State of Oregon Department of Environmental Quality

Draft: Shade Temperature Buffer Summary

Temperature Total Maximum Daily Load Replacements
Lower Columbia-Sandy Subbasin
April 5, 2023

Influences on Effective Shade

Effective shade is the percent of potential daily solar radiation flux that is blocked by vegetation and topography (Boyd and Kasper. 2007, McIntyre et al., 2018).

Physical and ecological factors affecting effective shade include, vegetation height, vegetation buffer width, vegetation density, topographic elevation, stream aspect, stream width, cloudiness, and latitude.

Vegetation and vegetation removal has strong relationship to shade and solar radiation loading. The response of shade to vegetation removal will depend on the interaction of vegetation height, density, and buffer width. Vegetation height has influence on shade because it affects shadow length (DeWalle 2010; DeWalle 2008, Cristea and Janish 2007, Li et al 2012). Vegetation density and vegetation buffer affects the attenuation of solar radiation through the canopy (DeWalle 2010; DeWalle 2008; Garner et al 2014; Groom et al 2011b; Groom et al 2018; McIntyre et al 2018; and Ehinger et al 2021). Allen and Dent (2001) found combinations of basal area, stand density (trees/acre), species composition, average stand diameter, and live crown ratios and the interaction between stand structure and aspect are important variables in predicting shade. Groom et al (2011b) found shade was best predicted by riparian basal area and tree height. Sites with higher stocking levels, wider uncut buffers, or fewer stream banks harvested had greater basal area and higher shade. Janisch et al 2012, McIntyre et al 2018, and Ehinger et al 2021 found that shade and canopy closure was reduced after harvest with post-harvest buffers ranging from 0 to 74 feet. Generally, effective shade is negatively correlated with riparian vegetation removal.

Srihdar et al 2004 conducted a sensitivity analysis altering factors that influence solar radiation on net heat fluxes and found that canopy density (measured through LAI) had the greatest effect on the study stream temperatures in Washington State. Solar radiation is almost completely attenuated by canopies with LAI between 7 and 10. Average tree height appeared to be the second most sensitive parameter followed by buffer width. Tree heights above 30 meters resulted in minimal change to the radiation penetration. Buffers widths greater than 30 meters only had minimal effect on stream temperature.

Gomi et al 2006 found 30-meter buffers minimized harvest effects. 10-meter buffers on north south oriented streams were found to be effective because they were shaded from late morning to

early afternoon by the overhead canopy, although the authors provided a caveat that anomalous warming occurred both preharvest and postharvest during low-flow periods, confounding interpretation.

Li et al 2012 found that tree height, canopy overhang from the bank, channel width, and latitude for east to west streams all had strong effects on the daily time series of shade. Latitude did not have a strong influence on shade for north south streams. Latitude determines the sun's altitude which has a direct impact on the amount of direct solar radiation (Dewalle, 2010; DeWalle, 2008). Maximum altitudes occur at solar noon and have higher altitudes at latitudes closest to the equator (NOAA 2002, Meeus 1998).

On streams with little or no vegetation, overcast days exert a first order control on net energy flux (Garner et al 2014, Rutherford et al 2004).

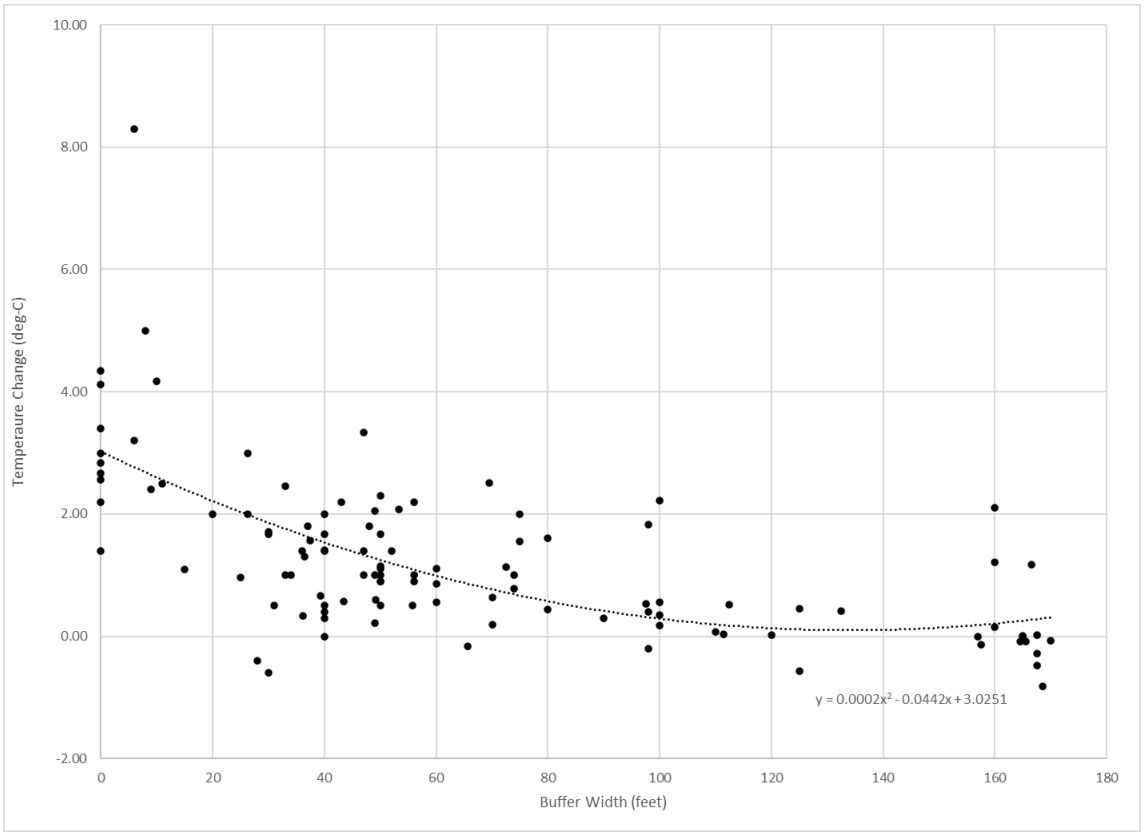
Height and density of plants varies by vegetation species and thus influence shading potential (Allen and Dent 2001; Brown and Brazier, 1972, Steinblums et al 1984).

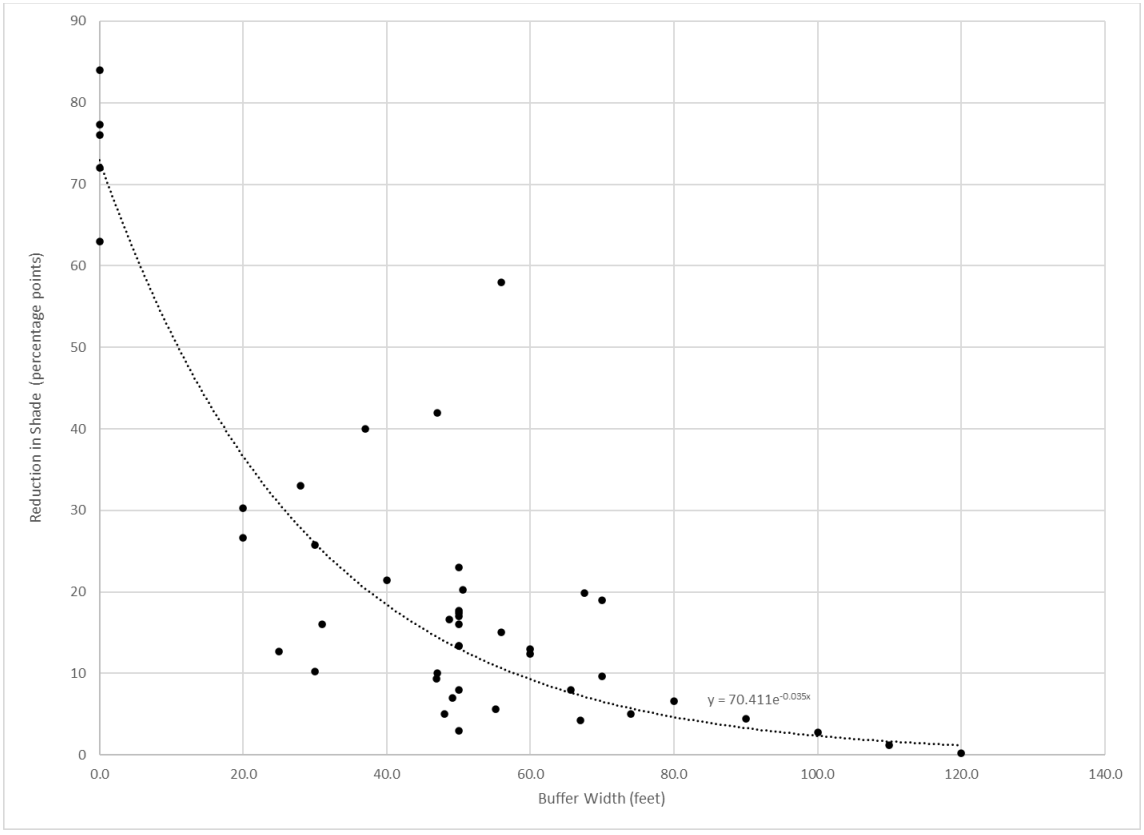
Shade Influences on Temperature

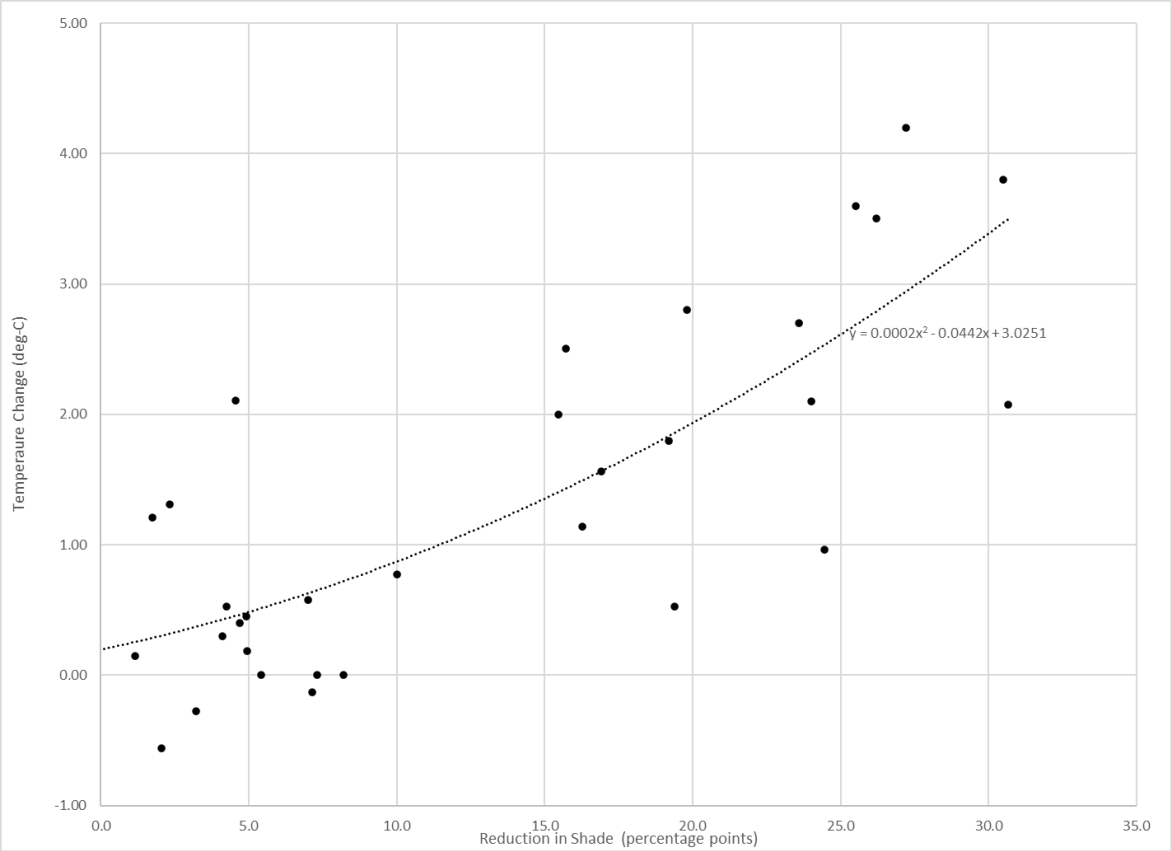
Summary of articles TBA

ODF (Cowan et al 2019) and EPA (Leinenback 2013) extracted the temperature response to different riparian buffer width treatments from published articles and reports. DEQ contacted these authors to obtain the summary data and added additional published results including Groom et al (2018), McIntyre et al. (2018), and Ehinger et al (2021). DEQ also developed a summary of temperature response directly from changes in effective shade.

Summary about number of studies, different metrics, and results (see plots) TBA


10.00
8.00
6.00
4.00
2.00
0.00
-2.00
Temperaure Change (deg-C)
0
20
40
60
80
100
120
140
160
180
Buffer Width (feet)
y = 0.0002x² - 0.0442x + 3.0251


90
80
70
60
50
40
30
20
10
0
Reduction in Shade (percentage points)
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
Buffer Width (feet)
y = 70.411e^-0.035x



Measuring Effective Shade

The effective shade measurement methods and quality control procedures for use of a solar pathfinder instrument are outlined in the Water Quality Monitoring Technical Guide Book (OWEB, 1999) and the solar pathfinder manual (Solar Pathfinder, 2016).

Methods for use of hemispherical imagery and analysis software are described in Ringwald et al 2003, WADOE 2019a, and WADOE 2019b.

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