Apr 6th, 2:45 PM - 3:00 PM

Assessing biological condition in small streams of the Puget Sound lowlands through collaborative regional monitoring

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Speaker
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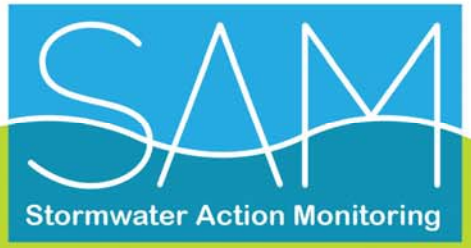


Study background

- The Stormwater Action Monitoring (SAM) program was developed as a collaborative, regional stormwater monitoring program funded by more than 90 Western Washington municipal stormwater permittees.
- Focus was to move from end of pipe monitoring to receiving water monitoring and implementation of effectiveness studies to better understand impacts of our stromwater management practices
- Written into the NPDES permits, and includes a long-term status and trends program for small streams.
- Goal –to track whether stream condition improves as a result of stormwater management practices.

Sites were selected using a probabilistic random sampling design

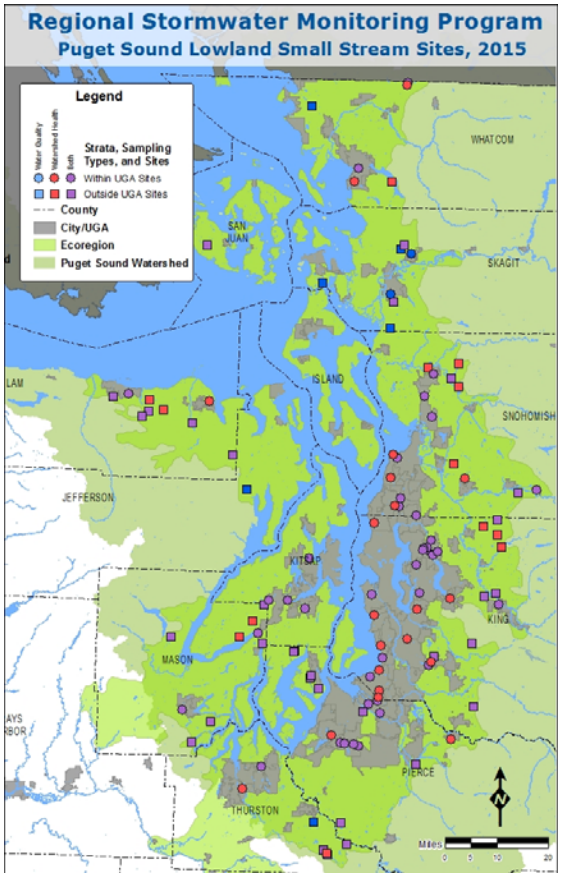
- Analogous to **modern** polling methods
- A complete census is not possible
- Survey-based sampling is efficient and provides confidence bounds on results
- Selection from the Washington Master Sample list

We avoided this:

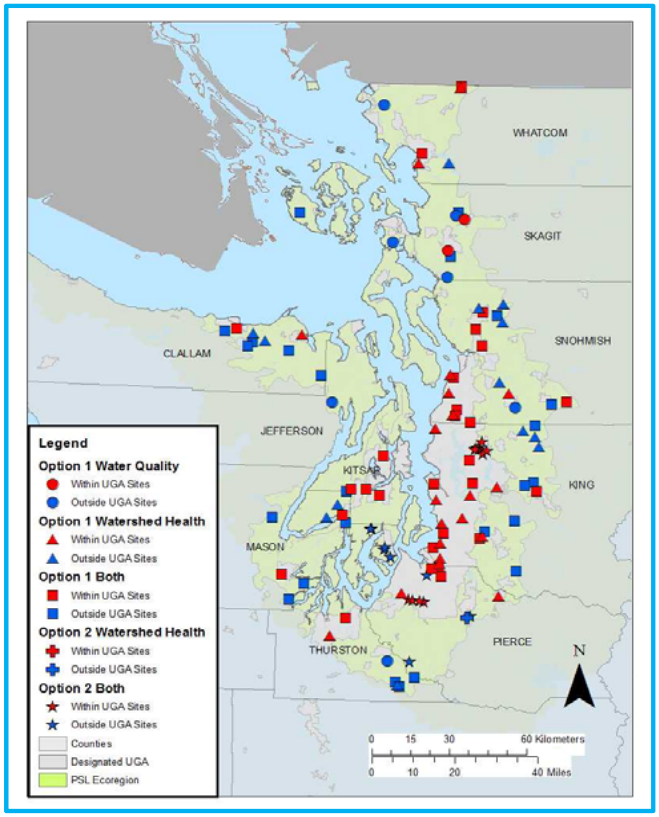
Prior to the 1948 presidential election, polling methods were not based on random polling.

Sampled small Puget Lowland Streams within and outside urban growth areas (UGAs) for:

- Monthly water quality Jan-Dec 2015
  - "Conventional" parameters, metals, PAHs, stream flow
- Summer Watershed Health Monitoring
  - Water quality (conventional parameters)
  - Benthic macroinvertebrates
  - Periphyton (chl-a and community composition)
  - Sediment chemistry (TOC, metals, phthalates, PAHs, PCBs, PBDEs, common roadside-use pesticides)



Sites Within and Outside Urban Growth Areas



UGA used as a proxy for urban development

A total of 105 Watershed Health sites

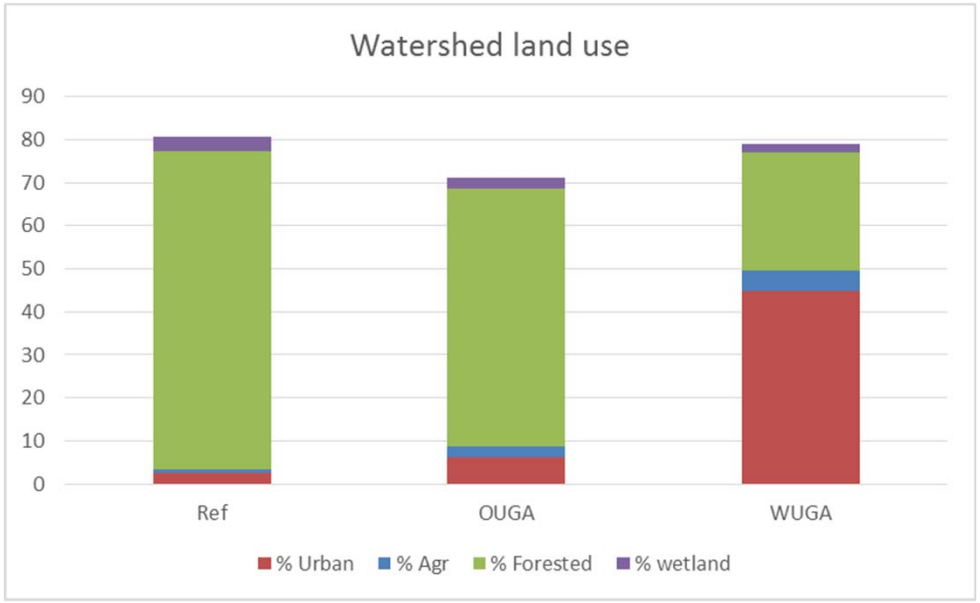
Monthly water quality sampling attempted at 80 sites, but with mixed success due to unusually low flows in 2015

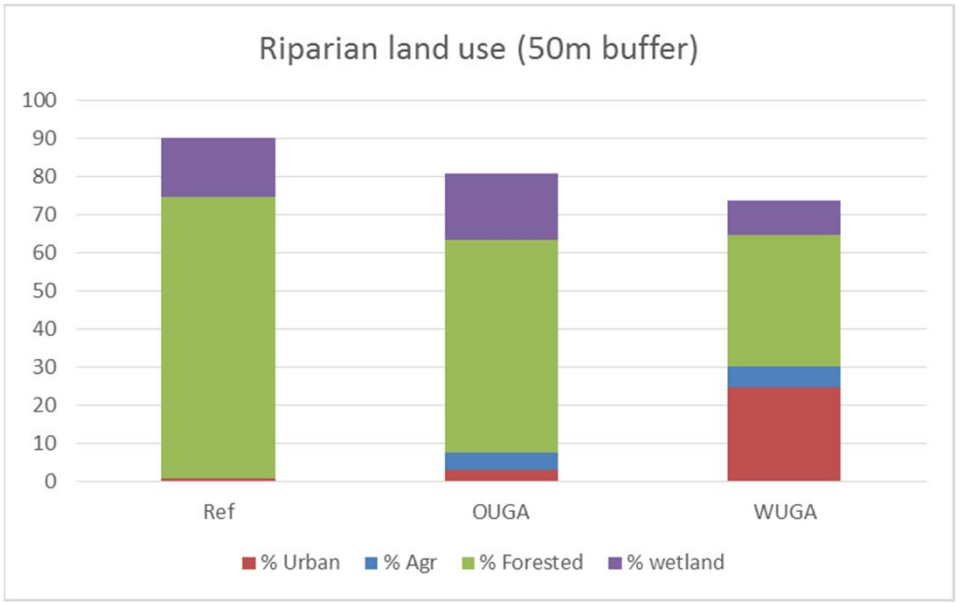
Sampling was also spatially balanced

Included watershed and riparian GIS analysis

- Derived land cover and other landscape parameters for all 105 sites and 16 least-disturbed reference sites
- Reference sites added in order to establish ‘least-disturbed’ thresholds
- Why? Because local riparian and upstream land cover shown to be important factor for biological communities

Land cover summary within and outside UGAs





Detected >50% of time	A
Detected 20-50% of time	B
Detected <20% of time	C

Parameter	Detection Freqency	
	Outside UGA	Within UGA
Ammonia	B	A
Arsenic	A	A
Arsenic dissolved	A	A
Chloride	A	A
Chromium	A	A
Chromium dissolved	B	A
Copper	A	A
Copper dissolved	A	A
Dissolved Organic Carbon	A	A
Fecal coliform	A	A
Hardness as CaCO3	A	A
Nitrite-Nitrate	A	A
Ortho-phosphate	A	A
Total Nitrogen	A	A
Total Phosphorus	A	A
Total Suspended Solids	A	A
Lead	B	B

Water Quality ----------

Parameter	Detection Freqency	
	Outside UGA	Within UGA
Naphthalene	C	B
Zinc	C	B
Zinc dissolved	C	B
1-Methylnaphthalene	C	C
2-Methylnaphthalene	C	C
Acenaphthene	C	C
Acenaphthylene	C	C
Anthracene	C	C
Benz(a)anthracene	C	C
Benzo(a)pyrene	C	C
Benzo(b)fluoranthene	C	C
Benzo(g,h,i)perylene	C	C
Benzo(k)fluoranthene	C	C
Cadmium	C	C
Cadmium dissolved	C	C
Carbazole	C	C
Chrysene	C	C
Dibenzo(a,h)anthracene	C	C
Dibenzofuran	C	C
Fluoranthene	C	C
Fluorene	C	C
Indeno(1,2,3-cd)pyrene	C	C
Lead dissolved	C	C
PCN-002	C	C
Phenanthrene	C	C
Pyrene	C	C
Retene	C	C
Silver	C	C
Silver dissolved	C	C
Total Benzofluoranthenes	C	C

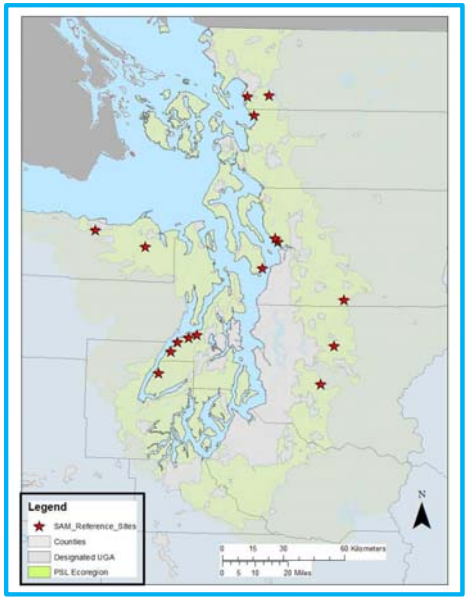
Parameter	Detection Frequency	
	Outside UGA	Within UGA
Arsenic	A	A
Cadmium	A	A
Chromium	A	A
Copper	A	A
Dichlobenil	A	A
Lead	A	A
Retene	A	A
Total PBDE	A	A
Total PCB	A	A
Zinc	A	A
Bis(2-Ethylhexyl) Phthalate	B	A
Silver	B	A

Sediment Quality ----------

Parameter	Detection Frequency	
	Outside UGA	Within UGA
1-Methylnaphthalene	C	C
2,4-D	C	C
2-Methylnaphthalene	C	C
Acenaphthene	C	C
Acenaphthylene	C	C
Anthracene	C	B
Benz(a)anthracene	C	B
Benzo(a)pyrene	C	B
Benzo(b)fluoranthene	C	B
Benzo(g,h,i)perylene	C	B
Benzo(k)fluoranthene	C	B
Butyl benzyl phthalate	C	C
Carbaryl	C	C
Carbazole	C	C
Chlorpyrifos	C	C
Chrysene	C	A
DCPMU	C	C
Dibenzo(a,h)anthracene	C	C
Dibenzofuran	C	C
Dibutyl phthalate	C	C
Diethyl phthalate	C	C
Dimethyl phthalate	C	C
Di-N-Octyl Phthalate	C	C
Diuron	C	C
Fluoranthene	C	A
Fluorene	C	C
Indeno(1,2,3-cd)pyrene	C	B
Naphthalene	C	C
PCN-002	C	C
Phenanthrene	C	B
Pyrene	C	A
Total Benzofluoranthenes	C	B
Total PAH	C	A
Triclopyr	C	C

Followed EPA status assessment approach

- Need to set thresholds for good, fair, and poor
  - Fixed thresholds (e.g., literature, state standards)
  - Distribution based thresholds (from 'least-disturbed' reference sites)



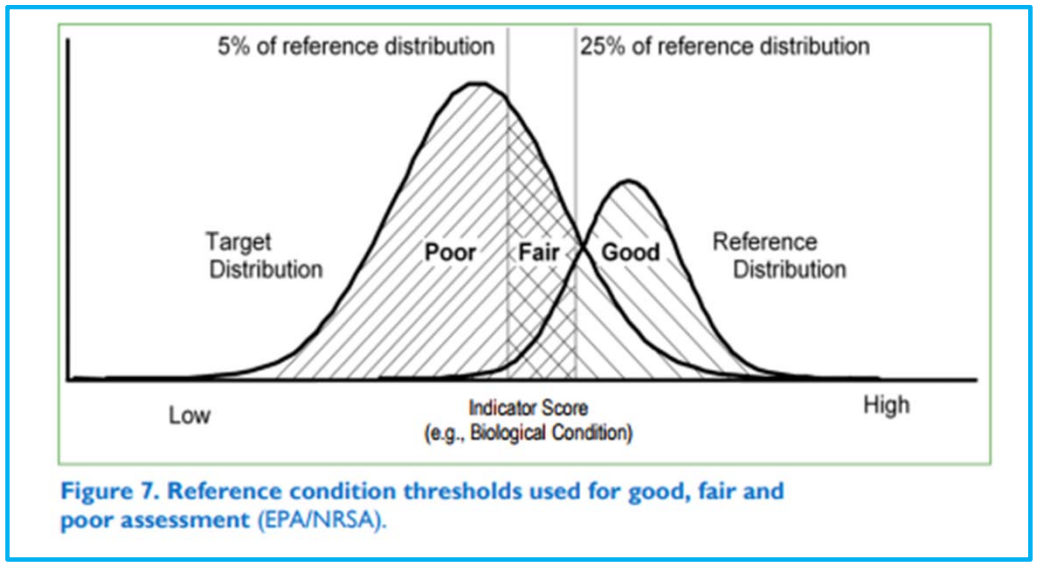
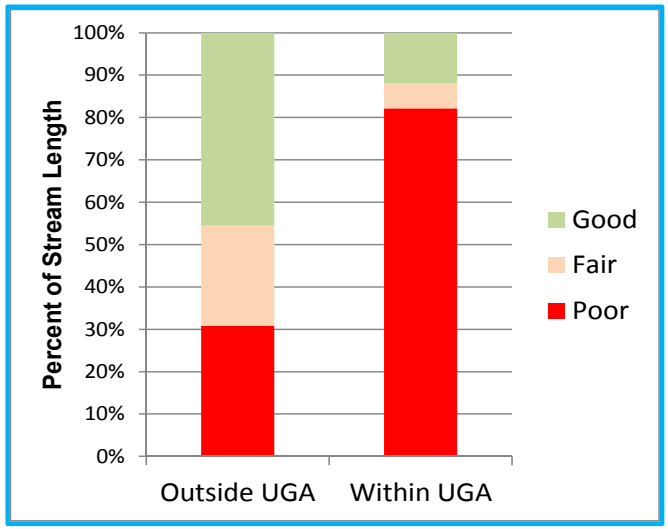


Figure 7. Reference condition thresholds used for good, fair and poor assessment (EPA/NRSA).

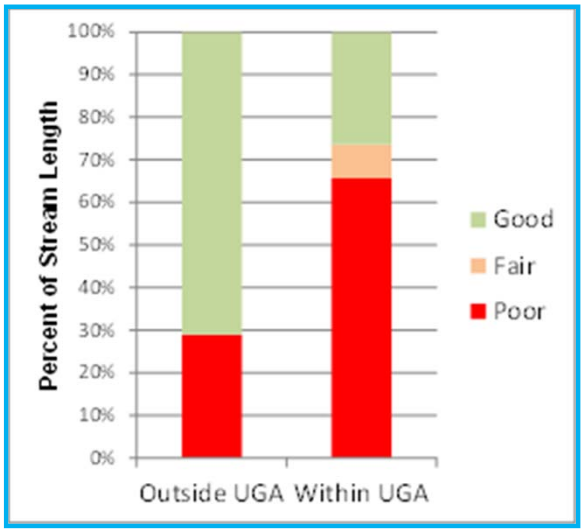
Biological Status

- Biological condition was generally worse in small streams within UGAs compared to streams outside UGAs

Benthic Index of Biotic Integrity



Trophic Diatom Index



A logical question

- What are the causes of poor biological condition?

Correlation with natural and human factors

- We used two techniques to examine factors that lead to poor biological condition (BIBI, TDI metrics)
  - Boosted Regression Trees
  - Relative risk/Attributable risk analysis
- Used all sites together not separated into UGA groups

Boosted Regression Trees

- Non-parametric model suited to problems where the number of predictor variables exceeds the number of samples, interactions exist among variables, non-linear relationships occur, data are missing
- It doesn't prove causal relationships, but does indicate the relative importance of each variable to the variability of target metric
- Can run 100s or 1000s of times to look at variability in explanatory variables.

Relative Risk and Attributable Risk (RR/AR)

- Assumes causal relationship between stressor and biological response and multiple stressors are independent and act in isolation
- Assumes stressor's effects would be completely reversed if stressor were eliminated
- Extension of the status assessment earlier, needs thresholds

Stressor → Biological Response

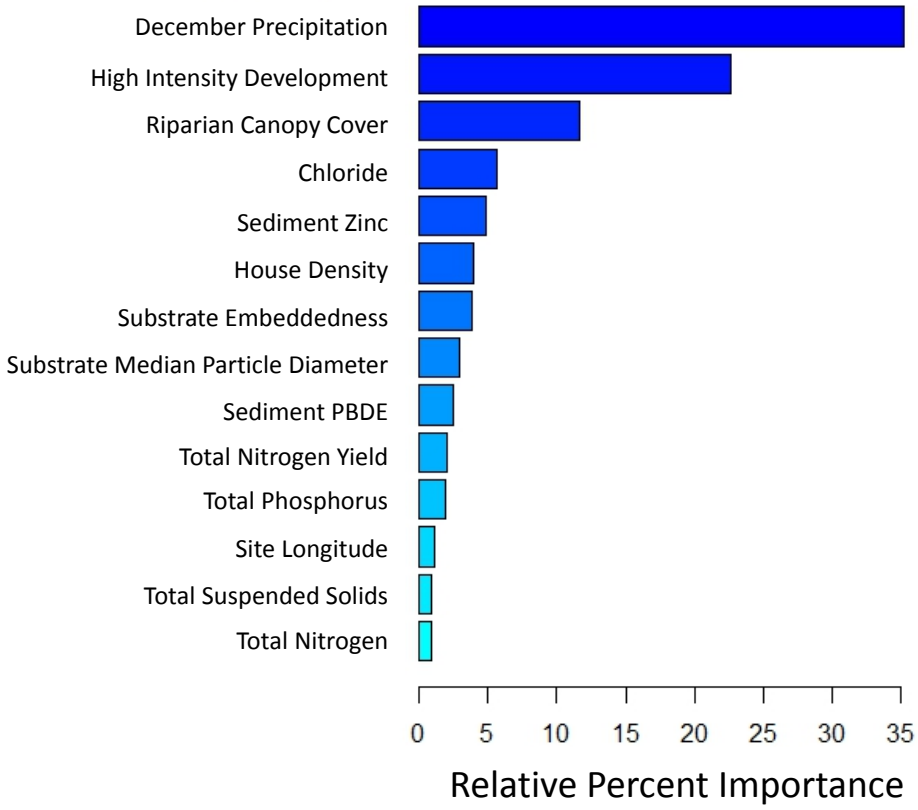
Relative Risk and Attributable Risk (RR/AR)

- **Relative risk**: ratio of the probability of poor condition taking place in a poor location to probability of poor condition taking place in good location

- **Attributable risk** : if a stressor condition is suddenly changed to not poor, what is the expected reduction in extent of the poor condition

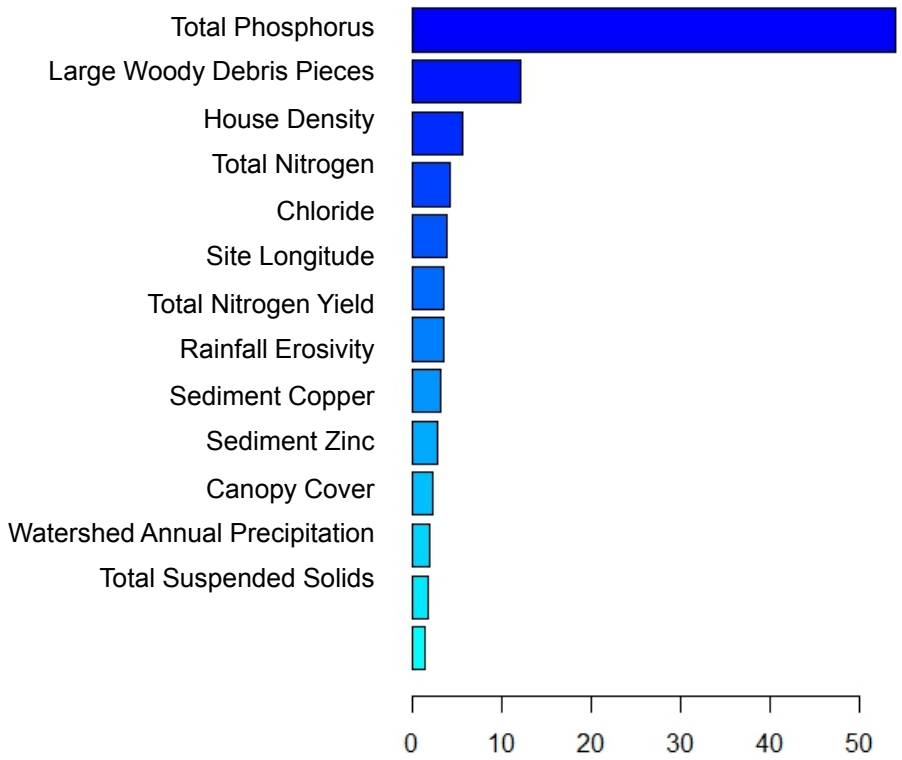
Boosted Regression Tree Model of BIBI scores

- Natural variables
  - Mean December precipitation
  - Longitude
- Human variables
  - High Intensity Development
  - Riparian Canopy Cover
  - Chloride in water
  - Zinc in sediment
  - House density
  - Stream embeddedness
  - Etc

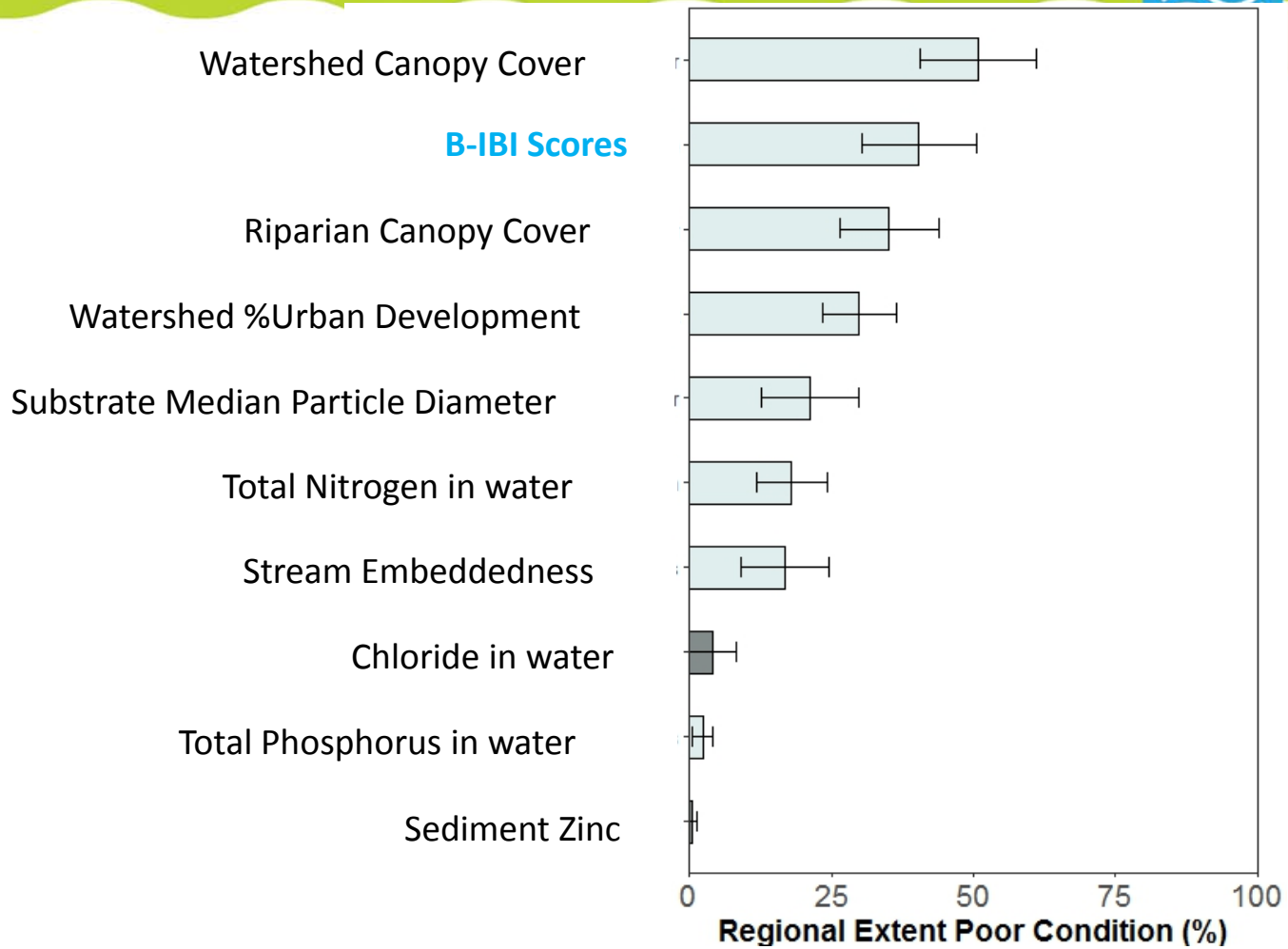


Boosted Regression Tree model of Trophic Diatom Index

- Natural variables
  - Longitude
- Human variables
  - Total Phosphorus
  - Large Wood Volume
  - House Density
  - Total Nitrogen
  - Chloride
  - Watershed Total Nitrogen Yield
  - Etc

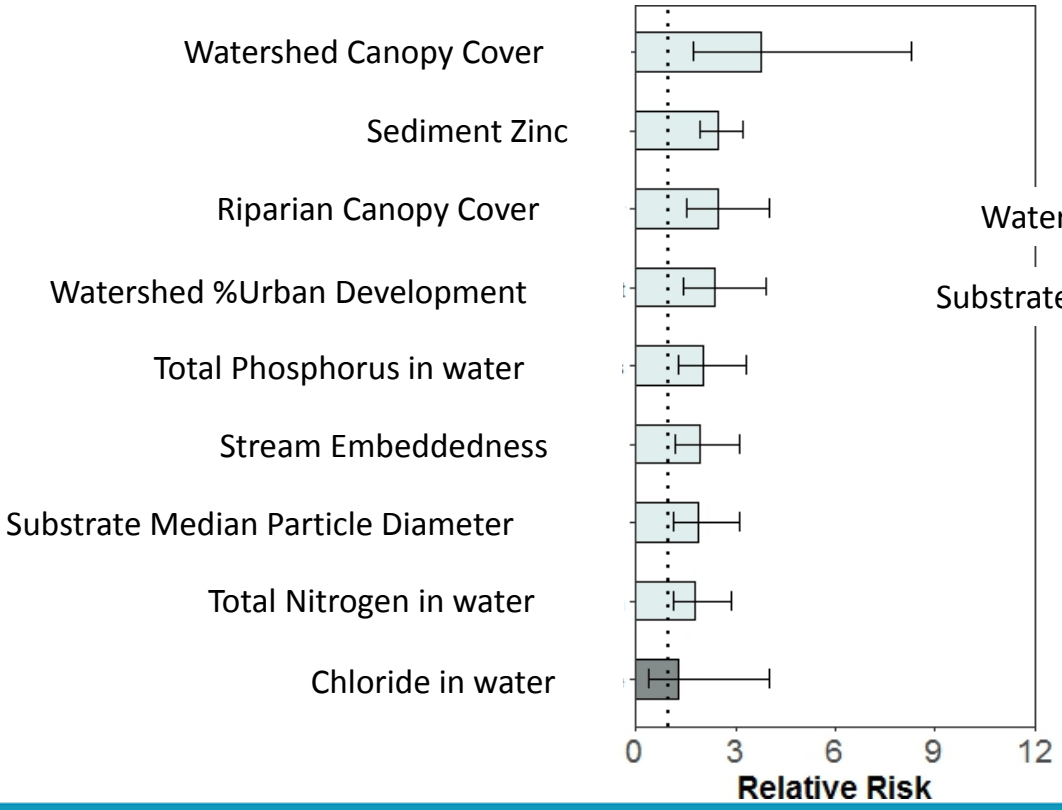


Extent of poor condition for BIBI

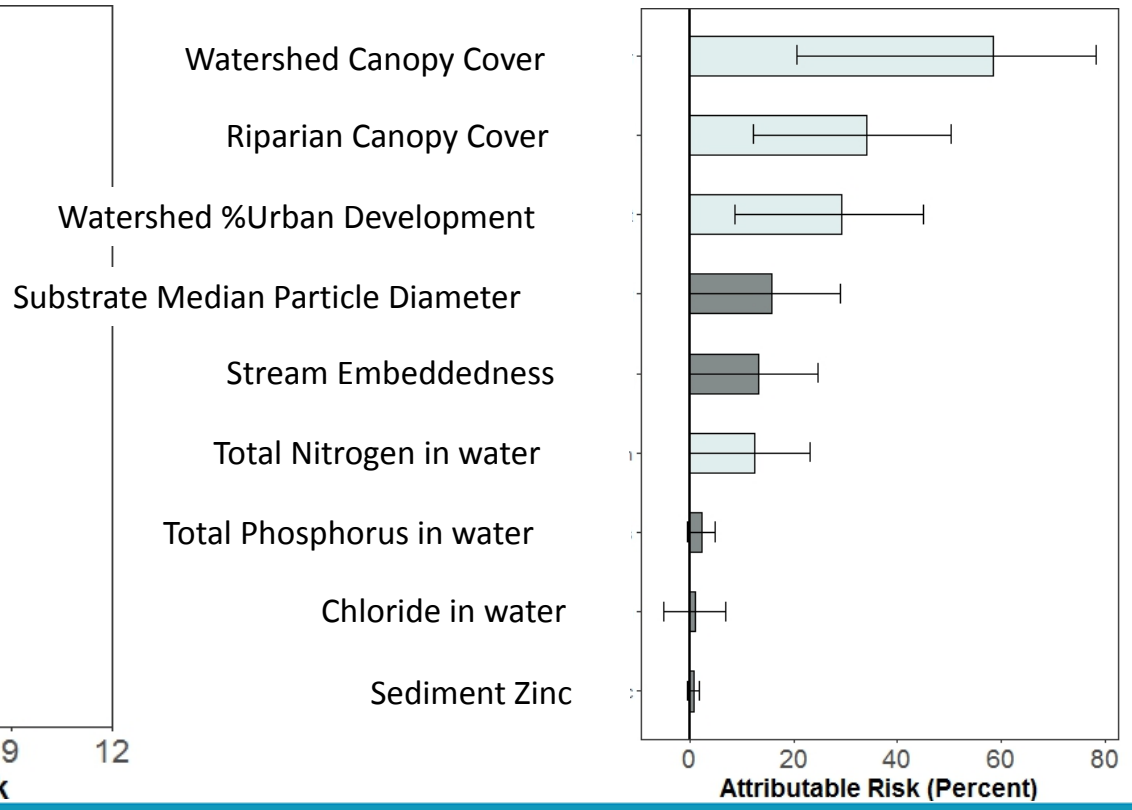


RR/AR for B-IBI scores

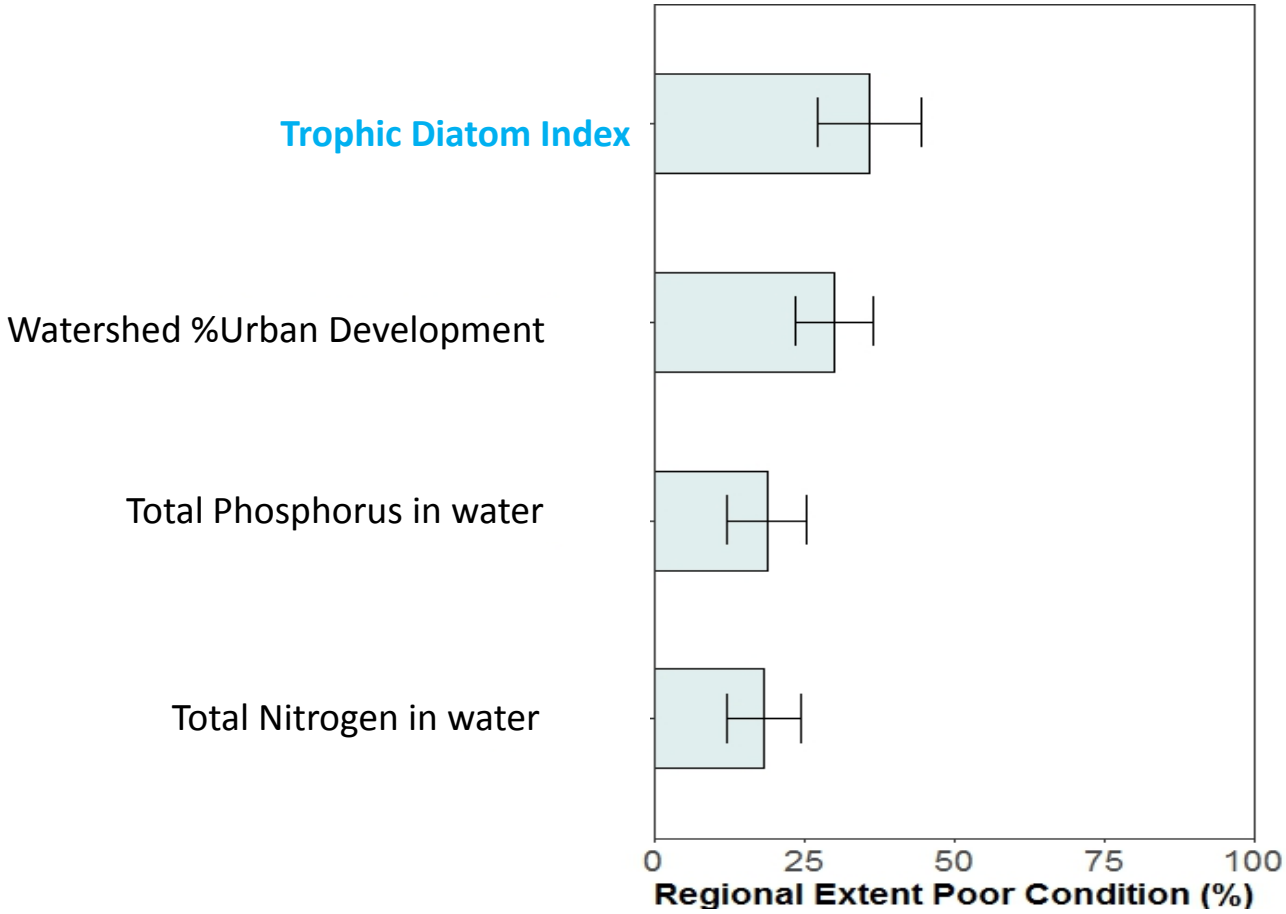
Relative Risk



Attributable Risk

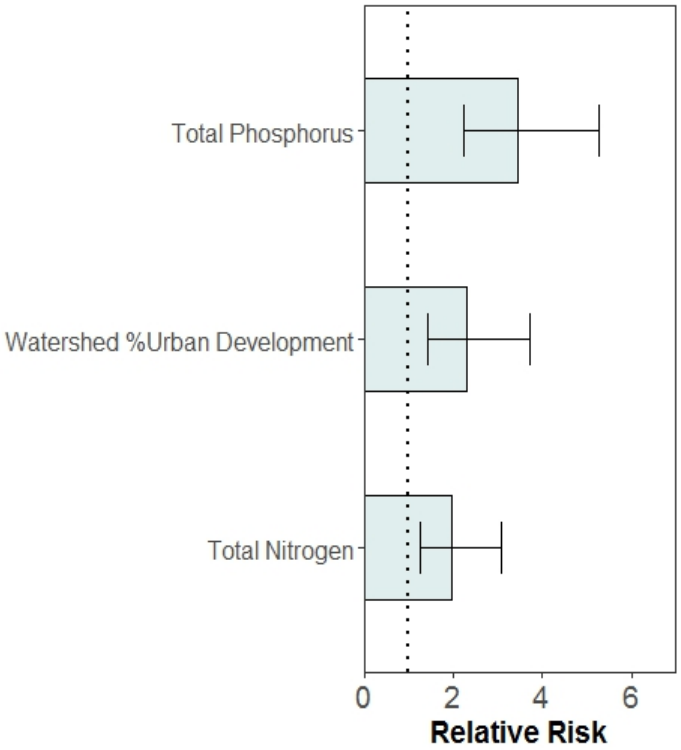


Extent of poor condition for TDI

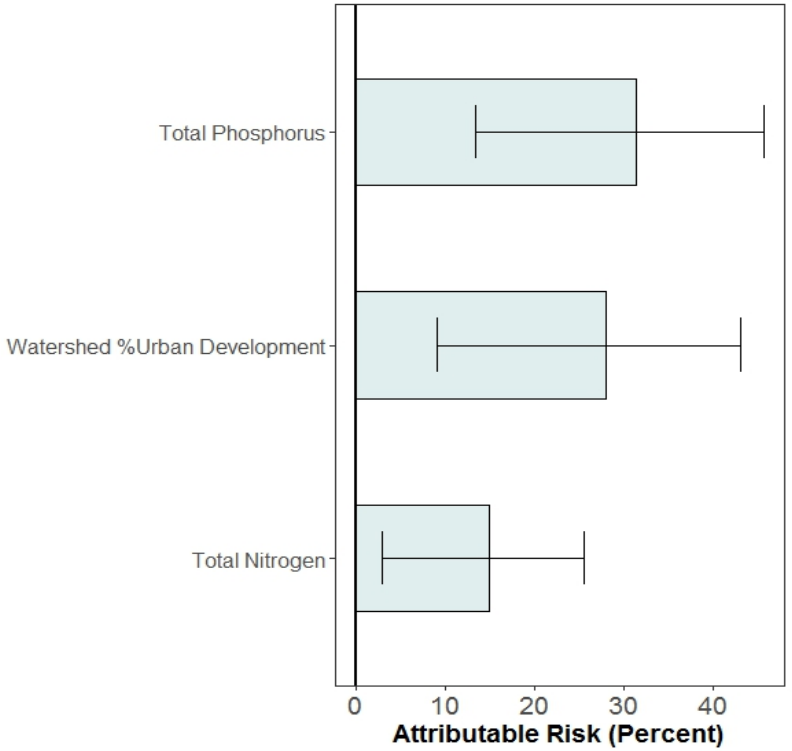


RR/AR for TDI scores

Relative Risk



Attributable Risk



Conclusions

- Results from the first round of small streams monitoring was successful and began to identify important factors leading to poor biological condition.
- Several factors of development have been shown to lead to poorer biological conditions.
- Next round of sampling will begin in 2020
- Modifications to the program are intended to efficiently identify trends for biological condition for Puget Lowland streams
- Information will provide stormwater managers with tools to help maintain and improve biological condition in their jurisdictions.

Questions?

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