TEMPERATURE: SIMPLE CONCEPTUAL MODEL NARRATIVE

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Water temperature is a key environmental variable for many aquatic biota, and many human-based activities can alter the temperature regimes of flowing waters. Most human activities alter stream temperature regimes through land cover alteration and subsequent changes in the delivery and distribution of heat from the ultimate source – solar radiation. These activities may influence water temperatures via five dominant pathways: (1) by increasing coldwater inputs; (2) by increasing warmwater inputs; (3) by increasing solar radiative heating (of the water and the streambed); (4) by decreasing the thermal buffering capacity of the system; and (5) by decreasing coldwater inputs. For example, impoundments may change the temperature of water released downstream, increasing warmwater inputs if releases are from warmer surface layers or increasing coldwater inputs if releases are from cooler deep-water layers. Some industrial activities generate thermal effluents, which also can increase warmwater inputs and significantly raise downstream temperatures.

Watershed land cover alteration (e.g., vegetation removal) can increase warmwater inputs by increasing in solar heating of the land and heated surface runoff from impervious surfaces. Riparian land cover alteration can increase solar heating of the water and stream bed via reductions in canopy cover. These land cover changes also can affect thermal buffering capacity. For example, groundwater inputs can help mediate temperature increases, as groundwater often is cooler than surface waters, especially in summer. If groundwater inputs are reduced (e.g., due to decreased groundwater recharge), coldwater inputs may decrease and this temperature-buffering capacity may be lost.

Changes in water temperature can be closely related to several other stressors. For example, DO saturation concentration decreases and dissolution of ionic compounds increases at warmer temperatures, so temperature increases can contribute to problems with these stressors. Increases in suspended sediments can increase temperature by increasing heat absorption, and reductions in baseflow (i.e., groundwater discharge) also can lead to water temperature increases. Alteration of water temperatures can affect aquatic organisms in several ways. Perhaps most obvious, water temperatures may exceed the upper and lower tolerance limits for specific taxa or life stages: decreases in minimum temperatures or increases in maximum temperatures may result in acute or chronic stress in organisms intolerant of these modified temperature conditions. Relatively rapid changes in temperature (e.g., increases in diurnal temperature range) also may be stressful for organisms that are not adapted to fluctuating conditions.

In addition to acute and chronic stress effects, changes in extreme temperature values may contribute to increases or decreases in average temperatures, and subsequent changes in the rate of total heat accumulation, a key developmental cue for many aquatic organisms. Water temperature can significantly affect a suite of physiological processes and behavioral characteristics in aquatic invertebrates and fishes, from metabolic rates to activity levels, each of which may contribute to temperature-based biological impairment.