Deschutes River Multi-Parameter TMDL Effectiveness Monitoring Pilot Project

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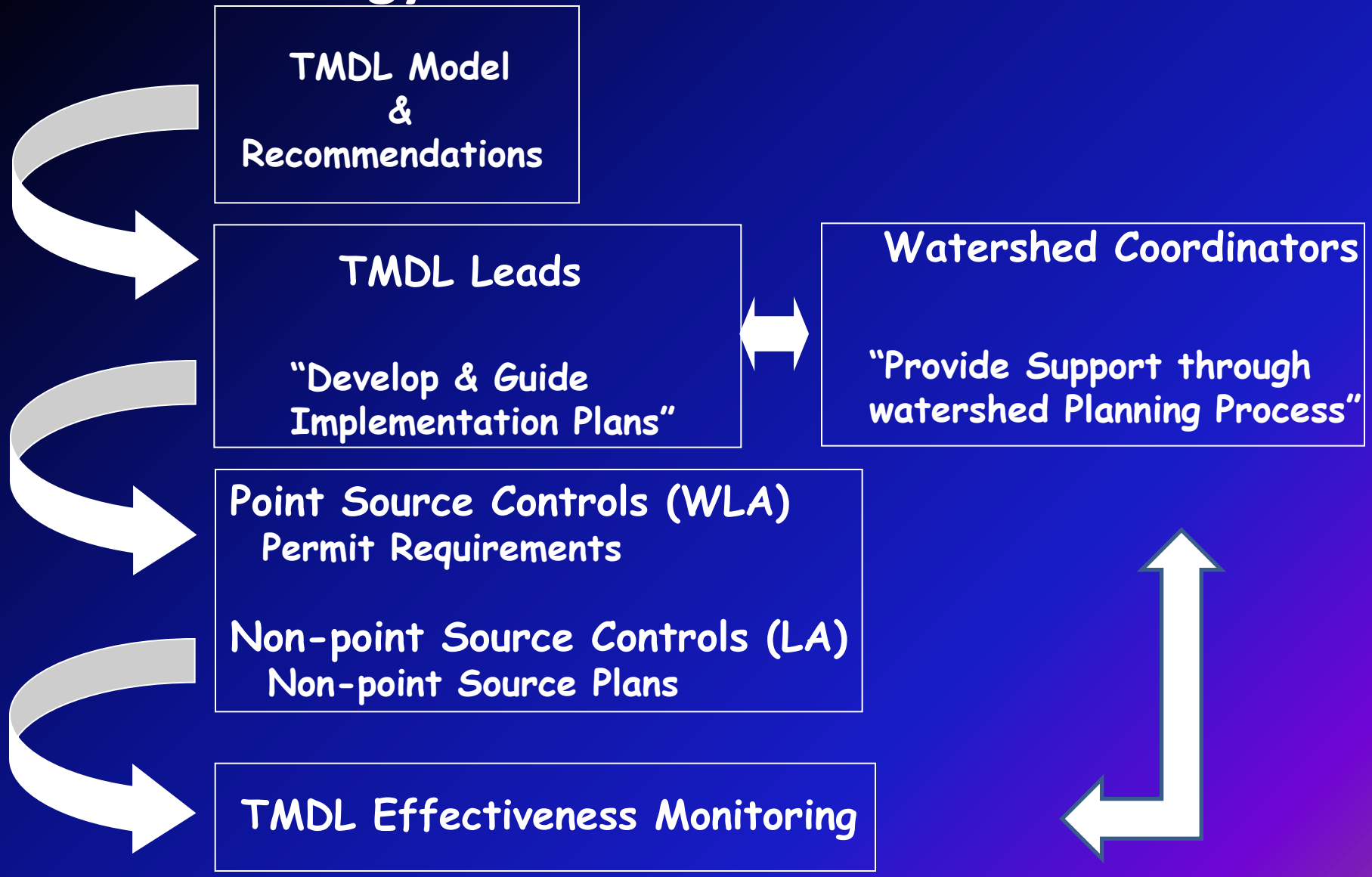
Washington Department of Ecology

TMDL Strategy



Goals

1) Summarize and link watershed-based cleanup efforts to changes in stream habitat and biological communities.
2) Distinguish between natural and anthropogenic variability that affect changes in biological communities over time.
3) Link biological community composition with WQ.

Study Design

- Select stations that will likely respond to upstream clean-up efforts.
- Collect macroinvertbrates, periphyton, chemical and habitat parameters.
- Two years of baseline data (2009-2010)
- Return to collect two years of post implementation data (2012-2013??).

Site Selection

- Sampling stations based on current 303(d) listed segments.
- Results from TMDL.
- Landscape Development Intensity Analysis

Landscape Development Intensity Index

- The LDI is a land use based index of potential human disturbance.
- It is calculated spatially based on energy coefficients applied to land uses within watersheds.
- Development intensity factors are a function of the non-renewable energy use per unit area of land use.
- All non-renewable energies including electricity, fuels, fertilizers, pesticides.

Land Use	Non Renewable Empower Density (E14 sej/ha/yr)	LDI Coefficients
Natural System	0.00	0.00
Pine Plantation	5.10	1.58
Recreational / Open Space (Low-intensity)	6.55	1.83
Woodland Pasture (with livestock)	8.00	2.02
Pasture (without livestock)	17.20	2.77
Low Intensity Pasture (with livestock)	33.31	3.41
High Intensity Pasture (with livestock	46.74	3.74
Row crops	107.13	4.54
Single Family Residential (Low-density)	1,077.00	6.79
Recreational / Open Space (High-intensity)	1,230.00	6.92
Single Family Residential (High-density)	2,371.80	7.55
Highway (2 lane)	3,080.00	7.81
Low Intensity Commercial	3,758.00	8.00
Industrial (commercial ,mining)	5,210.60	8.32
Multi-family Residential (High rise)	12,825.00	9.19
Central Business District (Average 4 stories)	29,401.30	10.00

LDI Score	Description
0-2.00	Low Impact Nearly Pristine conditions
2.01-5.50	Medium Impact Low Intensity Residential /Agricultural
5.51-10.00	High Impact Urban

Selected Attributes of Zone2ldia

OWNER_LI_2	OWNER_CITY	OWNER_STAT	OWNER_ZIP_	LANDUSE_CD	SHAPE_area	SHAPE_len	Shape_Prop	LDI	LDI_CAL	LDI_SUM	Shape_Pr_1	LDI_CAL2	Zone	Zone_LDICA
	OLYMPIA	WA	98512	88	3450469.72372	8867.728091	1.776502	1	1.776502	302.616342	0.07385	0.07385	2	4.09
	OLYMPIA	WA	98511-4652	79	259067.735222	5375.692272	0.133383	7.47	0.905671	302.616342	0.005545	0.04142	2	4.09
	OLYMPIA	WA	98507	59	3021530.72897	9671.646853	1.55566	8.32	10.889617	302.616342	0.064669	0.53805	2	4.09
	OLYMPIA	WA	98502	11	816334.227826	5930.06762	0.420296	6.79	2.853812	302.616342	0.017472	0.118634	2	4.09
	OLYMPIA	WA	98501	91	1461904.05356	6367.180244	0.752673	1	0.752673	302.616342	0.031289	0.031289	2	4.09
	MOUNT VERNO	WA	98273	94	1177701.1446	5499.48754	0.606349	3.41	1.679587	302.616342	0.025206	0.085953	2	4.09
	LACEY	WA	98516	79	522968.364015	3444.69649	0.269254	6.79	1.828238	302.616342	0.011193	0.076001	2	4.09
	NEW YORK	NY	10021	91	825689.300084	6059.433629	0.425113	3.41	0.425113	302.616342	0.017672	0.060262	2	4.09

Record: 1 Show: All Selected Records (8 out of 57 Selected) Options

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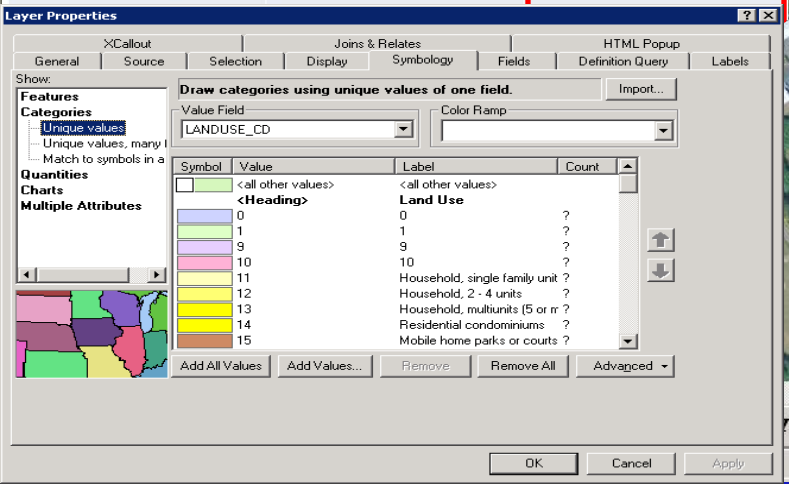
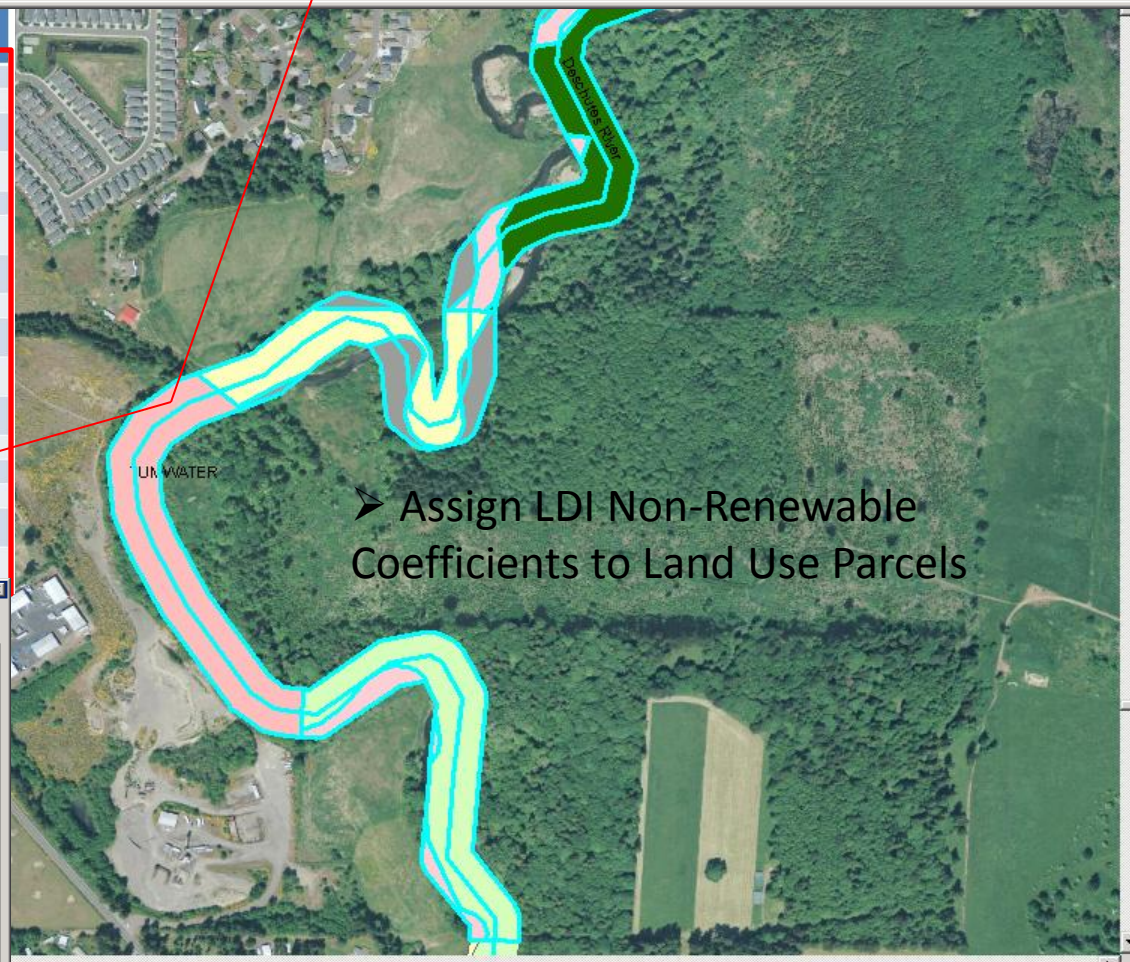
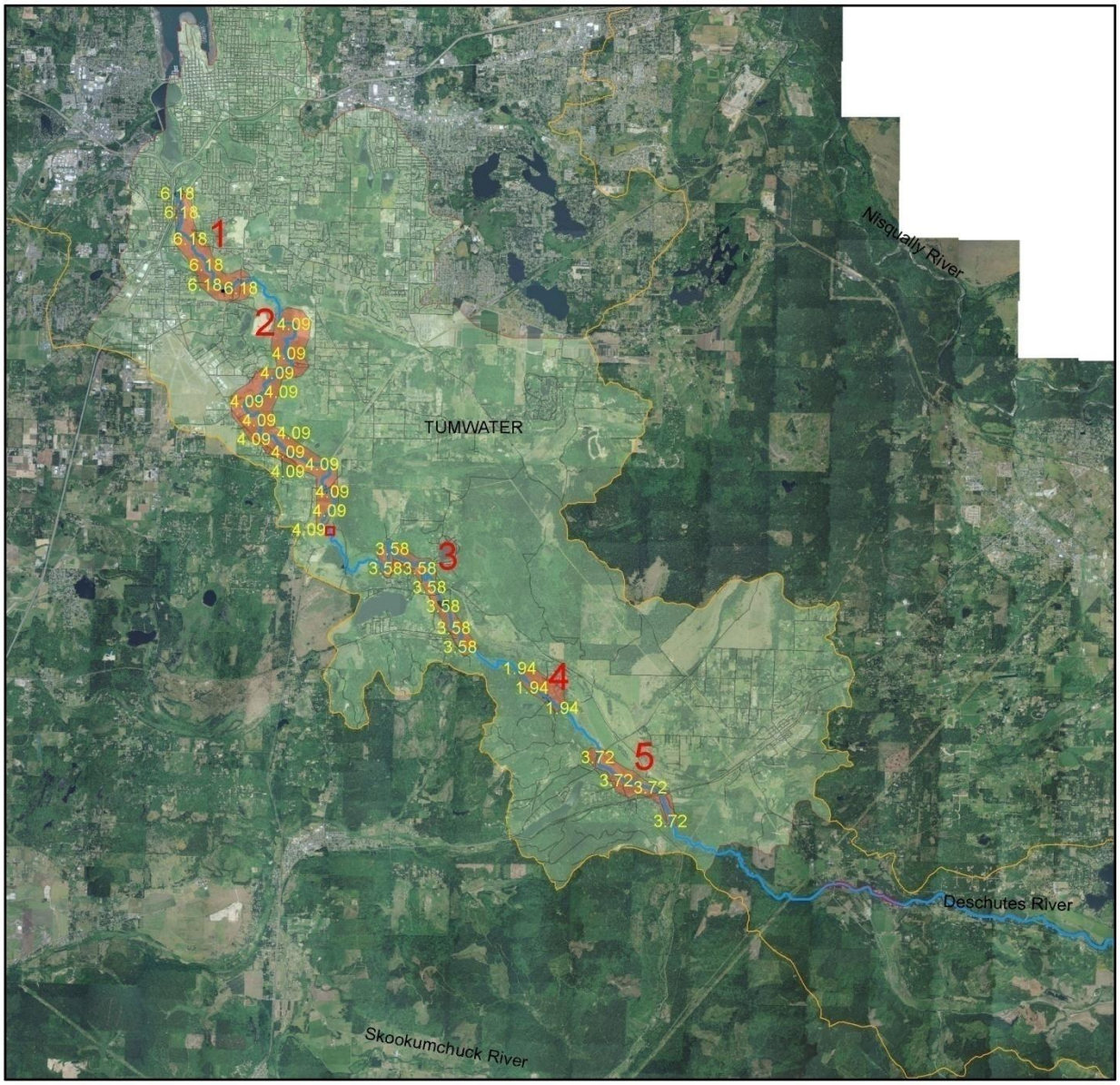




➢ Assign LDI Non-Renewable Coefficients to Land Use Parcels

Potential Reference Site Candidate Areas for WRIA 13 Tummwater HUC 6 Catchment



Huc 6 catchment	Catchment Road Density	LU Density 100ft	LDI Cal	Road Crossings
Tummwater	0.001195	2.14	3.17	8
	-2.92263			

LDI Zone Areas	LDI Cal	
1	6.18	3
2	4.09	2
3	3.58	1
4	1.94	0
5	3.72	2

LDI Score	Description
0-2.00	Nearly Pristine conditions
2.00-5.00	Low Residential /Agricultural
5.00-10.00	Urban

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W
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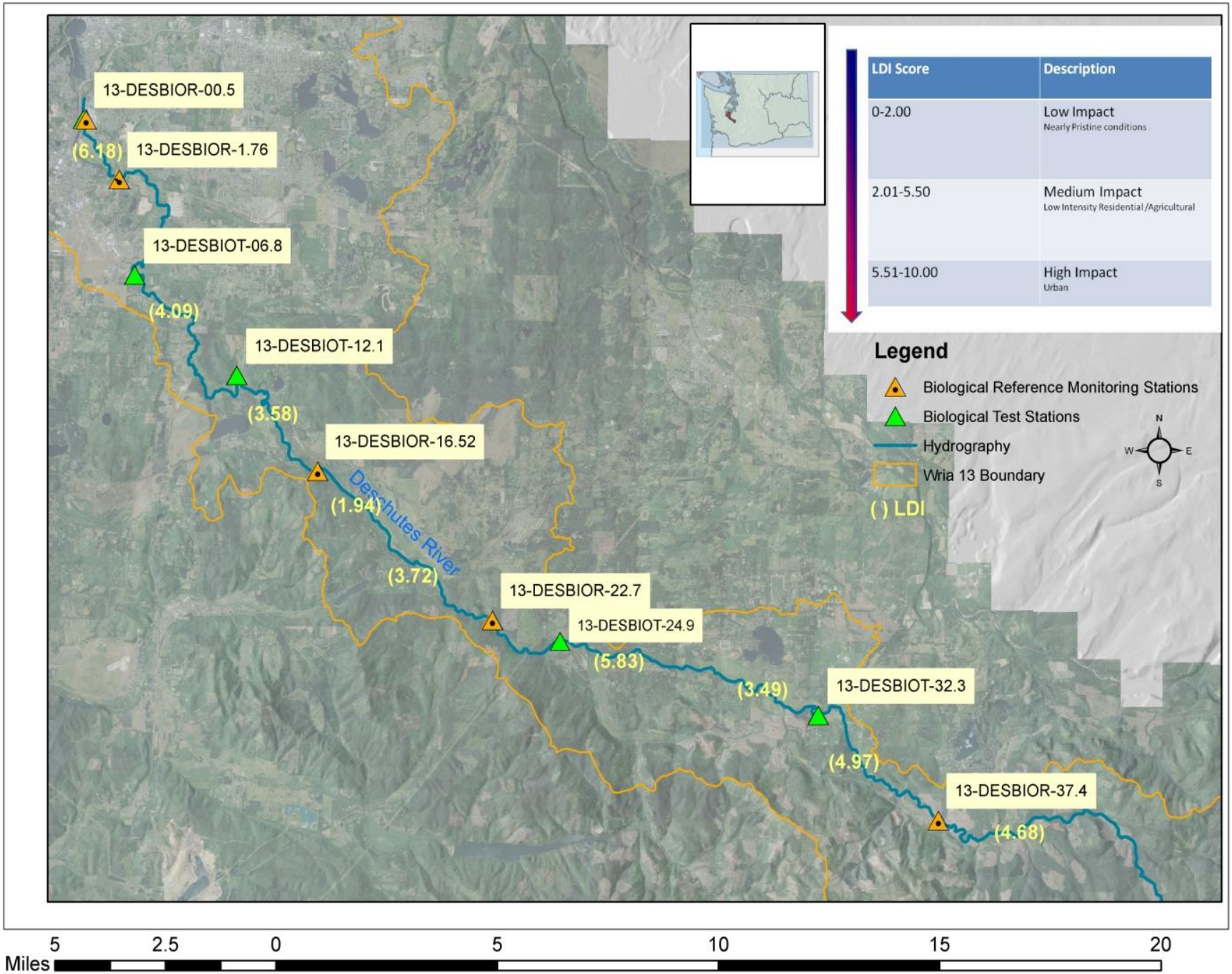
S


13-DESBIOR-00.5
(6.18)
13-DESBIOR-1.76
13-DESBIOT-06.8
(4.09)
13-DESBIOT-12.1
(3.58)
13-DESBIOR-16.52
(1.94)
Deschutes River
(3.72)
13-DESBIOR-22.7
13-DESBIOT-24.9
(5.83)
(3.49)
13-DESBIOT-32.3
(4.97)
13-DESBIOR-37.4
(4.68)
LDI Score
Description
0-2.00
Low Impact
Nearly Pristine conditions
2.01-5.50
Medium Impact
Low Intensity Residential /Agricultural
5.51-10.00
High Impact
Urban
Legend
Biological Reference Monitoring Stations
Biological Test Stations
Hydrography
Wria 13 Boundary
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Parameters

Habitat Parameters

- Substrate size
- Canopy cover
- Width/depth
- Slope
- Stream bank cover
- Discharge

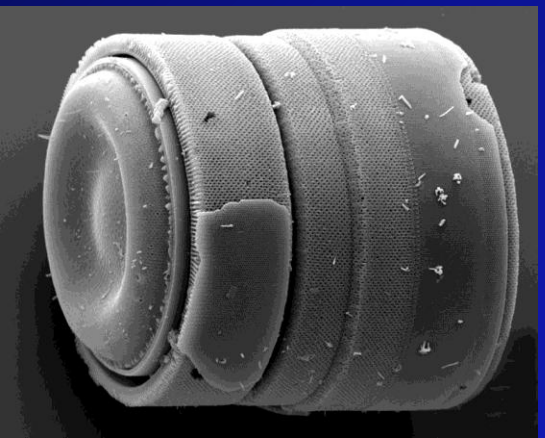
Chemical Parameters

- DO
- pH
- Conductivity
- Temp (continuous)
- Nutrients (some stations)

Biological Monitoring

Periphyton

- Diatoms/algae
- Cosmopolitan
- Communities similar world wide



Biological Monitoring

Macroinvertebrates

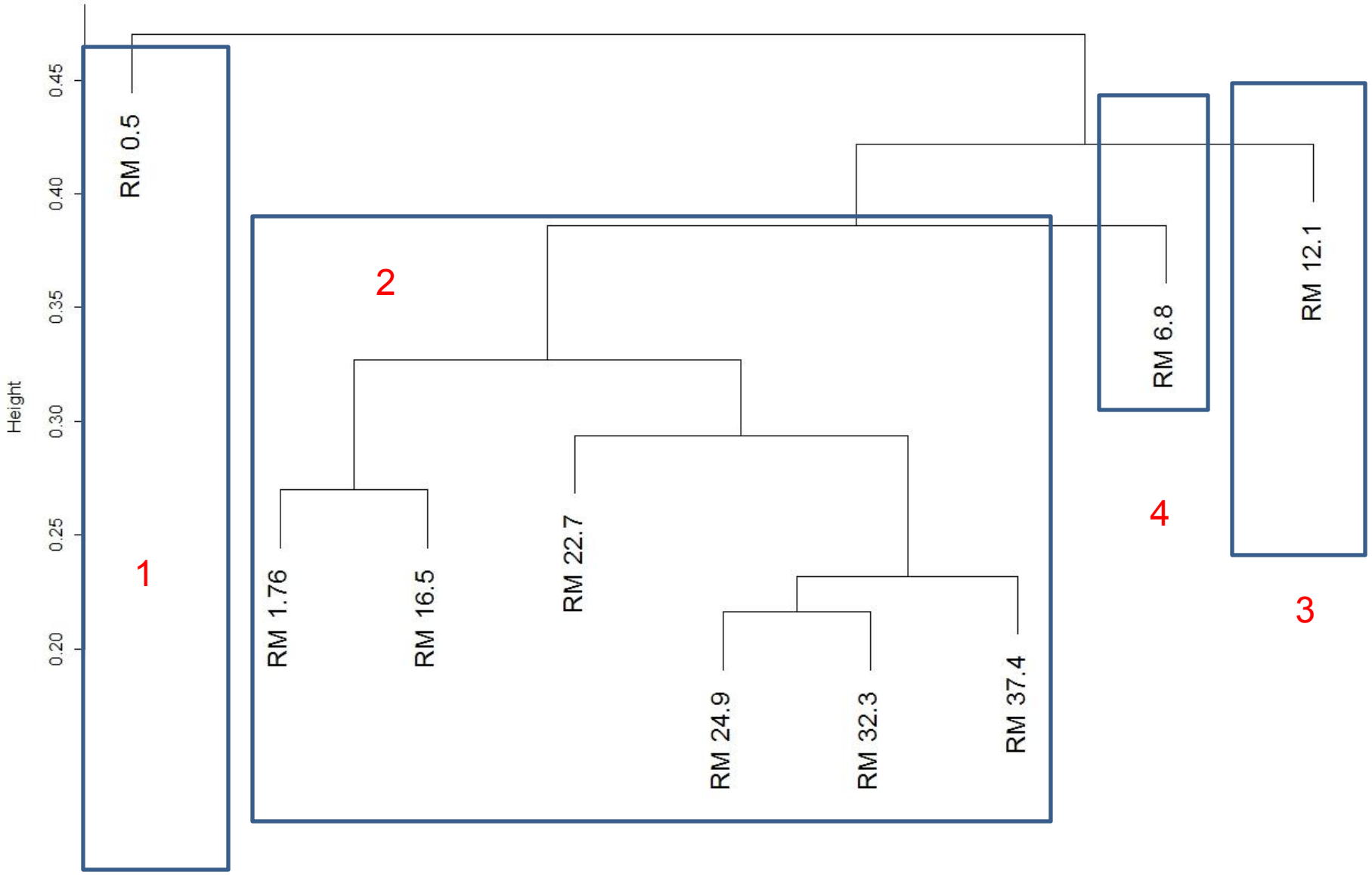
- Mayflies, stoneflies, etc.
- More regionally specific
- Good regional models useful for WQ standards
- Used statewide as WQ indicator

Preliminary Results

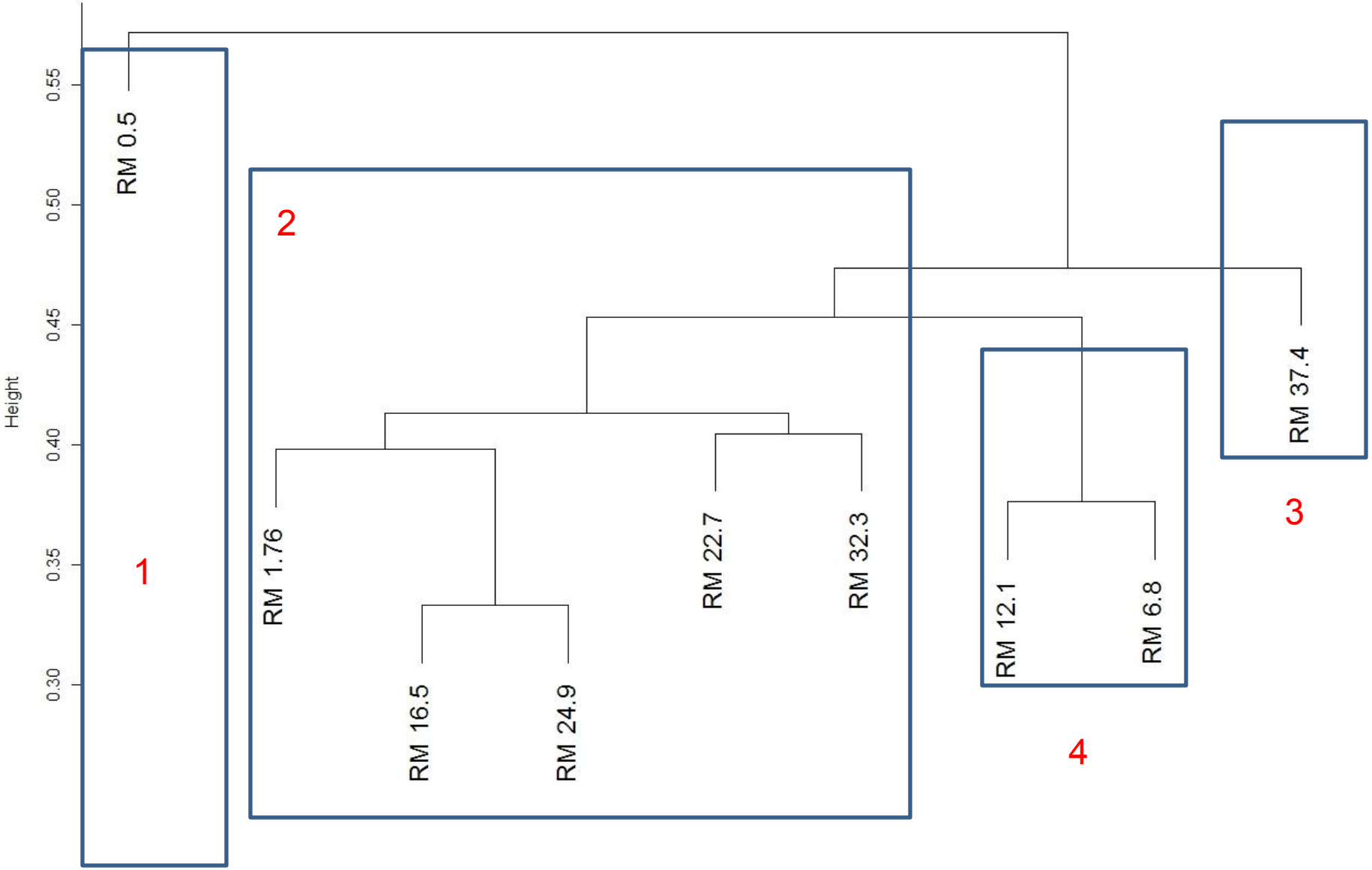
Similarity Analysis

- Groups sites based on species composition
- Does not include species abundance (yet!).
- It is the first step in a long statistical process.

Periphyton Similarity Analysis



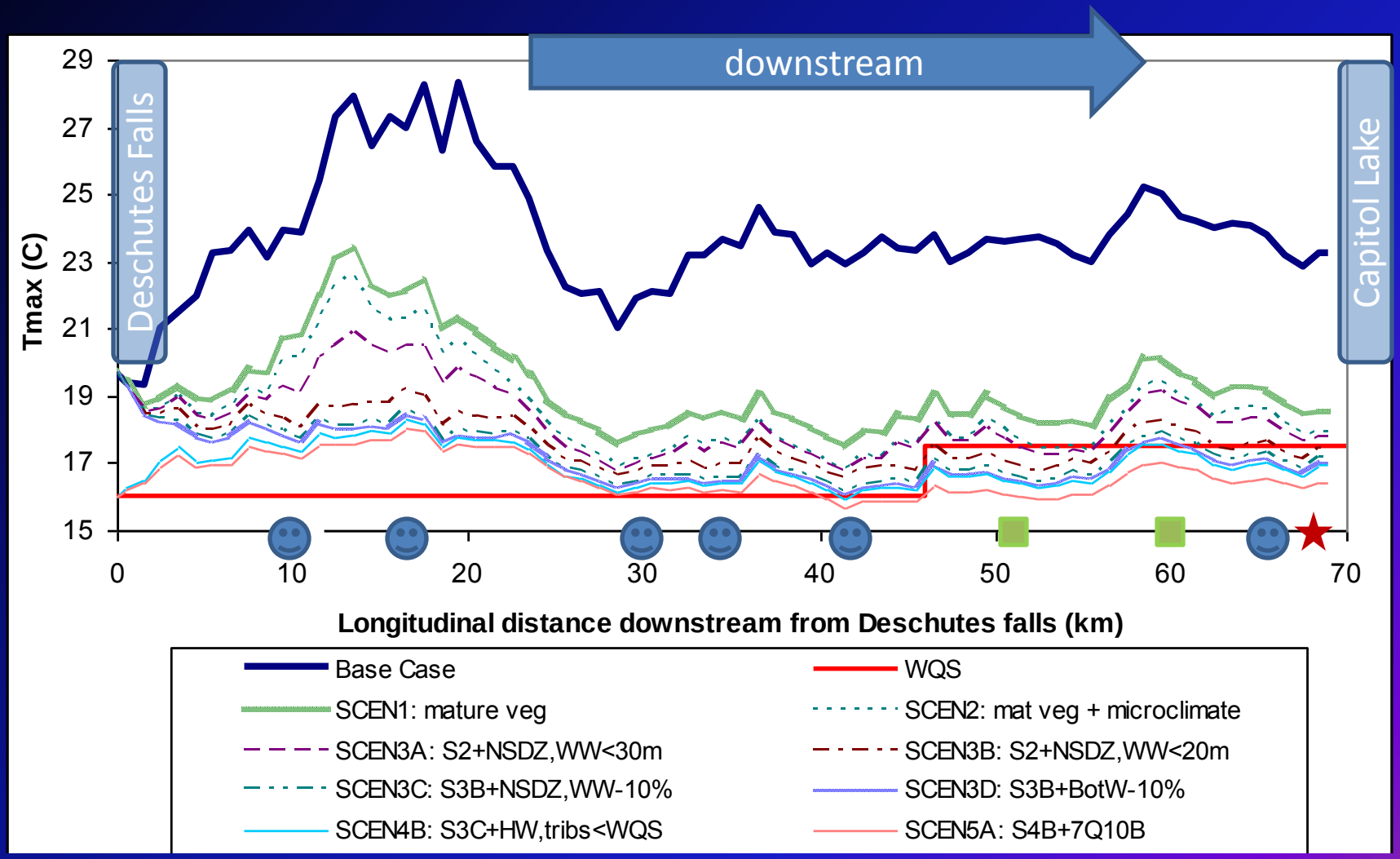
Macroinvertebrate Similarity Analysis



What does it all mean?

- RM 0.5 (Tumwater) had the most dissimilar macroinvertebrate and periphyton communities when compared to rest of stations
- All of our “least impact” stations (LDI based) group in the same category for periphtyon
- 3 of 4 for macroinvertebrates
- RM 6.8 and 12.1 group similar for both

What does it all mean?



Next Steps

- Perform analysis with other data to determine what driving community structure.
  - Compare with habitat, hydrograph, chemistry, land use
  - Compare with least impacted areas to determine anthropogenic impacts (based on LDI scores)

- What does the data say about water quality?

What do Metrics Say About WQ?

Metric	Response	Description
% Obligate Nitrogen-Heterotrophs	+	Taxa require continuous elevated concentrations of organically bound nitrogen, increases with severe organic enrichment.
% *Nitzschia individuals*	+	Generally increases in response to nutrient enrichment, sedimentation or salinity
% *Encyonema individuals*	-	Decrease in response to nutrients
% Acidobiontic	+	Diatoms mainly occur in waters pH <5.5, increases in response to acid-mine drainage
% Oligosaprobous	-	Taxa mainly occur in waters with dissolved oxygen sat. >85% and BOD <2 mg/L, decreases with inorganic and organic nutrient enrichment

Table A – Periphtyon metrics and their expected response to environmental stress. + = respond positively to stress, - = respond negatively to stress, V = variable response to stress.

Metric	Reference	Metric Responce	Description
Taxonomic Composition			
% *Achnanthes* / (*Achnanthes* + *Navicula*)	30	-	Decreases in reponse to stress (the ratio reduces the taxonomic variance of the *Achnanthes* metric)
% *Cymbella* / (*Cymbella* + *Navicula*)	30	-	Decreases in reponse to stress (the ratio reduces the taxonomic variance of the *Cymbella* metric)
% Dominant species	5	+	Increases in response to stress, particularly nutrient enrichment, toxic substances and sedimentation
% *Achnanthes* individuals	9,16,18,28,30	V	Generally decreases in response to stress, though some taxa may increase with nutrient enrichment
% *Amphora* individuals	16,28	V	May increase in response to nutrients or metal toxicity
% *Cocconeis* individuals	12,18,28,30	V	Generally decrease in response to stress, though some taxa may increase in response to nutrients or metal toxicity
% *Cyclotella* individuals	6,18,30	V	Variable response to stress. Some taxa increase in response to nutrients or salinity
% *Cymbella* individuals	12,18,20,28,30	-	Generally decreases in response to stress, commonly found on coarse substrates
% *Cymatopleura* individuals	6	+	Generally increases in response to sedimentation
% *Diatoma* individuals	18,28	V	May increase in response to nutrients or metal toxicity
% *Encyonema* individuals	18	-	Decrease in response to nutrients
% *Epithemia* individuals	s,18	-	Nitrogen-autotrophs decrease in response to organic nutrient enrichment
% *Eunotia* individuals	s,16,18,19,28,29	V	Increases in response to metals toxicity or periodic drying, commonly found in low pH nutrient-poor waters, may decrease with nutri
% *Fragilaria* individuals	6,9,12,18,30	-	Generally decreases in response to stress
% *Frustulia* individuals	16,18,20,29,30	V	Generally decreases in response to stress, though some taxa may increase with metals toxicity
% *Gomphonema* individuals	6,9,12,16,18,28,30	V	Generally decreases in response to stress, though some taxa may increase with nutrient enrichment or sedimentation
% *Gyrosigma* individuals	6,16,18	+	Generally increases in response to nutrient enrichment or sedimentation
% *Hantzschia* individuals	6	+	Generally increases in response to sedimentation
% *Navicula* individuals	s,6,9,16,18,20,21	+	Careful - large taxa group, however many taxa generally increase in response to nutrient enrichment, sedimentation or salinity
% *Neidium* individuals	28	+	Increases in response to metals toxicity, commonly found in low pH nutrient-poor waters
% *Nitzschia* individuals	6,9,14,16,18,20,21,28	+	Generally increases in response to nutrient enrichment, sedimentation or salinity
% *Pinnularia* individuals	20	+	Generally increases in response to metals toxicity
% *Rhoicosphenia* individuals	14,28,30	+	Generally increases in response to nutrient enrichment
% Rhopalodiales (*Rhopalodia* + *Epithemia*)	b	-	Nitrogen-autotrophs decrease in response to organic nutrient enrichment
% *Rhopalodia* individuals	6	-	Nitrogen-autotrophs decrease in response to organic nutrient enrichment
% *Stenopterobia* individuals	6,20	+	Generally increases in response to sedimentation or metals toxicity
% *Surirella* individuals	s,6,16,18	+	Generally increase in response to sedimentation and possibly nutrients
% *Synedra* individuals	12,18,30	-	Generally decreases in response to stress
% *Tabellaria* individuals	16,18	V	Some taxa may increase with metals toxicity, some increase with nutrients
% *Ulothrix* individuals	s	+	Generally increases in response to metals toxicity
% No. of *Achnanthes* species	30	-	Generally decreases in response to stress
% No. of *Amphora* species	30	V	May increase in response to nutrients or metal toxicity
% No. of *Cocconeis* species	30	-	Generally decreases in response to stress
% No. of *Cyclotella* species	30	-	Generally decreases in response to stress
% No. of *Cymbella* species	30	-	Generally decreases in response to stress, commonly found on coarse substrates
% No. of *Fragilaria* species	30	-	Generally decreases in response to stress
% No. of *Frustulia* species	30	V	Generally decreases in response to stress, though some taxa may increase with metals toxicity
% No. of *Gomphonema* species	30	-	Generally decreases in response to stress
% No. of *Navicula* species	30	V	Highly variable metric
% No. of *Nitzschia* species	30	V	Highly variable metric
% No. of *Rhoicosphenia* species	30	V	May decrease in response to stress, though is a highly variable metric
% No. of *Surirella* species	30	V	Highly variable metric
% No. of *Synedra* species	30	-	Generally decreases in response to stress
% Diatoms	8	-	Relative abundance of diatoms to green algae and Cyanobacteria. Generally declines with increased stress
% Green Algae	8	+	Relative abundance of green algae to diatoms. Increases in response to stress, particularly nutrient and organic enrichment
% Cyanobacteria	8	+	Relative abundance of Cyanobacteria to diatoms. Increases in response to stress, particularly nutrient and organic enrichment and toxic substances

Table A – Periphtyon metrics and their expected response to environmental stress. + = respond positively to stress, - = respond negatively to stress, V = variable response to stress.

Metric	Reference	Metric Response	Description
Pollution Tolerance			
% Sensitive individuals	5,6,24	-	Decreases in response to stress
% Most Tolerant individuals	5,6	+	Increases in response to severe stress
% Tolerant individuals	5,6	+	Increases in response to stress
Pollution Tolerance index	6,24	-	Decreases in response to stress
Stability index (percent araphid or non-motile diatoms)	b	-	Decreases in response to metal toxicity, nutrient enrichment, scouring and macroinvertebrate grazing
Disturbance index (percent *Achnanthes minutissimum* individuals)	1,4,5,6,12,14,24,29	V	May increase or decrease in response to moderate metals toxicity, nutrient enrichment, scouring, and grazing by macroinvertebrates. Values <25 indicate a normal level of disturbance, 25 to 50 indicate minor disturbance, 50 to 75 indicate moderate disturbance, >75 indicate major disturbance.
Heavy Metals index (percent of 18 diatoms tolerant to metals toxicity)	b	+	Increases in response to metals toxicity
Siltation index (percent abundance of Cylindrotheca + *Navicula* + *Nitzschia* + *Surirella*)	1,6	+	Increases in response to sedimentation
pH			
% Acidobiontic	24,28	+	Diatoms mainly occur in waters with pH <5.5, increases in response to acid-mine drainage
% Acidophilous	8,24,28	+	Diatoms mainly occur in waters with pH <7, increases in response to acid-mine drainage
% Circumneutral	24,28	V	Diatoms mainly occur in waters with pH around 7, variable response to stress
% Alkaliphilous	5,6,24,28	+	Diatoms mainly occur in waters with pH >7, increases in response to salt input, high ionic strength or soil erosion
% Alkalibiontic	24,28	+	Diatoms exclusively occur in waters with pH >7, increases in response to salt input, high ionic strength or soil erosion
Salinity			
% Very Fresh (Oligohalobous)	24,28	-	Diatoms mainly occur in waters with extremely low concentrations of chloride and salinity, decreases with high ionic strength
% Fresh (Oligohalobous)	24,28	-	Diatoms mainly occur in waters with chloride <100 mg/L or <0.2% salinity, decreases with high ionic strength
% Fresh-Brackish (Oligohalobous)	24,28	V	Diatoms mainly occur in waters with chloride <500 mg/L or <0.9% salinity, variable response to stress
% Brackish-Fresh (Mesohalobous)	5,24,28	+	Diatoms mainly occur in waters with chloride 500-1000 mg/L or 0.9-1.8% salinity, increases in response to high ionic strength
% Brackish (Mesohalobous)	5,24,28	+	Diatoms mainly occur in waters with chloride 1000-5000 mg/L or 1.8-9.0% salinity, increases in response to high ionic strength
% Marine (Euhalobous)	5,24,28	+	Diatoms mainly occur in waters with chloride >5000 mg/L or >9.0% salinity, increases in response to high ionic strength
Nitrogen-Uptake Metabolism			
% Obligate Nitrogen-Heterotrophs	5,6,28	+	Taxa require continuous elevated concentrations of organically bound nitrogen, increases with severe organic enrichment.
% Nitrogen Autotrophs (high organics)	28	+	Taxa can tolerate elevated concentrations of organically bound nitrogen, increases with organic enrichment
% Facultative Nitrogen-Heterotrophs	5,6,28	+	Taxa can tolerate periodic elevated concentrations of organically bound nitrogen, increases with episodic organic enrichment
% Nitrogen Autotrophs (low organics)	6,28	-	Taxa can tolerate only very small concentrations of organically bound nitrogen, decreases with organic enrichment
Saprobity			
% Oligosaprobous	6,24,28	-	Taxa mainly occur in waters with dissolved oxygen sat. >85% and BOD_5^{20} <2 mg/L, decreases with inorganic and organic nutrient enrichment
% β - Mesosaprobous	24,28	V	Taxa mainly occur in waters with dissolved oxygen sat. 70-85% and BOD_5^{20} 2-4 mg/L, variable response, may be indicative of elevated nitrates
% α - Mesosaprobous	24,28	V	Taxa mainly occur in waters with dissolved oxygen sat. 25-70% and BOD_5^{20} 4-13 mg/L, variable response to inorganic and organic nutrient enrichment, may be indicative of elevated ammonia
% α - Mesosaprobous/Polysaprobous	28	+	Taxa mainly occur in waters with dissolved oxygen sat. 10-25% and BOD_5^{20} 13-22 mg/L, increases with inorganic and organic nutrient enrichment, can be indicative of elevated ammonia and some hydrogen sulfide production
% Polysaprobous	5,6,24,28	+	Taxa mainly occur in waters with dissolved oxygen sat. <10% and BOD_5^{20} >22 mg/L, increases with severe inorganic and organic nutrient enrichment, indicative of elevated ammonia and hydrogen sulfide production

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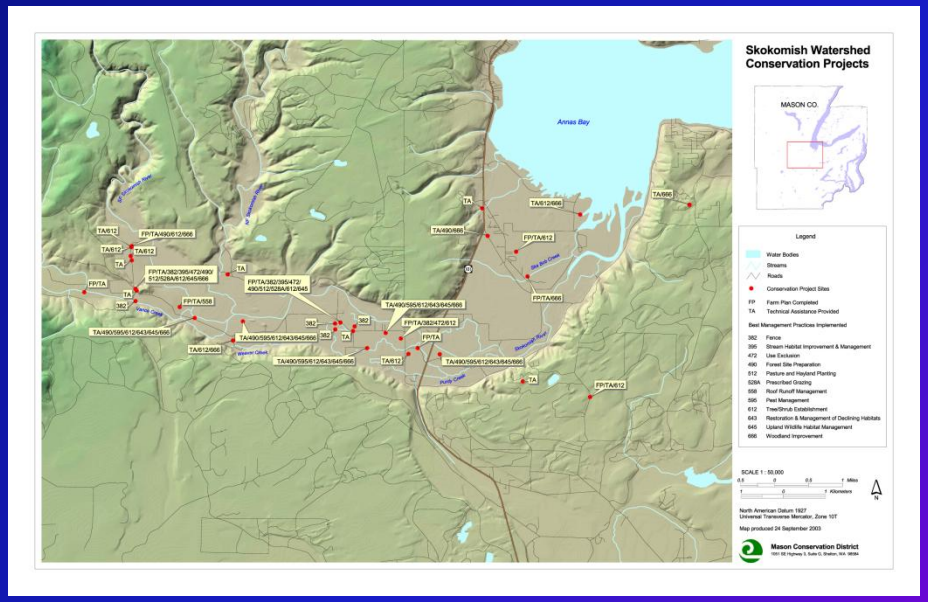
Metric	Reference	Metric Response	Description
Trophic State			
% Dystrophic	24,28	-	Taxa tolerant to high humic or dissolved organic carbon conditions, decreases with inorganic nutrient enrichment
% Oligotraphenic	6,24,28	-	Taxa can tolerate only very small concentrations of inorganic nutrients, decreases with inorganic nutrient enrichment
% Oligo-mesotraphentic	28	-	Taxa can tolerate only small concentrations of inorganic nutrients, decreases with inorganic nutrient enrichment
% Mesotraphentic	24,28	V	Taxa can tolerate moderate concentrations of inorganic nutrients, variable response to inorganic nutrient enrichment
% Meso-eutraphentic	28	V	Taxa can tolerate moderate to high concentrations of inorganic nutrients, variable response to inorganic nutrient enrichment
% Eutraphentic	5,6,8,24,28	+	Taxa can tolerate high concentrations of inorganic nutrients, increases in response to inorganic nutrient enrichment
% Hypereutraphentic	5,6,8,28	+	Taxa can tolerate very high concentrations of inorganic nutrients, increases in response to inorganic nutrient enrichment
Moisture Content of Waterbody			
% Exclusively Outside Waterbodies	28	+	Taxa mainly occur in non-aquatic environments, can increase in response to dewatering
% Mainly Wet Places; Sometimes in Water	28	+	Taxa mainly occur in wet and moist or temporarily dry places, can increase in response to dewatering
% Mainly in Waterbodies; Regularly Wet	28	V	Taxa mainly occur in waterbodies; also rather regularly on wet and moist places, variable response to dewatering
% Mainly in Waterbodies; Sometimes Wet	28	V	Taxa mainly occur in waterbodies; sometimes on wet places
% Rarely Outside Waterbodies	28	V	Taxa never or very rarely occur outside waterbodies
Oxygen Requirements			
% Very Low	5,6,28	+	Taxa mainly occur in waters with dissolved oxygen sat. around 10%, increases in response to nutrient and organic enrichment, possibly sedimentation
% Low	5,6,28	+	Taxa mainly occur in waters with dissolved oxygen sat. >30%, increases in response to nutrient and organic enrichment, possibly sedimentation
% Moderate	28	V	Taxa mainly occur in waters with dissolved oxygen sat. >50%, variable response to stress
% Fairly High	6,28	-	Taxa mainly occur in waters with dissolved oxygen sat. >75%, decreases in response to nutrient and organic enrichment, possibly sedimentation
% Continuously High	6,28	-	Taxa mainly occur in waters with dissolved oxygen sat. around 100%, decreases in response to nutrient and organic enrichment, possibly sedimentation
Nutrient Indices			
Chlorophyll a	8,20,24	-	Surrogate for standing crop, decreases in response to nutrient and organic enrichment and contaminant loading. Calculation = (Regional Median Chl a/(Absolute Value of Regional Median Chl a ± sample Chl a))
Phosphatase Activity	8	-	Decreases in response to nutrient enrichment and contaminant loading. Calculation = (Regional Median Phosphatase Value/(Absolute Value of Regional Median Phosphatase Value ± sample Phosphatase Value))
Biomass (Standing Crop)	8,24	V	Variable response to stress, though may decrease with nutrient enrichment and toxins. Calculation = (Regional Median Biomass Value/(Absolute Value of Regional Median Biomass Value ± Ash Free Dry Mass [AFDM])
Similarity			
Mean Similarity to Reference Sites	30	-	Mean Bray-Curtis similarity in species composition to reference sites; decreases in response to stress
% Reference Species	30	-	Percent of species found at reference sites that occur at disturbed sites; decreases in response to stress
No. of Distinct Reference Species	30	-	Number of species found primarily at reference sites but not at impaired sites; decreases in response to stress
% Community Similarity	24	-	Similarity in species composition to reference sites; decreases in response to stress
Motility			
% Motile Individuals	5,6,8,24	+	Increases in response to sedimentation
% Not Motile Individuals	6	-	Decreases in response to sedimentation
% Highly Motile Individuals	6	+	Increases in response to sedimentation
% Varible Motility Individuals	6	V	Variable response to stress
% Moderately Motile Individuals	6	+	Increases in response to sedimentation

Implementation Tracking

- What?
  - x feet of riparian fencing, x feet of riparian planting, septic system repair.
- Where?
  - At smallest scale possible (lat, long)
- When?
  - Dates when implementation occurred

Bringing it all together

- Spatially represent activities in GIS layer
- Statistically measure changes in biology, habitat and water quality with efforts.
- Feedback loop to effort
- Tracking success and propose future action.



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