JOHN DAY RIVER BASIN TMDL

APPENDIX F:
BIOLOGIAL CRITERION ASSESSMENT

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Summary of Biological Conditions of Wadeable Streams in the John Day Basin

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Background

The Oregon Department of Environmental Quality (ODEQ) surveyed streams in the John Day and Lower Deschutes basins in the summer months of 2000 – 2003. These surveys were part of USEPA's Environmental Monitoring and Assessment—Western Pilot (WEMAP). Information was collected for biological, chemical, and habitat conditions of perennial and wadeable streams. The sites were selected randomly, allowing results to be summarized as the percent of perennial wadeable stream miles in the two basins. (See Hubler 2007 for more details on the W-EMAP sampling in Oregon.)

The results were based on surveys of 76 randomly selected streams in the John Day and Lower Deschutes basins. However, only nine sites were surveyed in the Lower Deschutes. Additionally, access was denied to the majority of privately owned lands. Thus, the results presented here are largely representative of perennial, wadeable, and publicly owned streams in the John Day basin.

Biological Condition

Overall biological conditions were assessed on macroinvertebrate assemblages using ODEQ's PREDATOR model (Hubler 2008). The PREDATOR index is the primary tool ODEQ uses to assess whether a stream is meeting the narrative biological criteria water quality standard (OAR 340-041-0011). PREDATOR predicts the types of macroinvertebrates expected to occur in a stream, based on the bugs commonly observed at reference sites with similar environmental characteristics. Low PREDATOR scores represent loss of expected reference taxa, or decreased reference richness. This is an indication that a site is not in least disturbed reference conditions.

Sites in the John Day basin were assessed with a model utilizing 167 different reference sites. Taxa predictions were based on four environmental predictors: ecoregion (east or west of the Cascades crest, elevation, precipitation, and air temperature. The PREDATOR model uses the predictive function to assess the probability that a test site belongs to one of five reference groups. Bugs commonly found in these reference groups are used to calculate the expected (E) taxa list.

Biological Measures of Stress

Two other biological indices were used to measure potential causes of disturbance due to temperature or fine sediments. These two Stressor ID models (Temperature Stress and Fine Sediment Stress) utilize weighted averaging models to infer temperature and fine sediment conditions in a stream based on the macroinvertebrates collected (Huff et al. 2006). Inferences were made based on modeled optimum temperature and fine sediment conditions for each type of bug, as well as the abundance of each type of bug in a sample.

Stressor ID values were compared to stressor values observed at reference sites in the Blue Mountains ecoregion. A total of 46 sites were designated as reference in the Blue Mountains ecoregion. Reference designation procedures are outlined in Drake (2004).

Defining condition classes
For each biological index the distribution of scores observed at reference sites were used to establish condition benchmarks. Sites were classified as either 'least disturbed', 'moderately disturbed', or 'most disturbed'. The 10 percentile of reference sites was used to define the boundary between 'most' and 'moderately' disturbed and the 25th percentile to define the boundary between 'moderately' and 'least' disturbed.

For temperature and dissolved oxygen, existing numeric water quality criteria were used to determine condition. For all other stressors without water quality criteria, we used the same reference benchmark approach as for biological indices.

Extent of a Stressor and the Risk to the Biology
How pervasive a stressor is across the landscape is important to understand. Those stressors with the greatest extent of water quality violations or above reference benchmarks were assessed. Results were portrayed as percent of stream miles in the basin, but to be clear are limited to perennial and wadeable streams only.

Relative risk measures the likelihood that a biological indicator is in poor condition when a stressor is also in poor condition (Van Sickle et al. 2006). The risk to each of the biological indices from various water quality and habitat stressors was assessed. Stressors were considered to be a significant risk to biological condition when the lower 95% confidence interval was 1.0 or higher.

Results

Overall biological condition--PREDATOR
Twenty-six percent of perennial, wadeable streams in the John Day and Lower Deschutes basins had PREDATOR scores in most disturbed condition (Figure 1A). This means over one-quarter of wadeable streams had lost a considerable amount of macroinvertebrates common to reference sites in similar environments. The Temperature Stress and Fine Sediments Stress indices showed an even greater extent of streams in poor biological condition, each with over 40% of streams in most disturbed conditions. Streams in most disturbed condition for the Stressor ID indices have macroinvertebrate assemblages that are dominated by bugs with preferences for higher temperatures and fine sediments.

The most pervasive stressor to the biology (the stressors with the greatest extent in most disturbed condition) was high summer maximum water temperature (56% of stream miles) (Figure 1A). Human disturbances (agricultural = 41%, all human = 34%) were the next most common stressors in most disturbed condition. Other stressors with high extents included measures of sediment (relative bed stability, fine sediment) and ionic strength (conductivity, sulfate). However, none of these stressors with high extents proved to be significant risks to PREDATOR condition (although temperature, conductivity, and relative bed stability were close to being significant) (Figure 1B).

The stressor with the highest risk to overall biological condition was Total Suspended Solids (TSS) (Figure 1). If TSS in a stream was in poor condition, biological condition (PREDATOR) was 3.7 times more likely to also be in most disturbed condition. Turbidity, another indicator of suspended sediments, also showed a significant risk to the macroinvertebrate assemblages (risk = 2.9). We have observed this relationship between higher than reference suspended sediments and reduced PREDATOR condition throughout several other probabilistic studies.

Lack of canopy cover in the riparian and lack of large woody debris each had low percentages of stream miles in poor condition (Figure 1A), but posed among the highest risks to PREDATOR condition (Figure 1). Other significant stressors included excess nutrients (Total Phosphorus and Total Nitrogen), high chloride concentrations, and lack of fast water habitat.

The biological inferences of temperature and fine sediment (Temperature Stress and Fine Sediment Stress bars in Figure 1A) showed the highest risks associated with poor PREDATOR scores. If a site was considered most disturbed for Temperature Stress, the site was 4.5 times more likely to have lost a significant amount of common reference bugs (poor PREDATOR condition). Similarly, there was a 5.0 times greater chance of poor PREDATOR condition if the Fine Sediment Stress at a site was most disturbed.

Relationships with the biological stressor indices

There were 14 water quality and habitat stressors that showed significant risks to Temperature Stress or Fine Sediment Stress conditions (Figures 2A and 2B). Stressors related to ionic strength (conductivity, sulfate, chloride), suspended sediments (TSS, turbidity), instream habitat (habitat complexity, fast water habitat, large woody debris), and nutrients (total Nitrogen) were significant risks to both Stressor ID indices. Conductivity above levels observed at most reference sites posed the highest risk to both indices.

Stream temperature, dissolved oxygen, pH, and canopy cover all posed significant risks to biological measures of Temperature Stress (Figure 2A). Relative bed stability posed a significant risk to biological measures of Fine Sediment Stress (Figure 2B).

Conclusions

Temperature

Direct field measurements of temperature showed the majority of perennial, wadeable stream miles in the John Day and Lower Deschutes above water quality criteria (biologically based numeric criteria, designed to be protective of sensitive salmonids life history stages). However, the risk of violating the temperature standard to macroinvertebrate assemblages was small and not significant. Biological inferences of temperature also suggest a high extent of temperature stress; but unlike the direct measure of temperature, biological measures of temperature show a very high and significant risk.

The TMDL for the John Day Basin addresses violations of temperature, dissolved oxygen and bacteria standards. The WEMAP surveys of mostly publicly owned wadeable streams were predominantly in the upper parts of the basin. Even at the upper points of the basin a high extent of temperature criteria violations and a modest extent of dissolved oxygen violations were observed (Figure 1A). (No data was available for bacteria.) If data were collected throughout the basin it is highly likely the extent of violations would have been even greater. The results showed minimal risk of temperature standard violations to biological condition. Of the eight water quality and habitat stressors with significant risks, only one—canopy cover—can be considered a direct link to temperature. However, most if not all of these stressors can be linked to causes of high temperature. The other stressors with significant risks were related to nutrients, suspended sediments, and habitat availability.

A high and significant risk to biological condition (PREDATOR O/E) was observed with biological measures of temperature stress (Figure 1). Additionally, biological measures of temperature stress were extensive throughout the basin—over 40% of wadeable stream miles showed macroinvertebrate assemblages with higher temperature preferences than were observed for the majority of reference sites (Figure 1A). It is widely known that stream temperature is one of, if not the most, important environmental variables in shaping macroinvertebrate assemblage composition. While the direct measure of temperature is not as highly related to macroinvertebrate condition, it is clear that the Temperature Stress measured by the bugs is related to biological condition (PREDATOR). The exact reasons for the increased association among poor PREDATOR condition and poor Temperature Stress is unknown at this time, warranting further analysis. A hypothesis for this is that the probes used to assess actual water temperature may not be accurately characterizing all of the potential thermal habitats available to bugs in a stream reach. Probes are typically placed slightly above the stream bed, while the bugs are mostly associated within the stream sediments. It is possible that micro-thermal habitats are being more effectively measured by the bugs. Additionally, a single temperature probe was deployed at the bottom of the reach, while bugs were sampled throughout the reach. Again, this is an interesting result that should be looked into further.

Sediments

It appears as if sediment conditions play as important a role—or more—in affecting biological conditions in the John Day basin (at least in the upper parts of the watershed, and on public lands). TSS, turbidity, fast water habitat, and large woody debris can all be related to overall sediment conditions in streams, and each of these stressors posed a significant risk to biological condition (Figure 1B). Additionally, Fine Sediment Stress measured by the bugs was slightly higher than observed for Temperature Stress.

The list of nine significant stressors to both Stressor ID indices (common to both Figures 2A and 2B) provides an indication of the linkage between temperature and fine sediment and the overall biological condition of macroinvertebrate assemblages in the John Day basin. Ionic strength, suspended sediments, instream habitat, and nutrients at first glance do not appear to be directly related to temperature. However, a strong case can be made that all of these types of stressors can be managed more effectively with improvements in riparian condition to control erosion. Improvements in riparian condition should also result in improvements stream temperatures, especially in the smaller wadeable streams represented in this study.

Biological condition in the context of the John Day Basin TMDL

The John Day Basin temperature TMDL calls for reduced temperature through widespread improvements in riparian vegetation and channel morphology and instream flow. Based on this, both Fine Sediment Stress and Temperature Stress conditions in the basin should also improve. As the Stressor ID indices are both highly related to PREDATOR, this should result in improvements in overall biological condition throughout the basin.

References

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OAR 340-041-0011**.** "Waters of the State must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities." http://arcweb.sos.state.or.us/rules/OARs_300/OAR_340/340_041.html

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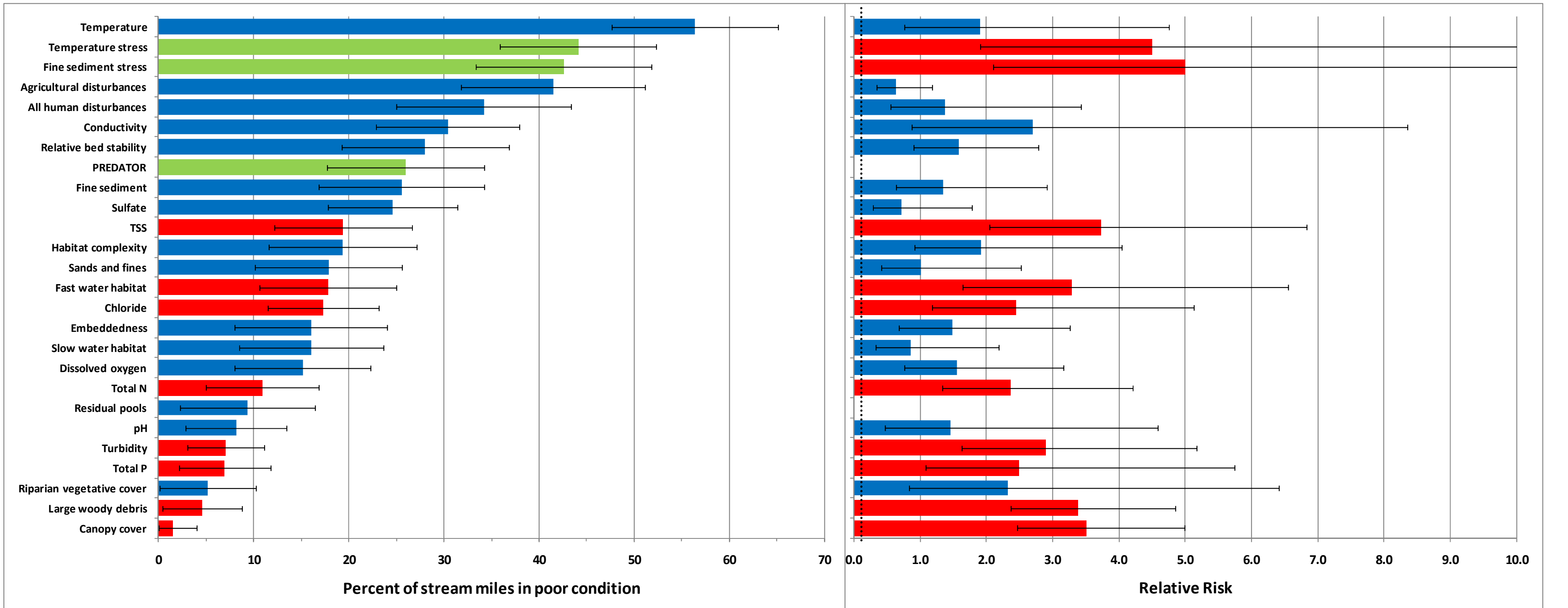

Figure 1A. The percent of stream miles in the John Day and Lower Deschutes basins in poor condition for various biological indices (green bars) and stressors. Streams were considered in poor condition (most disturbed) when the index or stressor values were beyond conditions observed at most reference sites. Red bars represent stressors that posed significant risks to biological condition measured by PREDATOR (see Fig. 1B). Error bars represent 95% confidence intervals.

Figure 1B. Relative risk, or likelihood of observing poor macroinvertebrate conditions (PREDATOR) in a stream when a given stressor or biological index is also in poor condition. Error bars represent 95% confidence intervals. Red bars represent stressors that posed significant risks to biological condition measured by PREDATOR. Lower confidence intervals above the dashed line (1.0) indicate a significant risk from a stressor to biological condition (red bars).

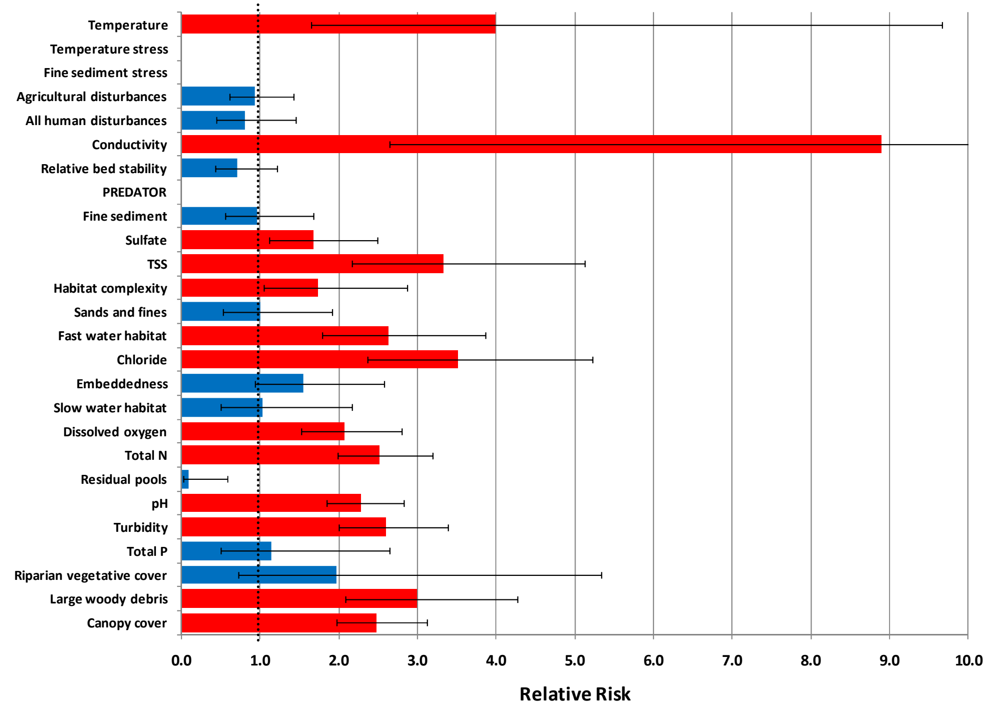

Figure 2A. Relative risk or likelihood of observing poor Temperature Stress conditions in a stream when a given stressor is also in poor condition. Error bars represent 95% confidence intervals. Red bars represent stressors that posed significant risks to Temperature Stress. Lower confidence intervals above the dashed line (1.0) indicate a significant risk from a stressor (red bars).

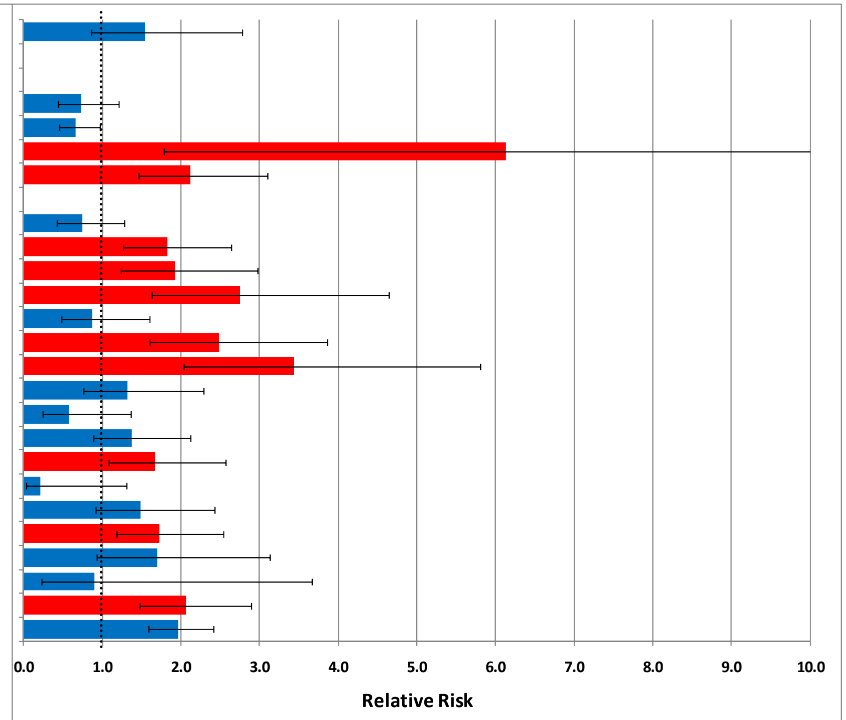

Figure 2B. Relative risk or likelihood of observing poor Fine Sediment Stress conditions in a stream when a given stressor is also in poor condition. Error bars represent 95% confidence intervals. Red bars represent stressors that posed significant risks to Fine Sediment Stress. Lower confidence intervals above the dashed line (1.0) indicate a significant risk from a stressor (red bars).