Stream Inventory Report

Hare Creek

September 1999

Jackson Demonstration State Forest
Mendocino County

California Department of Fish and Game

Northern California and North Coast Region
Fortuna, California

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INTRODUCTION

Habitat inventories conducted by the California Department of Fish and Game (DFG) of the west end streams in Jackson Demonstration State Forest (JSDF) have repeatedly revealed them to possess a high percentage of canopy cover and generally well-vegetated stream banks. However, their pools are often shallow and there is generally very little large woody debris (LWD) in the channel. It is believed that the addition of large woody material to stream channels could produce higher habitat quality in these streams for anadromous fish. Enhanced juvenile rearing and over-winter holding areas should improve the survival of juvenile anadromous fish to their smolt stage. However, little information currently exists regarding the physical response of the stream channel and the biological response of juvenile anadromous fish to the addition of LWD to California streams. Because LWD placement projects offer the possibility to increase salmon and steelhead productivity in California streams, and thereby aid in the recovery effort for these species, the California Department of Forestry and Fire Protection (CDF) and DFG have agreed that sections in two streams in the Jackson Demonstration State Forest, Caspar Creek and Hare Creek, Mendocino County, should be treated with a LWD placement project in conjunction with a pre- and post-project monitoring project to assess the physical and biological response to these projects. Habitat inventories and field inspections suggested that Caspar Creek, from the western boundary of Jackson Demonstration State Forest to the confluence of North Fork Caspar Creek, and Hare Creek, from Covington Gulch to Bunker Gulch, would benefit from the addition of LWD to their channels.

This report describes the findings of the a stream inventory conducted in Hare Creek on September 8, 9 and 10, 1999. The objectives of the inventory were to: 1) document the current habitat conditions in order to provide data for a comparison of habitat conditions in the LWD Project reach before and after the addition of the woody material to the stream channel, and 2) recommend options for the potential enhancement or maintenance of habitat for coho salmon and steelhead. Recommendations for habitat improvement activities are based upon target habitat values suitable for salmonids in California's north coast streams.

Annual biological inventories are also conducted in Hare Creek by the California Department of Fish

and Game (DFG). The objectives of these inventories are to: 1) to document the relative abundance of juvenile salmonids in four index reaches during the late summer-early fall period, and 2) to obtain a measure of relative juvenile salmonid outmigrant during the spring. This information will also be used to help assess the response to the LWD placement project.

WATERSHED OVERVIEW

Hare Creek is a tributary to the Pacific Ocean, located in Mendocino County, California (Map 1). Hare Creek's legal description at the confluence with Pacific Ocean is T18N R18W S13. Its location is 39E25'02" north latitude and 123E48'42" west longitude. Hare Creek is a second order stream, and has approximately 10.7 miles of blue line stream, including tributaries, according to the USGS Fort Bragg, CA 7.5 minute quadrangle. Hare Creek drains a watershed of approximately 10 square miles. Elevations range from 0 feet at Pacific Ocean to approximately 1,000 feet in the headwater areas. Redwood/Douglas fir forest dominates the watershed. The watershed is primarily state owned by the California Department of Forestry and Fire Protection (CDF) as part of the Jackson Demonstration State Forest and is managed for timber production. Vehicle access exists via Highway 1, CDF Road 400, and Highway 20.

METHODS

The stream inventory was conducted in a continuous reach of Hare Creek beginning at the confluence with Covington Gulch and extending upstream to the confluence with Bunker Gulch. This reach was described by a DFG 1995 stream inventory as an F4 channel type with a bankfull width of 28.5 ft. The 1999 survey reach included a section of stream upstream of the proposed LWD Placement Project reach (control section) and the section through the LWD Placement Project reach (treatment section). Results contained in this report pertain to the entire stream reach surveyed. Results for the control and treatment section will be dealt with in subsequent reports.

The habitat inventory conducted in Hare Creek follows the methodology presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al, 1998). The Watershed Stewards Project/AmeriCorps (WSP/AmeriCorps) Members that conducted the inventory were trained in standardized habitat inventory methods by the California Department of Fish and Game (DFG). This inventory was conducted by a two-person team.

SAMPLING STRATEGY

The inventory uses a method that samples approximately 10% of the habitat units within the survey reach. All habitat units included in the survey are classified according to habitat type and their lengths

are measured. All pool units are measured for maximum depth, depth of pool tail crest (measured in the thalweg), dominant substrate composing the pool tail crest, and embeddedness. Habitat unit types encountered for the first time are measured for all the parameters and characteristics on the field form. Additionally, from the ten habitat units on each field form page, one is randomly selected for complete measurement.

HABITAT INVENTORY COMPONENTS

A standardized habitat inventory form has been developed for use in California stream surveys and can be found in the *California Salmonid Stream Habitat Restoration Manual*. This form was used in Hare Creek to record measurements and observations. There are nine components to the inventory form.

1. Flow:

Flow is measured in cubic feet per second (cfs) at the bottom of the stream survey reach using a Marsh-McBirney Model 2000 flow meter.

2. Channel Type:

Channel typing is conducted according to the classification system developed and revised by David Rosgen (1985 rev. 1994). This methodology is described in the *California Salmonid Stream Habitat Restoration Manual*. There are five measured parameters used to determine channel type: 1) water slope gradient, 2) entrenchment, 3) width/depth ratio, 4) substrate composition, and 5) sinuosity. Channel characteristics are measured using a clinometer, hand level, hip chain, tape measure, and a stadia rod.

3. Temperatures:

Both water and air temperatures are measured and recorded at every tenth habitat unit. The time of the measurement is also recorded. Both temperatures are taken in degrees Fahrenheit at the middle of the habitat unit and within one foot of the water surface.

4. Habitat Type:

Habitat typing uses the 24 habitat classification types defined by McCain and others (1988). Habitat units are numbered sequentially and assigned a type identification number selected from a standard list of 24 habitat types. Dewatered units are labeled "dry". Hare Creek habitat typing used standard basin level measurement criteria. These parameters require that the minimum length of a described habitat unit must be equal to or greater than the stream's mean wetted width. All measurements are in feet to

the nearest tenth. Habitat characteristics were measured using a clinometer, hip chain, and stadia rod.

5. Embeddedness:

The depth of embeddedness of the cobbles in pool tail-out areas is measured by the percent of the cobble that is surrounded or buried by fine sediment. In Hare Creek, embeddedness was ocularly estimated. The values were recorded using the following ranges: 0 - 25% (value 1), 26 - 50% (value 2), 51 - 75% (value 3), and 76 - 100% (value 4). Additionally, a value of 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate particle size, a bedrock tail-out, or other considerations.

6. Shelter Rating:

Instream shelter is composed of those elements within a stream channel that provide salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition. The shelter rating is calculated for each fully-described habitat unit by multiplying shelter value and percent cover. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered is made. All cover is then classified according to a list of nine cover types. In Hare Creek, a standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) was assigned according to the complexity of the cover. Thus, shelter ratings can range from 0-300 and are expressed as mean values by habitat types within a stream.

7. Substrate Composition:

Substrate composition ranges from silt/clay sized particles to boulders and bedrock elements. In all fully-described habitat units, dominant and sub-dominant substrate elements were ocularly estimated using a list of seven size classes and recorded as a one and two, respectively. In addition, the dominant substrate composing the pool tail-outs is recorded for each pool.

8. Canopy:

Stream canopy density was estimated using modified handheld spherical densiometers as described in the *California Salmonid Stream Habitat Restoration Manual*. Canopy density relates to the amount of stream shaded from the sun. In Hare Creek, an estimate of the percentage of the habitat unit covered by canopy was made from the center of approximately every third unit in addition to every fully-described unit, giving an approximate 30% sub-sample. In addition, the area of canopy was estimated ocularly into percentages of coniferous or deciduous trees.

9. Bank Composition and Vegetation:

Bank composition elements range from bedrock to bare soil. However, the stream banks are usually covered with grass, brush, or trees. These factors influence the ability of stream banks to withstand winter flows. In Hare Creek, the dominant composition type and the dominant vegetation type of both the right and left banks for each fully-described unit were selected from the habitat inventory form. Additionally, the percent of each bank covered by vegetation (including downed trees, logs, and rootwads) was estimated and recorded.

BIOLOGICAL INVENTORY

Biological sampling during the stream inventory is used to determine fish species and their distribution in the stream. Fish presence was observed from the stream banks in Hare Creek, and four sites were electrofished using a Smith-Root Model 12 electrofisher. These sampling techniques are discussed in the *California Salmonid Stream Habitat Restoration Manual*.

LARGE WOODY DEBRIS (LWD) STREAM AND RIPARIAN INVENTORY

In Hare Creek, a large woody debris (LWD) stream and riparian inventory was conducted using the methodology as described in the *California Salmonid Stream Habitat Restoration Manual*. Data from the LWD Inventory Form are entered into a dBASE 4.2 data entry program developed by Inland Fisheries Division, California Department of Fish and Game. The Hare Creek LWD Inventory Report is included in this report as Appendix A.

DATA ANALYSIS

Data from the habitat inventory form are entered into Habitat, a dBASE 4.2 data entry program developed by Tim Curtis, Inland Fisheries Division, California Department of Fish and Game. This program processes and summarizes the data, and produces the following six tables:

- Riffle, flatwater, and pool habitat types
- Habitat types and measured parameters
- Pool types
- Maximum pool depths by habitat types
- Dominant substrates by habitat types
- Mean percent shelter by habitat types

Graphics are produced from the tables using Quattro Pro. Graphics developed for Hare Creek include:

- Riffle, flatwater, pool habitats by percent occurrence
- Riffle, flatwater, pool habitats by total length
- Total habitat types by percent occurrence
- Pool types by percent occurrence
- Total pools by maximum depths
- Embeddedness
- Pool cover by cover type
- Dominant substrate in the pool tail outs
- Mean percent canopy
- Bank composition by composition type
- Bank vegetation by vegetation type

HABITAT INVENTORY RESULTS

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of September 8, 9, and 10, 1999, was conducted by Toni Beaumont and Chris Ramsey (WSP/AmeriCorps). The total length of the stream surveyed was 19,897 feet.

Flow was measured at the bottom of the survey reach with a Marsh-McBirney Model 2000 flowmeter at 2.35 cfs on September 8, 1999.

Hare Creek is an F4 channel type for the entire 19,897 feet of stream reach surveyed. F4 channels are entrenched, meandering, riffle/pool channels with low gradients, high width/depth ratios, and gravel-dominant substrates.

Water temperatures taken during the survey period ranged from 53 to 58 degrees Fahrenheit. Air temperatures ranged from 56 to 71 degrees Fahrenheit.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 20% riffle units, 25% flatwater units, and 55% pool units (Graph 1). Based on total length of Level II habitat types there were 11% riffle units, 30% flatwater units, and 59% pool units (Graph 2).

Thirteen Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were low gradient riffles, 20%; runs, 20%; lateral scour pools - bedrock formed, 18%; lateral scour pools - log enhanced, 16%; and mid-channel pools, 12% (Graph 3). Based on percent total length, runs made up 23%; lateral scour pools - bedrock formed, 22%; lateral scour pools - log enhanced, 16%, mid-channel pools, 15%; and low gradient riffles, 10%.

A total of 176 pools were identified (Table 3). Scour pools were the most frequently encountered, at 77%, and comprised 74% of the total length of all pools. Main channel pools accounted for 23% of the pools encountered, and comprised 26% of the total length of all pools (Graph 4).

Table 4 is a summary of maximum pool depths by pool habitat types. In general pool quality for salmonids increases with depth. We found that 118 of the 176 pools (67%) had a depth of two feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 176 pool tail-outs measured, 25 had a value of 1 (14%); 81 had a value of 2 (46%); and 70 had a value of 5 (40%) (Graph 6). On this scale, a value of 1 indicates the highest quality of spawning substrate. The breakdown of dominant substrate composition for the 70 pool tail-outs that had an embeddedness value of 5 were as follows: 5.6% silt/clay/sand, 52.9% small gravel, 15.7% large cobble, 2.9% boulder, and 22.9% bedrock.

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Riffle habitat types had a mean shelter rating of 5, flatwater habitat types had a mean shelter rating of 6, and pool habitats had a mean shelter rating of 21 (Table 1). Of the pool types, the scour pools had the highest mean shelter rating, at 26. Main channel pools had a mean shelter rating of 9 (Table 3).

Table 5 summarizes mean percent cover by habitat type. Boulders were the dominant cover type in Hare Creek followed by bedrock ledges, large woody debris, and small woody debris. Graph 7 describes the pool cover in Hare Creek. Bedrock ledges are the dominant pool cover type followed by large woody debris, boulders, and small woody debris.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. Gravel was the dominant substrate observed in 75% of pool tail-outs while large cobble was the next most frequently observed substrate type at 8%.

The mean percent canopy density for the stream reach surveyed was 91% (Table 7). The mean percentages of deciduous and coniferous trees were 60% and 40%, respectively. Graph 9 describes the mean percent canopy in Hare Creek.

For the stream reach surveyed, the mean percent right bank vegetated was 88%. The mean percent left bank vegetated was 87% (Table 7). The dominant elements composing the structure of the stream banks consisted of 44% cobble/gravel, 26% sand/silt/clay, 27% bedrock, and 2% boulder (Graph 10). Coniferous trees were the dominant vegetation type observed in 80% of the units surveyed. Additionally, 11% of the units surveyed had deciduous trees as the dominant vegetation type, and 9% had brush as the dominant vegetation (Graph 11).

BIOLOGICAL INVENTORY RESULTS

Four sites were electrofished on September 21 and 22, 1999, in Hare Creek. The sites were sampled by Barry Collins (DFG), Don Rehberg and Paul Ferns (WSP\AmeriCorps). An abundance estimation by depletion electrofishing was employed in Hare Creek.

The first site sampled was approximately 2,414 feet upstream of the confluence with Covington Gulch. The site had an area of 3,880.8 square feet and a volume of 3,725 cubic feet. The total catch for three passes was 21 steelhead, 15 coho, 6 stickleback, 5 salamanders, 2 sculpin, 2 crayfish, and 1 lamprey.

The second site was approximately 7,614 feet upstream of the confluence with Covington Gulch. This site had an area of 3,586 square feet and a volume of 2,151.6 cubic feet. The total catch for three passes was 44 steelhead, 10 coho, 7 salamanders, 6 stickleback, 2 lamprey, and 1 crayfish.

The third site sampled was approximately 12,865 feet upstream of the confluence with Covington Gulch. The site had an area of 2,741.6 square feet and a volume of 2,028.8 cubic feet. The total catch for three passes was 40 steelhead, 3 coho, 9 salamanders, and 3 stickleback.

The fourth site sampled was approximately 15,760 feet above the confluence of Covington Gulch. The site had an area of 1,836.8 square feet and a volume of 979.6 cubic feet. The total catch for three passes was 38 steelhead, 7 salamanders, 2 coho, and 1 stickleback.

DISCUSSION

Hare Creek is an F4 channel type for the entire 19,897 feet of stream reach surveyed. The suitability of fish habitat improvement structures in F4 channels is as follows: good for bank-placed boulders; fair for plunge weirs, single and opposing wing deflectors, channel constrictors, and log cover; and poor for boulder clusters.

Air temperatures ranged from 56 to 71 degrees Fahrenheit. The water temperatures recorded on the survey days of September 8-10, 1999 ranged from 53 to 58 degrees Fahrenheit. This is considered a good water temperature range for salmonids. To make any further conclusions, temperatures would need to be monitored throughout the warm summer months, and more extensive biological sampling would need to be conducted.

Pool habitat types comprised 59% of the total length of this survey, flatwater 30%, and riffles 11%. One-hundred-eighteen of the 176 (67%) pools had a maximum depth greater than 2 feet. In general, pool enhancement projects are considered when primary pools comprise less than 40% of the length of total stream habitat. In first and second order streams, a primary pool is defined to have a maximum

depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel width.

Twenty-five of the pool tail-outs measured had an embeddedness rating of 1; 81 of the 176 tail-outs measured had embeddedness ratings of 2. A total of 70 of the pool tail-outs had a rating of 5, which is considered unsuitable for spawning. Thirty-seven of these 70 units were judged to be unsuitable for spawning because the dominant substrate consisted of small gravel. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered to indicate good quality spawning substrate for salmon and steelhead. Sediment sources in Hare Creek should be mapped and rated according to their potential sediment yields and control measures should be taken.

One-hundred-forty-four of the 176 pool tail-outs measured had gravel or small cobble as their dominant substrate. However, 21% of the gravel in the measured pool tail-outs was considered too small to be suitable for spawning salmonids.

The shelter rating in the flatwater habitats was 6. The mean shelter rating for pools was 21. A pool shelter rating of approximately 100 is desirable. The relatively small amount of cover that now exists is being provided primarily by boulders, bedrock ledges, large woody debris, and small woody debris. Log and root wad cover structure in the pool and flatwater habitats would enhance both summer and winter salmonid habitat. Log cover structure provides rearing fry with protection from predation, rest from water velocity, and also divides territorial units to reduce density related competition.

The mean percent canopy density for the stream was 91%. In general, revegetation projects are considered when canopy density is less than 80%. The percentage of right and left bank covered with vegetation was 88% and 87%, respectively.

RECOMMENDATIONS

1) Hare Creek should be managed as an anadromous, natural production stream.

2) The limited water temperature data available suggest that maximum temperatures are within the acceptable range for juvenile salmonids. To establish more complete and meaningful temperature regime information, 24-hour monitoring during the July and August temperature extreme period should be performed for 3 to 5 years.

3) Increase large wood component in the pools and flatwater habitat units. Most of the existing cover is from boulders. Adding high quality complexity with woody cover is desirable.

4) Active and potential sediment sources related to the road system need to be identified, mapped, and treated according to their potential for sediment yield to the stream and its tributaries.

COMMENTS AND LANDMARKS

The following landmarks and possible problem sites were noted. All distances are approximate and taken from the beginning of the survey reach. Right and left bank refers to the sides of the channel when one is facing downstream.

0'	Begin survey at confluence with Covington Gulch (approximately 19,047 feet above the mouth of Hare Creek). Channel type is F4.
80'	Six foot diameter pipe.
114'	Flagged six foot diameter pipe.
321'	Old road bed on right bank.
510'	Log debris accumulation on right bank, 10' long x 10' wide.
515'	Left bank failure.
643'	Left bank failure, 20' long x 10' high.
1,008'	Root wad in creek.
1,061'	Left bank tributary, high gradient, bedrock dominant, 56 degrees Fahrenheit water temperature.
1,128'	Log debris accumulation, 50' wide x 45' long x 10' high, retaining sediment. Accumulation contains 30 pieces of wood, including a root wad.
1,398'	Right bank failure recruited rootwad into the creek.
1,565'	California Conservation Corps habitat survey, 1995 flag, #338.
1,570'	Right bank tributary, left bank failure, 7' high.
1,666'	Right bank failure, 15' long x 10' high.
2,330'	Log debris accumulation, 20' wide x 10' long x 5' high, retaining sediment and gravel.
2,414'	First electrofishing site.
2,686'	Trail to road crosses creek.
2,797'	Left bank tributary, 55 degrees Fahrenheit water temperature.
2,826'	Bridge posts, old crossing, and bridge abutment.
2,966'	Right bank tributary enters through culvert.
3,067'	Road paralleling right bank.
3,033'	Left bank wood structure, part of old crossing.
3,056'	Right bank wood structure, part of old crossing.
3,153'	California Conservation Corps habitat survey, 1995 flag, #363.

3,205'	Turtle survey flag.
3,222'	Left bank failure, 15' high x 10' wide.
3,424'	Left bank failure including trees and root wad fallen into creek.
3,570'	Start of unanchored large woody debris recruitment/survey.
3,607'	Unanchored large woody debris and left bank failure.
3,633'	Log debris accumulation, 20' long x 30' wide x 7' high, containing 30 pieces of large woody debris.
3,668'	Culvert 8' up right bank, 1.5' diameter pipe.
3,729'	Sediment aggradation on right bank caused by previous debris accumulation.
3,864'	Right bank failure.
4,012'	Ephemeral right bank tributary.
4,132'	Right bank tributary enters from 1.5' culvert. Rip-rap is below culvert outlet to stabilize bank.
4,365'	Right bank failure.
4,481'	Right bank tributary, flowing out of 1.5 ' culvert, 20' above creek, 59 degrees Fahrenheit water temperature.
4,484'	Right bank failure influenced by tributary.
4,551'	Log debris accumulation, 20' long, mostly buried, retaining 3' sediment.
4,755'	Left bank failure, including downed tree and root wad.
5,096'	Right bank tributary, flowing from 1.5' diameter culvert 5' above creek.
5,262'	Right bank failure, 10' high x 10' long.
5,383'	Right bank tributary, flowing from 1.5' diameter culvert 4' above creek; Rip-rap below culvert.
5,533'	Right bank failure, 15' long x 15' high.
5,686'	Ephemeral tributary, culvert 6' above creek.
5,884'	Left bank tributary/spring.
5,949'	Right bank failure, 10' long x 15' high.
6,048'	Left bank tributary, high gradient and bedrock dominated, 54 degrees Fahrenheit water temperature.
6,138'	Unanchored large woody debris.
6,178'	Unanchored large woody debris.
6,265'	Unanchored large woody debris.
6,425'	Unanchored large woody debris.
6,545'	Unanchored large woody debris.
6,631'	Unanchored large woody debris.
6,658'	Unanchored large woody debris.
6,760'	Right bank tributary enters from culvert.
6,865'	Unanchored large woody debris.
6,869'	Unanchored large woody debris.
6,928'	Unanchored large woody debris.

6,956'	Right bank failure.
7,007'	Right bank tributary, 54 degrees Fahrenheit water temperature.
7,065'	Old posts in creek.
7,160'	Unanchored large woody debris.
7,290'	Unanchored large woody debris.
7,304'	Unanchored large woody debris.
7,329'	Unanchored large woody debris.
7,349'	Unanchored large woody debris.
7,380'	Left bank tributary, 54 degrees Fahrenheit water temperature; right bank tributary flowing from 1.5' diameter culvert 6' above creek. Rip-rap is at bottom of culvert.
7,395'	Unanchored large woody debris.
7,445'	Wood structure, 30' long x 10' high.
7,465'	Unanchored large woody debris.
7,597'	Unanchored large woody debris.
7,640'	Unanchored large woody debris.
7,698'	Unanchored large woody debris.
7,714'	Second electrofishing site.
7,721'	Unanchored large woody debris.
7,737'	Unanchored large woody debris.
7,854'	Left bank tributary.
7,917'	Ephemeral left bank tributary.
7,975'	Unanchored large woody debris.
8,025'	Unanchored large woody debris.
8,091'	Habitat survey flag, CCC 1995, #447.
8,458'	Old bridge posts.
8,581'	Log retaining 2' sediment.
8,872'	Rip-rap, 10' long.
8,894'	Right bank failure.
9,077'	Left bank failure, 40' long x 15' high.
9,117'	Habitat survey flag, CCC 1995, #457.
9,216'	Left bank tributary, 54 degrees Fahrenheit water temperature.
9,324'	Right bank wood structure failure, 20' long.
9,344'	Right bank rip-rap, 37' long.
9,381'	Left bank structure on top of bedrock, 35' long.
9,464'	Timber harvest boundary flag on left bank.
9,572'	Right bank tributary flowing from 1.5' diameter culvert 10' above creek. Log debris accumulation, 60' wide x 25' long x 10' high, containing 10 large pieces of wood, retaining sediment 3-4' high for approximately 150' upstream.
9,804'	Right bank wood structure, 35' long.
10,106'	Habitat survey flag, CCC 1995, #476.

10,131'	Left bank failure, 20' long x 20' high.
10,164'	Left bank failure, 10' high x 10' long.
10,547'	Rip-rap, 20' long.
11,037'	Right bank failure, 10' high x 10' long.
11,211'	Left bank failure, 25' high x 10 long.
12,028'	Right bank tributary, 56 degrees Fahrenheit water temperature.
12,133'	Left bank failure, 20' long x 16' high.
12,243'	Right bank failure, 50' long.
12,418'	Wood structures on right bank.
12,632'	Right bank failure, 25' high x 15' wide.
12,680'	Right bank tributary, 59 degrees Fahrenheit water temperature.
12,856'	Right bank failure, 20' long x 15' high.
12,865'	Third electrofishing site.
13,041'	Culvert, 1.5' diameter, 10' above creek.
13,227'	Right bank failure recruiting tree/root wad into creek.
13,551'	Right bank failure, 20' long x 10' high.
13,647'	Right bank failure, 16' long x 10' high.
13,768'	Old 2.5' diameter culvert in creek.
14,645'	Rusted 2.5' diameter culvert in creek.
14,756'	End of unanchored large woody debris recruitment/survey.
14,849'	Right bank tributary, 55 degrees Fahrenheit water temperature; small dams placed every 10'.
14,931'	Left bank erosion.
15,017'	Right bank failure, 30' high x 15' long.
15,144'	Bridge, 15' wide x 10' high.
15,455'	Right bank failure including tree/root wad.
15,656'	Pink and blue flagging for next 1,200'.
15,760'	Fourth electrofishing site.
15,857'	Left bank tributary, 54 degrees Fahrenheit water temperature, contributing sediment.
15,981'	Old crossing posts.
16,223'	Habitat survey flag, CCC 1995, #592.
16,304'	Right bank tributary coming from 6" half culvert.
16,919'	Posts from old structure, logs at top of unit retaining sediment and gravel.
17,129'	Timber Harvest Boundary, pink flagging on left bank.
17,205'	Road parallels right bank.
17,925'	Right bank culvert, 1.5' diameter, 8' above creek.
18,491'	Confluence with South Fork Hare Creek, 55 degrees Fahrenheit water temperature.
18,628'	Right bank failure.

18,774'	Habitat survey flag, CCC 1995, #636.
18,948'	Log debris accumulation, 48' wide x 20' long x 5' high, with associated left bank failure, 17' long x 20' high.
19,048'	Right bank, 1.5' diameter culvert, 15' above creek with rip-rap below.
19,897'	End of survey at the confluence with Bunker Gulch. This corresponds with the CCC 1995 end of survey, habitat unit #658.

REFERENCES

Flosi, G., Downie, S., Hopelain, J., Bird, M., Coey R., and Collins, B. 1998. *California Salmonid Stream Habitat Restoration Manual*, 3rd edition. California Department of Fish and Game, Sacramento, California.

LEVEL III and LEVEL IV HABITAT TYPES

RIFFLE					
Low Gradient Riffle	(LGR)	[1.1]		{ 1}	
High Gradient Riffle	(HGR)	[1.2]		{ 2}	
CASCADE					
Cascade	(CAS)	[2.1]		{ 3}	
Bedrock Sheet	(BRS)	[2.2]		{24}	
FLATWATER					
Pocket Water	(POW)		[3.1]		{21}
Glide	(GLD)	[3.2]		{14}	
Run	(RUN)	[3.3]		{15}	
Step Run	(SRN)	[3.4]		{16}	
Edgewater	(EDW)		[3.5]		{18}
MAIN CHANNEL POOLS					
Trench Pool	(TRP)	[4.1]		{ 8}	
Mid-Channel Pool	(MCP)		[4.2]		{17}
Channel Confluence Pool	(CCP)	[4.3]		{19}	
Step Pool	(STP)	[4.4]		{23}	
SCOUR POOLS					
Corner Pool	(CRP)	[5.1]		{22}	
Lateral Scour Pool - Log Enhanced	(LSL)	[5.2]		{10}	
Lateral Scour Pool - Root Wad Enhanced	(LSR)	[5.3]		{11}	
Lateral Scour Pool - Bedrock Formed	(LSBk)	[5.4]		{12}	
Lateral Scour Pool - Boulder Formed	(LSBo)	[5.5]		{20}	
Plunge Pool	(PLP)	[5.6]		{ 9}	
BACKWATER POOLS					
Secondary Channel Pool	(SCP)	[6.1]		{ 4}	
Backwater Pool - Boulder Formed	(BPB)	[6.2]		{ 5}	
Backwater Pool - Root Wad Formed	(BPR)	[6.3]		{ 6}	
Backwater Pool - Log Formed	(BPL)	[6.4]		{ 7}	
Dammed Pool	(DPL)	[6.5]		{13}	
ADDITIONAL UNIT DESIGNATIONS					
Dry	(DRY)	[7.0]			
Culvert	(CUL)	[8.0]			
Not Surveyed	(NS)	[9.0]			

Not Surveyed due to a marsh (MAR) [9.1]

Appendix A

California Department of Fish and Game
Northern California and North Coast Region

Large Woody Debris (LWD) Riparian Inventory

Hare Creek Drainage
Jackson Demonstration State Forest
Mendocino County
September 1999

BACKGROUND

The importance of large woody debris (LWD) in the development of a stream's morphological and biological productivity has been well documented over the last 20 years. It strongly influences stream habitat characteristics and biotic composition. Large woody debris is often the structural element associated with pool formation and is considered one of the major elements that create complex fish habitat vital for juvenile salmonid survival. Habitat complexity is particularly important for coho salmon and steelhead trout juveniles because these salmonids remain in the stream for at least one year before migrating to the ocean.

Large woody debris inventories describe the present relative abundance of LWD elements providing, or with the potential to provide, fish habitat within the stream channel. Large woody debris inventories also describe the relative abundance of "recruitable" LWD. Recruitable LWD is the large wood existing out of the stream channel that has a high potential of entering the stream channel in the future.

METHODS

Prior to conducting the LWD inventory, the stream reach was habitat- and stream channel-typed employing the methods described by Flosi, et al (1998). The LWD survey reach began at the confluence with Covington Gulch (approximately 19,047 feet above the mouth of Hare Creek) and extended upstream 3.8 miles to the confluence with Bunker Gulch. The survey area was divided into three LWD inventory reaches, all within the F4 channel type, corresponding with 3 management treatments. Reach 1 begins at the confluence with Covington Gulch and extends upstream 3, 570 feet; with no added wood treatment. Reach 2 continues upstream 11,186 feet; with an added wood treatment. Reach 3 continues upstream another 5,141 feet; with no added wood treatment.

Large woody debris inventory methods, data recording forms, and database structure for this inventory are described in Flosi, et al (1998). Large woody debris minimum size criteria was 12 inches in diameter and 6 feet in length. Root wads had the 12-inch minimum diameter criteria but had no minimum length requirement. Diameter and length categories consisted of the following:

Diameter Category	Length Category
1. 1-2 feet	1. 6 to 20 feet
2. 2-3 feet	2. Over 20 feet
3. 3-4 feet	
4. Over 4 feet	

Condition or status categories included:

a) dead and down
b) dead and standing
c) perched for imminent delivery to the stream channel
d) live coniferous trees
e) live broadleaf trees (a.k.a. deciduous)

The sampling strategy consisted of selecting a random starting point near the beginning of the LWD survey reach, and then systematically sampling 200 foot sections out of every 1,000 feet of stream length surveyed. The first 1,200 feet of stream was segmented into 200-foot sections and consecutively numbered 1 through 6. One of these six 200 foot sections was randomly selected as the beginning of the *first* sample section (6). After conducting the inventory survey in the initial 200 foot section, surveyors proceeded upstream 800 feet and surveyed the next 200 feet as the *second* sample section. The *third* sample section began 800 feet upstream of the end of the second sample section and the next 200 feet were surveyed, and so on. Systematic sampling continued upstream until the end of the LWD survey reach. This method produced a sampling level of approximately 20 percent.

Inventory data from the 200 foot sample sections were separated into 3 reach numbers. A LWD abundance index expressed as “number of pieces per 100 feet” was calculated for each reach.

RESULTS

ALL TABLES AND FIGURES ARE LOCATED AT THE END OF THE REPORT

The Hare Creek section surveyed consisted of one F4 channel type and was divided into 3 reaches. The reaches were divided in order to evaluate three different management schemes; no added wood in lowest reach (Reach 1), added wood in the middle reach (Reach 2), and no added wood in the

upstream reach (Reach 3).

Reach 1 (no added wood treatment) extended 3,570 feet upstream of Covington Gulch. This reach contained 16.8 pieces of LWD on both the right and left banks per 100 linear feet of stream (TABLE 1). In descending proportions, the condition of the pieces were 57% live coniferous, 17% dead and down, 14% live broadleaf, 11% dead and standing, and 1% perched. Within the bankfull channel, Reach 1 contained 9.7 pieces of LWD per 100 linear feet of stream. The conditions of the pieces were 98% dead and down and 2% live coniferous. The total number of pieces per 100 linear feet for both the banks and the bankfull channel were 26.5, of which 47% were dead and down, 37% live coniferous, 9% live broadleaf, 7% dead and standing, and 1% perched. Of the pieces in Reach 1, 61% were in the LWD size category of 1 - 2 foot in diameter, 28% were in the 2 - 3 foot category, 7% were in the 3 - 4 foot category and, 5 % were in the > 4 foot category (FIGURE 1).

Reach 2 (wood added treatment) and extended 11,186 feet upstream of the end of Reach 1. This reach contained 21.3 pieces of LWD on both the right and left banks per 100 linear feet of stream (TABLE 1). In descending proportions, the condition of the pieces were 69% live coniferous, 11% dead and down, 9% perched, 7% live broadleaf, and 5% dead and standing. Within the bankfull channel, Reach 2 contained 5.3 pieces of LWD per 100 linear feet of stream. The conditions of the pieces were 95% dead and down, 4% live broadleaf, and 1% dead and standing. The total number of pieces for both the banks and the bankfull channel were 26.7, of which 55% were live coniferous, 28% dead and down, 7% perched, 6% live broadleaf, and 4% dead and standing. Of the pieces in Reach 2, 62% were in the LWD size category of 1 - 2 foot in diameter, 30% were in the 2 - 3 foot category, 7% were in the 3 - 4 foot category, and 1% were in the > 4 foot category (FIGURE 1).

Reach 3 (no added wood treatment) extended 5,141 feet upstream of the end of Reach 2. This reach contained 21.4 pieces of LWD on both the right and left banks per 100 linear feet of stream (TABLE 1). In descending proportions, the condition of the pieces were 74% live coniferous, 15% live broadleaf, 7% dead and down, 2% dead and standing, and 1% perched. Within the bankfull channel, Reach 3 contained 2.6 pieces of LWD per 100 linear feet of stream. The conditions of the pieces were 88% dead and down and 12% live broadleaf. The total number of pieces for both the banks and the bankfull channel were 24.0, of which 66% were live coniferous, 16% dead and down, 15% live broadleaf, 2% dead and standing, and 1% perched. Of the pieces in Reach 3, 77% were in the LWD size category of 1 - 2 foot in diameter, 18% in the 2 - 3 foot category, 3% in the 3 - 4 foot category, and 1% in the > 4 foot category (FIGURE 1).

For all three reaches combined, there was a total of 26 pieces of LWD per 100 linear feet of stream. The reaches were dominated by live coniferous trees (55%), followed by dead and down (27.71%), live broadleaf trees (8.8%), perched trees (4.5%), and dead and standing (3.9%).

DISCUSSION

In all three reaches, LWD on the banks was dominated by live coniferous trees, while dead and down LWD dominated in the stream. The 1 - 2 foot diameter size category was the most common for all LWD pieces in both the stream channel and bank zones.

The number of pieces of LWD per 100 linear feet on the banks of Reaches 2 and 3 were very similar at 21.3 and 31.4, respectively. On the banks of Reach 1, only 16.8 pieces of LWD were observed per100 linear feet of stream.

In the stream channel of Reach 1, we observed 9.5 pieces of dead and down LWD per 100 linear feet of stream. This was higher than in either Reach 2 or 3 (5.3 and 2.6, respectively). However, most of this wood was located in a single large debris accumulation (LDA), which contained 50 pieces of wood. If the wood in this LDA is removed from the analysis then value for the number of dead and down LWD in the stream channel of Reach 1 drops to 1.2 pieces/100 ft. This is similar, but slightly lower than in Reach 3 (2.3 pieces/100 ft), the other no wood added treatment section. In Reach 2, the added wood treatment section, we observed 5.1 pieces/100 ft in the stream channel, about twice the LWD loading in the no wood added treatment sections.

One goal of conducting LWD inventories is to provide data that, along with fish population and habitat type data, will enable resource managers to characterize the quality of available and potential fish habitat. Although, the relationship between the number, size, and type of LWD pieces per 100 feet, and quality of fish habitat has not been fully established, it is generally accepted that LWD in the stream channel plays a vital role in contributing to the quality of fish habitat. Large woody debris within the bank zone is the source for future instream LWD and addresses the issue of LWD recruitment to the stream channel. Information in this report will enable resource managers to identify areas lacking in LWD, subsequently leading to planning and prioritizing prescriptions for improvement. This information will also be useful in detecting changes in LWD relative abundance with relation to land use practices or riparian zone restoration programs.

TABLE 1. Summary of Large Woody Debris Inventory for Hare Creek, Mendocino County, California 1999.

STREAM	REACH	CHANNEL TYPE	TOTAL LENGTH	DEAD DOWN	DEAD STANDING	PERCHED	--LIVE TREES-- CONIFER	BROADLEAF	TOTAL
Number of pieces per 100 linear feet of stream out of channel on right and left banks									
Hare Creek	1	F4	3,570	2.8	1.8	0.2	9.7	2.3	16.8
Hare Creek	2	F4	11,186	2.3	1	1.8	14.7	1.5	21.3
Hare Creek	3	F4	5,141	1.6	0.4	0.3	15.8	3.3	21.4
Number of pieces per 100 linear feet of stream within the bankfull channel									
Hare Creek	1	F4	3,570	9.5 *	0		0.2	0	9.7
Hare Creek	2	F4	11,186	5.1	0		0	0.2	5.3
Hare Creek	3	F4	5,141	2.3	0		0	0.3	2.6
Number of pieces per 100 linear feet of stream out of channel on right and left banks and within the bankfull channel									
Hare Creek	1	F4	3,570	12.3	1.8	0.2	9.8	2.3	26.5
Hare Creek	2	F4	11,186	7.4	1.1	1.8	14.7	1.7	26.7
Hare Creek	3	F4	5,141	3.9	0.4	0.3	15.8	3.6	24
Percentage of LWD pieces found out of channel on right and left banks									
Hare Creek	1	F4	3,570	17%	11%	1%	57%	14%	100%
Hare Creek	2	F4	11,186	11%	5%	9%	69%	7%	100%
Hare Creek	3	F4	5,141	7%	2%	1%	74%	15%	100%
Percentage of LWD pieces found within the bankfull channel									
Hare Creek	1	F4	3,570	98%	0%	0%	2%	0%	100%
Hare Creek	2	F4	11,186	95%	1%	0%	0%	4%	100%
Hare Creek	3	F4	5,141	88%	0%	0%	0%	12%	100%
Percentage of LWD pieces found out of channel on right and left banks and within the bankfull channel									
Hare Creek	1	F4	3,570	47%	7%	1%	37%	9%	100%
Hare Creek	2	F4	11,186	28%	4%	7%	55%	6%	100%
Hare Creek	3	F4	5,141	16%	2%	1%	66%	15%	100%

* This value resulted from a single large debris accumulation (LDA) in the stream channel, containing 50 pieces, measuring 50'W x 10'Hx 25'L. Removing this LDA reduces this value to 1.2 pieces per 100 linear feet of stream.

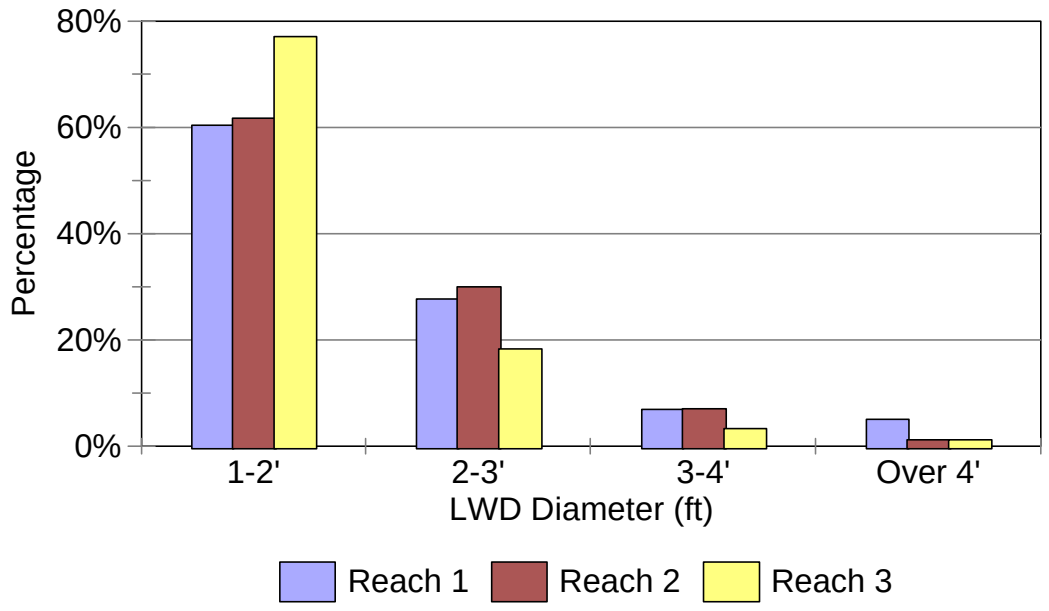

FIGURE 1. Percentage of LWD in each diameter size category found for each reach surveyed.