Regional Assessment of Sediment Quality in Puget Sound Lowland Streams

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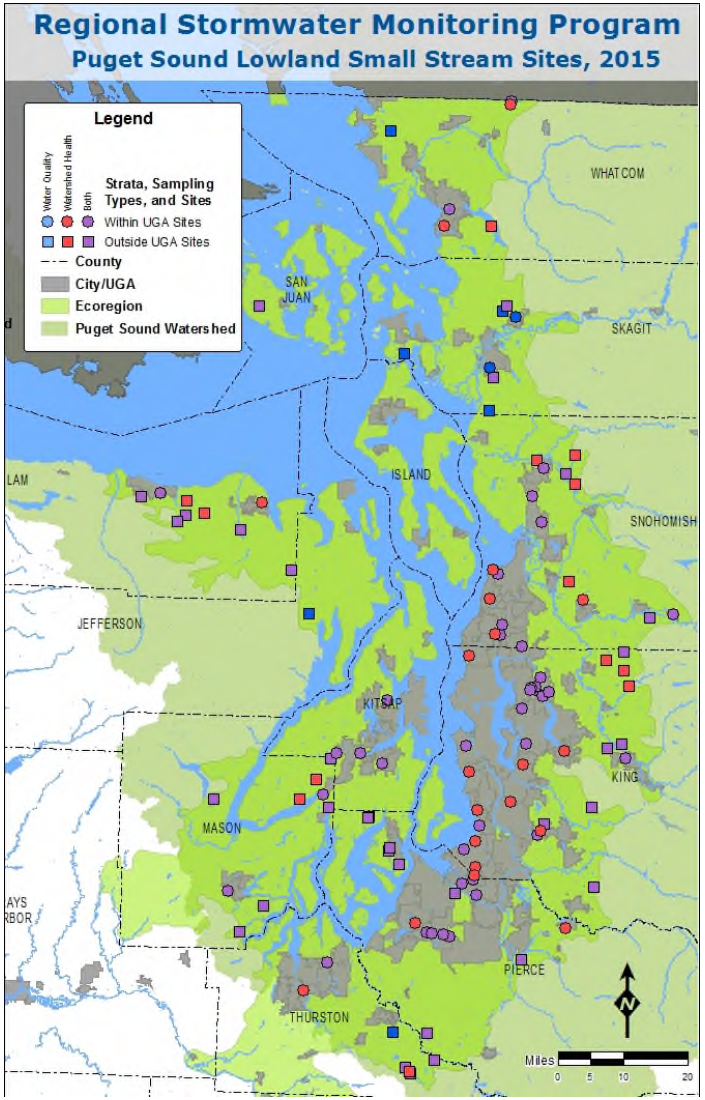
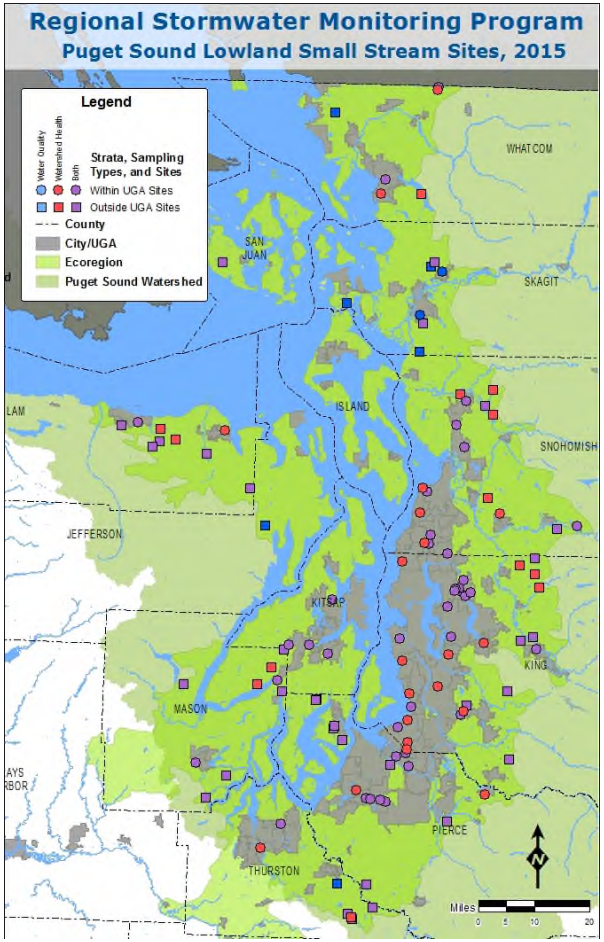
Collaborative regional monitoring project

- Funded by over 90 phase 1 and 2 municipal stormwater permittees and the ports
- Satisfies local requirements for NPDES permits
- Focus on the status and trends of receiving waters

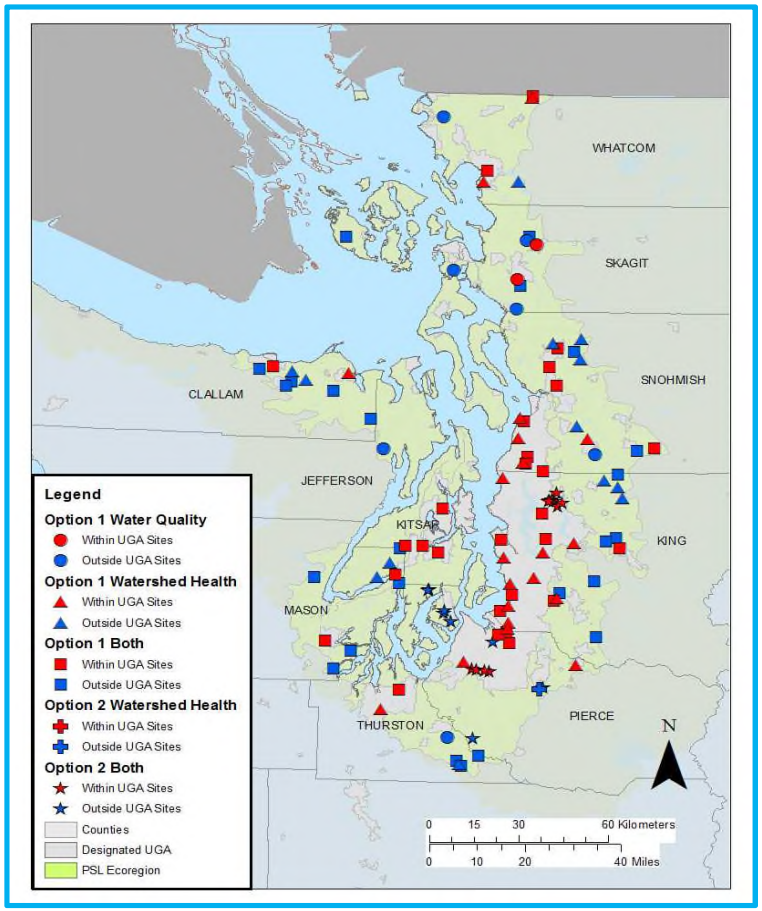


Sampled small Puget Lowland Streams within and outside urban growth areas (UGAs) for:

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



Sites Within and Outside Urban Growth Areas



Urban Growth Area (UGA) used as a proxy for urbanization

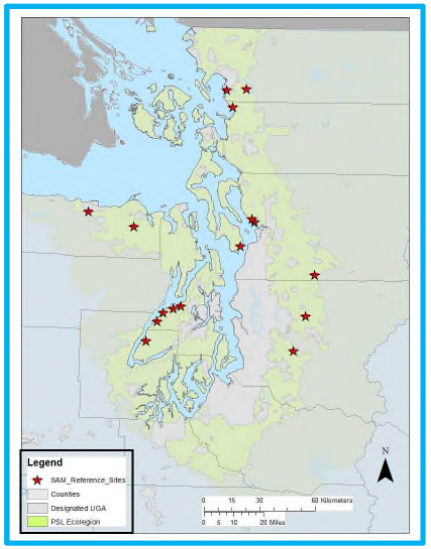
Sampling was probabilistic and spatially balanced

A total of 105 sediment chemistry sites

Design allows extrapolation to unsampled areas

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)



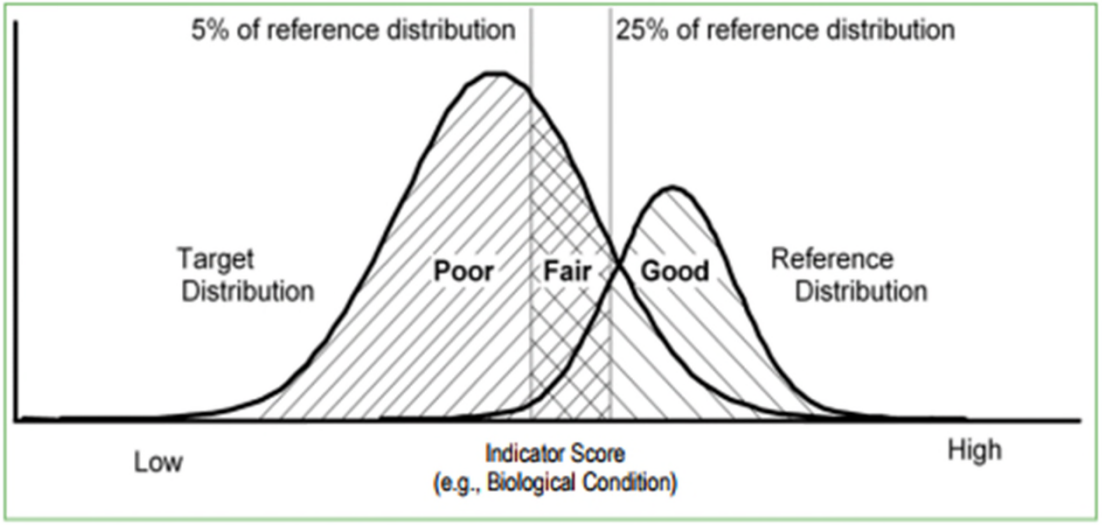
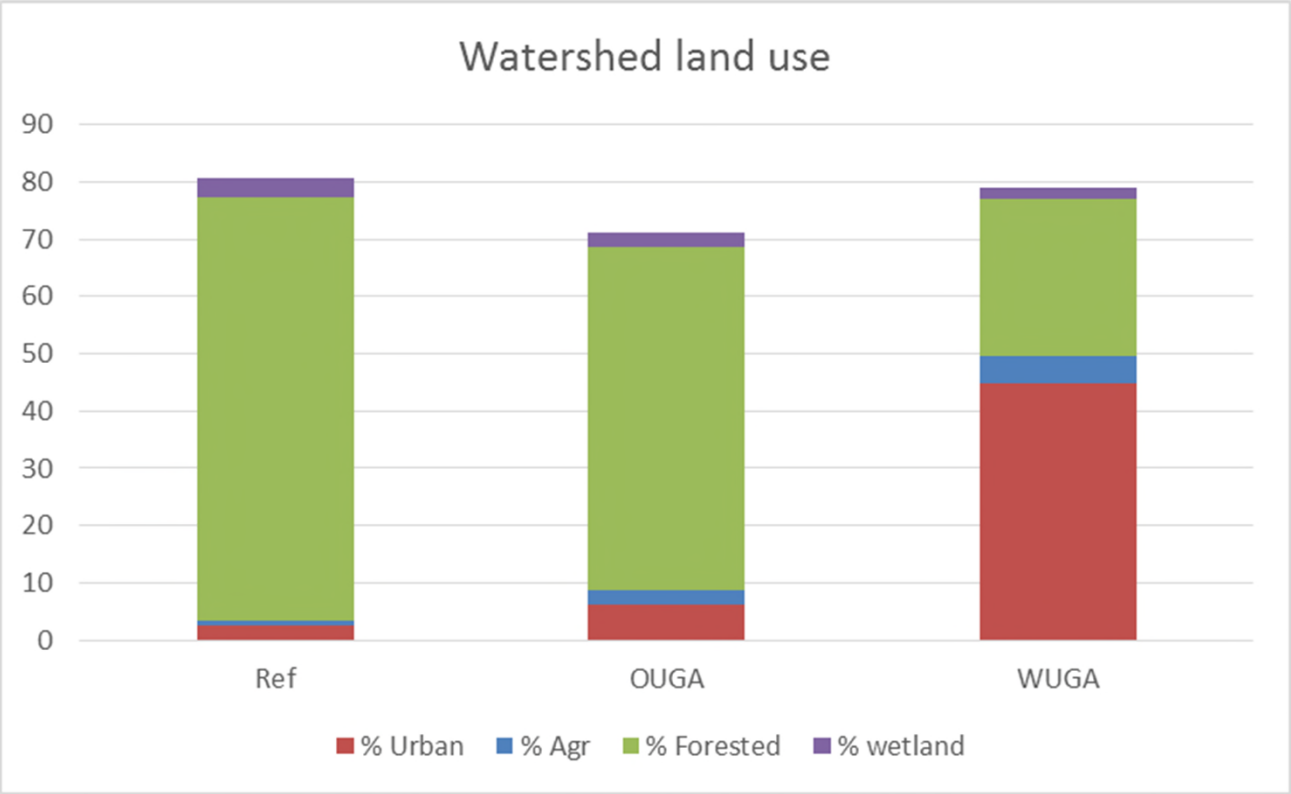


Figure 7. Reference condition thresholds used for good, fair and poor assessment (EPA/NRSA).

Sediment chemistry thresholds

- Focused on 6 metals (As, Cd, Cr, Cu, Pb, Zn) and total PCBs, PAHs, PBDEs, dichlobenil
- Most frequently detected across all sites
- Used MacDonald (2002) for determining good, fair, poor designations

Land cover summary within and outside UGAs



OUGA = Outside UGA

WUGA = within UGA

Detection Frequency in Sediment

Parameter	Detection Frequency Outside UGA	Detection Frequency 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

Parameter	Detection Frequency Outside UGA	Detection Frequency 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

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

Detection Frequency

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

Water

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

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

Sediment

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Arsenic	A	A
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Total PAH	C	A
Triclopyr	C	C

Comparison to sediment quality standards

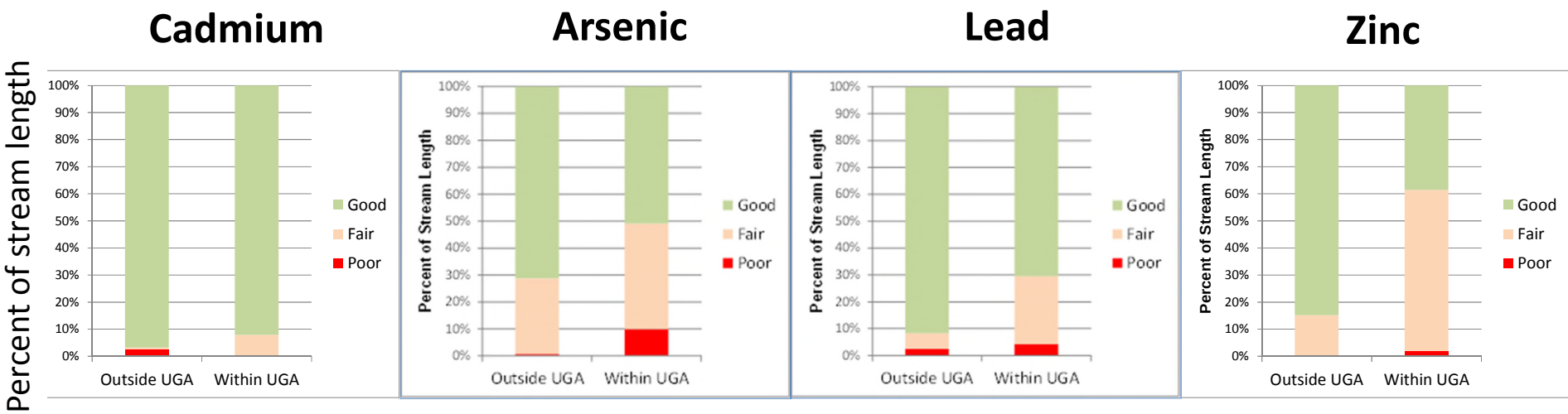
- Measured sediment contaminant concentrations did not typically exceed sediment quality standards within or outside UGAs

Big Questions

- Status: How bad is it?
- Trends: Are things getting better or worse? (come back in 10 years!)

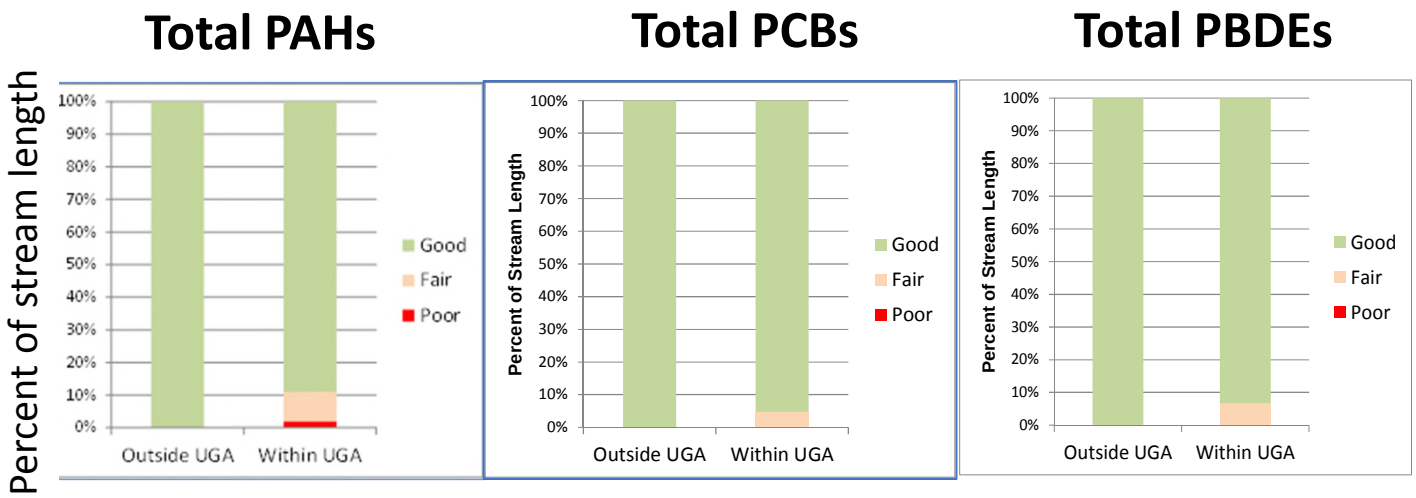
Sediment Quality Status - Metals

- Cadmium, arsenic, lead, and zinc concentrations elevated within UGAs
- Limited extent of stream length classified in Poor condition



Sediment Quality Status - Organics

- Highest concentrations of tPAH, tPCB, and tPBDE were found within UGAs
- Very limited extent of stream length classified in Poor condition

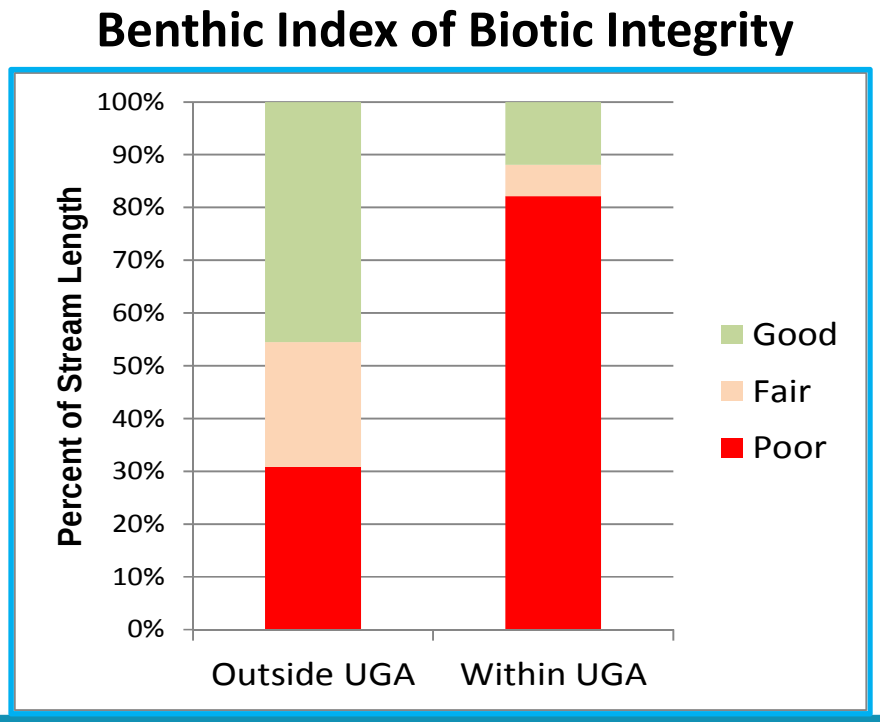


A logical question

- What are the causes of poor biological condition?

Biological Status

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

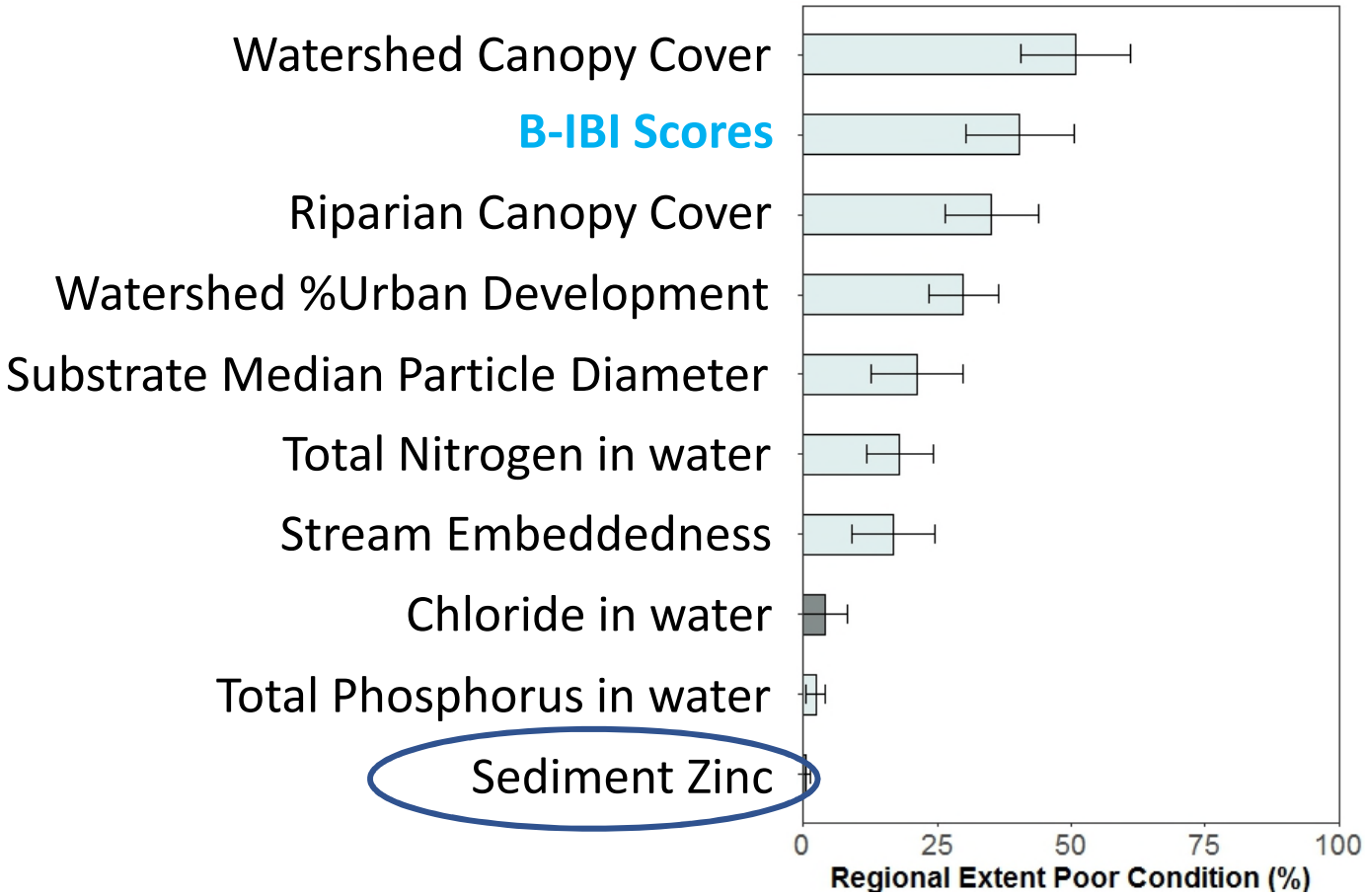


Methods for looking at causes

- Relative risk – Attributable Risk
  - Assumes causal relationship between stressor and biological response
  - Assumes the effects of multiple stressors are independent and act in isolation from other stressors
- Boosted regression trees
  - Good for models with a lot of variables shows relative importance

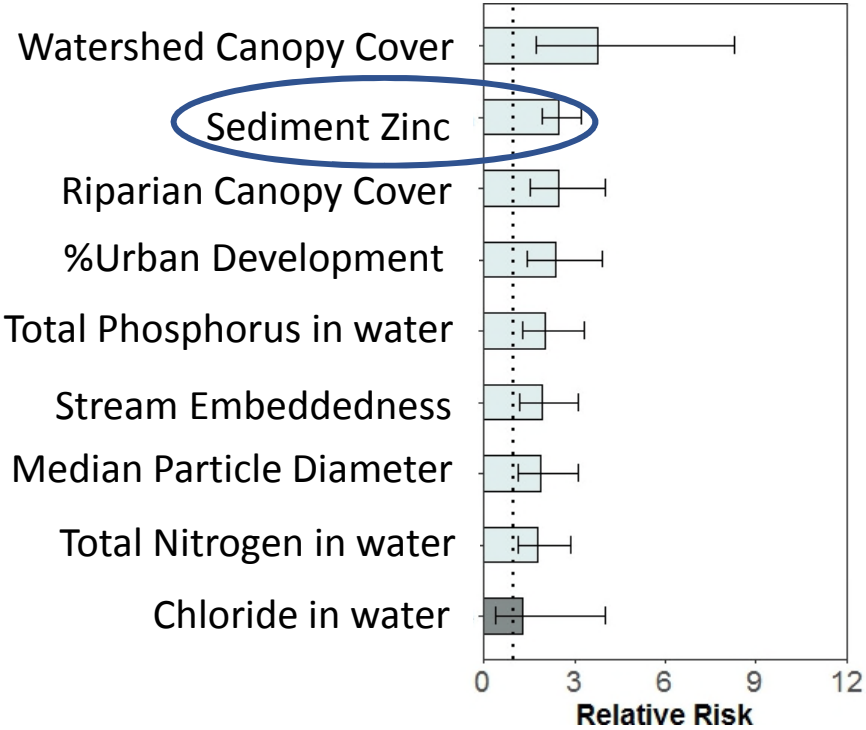
Stressor → Biological Response

Extent of poor condition



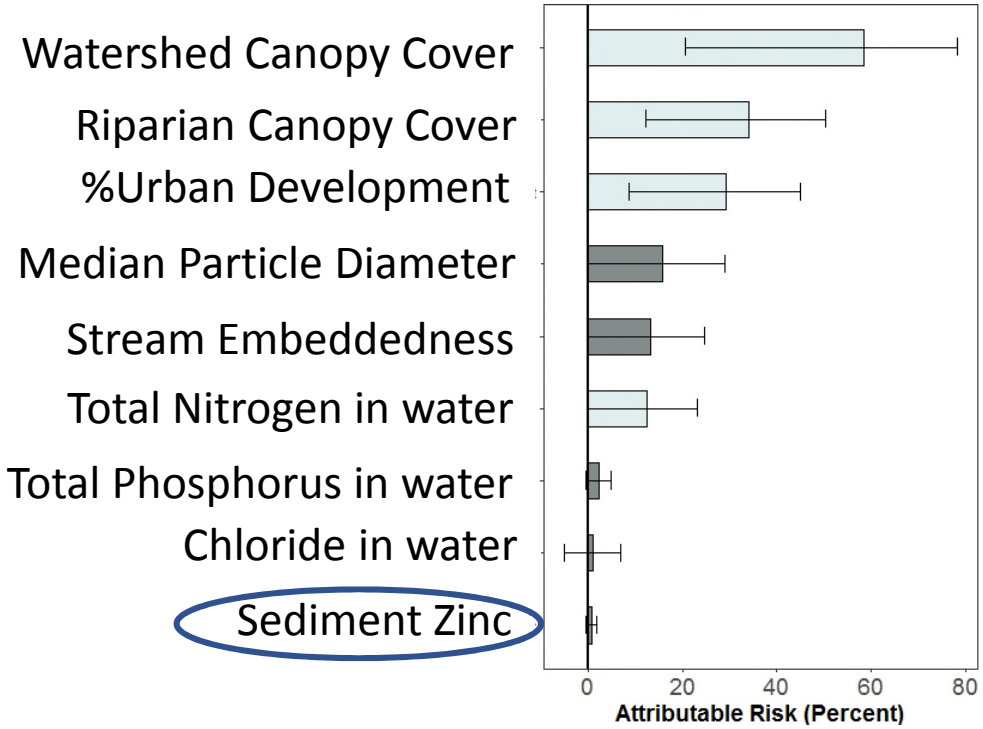
RR/AR for B-IBI scores

Relative Risk



Local effects

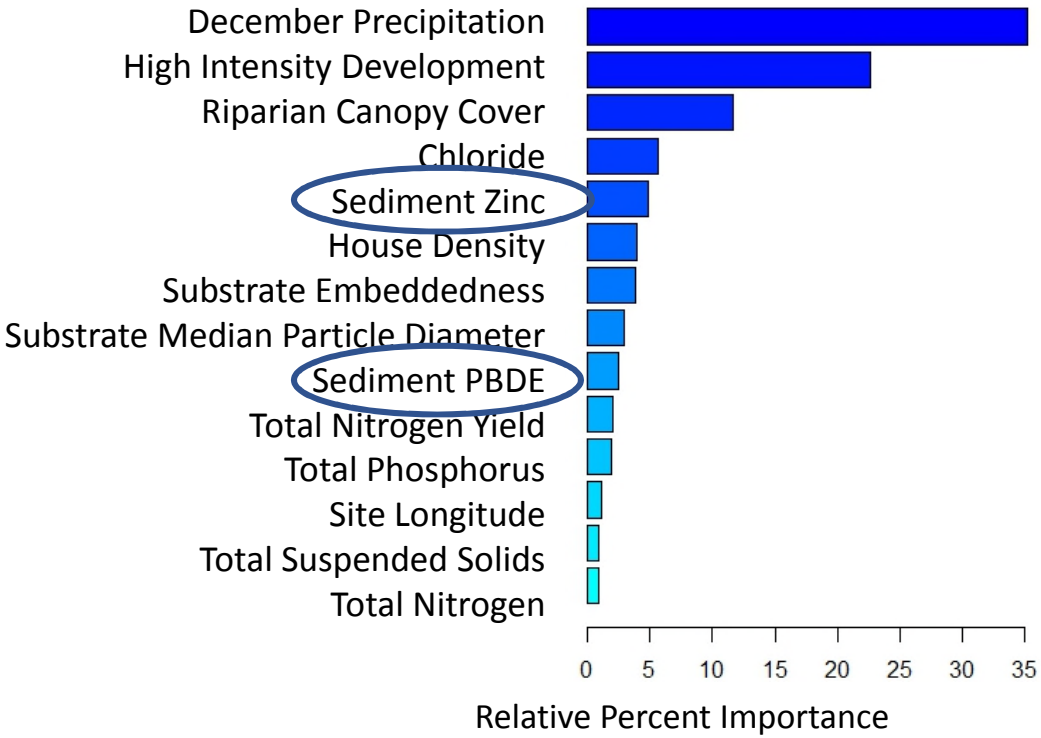
Attributable Risk



Regional effects

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
  - Sediment PBDEs
  - House density
  - Stream embeddedness
  - Etc



Key Findings

- Many of the sediment chemistry parameters were infrequently detected
- Common parameters found in sediments were metals, total organics (PCBs, PAHs, PBDEs) and a dichlobenil
- At the local scale sediment zinc contamination and stream substrate character were found to be important stressors to B-IBI
- Next round of sampling is in 2020 and sediment chemistry will continue

Questions?