Hydrol. Earth Syst. Sci. Discuss., 10, C4500–C4505, 2013
www.hydrol-earth-syst-sci-discuss.net/10/C4500/2013/

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Riparian forest as a management tool for moderating future thermal conditions of lowland temperate streams" *by* P. B. Kristensen et al.

Anonymous Referee #2

Received and published: 27 August 2013

GENERAL ASSESSMENT

This ms addresses the effect of riparian forest cover on stream thermal dynamics by studying longitudinal temperature patterns along five stream segments, each comprising two reaches: an upper reach lacking riparian forest, and a lower reach with riparian forest cover. The topic addressed by the ms is of broad interest to the readership of HESS. However, when viewed in the context of the existing literature, and considering fundamental limitations in the methodology employed in this study, I do not see that its contribution is sufficiently original and significant to warrant publication in a top-tier international journal like HESS. More detailed comments are provided below.

SPECIFIC COMMENTS

1. The influence of riparian forest on stream thermal dynamics is of great interest in the context of aquatic habitat, and has received a great detail more attention in the literature than indicated by the limited review offered by Kristensen et al., particularly in the form of rigorous experiments using a before-after/control-impact design (see review by Moore et al., 2005, and more recent studies by Gomi et al., 2006; Wilkerson et al., 2006; Gravelle and Link, 2007; Groom et al., 2011; Janisch et al. 2012; Rex et al., 2012; Newton and Cole, 2013). These studies consistently demonstrated that a reduction of stream shading results in an increase in stream temperature during summer. Furthermore, it has been well established that the main cause of this warming is an increase in solar radiation associated with the loss of shade (e.g., Johnson, 2004). Therefore, the conclusion that forest cover had a significant influence on stream temperature is not novel.

2. The longitudinal changes in temperature that occur when water flows from an unshaded environment into a reach shaded by riparian forest have also been documented by a number of studies (e.g., Greene, 1950; Brown et al. 1971; McGurk, 1989; Caldwell et al., 1991; Storey and Cowley, 1997; Keith et al. 1998; Zwieniecki and Newton, 1999; Story et al., 2003; Johnson, 2004). These studies revealed a broad range of behaviors that cannot be explained in the absence of knowledge about the specific energy and water exchanges in the shaded reach. Therefore, the finding that the shaded reaches of the five study streams exhibited a range of thermal patterns is not novel.

3. Two broad approaches are typically used to gain insight into the processes or factors that control a phenomenon of interest: a statistical approach based on variability across a landscape, and a deterministic approach involving field measurements to quantify the underlying processes. In this study, the authors have employed a landscape-scale approach, and found that three predictor variables were correlated with the observed thermal patterns: canopy cover, width:depth ratio and the water temperature at the upstream end of the forested reach. Unfortunately, the small sample size (n = 5) does

not permit a more detailed analysis to understand whether these correlations reflect true cause-and-effect relations or simply reflect a confounding due to multi-collinearity. For example, it may be that canopy cover and upstream temperature independently influence longitudinal temperature changes (as one might infer from an understanding of the underlying energy exchange processes) but that the correlation with width:depth ratio is spurious. The authors have performed a stepwise multiple regression analysis to try to identify which of the candidate predictor variables are most important. However, the results are unlikely to be robust, considering that the initial number of predictor variables is the same as the sample size. A common guideline is that the sample size should be at least ten times the number of predictor variables in a regression model.

4. A more rigorous approach to understanding thermal patterns in time and space is to quantify the energy and water budgets of the stream reaches. Hannah et al. (2008) compared surface energy exchanges between open and forest reaches, and at least three studies have applied this approach for shaded reaches below open areas (Brown et al., 1971; Story et al., 2003; Johnson, 2004). If the authors had adopted this approach here, then the comparison of results among the five reaches would have provided significant new knowledge and would have merited publication in HESS. A process-based approach would also provide a basis for making inferences regarding thermal dynamics in a changing climate. See next comment.

5. The authors aim to use their results to judge the importance of forest cover as a tool for climate change adaptation. However, thermal patterns observed under current climatic conditions, particularly contrasts between open and shaded reaches, will likely not be valid under an altered climate. A process-based modeling approach is required to make inferences about future thermal dynamics (e.g., Gooseff et al., 2005).

6. The authors provide a number of statistical comparisons of temperatures between upstream and downstream locations. It is not clear from the description of the analysis, but I presume that the authors are treating each day in the study period as an independent replicate in the statistical test. However, daily stream temperature data are

typically highly autocorrelated, which violates an important assumption that underlies standard statistical approaches like Student's t. Approaches that can explicitly account for the temporal autocorrelation are appropriate in such cases (e.g., Groom et al., 2011; Janisch et al., 2012; Newton and Cole, 2013).

REFERENCES

Brown, G.W., G.W. Swank, and J. Rothacher, 1971. Water Temperature in the Steamboat Drainage. Pacific Northwest Forest and Range Experimental Station Research Paper PNW-119, US Department of Agriculture, Forest Service, Portland, Oregon.

Caldwell, J.E., K. Doughty, and K. Sullivan, 1991. Evaluation of Downstream Temperature Effects of Type 4/5 Waters. T/F/W Report No. WQ5-91-004, T/F/W CMER Water Quality Steering Committee and Washington Department of Natural Resources, Olympia, Washington.

Gomi T, Moore RD, Dhakal AS. 2006. Headwater stream temperature response to clear-cut harvesting with different riparian treatments, coastal British Columbia. Water Resources Research 42, Art. No. W08437.

Gooseff, MN, K Strzepek, and SC Chapra. 2005. Potential effect of climate change on water temperature downstream of a reservoir: Lower Madison River, Montana. Climatic Change, 68(3): 331-353.

Greene, G.E., 1950. Land use and trout streams. Journal of Soil Water Conservations 5:125-126.

Groom J.D., Dent L., Madsen L.J. 2011. Stream temperature change detection for state and private forests in the Oregon Coast Range. Water Resources Research 47, W01501, doi:10.1029/2009WR009061.

Gravelle JA, Link TE. 2007. Influence of timber harvesting on water temperatures in a northern Idaho watershed. Forest Science 53: 189-205.

Hannah, D.M., Malcolm, I.A., Soulsby, C., Youngson, A.F., 2008. A comparison of forest and moorland stream microclimate, heat exchanges and thermal dynamics. Hydrol. Process. 22, 919–940.

Janisch J, Wondzell SM, Ehinger WJ. 2012. Headwater stream temperature: Interpreting response after logging, with and without riparian buffers, Washington, USA. Forest Ecology and Management doi.org/10.1016/j.foreco.2011.12.035.

Johnson, S.L., 2004. Factors influencing stream temperatures in small streams: substrate effects and a shading experiment. Canadian Journal of Fisheries and Aquatic Sciences 61:913-923

Keith, R.M., T.C. Bjornn, W.R. Meehan, N.J. Hetrick, and M.A. Brusven, 1998. Response of Juvenile Salmonids to Riparian and Instream Cover modifications in small streams flowing through second-growth forests of southeast Alaska. Transactions of the American Fisheries Society 127:889-907.

McGurk, B.J., 1989. Predicting stream temperature after riparian vegetation removal. In: Proceedings of the California Riparian Systems Conference. USDA Forest Service General Technical Report PSW-110, Davis, California, pp. 157-164.

Moore, R.D., Spittlehouse, D. and Story, A. 2005. Riparian microclimate and stream temperature response to forest harvesting: a review. Journal of the American Water Resources Association 41:813-834.

Newton, M. and Cole, L. 2013. Stream temperature and streamside cover 14-17 years after clearcutting along small forested streams, western Oregon. Western Journal of Applied Forestry 28: 107-115.

Rex, J.F., Maloney, D.A., Krauskopf, P.N., Beaudry, P.G., Beaudry, L.J. 2012. Variable-retention riparian harvesting effects on riparian air and water temperature of sub-boreal headwater streams in British Columbia. Forest Ecology and Management 269, 259–270.

Storey, R.G. and D.R. Cowley, 1997. Recovery of three New Zealand rural streams as they pass through native forest remnants. Hydrobiologia 353:63-76.

Story, A.C., Moore, R.D. and Macdonald, J.S. 2003. Stream temperatures in two shaded reaches below cut blocks and logging roads: downstream cooling linked to subsurface hydrology. Canadian Journal of Forest Research 33:1383-1396.

Wilkerson, E., J.M. Hagan, D. Seigel, and A.A. Whitman. 2006. The effectiveness of different buffer widths for protecting headwater stream temperature in Maine. Forest Science 52: 221-231.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 6081, 2013.