Riparian Buffers Affect Stream Temperature (RBAST)

An EREN **LIGHTNING** Project

Experimental Plan

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1. Background

As global warming increases air temperatures during the coming decades, we can expect stream temperatures to increase as well (Kaushal et al. 2010). Other human activities also have led to increased stream temperatures in some locations, including logging and agriculture. Consequently watershed managers will be looking for ways to manage stream temperature. One potentially effective solution that is widely recommended is restoration of riparian vegetation that provides shade to the stream. Although widely recommended, evidence for effectiveness of riparian shade is sparse and sometimes contradictory. Furthermore, the amount of cooling that can be achieved by shaded riparian zones is not well known.

The temperature regime of a stream is complex and spans a wide range of scales both spatially and temporally. The scale determines the type of impact temperature can have on biota. For example, fine-scale fluctuations (e.g., diurnal) have immediate effects on biochemical processes like photosynthesis. Moderate scale temperature variability as measured by daily mean temperatures can dictate what species are present or cause chronic stress. Seasonal and annual temperature variations can be summarized by mean annual temperature or growing season length and affect ecosystem-scale processes like NPP.

Stream temperature is governed by the stream's energy budget. Every component of the energy budget has the potential to influence stream temperature. These components include: incident solar radiation, air temperature, groundwater temperature, channel width:depth ratio, upstream water temperature, flow rate, vegetative cover, and substrate absorptivity (among others). There are several computer models available that simulate the energy budget of a stream.

2. Overview & Significance

In this project we will compare the change in stream temperature (ΔT) along forested stream reaches with the ΔT of paired stream reaches that have no canopy cover. Using continuously-recording data loggers allows us to document both fine scale temperature fluctuations (diurnal) as well as larger scale temperature variations (interseasonal an interannual). This project is unique in that:

- It includes multiple sites with a range of latitudes, topography, vegetation, stream orders and widths (most studies include a single site). This variability will test the strength of the riparian zone effect relative to the other spatially-variable factors;

- It will (eventually) cover multiple years of continuous temperature readings (most studies use intermittent (weekly or monthly) readings and shorter time periods (weeks to months);
- Because of the wide geographic range of sites, the results should be applicable to most 1st to 3rd order streams with similar cover.

3. Objectives

The primary objective is to quantify the extent and nature of change in stream temperature regime caused by the presence of vegetated riparian zones (with respect to streams with no riparian vegetation). Secondary objectives are to 1) identify the components of the energy budget that have the greatest influence on stream temperature over a wide geographic range, 2) determine the best methods for managing stream temperatures, 3) examine the implications of harmful temperature regimes on biota, and 4) establish a dataset of baseline stream temperatures at each of the study sites.

4. Writing the Manuscript

A Writing Team will be assembled in June 2011 to begin work on the manuscript. The Team will communicate by email and by quarterly conference calls (or face-to-face meetings). Authorship policies will be developed by the Writing Team and will be added to this document as an Appendix.

Date	Tasks
Jun – Sept 2011	Establish Team membership/requirements, assign tasks, literature review, generate outline, Methods section draft, (data collection is occurring during this time)
Oct – Dec 2011	Data analysis, Intro section draft, target journal selected
Jan – Mar 2012	Complete draft circulated among Team and revised;
Apr 2012	Friendly reviews, final revisions
May 2012	Submit manuscript to journal

5. Experimental Design and Timeline

The experiment will compare a Forested stream reach (full canopy cover, 80 – 200 m in length) with a nearby or adjacent stream reach (80 – 200 m in length) with no tree or shrub canopy cover (Open) at several different sites around the U.S. Thus, it is a paired design with replication among sites. The main dependent variable will be the mean change in temperature (ΔT) over the length of the reach. By using the ΔT we avoid the problem of climate differences among sites and by using short reaches with few inputs we minimize the effect of land-use at the large scale. Other dependent variables (that will be calculated from the raw temperature data at each location) will be daily mean temperature, daily maximum temperature, daily minimum temperature, mean daily range, degree days per year, mean net heat load per meter.

For this study data will be collected from 1 June 2011 to 30 September 2011 (4 months).

There will be two types of sites – low-intensity and high-intensity. At several low-intensity sites stream temperature will be monitored at 3 or 4 locations per site with temperature dataloggers. A few other infrequent or one-time measurements will be required. Two to three high-intensity sites will measure the same parameters plus additional climatic and hydrologic parameters to supply input to a stream temperature model and will be used to calibrate the model. The model can then be applied to all of the sites including the low-intensity sites.

A. Low-Intensity Sites
   1. Stream water temperature will be measured every 15 minutes at the upper and lower ends of each reach using dataloggers
   2. Supplemental Periodic Measurements (2 to 4 measurements during 4-month project): average shade, maximum daily air temperature, tributary temperature
   3. One-time Measurements: length of each stream reach, location and size of any known tributaries (including groundwater), latitude, longitude and elevation at each datalogger location, description of vegetation in riparian zone (dominant species, average height), percent canopy cover.

B. High-Intensity Sites
   1. All three of the measurements described above plus the following:
   2. Discharge (at least 5 dates with a range of flows; include all tributaries) and average width and average depth of study reaches (2 times, low flow and high flow)
   3. Daily PAR or PAR every 1 min (datalogger required);
   4. Air Temperature (continuously) at 0.5 m along stream bank (every 15 min.; datalogger required)
   5. Mean annual air temperature (from datalogger or nearby weather station)
   6. Daily average wind speed at stream reach (in forest and open site or nearby weather station)
   7. Daily average humidity at each stream reach (in forest and open site or nearby weather station)

6. Expected Outcomes

a. Significantly greater daily mean range and daily max temperatures in open reaches compared to forested reaches.
b. Differences among sites can be attributed to specific site factors (e.g., latitude, stream width, canopy cover, etc.)
c. Computer model shows that variables X and Y are the most important contributors to the observed differences in stream temperature regime in open reaches. Likely candidates are solar radiation and air temperature.