Monitoring Series No. 8

California Rangelands Research and Information Center

Monitoring Stream Temperature

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Why is monitoring stream temperature important?

Rangeland streams have many beneficial uses including habitat for a diversity of plant and wildlife species. Cold water fisheries (trout and salmon habitat) are often considered the most sensitive and easily impaired of these uses.

Salmonids, such as trout and salmon, are cold-blooded animals whose body temperature and associated biological processes are regulated by water temperature. As temperature increases, so does a fish's metabolic rate. Although cold water fish species can adapt to certain situations, eventually, increasing water temperature becomes stressful by pushing the metabolic rate too high, increasing susceptibility to disease, and reducing available oxygen. Trout and salmon are particularly sensitive to temperature when spawning. A summary of fish habitat requirements can be found in Rangeland Watershed Program Fact Sheets 26 - 29, written by Royce Larsen, November 1994.

Widened streams, unstable streambanks, and lack of vegetation or late seral vegetation are often considered limiting factors to cold water fish habitat and the causes of increased stream temperature. Livestock are often blamed for impacts on streambank stability and vegetation and therefore as contributors to increased stream temperature.

Stream temperature fluctuates considerably with the season, volume of flow, and time of day. As a result, constant recording of data over several seasons is necessary to fully understand the temperature dynamics of a given stream.

Factors Affecting Stream Temperature

The heating of a stream is governed by two primary radiation sources: the sun and the ambient radiation emitted by the atmosphere and the earth. Radiation reaching the water's surface is comprised of solar radiation (direct, diffuse, and scattered) and ambient radiation. Direct sunlight accounts for about 20% of this total radiation. As a result, shaded areas can still receive up to 80% of the total radiation which adds heat to streams (Larson and Larson, 1996).

Specific heat of water allows it to absorb significant amounts of energy before its temperature will increase. Similarly, a warm stream must release significant amounts of energy before cooling can take place. Streams warm up during the day as they receive energy from warm air and sunlight. At night, as air temperatures drop below that of the water, stream temperature will begin to drop. The minimum temperature that water can be cooled will be the lowest temperature in the local environment, i.e., air temperature or streambank temperature. This means that it will be difficult to cool a stream in a warm environment.

Many factors interact to influence stream temperature at a given time. Among them are:

1. **Ambient air temperature.** Energy is transferred between water and air at the stream's surface. As air temperature rises, so does the amount of energy transferred to the stream. Conversely, at night when air temperature drops below that of the stream, energy is transferred from the stream to the atmosphere and stream temperature drops.
2. **Temperature of ground water inflow.** Springs and seeps often provide a substantial amount of the base flow to small streams. The temperature of groundwater typically remains relatively constant throughout the year and may cool or warm a given reach of stream.
3. **Solar radiation.** This refers to the direct input of energy from the sun. Solar radiation is highest in summer when day length is longest and the sun is most directly overhead.
4. **Elevational gradient or flow velocity.** The faster water moves down stream from its original source (snowmelt, springs, etc.) the less time it has to absorb heat from surrounding sources. Thus, steep, fast moving streams have a lower potential to warm than do flat, meandering, meadow type streams.
5. **Volume of flow.** The greater the amount of water in a stream, the more energy input required to raise the temperature. Volume of flow varies seasonally, annually due to precipitation, snowmelt patterns, and human factors.
6. **Shading vegetation.** About 20% of the total radiant energy received by the earth's surface comes in the form of direct solar radiation (Larson & Larson, 1996). Shade over the stream channel can intercept this radiation and reduce warming.
7. **Stream channel width to depth ratio.** Wide, shallow streams are exposed to more radiation than narrow, deep ones, making them more likely to increase in temperature on hot sunny days.

How can grazing impact stream temperature?

Of the seven factors listed above (1-**7**) that influence stream temperature, livestock can directly influence two: **shading vegetation** and **channel width to depth ratio**.

Streambank stability and stream width to depth ratio is influenced by riparian vegetation. Excessive use by livestock can reduce streambank stability by reducing the vigor of streambank plants and/or shearing the banks by trampling. Unstable streambanks exposed to high water flows often result in a widened stream channel. These wide stream channels have more water surface area exposed to direct sunlight and other forms of radiation, thus potentially increasing the water temperature.

Trees, shrubs, sedges, and grasses growing along streambanks provide shade to the stream channel. Livestock grazing can reduce woody riparian vegetation, grasses, and sedges through over utilization, especially in certain times of the year. Range managers have observed that during late summer and fall livestock tend to browse woody shrubs and trees such as willow and aspen. Heavy browsing of these plants at this time may reduce their size and density and subsequently stream shade. In some cases, livestock rubbing and trampling may also reduce shading vegetation exposing water to more direct sunlight.

Grazing management strategies that allow expression of the vegetative potential for any given stream reach are desirable. Yet the impact of grazing management on stream temperature may be over-shadowed by other factors (**1-5** above) which are beyond our control. The amount of impact that riparian vegetation or any one of the factors will have on stream temperature can vary considerably from stream to stream and from year to year.

When to Monitor?

The critical time of year is generally mid to late summer when air temperatures are hottest and streams reach their lowest base flows. Often a June to September monitoring season is adequate to characterize the warmest water temperatures for a given year.

Four years of data in Modoc County have shown that during the summer diurnal (daily) stream temperature variation can be as great as 20º F. Sequential temperature readings every 30 minutes throughout the day are adequate to capture high and low daily temperatures (Figure 1).

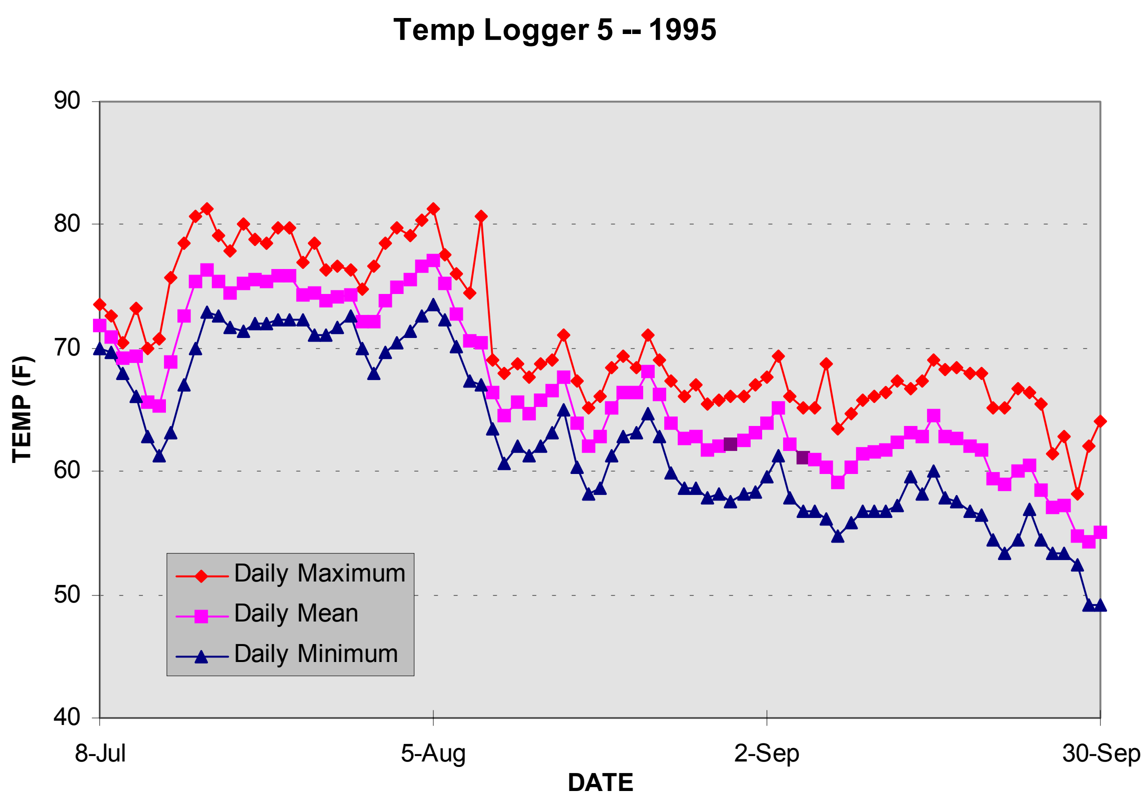

Figure 1.

What do you need to Monitor Stream Temperature?

The simplest device to accurately measure temperature is a hand-held ASTM (American Society of Testing Materials) quality thermometer. Simply dip the thermometer in the water until a stable reading is achieved.

For sequential readings over time, a data logger is needed. Hobo® and StowAway® data loggers from Onset Computer Corporation[1] are probably the most common data loggers used today. In addition to the temperature loggers, you will need submersible cases, a computer cord, and computer software to start taking readings and subsequently download data. You will also need some type of weight to hold the temperature recorder in place in the stream.

What is Your Monitoring Objective?

The relative simplicity and low cost of these loggers has generated a lot of stream temperature monitoring activity. However, it must be kept in mind that without a clear monitoring objective and plan the data has very limited value

Often we are trying to determine land use effects on stream temperature and whether a particular stream reach or tributary is increasing or maintaining the temperature of the water. If this is the case, plan your stream monitoring program accordingly. Place temperature loggers where you can determine the effects of any tributaries or known springs or irrigation diversions which may occur.

When placing a temperature logger in a stream, find a representative segment of the stream. Place the sensor out of sight near a rock, cutbank, or log. Remember that flows may change as the season progresses. Don't place the temperature logger where it will be left high and dry later in the summer. Record the exact location where you placed the temperature logger so you can retrieve it easily in the fall.

Literature Citations

Larson, L.L., and S.L. Larson. 1996. Riparian Shade and Stream Temperature: A Perspective. Rangelands, 18(4):149-152.

[1] Hobo® and StowAway® are registered trademark products of Onset Corporation. Other temperature data loggers are available. We are not endorsing this product or discriminating against any other similar product.