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

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Speaker
Richard Sheibley, Curtis DeGasperi, Chad Larson, Brandi Lubliner, Leska S. Fore, and Keunyea Song

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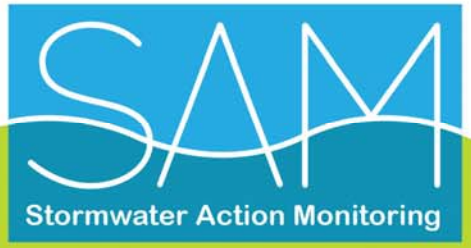
# Assessing biological condition in small streams of the Puget Sound Lowlands through collaborative regional monitoring

Curtis DeGasperi, King County; Rich Sheibley, USGS; Chad Larson and Keunyea Song, Brandi Lubliner, Ecology



# 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

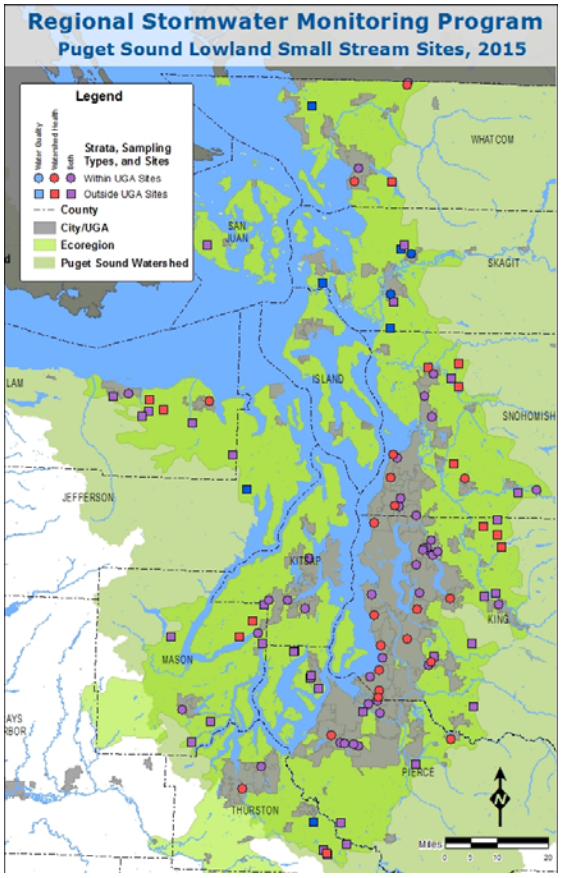
- Analogous to **modern** polling methods
- A complete census is not possible
- Survey-based sampling is efficient and provides confidence bounds on results
- Selection from the Washington Master Sample list

**We avoided this:**

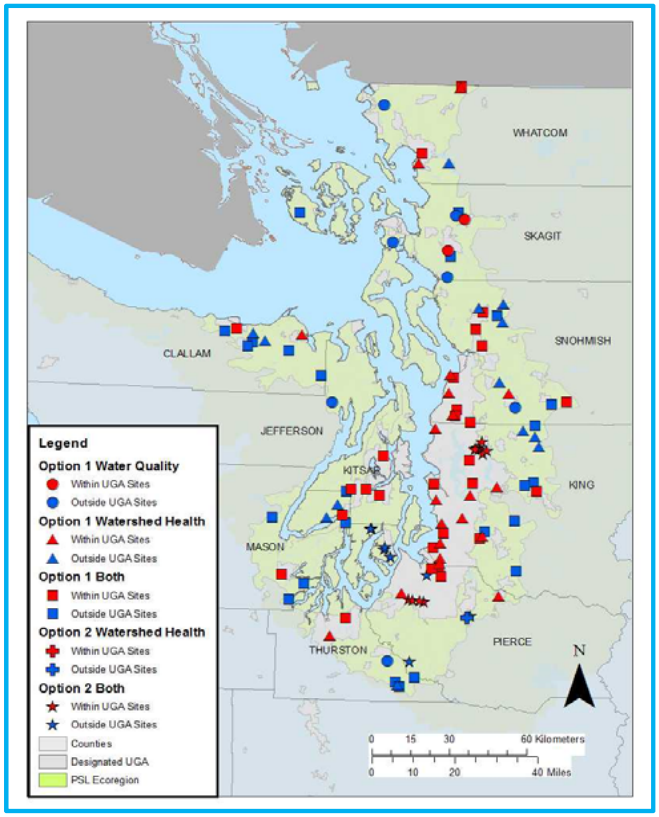

Prior to the 1948 presidential election, polling methods were not based on random polling.

# 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

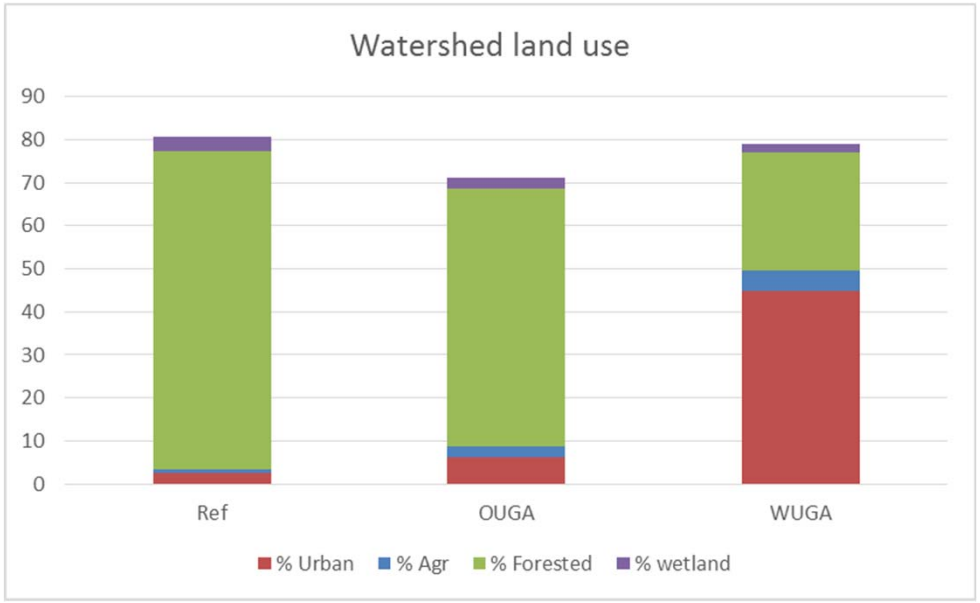
Monthly water quality sampling attempted at 80 sites, but with mixed success due to unusually low flows in 2015

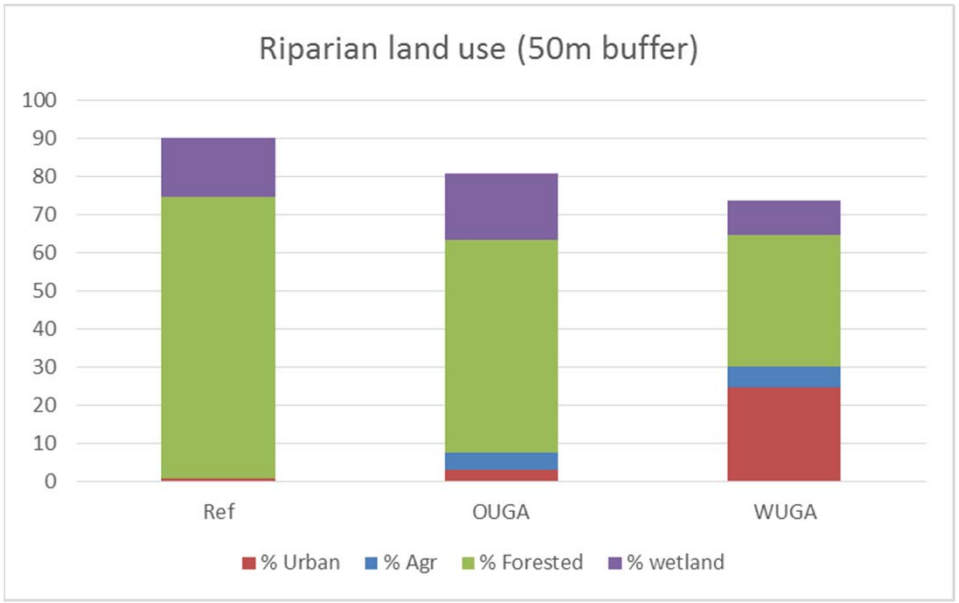
Sampling was also spatially balanced

# 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 |

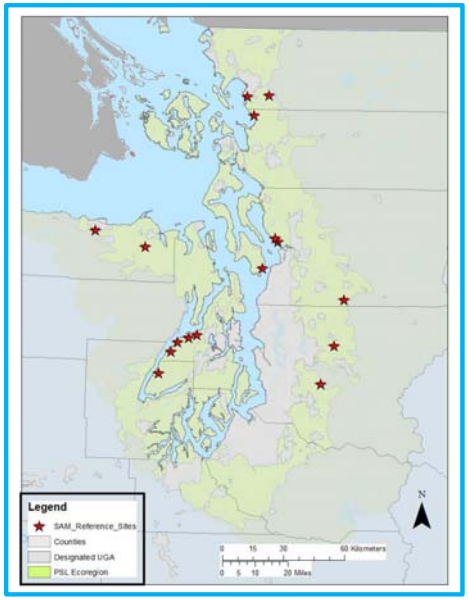
| Parameter | Detection Frequency | |
|---|---|---|
| | Outside UGA | Within UGA |
| Arsenic | A | A |
| Cadmium | A | A |
| Chromium | A | A |
| Copper | A | A |
| Dichlobenil | A | A |
| Lead | A | A |
| Retene | A | A |
| Total PBDE | A | A |
| Total PCB | A | A |
| Zinc | A | A |
| Bis(2-Ethylhexyl)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



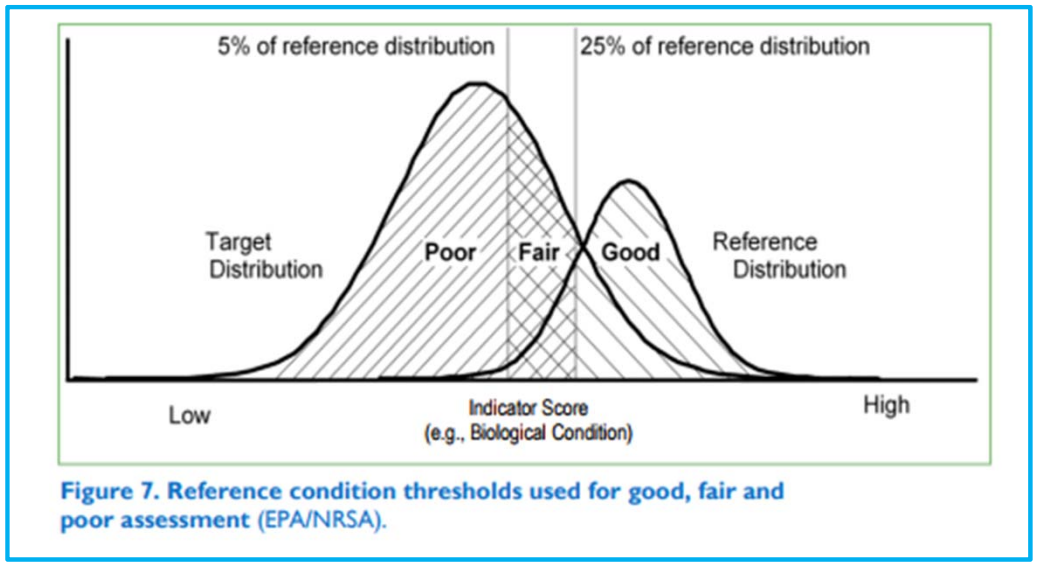
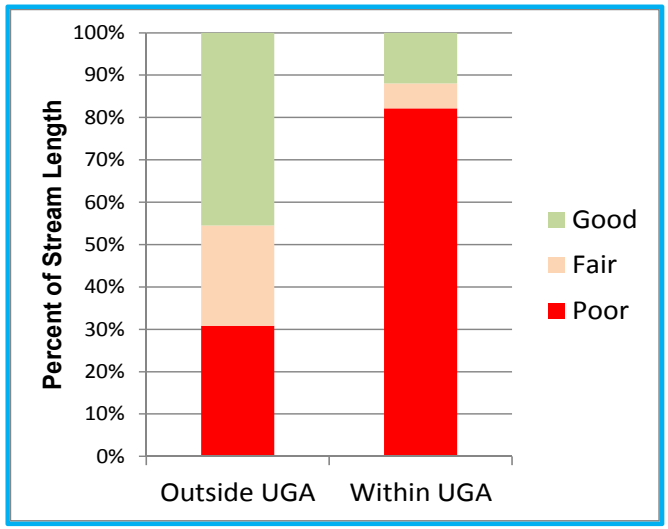




**Figure 7. Reference condition thresholds used for good, fair and poor assessment** (EPA/NRSA).

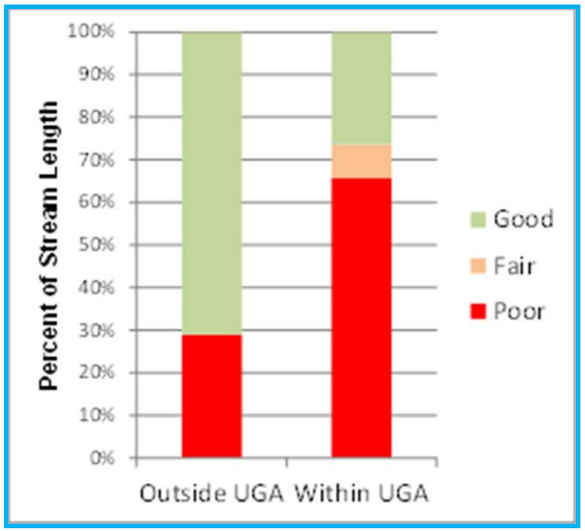
# Biological Status

- 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

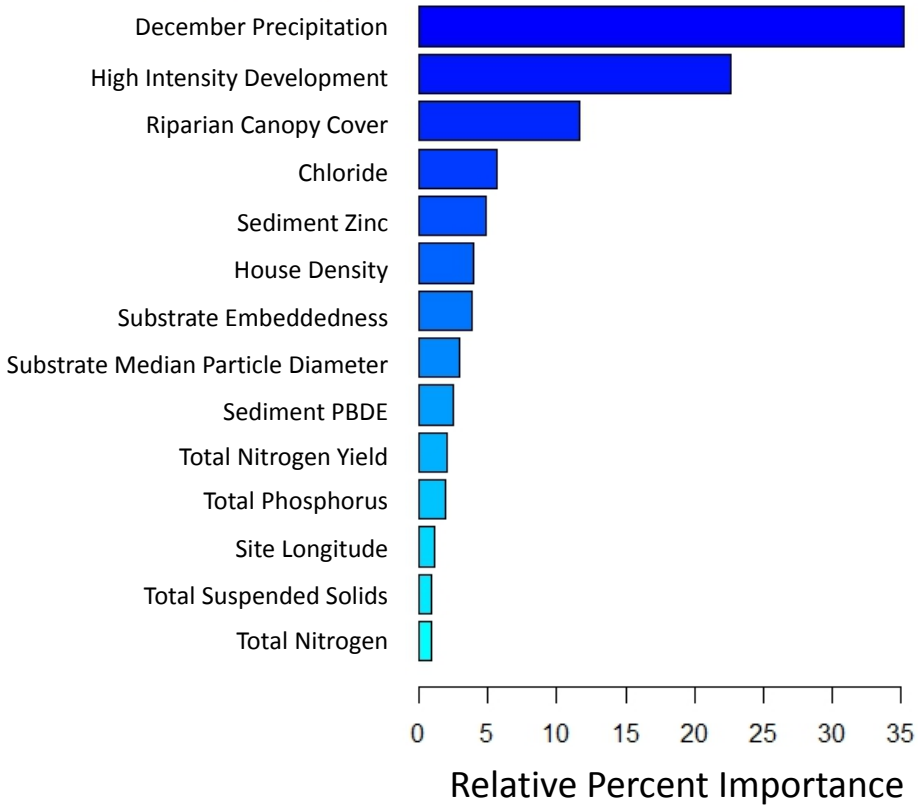
# Relative Risk and Attributable Risk (RR/AR)

- **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

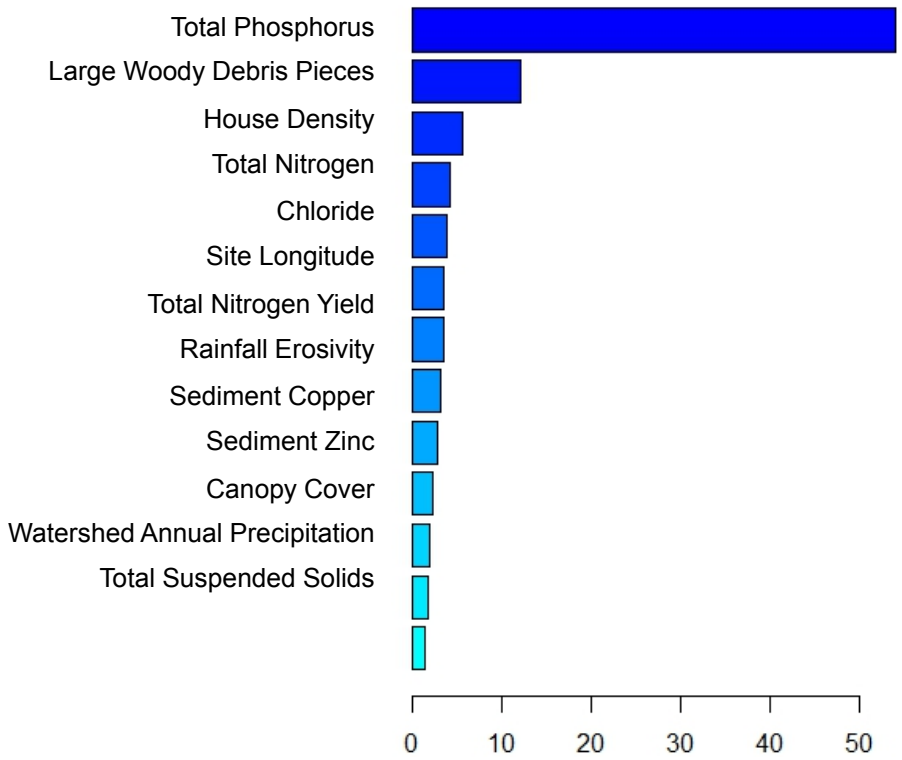
# Boosted Regression Tree Model of BIBI scores

- 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

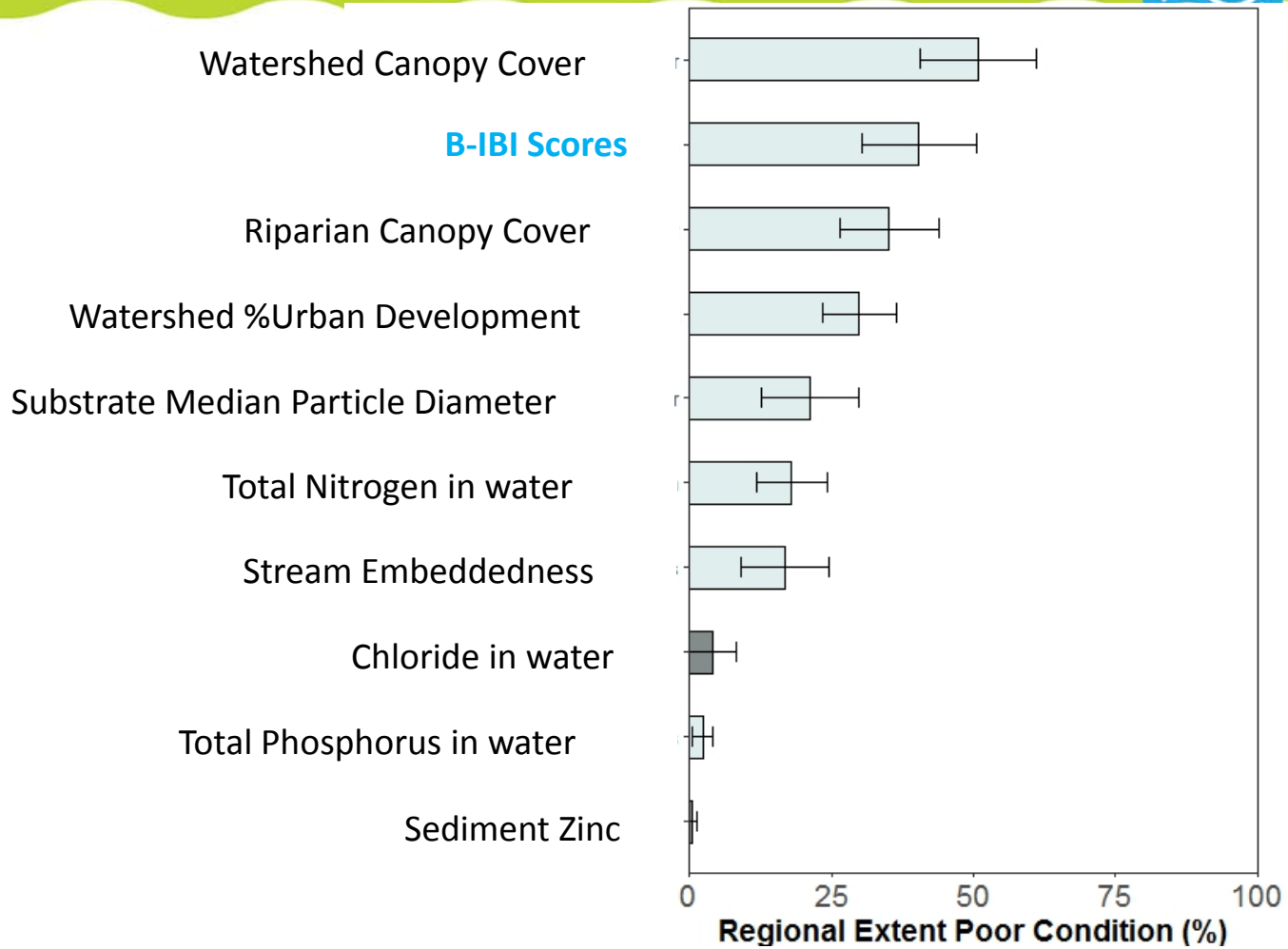


# Boosted Regression Tree model of Trophic Diatom Index

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

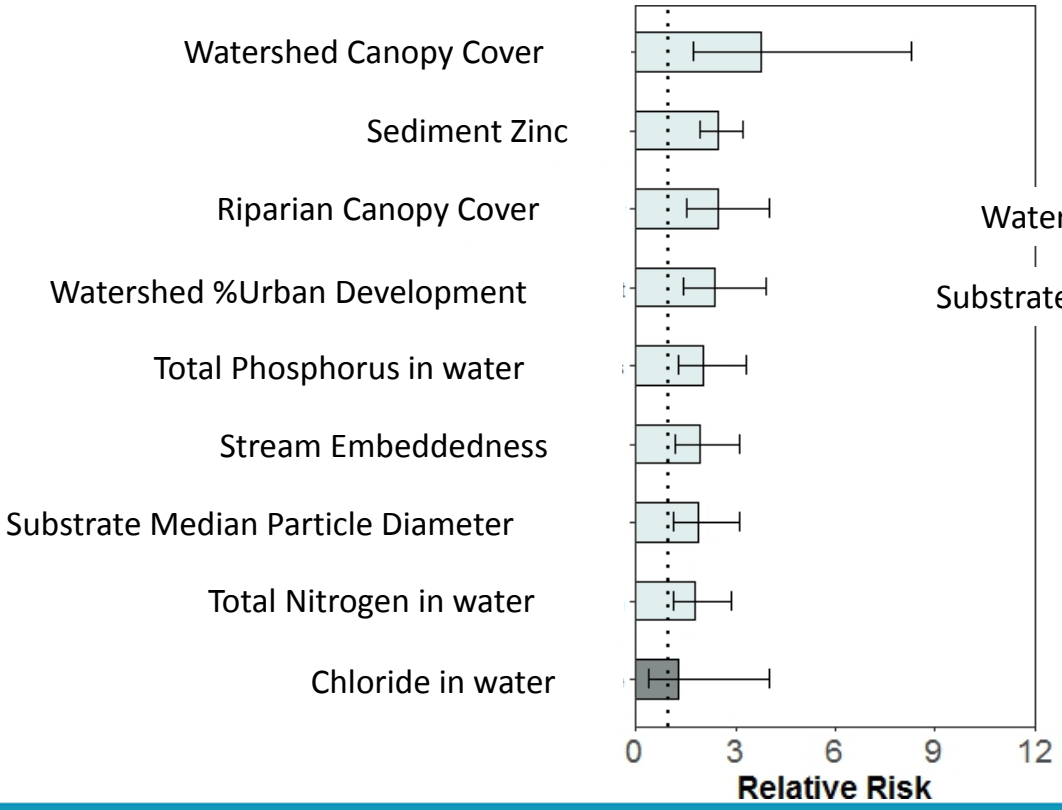


# Extent of poor condition for BIBI

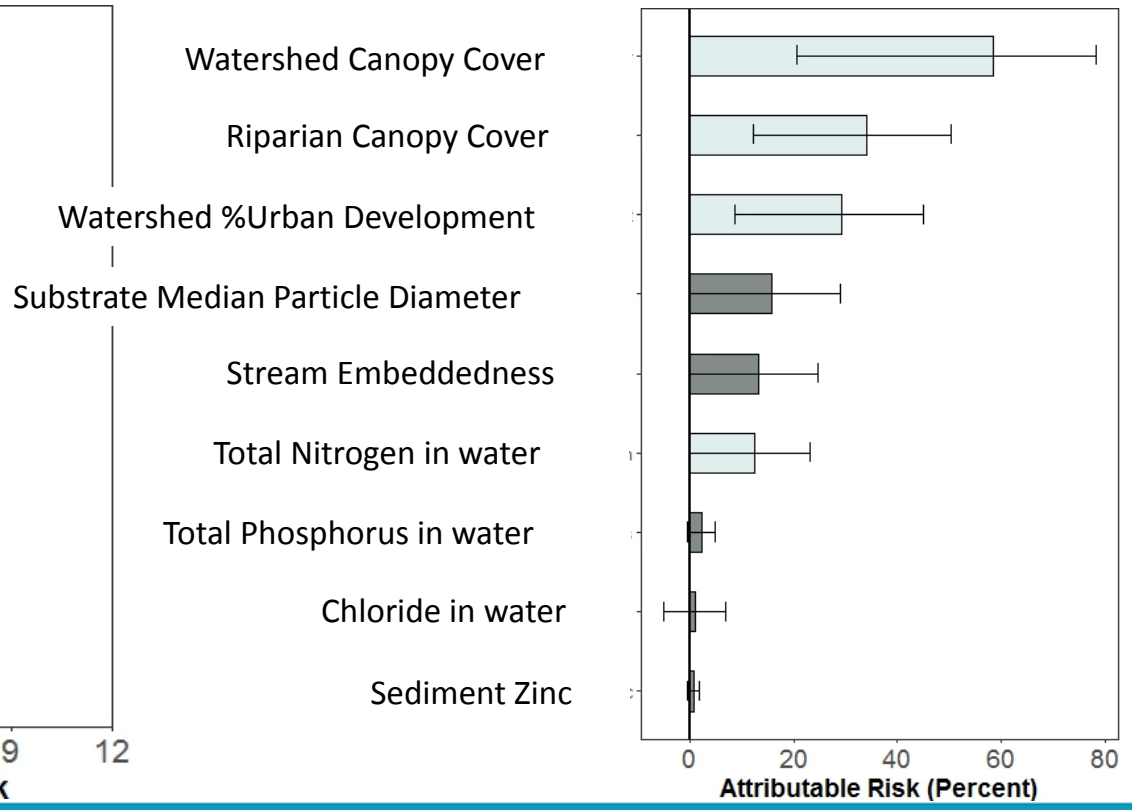


# RR/AR for B-IBI scores

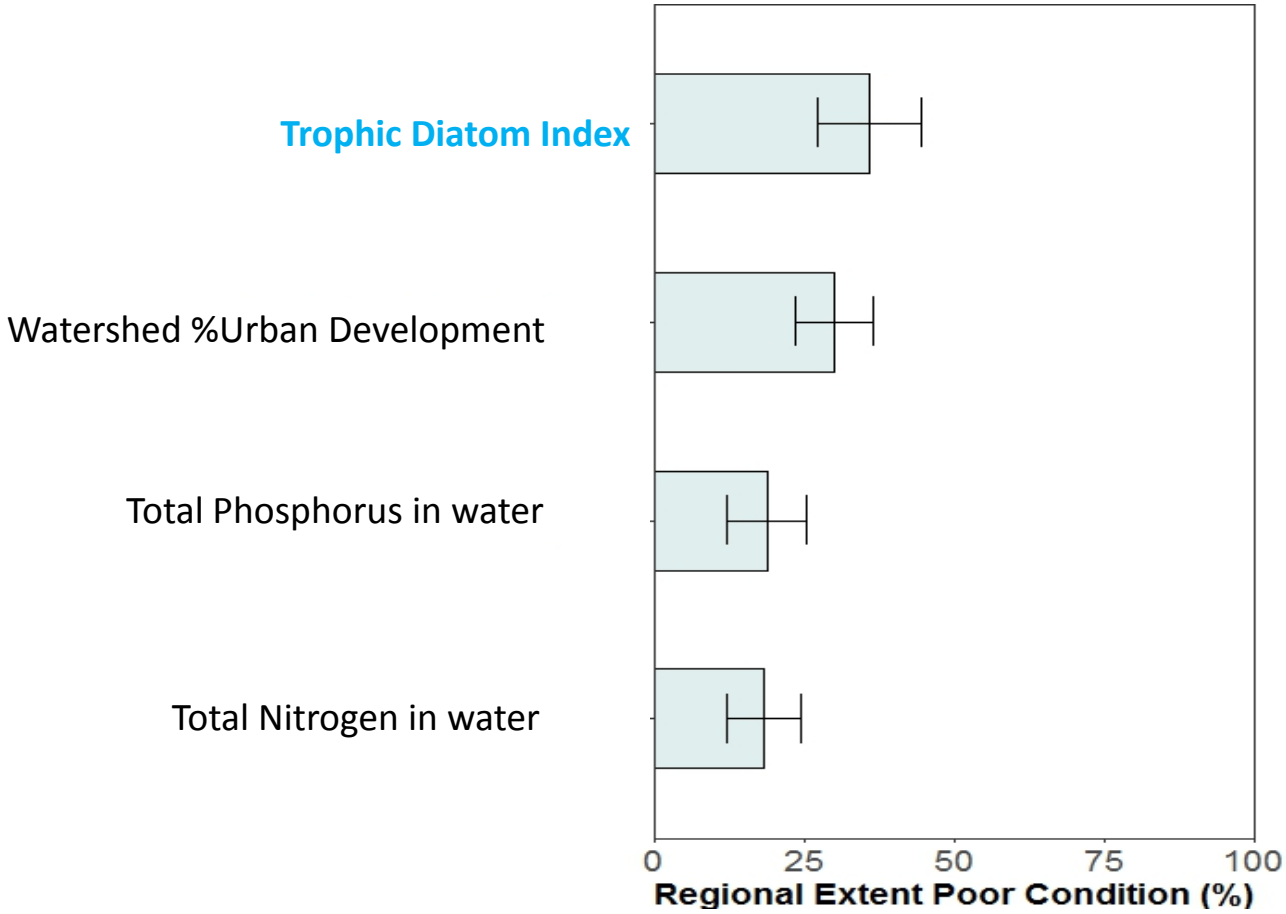
## Relative Risk




## Attributable Risk

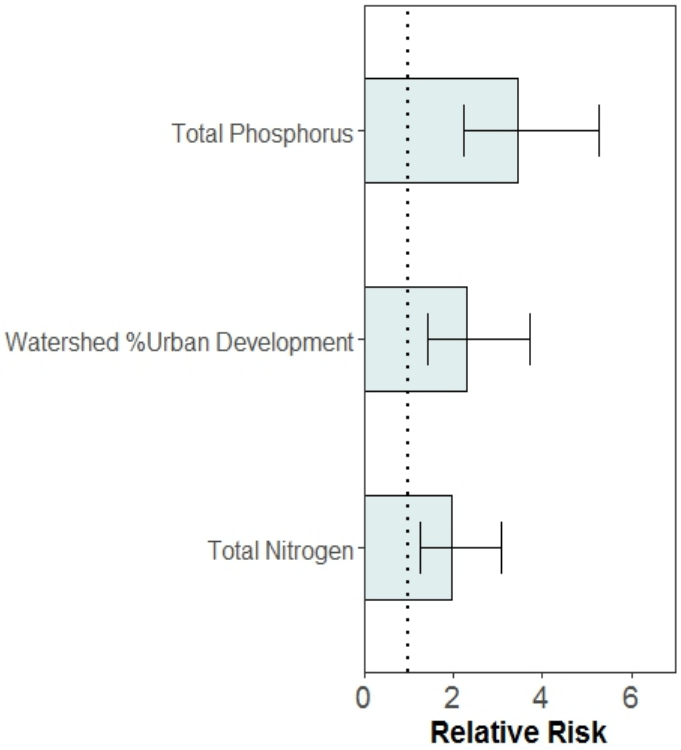


# Extent of poor condition for TDI

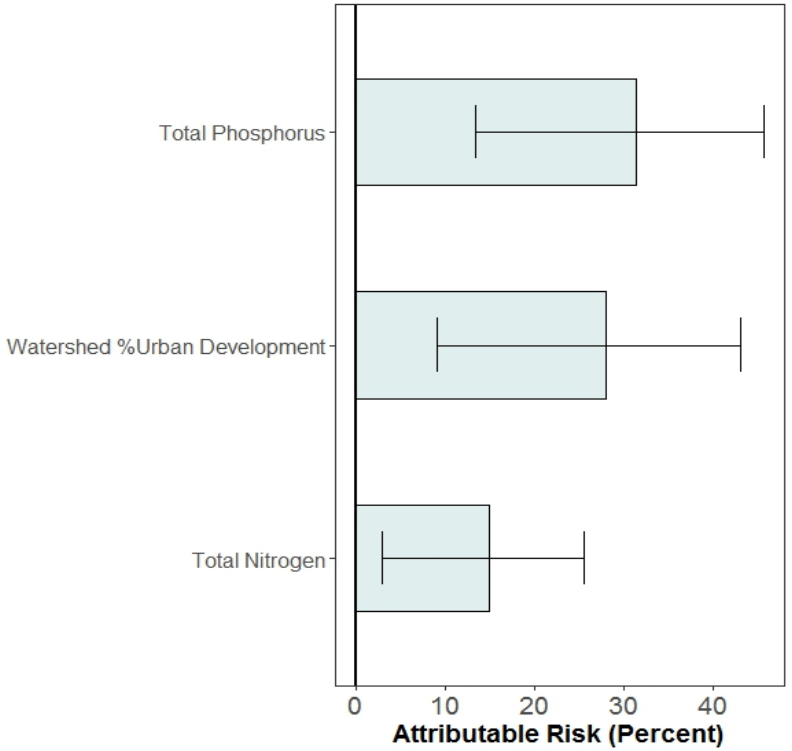


# RR/AR for TDI scores

## 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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