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Responses to Questions/Concerns Raised by Oregon Forest Industries Council Regarding the Protecting Cold Water Criterion of Oregon's Temperature Water Quality Standard

State of Oregon Department of Environmental Quality

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Reasons for a Protecting Cold Water Criterion:

- A natural thermal regime provides best conditions for fish & other native aquatic organisms;*
- There is ecological value in a diversity of temperatures, including streams colder than BBNC, in part because thermal diversity promotes aquatic biological productivity;*
- Prevent accumulation of heat in fish-bearing reaches;*
- Retain assimilative capacity to buffer climate variation & climate change.

*From Summary of 2003 Technical Advisory Committee findings

Responses to Forest Industry Questions/Concerns:

1. Paired watershed studies add to the body of science on the association of new harvest treatments on stream temperature & short-term fish response, but not in a way that shows a lack of need for the Protecting Cold Water Criterion.
    a. Hinkle & Alsea studies show increases in fish-bearing streams within the range of responses from RipStream.
    b. Biological inference of WRC studies is correlative, short-term, and at the sub-catchment scale in lower order tributaries, and primarily within the distribution of resident cutthroat trout.
    c. The purpose of the standard is maintenance and restoration of natural thermal regimes across the landscape for all aquatic species.
    d. Prevention of short-term, reach level effects to fish are a goal to the standard, but are not the primary purpose.
    e. Meeting the standard preserves the capacity of waterbodies to assimilate natural fluctuations in temperature due to year-to-year climate variations & to better maintain cold-water communities in a warming climate (Bisson *et al* 2003, Mote 2003, INR 2009, Ruesch *et al* 2012).

2. Thermal diversity across the landscape is biologically necessary. Small increases in stream temperature can have negative effects on fish populations, particularly when occurring across the landscape.
    a. Temperature 303(d) listings & TMDLs exist across Oregon.
    b. Heating of headwaters reduces the extent of downstream waters at optimal growth & physiological temperatures & increases the extent at high-risk & lethal temperatures for rearing & migration.
    c. Temperature effects typically occur on a continuum; increases from natural thermal potential increase risk to fish (McCullough 1999, US EPA 2001).
    d. The natural thermal regime (NTR) is dynamic & variable, promoting biological diversity & resilience among fish populations & other native aquatic organisms (e.g. Watters *et al* 2003, Olden & Naiman 2010).
        i. Landscape alteration & climate change alter the mean & ***the variance*** of these temperature components (Steel *et al* 2012).
        ii. Timing of fish life history attributes (adult migration, spawning, fry emergence, smolt migration) is partially mediated by the NTR (Vannote & Sweeney 1980).
        iii. Homing to natal streams & natural selective forces (including those imposed by NTR) result in distinct, ***locally adapted*** populations (Hillborn *et al* 2003).
    e. Thermal diversity promotes aquatic biological productivity.
        i. Fish use thermal diversity (temporally & spatially) so impacts to the "pattern" of temperature can be as significant as changes to the mean or maximum temperature (see DEQ 2003).
        ii. Fish detect & exploit thermal heterogeneity to avoid heat stress & to meet metabolic & reproductive requirements (Berman & Quinn 1991, Hodgson & Quinn 1991, Ebersole *et al* 2003, Torgersen *et al* 2012).
        iii. Variation in thermal regimes directly influences:
            1. Metabolic rates, physiology, & life-history traits of aquatic ectotherms (see Holtby *et al* 1989 for salmonid example);
            2. Rates of important ecological processes such as nutrient cycling & productivity;
            3. Indirectly mediates biotic interactions (references in Olden & Naiman 2010).
    f. Heat accumulation (& other homogenizing effects) can alter thermal heterogeneity before "average" main channel temperatures change (Poole & Berman 2001).
    g. Multiple stressors in the environment must be considered. By preventing or reducing temperature stress, we reduce the risks due to multiple stressors on fish populations (e.g. OCCCP bottlenecks; e.g. Laetz *et al* 2014, Ray *et al* 2014).
    h. When there is uncertainty, DEQ must make conservative choices to ensure protection of the resource.

3. Thermal loads do move downstream, heat loss mechanisms are much less efficient than heat gain by solar radiation, & dilution of thermal loads is not the same as dissipation, especially with multiple harvests.
    a. In open canopy streams, input of solar radiation typically composes about 50% – 90% of the total heat energy flux (Figures 1 & 2; see Johnson 2004, Benyahya *et al* 2012).
    b. A single source's temperature effects become hard to track downstream, but DEQ calculates thermal loads for TMDLs & permits.
    c. DEQ HeatSource modeling indicates long distances (>1000 meters) are required to lose thermal energy via evaporation & longwave radiation (when tributary & groundwater inputs are held constant).
        i. HeatSource modeling on 2 RipStream sites (5556 & 7854) shows persistent temperature increases a kilometer or more from the end of harvest units (Figures 3, 4, & 5); and
        ii. Harvest of an additional downstream unit on 5556 creates greater increase at confluence with Drift Creek (Figure 6).
    d. Cole & Newton (2013) showed that with uncut units interspersed with harvest units, stream reaches showed overall increases in temperature trends post-harvest for 3 of 4 study reaches.

4. The current disturbance regime is very different than the pre-settlement disturbance regime in both frequency & type of disturbance.
    a. Thermal recovery post-disturbance is 7-15 years, with 10 years as a reasonable mid-range value (Johnson & Jones 2000; D'Souza *et al* 2011; Rex *et al* 2012; RipStream data, *unpublished*).
    b. With a 40-year rotation (assuming steady yearly harvest rate), 25% of the private industrial forestland base would be in thermal recovery.
    c. Based on change in Landsat land cover from 1985-2009 (Figure 7), the average percentage of private forestland (65.1% of total land area) in the MidCoast basin in the 10-yr thermal recovery period is 17% for the time period 1994-2009.
        i. The total for all land uses combined is 10%.
        ii. Varies over time & space.
            1. In 2008, 39.9% of private forestland in the Middle Siletz River watershed was in thermal recovery.
            2. In 1996, 5.3% of private forestland in the Drift Creek watershed was in thermal recovery. [Maximum of 34.9% in 2008]
    d. Based on change in Landsat land cover from 1985-2009, the average percentage of private forestland riparian areas in the MidCoast basin (43.8% of total riparian area (within 100ft of streams)) in the 10-yr thermal recovery period is 14.1% for the time period 1994-2009.
        i. The average for private industrial forestland is 15.6% (36.2% of total riparian area) & for private nonindustrial forestland is 10.2% (7.6% of total riparian area).

ii. The percentage of recently+chronically disturbed riparian areas is 20.7% for private forestlands during the same time period (20.4% & 21.8% for industrial & nonindustrial, respectively).

iii. The average recent disturbance for riparian areas of all land uses collectively is 8.7%. The average chronic disturbance for riparian areas of all land uses collectively is 14.0%.

iv. Varies over time & space.

1. In 2008, 36.7% of private industrial forestland riparian area in the Middle Siletz River watershed was in thermal recovery (maximum). The minimum of 14.1% occurred in 1994 (Figures 8 & 9).
2. In 1996, 0.2% of private industrial forestland riparian area in the Drift Creek watershed was in thermal recovery (minimum). The maximum of 25.8% occurred in 2008 (Figures 10 & 11).
3. In 1999, 9.7% of private industrial forestland riparian area in the Lake Creek watershed was in thermal recovery (minimum). The maximum of 34.5% occurred in 2008 (Figures 12 & 13).

e. Agee (1990) estimates that historically (prior to Euro-American settlement) an average 0.24% and 0.67% of cedar/spruce/hemlock and western hemlock/Douglas-fir forests, respectively, burned annually.

i. Gives an average area in thermal recovery estimate of 2.4% for cedar/spruce/hemlock & 6.7% for western hemlock/Douglas-fir.

f. Wimberly (2002) estimates that a median of 17% of Oregon's coastal province would be in early successional condition (<30 years since fire of varying severity).

i. Using 10 years as above, Wimberly's estimate gives 5.7% of forestlands historically in thermal recovery.

g. High-severity fires leave more wood & live vegetation than clearcut harvest, and there are differences between unmanaged terrestrial & riparian early succession compared to clearcut harvest & replanting methods (Reeves *et al* 1995, Reeves *et al* 2006, Swanson *et al* 2011).

h. Fire return intervals in western Oregon range from 100-400 years. Shorter intervals typically are associated with less severity (Morrison & Swanson 1990).

i. Fire return for high severity fires is typically 200 years (Wimberly 2002), compared to harvest rotation of 40 years.

j. Periodic large scale disturbances create a mosaic of riparian & aquatic habitats (Bisson *et al* 2003). Pulses of sediment & large wood are delivered by post-fire erosion, in contrast to chronic inputs.

i. It is important to conserve & restore processes by managing for natural disturbances or like natural disturbances, not merely by creating structures or conditions.

k. Generally, riparian areas along streams higher in watersheds tend to burn along with upland forests, while riparian areas lower in watersheds are less likely to burn & more prone to flood disturbance (Reeves *et al* 2006, Pettit & Naiman 2007).

i. Fire can be less common in riparian areas due to higher moisture content & humidity.
ii. Some studies (e.g. Tollefson *et al* 2004, Olson & Agee 2005) have found no difference between upland & riparian fire frequency, particularly when riparian vegetation is similar to upland vegetation.
iii. Riparian areas often have higher fuel loads (higher productivity) & in prolonged drought can become more fire-prone.
iv. Riparian fires tend to be very patchy, primarily burning fine fuels. Conditions retard fuel drying & decrease severity. Extent & spread are complicated by ecosystem heterogeneity.
v. In very dry climatic conditions, riparian corridors can act as a route for fire to spread (wind tunnel effect). More often, riparian areas act as a natural fire break.
vi. Harvesting increases fuel loads & opens up the canopy, allowing faster drying of fuels.
vii. Riparian vegetation diversity & adaptations along with better access to water lead to faster recovery.

5. If taking a non-conservative approach to the effects of a single harvest, then we must address actual landscape conditions & the effects of multiple harvests.

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