Combining Multiple EMAP Data Sets that Expand Assessment Capability: an example from the OR and WA Marine West Coast Forest Level II Ecoregion.

Steve Barrett

Robert Plotnikoff

Tetra Tech, Inc.
Surface Water Group
Seattle, WA

Brett Marshall

Presentation Topics

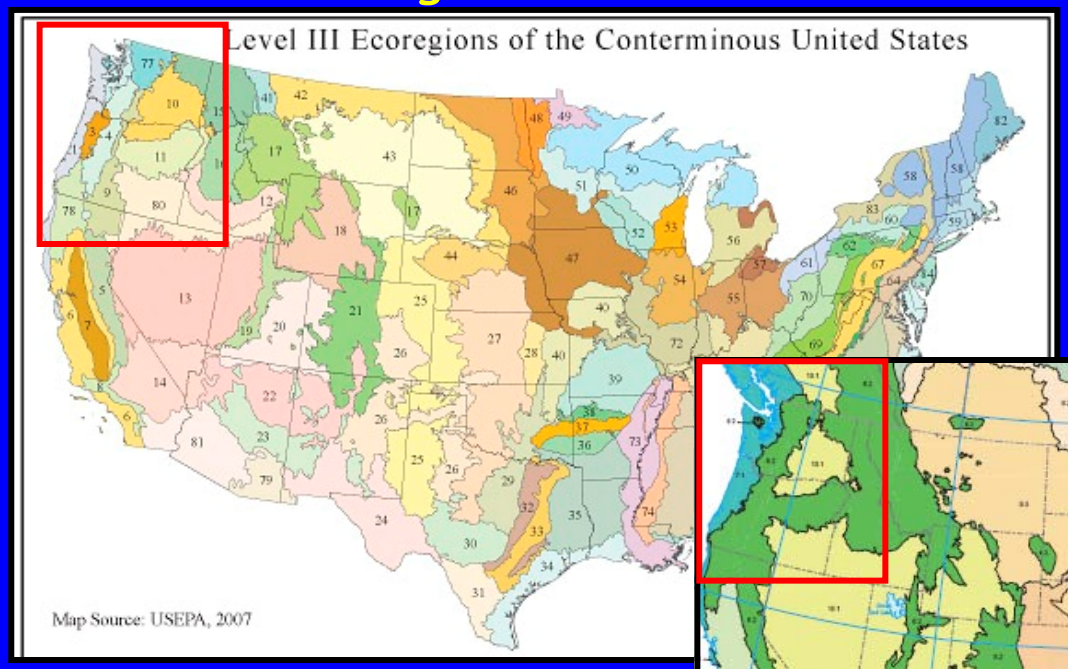
- Reasons for Combining Data Sets
- Regional Tools (Natural & Management)
- EMAP Projects and Combining Data
  - Project relationships & site membership
  - Identifying variables for analysis
- Re-Calculating Site Weights
- Developing an MMI (Level II Ecoregion)
  - Data comparability among EMAP projects
- Comparison of Assessments; EMAP projects at multiple scales

Applications for Agencies & Tribes

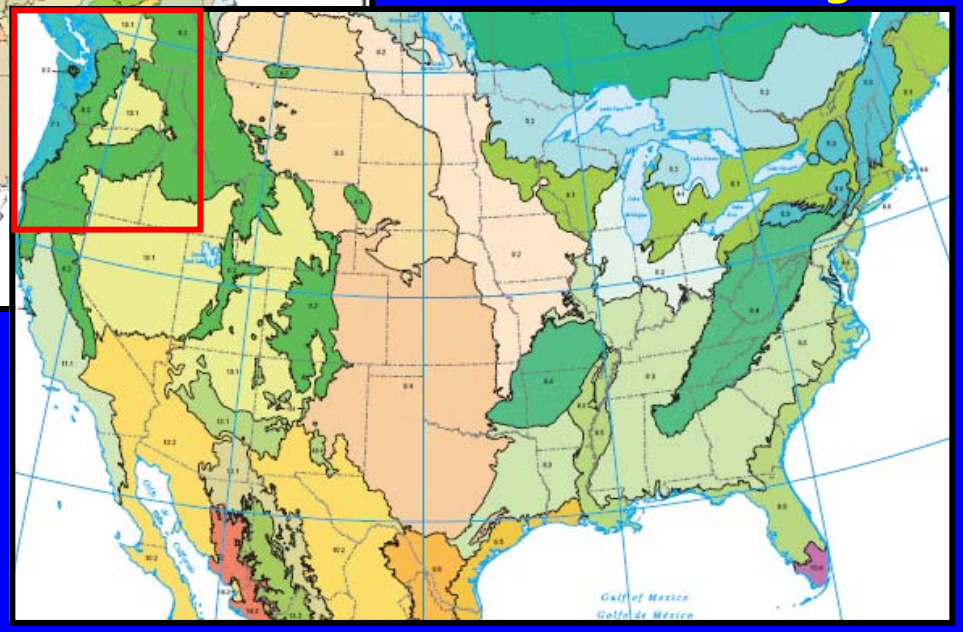
- Sharing monitoring data
  - Common restoration/regulatory goals
  - Salmon Recovery/Watershed Health
- Sharing work effort
  - Dedicate a portion of the monitoring effort
  - Expand the extent of an assessment
- Increasing detail for assessments
  - Increase no. of samples for assessments
  - Represent a greater variety of settings (stream/lake)
  - Detect subtle ecosystem stressors (not just the obvious ones!)

Natural Regions

Level III Ecoregions



Level II Ecoregions



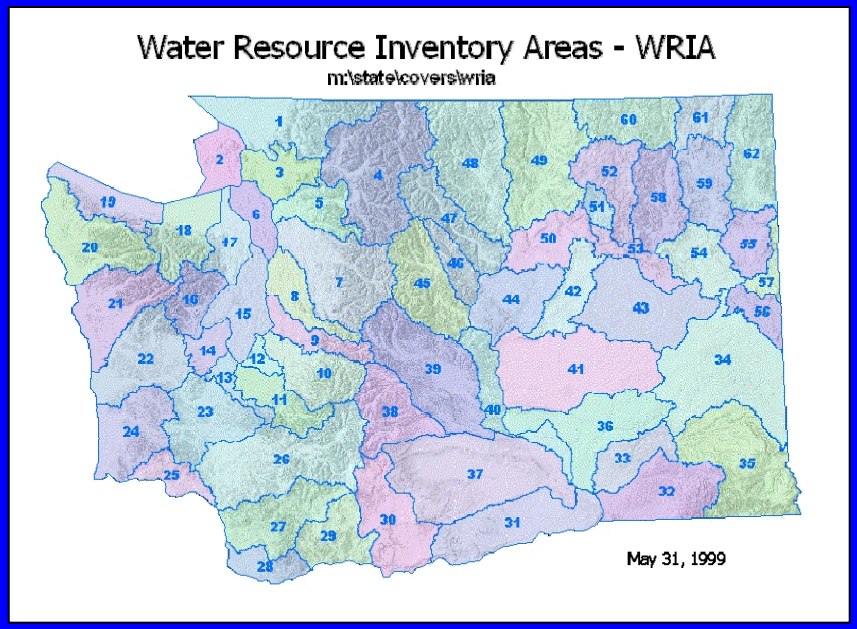
Management Regions

Salmon Recovery Regions

- Coarse aggregation of Watersheds
- Presence of salmon populations

WRIA's

- smaller scale of watersheds
- useful to County Governments
- water quality focus



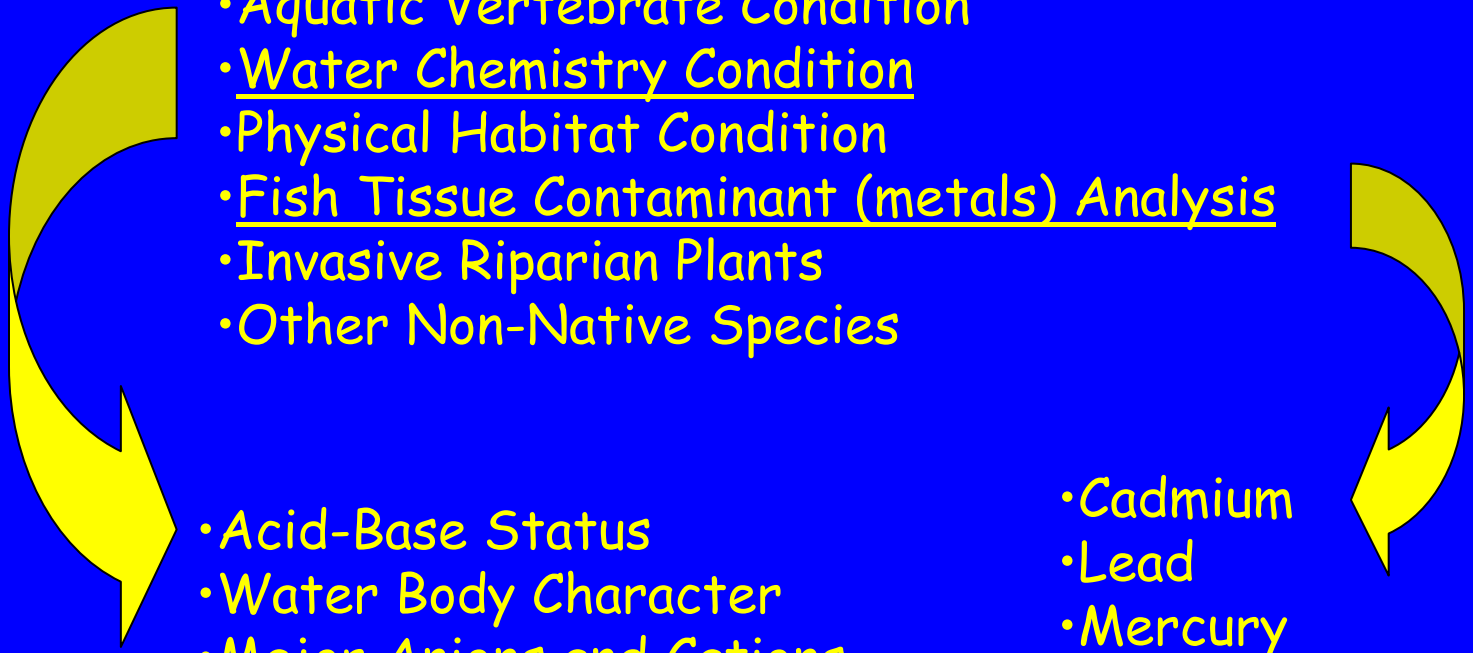
Identifying EMAP Projects

Project Year (field work)	Project Name	Project Description
1994-1995	OR_WA 1994-1996	Oregon/Washington Coast Range
1997	WA_CHEHALIS	Upper Chehalis Basin
1997	OR_STREAMS	Fish Tissue Survey
*1998-2003	*OR_SALMON	*Oregon Salmon Plan
1999-2004	EMAP_WEST	Western EMAP Rivers and Streams

*Data not currently available for use in this analysis. This project contains information from several years and from projects that were planned independently so that combining and re-weighting sites is beyond the scope of this project.

Assembling EMAP Data Sets

- Extent of Resources Sampled
- Benthic Macroinvertebrate Condition
- Aquatic Vertebrate Condition
- Water Chemistry Condition
- Physical Habitat Condition
- Fish Tissue Contaminant (metals) Analysis
- Invasive Riparian Plants
- Other Non-Native Species



- Acid-Base Status
- Water Body Character
- Major Anions and Cations
- Nutrients
- Trace Metals

- Cadmium
- Lead
- Mercury
- Zinc

Type of Metrics Used in Analysis

- Raw data
  - Single measurement (e.g., most WQ variables)
- Calculated metrics
  - Multiple observations on each transect (11 transects in the sampling reach; e.g., canopy cover)
- Assumptions & design of EMAP Projects
  - Site ID, Lat/Long, Stream Order, Site Weight, *etc.*

Criteria for Variable Selection

- Data availability among EMAP projects (limitations)
  - addition of new variables
  - changes in field protocols
  - mismatching variable names (i.e., between projects)

- Period of record limitations
  - Long time-frame for combined projects (1994 – 2004)
  - Normally 5-year periods for assessment

Final List of Analysis Variables
Physical Habitat

a. Substrate
b. Riparian condition
c. Wood
d. Pool condition

Variable	Full Name
XFC_NAT	Mean Areal Cover (Natural Types)
W1_HALL	Riparian Disturbance (human activities-proximity weighted)
LRBS_BW5	Bed Stability (Log_{10}[relative bed stability])
XPCMG	Riparian Vegetation
XCDENMID	Shade
W1_HAG	Riparian Disturbance (agricultural activities-proximity weighted)
V1TM100	Large wood volume in/above the bankfull channel (per 100m of stream)
RP100	Residual pool area per 100m of stream
XFC_BIG	Fish cover provided by large wood, rocks, undercut banks, or manufactured material
PCT_FN	% Substrate that is Fines (silt/clay/muck)
PCT_SAFN	% Substrate that is Sand of smaller in size (<2 mm diameter)
XEMBED	Embeddedness (reach average)

Final List of Analysis Variables

Water Quality

a. Field
b. Conventional
c. Nutrient
d. Metals
e. Ionic forms

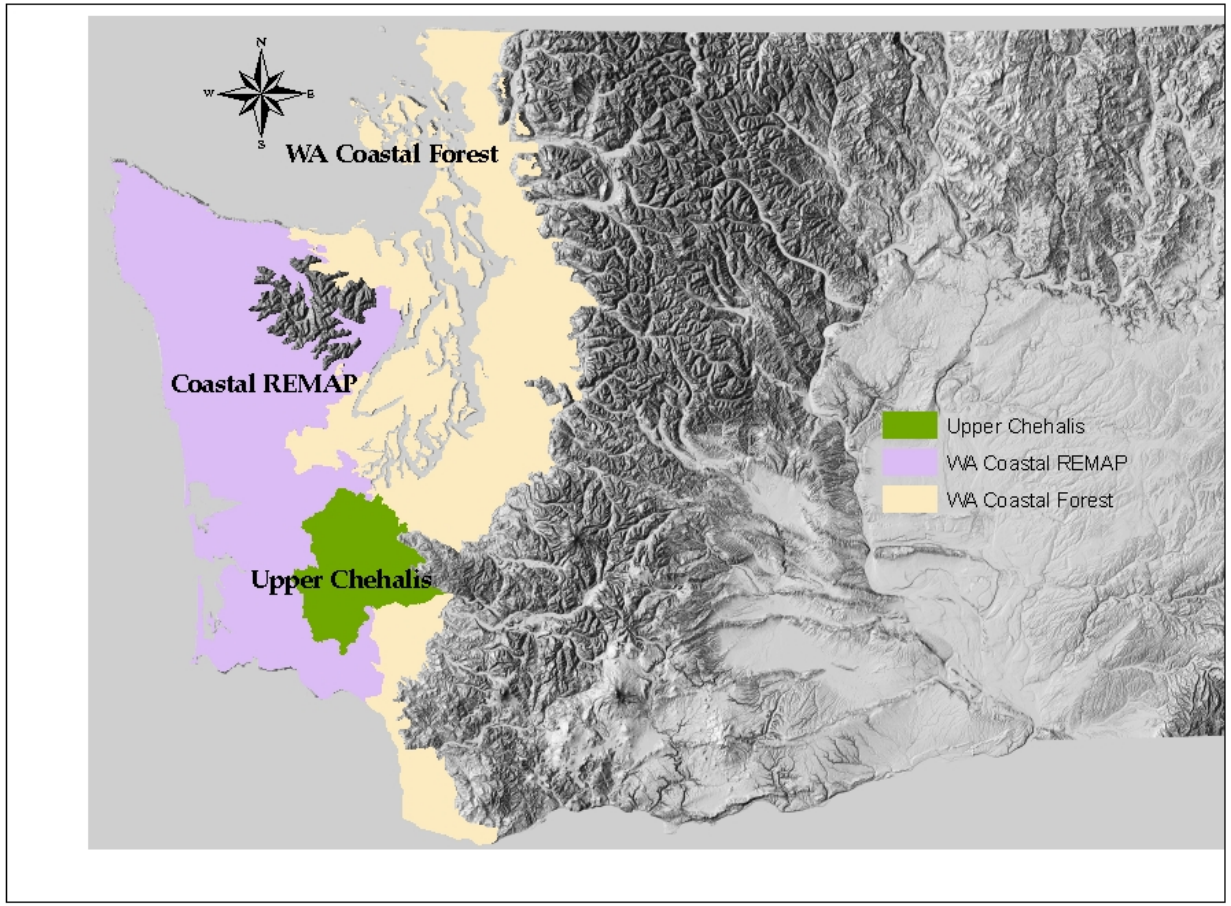
Variable	Full Name
PHSTVL	pH
COND	Specific Conductance
ANC	Acid Neutralizing Capacity
TURB	Turbidity
DOC	Dissolved Organic Carbon
CL	Chloride Concentration
SO4	Sulfate Concentration
TSS	Total Suspended Sediment
NH4	Ammonia
NO3	Nitrate
Zn	Zinc
SOBC	Sum of Base Cations
ORION	Estimated Organic Anions
DOSAT	Dissolved Oxygen Saturation
NTL	Total Nitrogen
PTL	Total Phosphorus
STRM_DO	Stream Dissolved Oxygen
STRMTEMP	Stream Temperature

Final List of Analysis Variables
Biological Expressions

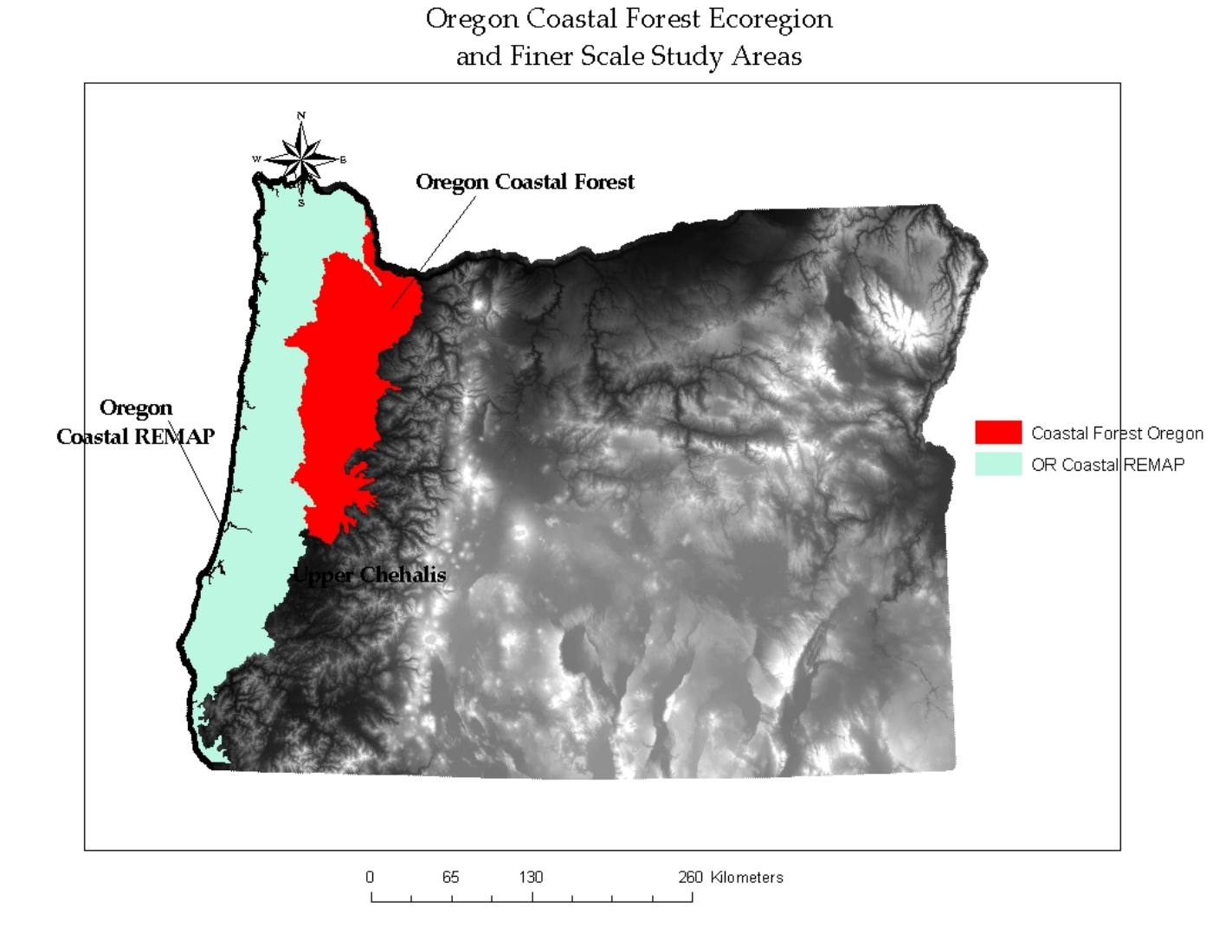
Variable	Full Name
MMI_WSABEST	Multi-Metric Index for WSA
OE300_zero	300 count, with probability of occurrence cutoff at > 0
OE300_five	[a]300 count, with probability of occurrence cutoff at > 0.5
Oe_5_3reg	[b]300 count, with probability of occurrence cutoff at > 0.5 (WSA's regression model)

EMAP Project Relationships

Washington Coastal Forest Ecoregion
and Finer Scale Study Areas



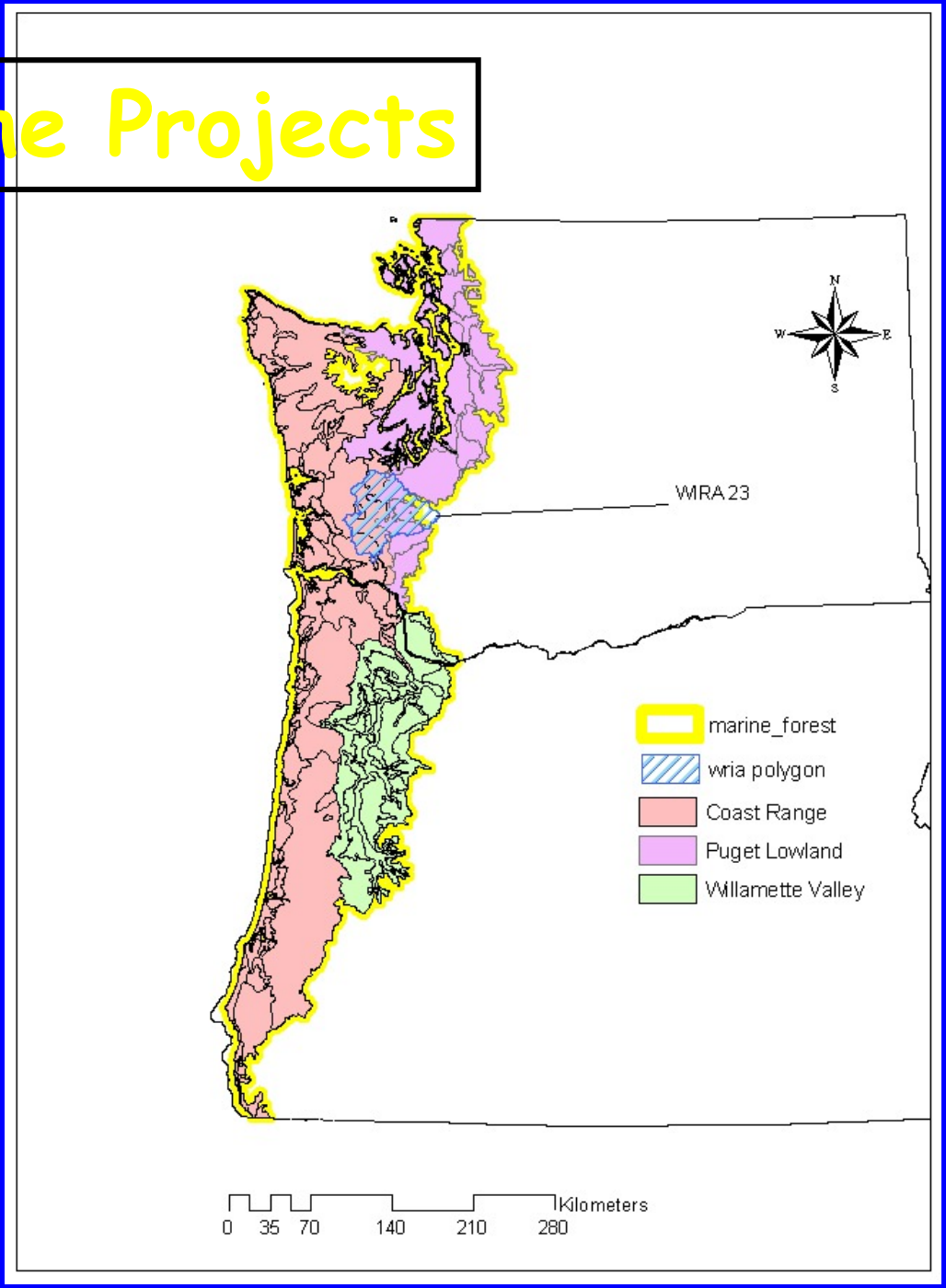
EMAP Project Relationships



Combine the Projects

Nature of Associations

a. Regional overlap
b. Sites outside of region



Site Membership Determination

- Procedure for determining site membership

EMAP/REMAP Project	Spatial Area	Groups
Western EMAP	WA & OR	WA in Marine West Coast Forest WA not in Marine West Coast Forest OR in Marine West Coast Forest OR not in Marine West Coast Forest
Upper Chehalis (WA)	WRIA 23	WA-in Marine West Coast Forest WA- not in Marine West Coast Forest
OR/WA REMAP	Coast Range	Coast Range-WRIA 23 Coast Range-not in WRIA 23 Puget Lowland-WRIA 23 Puget Lowland-not in WRIA 23
Oregon Streams	Oregon	OR-in Coast Range OR-in Willamette Valley

Note: avoid double-counting sites by placement in more than one spatial area.

Site Membership Determination

- Groupings for determining site weights

Final Spatial Groups	Group Codes	Stream Order (1:100,000 scale)
1. WA Marine West Coast Forest	EMAP_West	Stream Order 1 Stream Order 2 Stream Order 3 Stream Order 4 Stream Order 5
2. WA Coastal REMAP	WA_Coastal	Stream Order 1 Stream Order 2 Stream Order 3 Stream Order 4

Final Spatial Groups	Group Codes	Stream Order (1:100,000 scale)
3. OR Marine West Coast Forest	OR_Streams	Stream Order 1 Stream Order 2 Stream Order 3 Stream Order 4 Stream Order 5 Stream Order 6
4. OR Coastal REMAP	OR_Coastal	Stream Order 1 Stream Order 2 Stream Order 3 Stream Order 4 Stream Order 5
5. Upper Chehalis	WA_Chehalis	Stream Order 1 Stream Order 2 Stream Order 3

Site Re-Weighting Procedure

Example for Calculating Site Weights (Partitioning based on Stream Order)

Total Stream Miles in the Watershed (Spatial Area)
100 stream km

2nd Order Streams
80 stream km; 6 sites = 13.33 km/site

Remainder of Streams
20 stream km; 4 sites = 5 km/site

Calculating Site Weights

- Extent of stream length assessed
  - Example of % assessed in 2 Groups

Group	Total Stream Length (m)	Stream Order	Length by Stream Order (m)
WA_Coastal	12889711	1	7398127
		2	2477548
		3	1402026
		4	745868
OR_Coastal	18454080	1	11022259
		2	3010905
		3	2000150
		4	960265
		5	475568
		6	196257

Extent of Stream Length Assessed

- Partitioned by: Biological, Water Quality, and Physical Habitat
- Data unavailable from each site in each category
- Extent of assessment based on sums from 1st – 3rd stream orders

Extent of Assessment =

$$\sum \text{stream km}_{\text{1st - 3rd order}} / \text{Total stream km}$$

<u>Marine West Coast Forest</u> (extent of river miles assessed)
Biological = 70.3%
Water Quality = 45.4%
Physical Habitat = 45.8%

Biological Evaluations

- Determining no. of stations for each project

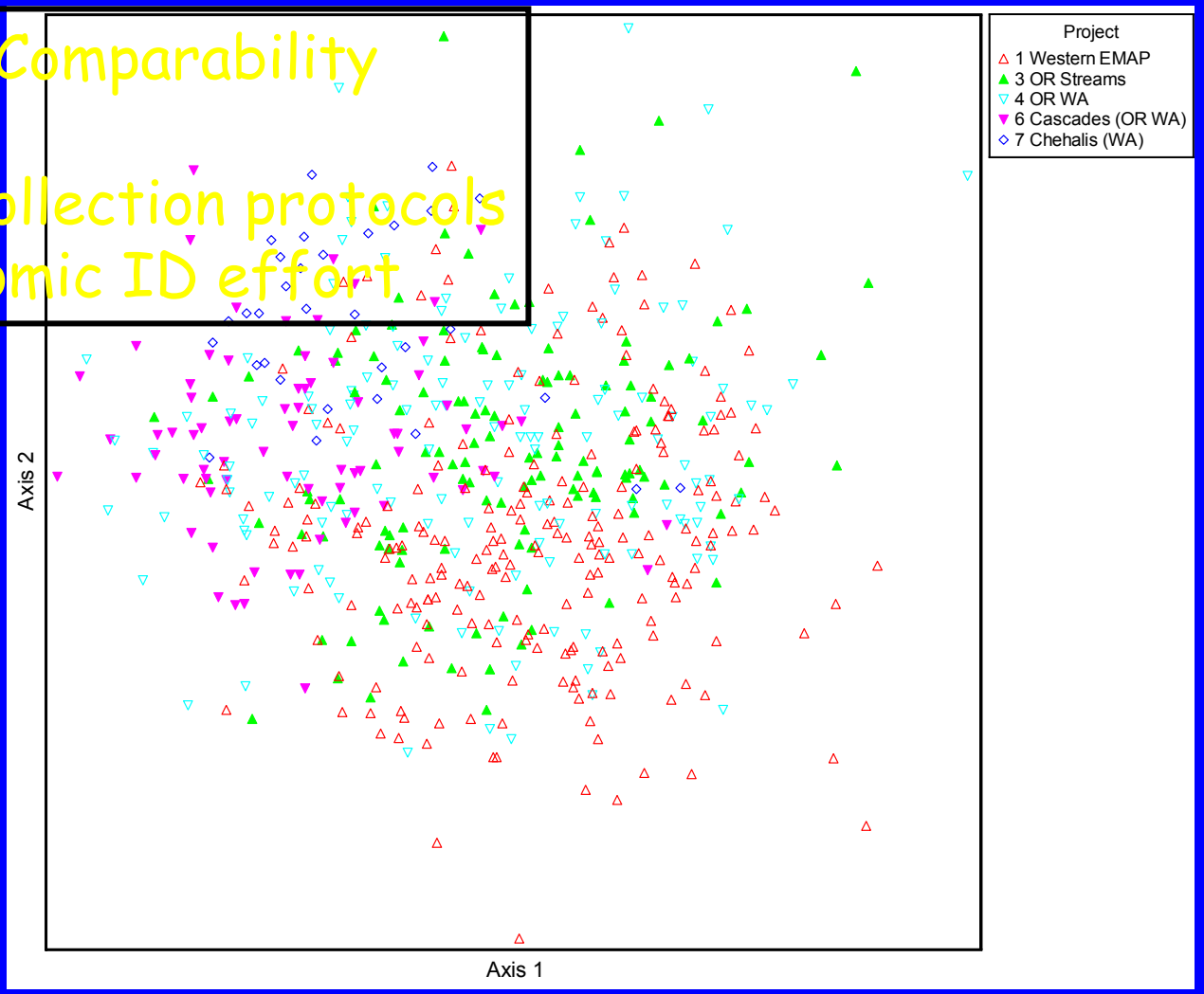
Project ID	Project Description	Total Number of Stations	Number of Stations in the Marine Ecoregion
1	EMAP West	430	50
3	Oregon Streams & Rivers (1997)	172	57
4	Oregon Washington (1994-6)	140	100
6	Region 10 Oregon Washington Cascades	106	0
7	Region 10 Washington Chehalis 1997	63	54

Biological Evaluations

- Comparability of biological data

Reasons for Non-Comparability

- changing field collection protocols
- improved taxonomic ID effort



NMDS Ordination

Developing a Multi-Metric Index

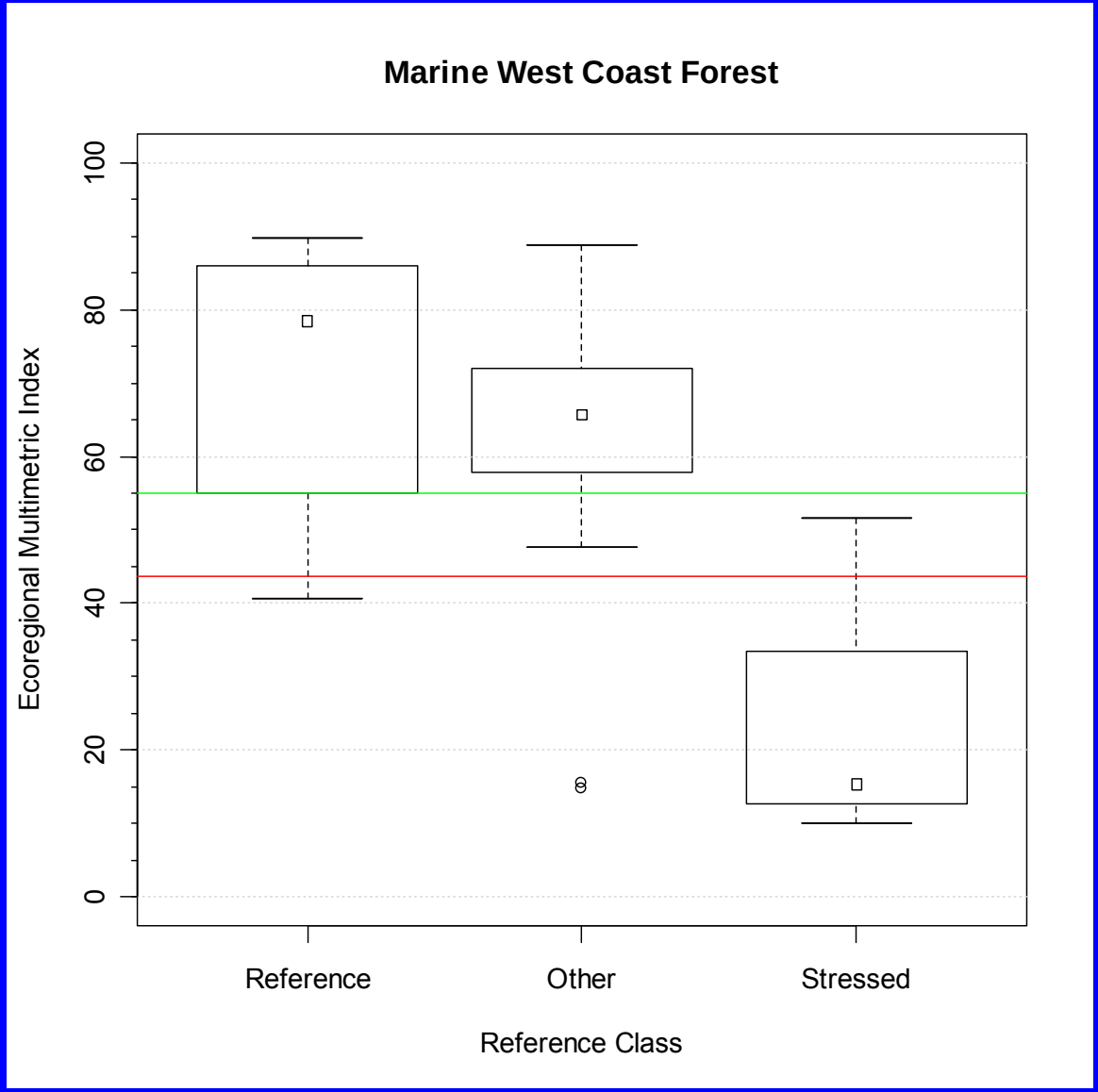
- **Biometric selection**
  - Composition
  - Feeding Group
  - Habit
  - Richness
  - Tolerance

% EPT
No. scraper taxa
No. clinger taxa
No. Plecoptera taxa

- **Verification of MMI performance**
  - 20% of sites reserved
  - Discrimination Efficiencies (DE) calculated

Determining Condition Categories

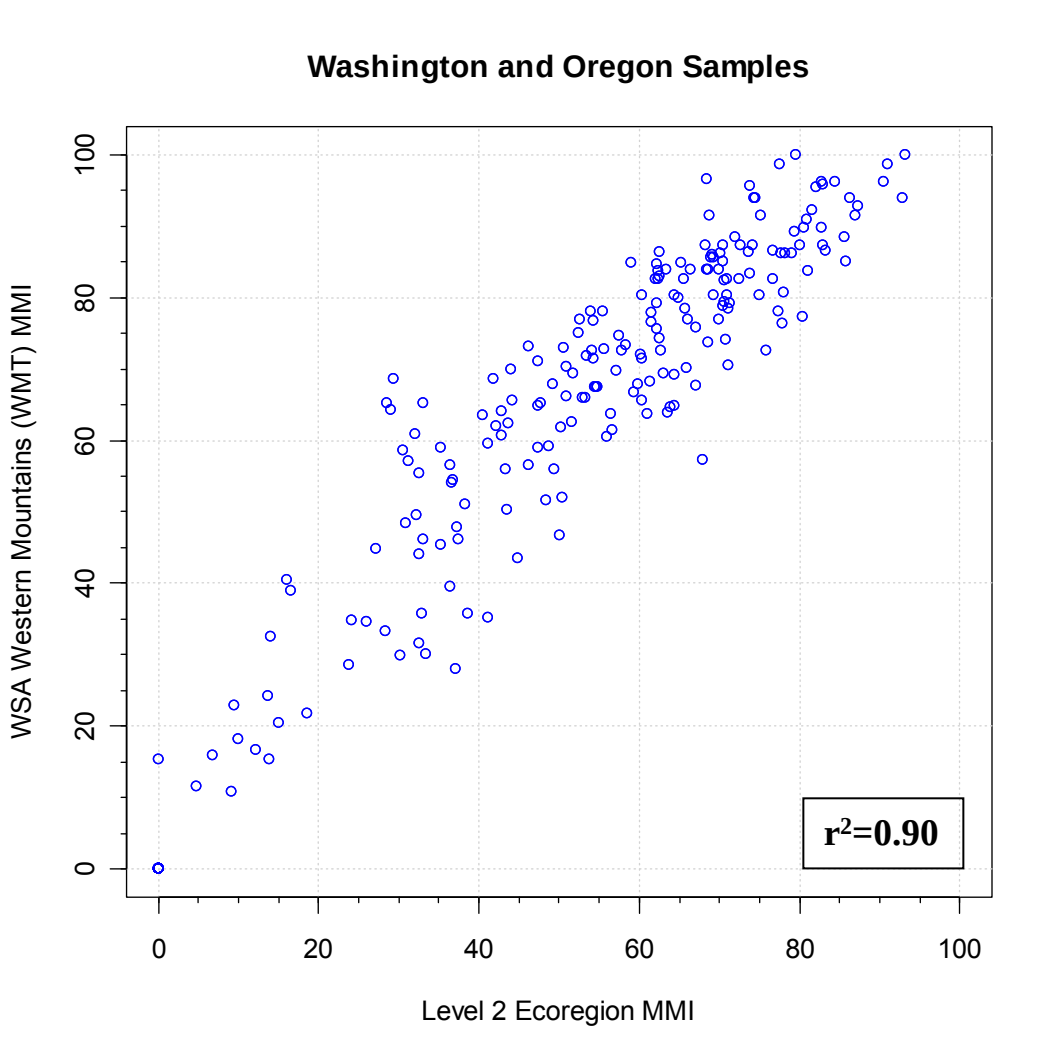
1. Reference site filter (adopted from WSA)
2. 5th & 25th percentile thresholds



Multi-metric Index Thresholds

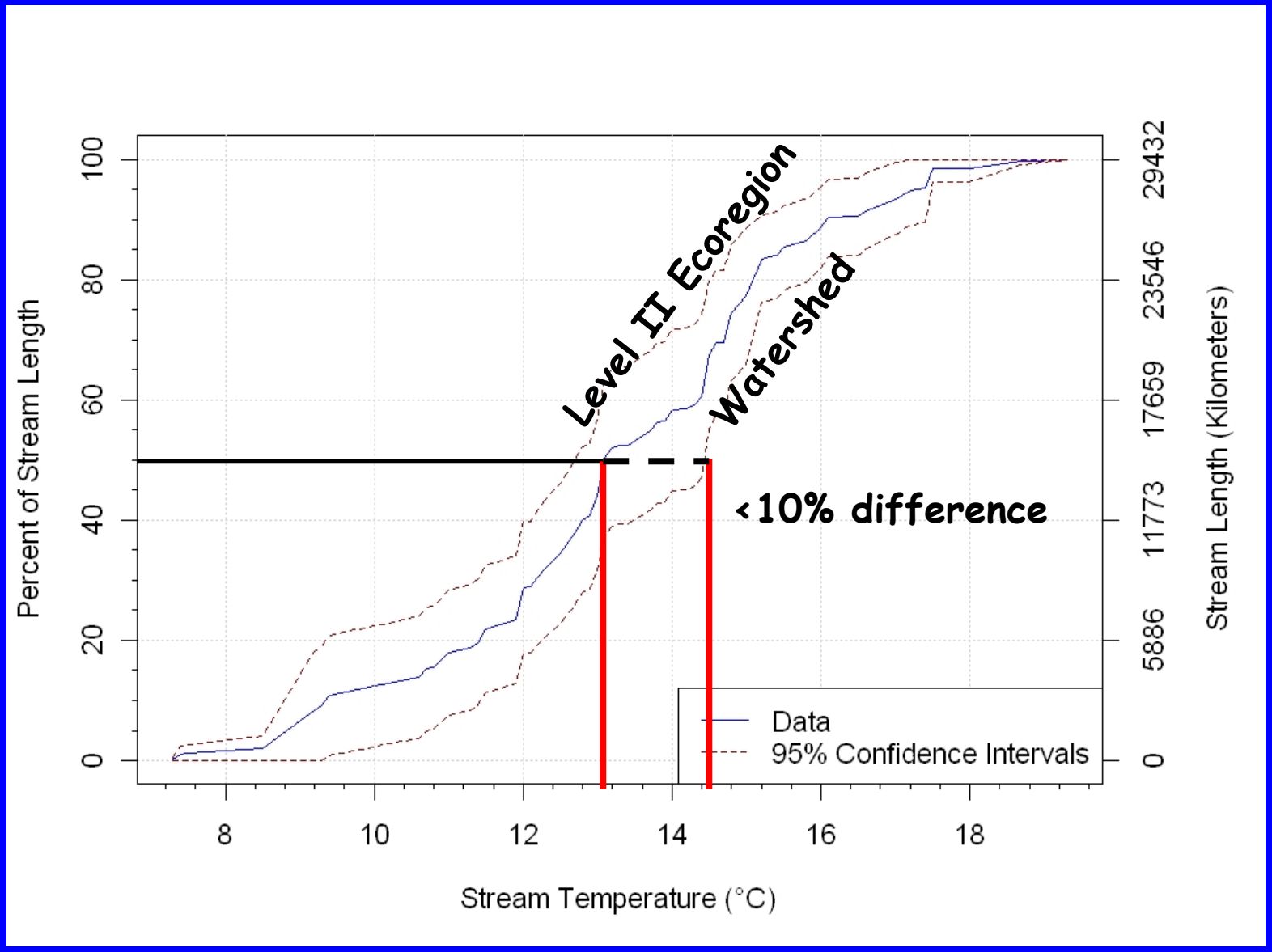
Narrative Category	Percentile of Reference	Numerical Range Marine West Coast Forest	Western EMAP Ranges
Good	≥ 25th	55.1 - 100	> 59 - 100
Fair	≥ 5th	43.6 – 55.0	45 - 59
Poor	< 5th	0 – 43.5	< 45

Similarity in Performance with the WSA Multimetric Index



Comparison of Assessments

Water Quality Example



Comparison of Project Results
median (50th percentile) of stream km assessed

Indicator (Water Quality, Habitat, and Biology)	Upper Chehalis REMAP	WA Level II Ecoregion	WEMAP (PNW-Mt.)
Water Quality			
Stream Temperature	14.4	13.1	n/a
Dissolved Organic Carbon	2.4	1.24	1.24
Physical Habitat			
%Substrate that is Fines	7.3	4.0	1.82
Riparian Disturbance (Human Activities)	1.1	1.0	0.61
Biological			
No. of EPT Taxa	21	13	19.37
Multi-Metric Index Score	n/a	61	51

Scale of Project & Assessment Results

- **Scale of assessment doesn't matter for some water quality & habitat characteristics:**
  - Assessments produce similar results
- **Spatially variable characteristics (within reach) produce different assessment results between scales:**
  - Smaller S:N ratio,
  - Longer period of time required to detect change.
- **Biological assessments are sensitive to recombination of data sets:**
  - Regionally unique representation of taxa,
  - Biometrics/OTU frequency of occurrences vary.

Lessons Learned

- Consistency in use/application of protocols for every project is imperative!
- Changes in protocols must be accompanied by a comparative study (cross-walk).
- Data management tools necessary for success of a long-term program.

The End

Thank you!