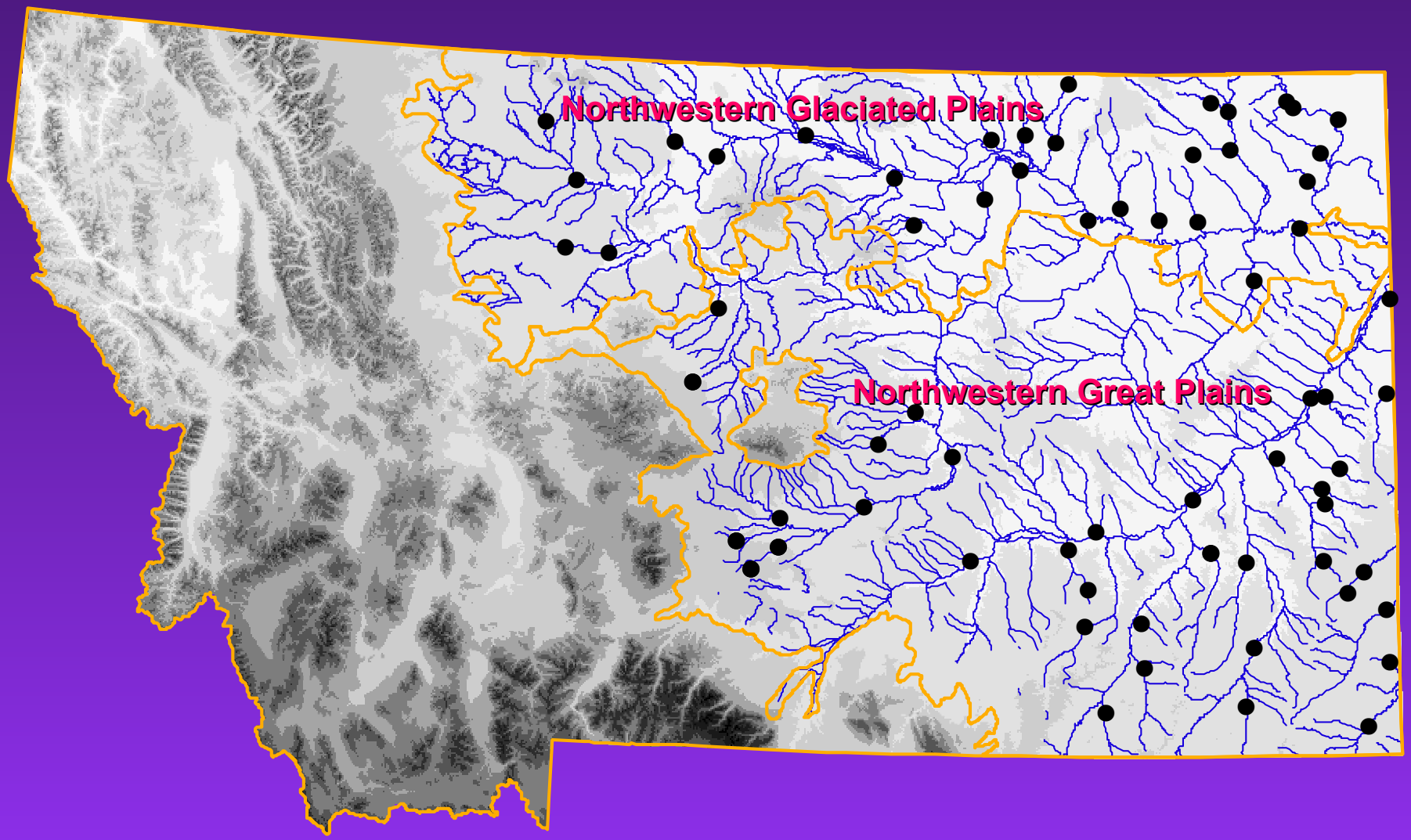
Sampled Sites

86 Sampling Events
- 67 Total Individual Stream Reaches
  - 44 Probability Sites (EMAP Design)
  - 6 Hand-picked Reference Sites
  - 6 Hand-picked Impaired Sites
  - 11 Additional Random Sites

10 Sites had Repeat Visits to Assess Temporal Variability (within and between year)

Sampled 2nd to 7th Order Perennial Streams during Late Summer of 1999, 2000, and 2001

Prairie streams (no mountain cold water influence).



● Sampled Sites

Sampling Protocols

√ Fish sampled reachwide by seining.

√ Macroinvertebrates sampled with a kick net in 5 pool and 5 riffle habitats; composited separately (not all sites had riffles).

√ Physical Habitat (fish cover, substrate size, channel dimensions, riparian condition, etc.) measured at each of 11 transects.

√ Water Chemistry sampled from one point in the reach.

Metric Screening

Candidate metrics (51 for fish, 70 for macroinvertebrates) screened for:

1) Range

2) Responsiveness (Spearman's rank, $p < 0.05$)

Disturbance Attributes

Reach-level Habitat

- Rapid habitat score
- Human influence index score
- Substrate metrics
- Riparian metrics
- Channel metrics

Landscape Disturbance

- Full catchment land use
- 1K and 10K slice land use
- Riparian land use
- Road density; road/stream crossings
- Landscape score

Water Chemistry

- Chemistry index
- Nutrient index
- Phosphorus, Nitrogen,
- Sulfate, Conductivity

Metric Screening

3) Signal-to-noise (variability among sites/ temporal variability within a site)

4) Redundancy (metric rejected if >0.75)

5) Watershed Area Adjustment

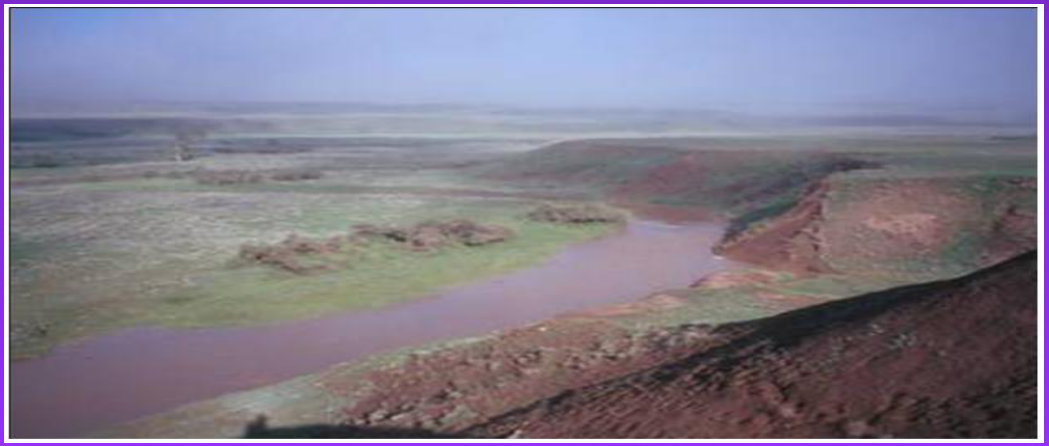
IBI Results

Fish – 10 metrics; Macroinvertebrates – 9 metrics

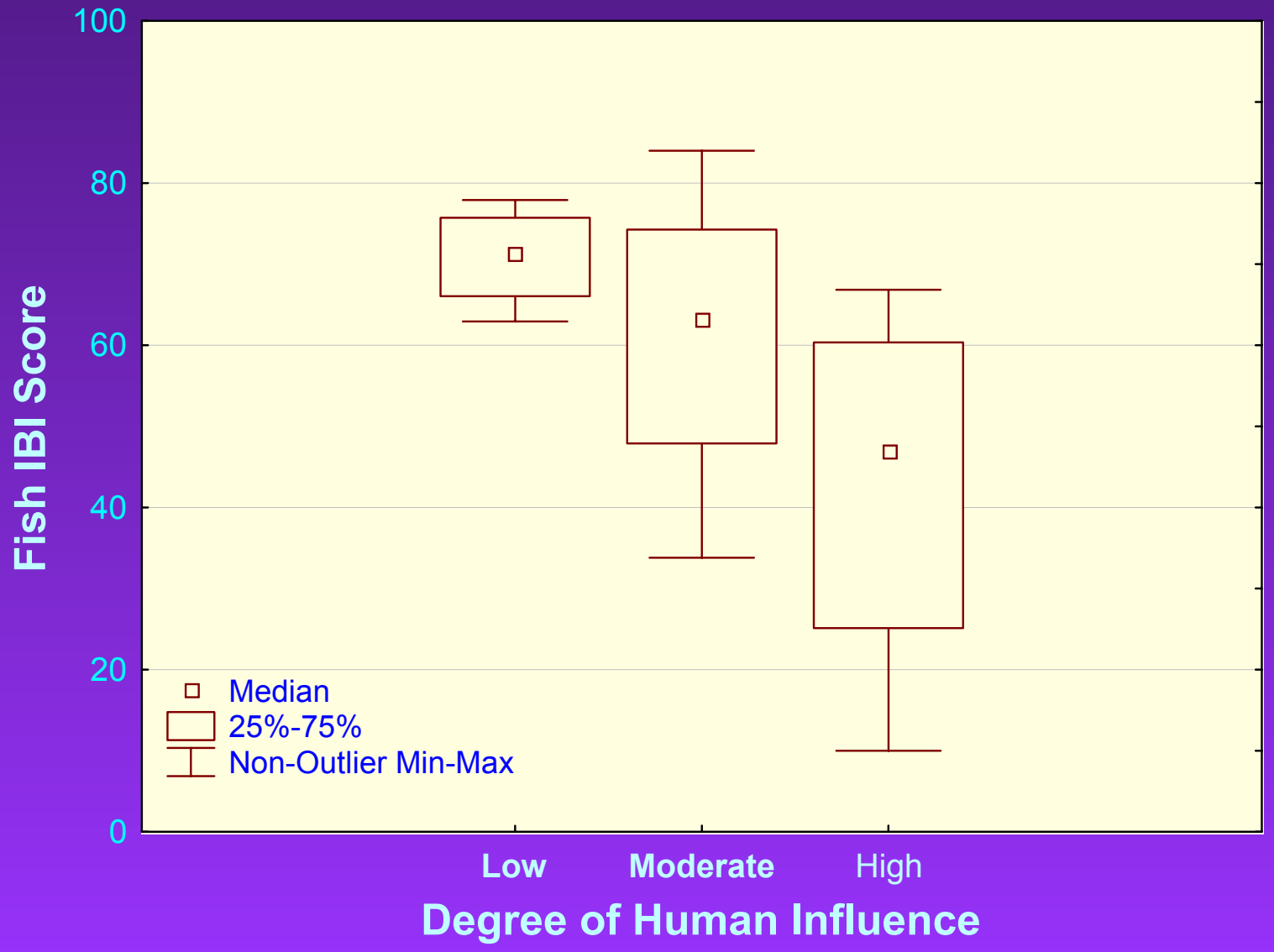
Each metric scored 0 – 10. Ecoregional differences in scores accounted for.

The 95th percentile (5th percentile for negative metrics) from calibration set was used as the top end for scoring criteria.

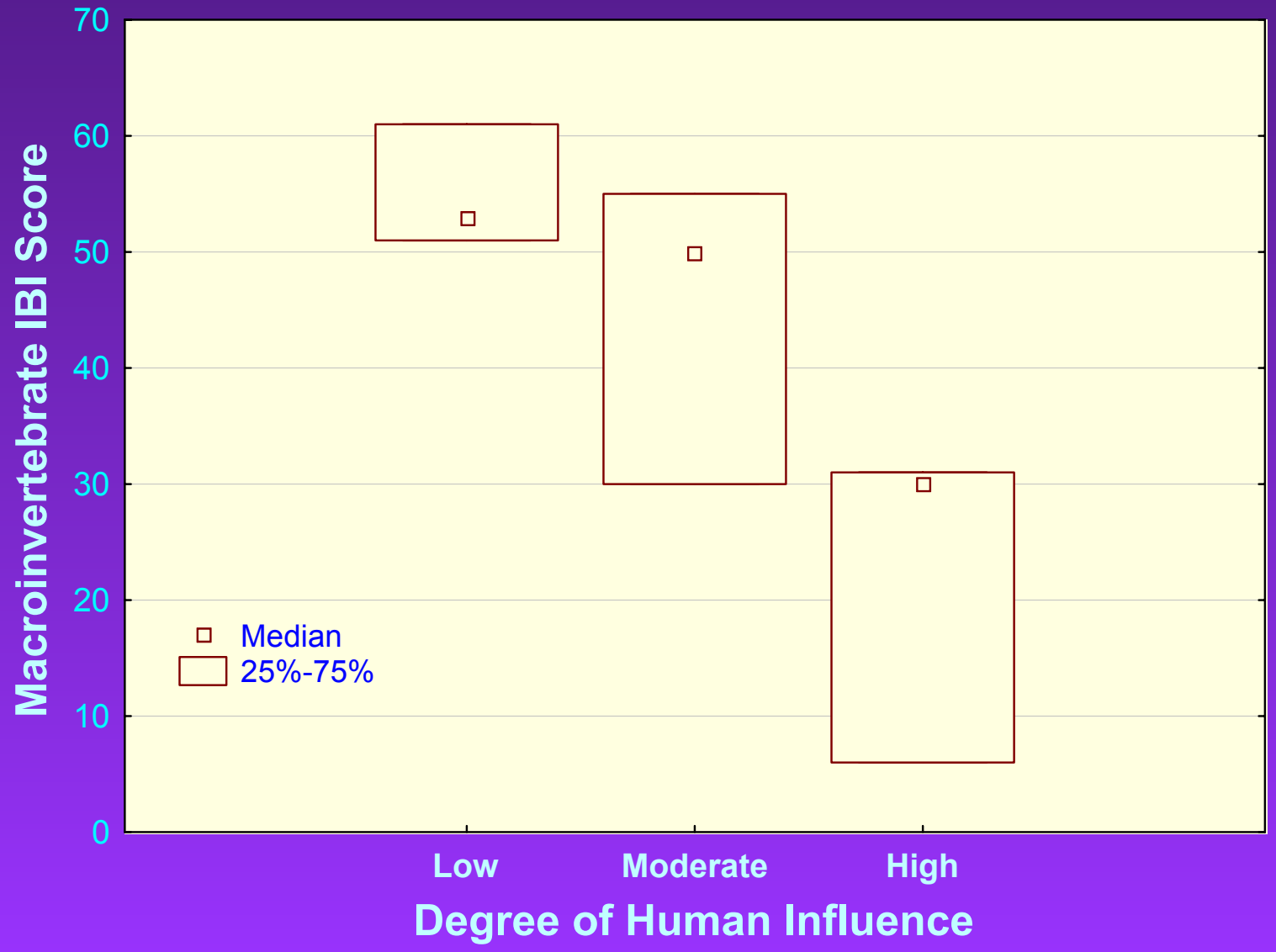
Metric scores were averaged and final IBI score ranged from 0 to 100.



Fish IBI Responsiveness



Macroinvertebrate IBI Responsiveness



IBI Findings/Conclusions

Fish and macroinvertebrate riffle IBIs were developed.

Responsive to human impacts, not responsive to natural variables, and temporally stable.

Macroinvertebrate pool IBI development - confounded by a temporal variability and could not be validated.

Diatom IBI development – still working to achieve this.

Separating human impacts from natural factors was difficult in these ecoregions, especially in determining grazing impacts.

The biota was generally more tolerant and adapted to great fluctuations in hydrology.

Assessment of Condition

Objectives:

Determine extent of stream resource in the study area.

Determine the condition of streams based on IBIs, other biological measures, chemistry, physical habitat, land cover.

Determine major stressors to streams.

Determine relative risk of the major stressors

Determine where the major stressors are most likely to be located within the area.

Definition of "Reference" Sites

For this work, screened sites from the dataset with the best values for:

Dissolved Oxygen
Sulfate
Total Phosphorus
Total Nitrogen

Embeddedness
Percent Fines
Human Influence Index
Human Land Cover 5km

This produced the best in the dataset, not necessarily the very best of what is out there.

In order to complete the assessment we hope to use sites screened for minimal human disturbance using the Western EMAP process.

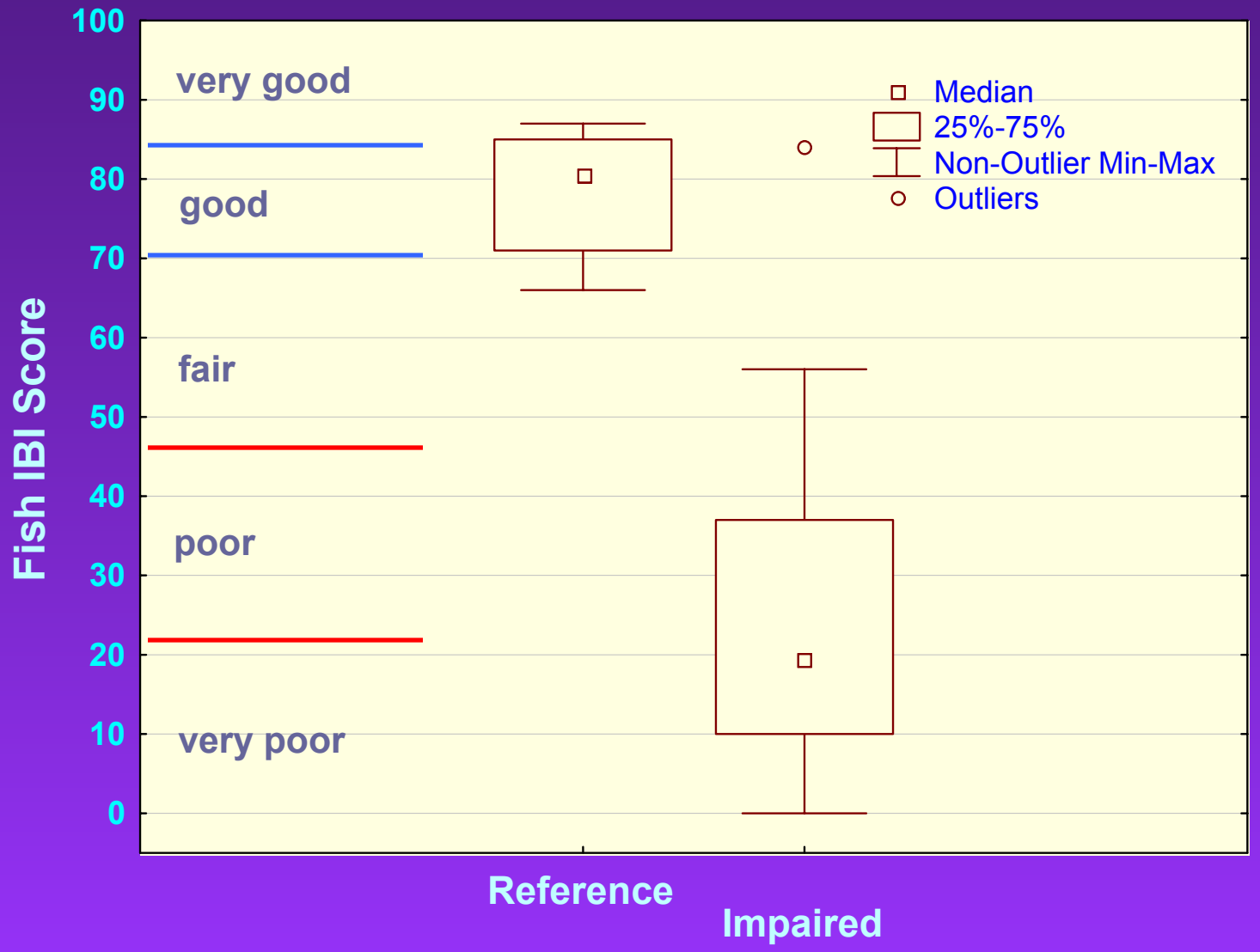
Determining Thresholds
(for Biological Parameters)

Defining what is "Good", "Fair", and "Poor" in assessing condition:

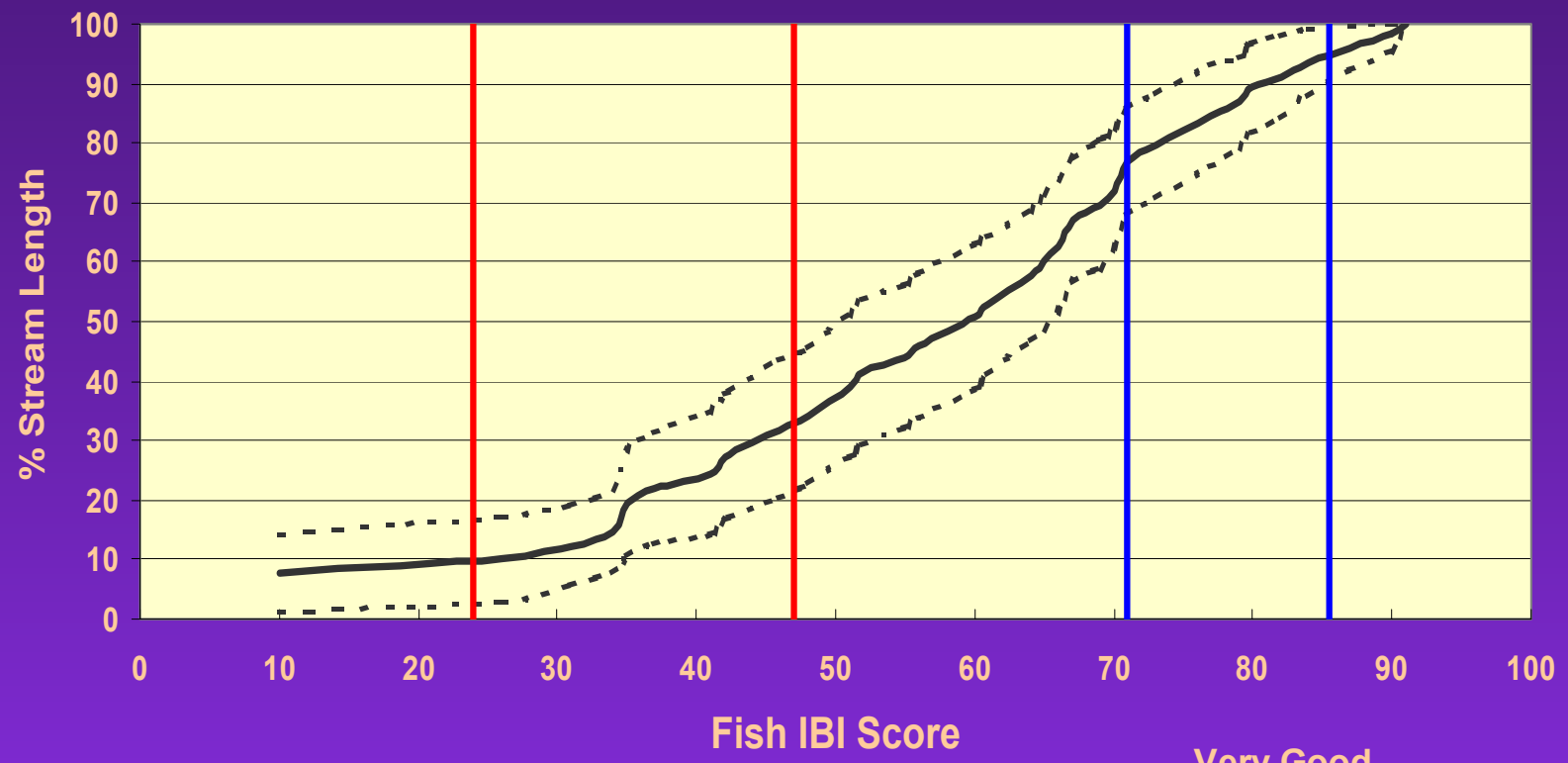
1) Use >25th Percentile of reference sites as "Good" and <5th Percentile as "Poor". In between is "Fair". Requires a large number of reference sites.

2) Use >25th Percentile as line between "Good" and "Fair" and divide the range into three equal parts below (very poor / poor / fair) and two equal parts above (good / very good).

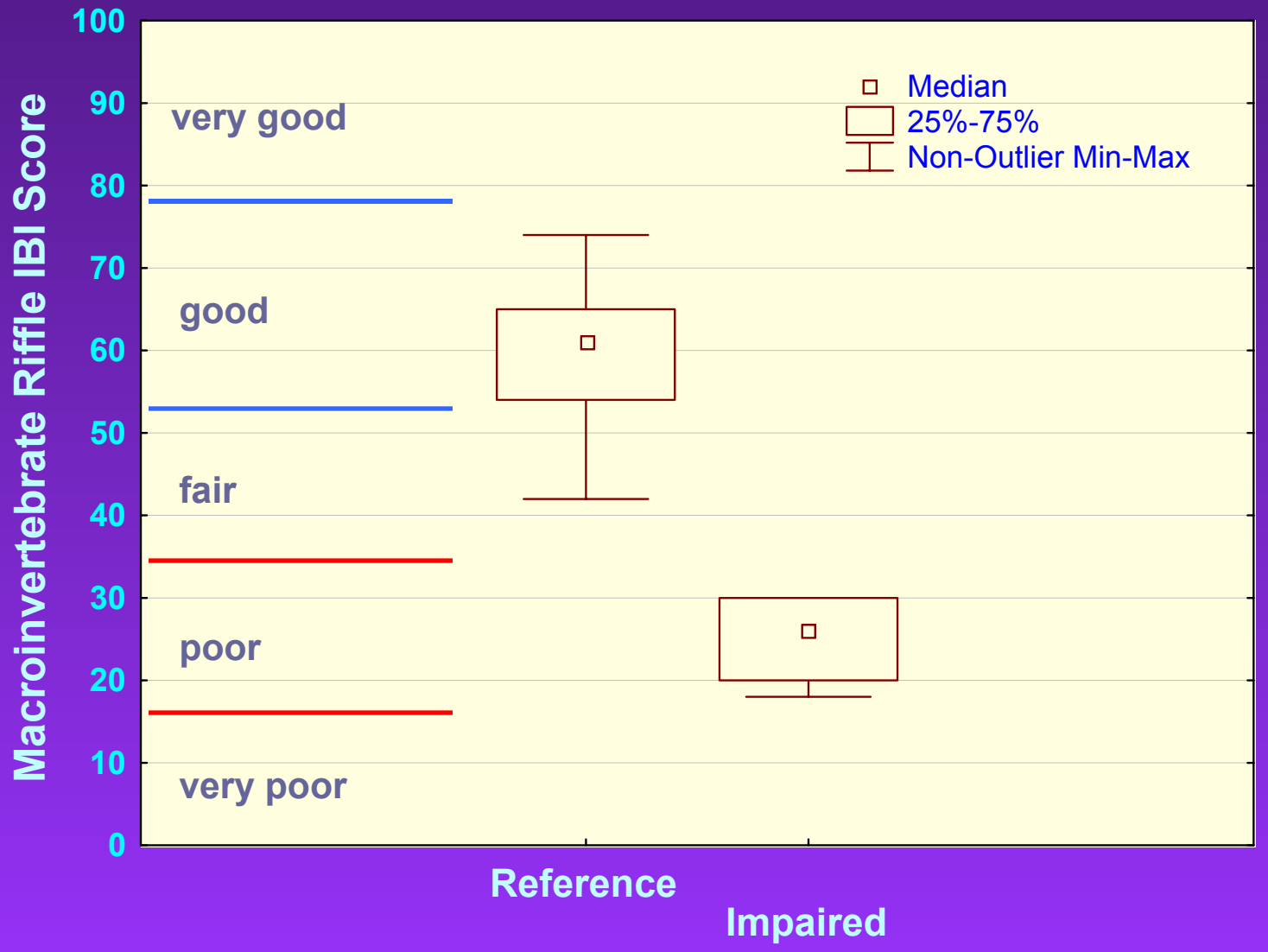
Fish IBI Thresholds



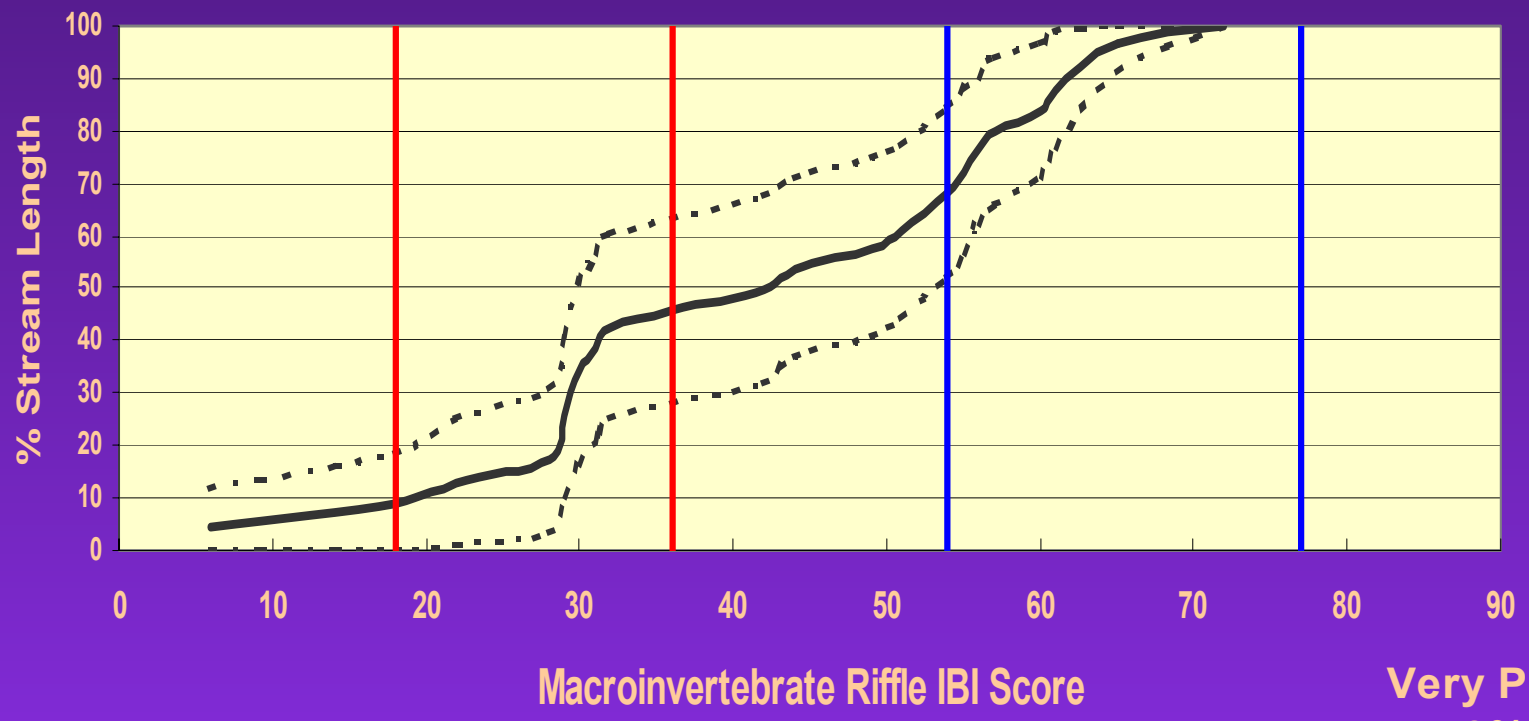
Condition Assessment (Fish IBI)

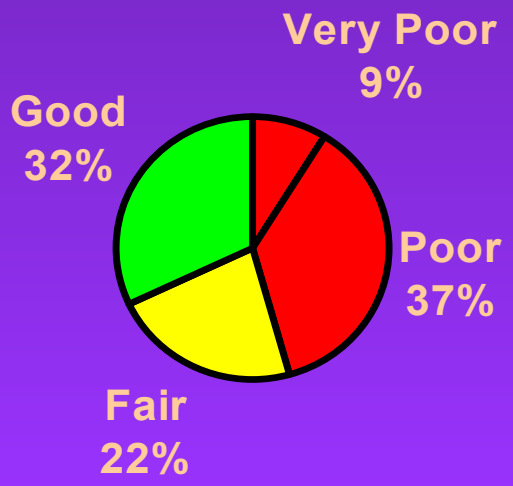


Macroinvertebrate IBI Thresholds

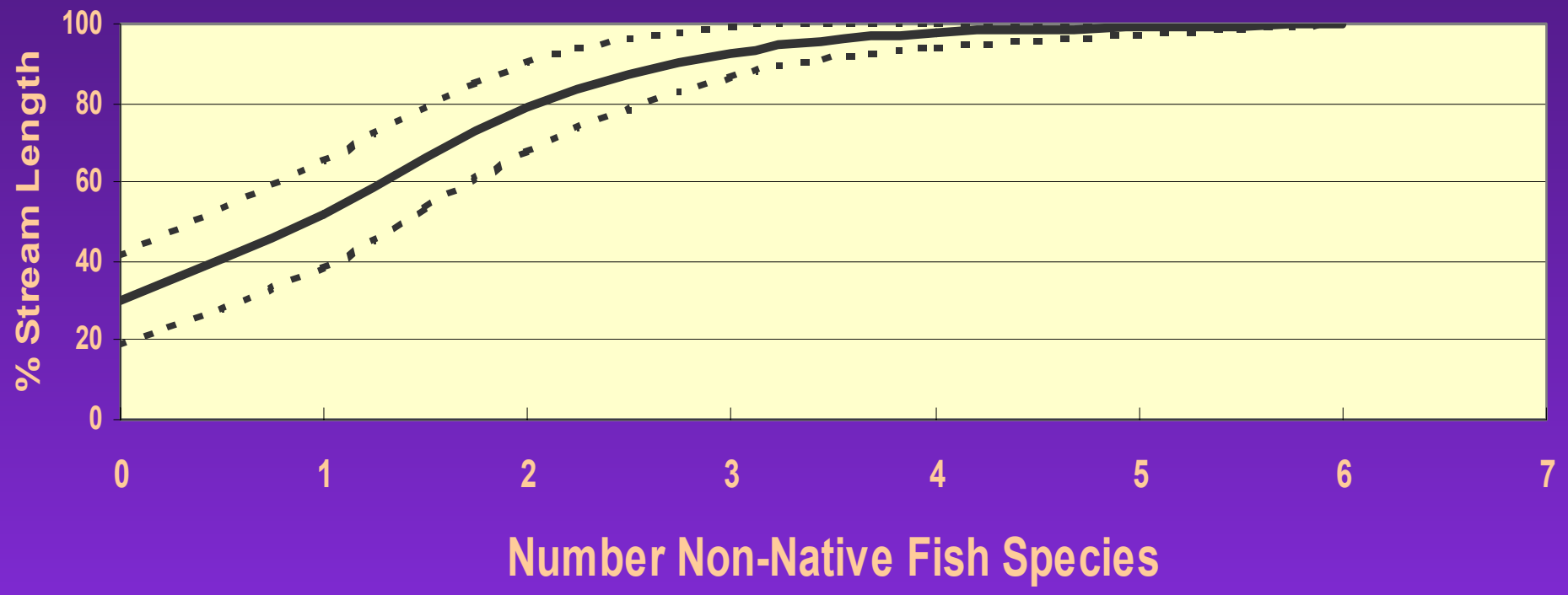


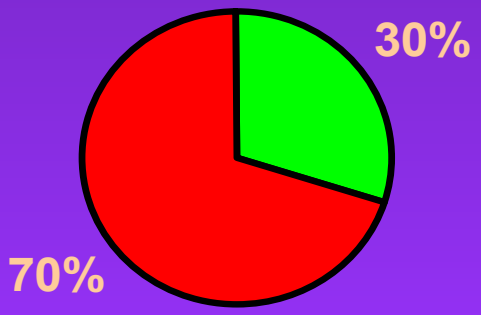
Condition Assessment (Macroinvertebrate IBI)



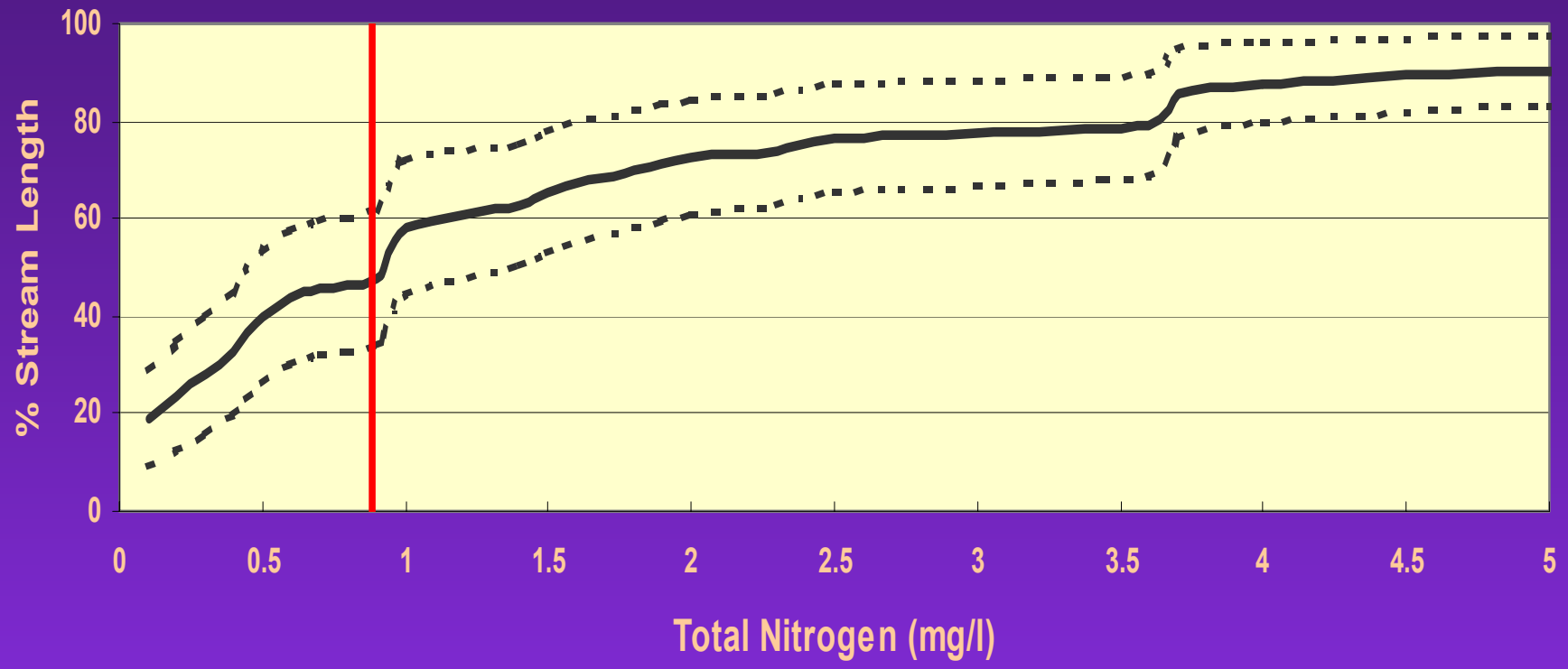


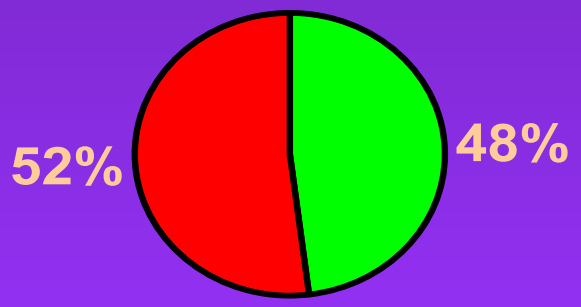
Exotic Fish Richness



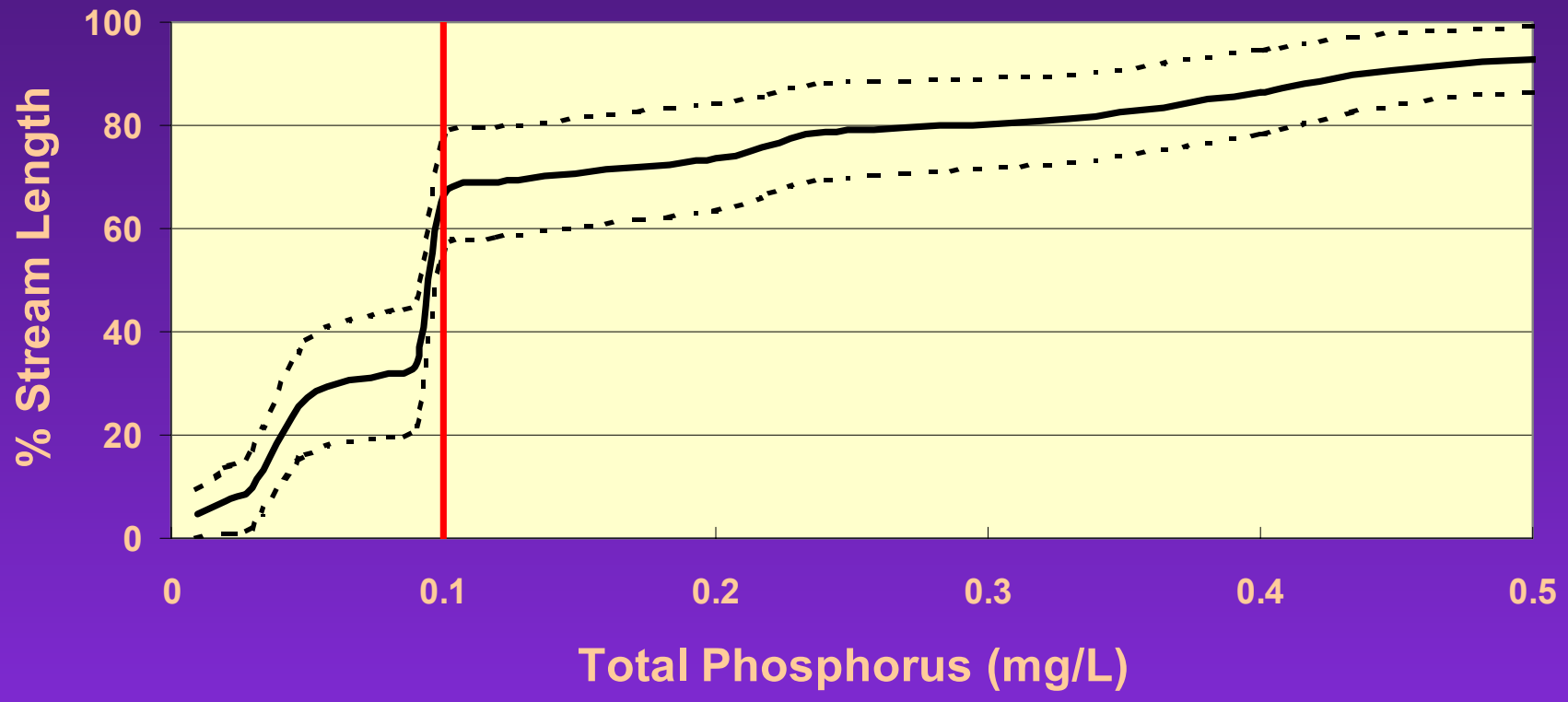


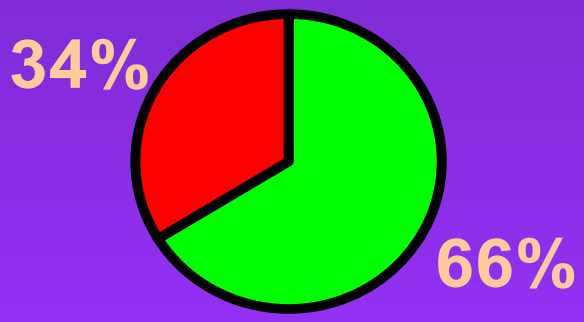
Total Nitrogen



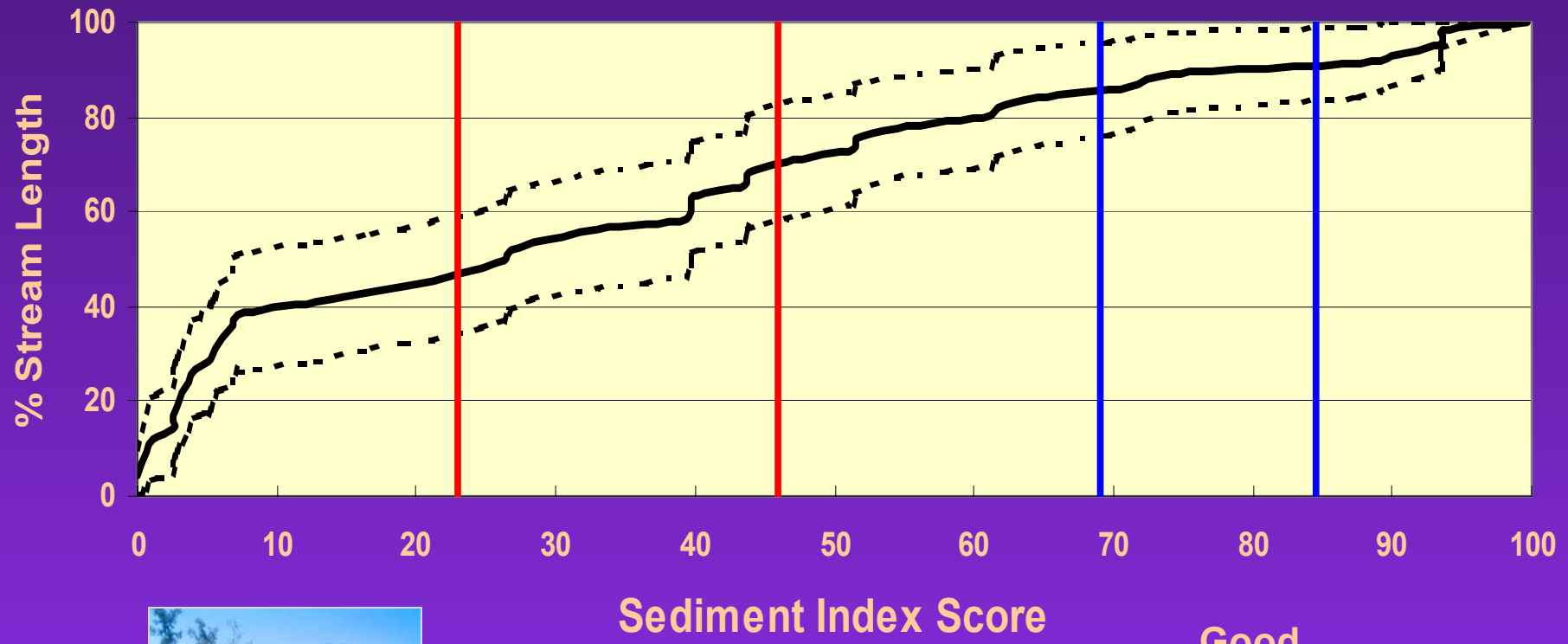


Total Phosphorus

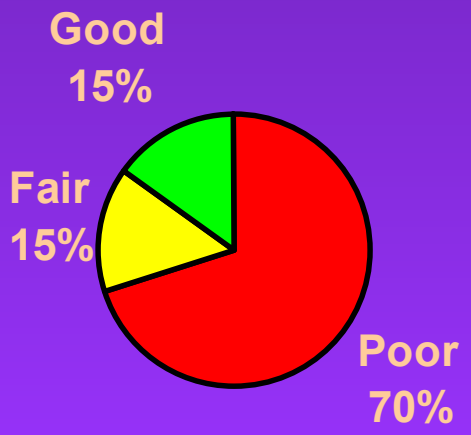




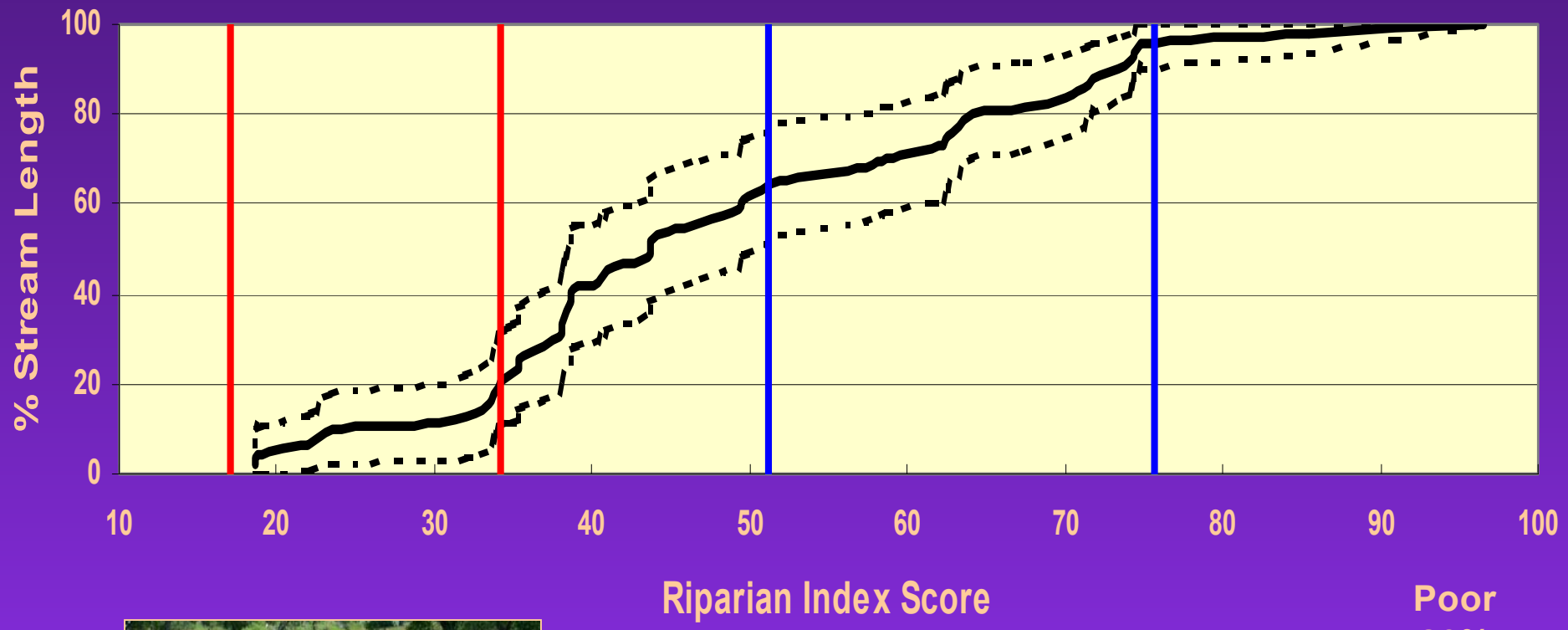
Sediment Index



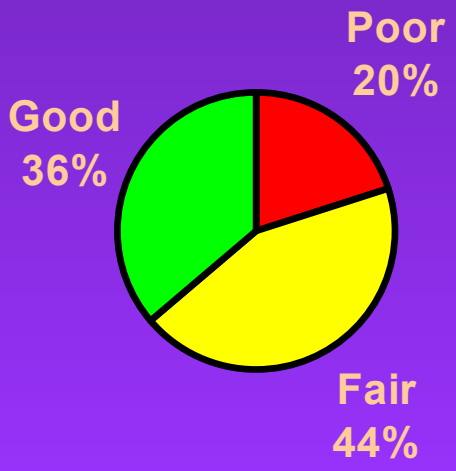
Sediment Index =
Percent Fines
Bed Load Stability
Embeddedness



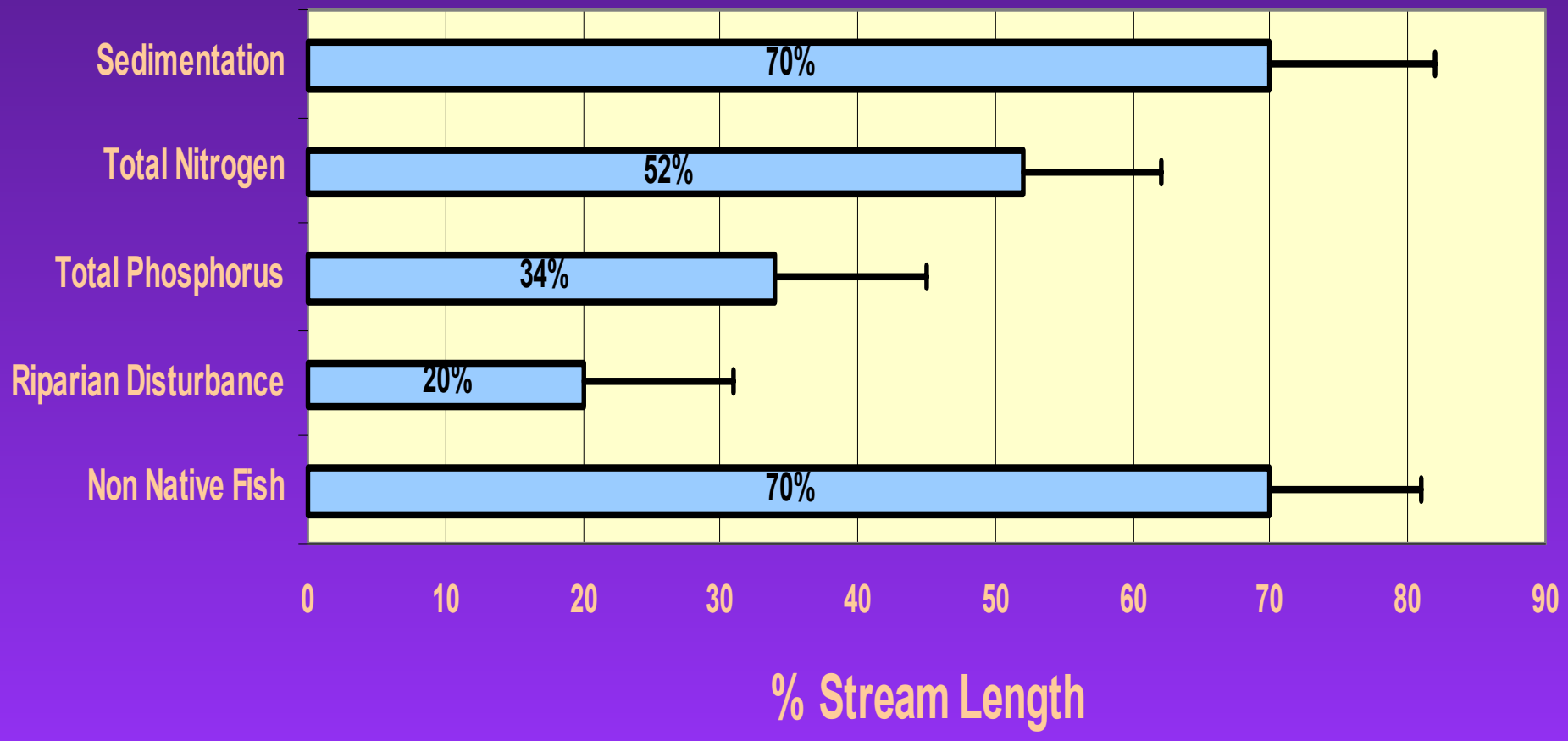
Riparian Index



Riparian Index =
Visual Disturbance
% Ground Cover
% Mid-layer Cover



MT Northern Plains Stressor Ranks (Percent in Poor Condition)



Prevalence (Extent) vs Relative Risk

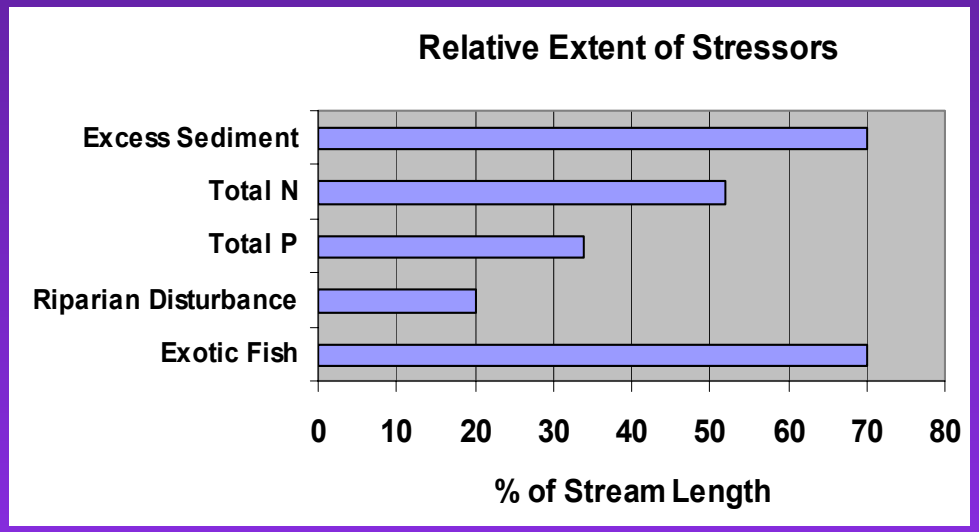
Stressor Importance should also be based on the severity of its impact on biological endpoints.

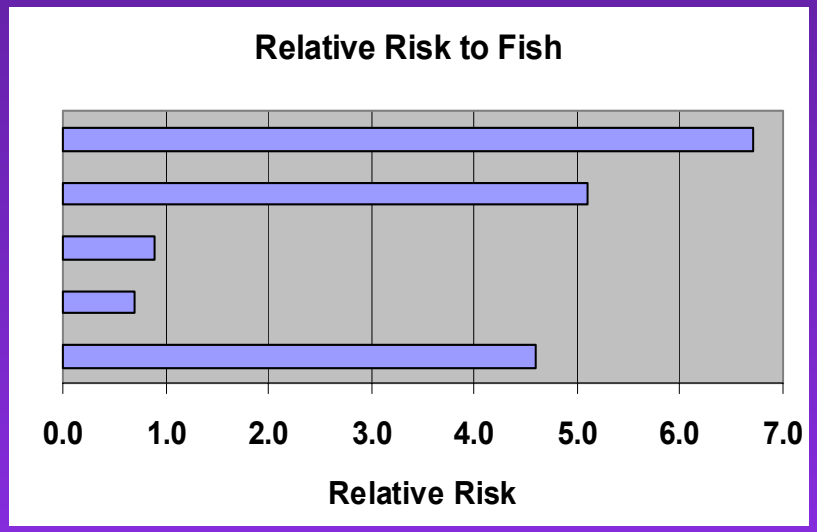
$$\text{Relative Risk} = \frac{\text{Pr (Poor IBI, given poor sediment)}}{\text{Pr (Poor IBI, given OK sediment)}}$$

$$\text{RR} = \frac{0.18/0.25}{0.10/0.75} = 5.4$$

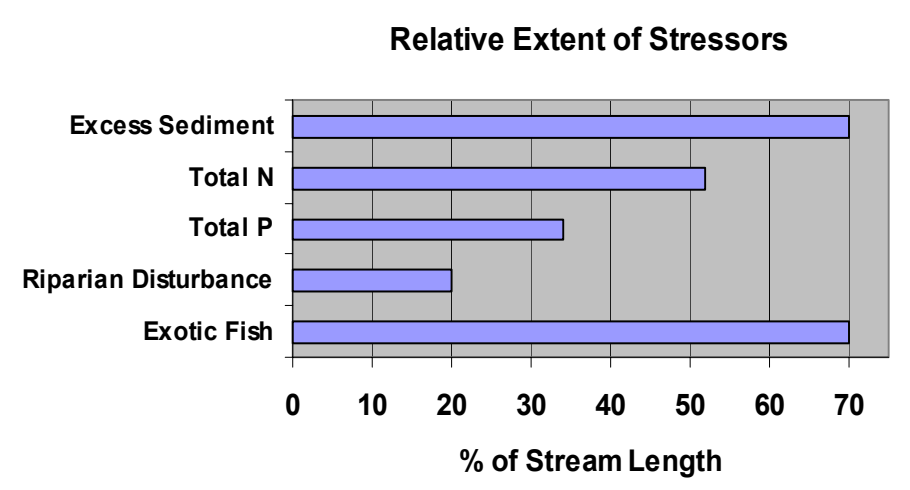
	Sed OK	Sed Poor	Total
IBI OK	0.65	0.07	0.72
IBI Poor	0.10	0.18	0.28
Total	0.75	0.25	1.00

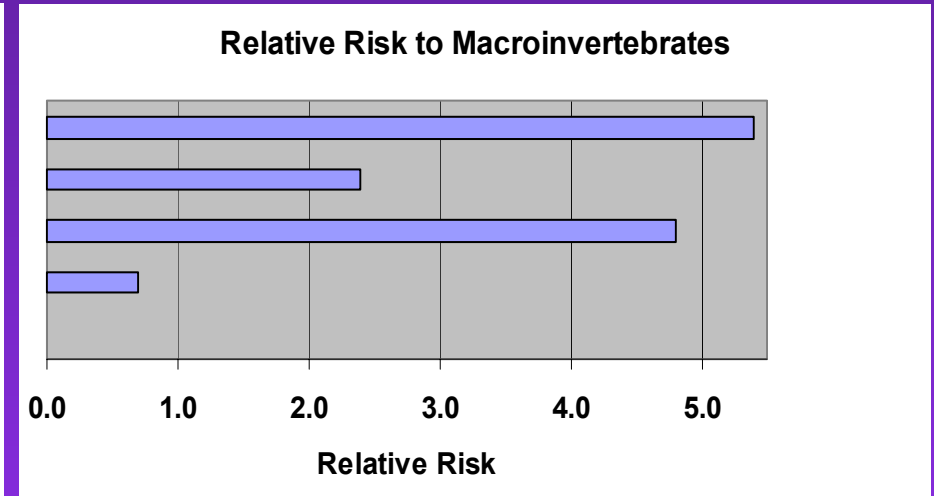
Extent and Relative Risk of Stressors to Fish





Extent and Relative Risk of Stressors to Macroinvertebrates





Future Work

Confirm “reference” sites and draw thresholds for biological measures.

Attempt again to create a diatom IBI for eastern MT.

Define final thresholds for chemical measures.

Refine sediment and riparian indexes. Define thresholds for physical habitat metrics.

Explore correlations between land cover metrics and nutrients, excess sediment, others. Create maps, if possible.

Create final stressor extent chart. Create chart of relative ranks.

Publish a final report that serves as the assessment for the Montana Northern Plains.