Oregon's National Rivers and Streams Assessment 2008-2009

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DEQ is a leader in restoring, maintaining and enhancing the quality of Oregon's air, land and water.

State of Oregon
Department of Environmental Quality

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Executive Summary

This report estimates the overall ecological conditions of rivers and streams throughout Oregon and ranks the relative impact of stressors on them. It is based on data that the Oregon Department of Environmental Quality collected during the summers of 2008 and 2009 as part of the National Rivers and Streams Assessment. The results are based on evaluations of water quality, biological, physical habitat and human health indicators at fifty randomly selected sites in Oregon. In addition, for a subset of sites, data on toxic compounds in fish tissue samples is assessed. DEQ evaluated each indicator using comparisons to conditions found at reference or least-impaired sites. The reference condition method is used to define condition class (good, fair, poor) in this assessment, as there are currently no numeric water quality standards for the indicators reported on.

Data from this assessment shows that the most widespread stressors to the ecological health of Oregon's rivers and streams are decreased availability of fish habitat, lack of adequate streamside vegetation cover, water clarity (turbidity), and higher levels of total phosphorus. Degradation to streamside vegetation poses the greatest risk to the condition of aquatic biological communities. While the estimated extent of stream miles in Oregon in poor condition for streamside vegetation is low, almost half of stream miles are categorized in fair condition. This is concerning, as a shift from fair into poor condition is expected to adversely affect the aquatic biological community. Mercury was found in all fish tissue samples, the banned pesticide DDT and/or its degradation products were found at almost all of the sites where tissue samples were taken. PCBs and PBDEs (flame retardants) were both detected in tissue collected at a majority of the sites. It is important to note that while these compounds were detected, in most cases they were below the levels considered to toxic/harmful to humans and aquatic life.

Key findings from this assessment:

- From 33 percent to 50 of stream miles assessed throughout the state are estimated to be in healthy biological condition, based three biological indicators; fish, macroinvertebrates (which include aquatic insects, clams, mussels, crustaceans, worms and other creatures that live in the streambed environment) and periphyton (bottom-dwelling algae).

- The most widespread stressors to the biological condition of rivers and streams in Oregon are:
    - General lack of fish habitat complexity
    - Lack of Streamside (riparian) canopy cover
    - Clarity of the water (turbidity) , typically caused by runoff and unstable stream banks
    - High phosphorus concentration, which can trigger algal growth and change water chemistry, typically the source of high phosphorus is runoff, although can be naturally occurring

- The most prominent threats to biological health of Oregon rivers and streams are:
    - Human disturbances to streamside areas
    - Lack of streamside canopy cover
    - Excess fine sediment in or on the streambed which can reduce habitat for juvenile fish, macroinvertebrates, and periphyton, typically caused by runoff and unstable stream banks

- Actions targeting protections of and improvements to streamside vegetation are likely to provide the most benefit to the aquatic biological communities evaluated measured in this study.

- Vulnerable populations of Oregonians—subsistence fishers, women of childbearing ages and children—are exposed to risks for mercury and PCBs when consuming certain fish species in certain areas of the state.

- The banned pesticide DDT was detected at low levels in over 90 percent fish tissue samples.

Introduction

Rivers and streams hold a special value to Oregonians. We rely on them for a variety of human uses including drinking water supplies, electrical power generation, crop irrigation and recreational activities such as fishing, boating and swimming. Ecologically, surface water ecosystems support communities of aquatic life, supply food and habitat to terrestrial species, and function to transport sediment and nutrients from the land to the ocean. Protecting the quality and health of rivers and streams so these uses can be maintained is important to the nation and to Oregonians.

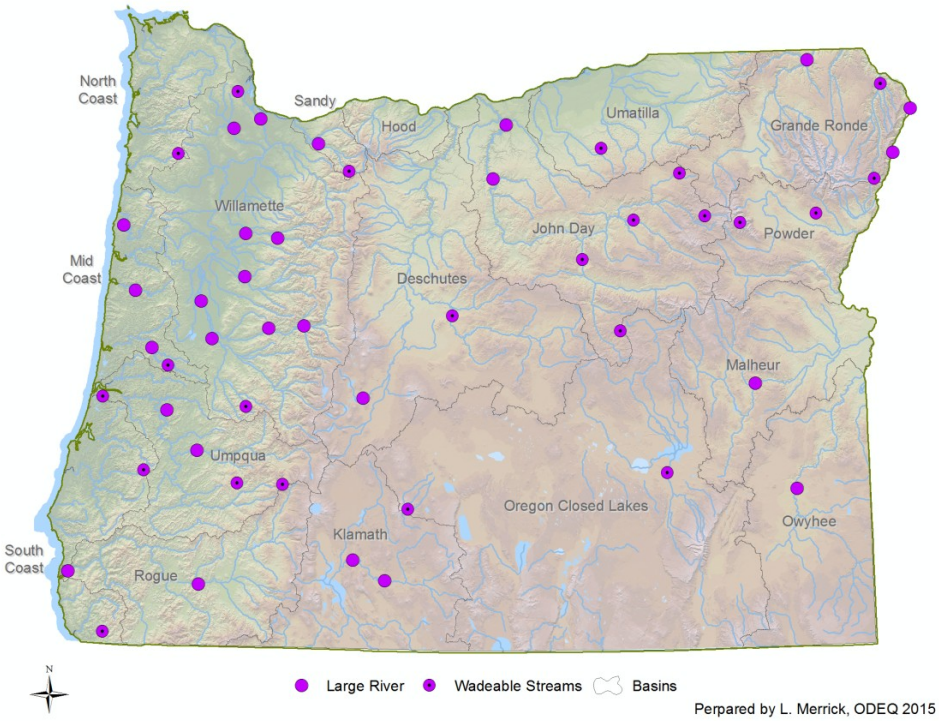

Figure 1. Sample Locations for the 2008-09 Oregon NRSA

This report presents the key findings for the National Rivers and Streams Assessment (NRSA) conducted in Oregon during the summers of 2008 and 2009. The goal of the NRSA is to assess the ecological condition of rivers and streams throughout the nation and identify the stressors that have the greatest impact on them. This survey was the first of its kind to cover the full range of Oregon's flowing waters, from the largest rivers in highly urbanized centers to small headwater streams in wilderness areas (Figure 1).

National Aquatic Resource Surveys

The National Rivers and Streams Assessment is part of the U.S. Environmental Protection Agency Office of Water's National Aquatic Resource Surveys (NARS). These aquatic resource surveys are nationally consistent probability-based surveys of the nation's surface waters. Survey results inform state and federal resource managers and the public on conditions in the nation's waters and guide decisions on how best to protect, maintain and restore those waters. The surveys are conducted on a five-year rotation of surface water body types including: lakes and reservoirs, rivers and streams, coastal waters, and wetlands. They are used to report to Congress on the ecological conditions of surface waters and our progress toward meeting federal Clean Water Act goals "…. to restore and maintain the chemical, physical, and biological integrity of the nation's waters" (GAO, 2000). DEQ has participated in all five years of the first round of these surveys and is continuing into round two. The NARS program is designed to answer the following questions (EPA, 2013):

- *What's the extent of waters that support a healthy biological condition, recreation and fish consumption?*
- *How widespread are the major stressors that affect ecological health?*
- *Are we investing wisely in water resource restoration and protection?*
- *Are our waters getting cleaner?*

Nationally Unified Approach to Monitoring

Since individual states and tribes develop unique monitoring programs, it is difficult to roll all state-level monitoring data into a comprehensive, consistent report at the national scale. The NARS program helps address this deficiency by creating a statistically valid approach to collecting and analyzing ecological and water quality data. This approach allows for consistent and comparable assessments of ecological conditions at many scales (state, ecoregion, nation).

What does this mean to Oregon? With the NARS approach, we can make comparisons of ecological, chemical and physical conditions observed in Oregon to conditions observed in neighboring states, or at a national scale. By participating in each round of the NARS, we have the ability to track if a water bodies condition is improving (or declining) over time. The NARS program also informs future resource management plans by identifying the most likely causes of poor ecological conditions.

Ecological Focus

The National Aquatic Resource Surveys program differs from traditional water monitoring efforts by placing emphasis on measurement of ecological conditions. Most water monitoring at DEQ tracks the level of physical water chemistry parameters established to protect the most sensitive "beneficial uses." The term beneficial uses comes from the Clean Water Act. It's used to define values or uses for certain rivers and basins. With NARS the condition of biological communities is a direct measure of beneficial use support. Emphasis is placed on the ecological condition, which uses water chemistry and the habitat, as indicators of stress on biological communities. Stressor identification can pinpoint the causes of impairments and factors that affect the aquatic ecosystem (Stoddard et al, 2005).

What are Beneficial Uses?

Beneficial uses are the purpose or benefit derived from a water body. Beneficial uses are designated in Oregon's water quality standards. These uses include human uses such as fishing, boating, recreation, visual appearance, irrigation, drinking water supply, navigation, and uses for fish and aquatic life.

Collection of Additional Information – Adding to Scientific Discovery

The National Aquatic Resource Surveys provides a cost-effective way to collect more data for the development of new indicators and screen for the prevalence of emerging concerns. This can be done at a national scale, or from a subset of sites to help answer questions on a smaller scale or targeted grouping of locations. For example, the 2008-09 National Rivers and Streams Assessment added the collection of fish tissue for analysis of toxic compounds to only large river sites. This collection of new indicators advances the science in the form of method development and research opportunities.

Survey Design and Indicators

Probabilistic Monitoring

Oregon has a large network of streams and rivers. Sampling every river and stream or watershed would take decades and be prohibitively expensive. However, we still need a way to evaluate the condition of the flowing waters in our state. A probabilistic or random sample design provides a cost-effective, statistically valid approach for assessing waters at the state scale. In probabilistic sampling, each potential river and stream segment in Oregon has a known chance (probability) of being selected from the pool of all possible river and stream segments. The randomly selected locations are a statistically valid representation of the entire river and stream network in Oregon. This approach is similar to an opinion poll, where each person polled represents a certain proportion of the total population (Olsen et al, 1999). DEQ has a long history of working with EPA on

probabilistic monitoring, dating back to 1994. Since then we've completed surveys of wadeable streams, lakes, and estuaries at multiple scales including ecoregions, basins and statewide (Hubler et al , 2010; Mulvey et al, 2009; Mulvey et al, 2008; Mulvey, 2008; Hubler, 2007). Probabilistic environmental sampling is intended to describe the condition of the target population. It is not meant to characterize an individual location as is a targeted monitoring with repeated visits.

In 2008-09 DEQ received funding from EPA to sample 50 sites throughout Oregon. DEQ staff reviewed the random site list provided by EPA to confirm that streams were perennial, obtained permission to access private property, and ensures that locations were safely accessible. The final site list for sampled locations encompassed a full range of stream types and ecological diversity, representing 38,700 total stream miles. This is equivalent to sampling the distance required to circle the earth over 1.5 times.

Survey Methods

DEQ followed standard survey design and methods and used EPA or contract labs for all analytical results for the National Rivers and Streams Assessment. EPA methods and manuals can be found at http://water.epa.gov/type/rsl/monitoring/riverssurvey/index.cfm

Indicators

DEQ collected more than 300 unique measurements and samples at each site for the NRSA. Data fall into four indicator categories: biological, water quality, physical habitat, and human health. The complex nature of habitat and biological data requires the development of metrics and indexes, whereby several data points are quantified into a single indicator. Physical habitat metrics are calculated using methods defined by EPA (EPA, 2013; Kaufmann, 1999). The biological indicator category uses three separate indexes for assessing different trophic levels. For macroinvertebrates an observed over expected (O/E) taxa loss model created by DEQ is used (Hubler, 2008). Fish are assessed with an Assemblage Tolerance Index (ATI) specific for western fish species, developed by EPA/Oregon State University (Whittier et al, 2007). A new Multimetric Index (MMI) developed by EPA is used for periphyton (EPA, 2013). Table 1 outlines indicator categories used in this assessment. These indicators were selected because they have been shown to be the most significant to Oregon's river and stream ecosystems in past studies (Mulvey et al, 2009; Hubler, 2007). Although temperature, pH and dissolved oxygen were collected, DEQ did not use them in this assessment because we had only one measurement for each per site. For Oregon's temperature water quality standard to be applied DEQ needs continuous data, this is not practical to collect in a statewide survey. Also, DEQ felt by missing diurnal changes it was not truly characterizing pH and DO.

Table 1. Indicators assessed for the Oregon NRSA.

Response Indicators	Stressor Indicators		
Biological	Water Quality	Physical Habitat Structure	Human Health
Macroinvertebrates (O/E)	Total Phosphorus	Canopy Cover	Fecal Bacteria
Fish Assemblage (ATI)	Total Nitrogen	Riparian Vegetation	Fish Tissue Toxics
Periphyton (MMI)	Turbidity	Sand and Fine Sediment	
	Total Suspended Solids	Fine Sediment	
		Streambed Stability	
		Fish Habitat Complexity	
		Riparian Human Disturbance	

Reference Condition

Reference condition is defined as "least disturbed" areas that represent the best available ecological condition in a specific region (Stoddard et al. 2006). The reference condition approach sets expectations (benchmarks) for indicators based on the distribution of values found at reference sites. In the early 2000s, DEQ and EPA developed methods to characterize reference condition independently. In reporting on national and regional results for the National Rivers and Streams Assessment, EPA used a different set of reference sites for different indicator categories. EPA uses data from the assessments to define reference condition for specific indicator categories at the broad NARS ecoregion scale (Herlihy et al, 2013). This assessment of perennial river and stream conditions across Oregon uses the DEQ reference population that is specific to the Pacific Northwest (Hubler, 2007). The only exception to this is periphyton, as we do not have a Pacific Northwest-specific model for this indicator at this time.

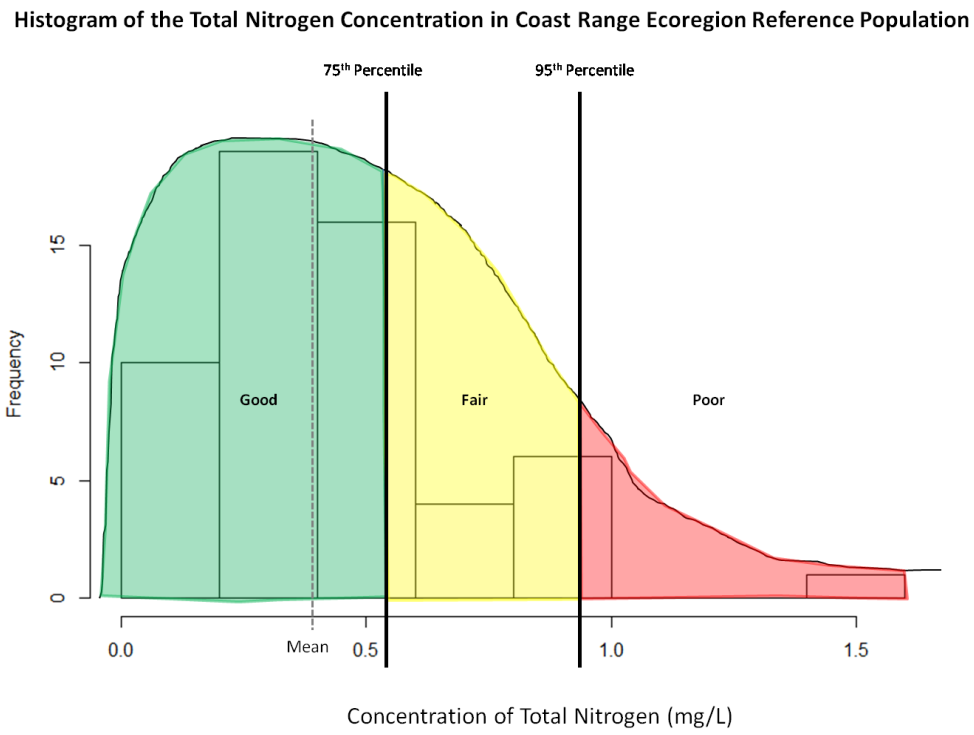

Figure 2. Condition assignment based on a reference data.

DEQ developed a three- tiered process for defining a reference population: 1) GIS screen at the watershed scale to characterize gradients of natural and human disturbance, 2) assessment of human disturbances at the local scale during our site visit, and 3) verification and grading (Drake, 2004). With the population of reference defined, benchmarks for each indicator were established for each Level III Ecoregion (Thorsens, 2003). Benchmarks are defined at the upper 95th and 75th percentiles, or lower 5th and 25th percentiles of the reference population, depending on indicator. The benchmarks are then used to assign condition classes: good, fair, and poor (Figure 2). To increase sample sizes across Oregon ecoregions, reference sites identified by state agencies in Washington and Idaho were included. A few ecoregions with low sample sizes and similar attributes were merged (Hubler, 2007).

Benchmarks Used in This Report

None of the indicators used in this assessment have numeric water quality standards. DEQ used reference conditions approach benchmarks for all water quality, physical habitat, macroinvertebrate and fish condition assignment (good, fair, poor) and EPA benchmarks for periphyton. Finally, DEQ used EPA criteria for safe human exposure to *enterococci* in ambient waters for human health condition (EPA, 2013) (Table 2).

Table 2. Indicators assessed for the Oregon NRSA.

Ecoregion	Coast Range N=82		Willamette Valley (2009) N=24		Cascades N=110		East Cascades N=21		Blue Mountains N=47		Klamath Mountains N=28		Columbia Plateau + Northern Basin and Range + Snake River Plains N=7		
	Good	Poor	Good	Poor	Good	Poor	Good	Poor	Good	Poor	Good	Poor	Good	Poor	Basis
Total Phosphorus (mg/L)	< 0.020	> 0.040	<0.053	>0.129	< 0.030	> 0.066	< 0.040	> 0.100	< 0.031	> 0.065	< 0.030	> 0.060	< 0.044	> 0.069	75th and 95th reference percentile
Total Nitrogen (mg/L)	< 0.570	> 0.855	<0.344	>0.505	< 0.260	> 0.318	< 0.260	> 0.524	< 0.244	> 0.284	< 0.261	> 0.340	< 0.255	> 0.399	75th and 95th reference percentile
Turbidity	< 1	> 6	<6	>22	< 1	> 2	< 1	> 2	< 1	> 2	< 1	> 3	< 4	> 13	75th and 95th reference percentile
Total Suspended Solids	< 2	> 9	<6	>21	< 1	> 66	< 3	> 9	< 2	> 5	< 1	> 10	< 7	> 23	75th and 95th reference percentile
Macroinvertebrate Assemblage	Benchmarks based on Level 2 Ecoregions provided in Hubler, 2008.														
Fish Assemblage Tolerance Index	<2.66	>3.28	<3.31	>3.65	<1.77	>2.90	<2.00	>2.60	<2.10	>2.30	<1.91	>2.74	<2.47	>3.69	75th and 95th reference percentile
Periphyton (MMI)	Benchmarks based on the modified Level 2 (NARS) Ecoregions provided in USEPA, 2013														
Canopy Cover at Bank(XCDENBK)	>85	<70	>91	<77	>89	<77	>86	<68	>57	<26	>85	<68	>70	<40	5th and 25th reference percentile
Riparian Vegetation (XPCMG)	1.00	< 0.73	>0.97	<0.92	> 0.95	< 0.68	> 0.91	< 0.77	> 0.8	< 0.05	1.00	< 0.32	> 0.55	0.00	5th and 25th reference percentile
Sand and Fine Sediment (PCT_SAFN)	< 24	> 45	<33	>90	< 13	> 45	< 28	> 44	< 22	> 31	< 7	> 31	< 30	> 71	75th and 95th reference percentile
Fine Sediment (PCT_FN)	< 7	> 38	<18	>90	< 5	> 17	< 13	> 19	< 11	> 22	< 3	> 7	< 23	> 63	75th and 95th reference percentile
Streambed Stability (LRBS_BW5)	> -0.8	< -1.8	>-0.9	<-3.4	> -0.9	< -1.7	> -1.2	< -1.8	> -1.3	< -1.5	> -0.4	< -0.6	> -2	< -2.9	5th and 25th reference percentile
Fish Habitat Complexity (FC_BIG)	> 0.25	< 0.14	>0.14	<0.04	> 0.35	< 0.2	> 0.25	< 0.12	> 0.22	< 0.04	> 0.41	< 0.05	> 0.2	< 0.08	5th and 25th reference percentile
Riparian Human Disturbance (W1HALL)	< 0.7	> 1.6	<1.5	>2.7	< 0.1	> 0.9	< 0.7	> 1.1	<0.03	> 1.8	< 1.2	> 1.4	< 1	> 1.5	75th and 95th reference percentile
Enterococci	EPA national criteria for human health protection in recreational waters provided in USEPA, 2013														

Assessment Tools

Extent Estimates – Condition of the Resource

With the probabilistic survey design, we are able to make statements about the general condition of the entire population of perennial rivers and streams in Oregon (38,700 stream miles) using data from only 50 sites. Stream miles are classified into three conditions classes (good, fair, poor) based on comparison to reference site conditions. The extent is calculated by combing the total number of sites in each condition with the associated site weighting factor. Site weighting is based on stream order (Figure 3). Streams with a low order (small headwaters) are given a higher numerical weight than sites with a higher order (large river); due to the greater density of small streams, these sites represent a larger portion of the population (EPA, 2013). Error bars represent the 95 percent confidence interval. The size of the error bars mostly depends on number of sites

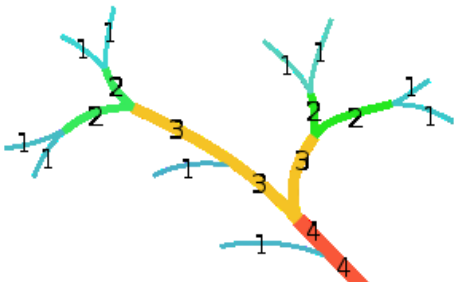

Figure 3. Schematic of stream order.
http://en.wikipedia.org/wiki/Strahler_number

sampled (EPA, 2013). Increasing the number of sites visited would allow us to be more confident in the conclusion we reach. Sites that were not visited due to land owner denial or unsafe conditions remain in the population as not available (NA). In these cases we are uncertain about the condition of a certain percentage of Oregon's rivers and stream miles.

Relative Extent and Relative Risk

The idea of ranking stressors and evaluating the risk posed by each stressor to the health of a population is widely used in the medical field. For example stressors of a particular person (smoking, high blood pressure, physical inactivity, being overweight) all go into determining that individual's risk factors for developing conditions such as heart disease and certain cancers (American Heart Association, 2014). Looking over the occurrence of these stressors in the entire population provides insight to public health officials on where to focus outreach efforts. Additionally, for each individual stressor, a relative risk value can be calculated to describe how likely it is to have an effect on the population. A well known example is a person who smokes is 25 times more likely to develop lung cancer than a person who does not smoke (U.S. Department of Health and Human Services, 2014).

Field staff collecting stressor (physical habitat) and response (macroinvertebrate) data.

The National Rivers and Streams Assessment survey design allows DEQ to use the same principle. The extent (percent of stream miles) of each stressor in poor condition is ranked from highest to lowest, thus telling us how extensive poor conditions for each stressor are in our rivers and streams. Relative risk is used to evaluate which stressors pose the greatest risk to the health of biological communities. A relative risk greater than 1.0—at the 95 percent confidence interval—is considered significant in these studies (Van Sickle, et al 2006). This tool does not evaluate the cumulative effects of multiple stressors.

Correlation Analysis

Another widely used tool in assessing relationships between biology and stressors is to perform a correlations analysis. This tool is used to explore relationships among biological communities and watershed landscape characteristics. We calculated the watershed characteristics using Geographic Information Systems. For this analysis, we correlated results from the three biological indexes against percent landuse and impervious surface, minimum and maximum elevation, mean slope or gradient, maximum temperature in the summer months, mean rainfall fall, population density, number of National Pollutant Discharge Elimination System (NPDES) permitted facilities, and number of dams in the watershed above the sample location.

Results

Extent Estimates

Biological Indicators

Field photos of biological indicators.

The biological condition for this assessment is based on three separate communities: benthic macroinvertebrates, periphyton and fish. The benthic macroinvertebrate community showed the most impairment at 33 percent poor, followed by the fish community at 16 percent poor, and the periphyton showing the least impairment at 6 percent poor (Figure 4). It is important to note that fish also had a substantially higher percent of miles not assessed due to either restrictions from encountering threatened or endanger species being present or ineffective sampling.

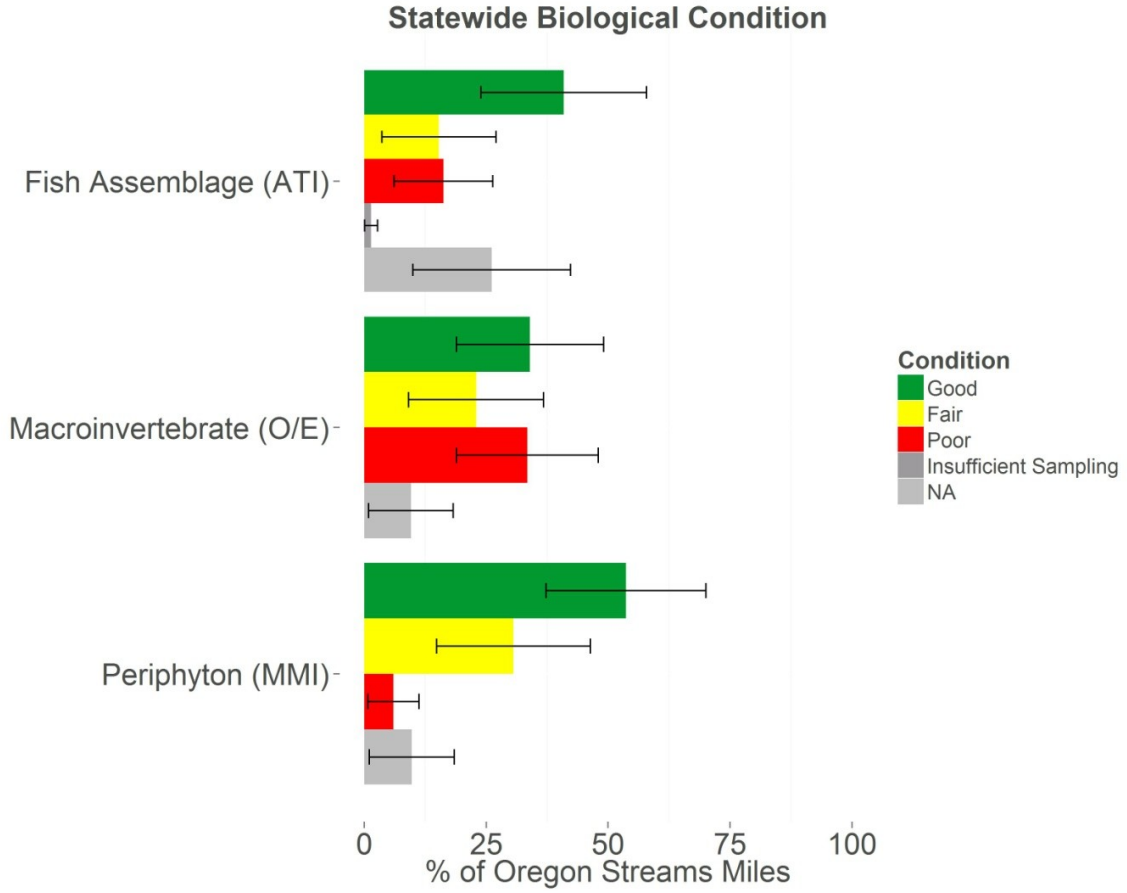

Figure 4. Extent Estimates for the Biological Indicators.

Water Quality Indicators

Field staff collecting and preserving water quality samples.

The nutrient condition of Oregon's streams and rivers were 45 percent good and 20 percent poor for total phosphorous and 85 percent good and 4 percent poor for total nitrogen. Similar results were seen for the sediment load condition; 49 percent good and 20 percent poor for turbidity and 62 percent good and 2 percent poor for total suspended solids (Figure 5).

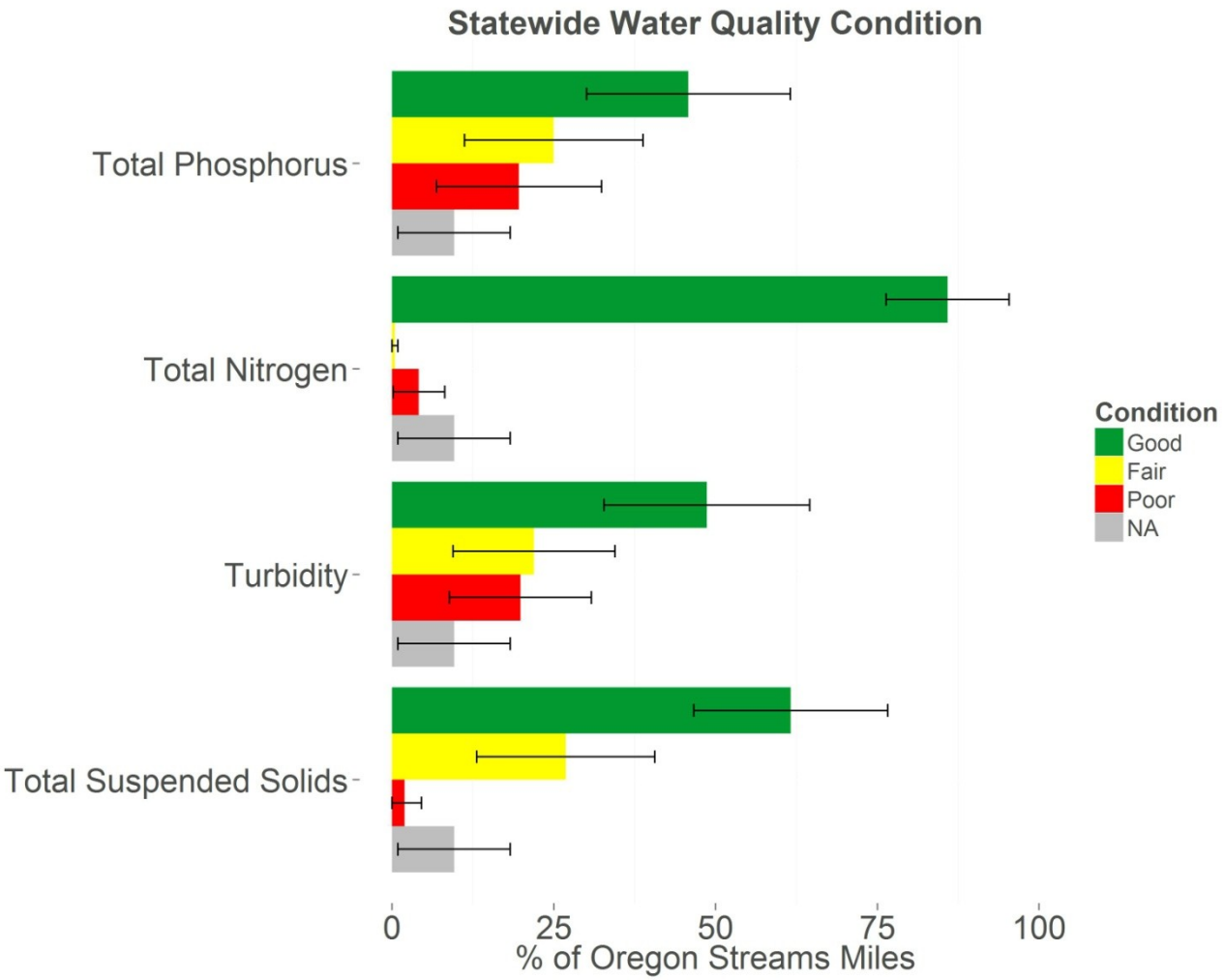

Figure 5. Extent Estimates for the Water Quality Indicators.

Physical Habitat Indicators

Fine sediment, streambed stability, canopy cover and riparian vegetation metrics assessed in this report showed a higher percentage of stream miles in good condition than either fair or poor. On the other hand, over half of the stream miles were in fair or poor condition for fish habitat complexity (70 percent) and riparian human disturbance (51 percent) (Figure 6).

Field photos of various riparian conditions seen throughout the state.

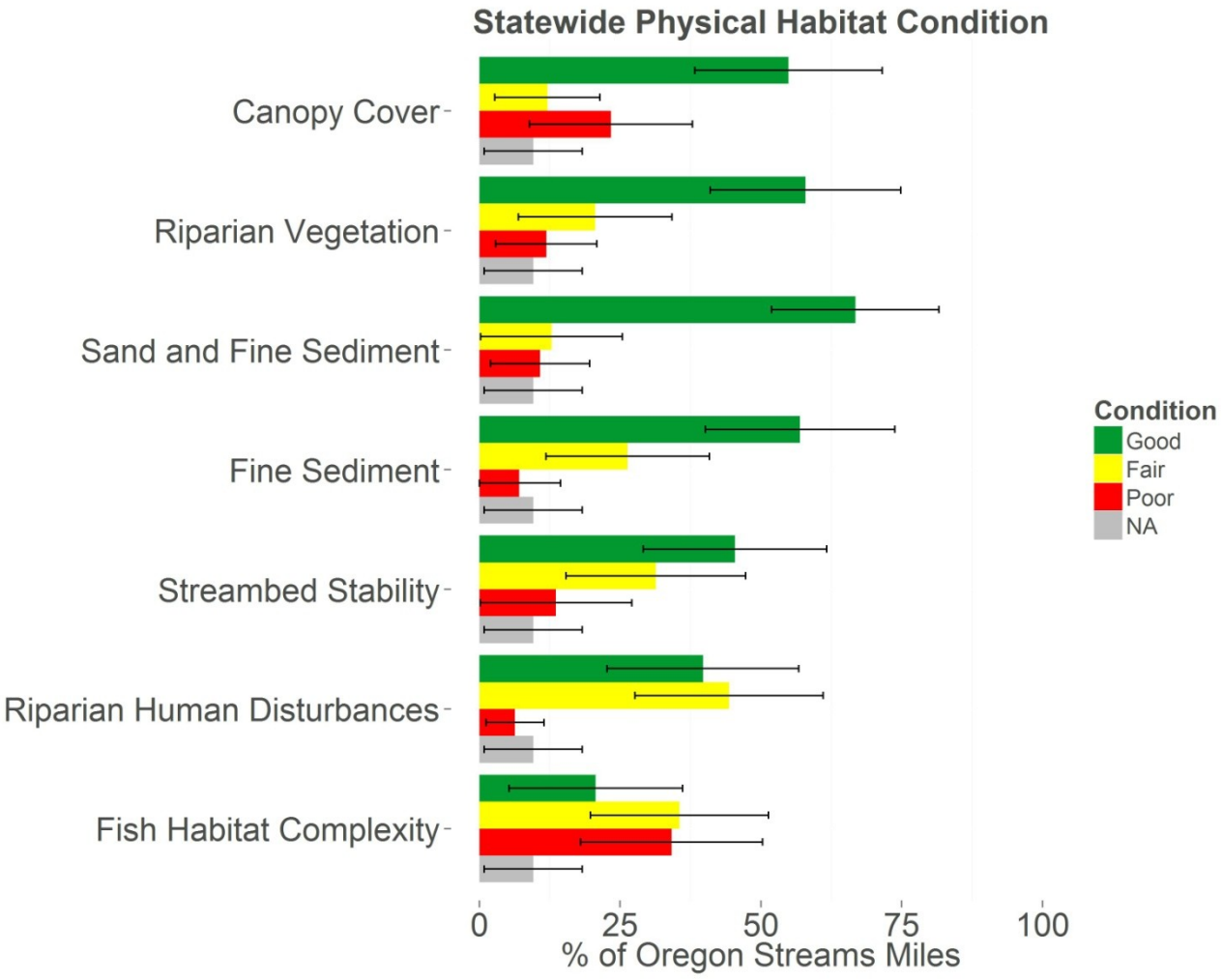

Figure 6. Extent Estimates for the Physical Habitat Indicators.

Human Health Indicators

DEQ assessed the extent of stream miles meeting the recommended conditions for recreational contact purposes using EPA's national criteria for human health protection in recreational waters for the fecal bacteria *enterococci* (EPA, 2013). In terms of these benchmarks, 78 percent of stream miles are swimmable (good), 4 percent pose some risk (poor), and 18 percent are of unknown threat (NA) (Figure 7). In Oregon, the water quality standard for bacteria is based on E. *coli* and therefore could not be applied. With site weighting, these results are skewed toward smaller streams, where fewer people swim.

Field photos of an assortment of human contact with water.

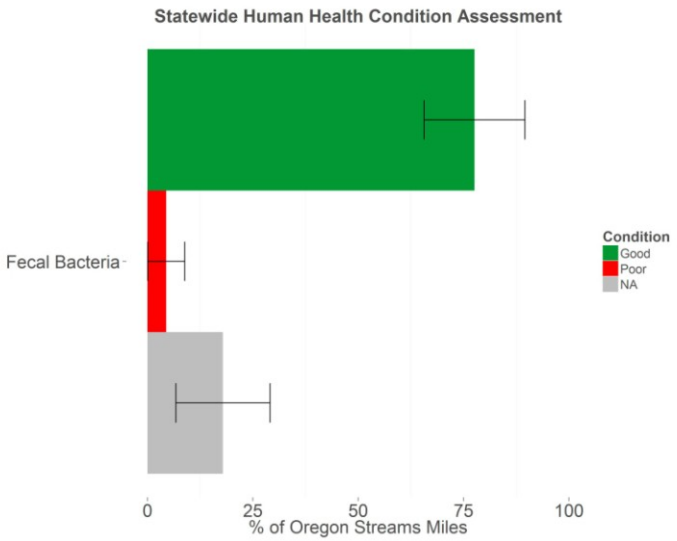

Figure 7. Extent Estimates for the Human Health Indicator.

Risk Factors in Oregon

The most widespread stressors to ecological health in Oregon's rivers and streams were fish habitat complexity, canopy cover, turbidity and total phosphorus. The extent of stream miles in poor condition for these stressors ranged from 34 percent to 20 percent (Figure 8a). Generally, rivers and streams in Oregon have a relatively low percent poor for most stressors. When looking at the macroinvertebrates, we see that the greatest risks are posed by sand and fine sediment in or on the streambed, total suspended solids in the water column, riparian human disturbance, and presence of fecal bacteria (likely a surrogate for sediment runoff which can contain toxins and other contaminants) (Figure 8b). For fish, canopy cover and riparian human disturbance have a relative risk of 5, meaning when streams are in poor condition for these stressors they are five times more likely to have a fish community in poor condition (Figure 8c). The periphyton is affected by riparian human disturbance, canopy cover, total nitrogen and, to a lesser extent, fine sediment (Figure 8d). It should be noted that with a small sample size, the relative risk values may be inflated (particularly in the case of periphyton). While we understand this

limitation, we felt it was worth reporting as the stressors associated with each community are consistent with findings from past assessments.

By looking at all trophic levels we notice different responses to stressors and gain a greater perspective of the whole biological community. Additionally, we see that riparian human disturbance was a risk factor to all three biological indicator groups. This indicates factors that degrade streamside vegetation posed the greatest risk to the biological health of rivers and streams in Oregon. While at this time the extent of the human disturbance stressor in poor condition is low (6 percent of stream miles), there are 44 percent of stream miles in fair condition. A shift from "fair" to "poor" condition typically has an adverse effect on biological conditions.

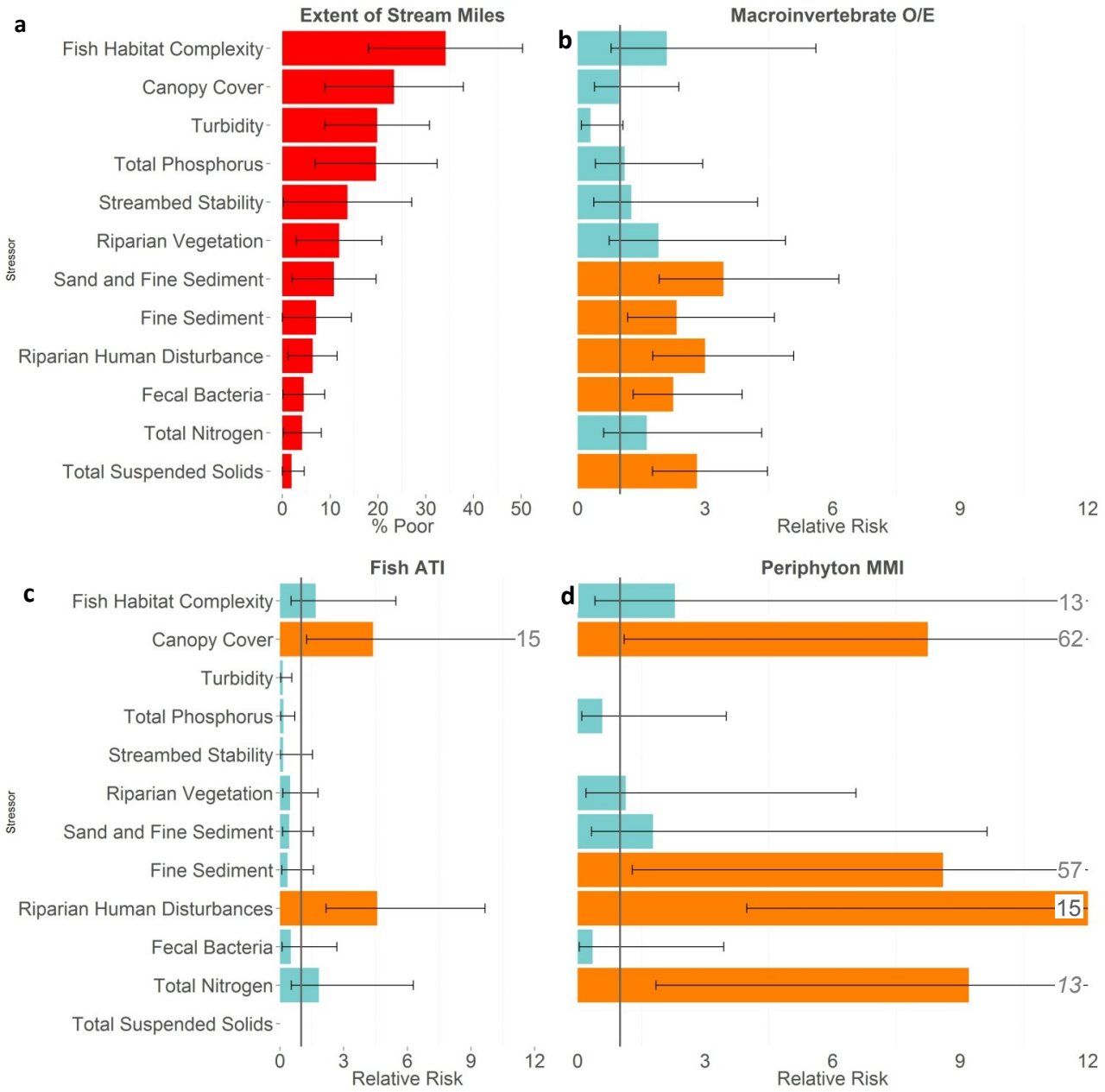

Figure 8. Relative Risk results for three biological communities in Oregon. The first panel (a) depicts the percent of stream miles in poor condition for all stressor indicators. Panels (b-d) show the relative risk for each biological community. Stressors with a relative risk greater than 1 at the 95 percent confidence interval (vertical line) pose a statistically significant risk (orange bars). Some care should be taking on using these values as a small sample size effects the magnitude of the risk (particularly in the case of periphyton).

Correlation Analysis for Oregon

We observed the strongest relationships (r^2 >0.5) between biological communities and landscape characteristics with watershed area (indicating large rivers) and percent agriculture cover. As watershed area and percent agriculture increase, there is a tendency for the condition of the biology to decrease. Poor macroinvertebrate condition showed the strongest correlation to higher urban influences (percent impervious, mean population density and percent urban), while better condition was positively correlated to steeper, smaller watersheds. We also saw weaker negative correlations (r^2 0.5-0.3) between the biology and lower-gradient watersheds and the number of NPDES permitted facilities upstream. Conversely, we found weaker positive correlations between biological indexes and percent forest and percent grassland/shrub land. Overall, stream or river size appears to be the greatest factor.

Toxins in Fish Tissue

A supplemental portion of the NRSA was to collect and analyze fish tissue for mercury, legacy pesticides, flame retardants and polychlorinated biphenyls (PCBs). Due to the small sample size of fish tissue data (23 large river sites), we are unable to confidently make statements about the extent of toxins across the entire population of Oregon's perennial river and stream miles. Additionally, the benchmarks for this type of data can be tricky to attain, as toxic exposure risks are measured differently for different populations.

Field staff electroshocking for fish tissue samples.

What was detected?

We detected both PCBs and flame retardants at 17 of the 23 sites. The sites where these compounds were not detected were in rural areas without large urban areas upstream. We also found at least one unique legacy pesticide or pesticide degradation product at 22 of the 23 sites, and mercury at all 23 sites (Figure 9). It's important to note that while these compounds were detected, they were almost all below levels considered toxic/harmful to humans and aquatic life.

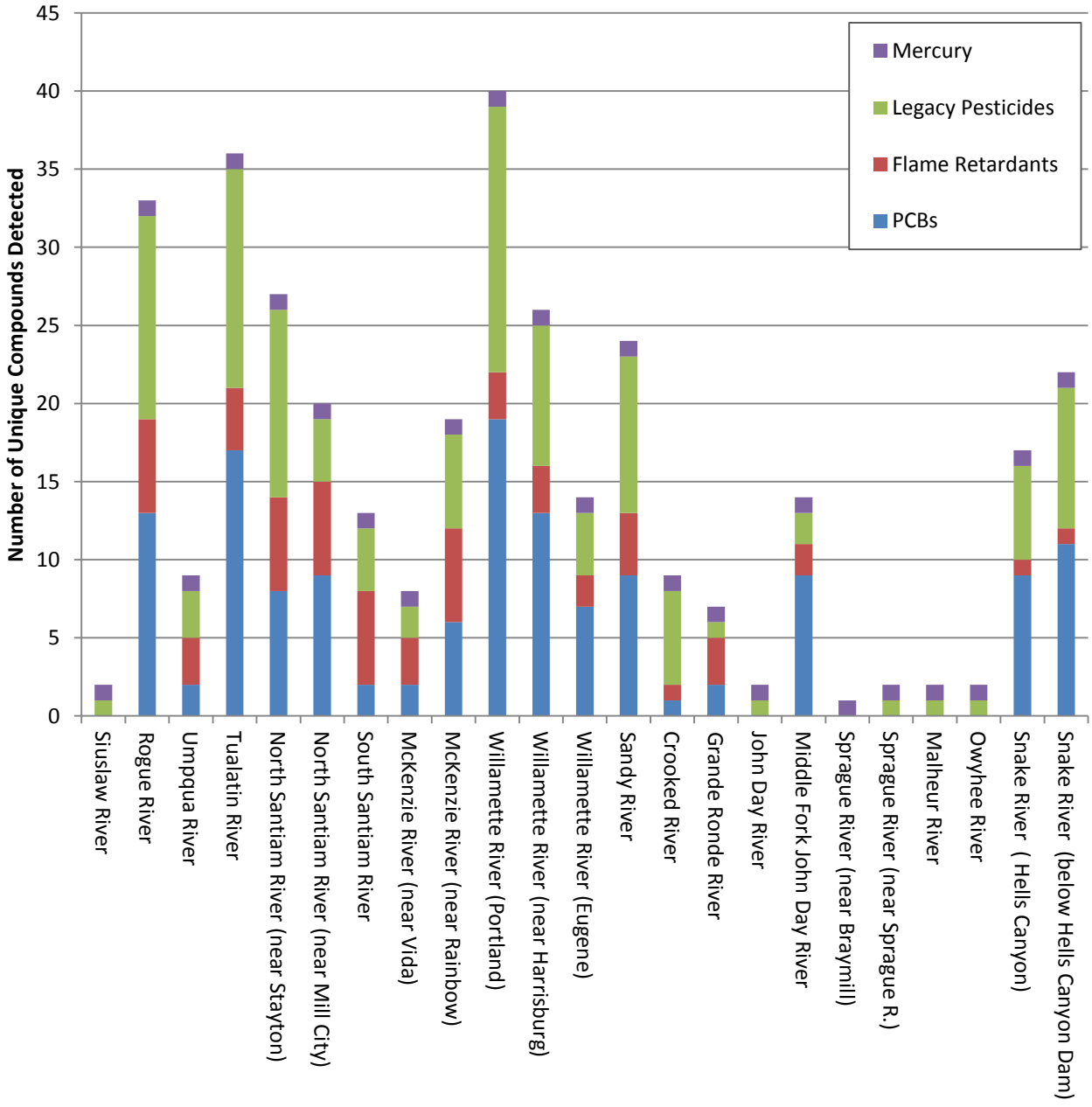

Figure 9. Number of unique compounds detected in fish tissue samples collected at 23 large river sites throughout Oregon.

Mercury in Fish Tissue

DEQ detected mercury in all fish tissue samples (23) collected for this project. The fish species varied between sites, based on differences in fish populations and sample collection technique. In all, 83 percent of sites (19/23) exceeded the Oregon water quality standard for methylmercury in fish tissue of 0.04 mg/kg wet weight (ODEQ, 2014). While 49 percent of sites exceeded the Oregon Health Authority (OHA) screening level of 0.2 mg/kg wet weight (Farrer, 2013). Concentrations of mercury in tissue have been shown to be predominately in the methylated, or biologically available, form (EPA, 2000). These results represent a mix of trophic levels. Species in lower trophic levels (carp, suckers and mountain whitefish) were collected at 10 sites (Figure 10). Results from sites with species in lower trophic levels may be lower than those from fish that consume other fish, as mercury is biomagnified up the food chain.

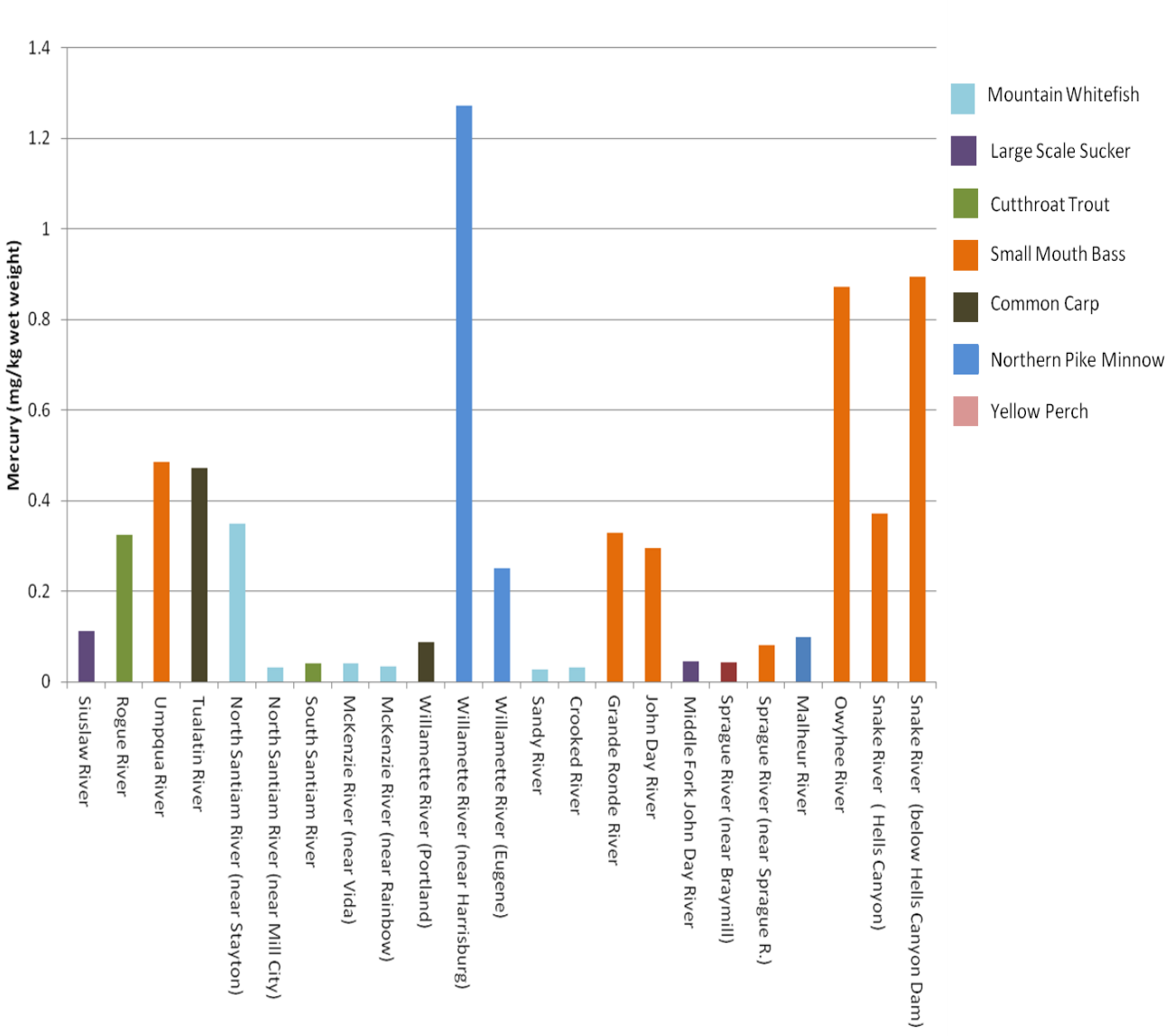

Figure 10. Concentration of mercury found in fish tissue samples collected at 23 large river NRSA sites throughout Oregon.

Organic Toxic Compounds in Fish Tissue

The most prominent of legacy organic compounds detected in the fish analyzed in this study was the pesticide DDT. We found DDT and/or its degradation products at 21 out of 23 sites (91 percent) (Figure 11). While the concentrations did not exceed the OHA fish tissue consumption screening levels for humans and were rarely above DEQ acceptable tissue levels (9 percent for individual birds, 34 percent egg shell development and 9 percent fish toxicity), the data demonstrates the continued prevalence of this pesticide, which was banned from usage in the U.S. in 1972 (Farrer, 2013; ODEQ, 2007). Other pesticides detected at high percentages of sites sampled were total chlordanes (56 percent), hexachlorobenzene (52 percent) and dieldrin (48 percent) (Figure 11). None of these surpassed the OHA fish tissue screening levels or DEQ ecological acceptable tissue levels (where available) (Farrer, 2013; ODEQ, 2007). PCBs and PBDEs (flame retardants) were both detected at 73 percent of sites, showing the ubiquitous nature of these compounds in aquatic ecosystems (Figure 11). The concentrations of summed PCBs are above the 0.002 mg/kg wet weight OHA screening value for sensitive populations (children and women of childbearing age) at more than half of the sites, and at 9 percent of sites for the screening value for the general population (0.05 mg/kg wet weight). No sites exceeded the screening values for the PBDE congeners (Farrer, 2013).

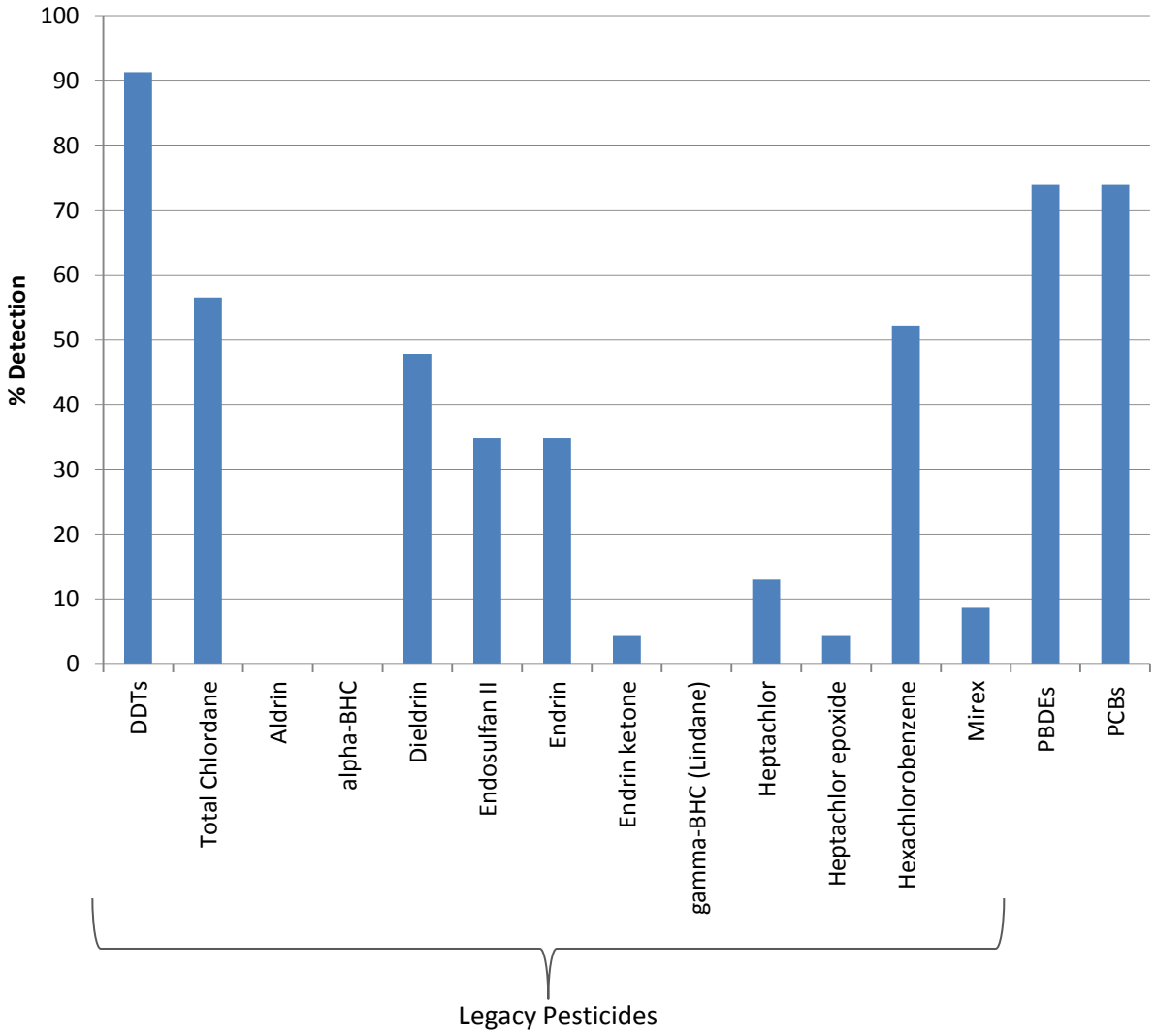

Figure 11. Percent detection of legacy and current use organic compounds in fish tissue samples collected at 23 large river NRSA sites throughout Oregon.

Conclusion

What did we learn?

- *What's the extent of waters that support a healthy biological condition, recreation and fish consumption (beneficial use)?*

Using National Rivers and Streams Assessment methodology, Oregon's rivers and streams support healthy biological conditions in one third to just over a half of the total stream miles DEQ assessed, based on the three biological communities (macroinvertebrates, fish and periphyton). Our data shows a small percentage of stream miles pose a risk of fecal bacterial infection; however, this is across the state as a whole, and the smaller streams that dominated our results are unlikely to portray the risk associated with larger rivers. Sensitive populations of Oregonians—subsistence fishers, women of childbearing ages and children—are exposed to risks for mercury and PCBs when consuming certain fish species in certain areas of the state.

- *How widespread are the major stressors that affect ecological health?*

The most widespread ecological stressors identified in this study are lack of fish habitat complexity, poor riparian canopy cover, high turbidity and total phosphorus concentrations. The extent of stream miles in poor condition from these stressors ranged from one fifth to one third.

- *Are we investing wisely in water resource restoration and protection?*

Our relative risk analysis showed that the greatest threats to the biological condition in Oregons' rivers and streams are human disturbances to the riparian area, riparian canopy cover and fine streambed sediments. Actions targeting protections of and improvements to streamside vegetation are likely to provide the most benefit to the biological indicators measured in this study.

- *Are our waters getting cleaner?*

To use NRSA data to answer this question, we must have multiple years of data. During the summers of 2013 and 2014, DEQ sampled 52 NRSA sites, with 25 being repeat sites from the 2008-2009 survey. DEQ will sample the repeat sites in each five-year cycle. In the future, we can use results from these sites to calculate statistically valid trends in ecological condition (improving or declining). Additionally, we'll be able to compare the extent of individual stressors in each condition class to look for changes.

How do the Oregon NRSA Results Compare?

Previous DEQ Studies

DEQ has produced reports which sought to answer similar questions, based on probabilistic survey design, for the past 10 years (Hubler et al, 2010; Mulvey et al, 2009; Mulvey et al, 2008; Mulvey, 2008; Hubler, 2007). Each assessment indentified a common group of stressors to Oregon's rivers and streams. These include: temperature (not assessed in this study due to lack of continuous data), fine sediment, canopy cover, riparian human disturbances, total phosphorus and riparian vegetation (Table 3). Total phosphorus, canopy cover and fine sediment stressors are common to at least two assessments (Table 4). The common story in each of these assessments is that focusing on riparian protection and/or restoration will provide the greatest benefit to maintaining or improving the beneficial use of biological condition.

Table 3. Comparison of Most Extensive Stressor Results Across Multiple DEQ Probability Ecological Assessments.

	Top 4 Stressors (greatest % stream miles in poor)					
	Oregon 2008-2009 NRSA	Willamette Basin Rivers and Streams Assessment	The 2007 Survey of Oregon Lakes	Coastal Coho Streams Assessment	Lower Columbia Wadeable Streams Assessment	Wadeable Streams Conditions in Oregon
Water Quality						
Total Phosphorus	X		X	X		
Turbidity	X		X			
Temperature*		X		X	X	X
Total Solids				X		
Physical Habitat						
Riparian Vegetation		X	X			
Canopy Cover	X	X				
Fine Sediment *				X	X	
Excess Fine Sediment (RBS)*					X	
Slow Water Habitat*						X
Fish Habitat Complexity	X		X			
Riparian Human Disturbance		X			X	X
Agricultural Disturbance*						X

** Indicator was not collected and or assessed in all surveys*

Table 4. Comparison of highest Relative Risk to Macroinvertebrates from DEQ Probability based Ecological Assessments.

	4 Highest Relative Risk Values to Macroinvertebrate Condition					
	Oregon 2008-2009 NRSA	Willamette Basin Rivers and Streams Assessment	The 2007 Survey of Oregon Lakes	Coastal Coho Streams Assessment	Lower Columbia Wadeable Streams Assessment	Wadeable Streams Conditions in Oregon
Water Quality						
Total Phosphorus		X				X
Total Suspended Solids	X					X
Total Solids				X		
Dissolved Oxygen				X		
Oregon Water Quality Index*		X				
Physical Habitat						
Riparian Vegetation		X				
Canopy Cover		X			X	
Fine Sediment*	X			X		
Sand and Fine Sediment*	X					
Excess Fine Sediment (RBS)*					X	X
Glide Habitat*					X	
Residual Pools*						X
Large Woody Debris					X	
Non-Native Species*				X		
Riparian Human Disturbance	X					

** Indicator was not collected and or assessed in all surveys*

National NRSA Report

Oregon has a higher percentage of stream miles in good condition for nutrients and riparian disturbance when compared to the nation and other western states. However, for streambed stability and fish habitat complexity,

there are fewer total stream miles in good condition when compared to these two regions. Oregon was consistent with both the lower 48 and the western states in riparian human disturbance condition classes. In the West, the greatest risk factors to macroinvertebrates were total nitrogen, total phosphorus, streambed stability and riparian human disturbance. These are not direct comparisons as the reference sites used to define condition are different and we included indicators not assessed in the national report.

How can the NRSA be Improved in Oregon?

Increase Sample Size

This assessment is based on 50 site visits throughout the entire state of Oregon. This is typically deemed as the minimum amount of sites needed to provide a statistically valid estimate of conditions. Additional sites would increase the precision of the extent graphs and relative risk estimates. This could be done statewide or with a regional focus. In addition, detailed landuse analysis would help to better develop the relationships between stress factors, ecological health and land use. This would provide more focused recommendations for targeted management actions.

Reference Sites

The population of DEQ reference sites used to assign condition to all indicators in this assessment (with the exception of periphyton) are all wadeable, 1st through 5th order streams. Typically these streams are high gradient in the upper watershed. There is a challenge in finding low-gradient larger rivers and streams in reference or least disturbed condition as these tend to be areas with greater human disturbances. We realize that this may affect the condition class for larger rivers, although the site weighting diminishes the impact this has on the overall population estimate. DEQ is currently reassessing the reference population it uses for these assessments. We're considering new ways of setting benchmarks that will hopefully address this potential concern.

Expanded Toxics Monitoring

This survey, as well as other monitoring results from the DEQ Toxics Monitoring Program, indicate certain areas of the state are at higher risk for toxic contamination. In 2013-2014, the National Rivers and Streams Assessment collected fish tissues samples at 15 sites for the monitoring program which will be analyzed for legacy and current- use pesticides, and potentially other chemicals. In the future this could be expanded to sediment and water collection as well. The combination of toxic and biological data will help us understand the influence of these chemicals on the biological condition.

Where do we go from here?

Since this data was collected, DEQ has continued with the National Aquatic Resource Surveys program, sampling coastal bays and estuaries, wetlands and lakes. In 2013 and 2014 we completed the second round of the National Rivers and Streams Assessment. We plan to begin to implement statewide assessments, based on continued participation in the NRSA and renewing the DEQ Laboratory's Biological Monitoring Program, on a regular cycle.

Glossary of Terms

Canopy Cover: A direct measurement of the overhead stream channel cover, or shade. This includes cover by riparian plants, topographic features, and anthropogenic structures. Increased cover or shade results in lower stream temperatures and inhibits the growth of excess algae which is beneficial to fish.

Ecoregions: Ecological regions are areas that share similar natural characteristics, such as climate, vegetation, soil type, and geology. Water resources within the same ecoregion have comparable responses to stressors.

Fine Sediment: Silt, clay and muck material that feels slick between the fingers and is not gritty (<0.06 mm diameter). Excess fine sediment can fill in the spaces between boulders and cobbles in the streambed and have detrimental effects on juvenile fish, macroinvertebrates, and periphyton.

Fish Habitat Complexity: A metric calculated from measurements of near shore fish habitat with the reach. These include, large woody debris, undercut banks, boulders, and tree roots.

Flame Retardants (PBDEs): Brominated flame retardants or polybrominated diphenyl ethers; Compounds added to consumer products to decrease flammability. They have been shown to be endocrine disruptors. PBDEs tend to persist in the environment and bioaccumulate in organisms.

Fish Assemblage Tolerance Index (ATI): An index used to rank the fish species found at a site in terms of tolerance to poor water quality or habitat conditions. Each fish species is assigned a tolerance value and those values are weighted by a species' abundance. All weighted tolerances are then summed to create an overall index score for the site. Higher index values indicate fish communities that are more adapted to poor condition.

Legacy Pesticide: Pesticides banned from use in the United States, but still widely found in the environment. They tend to persist in the environment and bioaccumulate in organisms. DDT is a legacy pesticide.

Macroinvertebrates: Aquatic insects (typically in the larval, or immature stage), clams, mussels, crustaceans, worms and other creatures that live in the stream bed (benthic) environment. They are found attached to rocks, vegetation, woody debris, or burrowed into the substrate.

Metric: A standard for measuring or evaluating something.

Mulitmetric Index (MMI): The sum of multiple measures of biological condition. Measures can include number of unique species, number of species adapted to specific habits, and specific feeding methods. MMIs are used to express biological integrity (state of being able to support a balanced and complex community of organisms similar to those observed in reference condition).

Nutrients (Total Nitrogen and Total Phosphorus): Typically considered substances that are essential for growth and sustaining life. When these nutrients in particular enter rivers and streams via surface runoff, they can over-stimulate the growth of algae and plants. This leads to changes in water chemistry that can have adverse effects on biology.

Observed over Expected (O/E) Model: Also called a "taxa loss" model. In this model the species (taxa) we observed (O) or collected at a site is compared to the species expected (E) to be present at reference sites with similar environmental characteristics. The ratio of O/E is used to score the site for macroinvertebrate condition.

Periphyton: Bottom dwelling algae that are found attached to river and stream beds, plants, rocks, and woody debris. As primary producers (they use sunlight for energy), the periphyton assemblage forms the base of the food-webs for streams and rivers.

Riparian: The area adjacent to a river or stream, the riparian zone, acts as a buffer to protect water quality from both natural and human caused disturbances.

Riparian Human Disturbance: A summation of the presence and proximity of eleven types of human land use or disturbance at riparian plots along the survey reach.

Riparian Vegetation: Is the sum of plant densities measured at three layers (ground cover, mid-layer, and canopy) at eleven 10 meter square plots throughout the sample reach. It is a metric used to express riparian vegetation complexity.

PCBs (Polychlorinated biphenyls): Used in a wide variety of industrial products including electrical insulating fluid, dyes, pigments, sealants & more. Manufacture of PCBs was banned in the United States in 1979; however, these chemicals still persist in items manufactured prior to that date. They tend to persist in the environment and bioaccumulate in organisms.

Sand and Fine Sediment: A measure of the percent sand and fine sediment in the sample reach.

Streambed Stability: A value that models the expected mean substrate size for a sample reach based on natural factors, such as gradient, stream size, and geology, and compares it to the observed mean particle size. Also called Relative Bed Stability (RBS) and Excess Sedimentation.

Stressors: Circumstances or substances that cause degradation to aquatic ecosystems. Stressors can be chemical (excess nutrients), physical (riparian disturbance), or biological (invasive species). While many of the parameters we call stressors occur naturally in the environment (e.g., nutrients, sediment), beyond some threshold they can impact water quality (e.g., excess nutrients trigger nuisance algae growth, or excess fine sediments smother salmon eggs).

Taxa: Different types of macroinvertebrates. Which can represent various levels of taxonomic identification, from species to order, but at each level represent a unique group.

Total Suspended Solids: Fine particles suspended in the water column that, in excess, interferes with gill function and the ability for young fish to forage for food.

Turbidity: A direct measure of the clarity or cloudiness of water due to dissolved and suspended material. Values are highly dependent on stream flow.

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