SECTION D
RIPARIAN FUNCTION

INTRODUCTION

Mendocino Redwood Company conducted an assessment of riparian function in the Elk Creek Watershed Analysis Unit (WAU) during the summer of 2005. This assessment is divided into two groups: 1) the potential of the riparian stand to recruit large woody debris (LWD) to the stream channel and 2) a shade and stream temperature assessment. The LWD potential assessment evaluates short-term (the next two to three decades) LWD recruitment. Field observations of current LWD levels in the stream channels and the riparian stand's ability to recruit LWD are presented in relation to channel sensitivity to LWD in order to determine current in-stream needs. The shade and stream temperature assessment presents current shade conditions and how these are related to the ongoing stream temperature monitoring. The goal of these evaluations is to provide baseline information on the current LWD loading in the channel and current status of riparian stand function in the Elk Creek WAU, which includes the Upper and Lower Elk Creek Calwater planning watersheds.

LARGE WOODY DEBRIS RECRUITMENT AND IN-STREAM DEMANDS

METHODS

Short-term LWD recruitment potential (next 20-30 years) was evaluated in designated stream segments within the Elk Creek WAU. Stream segments were designated in the stream channel condition assessment and are shown on map E-1 (Stream Channel Condition Module). Generally, stream segments were designated on any watercourse with less than a 20 percent gradient. In this assessment, vegetation type, size and density is assumed to influence LWD recruitment with the best riparian vegetation being large conifer trees.

To determine the LWD recruitment potential, riparian stands were classified using year 2004 aerial photographs and field observations from the summer of 2005. The riparian stands were evaluated for a distance of approximately one tree height on either side of the watercourse. Riparian stands were evaluated separately for each side of the watercourse. The following vegetation classification scheme for the Mendocino Redwood Company (MRC) timber inventory was used to classify the riparian stands:

Vegetation Species Classes

RW	Greater than 75% of the stand basal area in coast redwood
RD	Combination of Douglas-fir and coast redwood basal area exceeds 75% of the stand, but neither species alone has 75% of the basal area.
MH	Mix of hardwood basal area exceeds 75% of the stand, but no one hardwood species has 75% of the basal area.
CH	Mix of conifer and hardwood basal area exceeds 75% of the stand, but no one hardwood or conifer species has 75% of the basal area.
Br	Brush

Vegetation Size Classes

1	Less than eight inches dbh (diameter at breast height)
2	Eight to 15.9 inches dbh
3	16 to 23.9 inches dbh
4	24 to 31.9 inches dbh
5	Greater than 32 inches dbh

The size class is determined by looking at the diameters of the trees in the riparian stand. The size class which exceeds 50% of the total basal area is the size class assigned to the stand.

Vegetation Density

O	5-20% tree canopy cover range
L	20-40% tree canopy cover range
M	40-60% tree canopy cover range
D	60-80% tree canopy cover range
E	>80% tree canopy cover

The codes for vegetation classification of riparian stand condition are based on the three classes listed above. The vegetation code is a string of the classes with the vegetation class first, the size class second, and the vegetation density last. For example, the vegetation code for a redwood stand with greater than 50% of the basal area with 16-23.9 inch dbh or larger and 60-80% canopy cover would be classified RW3D.

In this assessment, vegetation type, size and density is assumed to affect LWD recruitment to the stream channel with the best riparian vegetation being large conifer trees. The LWD recruitment potential ratings reflect this. The following table presents the vegetation classification codes for the different LWD recruitment potential ratings (Table D-1)

Table D-1. Description of LWD Recruitment Potential Rating by Riparian Stand Classification for the Elk Creek WAU.

Vegetation Type	**Size and Density Classes**					
	Size Classes 1-2 (Young)		**Size Class 3 (Mature)**		**Size classes 4-5 (Old)**	
	Sparse (O, L)	**Dense (M, D, E)**	**Sparse (O, L, M)**	**Dense (D, E)**	**Sparse (O, L, M)**	**Dense (D, E)**
RW	Low	Low	Low	Moderate	Moderate	High
RD	Low	Low	Low	Moderate	Moderate	High
CH	Low	Low	Low	Moderate	Low	High
MH	Low	Low	Low	Low	Low	Moderate

LWD was inventoried in watercourses during the stream channel assessment. All "functional" LWD was tallied within the active channel and the bankfull channel for each sampled stream segment. Functional LWD provides some habitat or morphologic function in the stream channel (i.e. pool formation, scour, debris dam, bank stabilization, or gravel storage) and is designated as having dimensions of greater than four inches in diameter and six feet in length. The LWD was classified by tree species class, either redwood, fir (Douglas-fir, hemlock, grand fir), hardwood (alder, tan oak, etc.), or unknown (if tree species is indeterminable). Length and diameter were recorded for each piece so that volume could be calculated. LWD associated with an

accumulation of three pieces or more was recorded and the number of LWD accumulations in the stream survey reach was tallied.

LWD pieces were also classified into categories representing physical characteristics. These categories are: if the LWD piece was part of a living tree, root associated (i.e. does it have a rootwad attached to it), was part of the piece buried within stream gravel or the bank, or associated with a restoration structure. By assigning these attributes, the number of pieces in a segment which, for example, have a rootwad associated with the piece can be calculated. This is important as these types of pieces can be more stable or have ecological benefits above that which a LWD piece alone may have.

Pieces that were partially buried were noted, because the dimensions and calculated volume for these pieces are not known they would represent a minimum dimension. There may likely be a significant amount of volume that is buried that we cannot measure. Also, these pieces are more stable in the channel during high flows. The percentage of total pieces which are partially buried was calculated for each stream segment. The LWD is further classified as a key LWD piece if it meets the size requirements listed below in Table D-2.

Table D-2. Key LWD Piece Size Requirements (adapted from Bilby and Ward, 1989)

Bankfull width (ft.)	Diameter (in.)	Length (ft.)		Minimum volume alternative* (yds^3)
0-10	13	1 or 1.5 times bankfull width**		1
10-20	16	1 or 1.5 times bankfull width**		3
20-30	18	1 or 1.5 times bankfull width**	OR	5
30-40	21	1 or 1.5 times bankfull width**		8
40-60	26	1 or 1.5 times bankfull width**		15
60-80	31	1 or 1.5 times bankfull width**		25
80-100	36	1 or 1.5 times bankfull width**		34

* A piece of LWD counts as a "key piece" if it does not meet the diameter and length criteria but exceeds this minimum volume.
** 1.0 times bankfull width if a rootwad is attached, 1.5 times bankfull width if not.

Debris jams (>10 pieces) were noted and total dimensions of the jam recorded. A correction factor is used to account for the void space within debris jams. Total number of pieces and number of key pieces were noted. Species and dimensions were not recorded for individual pieces contained in debris jams. All volume estimates and piece counts were separated in two groups, one not considering jams and one considering all LWD pieces in the segment, debris jams included. The percentage of total volume and total pieces per segment which was contained in debris jams was also calculated.

The quantity of LWD observed was normalized by distance, for comparison through time or to other similar areas, and was presented as a number of LWD pieces per 100 meters. This normalized quantity, by distance, was performed for functional and key LWD pieces within the active and bankfull channel. The key piece quantity in the bankfull channel (per 100 meters of channel) is compared to the target for what would be an appropriate key piece loading. The target for appropriate key piece loading is derived from Bilby and Ward (1989) and Gregory and Davis (1992) and presented in Table D-3.

Table D-3. Target for Number of Key Large Woody Debris Pieces in Watercourses of the WAU.

Bankfull width	Number of Key Pieces Per 100 meters
<15	6.6
15 – 35	4.9
35 – 45	3.9
> 45	3.3

An in-stream LWD demand is identified in addition to the riparian stand recruitment potential, as discussed previously. The in-stream LWD demand is an indication of what level of concern there is for in-stream LWD for stream channel morphology and fish habitat associations within the Elk Creek WAU. The in-stream LWD demand is determined by stream segment considering the overall LWD recruitment, the stream segment LWD sensitivity rating (as determined in the Stream Channel and Fish Habitat Assessment for stream geomorphic units), and the level of LWD currently in the stream segment (on target or off target). Table D-4 shows how these three factors are used to determine the in-stream LWD demand.

Table D-4. In-stream LWD Demand

Recruitment Potential Rating	In-channel LWD On Target / In-channel LWD Off Target	Channel LWD Sensitivity Rating: LOW	MODERATE	HIGH
LOW		LOW	MODERATE	HIGH
		MODERATE	HIGH	HIGH
MODERATE		LOW	MODERATE	MODERATE
		MODERATE	HIGH	HIGH
HIGH		LOW	MODERATE	MODERATE
		LOW	HIGH	HIGH

Low In-stream LWD Demand - this classification suggests that current riparian LWD recruitment conditions and in-stream LWD are at levels which are sufficient for LWD function in these stream channel types.

Moderate In-stream LWD Demand - this classification suggests that current riparian LWD recruitment conditions and in-stream LWD are at levels which are moderately sufficient for fish habitat and stream channel morphology requirements. Consideration must be given to these areas to improve the LWD recruitment potential of the riparian stand. These areas may also be considered for supplemental LWD or stream structures placed in the stream channel.

High In-stream LWD Demand - this classification suggests that current riparian LWD recruitment conditions and in-stream LWD are at levels which are not sufficient for LWD function in these stream channel types. These areas must consider improvement of the LWD recruitment potential of the riparian stand. These areas should be the highest priority for supplemental LWD or stream structures placed in the stream channel.

Major streams and stretches of river within each Calwater planning watershed were further evaluated for meeting target conditions. Within each hydrologic watershed of the stream segment analyzed, the percentage of watercourses with low or moderate LWD demand and the percentage of watercourses with an appropriate number of key LWD pieces determine the overall quality rating of watercourse LWD in each stream or stream segment of a Calwater planning watershed. Under this scheme, LWD quality falls into the following categories:

D-5 Large woody debris quality rating for each Planning Watershed

ON TARGET	Over 80% of surveyed segments by length have low or moderate LWD demand
MARGINAL	50-80% of surveyed segments by length have low or moderate LWD demand OR over 80% of stream segments have at least half of the target key LWD pieces desired.
DEFICIENT	Less than 50% of surveyed segments by length have low or moderate LWD demand, and low numbers of functional or key LWD.

The percentages that define the break between each of the LWD quality ratings have the intent of realizing that streams and watersheds are dynamic. LWD loadings are naturally found to be variable. Therefore a target of 100% of stream segment meeting LWD quality demand would be inappropriate. However, it seems that if less than half of the watercourses (50%) do not meet LWD demand then a LWD deficiency is assumed.

We consider key LWD for determination of both in-stream LWD demand and overall LWD quality to help ensure that enough key LWD exists at both small (i.e., stream segment) and large (i.e., planning watershed) spatial scales.

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RESULTS

The large woody debris recruitment potential and in-stream LWD demand for the Elk Creek WAU is illustrated in Map D-1. The large woody debris recruitment potential and in-stream LWD demand provides baseline information on the structure and composition of the riparian stand and the level of concern about current LWD conditions in the stream. This map provides a tool for prioritizing riparian and stream management for improving LWD recruitment and in-stream LWD. These areas must be monitored over time to ensure that the recruitment potential is improving and that large woody debris is providing the proper function to the watercourses. Map D-1 differs from previous Watershed Analysis maps of years past due to changes stemming from Mendocino Redwood Company's proposed Habitat Conservation Plan / Natural Communities Conservation Plan. The objectives of the plan for large woody debris are based on survey effort

(length of stream surveyed in Class I watercourses), so only field surveyed segments are shown in Map D-1. In years past MRC would conduct an aerial photo and GIS review of the entire watershed and infer conditions on stream conditions such as canopy, large woody debris and stream channel morphology.

The raw LWD data is shown in Tables D-6 a, b, c, d and e. Map D-1 displays the results of the large woody debris in-stream demand and recruitment potential. In summary, three segments in Upper Elk were determined to have moderate large woody debris demand, with the remaining having high demand. The total length for those segments surveyed was 2,695 feet. Thus, since MRC surveyed a total of 25,818 feet of habitat in Upper Elk, MRC concludes that 10.4% of the segments had moderate (or low) demand for large woody debris. By the same logic, MRC determined that only 1.8% of habitat surveyed (one segment of 200 feet out of a total of 11,205 feet surveyed) had low or moderate demand. Therefore, based on Table D-5, both Upper and Lower Elk Planning Watersheds are rated as deficient for large woody debris. The following text and tables describe how MRC came to this conclusion.

Debris jams made up an average of 28% of the total volume of large woody debris in Elk (Table D-6a). None of the segments in the Upper Elk Planning Watershed achieved the key piece target without wood from the debris jams, but three segments (CE31, CE40 and CE51) had enough wood in debris jams to achieve the key piece targets. Whereas in the Lower Elk Planning Watershed, only one segment (CL16) achieved the key piece target even without wood from debris jams.

LWD species composition was largely redwood dominated (Table D-6b) with a WAU-wide average of 84% of the total volume in each segment. This analysis was limited to pieces not contained within debris jams.

The majority of the segments (74%) in the Elk Creek WAU contained LWD that was not recently contributed to the stream (Table D-6c). This may be a result of past riparian harvest or natural stand types. Needless to say, more LWD must be contributed to the stream channel in future years, especially considering the fact that none of the stream segments in the Elk WAU were rated as having a high recruitment potential.

As shown in the tables below, there is a need for large woody debris in most of the channel segments of the Elk Creek WAU. Channel segments with LWD levels which are well below the target will need to be the priority for monitoring future recruitment and restoration work. Even the segments that met the target need LWD levels to be maintained to ensure LWD is providing fish habitat and morphological function in the stream channels.

Riparian recruitment potential in the Elk Creek WAU is low (see Map D-1). The majority (52%) of the segments observed (16 out of 31) had a low recruitment potential (see Table D-1 for clarification). The low recruitment potential throughout the Elk WAU is most likely due to past riparian harvest practices. As much as possible, these types of areas will have to be managed to attempt to provide for future stream LWD and habitat.

Table D-6 (a). Large Woody Debris Pieces

Stream Segment Name	ID	Segment length (feet)	Functional LWD Pieces w/o Debris Jams	Functional LWD Pieces w/ Debris Jams	Number Debris Jams	Number Debris Accum.	Functional LWD (#/100m) w/o Debris Jams	Functional LWD (#/100m) w/ Debris Jams	Key LWD w/o Debris Jams	Key LWD with Debris Jams	Key LWD /100m w/o Debris Jams	Key LWD /100m w/Debris Jams
Upper Elk	CE01	1414	32	32	0	0	7.4	7.4	2	2	0.5	0.5
Upper Elk	CE02	4183	51	51	0	19	4.0	4.0	2	2	0.2	0.2
Upper Elk	CE04	1130	3	3	0	0	0.9	0.9	0	0	0.0	0.0
Upper Elk	CE05	1230	14	14	0	0	3.7	3.7	1	1	0.3	0.3
Upper Elk	CE06	1100	24	44	1	7	7.2	13.1	1	6	0.3	1.8
Upper Elk	CE07	1500	18	18	0	4	3.9	3.9	2	2	0.4	0.4
Upper Elk	CE08	1000	19	19	0	4	6.2	6.2	7	7	2.3	2.3
Upper Elk	CE09	640	16	51	2	4	8.2	26.1	0	12	0.0	6.2
Twin Bridges	CE10	750	37	37	0	9	16.2	16.2	3	3	1.3	1.3
Twin Bridges	CE11	1400	16	46	1	0	3.7	10.8	2	7	0.5	1.6
Twin Bridges	CE12	1200	44	44	0	15	12.0	12.0	7	7	1.9	1.9
Three Springs	CE30	1100	22	32	1	9	6.6	9.5	7	11	2.1	3.3
Three Springs	CE31	1095	17	54	2	3	5.1	16.2	4	20	1.2	6.0
Sulfur Creek	CE39	1000	8	33	1	0	2.6	10.8	4	17	1.3	5.6
Sulfur Creek	CE40	950	20	35	1	11	6.9	12.1	5	17	1.7	5.9
Sulfur Creek	CE41	850	7	22	1	0	2.7	8.5	2	10	0.8	3.9
Soda Fork	CE44	1500	29	49	1	19	6.3	10.7	3	13	0.7	2.8
Soda Fork	CE46	1486	2	12	1	0	0.4	2.6	0	5	0.0	1.1
Upper Elk	CE50	550	13	13	0	4	7.8	7.8	2	0	1.2	0.0
Upper Elk	CE51	650	20	30	1	7	10.1	15.1	6	14	3.0	7.1
Upper Elk	CE52	640	23	23	0	11	11.8	11.8	3	3	1.5	1.5
Mayville	CE61	450	12	12	0	0	8.7	8.7	3	3	2.2	2.2
Lower Elk	CL01	1300	12	12	0	4	3.0	3.0	0	0	0.0	0.0
Lower Elk	CL02	1600	20	20	0	9	4.1	4.1	2	2	0.4	0.4
Lower Elk	CL03	1600	29	29	0	9	5.9	5.9	0	0	0.0	0.0
Lower Elk	CL05	2555	59	59	0	17	7.6	7.6	4	4	0.5	0.5
South Fork Elk	CL06	800	19	19	0	6	7.8	7.8	3	3	1.2	1.2

Table D-6 (a). Large Woody Debris Piece (continued)

Stream Segment Name	ID	Segment length (feet)	Functional LWD Pieces w/o Debris Jams	Functional LWD Pieces w/ Debris Jams	Number Debris Jams	Number Debris Accum.	Functional LWD (#/100m) w/o Debris Jams	Functional LWD (#/100m) w/ Debris Jams	Key LWD w/o Debris Jams	Key LWD with Debris Jams	Key LWD /100m w/o Debris Jams	Key LWD /100m w/Debris Jams
South Fork Elk	CL07	600	35	35	0	8	19.1	19.1	9	9	4.9	4.9
Little South Fork Elk	CL12	2000	67	67	0	14	11.0	11.0	5	5	0.8	0.8
Hunters Camp	CL16	200	10	30	1	7	16.4	49.2	5	15	8.2	24.6
Lower Elk	CL24	550	45	45	0	24	26.8	26.8	8	8	4.8	4.8

Table D-6 (b). Large Woody Debris Volume in Select Stream Segments of the Elk Creek WAU.

Stream Segment Name	ID	Total Volume (yd^3) w/o Debris Jams	Total Volume (yd^3) w/ Debris Jams	Total Vol/100m (yd^3) w/o Debris Jams	Total Vol/100m (yd^3) w/ Debris Jams	% of Total Volume in Debris Jams	% of Vol in Key Pieces w/o Jams	% of Total Volume By Species w/o Jams				
								RW	Fir	Alder	HW	Unk.
Upper Elk	CE01	133.2	133.2	30.9	30.9	0%	50%	86%	9%	0%	1%	4%
Upper Elk	CE02	162.0	162.0	12.7	12.7	0%	51%	81%	11%	2%	2%	4%
Upper Elk	CE04	2.3	2.3	0.7	0.7	0%	0%	8%	83%	0%	9%	0%
Upper Elk	CE05	16.1	16.1	4.3	4.3	0%	0%	46%	53%	0%	1%	0%
Upper Elk	CE06	35.7	183.7	10.6	54.8	81%	16%	85%	9%	0%	0%	7%
Upper Elk	CE07	23.3	23.3	5.1	5.1	0%	58%	97%	0%	0%	3%	0%
Upper Elk	CE08	17.3	17.3	5.7	5.7	0%	72%	40%	18%	0%	28%	0%
Upper Elk	CE09	10.0	73.0	5.1	37.4	86%	0%	100%	0%	0%	0%	0%
Twin Bridges	CE10	57.0	57.0	24.9	24.9	0%	9%	90%	4%	0%	0%	6%
Twin Bridges	CE11	18.2	199.2	4.3	46.7	91%	50%	87%	7%	4%	0%	2%
Twin Bridges	CE12	55.3	55.3	15.1	15.1	0%	54%	95%	2%	0%	0%	3%
Three Springs	CE30	51.7	88.7	15.4	26.5	42%	70%	100%	0%	0%	0%	0%
Three Springs	CE31	43.0	271.0	12.9	81.2	84%	65%	95%	0%	0%	5%	0%
Sulfur Creek	CE39	16.9	183.9	5.5	60.3	91%	90%	76%	24%	0%	0%	0%
Sulfur Creek	CE40	28.4	69.4	9.8	24.0	59%	60%	71%	29%	0%	0%	0%
Sulfur Creek	CE41	13.1	50.1	5.0	19.3	74%	71%	100%	0%	0%	0%	0%
Soda Fork	CE44	70.7	226.7	15.5	49.6	69%	45%	67%	26%	0%	4%	2%
Soda Fork	CE46	3.3	10.3	0.7	2.3	68%	0%	100%	0%	0%	0%	0%
Upper Elk	CE50	12.6	12.6	7.5	7.5	0%	54%	98%	0%	0%	2%	0%
Upper Elk	CE51	20.6	38.6	10.4	19.5	47%	66%	99%	0%	0%	0%	1%
Upper Elk	CE52	18.5	18.5	9.5	9.5	0%	47%	100%	0%	0%	0%	0%
Mayville	CE61	14.2	14.2	10.3	10.3	0%	74%	87%	0%	0%	13%	0%
Lower Elk	CL01	19.2	19.2	4.8	4.8	0%	0%	53%	1%	10%	1%	35%
Lower Elk	CL02	124.5	124.5	25.5	25.5	0%	73%	92%	0%	6%	0%	2%
Lower Elk	CL03	65.3	65.3	13.4	13.4	0%	0%	93%	2%	0%	2%	3%
Lower Elk	CL05	158.9	158.9	20.4	20.4	0%	46%	87%	5%	3%	1%	4%
South Fork Elk	CL06	51.6	51.6	21.2	21.2	0%	71%	95%	2%	1%	1%	1%

Table D-6 (b). Large Woody Debris Volume (continued)

Stream Segment Name	ID	Total Volume (yd^3) w/o Debris Jams	Total Volume (yd^3) w/ Debris Jams	Total Vol/100m (yd^3) w/o Debris Jams	Total Vol/100m (yd^3) w/ Debris Jams	% of Total Volume in Debris Jams	% of Vol in Key Pieces w/o Jams	% of Total Volume By Species w/o Jams				
								RW	Fir	Alder	HW	Unk.
South Fork Elk	CL07	90.3	90.3	49.4	49.4	0%	70%	90%	1%	7%	0%	2%
Little South Fork Elk	CL12	45.3	45.3	7.4	7.4	0%	32%	87%	7%	3%	3%	0%
Hunters Camp	CL16	10.8	121.8	17.8	199.8	91%	88%	100%	0%	0%	0%	0%
Lower Elk	CL24	70.1	70.1	41.8	41.8	0%	47%	96%	0%	3%	0%	1%

Table D-6 (c). Large woody debris decay class averaged over each Planning Watershed

Planning watershed	Decay class				
	1 = bark + twigs	2 = bark, no twigs	3 = some bark, dark	4 = no bark or twigs	5 = holes, oval shape
Lower Elk	13%	7%	8%	6%	66%
Upper Elk	7%	5%	6%	4%	77%

Table D-6 (d). LWD demand and key piece requirements in the Upper Elk Creek Planning Watershed.

Stream Segment Name	Stream Segment ID#	Segment length (feet)	Bankfull width (feet)	Target number of key pieces of LWD per 100 meters	Observed number of key LWD pieces/100m w/debris jams	In-stream sensitivity rating (geomorphic response potential)	Recruitment potential (riparian stand conditions)	LWD demand (includes debris jams)
Upper Elk	CE01	1414	50	3.3	0.5	High	Moderate	High
Upper Elk	CE02	4183	46	3.3	0.2	High	Moderate	High
Upper Elk	CE04	1130	32	4.9	0.0	High	Low	High
Upper Elk	CE05	1230	29	4.9	0.3	High	Moderate	High
Upper Elk	CE06	1100	30	4.9	1.8	High	Low	High
Upper Elk	CE07	1500	22	4.9	0.4	High	Low	High
Upper Elk	CE08	1000	10	6.6	2.3	High	Moderate	High
Upper Elk	CE09	640	13	6.6	6.2	Moderate	Moderate	High
Twin Bridges	CE10	750	22	4.9	1.3	Moderate	Low	High
Twin Bridges	CE11	1400	19	4.9	1.6	Moderate	High	High
Twin Bridges	CE12	1200	16	4.9	1.9	Moderate	Moderate	High
Three Springs	CE30	1100	20	4.9	3.3	High	Moderate	High
Three Springs	CE31	1095	23	4.9	6.0	High	Moderate	Moderate
Sulfur Creek	CE39	1000	13	6.6	5.6	High	Low	High
Sulfur Creek	CE40	950	16	4.9	5.9	Moderate	Moderate	Moderate
Sulfur Creek	CE41	850	15	4.9	3.9	Moderate	Moderate	High
Soda Fork	CE44	1500	25.5	4.9	2.8	High	Moderate	High
Soda Fork	CE46	1486	20.7	4.9	1.1	Moderate	Moderate	High
Upper Elk	CE50	550	11	6.6	0.0	High	Low	High
Upper Elk	CE51	650	9.5	6.6	7.1	Moderate	Low	Moderate
Upper Elk	CE52	640	10.5	6.6	1.5	Moderate	Low	High
Mayville	CE61	450	10	6.6	2.2	High	Moderate	High

Table D-6 (e). LWD demand and key piece requirements in the Lower Elk Creek Planning Watershed

Stream Segment Name	Stream Segment ID#	Segment length (feet)	Bankfull width (feet)	Target number of key pieces of LWD per 100 meters	Observed number of key LWD pieces/100m w/debris jams	In-stream sensitivity rating (geomorphic response potential)	Recruitment potential (riparian stand conditions)	LWD demand (includes debris jams)
Lower Elk	CL01	1300	59	3.3	1.0	High	Moderate	High
Lower Elk	CL02	1600	44.5	3.9	0.4	High	High	High
Lower Elk	CL03	1600	45	3.9	0.0	High	Moderate	High
Lower Elk	CL05	2555	52	3.3	0.5	High	Moderate	High
South Fork Elk	CL06	800	17	4.9	1.2	High	Low	High
South Fork Elk	CL07	600	14	6.6	4.9	Moderate	Low	High
Little South Fork Elk	CL12	2000	12	6.6	0.8	Moderate	Low	High
Hunters Camp	CL16	200	10	6.6	24.6	Moderate	Low	Moderate
Lower Elk	CL24	550	15.4	4.9	4.8	Moderate	Low	High

Table D-7 shows the in-stream LWD quality rating for major streams and sections of stream or river in individual Calwater planning watersheds. This quality rating includes data from debris jams. Currently all the stream segments in Elk Creek have a deficient LWD quality rating, except for South Fork and Upper Elk.

Table D-7. In-stream LWD Quality Ratings for Calwater Planning Watersheds in the Elk Creek WAU.

Stream	Calwater Planning Watershed	Percent of segments† with low or moderate demand	Percent of segments† meeting at least half of the key piece target	In-stream LWD Quality Rating*
Elk Creek	Lower Elk	1.8%	12.0%	Deficient
Elk Creek	Upper Elk	10.4%	30.2%	Deficient

† – normalized by segment lengths
* – includes debris jams

SHADE AND STREAM TEMPERATURE METHODS

Many physical factors can influence stream temperature. These include: solar radiation, air temperature, relative humidity, water depth and ground water inflow. Forest management can most influence solar radiation input, riparian air temperature and relative humidity by alteration of streamside vegetation and cover. Water depth and ground water inflow are more difficult to correlate to forest management practices. Therefore, our analysis focused on present shade conditions for consideration of future forest management actions.

Shade, over watercourses, was estimated from field measurements and 2004 aerial photographs. Four shade classes were determined using aerial photographs. These classes are shown in table D-8. Field measurements of shade are used to calibrate the aerial photograph measurements. A map (D-2) was produced for the Elk Creek WAU based on the aerial photograph interpretations.

Table D-8. Estimated levels of Shade from Aerial Photographs.

Characteristics Observed on Aerial Photograph	Shade Class
Stream surface not visible	>90%
Stream surface visible in patches	70-90%
Stream surface visible but banks not visible	40-70%
Stream surface visible and banks visible at times	20-40%
Stream surface and banks visible	0-20%

In 2004, field measurements of shade over select stream channels were performed. The field measurements were taken during the stream channel assessments in the Elk Creek WAU. The field measurements consisted of estimating shade over a watercourse using a spherical densiometer and a solar pathfinder. The densiometer estimates were taken at approximately 3-5 evenly spaced intervals along a channel sample segment, typically a length of 20-30 bankfull widths. The results of the densiometer readings were averaged across the channel to represent the percentage of shade for the channel segment. Solar pathfinder measurements were taken at one location in each segment sampled. The riparian stream shade is shown in Map D-2.

Stream temperature has been monitored since 1992 in the Lower Elk Creek Planning Watershed and since 1997 in Upper Elk. Stream temperature was measured with continuous recording electronic temperature recorders (Stowaway, Onset Instruments). Stream temperatures are monitored during the summer months when the water temperatures are highest. The stream temperature recorders were typically placed in shallow pools (<2 ft. in depth) directly downstream of riffles. Stream temperature monitoring probe locations are also shown on Map D-2 indicated by the site identification code (for example, 87-1). The number below the site identification code (in parenthesis) is the most recent three year average MWAT (maximum weekly average temperature) in degrees Celsius. Table D-9 describes the temperature monitoring locations.

Table D-9. Stream Temperature Monitoring Locations and Time Periods in the Elk Creek WAU (see map D-2).

Temperature Station	Segment #	Stream Name	Years Monitored
87-1	CL02	Lower Elk Creek Mainstem (above South Fork)	92, 93, 94, 97, 99, 00, 01, 02, 03, 04, 05, 06
87-2	CL06	South Fork Elk Creek	97, 99, 00, 01, 02, 03, 04, 05, 06
87-4	CE05	Upper Elk Creek Mainstem (above Three Springs)	03, 04, 05, 06
87-5	CE08	Upper Elk Creek Mainstem (above Soda Fork)	03, 04, 05, 06
87-6	CE44	Soda Fork Creek	03, 04, 05, 06
87-7	CE30	Three Springs Creek	03, 04, 05, 06
87-8	CE61	Mayville	03, 04, 05, 06
87-9	CL16	Tributary to Elk Creek (at Hunters Camp)	03, 04, 05, 06
87-10	CE39	Sulphur Fork Creek	06

Maximum, maximum weekly average temperatures (MWAT), and maximum weekly maximum temperatures (MWMT) were calculated for each temperature monitoring site and year. Maximum weekly average temperatures (MWATs) and maximum weekly maximum temperatures (MWMT) were calculated by taking a seven day average of the mean and maximum daily stream temperature.

Maximum and mean daily temperatures were calculated for each temperature monitoring site and year and are presented in graphs in Appendix D. The instantaneous maximum temperature for each year is also reported.

A stream shade quality rating was derived for major tributaries or river segments within a Calwater planning watershed. MRC uses two sequential sets of criteria to determine if a watershed has "on-target" effective shade, the first based on stream temperature, the second on effective shade:

- If the MWAT (averaged over 3 consecutive seasons) for the watercourse segment is below 15°C, current shade conditions provide *on-target* effective shade for all watercourses in that basin.

However, if the MWAT value (averaged over 3 consecutive seasons) for the watercourse segment is above 15°C, or if no temperature data is available, then the percentage of effective shade over

each watercourse in the planning watershed determines the streams effective shade quality rating. The percentage of effective shade required for an "on-target" rating varies by bankfull width of the watercourse:

- For watercourses with bankfull widths <30 feet, >90% effective shade.
- For watercourses with bankfull widths of 30-100 feet, >70% effective shade.
- For watercourses with bankfull widths of 100-150 feet, >40% effective shade.

We use the following categories of watercourse-shade rating to determine overall shade quality in each major stream or river/stream segment of a planning watershed:

Table D-10 Effective Shade Ratings for Planning Watersheds

ON TARGET	Over 80% of surveyed watercourse segments have on-target effective shade.
MARGINAL	60-80% of surveyed watercourse segments have either (a) on-target effective shade or (b) over 70% canopy.
DEFICIENT	Less than 60% of surveyed watercourse segments have either (a) on-target effective shade or (b) less than 70% canopy.

SHADE AND STREAM TEMPERATURE

RESULTS

Overall average shade over watercourses is rated marginal in the Upper Elk Creek Planning Watershed and on-target in the Lower Elk Creek Planning Watershed (Table D-15). All stream temperature observations (recent MWAT averages) in Upper Elk Creek were above 15°C and less than 80% of the segments observed met the shade targets, so this watershed was rated as marginal for effective shade. Two tributaries (South Fork Elk Creek and the tributary at Hunters Camp) in the Lower Elk Creek Planning Watershed were determined to have desirable stream temperatures (recent MWAT averages below 15°C) and greater than 80% of the segments observed throughout the remainder of this planning watershed were above their target shade values. Thus, Lower Elk Creek was rated as on-target for effective shade. Table D-11 below contains the data used to determine the shade quality ratings in the Elk Creek WAU.

Table D-11. 2004 Field Observations of Stream Shade for Select Stream Channel Segments of the Elk Creek WAU.

Stream Name	Segment Number	Solar pathfinder shade (%)	Average of densiometer readings (%)	Topography shading (%)	Mean Shade Canopy (%)	Bankfull width (ft)	Shade target (%)	Temp. station	Average MWAT (°C)	On-target for shade or temperature?	Average shade > 70%?
Upper Elk	CE01	85.5	62	3.5	74	50	70			yes	yes
Upper Elk	CE02	100	91	5	95	46	70			yes	yes
Upper Elk	CE04	100	79	6	90	32	70			yes	yes
Upper Elk	CE05	97	82	4	89	29	90	87-04	16.2	no	yes
Upper Elk	CE06	78	61	4	69	30	70			no	no
Upper Elk	CE07	99	99	4	99	22	90			yes	yes
Upper Elk	CE08	100	94	8	97	10	90	87-05	15.1	yes	yes
Upper Elk	CE09	100	95	14	97	13	90			yes	yes
Twin Bridges	CE10	97	96	15	96	22	90			yes	yes
Twin Bridges	CE11	100	68	20	84	19	90			no	yes
Twin Bridges	CE12	94	60	8	77	16	90			no	yes
Three Springs	CE30		95		95	20	90	87-07	15.4	yes	yes
Three Springs	CE31	93	87	8	90	23	90			no	yes
Sulfur Creek	CE39	100	80	8	90	13	90			no	yes
Sulfur Creek	CE40	100	96	26	98	16	90			yes	yes
Sulfur Creek	CE41		85		85	15	90			no	yes
Soda Fork	CE44		70		70	26	90	87-06	15.9	no	no
Soda Fork	CE46	100	95	4	98	21	90			yes	yes
Upper Elk	CE50	98	96	4	97	11	90			yes	yes

Table D-11 (continued). 2004 Field Observations of Stream Shade for Select Stream Channel Segments of the Elk Creek WAU.

Stream Name	Segment Number	Solar pathfinder shade (%)	Average of densiometer readings (%)	Topography shading (%)	Mean Shade Canopy (%)	Bankfull width (ft)	Shade target (%)	Temp. station	Average MWAT (°C)	On-target for shade or temperature?	Average shade > 70%?
Upper Elk	CE51	97	95	23	96	10	90			yes	yes
Upper Elk	CE52	100	92	4	96	11	90			yes	yes
Mayville	CE61		98		98	10	90	87-08	13.9	yes	yes
Lower Elk	CL01	56	54	4	55	59	70			no	no
Lower Elk	CL02	97	85	2	91	45	70	87-01	15.7	yes	yes
Lower Elk	CL03	90	92	15	91	45	70			yes	yes
Lower Elk	CL05	85	67	5	76	52	70			yes	yes
South Fork Elk	CL06	99	79	12	89	17	90	87-02	12.9	yes	yes
South Fork Elk	CL07	98	93	14	96	14	90			yes	yes
Little South Fork Elk	CL12	95	95	16	95	12	90			yes	yes
Hunters Camp	CL16	100	93	25	96	10	90	87-09	13.5	yes	yes
Lower Elk	CL24	100	99	12	100	15	90			yes	yes
Sulfur Creek	CE40	97	95	23	96	10	90			yes	yes

Stream temperatures in the Elk Creek WAU are generally not at levels preferred by salmonids. Instantaneous maximum temperatures recorded at all sites typically do not exceed the maximum lethal ranges for coho salmon (23C^{o}) and steelhead trout (26C^{o}) (Brett, 1952). MWAT values, however, for a significant number of sites are above the maximums for coho salmon (17-18 C^{o}) (Brett, 1952 and Becker and Genoway, 1979). See Tables D-12, D-13 and D-14 for detailed temperature information.

Table D-12. Maximum Daily Temperatures by Year for the Elk Creek WAU.

Station	1997	1999	2000	2001	2002	2003	2004	2005	2006
87-1	18.4	15.9	17.7	15.8	16.8	17.1	17.5	16.5	17.5
87-2	14.3	13.4	13.1	13.2	12.9	13.7	13.7	13.9	14
87-3	19.1	**	**	17.7	**	**	**	**	**
87-4	**	**	**	**	17.9	17.8	17.9	18.1	20.7
87-5	**	**	**	**	**	16.5	16.4	16.6	18.7
87-6	**	**	**	**	**	17.8	16.4	18	20
87-7	**	**	**	**	**	16.8	16.8	17.2	19.2
87-8	**	**	**	**	**	14.9	14.5	15.1	16.3
87-9	**	**	**	**	**	14	14.1	14.1	14.7
87-10	**	**	**	**	**	**	**	**	20.3

**data not collected

Table D-13. Maximum Weekly Average Temperature (MWAT) for the Elk Creek WAU.

Station	1997	1999	2000	2001	2002	2003	2004	2005	2006
87-1	16.4	14.4	15.3	14.3	15	15.6	15.9	15.6	16.2
87-2	13.3	12.5	12	12.2	11.8	12.7	12.9	13	13.2
87-3	16.3	**	**	15.4	**	**	**	**	**
87-4	**	**	**	**	15.4	16.1	16.3	16.3	18.6
87-5	**	**	**	**	**	15	15	15.2	17
87-6	**	**	**	**	**	16	15.5	16.2	18.1
87-7	**	**	**	**	**	15.1	15.3	15.7	17.3
87-8	**	**	**	**	**	14	13.6	14	15.2
87-9	**	**	**	**	**	13.5	13.5	13.5	14.2
87-10	**	**	**	**	**	**	**	**	17.9

**data not collected

Table D-14. 7-Day Moving Average of the Daily Maximum (MWMT) for the Elk Creek WAU.

Station	1997	1999	2000	2001	2002	2003	2004	2005	2006
87-1	17.5	15.1	16.6	15.2	16.1	16.4	16.9	16.1	17.3
87-2	14.3	13.4	12.7	13	12.6	13.5	13.6	13.8	13.9
87-3	18.4	**	**	16.6	**	**	**	**	**
87-4	**	**	**	**	17	17.2	17.5	17.6	19.9
87-5	**	**	**	**	**	16	16.1	16.2	18
87-6	**	**	**	**	**	17.3	16.1	17.5	19.3
87-7	**	**	**	**	**	16.3	16.3	16.8	18.5
87-8	**	**	**	**	**	14.6	14.1	14.8	15.8
87-9	**	**	**	**	**	13.7	13.8	13.8	14.5
87-10	**	**	**	**	**	**	**	**	19.4

** Data not collected

Only one segment (CL01) in the Lower Elk Creek Planning Watershed had stream temperature and shade values below desirable levels. This can be expected since it is the most downstream segment within the watershed. The large bankfull width and wide floodplain allows for more solar insolation. The remainder of the segments in Lower Elk Creek had acceptable values for effective shade (Table D-15). The Upper Elk Planning Watershed had 14 segments that were acceptable as far as effective shade ratings out of a total of 22.

Table D-15. Stream Shade Quality Ratings for Planning Watersheds in the Elk Creek WAU.

Planning watershed	Number of segments surveyed	% segments with MWAT < 15 deg C and/or average canopy greater than target	% segments with >70% average canopy	Stream Shade Quality Rating
Lower Elk Creek	9	89%	89%	ON TARGET
Upper Elk Creek	22	64%	91%	MARGINAL*

Marginal due to the fact that greater than 70% of the stream segments surveyed had canopy values that were greater than 70%

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Appendix D

Figure T87-01. Maximum Daily Air Temperature and Mean and Maximum Daily Stream Temperatures During Summer 2008 at Elk Creek (Site T87-01), Mendocino County, California.

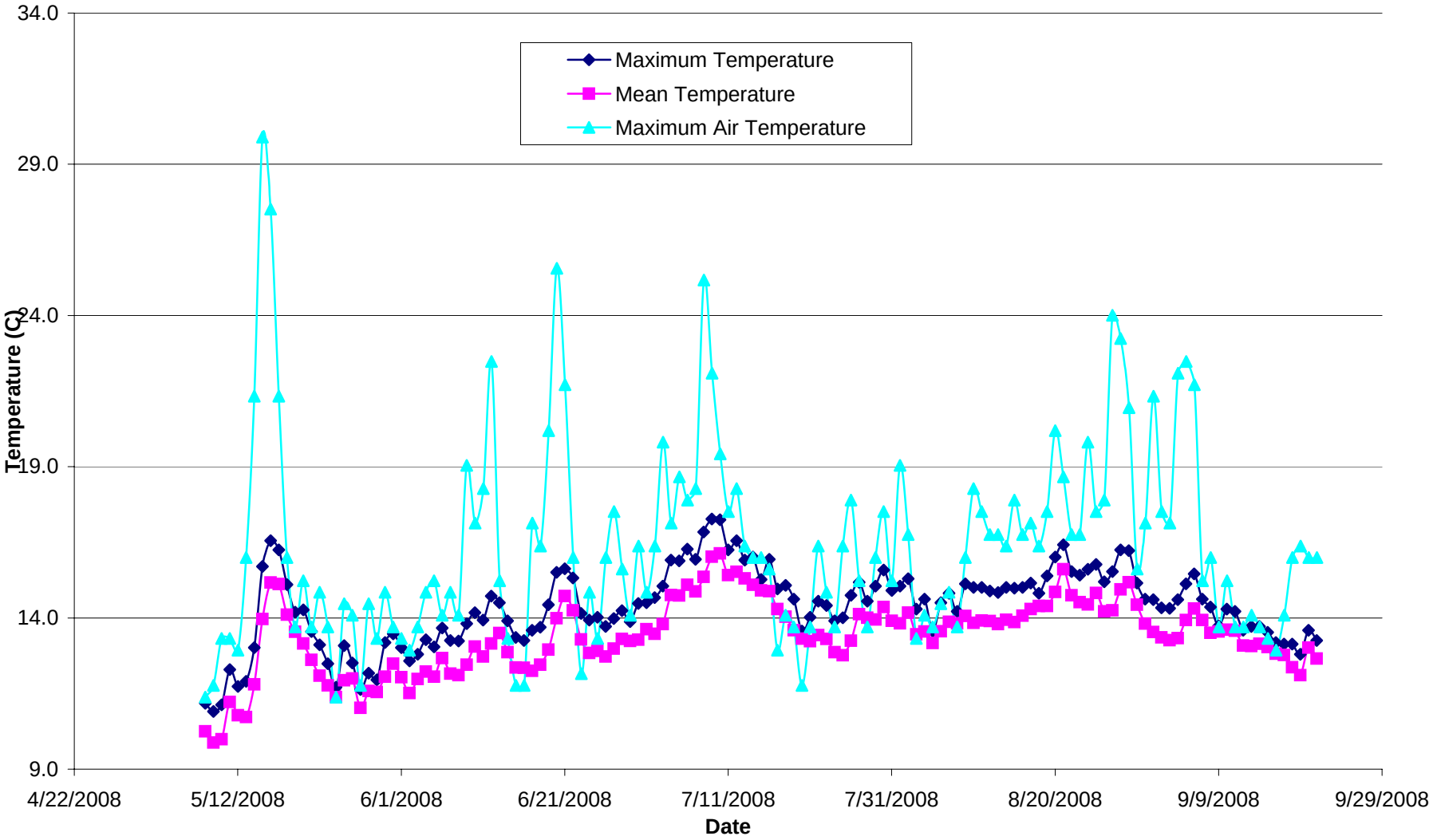


Figure T87-02. Maximum Daily Air Temperature and Mean and Maximum Daily Stream Temperatures During Summer 2007 at South Fork Elk Creek (Site T87-02), Mendocino County, California.

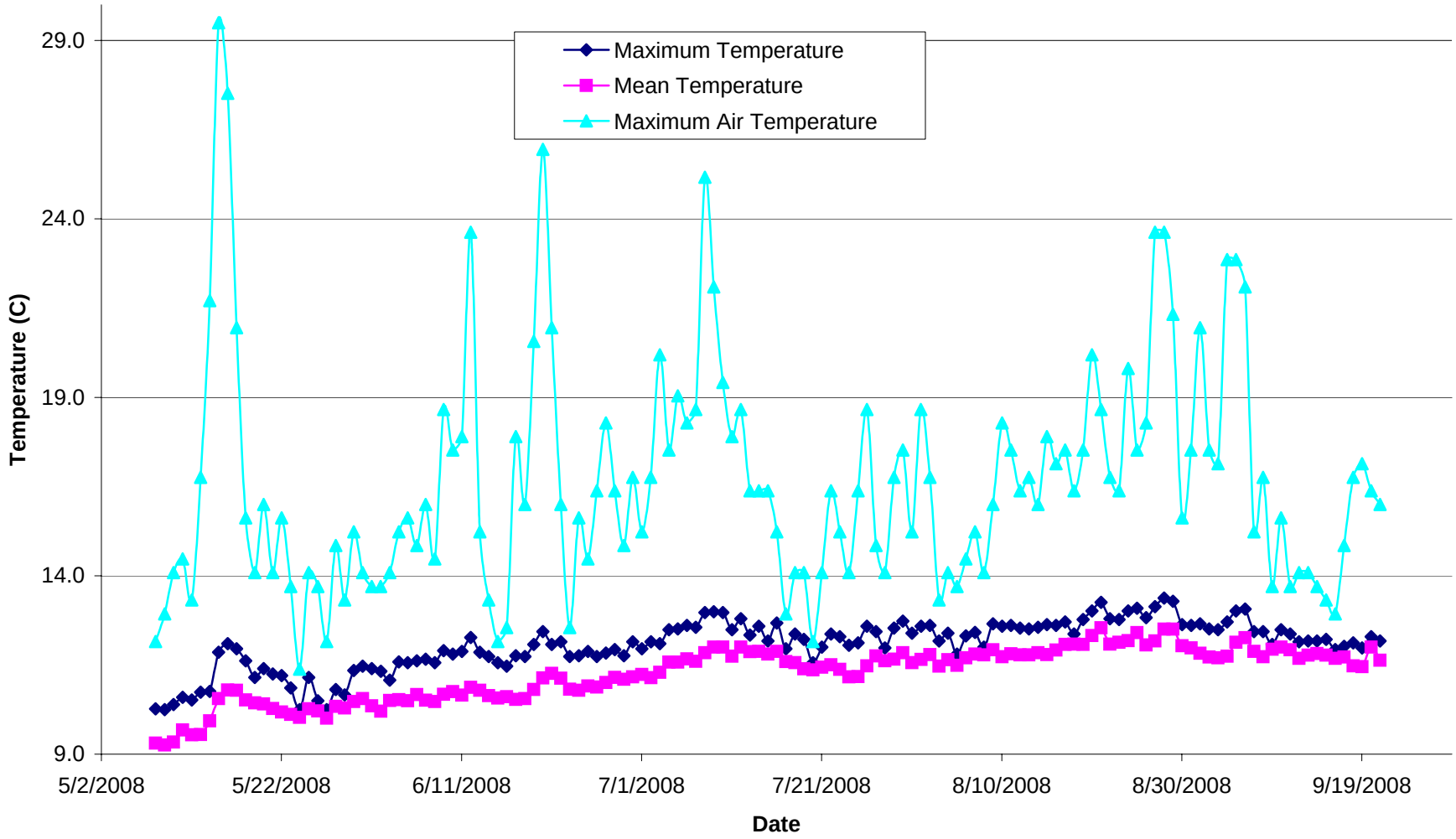


Figure T87-04. Maximum Daily Air Temperature and Mean and Maximum Daily Stream Temperatures During Summer 2008 at Elk Creek (Site T87-04), Mendocino County, California.

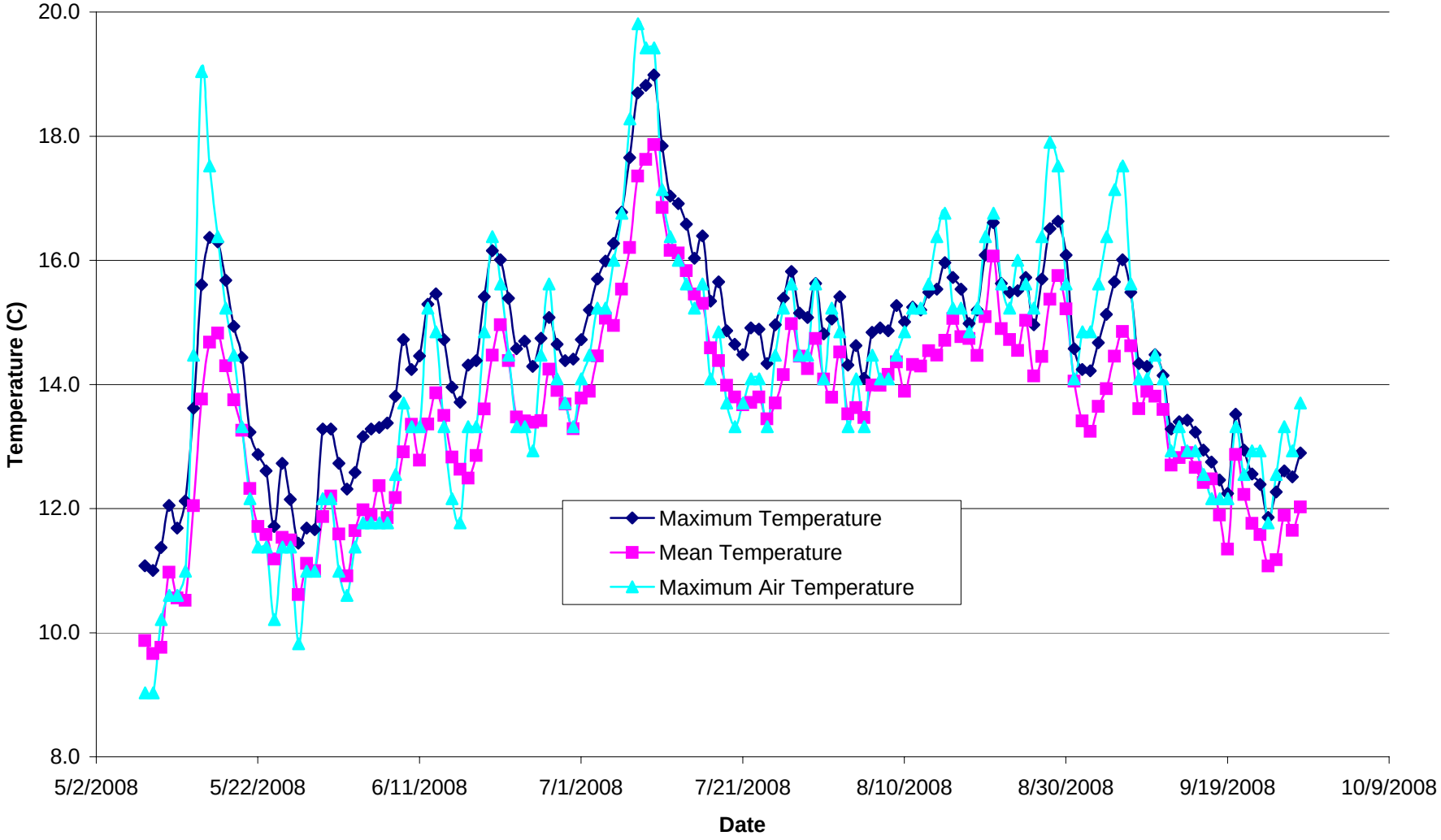


Figure T87-05. Maximum Daily Air Temperature and Mean and Maximum Daily Stream Temperatures During Summer 2008 at Elk Creek (Site T87-05), Mendocino County, California.

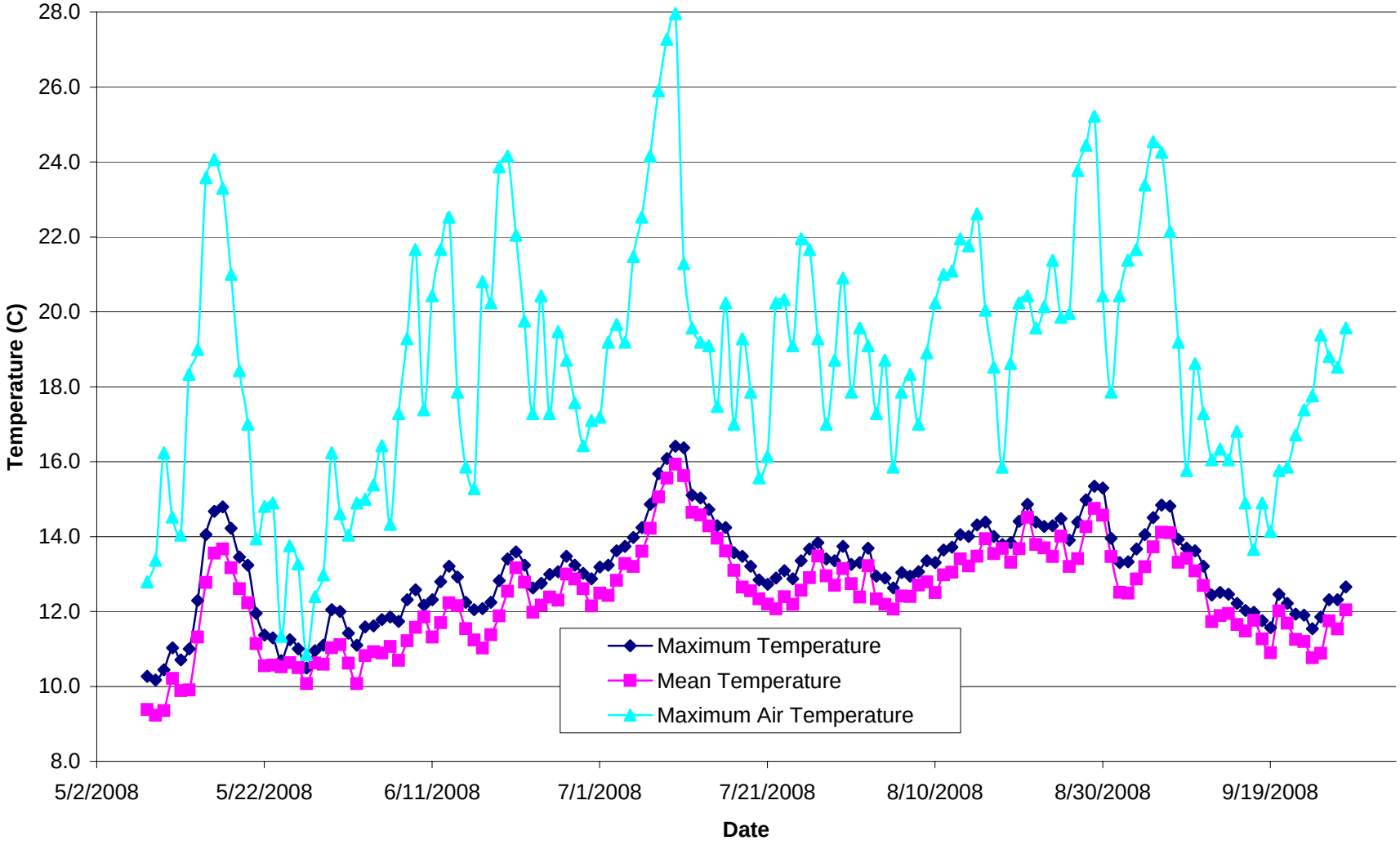


Figure T87-06. Maximum Daily Air Temperature and Mean and Maximum Daily Stream Temperatures During Summer 2008 at Soda Fork Creek (Site T87-06), Mendocino County, California.

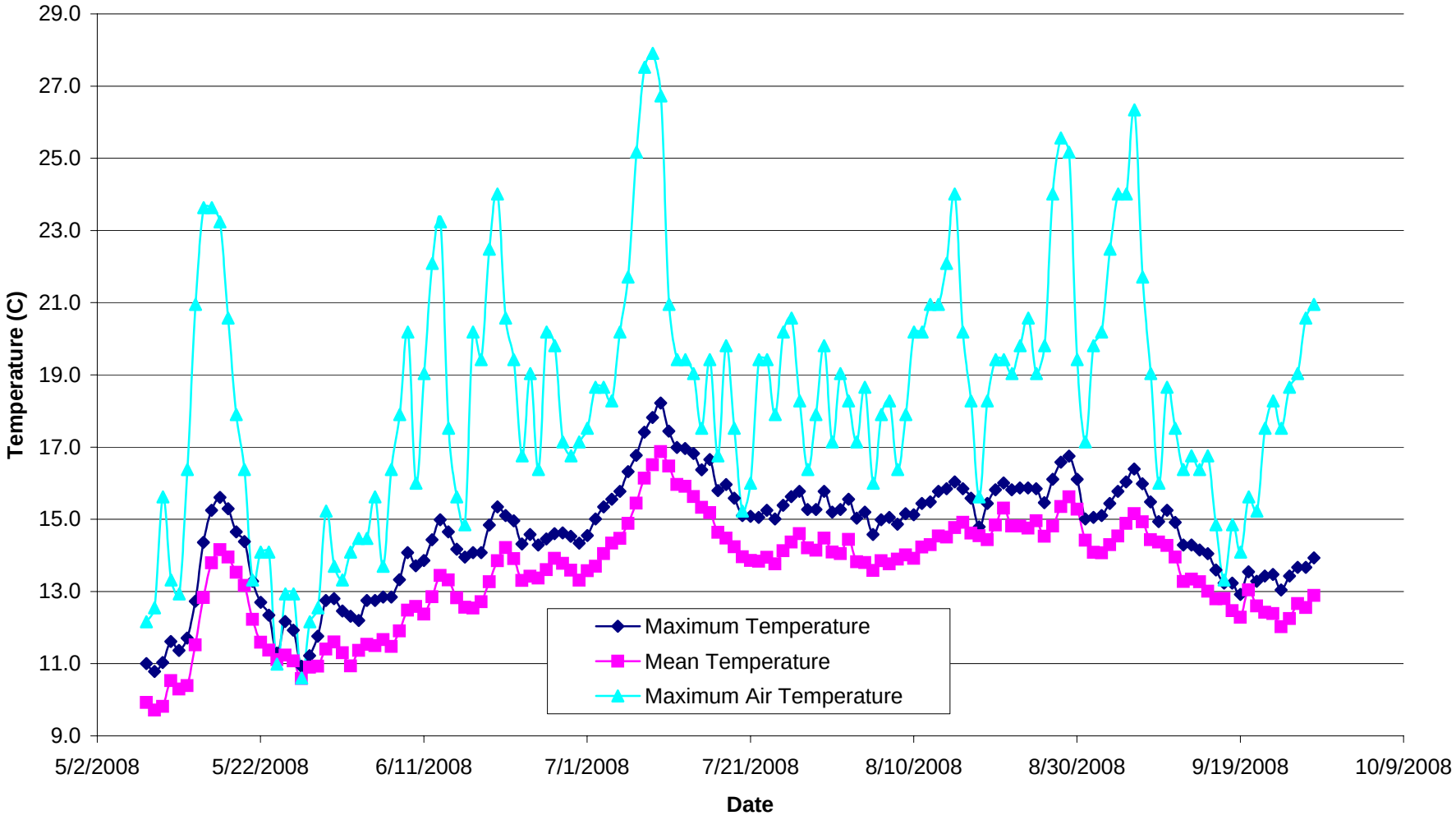


Figure T87-07. Maximum Daily Air Temperature and Mean and Maximum Daily Stream Temperatures During Summer 2008 at Three Springs Creek (Site T87-07), Mendocino County, California.

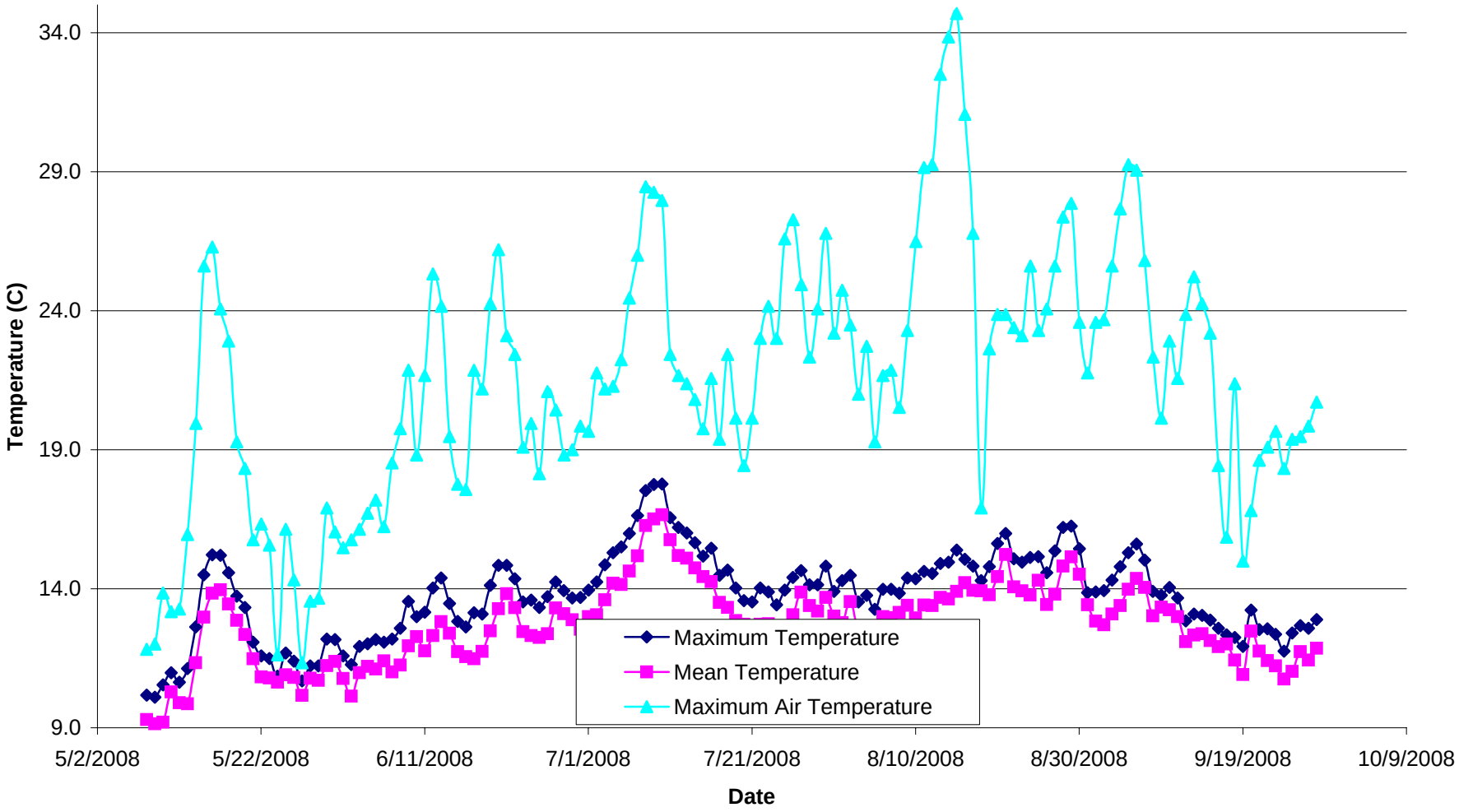


Figure T87-08. Maximum Daily Air Temperature and Mean and Maximum Daily Stream Temperatures During Summer 2008 at Mayville Gulch (Site T87-08), Mendocino County, California.

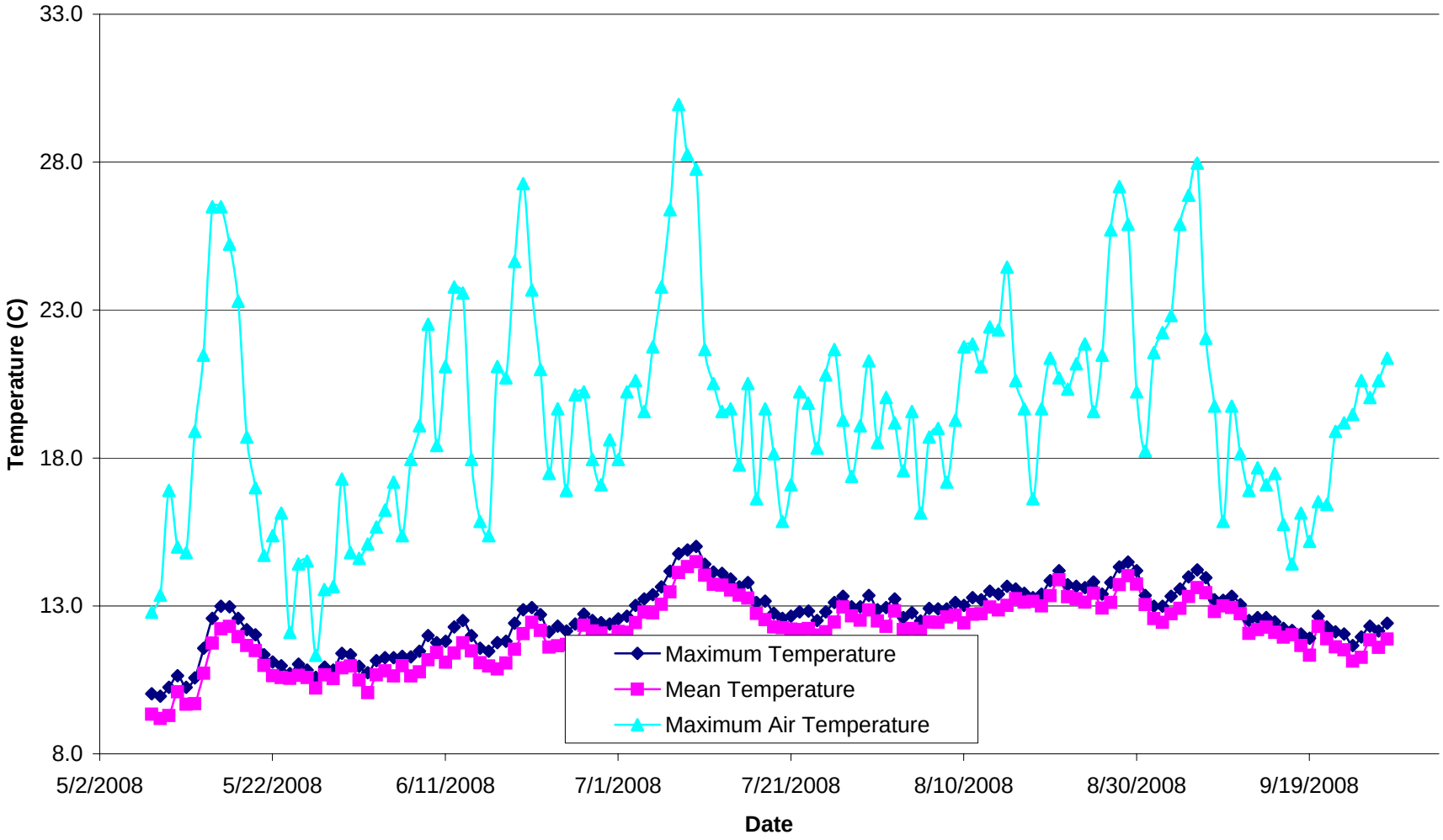


Figure T87-09. Maximum Daily Air Temperature and Mean and Maximum Daily Stream Temperatures During Summer 2008 at Unnamed Tributary to Elk (Site T87-09), Mendocino County, California.

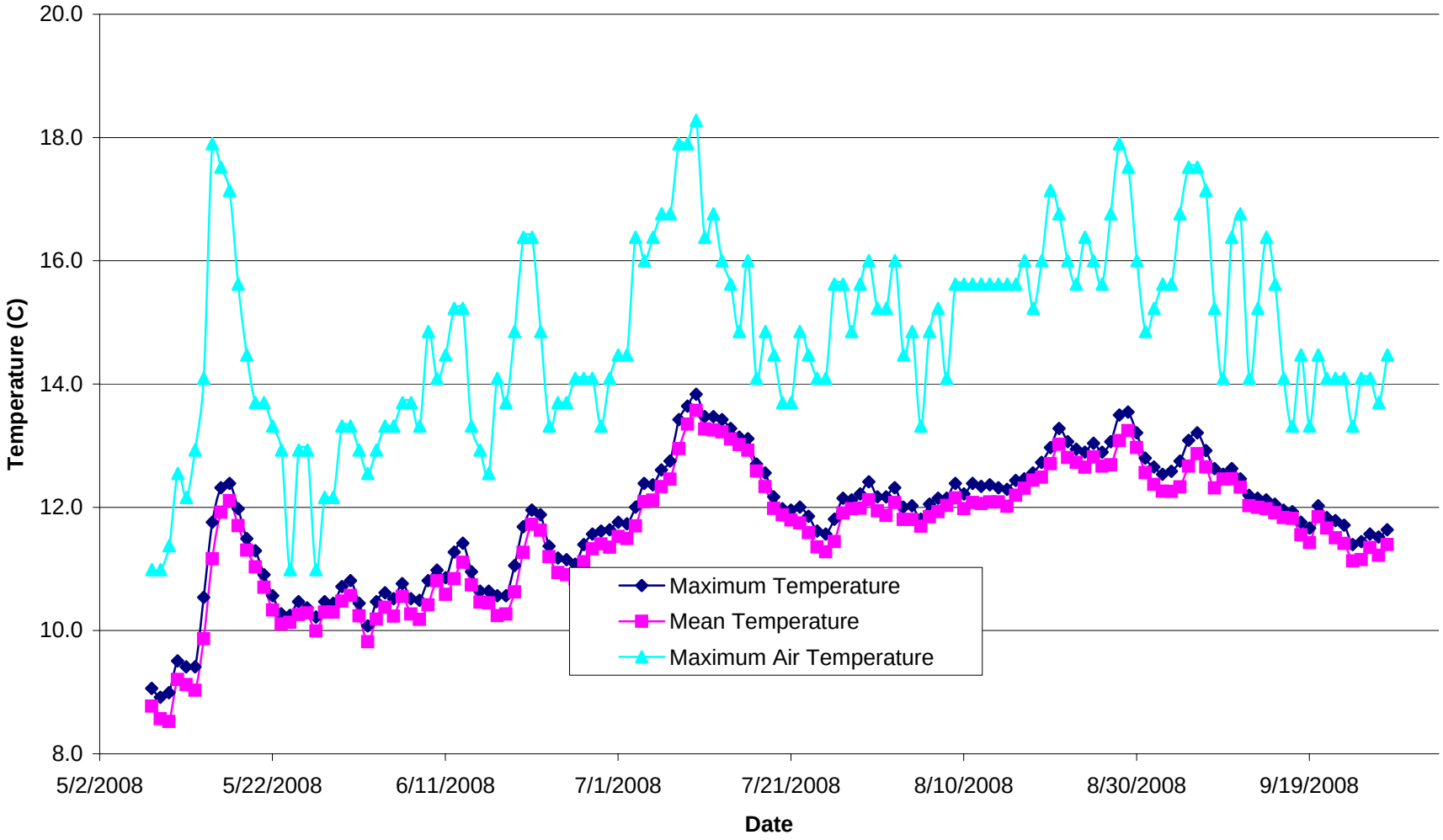
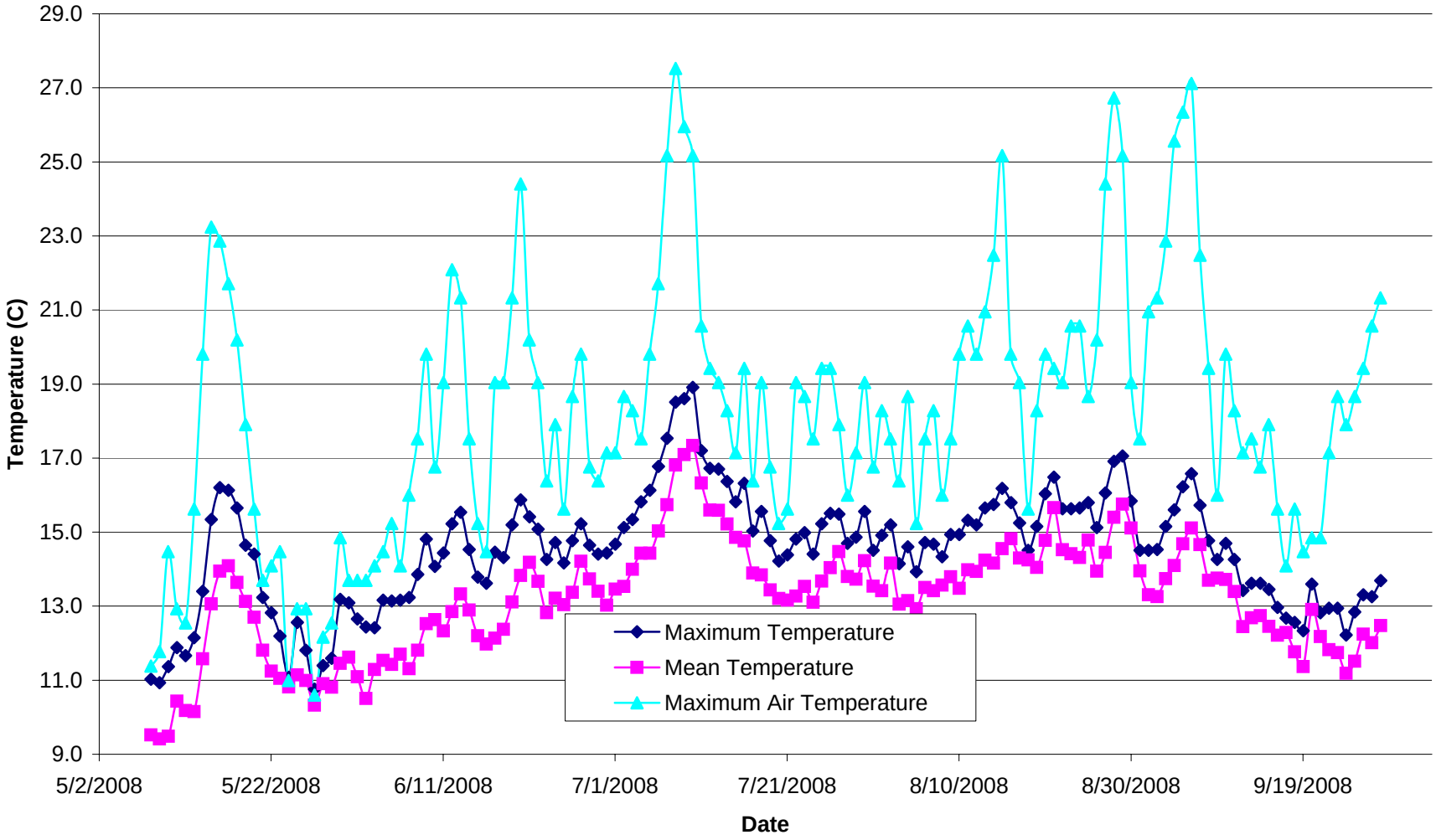
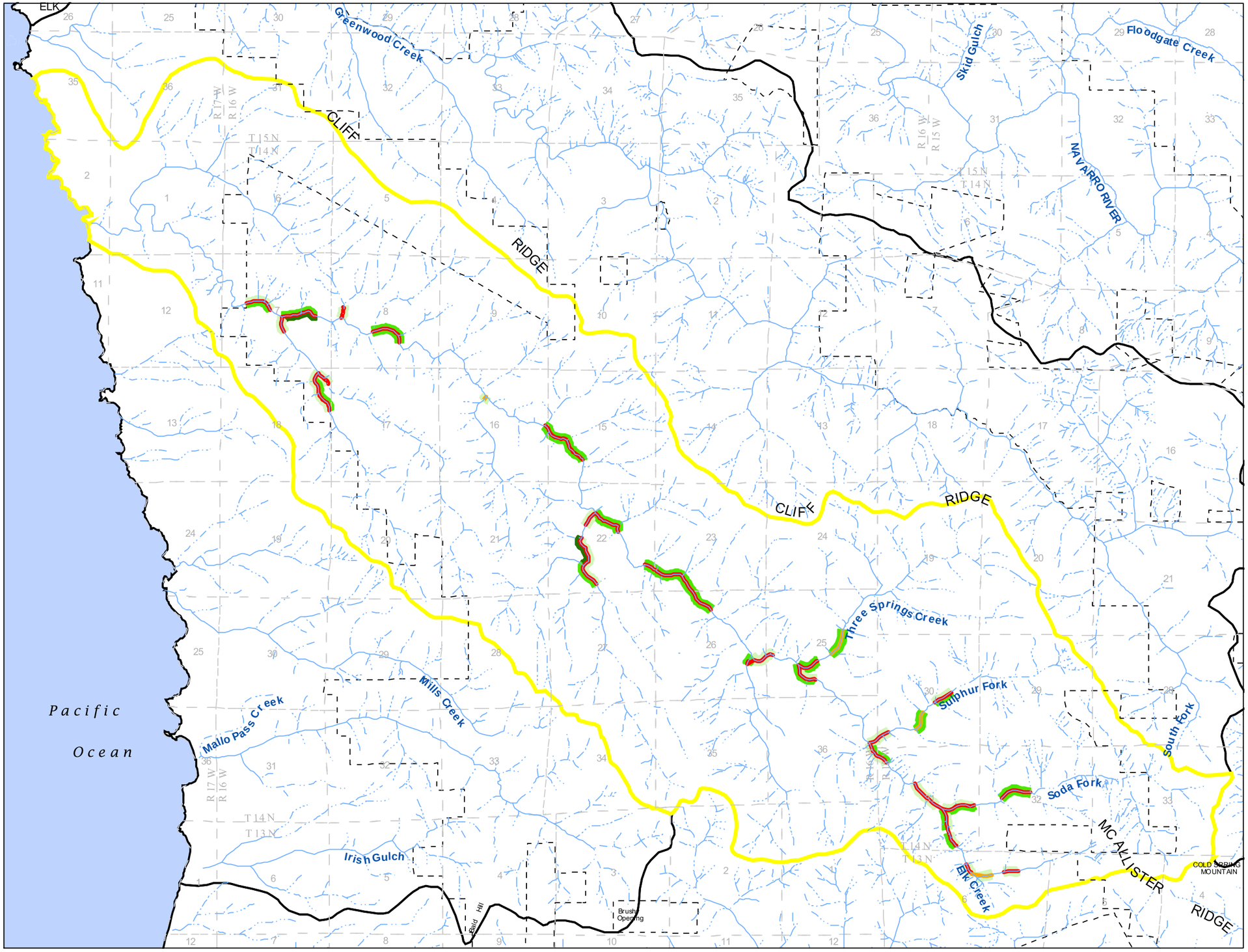


Figure T87-10. Maximum Daily Air Temperature and Mean and Maximum Daily Stream Temperatures During Summer 2008 at Sulphur Fork Creek (Site T87-10), Mendocino County, California.





Elk Creek Watershed Analysis Unit

Map D-1
Large Woody Debris Recruitment Potential and Demand

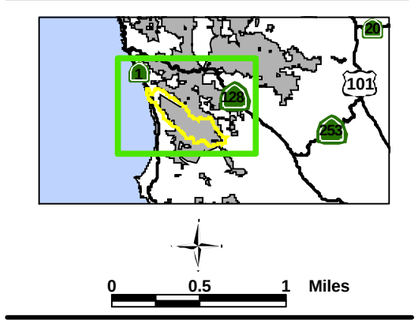
This map presents the large woody debris recruitment potential and in-stream large woody debris (LWD) demand for the streams on MRC lands in the Elk Creek WAU. This map provides baseline information on the structure and composition of the riparian stand and the level of concern about current LWD conditions in the stream. It is based on the stream-side stand characteristics, amount of LWD in the stream and the sensitivity of the stream channel to LWD from aerial photograph interpretation of 2004 photographs and field observations in 2005. This map provides a tool for prioritizing riparian and stream management for improving LWD recruitment and in-stream LWD.

LWD Recruitment Potential Classes
- High
- Moderate
- Low

Instream LWD Demand
- High
- Moderate
- Low

- MRC Ownership
- Planning Watershed Boundary
- Elk Creek Watershed Analysis Unit Boundary

Flow Class
- Class I
- Class II
- Class III



November 2005

Elk Creek Watershed Analysis Unit

Map D-2
Stream Canopy Classification and Temperature Monitoring Locations

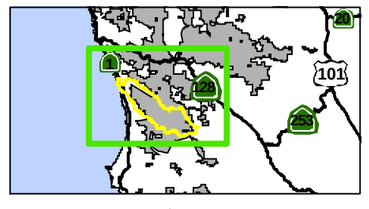
This map presents the canopy closure, over watercourses, for streams and rivers within the MRC ownership in the Elk Creek WAU. The canopy was estimated for four canopy closure classes from 2004 aerial photographs and 2005 field observations. The location of stream temperature monitored locations is also presented, these locations are monitoring each year during summer.

Stream Canopy Classes
- > 90%
- 70-90%
- 40-70%
- 0-40%

Temperature Monitoring Locations

- MRC Ownership
- Planning Watershed Boundary
- Elk Creek Watershed Analysis Unit Boundary

Flow Class
- Class I
- Class II
- Class III



0 0.5 1 Miles

November 2005