The Thermal Characteristics of Hydrologically Intact Type C and E Streams in Eastern Oregon

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Introduction

Many streams in eastern Oregon are listed as water-quality impaired on the basis of water temperature. Stream heating and cooling is commonly driven by exchanges of heat energy between the stream and its environment. We measured air and water temperature and stream characteristics on three Rosgen type C and E channel streams to determine whether stream type can help predict stream thermal characteristics. Type C and E streams typically are located in broad, alluvial meadows that are commonly used in agriculture. The main difference between the stream types is that type C streams have greater width-to-depth ratios than type E streams. Larger width-to-depth ratios indicate that type C streams are wider than type E streams for the same channel depth. Type C streams tend to have triangular-shaped cross-sectional profiles, as one side of the channel cuts into its bank and forms deeper water. The opposite side of the channel becomes shallow as it collects sediment. Type E streams usually have a square cross-sectional profile, as the channel is well confined by dense sedge establishment. All six streams were hydrologically intact, assessed as Proper Functioning Condition (PFC), and were located in eastern and south-central Oregon (Table 1).

Experimental Protocol

Water and air temperatures and stream geomorphic data were gathered during the summer months of 1998 and 1999. Average daily maximum and minimum water temperature and average daily maximum and minimum rates of change in water temperature were calculated following normalization of data with estimated water residence time. Water temperatures were taken at cross-sections one (beginning of measured stream) and three (end of measured stream).

Results and Discussion

More variation was detected within stream type rather than between stream types, which precluded separation of stream types C and E groups based on thermal characteristics (Table 2). Most streams, regardless of type and year, exhibited similar daily mean nighttime recoveries of approximately 0.95°F/hour cooling in the downstream direction, following normalization by water residence time. Water residence time was the calculated amount of time in hours that water would flow from the beginning to the end of the study reach. All of the streams heated at least 2.0°F/hour during the day, with some streams gaining 4.0°F/hour in the downstream direction, following normalization by water residence time. Thermal variation among the streams was likely a result of the daily initial water temperature, the gradient between stream and thermal environment, and the varied physical character of each stream within type. Atmospheric temperature is the single most critical factor for characterizing stream temperature behavior during the periods of heating and cooling.

Management Implications

Predicting the thermal character of a stream based on its Rosgen type may be difficult, considering the varied physical and thermal characteristics that streams of the same type express. Eastern Oregon streams should be managed under an adaptable and flexible plan that accounts for the individual thermal character of streams. Monitoring stream and atmospheric temperature is crucial for successful management practices. Management practices that encourage conservation of streamside vegetation and watershed function should provide desirable stream channel characteristics and flow regimes essential for high water quality.

Table 1. Rosgen stream description for each stream used in study[1] in eastern and south-central Oregon.

Year	Stream	*Minimum*			*Maximum*		
		Water T (°F)[1]	*Water T-residence (°F/hour)[2]*	*Air temp (°F)[3]*	*Water T (°F)[1]*	*Water T-residence (°F/Hour)[2]*	*Air temp (°F)[3]*
1998	C1	57	-1.5	39	72	2.5	93
	C2	52	-0.8	40	64	4.1	87
	C3	65	-0.9	45	76	2.2	94
	E1	58	-0.7	52	70	2.1	92
	E2	52	-0.9	40	65	3.8	86
	E3	48	-1.1	44	69	3.8	90
1999	C1	56	-1.0	36	71	3.0	90
	C2	50	-0.8	38	62	3.9	88
	C3	64	-1.0	45	76	2.0	86
	E1	56	-0.8	48	68	2.3	91
	E2	50	-0.9	38	64	4.2	85
	E3	56	-1.1	42	68	4.5	85

[1] All measurements taken at bankfull following procedures listed in Rosgen, D. (1996). Applied river morphology. Wildland Hydrology, Pagosa Springs, Colo.

Table 2. Average daily maximum and minimum water temperature at cross-section three, change in water temperature normalized by residence time, and air temperature for 39 days in 1998 (July, August, and September) and 22 days in 1999 (July and August).

Year	Stream	*Minimum*			*Maximum*		
		Water T (°F)[1]	*Water T-residence (°F/hour)[2]*	*Air temp (°F)[3]*	*Water T (°F)[1]*	*Water T-residence (°F/Hour)[2]*	*Air temp (°F)[3]*
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[1] The average maximum and minimum water temperature at cross-section three.
[2] The average change in water temperature cross-section one to three normalized by residence time (°F/hour).
[3] Average stream air temperature.