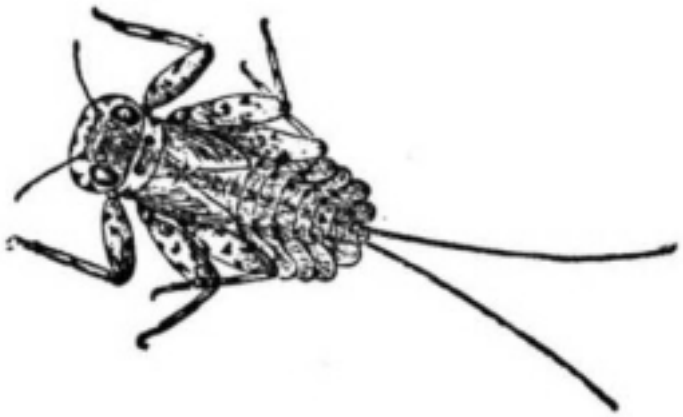
Oregon Coast Range REMAP Study

Stream Habitat Index Development and Site Results 1994-1996



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March 1999

Technical Report No. BIO98-06

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Abstract

The Regional Environmental Monitoring and Assessment Program (REMAP) is an approach to produce ecological assessments at a regional, state and local scale. In this study vertebrate, invertebrate, physical habitat, and water quality of randomly selected first through third order streams of the Oregon Coast Range were evaluated. This paper summarizes the physical habitat analysis and consequent Reference Habitat Index (RHI) development. The index depends upon the reference conditions existing within the same geographic region for the population of streams sampled. High quality reference conditions allows for a more discriminating index. This index is the initial step of an iterative process that is dependent upon a long term monitoring program.

Introduction

The Regional Environmental Monitoring and Assessment Program (REMAP) uses the statistical design and indicator concepts developed by EPA's Environmental Monitoring and Assessment Program (EMAP). REMAP conducts projects at smaller geographic scales and shorter time frames than the national EMAP program. A primary goal of this program is to evaluate the utility of EMAP indicators and sampling design for the stream resources of Oregon. This study was conducted during 1994 and 1995, with an additional year of sampling in 1996 following the flood event of that year. A randomized, systematic sample of stream reaches was selected and field measurements were made between July and September of each year. Thirty-two sites were visited in 1994, 28 sites were surveyed in 1995 and 54 of the original sites were revisited in 1996.

Historically stream habitat concerns have centered on fish and their habitat requirements. The REMAP protocol samples both vertebrates and invertebrates. A thorough habitat quality evaluation should address the requirements of both groups. This has been attempted with a qualitative approach in the Rapid Bioassessment Protocol (RBP) methodology (Plafkin et al, 1989). This protocol focuses on estimates of habitat components such as substrate and instream cover, channel morphology, and riparian and bank structure.

In contrast, the physical habitat (PHAB) protocol for the REMAP program relies on direct measurements of habitat parameters (Hayslip et al, 1994; Kaufmann et al, 1999). A number of these parameters have some equivalency across protocols, however an advantage of the REMAP approach is that data are quantifiable and reproducible to a higher degree than is possible with the RBP. This leads to a more robust analysis and more powerful hypothesis testing.

The REMAP protocol centers around 12 habitat categories (Table 1). Each category is comprised of reach averaged statistical products (means, percent, proportion, etc.) of individual variables. The total number of individual PHAB variables approaches 300 (Appendix 1). These

variables are felt to include those that most strongly influence the biota and measure human disturbance.

Table 1. REMAP Physical Habitat category definitions*

Habitat Category	Definitions
Bank	Bank angle and undercut variables
Channel	Wet and bankfull depths and width, incision variables
Densiometer	Densiometer (shade) variables
Fish Cover	Fish cover variables (LWD, overhanging veg., undercut bank, boulder, etc.)
Gradient	Channel slope variables
Habitat Unit	Percent riffle, glide, pool (with types), etc. variables
Human Disturbance	Human disturbance on bank, in riparian, and beyond variables
Large Woody Debris	24 categories of LWD (wet and dry) summary variables
Pool	Residual pool variables (calculated from thalweg/slope values)
Riparian	Riparian vegetation variables
Sinuosity	Channel sinuosity variables
Substrate	Wolman substrate category variables (% cobble, % fine gravel, etc.)

* see Appendix 1 for a complete list of individual PHAB metrics

Reference Habitat Index (RHI) Development

The list of variables was initially reduced to a subset of 90 parameters. Presence/absence and variables displaying a high degree of noise were eliminated (Drake, 1998). Statistical outliers were retained after verification as accurate and meaningful values. This subset was then analyzed using Principal Component Analysis (PCA). PCA is an ordination and data reduction technique that extracts significant parameters based upon their contribution to the overall matrix variability.

Generally, the first two axes extracted in a PCA ordination accounts for the bulk of variability within the data set (Figure 1). Individual loadings along each axis can then be used as a guide to which habitat characteristics best describe these multivariate axes.

In this analysis the first two axes explained 65.6% of the variance in the habitat data. Important factor loadings on axis 1 were percent fines and sand, human disturbance-agricultural, coarse substrate, canopy, fish cover and fast water habitat. Significant factor loadings on axis 2 were mid-channel canopy density and mean residual depth. Large woody debris and bank stability variables were found to be important in axis 3, but were found to show poor discrimination between reference and non-reference sites.

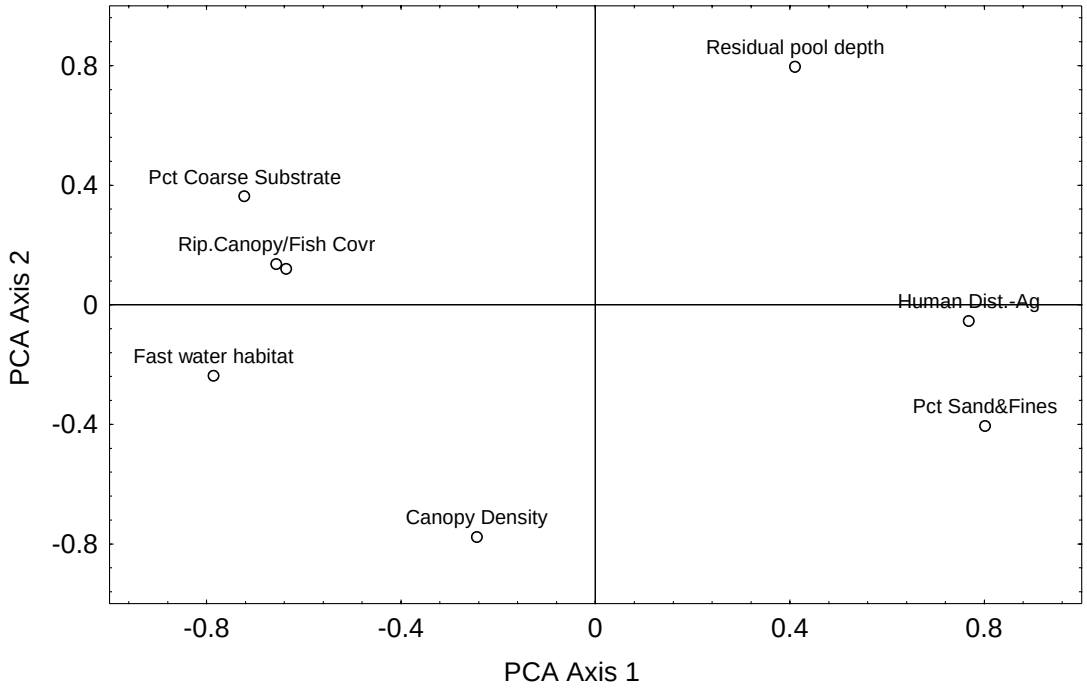

Figure 1. PCA ordination of first two axes for 1994-1995 Coast Range REMAP survey showing relationships between eight PHAB variables determined through principal component analysis. Percent coarse substrate and percent sand&fines are both substrate measurements but are not mutually exclusive. Coarse substrate is an indicator of good quality substrate while sand&fines is a measure of embeddedness or poor quality habitat. Appendix 2 presents the PCA loading scores for the eight variables.

Correlation analysis

To test the correlation of PHAB variables with biota, Pearson product-moment correlation analysis was conducted. The eight PHAB variables identified with PCA showed significant relationships with macroinvertebrate and vertebrate measures (Table 2). Six water chemistry parameters were included in this analysis as a comparison.

Strongest of the correlations include: number of stonefly taxa positively correlated with coarse substrate, fish cover, fast water and dissolved oxygen. Stonefly taxa are also negatively correlated with agricultural disturbance, sedimentation (percent sand and fines), and temperature. Percent coldwater vertebrates are significantly and positively correlated with coarse substrate and fast water. Negative correlations with percent coldwater fish and amphibians are agricultural disturbance, sedimentation (percent sand and fines), and ammonia.

Generally, this analysis demonstrates that pollution sensitive biota positively correlate with habitat and chemical variables indicative of minimal human impact, whereas pollution tolerant biota positively correlate with environmental parameters related to high human impact.

Table 2. Pearson product-moment correlations of biotic metrics with selected environmental variables from 67 sites visits from the 94-95 Coast Range REMAP survey.

	Macroinvertebrate Metrics				Vertebrates Metrics					
Environmental variables	# Stonefly Taxa	%Dominant (3)	%t Tolerant Taxa	% EPT Taxa	Amphibian Richness	% Salmonid	% Filter Feeders	% Sensitive	% Warmwater	% Coldwater
Percent Coarse Substrate	**0.415**	**-0.332**	-0.290	0.283	-0.192	**0.320**	**-0.355**	**0.315**	**-0.335**	**0.385**
Mean Canopy	0.226	-0.304	-0.181	0.156	0.167	0.130	-0.021	0.133	**-0.321**	0.168
Human Disturbance-Agricultural	**-0.458**	**0.360**	**0.352**	-0.296	-0.286	-0.226	0.289	**-0.393**	**0.551**	**-0.370**
Percent Sand and Fines	**-0.429**	0.208	0.243	-0.148	-0.060	-0.297	0.228	-0.307	**0.436**	**-0.366**
Mean Canopy Density – Midchannel	0.237	-0.142	-0.279	0.098	-0.088	0.257	-0.186	0.264	0.056	0.298
Mean Fish Cover-Big	**0.385**	-0.133	-0.242	**0.393**	0.130	0.179	**-0.312**	0.282	-0.213	0.306
Mean residual depth/100m	-0.295	0.028	0.244	-0.232	-0.008	0.003	0.275	-0.178	0.055	-0.132
Percent Fast Water	**0.651**	-0.247	**-0.410**	**0.440**	0.212	0.212	**-0.382**	**0.383**	-0.305	**0.376**
Dissolved Oxygen	**0.343**	**-0.407**	**-0.398**	0.086	0.259	0.132	-0.056	0.118	0.010	0.154
pH	-0.144	-0.275	-0.115	0.066	**0.328**	0.188	0.152	0.046	0.095	0.081
Temperature (grab)	**-0.459**	0.108	**0.368**	-0.163	-0.080	-0.026	0.040	-0.176	0.080	-0.096
Ammonia	-0.159	**0.379**	**0.437**	-0.078	-0.142	**-0.347**	0.246	**-0.380**	0.182	**-0.381**
Total Solids	-0.233	0.198	0.239	0.040	-0.195	-0.192	0.082	-0.301	0.169	-0.289
Chloride	-0.083	0.239	**0.328**	0.173	-0.080	-0.179	0.012	-0.264	-0.012	-0.245

Note: Critical values, p=0.05 if r=0.242 (shaded) and p=0.01 if r= 0.312 (bolded).

Reference Streams

Fourteen of the 57 REMAP sites fulfilled the criteria for candidate reference sites. The Best Professional Judgment approach developed for the DEQ Sub-ecoregion Reference Site program (ODEQ, 1994) was used to determine reference streams with this set of streams. Each reference site is considered as either high quality (A - Nearly pristine) or best available (B - Some human impacts). Only 14 reference sites are available to develop an index, therefore caution should be exercised when using the impairment categories that follow.

Streams were split into preliminary categories based on watershed area and elevation (see Table 3). Each preliminary category had at least one of either reference type. Category 3 (low elevation, headwater streams) is the least adequately represented group. As the number of streams surveyed increases, a more definitive categorical scheme should be developed. That will help identification of gaps in the reference site pool.

Table 3. Reference Sites by Preliminary Category

Category*	A Reference#	B Reference
1-Medium/Low (Medium Lowland)	S.F. Chetco River at RM 2.5	Lobster Cr. at RM 6.2
2-Small/Low (Small Lowland)	Benson Cr. at RM 5.0	Fall Cr. at RM 0.7 Tenmile Cr. at USFS Campgrd Trout Cr. at RM 0.2
3-Headwater/Low (Headwater Lowland)	No sites	Trib to Bernhardt Cr. at RM 3.0
4-Medium/High (Medium Upland)	No sites	E.F. Coquille R. at RM 26 Elk R. at RM 24.0
5-Small/High (Small Upland)	No sites	Elk Cr. at RM 3.0 MF/NF Trask R. at RM 3.0 Salmon R. at RM 21.0
6-Headwater/High (Headwater Upland)	Butler Cr. at RM 2.1 Cullen Cr. at 0.3	No sites

* Categories are defined as follows: Watershed area; Medium >5000 hectares, Small 350-5000 hectares, and Headwater <350 hectares. Elevation; Low <500 feet and High >500 feet. # Reference site: A - Nearly pristine, high quality ; B - Some human impacts, best available.

Index Scoring Criteria

The range of habitat values for each parameter for the reference sites population was then used to set scoring criteria. Significant departures from reference site condition are considered to be indicative of impairment from anthropogenic activities. In order to allow for reference site natural variability and at the same time describe impairment, a departure of one standard deviation from the mean of the reference sites was considered sufficient to indicate impairment.

Seven of the eight parameters showed satisfactory agreement between stream size categories so that one set of criteria could be applied. The variability in mean residual depth due to stream size required different criteria for small/headwater and medium watershed area stream categories. As the data set increases, similar stream sized-based criteria may be required for other variables such as fast water habitat and shade.

The issue of reference site quality and variability must be addressed. The majority of reference sites are B type, which reduces the ability to accurately characterize impairment. Where possible, increasing the number of A reference sites should improve the index. For this data set, a value of a variable measured at any site that falls within one standard deviation of reference site mean was considered non-impaired; values between one and two standard deviations slightly impaired, and greater than two significantly impaired. Table 4 below summarizes the results of index scoring criteria analysis.

Table 4. Reference Habitat Index Parameter Scoring Criteria

Parameter - **PHAB variable name** (units)	± 1 Std. Dev. Score = 5*	1-2 Std. Dev. Score = 3	> 2 Std. Dev. Score = 1
Percent sand/fines - **PCT_SAFN** (%)	<27	27-39	>39
Percent Fast Water - **PCT_FAST** (%)	>31	31-15	<15
Percent Coarse Substrate - **PCT_GCB** (%)	>33	33-15	<15
Fish Cover - **XFC_BIG** (Areal proportion)	>0.30	030-0.10	<0.10
Human Disturbance –Ag - **W1_HAG** (Proximity weighted pressure)	0	0-0.65	>0.65
Riparian Canopy – **XC** (mean cover)	>0.38	0.38-0.18	<0.18
Mid-Channel Shade – **XCDENMID** (%)	>49	49-26	<26
Mean residual depth - **RP100** (cm) Small/Headwater streams	>6.4	6.4-1.6	<1.6
Mean residual depth - **RP100** (cm) Medium streams	>16	16-10	<10

* RHI scoring approach of 5,3, and 1 is adapted from EPA Rapid Bioassessment Protocol (Plafkin et al, 1989). See Appendix 4 for boxplot of RHI metrics by reference and non-reference. Residual pool criteria reflects top 75% of sites in each group, therefore boxplots do not correspond to above criteria.

All streams were then scored for each parameter using the scoring criteria from Table 4. The reference site score results were used to set impairment categories. As with the individual parameters, the cumulative score is based on deviations from reference site mean. Based on standard deviations of 2 and 4 from reference conditions site impairment categories were determined (Table 5).

Table 5. Reference Habitat Index Impairment Criteria

Category	RHI Scoring Range*	Standard Deviation
No Impairment	76-100	< 2
Moderate Impairment	75-60	2-4
Severe Impairment	<60	>4

* Based on Reference Mean of 92.9 and Std. Dev. 8.2, range converted to 8-100.

Results

The detailed Reference Habitat Index site results are presented in Appendix 3. The results include the raw values for the individual index parameters as well as the RHI scores for each site. The final results are sorted by DEQ basin, sub-basin, site, and date. The random sampling strategy of the REMAP study allows estimates of conditions in the Coast Range based on percent

of total 1st through 3rd order stream miles (ODEQ, 1998). For this paper, the impairment category results are based on percent of sites surveyed. The results are broken down first by original study years (1994 and 1995) versus the follow-up year (1996) and then by DEQ basin. The number of sites surveyed was 60 site visits for 1994 and 1995, and 54 return site visits in 1996.

1994/1995 versus 1996

The RHI results for 94/95 showed 40% of the sites in the No Impairment category, 22% with Moderate Impairment and 38% as Severely Impaired. In 1996 the return visits showed 41% of the sites with No Impairment, 28% as Moderately Impaired and 32% as Severely Impaired. 1994/1995 to 1996 results is presented in Figure 2. No change in stream habitat quality is evident with these results. The wetter post flood conditions of 1996 could also be responsible for the slight improvement in habitat scores for that year. Previous analysis (Drake,1999) has suggested a seasonal/discharge related improvement in some habitat scores for 1996.

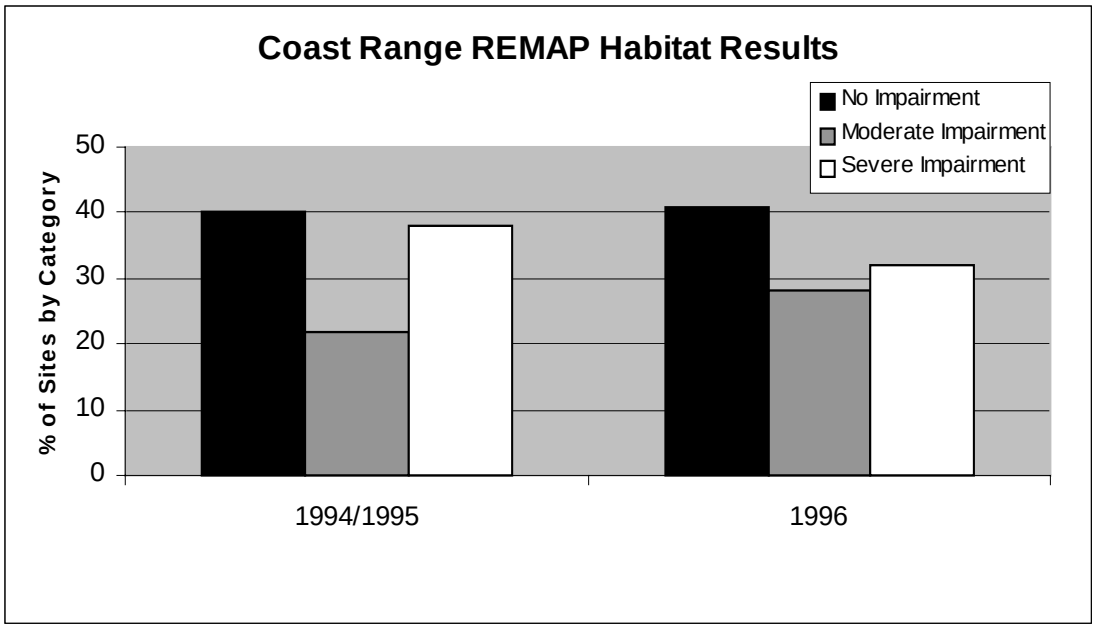

Figure 2. Coast Range Habitat Results – 1994/1995 versus 1996

Results by Basin

Figure 3 presents the habitat results for the five basins of the study area where a minimum of seven sites per basin existed. The Rogue basin had only two sites sampled, so was excluded from this summary discussion. Again the results for 1994 and 1995 were pooled so that comparisons between initial study visits and return visits could be made.

The North and South Coast basins had the largest percentage of non-impaired classified sites for both 1994/5 and 1996 years. The Willamette and Umpqua basins had the largest percentage of moderate to severely impaired sites for the same period. The Mid Coast basin had site results

similar to the North and south Coast basins but fewer non-impaired sites and more moderate to severe impaired sites.

There is some year to year variability. For example, the Willamette had 33% (3 of 9) of the sites in 1994-1995 classed as non-impaired, but when resurveyed in 1996 produced 0% (0 of 7) non-impaired sites. Closer analysis shows that those three sites scored at the low end of the non-impaired range and were reevaluated as moderately impaired with the follow-up survey. By contrast the Umpqua basin had a number of sites move from severely impaired status in 1994/1995 to moderately impaired in 1996. The shift in index scores may be due to the error range of 11% (Drake, 1999). Generally the status of the streams assessed in 1994 and 1995 compared with the status in 1996.

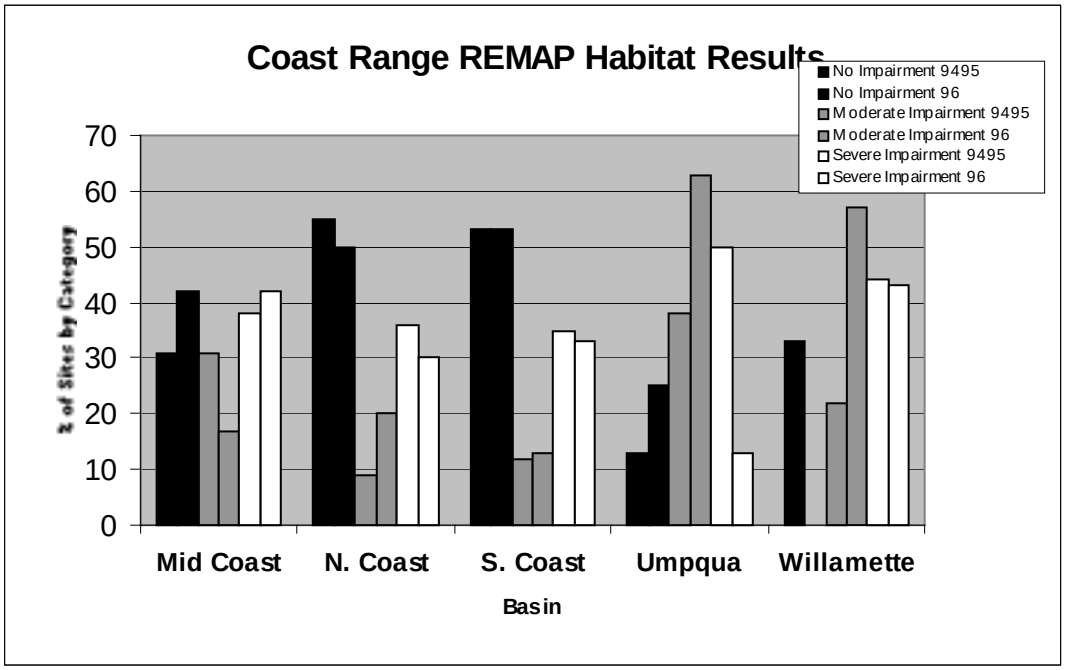

Figure 3. Coast Range Habitat Results by Basin

Biological Agreement

The habitat index score was plotted against the corresponding macroinvertebrate discriminant model scores (Canale, 1999). The comparison shows good agreement between the Reference Habitat Index and Benthic evaluation of ORegon rIverS (BORIS) model scores (Figure 4). Disagreement between habitat and biotic response indicates the need to evaluate other parameters, such as water chemistry or landscape features.

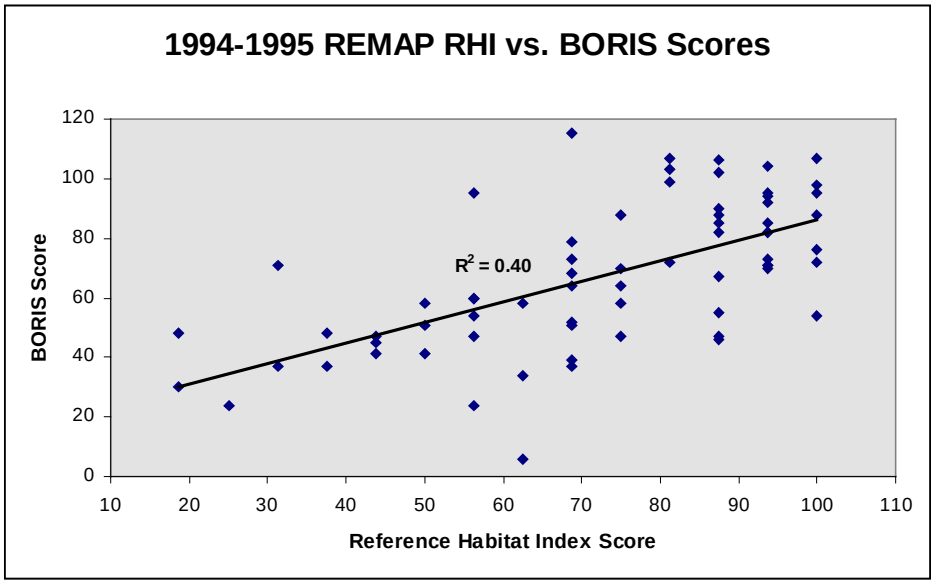

Figure 4. Coast Range REMAP RHI versus Macroinvertebrate (BORIS) Scores

Discussion

The paper is intended to document the process of developing a Reference-based Habitat Index from the REMAP/EMAP studies. The value for this Index-model is that it could be used with any similar data set. It has also been useful in identifying some method and analysis issues. Assumptions about linearity were made, both in the PCA and correspondence analysis, to facilitate development of this index. Other response models, such as unimodal or quadratic may be better suited to describe the actual biological response to specific habitat parameters. As such this index infers possible cause-effect relationships but can not prove those relationships.

While habitat is in some ways the most important component and most often the limiting factor of the biota, it is also the most complex. Because of its complexity other qualitative index approaches may be just as valid. Another approach would be to focus on a set of indicators that show the greatest biological correlation using the appropriate response model. The least variable of these indicators from the reference site pool could then be selected as index parameters.

This analysis has shown that different PHAB variables are associated with differing biological components. Whether it is stoneflies, sediment, coldwater vertebrates, or land use, the entire range of conditions of habitat, water quality, and biota should be considered. The keys are to rely on reference conditions and representative indicators.

Based on the Reference Habitat Index the sites surveyed from 1994 to 1996 indicates that approximately 40 percent of these sites are not impaired, between 20 and 30 percent are moderately impaired, and between 30 and 40 percent are severely impaired. This suggests that many of the 1st through 3rd order streams in the Coast Range are, because of habitat limitations, unable to fully support the designated beneficial uses.

Recommendations

- As a way of calibration take a completely new set of data and rerun the index.
- Increase the number of Reference sites to improve the model. Especially low elevation headwater (1st order) and medium size (3rd order) streams.
- Address issues related to subjective versus objective habitat measurements.
- Develop a consistent broad-based stream classification system.
- A power analysis could be done to verify the validity of the impairment categories once sufficient re-sampling has been conducted.

References

Canale, G. 1999. BORIS – Benthic evaluation of ORegon rIverS. Draft report. Department of Environmental Quality Laboratory - Biomonitoring Section. Portland, Oregon.

Drake, D. 1998. REMAP Habitat Analysis – PCA of PHAB variables. Report to File. Department of Environmental Quality Biomonitoring Section. Portland, Oregon.

Drake, D. 1999. REMAP Habitat Analysis – Reference Habitat Index Error Range and Seasonal Analysis. Report to File. Department of Environmental Quality Laboratory - Biomonitoring Section. Portland, Oregon.

Hayslip, G., D.J. Klemm & J.M. Lazorchak. 1994 Field Operations and Methods Manual For Streams in the Coast Range Ecoregion of Oregon and Washington and the Yakima River Basin of Washington. Environmental Monitoring Systems Laboratory. U.S. Environmental Protection Agency. Cinncinnati, Ohio.

Kaufmann, P.R., P. Levine, E.G. Robison, and D. Peck. 1999. Quantifying Physical Habitat in Wadeable Streams - DRAFT. EPA/620/xxx/xxx. U.S. Environmental Protection Agency, Corvallis, Oregon.

ODEQ, 1994. Oregon Coast Range Subecoregion Reference Site Study Status Report: January 1994. Department of Environmental Quality Laboratory – Biomonitoring Section. Portland, Oregon.

ODEQ, 1998. Natural Resource Status of Oregon Coastal Streams. Department of Environmental Quality Laboratory – Biomonitoring and Water Quality Monitoring Sections. Portland, Oregon.

Plafkin, James L., M. T. Barbour, K. D. Porter, S. K. Gross, R. M. Hughes. 1989. Rapid Bioassessment Protocols For Use In Streams And Rivers – Benthic Macroinvertebrates And Fish. EPA/444/4-89-001. U.S. Environmental Protection Agency, Washington D.C.

Appendix 1. REMAP protocol Physical Habitat (PHAB) variables

PHAB#	Habitat Category	Variable	Label
1	ID	STRM_ID	individual site identification
2	ID	YEAR	Sample Year
3	ID	VISIT_NO	visit number-within year
3.1	ID	SVN	Site Visit Number
4	Bank	N_BA	number of nonmissing values, ANGLE
5	Bank	XBK_A	the mean, ANGLE
6	Bank	SDBK_A	the standard deviation, ANGLE
7	Bank	BKA_Q3	the upper quartile, ANGLE
8	Bank	MEDBK_A	the median, ANGLE
9	Bank	BKA_Q1	the lower quartile, ANGLE
10	Bank	INTQBKA	the interquartile range, ANGLE
11	Bank	N_UN	number of nonmissing values, UNDERCUT
12	Bank	XUN	the mean, UNDERCUT
13	Bank	SDUN	the standard deviation, UNDERCUT
14	Bank	BKUN_Q3	the upper quartile, UNDERCUT
15	Bank	MEDBKUN	the median, UNDERCUT
16	Bank	BKUN_Q1	the lower quartile, UNDERCUT
17	Bank	INTQBKUN	the interquartile range, UNDERCUT
18	Channel	N_BW	# obs-BANKWD 93 see data documentation
19	Channel	XBKF_W	mean BANKWD, 93 see data documentation
20	Channel	SDBKF_W	StDev BANKWD, 93 see data documentation
21	Channel	N_BH	# obs-BANKHT, 93 see data documentation
22	Channel	XBKF_H	mean BANKHT 93 see data documentation
23	Channel	SDBKF_H	StDev BANKHT 93 see data documentation
24	Channel	N_INCIS	# obs-incis 93 see data documentation
25	Channel	XINC_H	mean incis ht 93 see data documentation
26	Channel	SDINC_H	StDev XINC_H 93 see data documentation
27	Riparian	XPCAN	Rip Canopy Present (Prop reach)
28	Riparian	XPMID	Rip MidLayer Present (Prop reach)
29	Riparian	XPGVEG	Rip Ground Layer Present (Prop reach)
30	Riparian	XPCM	Rip Can & MidLayer Present (Prop reach)
31	Riparian	XPCMG	Riparian 3-Layers Present (Prop reach)
32	Riparian	XCL	Riparian Canopy >.3m DBH (Cover)
33	Riparian	XCS	Riparian Canopy <.3m DBH (Cover)
34	Riparian	XMW	Rip Mid Layer Woody (Cover)
35	Riparian	XMH	Rip Mid Layer Herbaceous (Cover)
36	Riparian	XGW	Rip Ground Layer Woody (Cover)
37	Riparian	XGH	Rip Ground Layer Herbaceous (Cover)
38	Riparian	XGB	Rip Ground Layer Barren (Cover)
39	Riparian	XC	Riparian Veg Canopy Cover
40	Riparian	XM	Riparian Veg Mid Layer Cover
41	Riparian	XG	Riparian Veg Ground Layer Cover
42	Riparian	XCM	Rip Veg Canopy+Mid Layer Cover
43	Riparian	XCMW	Rip Veg Canopy+Mid Layer Woody Cover
44	Riparian	XCMG	Rip Veg Canopy+Mid+Ground Cover
45	Riparian	XCMGW	Rip Veg Canopy+Mid+Ground Woody Cover
46	Riparian	PCAN_C	Riparian Canopy Coniferous (Prop reach)
47	Riparian	PCAN_D	Riparian Canopy Deciduous (Prop reach)
48	Riparian	PCAN_M	Rip Canopy Mix Conif-Decid (Prop reach)
49	Riparian	PCAN_N	Rip Canopy Absent (Proportion of reach)
50	Riparian	PMID_C	Rip MidLayer Coniferous (Prop reach)
51	Riparian	PMID_D	Rip MidLayer Deciduous (Prop reach)
52	Riparian	PMID_M	Rip MidLayer Mix Con-Decid (Prop reach)
53	Riparian	PMID_N	Rip MidLayer Absent (Prop of reach)
54	Densiometer	NBNK	number of nonmissing values, DENSIOM
55	Densiometer	CDEN_BX	the mean, DENSIOM
56	Densiometer	CDEN_BV	the standard deviation, DENSIOM
57	Densiometer	NMID	number of nonmissing values, DENSIOM
58	Densiometer	CDEN_MX	the mean, DENSIOM
59	Densiometer	CDEN_MV	the standard deviation, DENSIOM
60	Densiometer	XCDENBK	Mean Bankside Canopy Density (%)
61	Densiometer	VCDENBK	Std Dev, Bankside Canopy Density (%)
62	Densiometer	XCDENMID	Mean MidChannel Canopy Density (%)
63	Densiometer	VCDENMID	Std Dev, MidChannel Canopy Density (%)
64	Fish Cover	XFC_ALG	Filamentous Algae Cover (Areal Prop.)
65	Fish Cover	XFC_AQM	Aq. Macrophytes Cover (Areal Prop.)
66	Fish Cover	XFC_LWD	Lg. Woody Debris Cover (Areal Prop.)
67	Fish Cover	XFC_BRS	Brush & Small Debris Cvr (Areal Prop.)
68	Fish Cover	XFC_OHV	Overhang. Veg. Cover (Areal Prop.)
69	Fish Cover	XFC_UCB	Undercut Bank Cover (Areal Prop.)
70	Fish Cover	XFC_RCK	Fish Cover--Boulders (Areal Prop.)
71	Fish Cover	XFC_HUM	Fish Cvr--Artif. Structs. (Areal Prop)
72	Fish Cover	XFC_NAT	Fish Cvr--Natural Types (Sum Areal Prop)
73	Fish Cover	XFC_ALL	Fish Cvr--All Types (Sum Areal Prop)
74	Fish Cover	XFC_BIG	Fish Cvr--LWD,Bldr,OHBk,Struct (Areal P)

Appendix 1 cont.. REMAP protocol Physical Habitat (PHAB) variables

PHAB#	Habitat	Variable	Label
75	Fish Cover	PFC_ALG	Filamentous Algae Cover (%)
76	Fish Cover	PFC_AOM	Aq. Macrophytes cover (%)
77	Fish Cover	PFC_LWD	Large Woody Debris Cvr. (%)
78	Fish Cover	PFC_BRS	Brush & Small Debris Cvr (%)
79	Fish Cover	PFC_OHV	Overhang Veg. Cover (%)
80	Fish Cover	PFC_UCB	Undercut Bank Presence (Prop of Banks)
81	Fish Cover	PFC_RCK	Fish Cvr.--Boulders (%)
82	Fish Cover	PFC_HUM	Fish Cvr--Artif. Structs. (%)
83	Fish Cover	PFC_ANY	Fish Cvr--All Types (%)
84	Fish Cover	PFC_BIG	Fish Cvr--LWD,Bldr,UCBk,HUM struct (%)
85	Fish Cover	PFC_NAT	Fish Cover Natural Types (%)
86	Human Dist	BXPBLDG	The mean. BLDG. on Bank
87	Human Dist	BXPCROP	The mean. CROP. on Bank
88	Human Dist	BXPLDFL	The mean. LDFL. on Bank
89	Human Dist	BXPLOG	The mean. LOG. on Bank
90	Human Dist	BXPPARK	The mean. PARK/LAWN. on Bank
91	Human Dist	BXPPIPE	The mean. PIPE. on Bank
92	Human Dist	BXPPSTR	The mean. PSTR. on Bank
93	Human Dist	BXPPVMT	The mean. PVMT. on Bank
94	Human Dist	BXPROAD	The mean. ROAD. on Bank
95	Human Dist	BXPWALL	The mean. WALL. on Bank
96	Human Dist	BXPMINE	The mean. MINE. on Bank
97	Human Dist	CXPBLDG	The mean. BLDG. in Ripar Plot
98	Human Dist	CXPCROP	The mean. CROP. in Ripar Plot
99	Human Dist	CXPLDFL	The mean. LDFL. in Ripar Plot
100	Human Dist	CXPLOG	The mean. LOG. in Ripar Plot
101	Human Dist	CXPPARK	The mean. PARK/LAWN. in Ripar Plot
102	Human Dist	CXPPIPE	The mean. PIPE. in Ripar Plot
103	Human Dist	CXPPSTR	The mean. PSTR. in ripar Plot
104	Human Dist	CXPPVMT	The mean. PVMT. in Ripar Plot
105	Human Dist	CXPROAD	The mean. ROAD. in Ripar Plot
106	Human Dist	CXPWALL	The mean. WALL. in Ripar Plot
107	Human Dist	CXPMINE	The mean. MINE. in Ripar Plot
108	Human Dist	FXPBLDG	The mean. BLDG. Beyond Ripar Plot
109	Human Dist	FXPCROP	The mean. CROP. Beyond Ripar Plot
110	Human Dist	FXPLDFL	The mean. LDFL. Beyond Ripar Plot
111	Human Dist	FXPLOG	The mean. LOG. Beyond Ripar Plot
112	Human Dist	FXPPARK	The mean. PARK/LAWN. Beyond Ripar Plot
113	Human Dist	FXPPIPE	The mean. PIPE. Beyond Ripar Plot
114	Human Dist	FXPPSTR	The mean. PSTR. Beyond Ripar Plot
115	Human Dist	FXPPVMT	The mean. PVMT. Beyond Ripar Plot
116	Human Dist	FXPROAD	The mean. ROAD. Beyond Ripar Plot
117	Human Dist	FXPWALL	The mean. WALL. Beyond Ripar Plot
118	Human Dist	FXPMINE	The mean. MINE. Beyond Ripar Plot
119	Human Dist	XB_HALL	Rip Dist--Sum All Types instrm & on bank
120	Human Dist	XC_HALL	Rip Dist--Sum All Types in Ripar Plots
121	Human Dist	XF_HALL	Rip Dist--Sum All Types beyond Rip Plots
122	Human Dist	XCB_HALL	Rip Dist--Sum All Types instrm & in plot
123	Human Dist	X_HALL	Rip Dist--Sum All Types str plt & beyond
124	Human Dist	XB_HNOAG	hum Dist Sum-Non ag Types instrm & Plot
125	Human Dist	XC_HNOAG	hum Dist Sum-Non Ag Types in Ripar Plot
126	Human Dist	XF_HNOAG	hum Dist Sum-Non Ag Types Beyond Rip Plt
127	Human Dist	XCB_HNAG	hum Dist Sum-Non Ag Types instrm & Bank
128	Human Dist	X_HNOAG	hum Dist Sum-Non Ag rip Plt & Beyond
129	Human Dist	XB_HAG	hum Dist-Sum Ag Types instrm & in plot
130	Human Dist	XC_HAG	hum Dist-Sum of Ag Types in Ripar Plot
131	Human Dist	XF_HAG	hum Dist Sum-Ag Types Beyond Ripar Plot
132	Human Dist	XCB_HAG	hum Dist Sum-Ag Types instrm & on Bank
133	Human Dist	X_HAG	hum Dist Sum-Ag Types rip Plt & Beyond
134	Human Dist	W1_HALL	Rip Dist--Sum All Types (ProxWt Pres)
135	Human Dist	W1_HNOAG	Rip Dist--Sum NonAg Types (ProxWt Pres)
136	Human Dist	W1_HAG	Rip Dist--Sum Agric Types (ProxWt Pres)
137	Human Dist	W1H_BLDG	Rip Dist--Buildings (ProxWt Pres)
138	Human Dist	W1H_WALL	Rip Dist--Wall/Bank Revet. (ProxWt Pres)
139	Human Dist	W1H_PVMT	Rip Dist--Pavement (ProxWt Pres)
140	Human Dist	W1H_ROAD	Rip Dist--Road/Railroad (ProxWt Pres)
141	Human Dist	W1H_PIPE	Rip Dist--Pipes infl/effl (ProxWt Pres)
142	Human Dist	W1H_LDFL	Rip Dist--Trash/Landfill (ProxWt Pres)
143	Human Dist	W1H_PARK	Rip Dist--Lawn/Park (ProxWt Pres)
144	Human Dist	W1H_CROP	Rip Dist--Row Crop (ProxWt Pres)
145	Human Dist	W1H_PSTR	Rip Dist--Pasture/Hayfield (ProxWt Pres)
146	Human Dist	W1H_LOG	Rip Dist--Logging Activity (ProxWt Pres)

Appendix 1 cont.. REMAP protocol Physical Habitat (PHAB) variables

PHAB#	Habitat	Variable	Label
147	Human Dist	W1H_MINE	Rip Dist--Mining Activity (ProxWt Pres)
148	Bed Stability	LTEST	LOG 10 est. erodible Substrate Diam (mm)
149	Bed Stability	LRBS_TST	LOG10 relative bed stability tst
150	Sinuosity	TRAN_N	The Number nonmissing values, BEARING
151	Sinuosity	TRDIST	REACHLEN/10-Dist btween transects
152	Sinuosity	REACH	The Sum, TRANDIST=reach length
153	Sinuosity	CROWS_D	Straight Line Valley Length
154	Sinuosity	SINU	Channel Sinuosity (m/m)
155	Gradient	NSLP	# of values used to calc ave. slope
156	Gradient	XSLOPE	Channel Slope -- reach mean (%)
157	Gradient	VSLOPE	Std Dev of Channel % Slope
158	LWD	N	number of nonmissing values, SIZE_CD
159	Substrate	SUB_X	Substrate--Mean Size Class (1-6)
160	Substrate	SUB_V	Substrate--StDev Size Class (1-6)
161	Substrate	SUB_O3	Substrate--O75 Size Class (1-6)
162	Substrate	SUB_MED	Substrate--Median Size Class (1-6)
163	Substrate	SUB_O1	Substrate--O25 Size Class (1-6)
164	Bed Stability	LSUB_DMM	Log10 est substrate geom mean diam (mm)
165	Substrate	SUB_IQR	Substrate--Int-Quart Rg Size Class (1-6)
166	Substrate	PCT_BL	Substrate Boulders -- 250-4000 mm (%)
167	Substrate	PCT_BS	Substrate, Bedrock Smooth, > 4000 mm (%)
168	Substrate	PCT_CB	Substrate Cobbles -- 64-250 mm (%)
169	Substrate	PCT_FN	Substrate Fines -- Silt/Clay/Muck (%)
170	Substrate	PCT_GC	Substrate Coarse Gravel -- 16-64 mm (%)
171	Substrate	PCT_GF	Substrate Fine Gravel -- 2-16 mm (%)
172	Substrate	PCT_SA	Substrate Sand -- .06-2 mm (%)
173	Substrate	PCT_WD	Substrate Woody -- (%)
174	Substrate	PCT_BR	Substrate, Bedrock Rough, > 4000 mm (%)
175	Substrate	PCT_OT	Substrate Miscellaneous -- (%)
176	Substrate	PCT_RC	Substrate Concrete (%)
177	Substrate	PCT_OM	Substrate Organic Detritus -- (%)
178	Substrate	PCT_HP	Substrate Hardpan -- (%)
179	Substrate	PCT_SAFN	Substrate Sand & Fines -- <2 mm (%)
180	Substrate	PCT_SFGF	Substrate <= Fine Gravel <16 mm (%)
181	Substrate	PCT_BIGR	Substrate >= Coarse Gravel >16 mm (%)
181.1	Substrate	PCT_GCB	Substrate >= Coarse Gravel <4000mm (%)
182	Substrate	PCT_BDRK	Substrate Bedrock (%)
183	Substrate	PCT_ORG	Substrate Wood or Detritus -- (%)
184	LWD	NC	reach tot # nonmissing values-WETTOT
185	LWD	NS	reach tot # nonmissing values-DRYTOT
186	LWD	C1W	rch tot wet count cls 1 (all wood)
187	LWD	C2W	rch tot wet count cls 2 (S,M,L,X wood)
188	LWD	C3W	rch tot wet count cls 3 (M,L,X wood)
189	LWD	C4W	rch tot wet count cls 4 (L,X wood)
190	LWD	C5W	rch tot wet count cls 5 (X wood)
191	LWD	C1D	rch tot dry count cls 1 (all wood)
192	LWD	C2D	rch tot dry count cls 2 (S,M,L,X wood)
193	LWD	C3D	rch tot dry count cls 3 (M,L,X wood)
194	LWD	C4D	rch tot dry count cls 4 (L,X wood)
195	LWD	C5D	rch tot dry count cls 5 (X wood)
196	LWD	V1W	rch tot wet vol cls 1 (all wood)
197	LWD	V2W	rch tot wet vol cls 2 (S,M,L,X wood)
198	LWD	V3W	rch tot wet vol cls 3 (M,L,X wood)
199	LWD	V4W	rch tot wet vol cls 4 (L,X wood)
200	LWD	V5W	rch tot wet vol cls 5 (X wood)
201	LWD	V1D	rch tot dry vol cls 1 (all wood)
202	LWD	V2D	rch tot dry vol cls 2 (S,M,L,X wood)
203	LWD	V3D	rch tot dry vol cls 3 (M,L,X wood)
204	LWD	V4D	rch tot dry vol cls 4 (L,X wood)
205	LWD	V5D	rch tot dry vol cls 5 (X wood)
206	LWD	C1T	rch tot count cls 1 (all wood)
207	LWD	C2T	rch tot count cls 2 (S,M,L,X wood)
208	LWD	C3T	rch tot count cls 3 (M,L,X wood)
209	LWD	C4T	rch tot count cls 4 (L,X wood)
210	LWD	C5T	rch tot count cls 5 (X wood)
211	LWD	V1T	rch tot vol cls 1 (all wood)
212	LWD	V2T	rch tot vol cls 2 (S,M,L,X wood)
213	LWD	V3T	rch tot vol cls 3 (M,L,X wood)
214	LWD	V4T	rch tot vol cls 4 (L,X wood)
215	LWD	V5T	rch tot vol cls 5 (X wood)
216	LWD	C1W_MSQ	ave. c1w per square meter stream
217	LWD	C2W_MSQ	ave. c2w per square meter stream
218	LWD	C3W_MSQ	ave. c3w per square meter stream

Appendix 1 cont.. REMAP protocol Physical Habitat (PHAB) variables

PHAB#	Habitat	Variable	Label
219	LWD	C4W_MSO	ave. c4w per square meter stream
220	LWD	C5W_MSO	ave. c5w per square meter stream
221	LWD	V1W_MSO	ave. v1w per square meter stream
222	LWD	V2W_MSO	ave. v2w per square meter stream
223	LWD	V3W_MSO	ave. v3w per square meter stream
224	LWD	V4W_MSO	ave. v4w per square meter stream
225	LWD	V5W_MSO	ave. v5w per square meter stream
226	LWD	C1WM100	ave. c1w per 100m stream
227	LWD	C2WM100	ave. c2w per 100m stream
228	LWD	C3WM100	ave. c3w per 100m stream
229	LWD	C4WM100	ave. c4w per 100m stream
230	LWD	C5WM100	ave. c5w per 100m stream
231	LWD	V1WM100	ave. v1w per 100m stream
232	LWD	V2WM100	ave. v2w per 100m stream
233	LWD	V3WM100	ave. v3w per 100m stream
234	LWD	V4WM100	ave. v4w per 100m stream
235	LWD	V5WM100	ave. v5w per 100m stream
236	LWD	C1DM100	ave. c1d per 100m stream
237	LWD	C2DM100	ave. c2d per 100m stream
238	LWD	C3DM100	ave. c3d per 100m stream
239	LWD	C4DM100	ave. c4d per 100m stream
240	LWD	C5DM100	ave. c5d per 100m stream
241	LWD	V1DM100	ave. v1d per 100m stream
242	LWD	V2DM100	ave. v2d per 100m stream
243	LWD	V3DM100	ave. v3d per 100m stream
244	LWD	V4DM100	ave. v4d per 100m stream
245	LWD	V5DM100	ave. v5d per 100m stream
246	LWD	C1TM100	c1wm100+c1dm100
247	LWD	C2TM100	c2wm100+c2dm100
248	LWD	C3TM100	c3wm100+c3dm100
249	LWD	C4TM100	c4wm100+c4dm100
250	LWD	C5TM100	c5wm100+c5dm100
251	LWD	V1TM100	v1wm100+v1dm100
252	LWD	V2TM100	v2wm100+v2dm100
253	LWD	V3TM100	v3wm100+v3dm100
254	LWD	V4TM100	v4wm100+v4dm100
255	LWD	V5TM100	v5wm100+v5dm100
256	Channel	N_D	Number of obs -- Thalweg Depth
257	Channel	XDEPTH	Thalweg Mean Depth (cm)
258	Channel	SDDEPTH	Std Dev of Thalweg Depth (cm)
259	Channel	N_W	Number of obs -- Wetted Width
260	Channel	XWIDTH	Wetted Width -- Mean (m)
261	Channel	SDWIDTH	Std Dev of Wetted Width (m)
262	Channel	N_WD	Number of obs -- W*D Product
263	Channel	XWXD	Mean Width*Depth Product (m2)
264	Channel	SDWXD	Std Dev of Width*Depth Product (m2)
265	Channel	N_WDR	Number of obs -- W/D Ratio
266	Channel	WD_RAT	Mean Width/Depth Ratio (m/m)
267	Channel	SDWD_RAT	Std Dev of Width/Depth Ratio (m/m)
268	Pool	AREASUM	Residual Pool Area -- Long Profile (m2)
269	Pool	INTSUM	reach lngth resid pools evaluated over
270	Pool	RP100	Residual Mean Depth (cm or m2/100m)
271	Sinuosity	REACHLEN	total length of sample reach
272	Pool	RPGT50	number of nonmissing values, MAXDEP
273	Pool	RPGT75	number of nonmissing values, MAXDEP
274	Pool	RPGT100	number of nonmissing values, MAXDEP
275	Pool	RPXMDEP	the mean, MAXDEP
276	Pool	RPXLEN	the mean, POOLEN
277	Pool	RPXAREA	the mean, POOLAR
278	Pool	RPVMDEP	the standard deviation, MAXDEP
279	Pool	RPVLEN	the standard deviation, POOLEN
280	Pool	RPVAREA	the standard deviation, POOLAR
281	Pool	RPMDEP	the largest value, MAXDEP
282	Pool	RPMLEN	the largest value, POOLEN
283	Pool	RPMAREA	the largest value, POOLAR
284	Hab Unit	PCT_DR	Dry channel (% of reach)
285	Hab Unit	PCT_PD	Impoundment Pool (% of reach)
286	Hab Unit	PCT_RI	Riffle (% of reach)
287	Hab Unit	PCT_GL	Glide (% of reach)
288	Hab Unit	PCT_PL	Lateral Scour Pool (% of reach)
289	Hab Unit	PCT_PT	Trench Pool (% of reach)

Appendix 1 cont.. REMAP protocol Physical Habitat (PHAB) variables

PHAB#	Habitat	Variable	Label
290	Hab Unit	PCT_RA	Rapids (% of reach)
291	Hab Unit	PCT_CA	Cascade (% of reach)
292	Hab Unit	PCT_FA	Falls (% of reach)
293	Hab Unit	PCT_PP	Plunge Pool (% of reach)
294	Hab Unit	PCT_PB	Backwater Pool (% of reach length)
295	Hab Unit	PCT_P	Pool -- Type not noted (% of reach)
296	Hab Unit	PCT_R	rapids/riffles (unknown) (% of reach)
297	Hab Unit	PCT_SB	Subsurface Flow (% of reach)
298	Hab Unit	PCT_FAST	Fast Wtr Hab (% riffle & faster)
299	Hab Unit	PCT_SLOW	Slow Wtr Hab (% Glide & Pool)
300	Hab Unit	PCT_POOL	Pools -- All Types (% of reach)
301	Hab Unit	PCT_DRS	Dry Channel or Subsurf Flow (%)

Appendix 2. PCA loadings for 67 site visits from the 94-95 Coast Range REMAP survey.

Variable **(Variable code)**	Habitat Category	PCA axis 1	PCA axis 2
Percent Coarse Substrate (PCT_GCB)	Substrate	-0.722	0.362
Mean Canopy (XC)	Riparian	-0.656	0.136
Human Disturbance-Agricultural (W1_HAG)	Human Disturbance	0.768	-0.055
Percent Sand and Fines (PCT_SAFN)	Substrate	0.802	-0.406
Mean Canopy Density – Midchannel (XCDENMID)	Densiometer	-0.244	-0.777
Mean Fish Cover-Big (XFC_BIG)	Fish Cover	-0.636	0.120
Mean residual depth/100m (RP100)	Residual Pool	0.411	0.796
Percent Fast Water (PCT_FAST)	Hab Unit	-0.785	-0.238
Proportion variance explained		0.383	0.273
Cumulative proportion variance explained		0.383	0.656

Appendix 3. 1994-1996 Coast Range REMAP Habitat Results – RHI and Metric results

DEQ BASIN	SUB-BASIN	SITE_NAME	Ref Type	DATE	RHI	PCT_ GCB	XC	W1_ HAG	PCT_ SAFN	XCDE NMID	XFC_ BIG	RP100	PCT_ FAST	AREA
Mid Coast	ALSEA	CULLEN CREEK AT RM 0.3	A	25-Aug-94	88	67.3	0.63	0.000	7.3	90.0	0.78	1.9	72.0	135
Mid Coast	ALSEA	CULLEN CREEK AT RM 0.3	A	06-Aug-96	75	47.3	0.11	0.000	18.2	99.6	0.32	1.0	44.9	135
Mid Coast	ALSEA	DRIFT CREEK AT RM 7.3		09-Aug-95	69	40.0	0.50	0.000	21.8	18.9	0.05	13.0	31.0	15804
Mid Coast	ALSEA	DRIFT CREEK AT RM 7.3		11-Sep-96	50	29.1	0.23	1.500	16.4	40.2	0.09	15.9	33.7	15804
Mid Coast	ALSEA	HONEY GROVE CREEK AT RM 1.2		12-Sep-94	69	21.8	0.66	0.000	34.5	89.7	0.14	18.2	13.3	1625
Mid Coast	ALSEA	HONEY GROVE CREEK AT RM 1.2		13-Aug-96	81	27.3	0.52	0.000	52.7	87.8	0.49	24.3	36.0	1625
Mid Coast	ALSEA	HONEY GROVE CREEK AT RM 1.2		03-Sep-96	63	7.3	0.27	0.000	41.8	91.0	0.33	15.8	30.1	1625
Mid Coast	ALSEA	Lint Cr. @ RM 3.1		26-Aug-94	31	0.0	0.16	0.000	60.0	13.4	0.10	58.2	0.0	556
Mid Coast	ALSEA	TENMILE CREEK AT USFS TENMILE CREEK CAMPGROUND	B	19-Jul-95	100	78.2	0.44	0.000	10.9	80.1	0.39	20.2	64.0	3681
Mid Coast	ALSEA	TENMILE CREEK AT USFS TENMILE CREEK CAMPGROUND	B	30-Aug-95	88	67.3	0.29	0.000	10.9	67.0	0.12	19.2	63.0	3681
Mid Coast	ALSEA	TENMILE CREEK AT USFS TENMILE CREEK CAMPGROUND	B	04-Sep-96	94	47.3	0.55	0.000	23.6	54.3	0.28	27.8	56.0	3681
Mid Coast	ALSEA	TROUT CREEK AT RM 0.2	B	08-Aug-95	75	14.5	0.39	0.500	23.6	69.0	0.16	15.6	52.0	1665
Mid Coast	ALSEA	TROUT CREEK AT RM 0.2	B	12-Sep-96	75	23.6	0.45	1.000	21.8	75.8	0.24	13.3	56.0	1665
Mid Coast	SILETZ/YAQUINA	SALMON RIVER AT RM 21.0	B	07-Aug-95	94	64.8	0.49	0.000	9.3	69.3	0.29	8.3	62.0	960
Mid Coast	SILETZ/YAQUINA	SALMON RIVER AT RM 21.0	B	22-Sep-95	100	78.2	0.68	0.000	1.8	81.4	0.97	7.9	54.0	960
Mid Coast	SILETZ/YAQUINA	SALMON RIVER AT RM 21.0	B	25-Sep-96	94	85.5	0.71	0.000	0.0	77.8	0.76	5.6	81.0	960
Mid Coast	SILETZ/YAQUINA	YAQUINA RIVER AT EDDYVILLE RM 32.0		30-Aug-94	19	5.6	0.28	0.972	55.6	25.4	0.06	45.8	3.0	10279
Mid Coast	SILETZ/YAQUINA	YAQUINA RIVER AT EDDYVILLE RM 32.0		14-Aug-96	38	5.5	0.22	0.167	67.3	40.6	0.11	45.0	8.3	10279
Mid Coast	SILETZ/YAQUINA	YAQUINA RIVER U/S OF EDDYVILLE RM 34.1		31-Aug-94	63	16.4	0.40	0.667	34.5	62.3	0.57	22.3	4.0	9672
Mid Coast	SILETZ/YAQUINA	YAQUINA RIVER U/S OF EDDYVILLE RM 34.1		12-Aug-96	44	3.6	0.28	0.750	50.9	61.8	0.26	22.8	29.0	9672
Mid Coast	SIUSLAW	EAMES CREEK AT RM 4.8		10-Aug-95	44	0.0	0.14	0.000	80.0	89.7	0.28	0.1 est	81.3	10
Mid Coast	SIUSLAW	EAMES CREEK AT RM 4.8		06-Aug-96	50	14.5	0.19	0.000	29.1	88.1	0.29	0.1	24.0	10
Mid Coast	SIUSLAW	SOUTH FORK SIUSLAW RIVER AT RM 2.3		03-Aug-94	31	0.0	0.13	1.319	100.0	79.9	0.18	18.8	6.0	5374
Mid Coast	SIUSLAW	SOUTH FORK SIUSLAW RIVER AT RM 2.3		23-Sep-96	38	1.8	0.23	1.569	87.3	95.1	0.05	18.9	17.0	5374
Mid Coast	SIUSLAW	UNAMED TRIB ENTERING BERNHARDT CREEK AT RM 3.0	B	16-Aug-95	81	21.8	0.53	0.000	34.5	95.9	0.68	4.5	50.0	136
Mid Coast	SIUSLAW	UNAMED TRIB ENTERING BERNHARDT CREEK AT RM 3.0	B	10-Sep-96	94	51.9	0.65	0.000	22.2	96.7	0.37	5.2	50.6	136
Mid Coast	SIUSLAW	UNAMED TRIB ENTERING WOLF CREEK AT RM 13.5		17-Aug-95	56	9.1	0.30	0.000	63.6	73.3	0.20	14.0	30.9	99

Mid Coast	SIUSLAW	UNAMED TRIB ENTERING WOLF CREEK AT RM 13.5		07-Aug-96	88	27.3	0.39	0.000	38.2	69.8	0.37	9.5	41.3	99
N.Coast	LOWER COLUMBIA/CLATSKANIE	S.F. GOBLE CREEK AT RM 0.9		21-Jul-95	69	21.8	0.52	0.111	38.2	98.0	0.28	8.6	30.0	833
N.Coast	LOWER COLUMBIA/CLATSKANIE	S.F. GOBLE CREEK AT RM 0.9		06-Sep-95	88	49.1	0.40	0.000	30.9	97.1	0.14	11.5	39.3	833
N.Coast	LOWER COLUMBIA/CLATSKANIE	S.F. GOBLE CREEK AT RM 0.9		29-Jul-96	88	45.5	0.51	0.333	25.5	94.9	0.35	10.5	26.0	833
N.Coast	LOWER COLUMBIA/YOUNGS	BIG CREEK AT RM 2.9		08-Sep-94	88	78.2	0.61	0.611	5.5	48.9	0.72	10.6	70.0	8335
N.Coast	LOWER COLUMBIA/YOUNGS	BIG CREEK AT RM 2.9		29-Jul-96	75	66.7	0.48	1.083	24.1	40.0	0.77	14.5	78.0	8335
N.Coast	NEHALEM	FISHHAWK CREEK AT RM 1.7		07-Sep-94	38	14.5	0.27	2.111	50.9	89.0	0.17	24.5	11.0	5704
N.Coast	NEHALEM	FISHHAWK CREEK AT RM 1.7		31-Jul-96	44	10.9	0.23	2.069	54.5	72.9	0.29	39.7	18.0	5704
N.Coast	NEHALEM	N.F. NEHALEM RIVER AT RM 13.1		20-Sep-95	94	36.4	0.43	0.000	10.9	71.8	0.27	28.0	32.0	11114
N.Coast	NEHALEM	N.F. NEHALEM RIVER AT RM 13.1		30-Jul-96	94	36.4	0.39	0.000	21.8	59.4	0.19	20.8	38.0	11114
N.Coast	NEHALEM	N.F. NEHALEM RIVER AT RM 13.1		12-Sep-96	94	41.8	0.39	0.000	12.7	59.1	0.23	21.0	57.0	11114
N.Coast	NEHALEM	UNAMED TRIB ENTERING NEHALEM R AT RM 70.5		18-Sep-95	31	0.0	0.13	1.875	94.5	93.2	0.10	13 est	0.0	154
N.Coast	NEHALEM	UNAMED TRIB ENTERING NEHALEM R AT RM 70.5		30-Jul-96	44	0.0	0.30	1.208	90.9	80.5	0.38	13.1	2.0	154
N.Coast	WILSON/TRASK/NESTUCCA	BEWLEY CREEK AT RM 0.3		20-Sep-94	44	23.6	0.23	1.056	60.0	82.6	0.25	39.4	4.0	1476
N.Coast	WILSON/TRASK/NESTUCCA	BEWLEY CREEK AT RM 0.3		27-Aug-96	69	16.4	0.40	0.417	72.7	72.2	0.36	38.1	17.0	1476
N.Coast	WILSON/TRASK/NESTUCCA	FALL CREEK AT RM 0.7	B	06-Jul-94	94	83.6	0.79	0.000	9.1	95.3	0.82	4.4	54.2	975
N.Coast	WILSON/TRASK/NESTUCCA	FALL CREEK AT RM 0.7	B	29-Aug-96	100	63.6	0.77	0.000	5.5	70.5	0.47	11.5	66.0	975
N.Coast	WILSON/TRASK/NESTUCCA	JOES CREEK AT RM 0.5		27-Sep-95	88	36.4	0.72	0.000	25.5	99.5	0.26	3.8	65.8	133
N.Coast	WILSON/TRASK/NESTUCCA	JOES CREEK AT RM 0.5		26-Aug-96	88	80.0	0.33	0.000	3.6	78.9	0.52	3.1	70.7	133
N.Coast	WILSON/TRASK/NESTUCCA	Kilchis Rv. @ RM 8.5		07-Jul-94	94	56.4	0.74	0.000	18.2	30.2	0.54	38.2	37.0	9130
N.Coast	WILSON/TRASK/NESTUCCA	M.F./N.F. TRASK RIVER AT RM 3.0	B	26-Sep-95	100	58.2	0.57	0.000	1.8	70.3	0.68	19.5	58.0	3089
N.Coast	WILSON/TRASK/NESTUCCA	M.F./N.F. TRASK RIVER AT RM 3.0	B	27-Aug-96	100	45.5	0.40	0.000	1.8	70.5	0.43	23.2	53.0	3089
N.Coast	WILSON/TRASK/NESTUCCA	Mill Cr. @ RM 1.0		19-Sep-94	19	12.7	0.11	1.639	58.2	39.7	0.07	16.1	6.0	1099
N.Coast	WILSON/TRASK/NESTUCCA	Mill Cr. @ RM 1.0		28-Aug-96	19	11.0	0.10	1.000	64.0	23.0	0.11	21.0	5.0	1099
Rogue	ROGUE WILDERNESS	LOBSTER CREEK AT RM 6.2	B	12-Jul-95	69	42.6	0.83	0.000	48.1	39.4	0.15	26.8	21.0	14278
Rogue	ROGUE WILDERNESS	LOBSTER CREEK AT RM 6.2	B	22-Aug-95	81	63.6	0.52	0.000	12.7	25.4	0.36	26.4	22.0	14278
Rogue	ROGUE WILDERNESS	LOBSTER CREEK AT RM 6.2	B	21-Aug-96	81	63.0	0.47	0.000	25.9	28.7	0.22	26 est	23.2	14278
Rogue	ROGUE WILDERNESS	TWOMILE CREEK AT RM 0.2		22-Jun-94	100	54.5	0.77	0.000	9.1	88.6	0.63	16.8	56.0	1364
Rogue	ROGUE WILDERNESS	TWOMILE CREEK AT RM 0.2		19-Aug-96	100	45.5	0.64	0.000	1.8	83.4	0.75	10.9	60.0	1364
S.Coast	CHETCO	EMILY CREEK AT RM 7.1		21-Jun-94	100	70.9	0.80	0.000	12.7	94.3	0.36	7.6	70.7	163
S.Coast	CHETCO	EMILY CREEK AT RM 7.1		18-Aug-96	94	70.9	0.75	0.000	0.0	87.3	0.35	4.2	88.0	163

S.Coast	CHETCO	S.F. CHETCO RIVER AT RM 2.5	A	11-Jul-95	94	38.2	0.71	0.000	21.8	33.8	0.35	25.0	61.0	8001
S.Coast	CHETCO	S.F. CHETCO RIVER AT RM 2.5	A	22-Aug-96	88	57.4	0.76	0.000	20.4	47.2	0.38	25 est	25.0	8001
S.Coast	COOS	BENSON CREEK AT RM 5.0	A	15-Aug-95	88	25.5	0.68	0.000	36.4	79.1	0.36	11.5	39.3	935
S.Coast	COOS	BENSON CREEK AT RM 5.0	A	17-Jul-96	100	36.4	0.49	0.000	3.6	59.5	0.46	13.8	56.0	935
S.Coast	COOS	ELK CREEK AT RM 3.0	B	28-Jul-94	94	36.4	0.34	0.000	21.8	77.4	0.30	9.3	44.0	1091
S.Coast	COOS	ELK CREEK AT RM 3.0	B	18-Aug-94	100	45.5	0.79	0.000	7.3	81.1	0.46	9.5	34.0	1091
S.Coast	COOS	ELK CREEK AT RM 3.0	B	13-Sep-94	88	40.0	0.36	0.000	5.5	87.3	0.63	7.7	30.3	1091
S.Coast	COOS	ELK CREEK AT RM 3.0	B	03-Aug-95	100	42.6	0.67	0.000	11.1	83.2	0.48	7.5	41.0	1091
S.Coast	COOS	ELK CREEK AT RM 3.0	B	29-Aug-95	94	49.1	0.22	0.000	9.1	92.1	0.45	6.7	46.0	1091
S.Coast	COOS	ELK CREEK AT RM 3.0	B	16-Jul-96	100	45.5	0.47	0.000	12.7	79.3	0.45	8.8	38.0	1091
S.Coast	COOS	ELK CREEK AT RM 3.0	B	10-Sep-96	94	25.5	0.48	0.000	12.7	94.0	0.44	8.2	45.0	1091
S.Coast	COOS	METTMAN CREEK AT RM 0.5		26-Jul-94	44	1.8	0.01	0.500	94.5	63.5	0.40	11.2	0.0	734
S.Coast	COOS	METTMAN CREEK AT RM 0.5		17-Jul-96	31	0.0	0.03	1.306	76.4	99.3	0.13	13.4	0.0	734
S.Coast	COOS	MORGAN CREEK AT RM 1.5		02-Aug-95	56	30.9	0.05	0.778	29.1	63.8	0.13	13.2	50.0	1029
S.Coast	COOS	MORGAN CREEK AT RM 1.5		16-Jul-96	69	72.7	0.17	1.042	20.0	54.7	0.14	16.5	62.0	1029
S.Coast	COOS	PANTHER CREEK AT RM 4.6		21-Jul-94	56	0.0	0.31	0.000	63.6	49.7	0.54	18.2	8.7	304
S.Coast	COOS	PANTHER CREEK AT RM 4.6		23-Jul-96	56	1.8	0.25	0.000	58.2	42.8	0.35	29.0	22.8	304
S.Coast	COOS	WEST FORK MILICOMA R ST RM 22.5		27-Jul-94	75	45.5	0.29	0.000	3.6	48.0	0.24	15.8	33.0	7384
S.Coast	COOS	WEST FORK MILICOMA R ST RM 22.5		18-Jul-96	81	23.6	0.62	0.000	16.4	33.6	0.25	19.5	32.0	7384
S.Coast	COOS	WILLIAMS RIVER AT RM 19.2		13-Jul-94	94	21.8	0.66	0.000	16.4	64.8	0.31	20.2	52.0	3276
S.Coast	COOS	WILLIAMS RIVER AT RM 19.2		09-Jul-96	94	47.3	0.53	0.000	10.9	61.1	0.23	18.6	56.0	3276
S.Coast	COQUILLE	EAST FORK COQUILLE R. TRIBUTARY @ RM 0.8		19-Jul-94	50	14.5	0.05	0.000	49.1	48.8	0.55	4.0	30.7	73
S.Coast	COQUILLE	EAST FORK COQUILLE R. TRIBUTARY @ RM 0.8		11-Jul-96	50	21.8	0.03	0.000	61.8	42.6	0.44	5.8	28.7	73
S.Coast	COQUILLE	EAST FORK COQUILLE RIVER AT RM 26	B	14-Jul-94	94	42.6	0.33	0.000	11.1	74.5	0.41	23.8	58.1	5368
S.Coast	COQUILLE	EAST FORK COQUILLE RIVER AT RM 26	B	11-Jul-96	100	41.8	0.56	0.000	9.1	75.0	0.51	19.2	75.0	5368
S.Coast	COQUILLE	FISHTRAP CREEK AT RM 1.4		18-Jul-95	31	1.8	0.13	1.806	81.8	88.1	0.26	17.1	10.0	1582
S.Coast	COQUILLE	FISHTRAP CREEK AT RM 1.4		23-Aug-95	44	10.9	0.22	0.667	74.5	86.5	0.13	13.7	20.0	1582
S.Coast	COQUILLE	FISHTRAP CREEK AT RM 1.4		09-Jul-96	44	10.9	0.22	1.528	63.6	51.3	0.22	22.1	18.0	1582
S.Coast	COQUILLE	FISHTRAP CREEK AT RM 1.4		16-Sep-96	31	3.6	0.18	0.667	78.2	47.5	0.31	17.1	9.0	1582
S.Coast	COQUILLE	HONCHO CREEK AT RM 1.2		17-Aug-94	63	78.2	0.16	0.000	0.0	88.8	0.39	0.2	2.0	30
S.Coast	COQUILLE	HONCHO CREEK AT RM 1.2		24-Jul-96	81	50.9	0.51	0.000	16.4	85.3	0.52	1.4	19.3	30

S.Coast	COQUILLE	MIDDLE CREEK AT RM 1.6		20-Jul-94	38	5.5	0.12	0.611	83.6	51.7	0.16	37.2	14.0	12671
S.Coast	COQUILLE	MIDDLE CREEK AT RM 1.6		10-Jul-96	50	5.5	0.58	1.361	67.3	58.2	0.32	40.2	9.0	12671
S.Coast	SIXES	Butler Cr @ RM 2.1	A	12-Sep-95	88	32.7	0.88	0.000	0.0	92.9	0.38	30.9	25.0	70
S.Coast	SIXES	ELK RIVER AT RM 24.0	B	25-Jul-95	81	45.5	0.73	0.000	12.7	23.7	0.35	71.6	27.0	9019
S.Coast	SIXES	ELK RIVER AT RM 24.0	B	20-Aug-96	75	55.6	0.36	0.000	9.3	46.0	0.30	90.6	25.0	9019
Umpqua	SOUTH UMPQUA	BEALS CREEK AT RM. 0.6		12-Jul-94	50	53.3	0.23	0.697	33.3	55.1	0.17	5.5	0.0	1684
Umpqua	SOUTH UMPQUA	BEALS CREEK AT RM. 0.6		20-Aug-96	75	60.0	0.15	0.278	10.9	51.1	0.12	7.6	58.0	1684
Umpqua	SOUTH UMPQUA	OLALLA CREEK AT RM 11.6		31-Jul-95	75	37.0	0.53	0.611	31.5	73.8	0.28	21.7	30.3	15957
Umpqua	SOUTH UMPQUA	OLALLA CREEK AT RM 11.6		13-Sep-95	69	36.4	0.49	1.111	10.9	44.3	0.21	19.3	21.0	15957
Umpqua	SOUTH UMPQUA	OLALLA CREEK AT RM 11.6		10-Jul-96	75	42.6	0.45	1.000	20.4	68.9	0.10	19.9	26.0	15957
Umpqua	UMPQUA	CABIN CREEK AT RM 5.6		27-Jul-95	38	1.8	0.33	0.667	61.8	93.3	0.05	23.9	16.7	1283
Umpqua	UMPQUA	CABIN CREEK AT RM 5.6		23-Jul-96	31	20.0	0.15	1.667	76.4	77.1	0.07	25.5	10.7	1283
Umpqua	UMPQUA	COX CREEK AT RM 0.3		04-Aug-94	38	12.0	0.57	0.708	40.0	77.8	0.12	15 est	0.0	1367
Umpqua	UMPQUA	COX CREEK AT RM 0.3		22-Jul-96	69	29.1	0.32	1.000	21.8	77.1	0.12	14.6	31.3	1367
Umpqua	UMPQUA	COX CREEK AT RM 0.3		11-Sep-96	44	9.1	0.54	0.417	32.7	80.3	0.11	2.0	0.0	1367
Umpqua	UMPQUA	ELK CREEK AT RM 34.2		03-Aug-94	69	32.7	0.43	0.361	23.6	69.1	0.31	12.8	11.0	11108
Umpqua	UMPQUA	ELK CREEK AT RM 34.2		25-Jul-96	63	27.3	0.40	1.611	38.2	79.1	0.19	14.3	33.0	11108
Umpqua	UMPQUA	N.F. SMITH RIVER AT RM 23.0-1500' U/S NF FALLS		24-Aug-95	88	40.7	0.88	0.000	25.9	87.3	0.58	18.0	12.0	2756
Umpqua	UMPQUA	N.F. SMITH RIVER AT RM 23.0-1500' U/S NF FALLS		08-Aug-96	88	27.3	0.66	0.000	27.3	73.4	0.38	22.4	31.0	2756
Umpqua	UMPQUA	N.F. SMITH RIVER AT RM 23.0-1500' U/S NF FALLS		18-Sep-96	88	36.0	0.65	0.000	29.0	76.0	0.20	20.0	26.0	2756
Umpqua	UMPQUA	SMITH RIVER AT RM 81.3		10-Aug-94	63	18.2	0.73	0.278	43.6	71.0	0.37	15.3	8.0	3994
Umpqua	UMPQUA	SMITH RIVER AT RM 81.3		24-Jul-96	81	23.6	0.59	0.000	27.3	92.9	0.36	13.9	24.0	3994
Umpqua	UMPQUA	UNNAMED TRIB OF WEST FORK LAKE CREEK AT RM 1.0		09-Aug-94	50	7.3	0.33	0.000	60.0	88.8	0.15	0.8	59.3	13
Umpqua	UMPQUA	UNNAMED TRIB OF WEST FORK LAKE CREEK AT RM 1.0		18-Jul-96	69	10.9	0.83	0.000	49.1	87.4	0.39	3.6	34.2	13
Willamette	LOWER WILLAMETTE	DART CREEK AT RM 3.7		18-Jul-94	88	36.4	0.81	0.000	36.4	95.1	0.31	2.6	58.0	152
Willamette	LOWER WILLAMETTE	DART CREEK AT RM 3.7		19-Aug-94	69	3.6	0.95	0.000	29.1	95.6	0.42	1.4	76.0	152
Willamette	LOWER WILLAMETTE	DART CREEK AT RM 3.7		09-Sep-94	75	20.0	0.76	0.000	34.5	99.7	0.29	2.2	57.3	152
Willamette	LOWER WILLAMETTE	DART CREEK AT RM 3.7		22-Jun-95	69	24.5	0.90	0.056	28.3	98.0	0.22	3.0	70.7	152
Willamette	LOWER WILLAMETTE	DART CREEK AT RM 3.7		28-Jul-95	75	20.0	0.58	0.000	38.2	98.4	0.12	2.2	70.0	152
Willamette	LOWER WILLAMETTE	DART CREEK AT RM 3.7		01-Aug-96	69	12.7	0.58	0.000	60.0	82.6	0.30	3.5	59.3	152

Willamette	TUALATIN	WILLIAMS CANYON CREEK AT RM 1.8		19-Sep-95	25	3.6	0.11	0.833	87.3	91.6	0.04	16.2	6.0	346
Willamette	TUALATIN	WILLIAMS CANYON CREEK AT RM 1.8		26-Aug-96	31	0.0	0.12	1.444	72.7	94.8	0.02	14.1	25.0	346
Willamette	TUALATIN	WILLIAMS CANYON CREEK AT RM 1.8		19-Sep-96	38	1.9	0.20	0.958	74.1	78.6	0.06		23.7	346
Willamette	UPPER WILLAMETTE/LONG TOM	FOX HOLLOW CREEK AT RM 1.3		02-Aug-94	56	34.5	0.11	0.972	54.5	47.5	0.39	13.3	44.7	2472
Willamette	UPPER WILLAMETTE/LONG TOM	FOX HOLLOW CREEK AT RM 1.3		05-Aug-96	38	35.2	0.16	1.708	42.6	38.2	0.10	13.1	27.3	2472
Willamette	UPPER WILLAMETTE/LONG TOM	LONG TOM RIVER AT RM 48.5		14-Sep-95	69	9.1	0.73	0.000	36.4	65.8	0.17	14.1	36.0	6738
Willamette	UPPER WILLAMETTE/LONG TOM	LONG TOM RIVER AT RM 48.5		05-Sep-96	69	9.1	0.31	0.000	20.0	65.9	0.07	17.3	72.0	6738
Willamette	YAMHILL/NEWBERG POOL	AGENCY CREEK AT RM 0.2		22-Aug-94	56	54.5	0.19	1.319	21.8	32.4	0.06	32.5	19.0	7137
Willamette	YAMHILL/NEWBERG POOL	AGENCY CREEK AT RM 0.2		14-Aug-96	56	30.9	0.06	0.000	32.7	17.1	0.13	31.7	31.0	7137
Willamette	YAMHILL/NEWBERG POOL	CEDAR CREEK AT RM 0.6		20-Jul-95	56	0.0	0.58	0.000	81.8	95.6	0.08	20.5	15.3	471
Willamette	YAMHILL/NEWBERG POOL	CEDAR CREEK AT RM 0.6		31-Aug-95	63	1.8	0.78	0.000	47.3	88.5	0.16	20.3	19.3	471
Willamette	YAMHILL/NEWBERG POOL	CEDAR CREEK AT RM 0.6		13-Aug-96	63	7.3	0.65	0.000	45.5	88.8	0.15	25.5	19.3	471
Willamette	YAMHILL/NEWBERG POOL	Rock Cr. @ RM 1.4		11-Jul-94	94	65.5	0.80	0.056	3.6	56.0	0.52	24.9	36.0	5747
Willamette	YAMHILL/NEWBERG POOL	Rock Cr. @ RM 1.4		11-Aug-94	94	66.7	0.77	0.000	5.6	48.8	1.07	15.0	33.0	5747
Willamette	YAMHILL/NEWBERG POOL	Rock Cr. @ RM 1.4		14-Sep-94	88	45.3	0.25	0.556	13.2	55.3	0.66	19.2	36.0	5747
Willamette	YAMHILL/NEWBERG POOL	UNAMED TRIB ENTERING PANTHER CREEK AT RM 14		28-Sep-95	81	60.0	0.27	0.000	9.1	100.0	0.34	1.0	84.6	102
Willamette	YAMHILL/NEWBERG POOL	UNAMED TRIB ENTERING PANTHER CREEK AT RM 14		28-Aug-96	69	76.0	0.12	0.000	4.0	52.9	0.24	2.8	28.1	102

Appendix 4. Box plots of RHI metrics – Reference and Non-reference