Central Coast Watershed Studies

CCoWS

Carmel River Large Woody Debris Inventory from Stonepine To Carmel Lagoon Fall 2003

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Preface

The following report documents the Fall 2003 locations and characteristics of large woody debris along the lower reach of the Carmel River in California, from Stonepine Bridge to the Carmel Lagoon. The report includes an ArcMap GIS project and electronic spreadsheets containing the data presented in the appendices to this report.

This report may be cited as:
Smith, D.P. and Huntington, P., 2004, Carmel River large woody debris inventory from Stonepine to Carmel Lagoon, Fall 2003: Watershed Institute, California State University Monterey Bay, Publication No. WI-2004-01, 72 pp.

A pilot study was completed in 2002:
Smith, D.P., Huntington, P, and Harter, K., 2003, Carmel River Large Woody Debris Inventory from San Clemente Dam to the Lagoon Fall 2002: Watershed Institute, California State University Monterey Bay, Publication No. WI-2003-13, 38 pp.

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1 Executive Summary

Large woody debris (LWD) in the Carmel River includes significant branches, trunks, and accumulations of dead wood lying in, or near, the active channel. LWD plays myriad roles in the life cycles of aquatic and terrestrial biota. Its utilization in the biosphere ranges from being a substrate for microbes to serving as shelter and resting places for western pond turtles *(Clemmys marmorata)* and Federally-threatened California red-legged frogs (*Rana aurora draytonii*) and endangered steelhead (*Oncorhynchus mykiss*). LWD is utilized by every level of the food chain from microbes to large predators; its typical occurrence, half submerged, half exposed, makes it an intersection between aquatic and terrestrial riparian habitats. LWD is also considered to be a factor in channel shape, bank stability, bridge safety, and aesthetics. Few studies have been undertaken to analyze the amount, location, and function of LWD in the rivers of central coastal California from the San Francisco Bay to Santa Barbara County.

We present the results of a comprehensive inventory of LWD on the lower Carmel River undertaken in summer and fall of 2003. The precise position of each piece of wood falling within the definition of LWD was recorded and plotted using GPS/GIS technology or was plotted using high resolution aerial photographs; each piece was then assessed in several ways to improve our understanding of the biological and physical function of wood in the river. These data are summarized in graphical and tabular format, and as GIS layers in an accompanying ArcMap 8 GIS project.

Our 2003 survey did not include the reach from Via Mallorca at River Mile (RM, measured from the ocean) 3.2 to the Carmel Lagoon (RM 0.5). We use data from a pilot study conducted in 2002 to fill in that data gap. We recognize that this approach might introduce small errors if wood in this reach moved during the subsequent 2002-2003 flows. We believe that the combination of relatively low peak discharges in winter 2002-2003 and relatively large average size of LWD in this reach lowers the risk of introducing significant errors. We feel confident that the combination of 2003 data from the majority of the river and 2002 data from the lowest reach provides a relatively complete snapshot of the LWD in the Carmel River at the beginning of the 2003-2004 rainy season.

The 2003 survey reached to within 5 km (3 mi.) of San Clemente Dam. This upper section contains a great surplus of LWD. The time and effort that would be required to catalog the LWD at a comparable scale to the rest of the river put this reach outside the limits of the project budget. For this reason we focused our efforts on the lower 25.5 km (16 miles) of river.

We conclude the following points.

2003 Inventory

- A comprehensive survey was completed on 23 km (14 mi) of the Carmel River. In this section of river there are 471 occurrences of large wood or large wood accumulations. This figure leads to an average frequency of 20.5 significant LWD pieces (or accumulations) per kilometer of river (36.7 occurrences/mi).
- The density is not evenly distributed; the density decreases downstream at an average rate of approximately 0.8 pieces/km ($p<0.01$) and shows marked non-linear variability.
- 71% of LWD pieces are between 15 cm and 30 cm in diameter. 84% of the wood is between 1.5 m and 6 m in length. There is an increase in LWD size downstream from Via Mallorca.
- 70% of the LWD in the Carmel River has no significant impact lateral channel stability, or is protecting the banks from erosion. Only 3% of the wood was causing bank erosion.
- 29% of the wood was fostering pool habitat in the bed.
- 77% of the naturally occurring woody debris tends to be aligned either parallel with the bank or pointing downstream. Only 9% were angled upstream and 12% were perpendicular to flow.
- 50% of the occurrences of wood were associated with aquatic fauna sightings, commonly with multiple taxa per sighting. Fauna included steelhead trout, stickleback, crayfish, western pond turtles, California red-legged frogs, and bullfrogs.
- 7% (35 pieces) of the LWD surveyed in 2003 had been deliberately placed in the stream for management purposes.

2 Introduction

Large woody debris (LWD) has been the focus of considerable research. It is considered to be a great benefit to natural river function, a threat to bridges, and a factor in flood risk. There is currently interest in quantifying the ecosystem benefits of LWD, understanding the role of LWD in channel stability, and determining how much LWD is optimal or minimal for riverine ecosystems and bank stability.

Recent research has identified a substantial number of specific benefits of LWD (Harvey et al., 1999; Harmon et al., 1986; Maser and Sedell, 1994; Flosi et al., 1998; Montgomery et al., 2002; Triska and Cromack, 1980; Franklin et al., 1981). Environmental benefits of LWD, which apply directly to the Carmel River (Fig. 1) include:

- fish resting zone during high flow
- shade and cover for juvenile and adult fish
- traps gravel for spawning habitat
- perching platforms for reptiles, amphibians, aquatic insects, birds, and riparian mammals
- forces bed scour and pool formation for habitat diversity
- bank protection
- collection of organic matter (leaves and other detritus)
- provide nutrients to the river and near-stream soils
- physical and nutritional support for macro- and aquatic microbes
- trap soil to provide substrate for new vegetation
- adds hydraulic roughness to break-up and slow flood waters, thereby reducing the erosional forces.

Because LWD spans the physical realm between purely aquatic and terrestrial parts of the river system, it serves as a biological bridge providing a flow of nutrients and energy between the two areas of the river corridor. Despite these benefits, if too much wood is present and logjams begin to develop, there can be some negative consequences including bridge damage, increased flooding, and temporary barriers to fish migration.

The present study provides an inventory and summary of LWD on the Carmel River between Stonepine Bridge and the coastal lagoon of the Carmel River. The data set represents the most detailed look at LWD in the Carmel River to date, and may be the most detailed LWD inventory in any Central California stream. In 2002, seven representative reaches of the Carmel River located between Tularcitos Creek and the Carmel Lagoon were inventoried for LWD (Smith et al., 2003). This sub-sample included eight miles of river channel, or 44% of the river. The current 2003 inventory repeated most of those reaches and included nearly all of the river between the Tularcitos Creek and Via Mallorca. In addition to providing a catalog of each piece of wood in or near the active channel, the data provide the opportunity to evaluate the physical function of the LWD in terms of bank protection and bed scour.

3 Methods

LWD is defined in the present study as any piece of wood with at least 15 cm diameter and 1.5 m length. The LWD was included in the survey if it occurred in the dominant channel of the Carmel River. By this, we mean the approximate bankfull channel, which, by our estimate, conveys approximately the 1.5 to 2 year flow. In the data tables there are also several instances of LWD that occurred on the floodplain adjacent to the channel, and these are so indicated; however, the scope of the study did not include all floodplain areas.

In the Fall of 2002 (October 5 – November 20) seven reaches of the Carmel River were surveyed for LWD (Smith et al., 2003; Fig 1). From upstream to downstream, these reaches include Stonepine Bridge to Lower Circle, Rosie's Bridge to deDampierre, deDampierre to the Carmel Valley Trail and Saddle Club, Garland Park downstream from Dan Juan Bridge, Scarlett Road to Robinson Canyon Road, Via Mallorca Road along the Rancho Cañada Golf Course, and from Rancho Cañada Golf Course to the head of the Carmel Lagoon. In summer and fall of 2003 thirteen nearly contiguous river reaches were surveyed. The 2003 survey included all of the above reaches, except for the last two. The following additional reaches were added in 2003: Garland Stables to Garland Park, Garland Park to the Narrows, Narrows to Scarlett Road, Robinson Canyon Road to Upstream of Schulte Bridge, Upstream of Schulte Bridge to Downstream of Schulte Bridge, and Quail Lodge Bridge to Via Mallorca. The 2003 survey did not repeat the reach from Via Mallorca (Rancho Cañada Golf Course) to the upstream end of the Carmel Lagoon, but we include that reach from 2002 in our overall analysis of the 2003 data (Fig. 1). This combination gives a more complete picture of the distribution of LWD at the beginning of the 2003-04 rains, and introduces few errors, since the majority of wood in that reach is large enough to have remained immobile during the two-year study period. In summary, this 2003 report includes the analysis of 15 reaches of the Carmel River, including the lowest two reaches that were surveyed in 2002. Figure 1 shows an additional reach (Stonepine to Sleepy Hollow), which was not completed and was not included in computing and reporting the LWD statistics in this report.

For clarification, the study reaches that refer to points upstream and downstream of Schulte Bridge do not have the bridge as an end point. "Upstream of Schulte Bridge" is a point approximately 850 m (+/- 10 m) upstream from Schulte Bridge, as measured along the thalweg of the river. "Downstream of Schulte Bridge" is a point 350 m downstream from Schulte Bridge, as measured along the thalweg of the Carmel River.

The upper limit of the study is Stonepine Bridge. The lower limit of the study, the Carmel Lagoon, was the point at which the water became to deep to wade during low-flow conditions of Summer 2002.

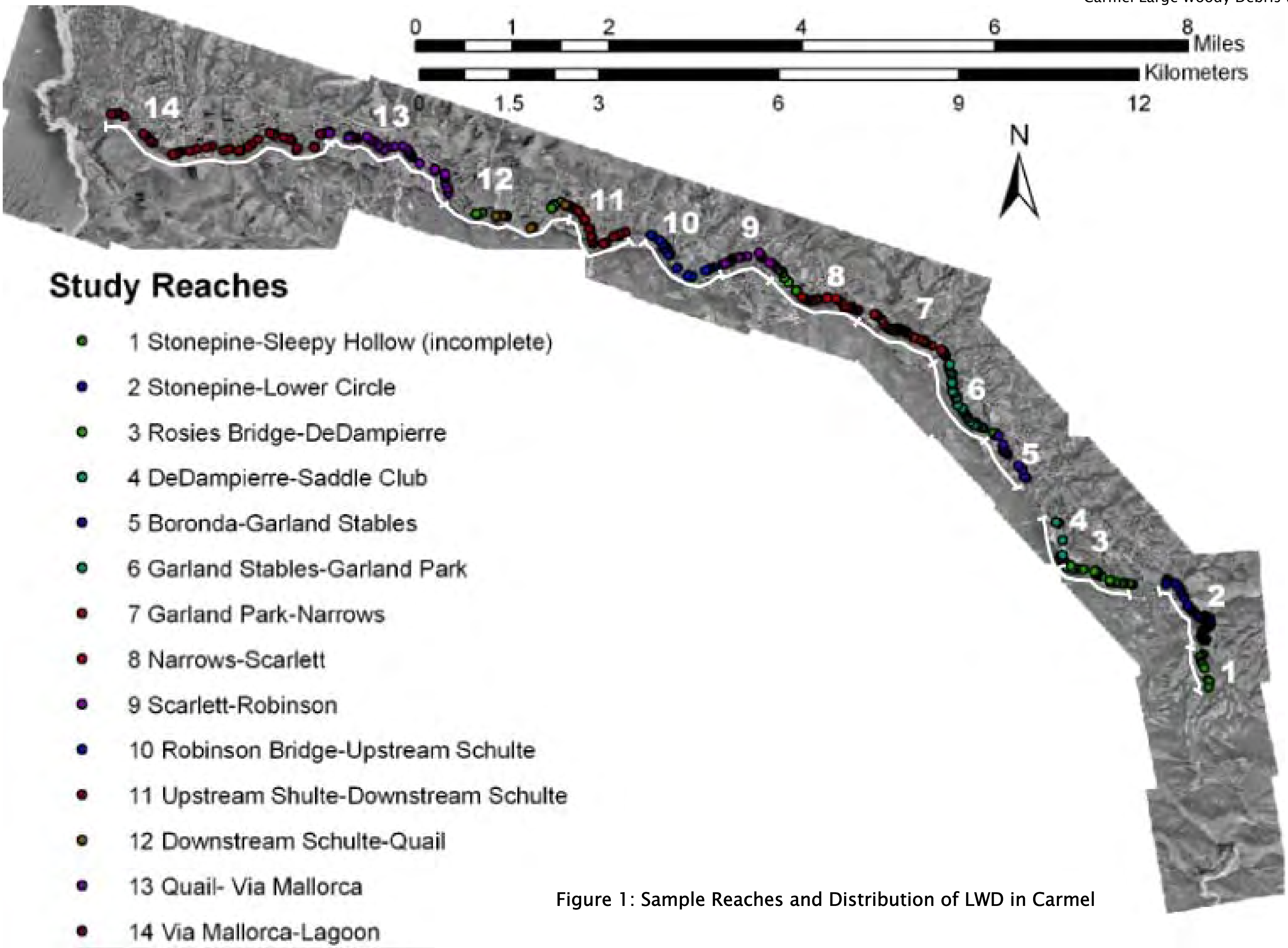


Figure 1: Sample Reaches and Distribution of LWD in Carmel

The great majority of locations reported in this inventory were obtained by differentially correcting GPS locations obtained with a handheld Trimble GeoExplorer-III receiver. The error of those locations is likely to be much less than 5 m. Several locations were obtained by reference to georeferenced, high resolution digital aerial photography (Mussetter, 2002)

California red-legged frog sightings reported here include a combination of positively identified individuals and frog sightings that were probably California red-legged frogs. Along the fifteen sample reaches, each occurrence of LWD or LWD accumulation was assigned coordinates and several kinds of data were collected (Table 1). Definitions of the data are provided in Appendix A. Sample data sheets are provided in Appendix B. We have provided digital photographs of 93 instances of LWD as part of the monitoring data. We have also tagged 29 pieces of LWD with circular brass-colored metal identifiers that will help track their progress in future studies (Fig. 2).

An ArcMap (v.8.2) GIS project was created that displays each single and multiple LWD occurrence projected on a very high resolution (0.5 ft/pixel), georeferenced aerial photograph provided by the Monterey Peninsula Water Management District (Mussetter, 2002). The attribute table in the GIS project contains all the data from the project as well.

Table 1: Data fields for Carmel LWD. See Appendix A for details.

DATA	BRIEF DESCRIPTION
Date and general river reach name	
Location	Eastings and northings in feet (NAD 1983 California State Plane Zone IV)
Log type	Single, multiple, +/- rootball
Width	Centimeters of diameter (15 cm minimum)
Length	Meters (1.5 m minimum)
#Pieces	Estimated number of pieces in a multiple log accumulation
Mobility	How frequently it might move based upon elevation and embeddedness
Influence	Influence on bed and bank protection or scour
Condition	Degree of wood decay
Embedment	How well anchored the wood is in the bed or bank
Orientation	Is the wood pointing upstream, downstream, parallel or perpendicular with respect to the bank?
Degrees from bank	A general index of acute angle between bank and log
Reach type	Hydraulic habitat (pool, riffle, run, or glide)
Projected reach type	Estimated hydraulic habitat at approximately 200 cfs
Reach length	Meters of extent of reach type
Part of channel	Center, edge of low flow channel, bankfull channel, floodplain
Substrate	Visual approximation median grain size category (sand, pebble, cobble, boulder, bedrock.)
Species	Species of log
Fauna	Animal sightings during survey
Comments	
Structural size	Approximate dimensions of LWD accumulations and jams Length X Width X Height (meters)

Figure 2: Attaching an identifying tag to a piece of LWD

4 Results

The data are provided in an electronic Excel file, and in Appendix C. A simple data summary stratified among the fifteen reaches is provided in Tables 2 and 3.

Table 2: Positions of fifteen sample reaches in 2002-2003 LWD survey. Right two columns are the frequency of single pieces and accumulations per kilometer (mile) of channel in each reach.

Reach	Reach Length (km)	Cum. dist (km)	Cum. dist (mi.)	Occurrences of LWD	LWD/km	LWD/mi
Stonepine-Lower Circle	1.59	1.6	1.0	65	41	68
Rosie’s Bridge-deDampierre	1.18	2.8	1.7	31	26	44
deDampierre-Saddle Club	0.93	3.7	2.2	17	18	30
Boronda-Garland Stables	1.3	5.0	3.0	28	22	36
Garland Stables-Garland Park	1.31	6.3	3.8	34	26	43
Garland Park-Narrows	1.68	8.0	4.8	46	27	46
Narrows-Scarlett	1.67	9.7	5.8	39	23	39
Scarlett-Robinson	1.01	10.7	6.4	22	22	36
Robinson-Upstream Shulte	1.58	12.3	7.4	24	15	25
Upstream Shulte-Downstream Shulte	1.16	13.4	8.0	20	17	29
Downstream Shulte-Quail Lodge	2.54	16.0	9.6	49	19	32
Quail Lodge-Via Mallorca	2.54	18.5	11.1	43	17	28
Via Mallorca along R. Cañada (2002)	2.27	20.8	12.5	32	14	23
Rancho Cañada-Lagoon (2002)	2.203	23.0	13.8	21	10	16

Table 3: Summary statistics for key variables in the dataset. Other variables are present in the data sheets.

	Pieces					Diameter (% of total in cm ranges)				
Reach	**Total**	**Multiple (%)**	**Single (%)**	**Only rootball**	**Rootballs present (%)**	**15-30 cm**	**30-45 cm**	**45-60 cm**	**>60 cm**	**unknown**
Stonepine-Lower Circle	65	38	61		32	76	15	8	1	0
Rosie's Bridge-deDampierre	31	26	74		29	74	16	6	3	0
deDampierre-Saddle Club	17	29	65	6	71	35	12	6	47	0
Boronda-Garland Stables	28	18	82		25	86	11	4	0	0
Garland Stables-Garland Park	34	50	50		32	76	0	24	0	0
Garland Park-Narrows	46	22	76		20	89	9	2	0	0
Narrows-Scarlett	39	8	87	5	39	84	8	8	0	0
Scarlett-Robinson	22	41	59		32	82	14	5	0	0
Robinson-Upstream Shulte	24	41	59		4	67	25	8	0	0
Upstream Shulte-Downstream Shulte	20	25	75		30	95	0	5	0	0
Downstream Shulte-Quail Lodge	49	8	92		10	37	2	57	4	0
Quail Lodge-Via Mallorca	43	16	82		28	47	33	19	2	0
Via Mallorca along R. Cañada (2002)	32	22	78		0	34	34	0	25	6
Rancho Cañada-Lagoon (2002)	21	38	62		0	33	43	5	19	0
Total and weighted means[1]	**471**	**26**	**73**	**1**	**24**	**66**	**15**	**13**	**5**	**2**

1. Averages are weighted by the number of occurrences of LWD in each reach.

Table 3 Continued

	Length (% of total in m ranges)							Physical function (% of total with function)[1]			
reach	**1.5-3 m**	**3-4.5 m**	**4.5-6 m**	**6-7.5 m**	**7.5-9 m**	**>9 m**	**unknown**	**bank prot. (%)**	**bank scour (%)**	**bed scour (%)**	**no impact (%)**
S.P.-L.C.	69	14	12	5	0	0	0	7	1	15	77
R.B.-deD.	32	39	23	3	3	0	0	6	0	33	58
deD.-S.C.	29	6	12		6	47	0	0	0	71	29
B.-G.S.	57	18	7	7	0	11	0	11	0	25	64
G.S.-G.P.	26	21	44	3	3	6	0	6	6	32	65
G.P.-N.	61	26	17	0	2	0	0	18	9	20	53
N.-S.	57	13	13	8	6	3	0	5	0	28	67
S.-R.	50	23	27	0	0	0	0	0	9	36	55
R.-U.S.	71	5	14	10	0	5	0	13	0	38	58
U.S.-D.S.	55	25	10	10	0	0	0	10	0	35	65
D.S.-Q	64	2	18	8	0	8	0	14	0	41	45
Q.-V.M.	40	14	14	7	5	21	0	40	0	26	40
V.M.-R.C.	28	25	6	6	6	22	6	12	0	9	78
R.C.-L.	0	10	29	14	14	33	0	29	24	38	9
Wt. Mean	**49**	**17**	**17**	**6**	**3**	**9**	**0**	**13**	**3**	**29**	**57**

1. Sums of individual reach percent and weighted mean percents of "Physical function" may exceed 100% because many pieces of LWD served both to protect the bank and provide bed scour.

Table 3 Continued

	Fauna present (% of total with fauna)							Environment (% of total in specific hydraulic habitat)					
reach	**crayfish**	**steelhead**	**other fish**	**frog**	**turtle**	**none**		**riffle (%)**	**run (%)**	**pool (%)**	**glide (%)**	**unknown**	**N/A**
S.P.-L.C.	5	5	5	0	0	85		57	14	18	8	0	0
R.B.-deD.	3	10	29	3	0	71		32	48	19	0	0	0
deD.-S.C.	41	7	59	6	6	41		12	53	29	0	0	0
B.-G.S.	11	32	54	0	0	43		11	32	15	43	0	0
G.S.-G.P.	18	47	65	6	0	38		9	50	38	3	0	0
G.P.-N.	28	24	17	2	2	27		37	32	14	17	0	0
N.-S.	44	3	23	5	0	46		18	33	31	13	3	0
S.-R.	18	27	36	14	5	54		18	55	18	9	0	0
R.-U.S.	67	83	83	37	0	17		25	42	18	18	0	0
U.S.-D.S.	0	25	45	20	0	50		15	70	15	0	0	0
D.S.-Q	10	80	80	0	0	20		12	51	31	0	0	0
Q.-V.M.	0	63	84	0	0	16		7	58	30	5	0	0
V.M.-R.C.	0	0	0	0	0	100		0	100	0	0	0	0
R.C.-L.	0	0	0	0	0	100		0	100	0	0	0	0
Wt. Mean	**16**	**30**	**40**	**5**	**1**	**50**		**21**	**48**	**21**	**8**	**0**	**0**

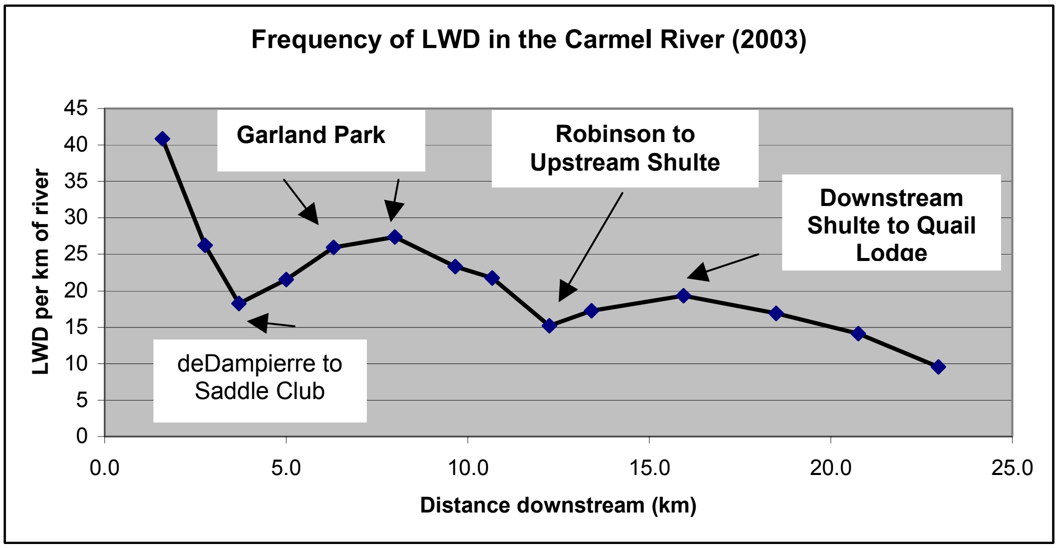
Table 3 Continued

	Part of channel (% of total in specific channel region)					Mobility (% of total with specific mobility)		
reach	**center**	**low flow edge**	**bankfull edge**	**floodplain**		**highly**	**peak flows**	**well-embedded**
S.P.-L.C.	4	61	35	0		11	9	80
R.B.-deD.	10	39	51	0		19	6	75
deD.-S.C.	0	71	24	0		12	47	41
B.-G.S.	7	46	43	4		7	0	93
G.S.-G.P.	3	53	44	3		12	6	82
G.P.-N.	2	63	35	0		9	0	91
N.-S.	13	61	26	0		15	0	85
S.-R.	5	45	45	5		5	5	90
R.-U.S.	14	14	67	0		14	0	86
U.S.-D.S.	5	80	5	10		5	5	90
D.S.-Q	0	84	14	2		8	35	57
Q.-V.M.	0	79	16	5		12	7	81
V.M.-R.C.	16	28	44	12		9	34	56
R.C.-L.	0	67	33	0		5	38	57
	5	**58**	**33**	**3**		**11**	**12**	**77**

Approximately 470 instances of single or multiple LWD occurrences were recorded within the 23 km (14 mi.) of surveyed river. Most pieces were between 15 cm and 45 cm in diameter and between 1.5 m and 6 m long (Table 3). The average density of LWD in the surveyed river is 21 occurrences per km (37 occurrences/km).

The density of LWD (occurrences per km) decreases downstream at a rate of 0.8 occurrences/km, and shows an interesting pattern that may be linked to land-use (Fig. 3).

Figure 3: Density of LWD with distance downstream from Stonepine Bridge.



Garland Park has a relatively high concentration of LWD—26 pieces LWD/km (Figs. 3 and 4). The frequency and complexity of LWD and hydraulic habitat in the Garland Stables to Garland Park reach make this section of river a reference reach in terms of overall apparent habitat diversity. The poorest concentration of LWD was between Robinson Bridge and Upstream Schulte (Fig. 5). This reach is below the Carmel Valley Ranch Golf Course where recruitment would be low because of riparian tree management. Other reaches with low concentrations include the stream-side golf courses, such as Rancho Cañada Golf Course (Fig. 6).

Figure 4: LWD along Garland Park.

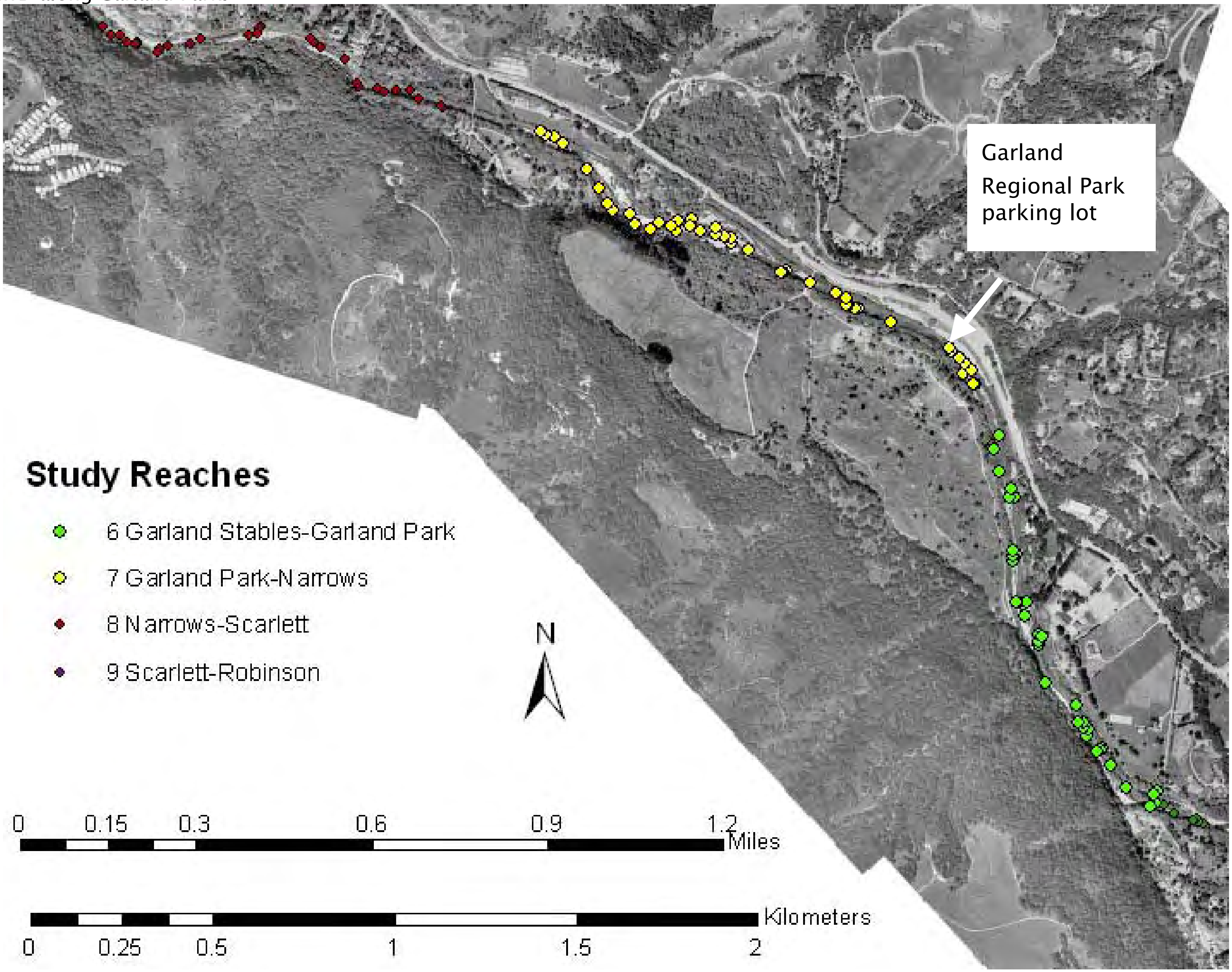


Figure 5: Low concentration of LWD downstream from Robinson Canyon.

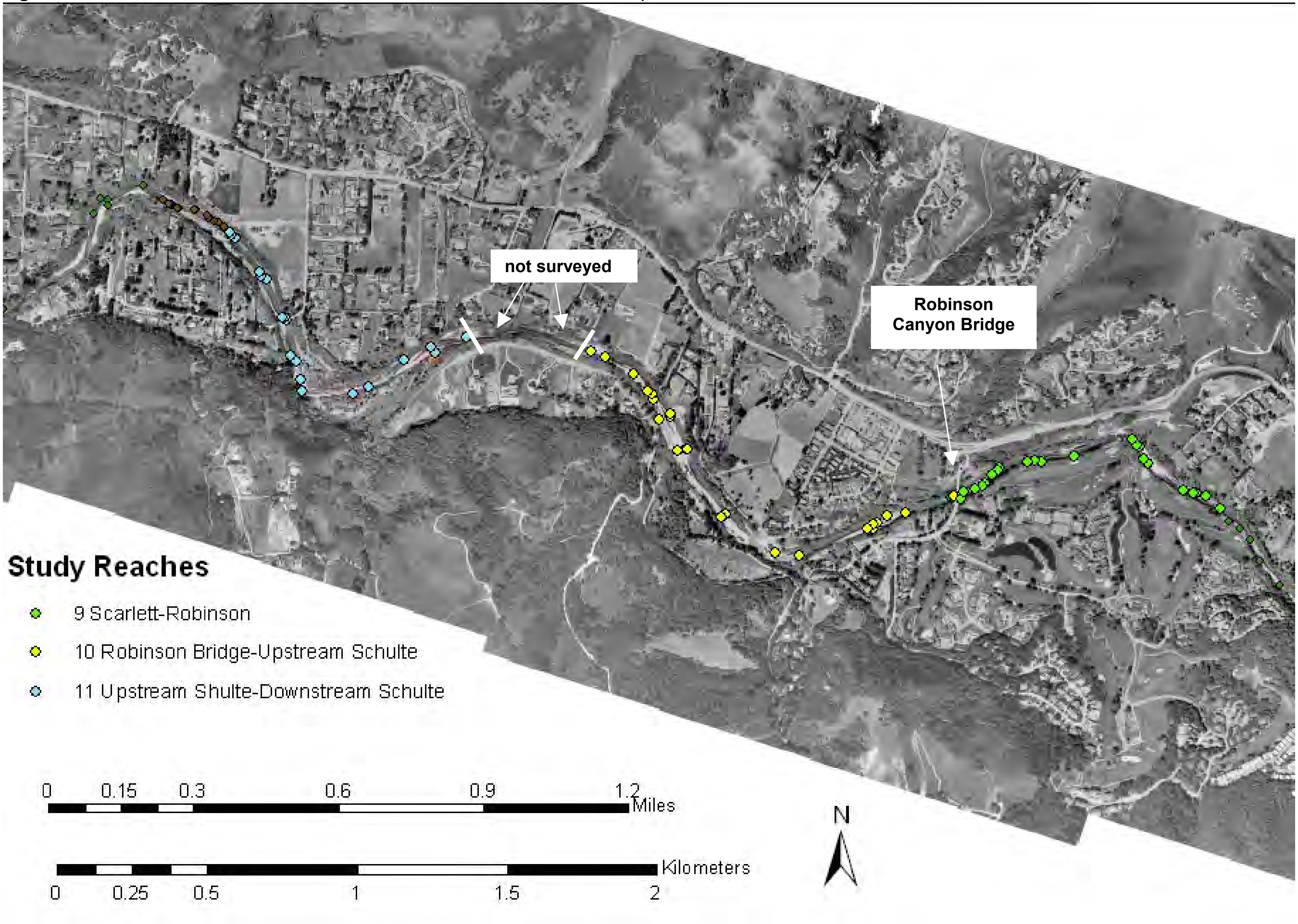
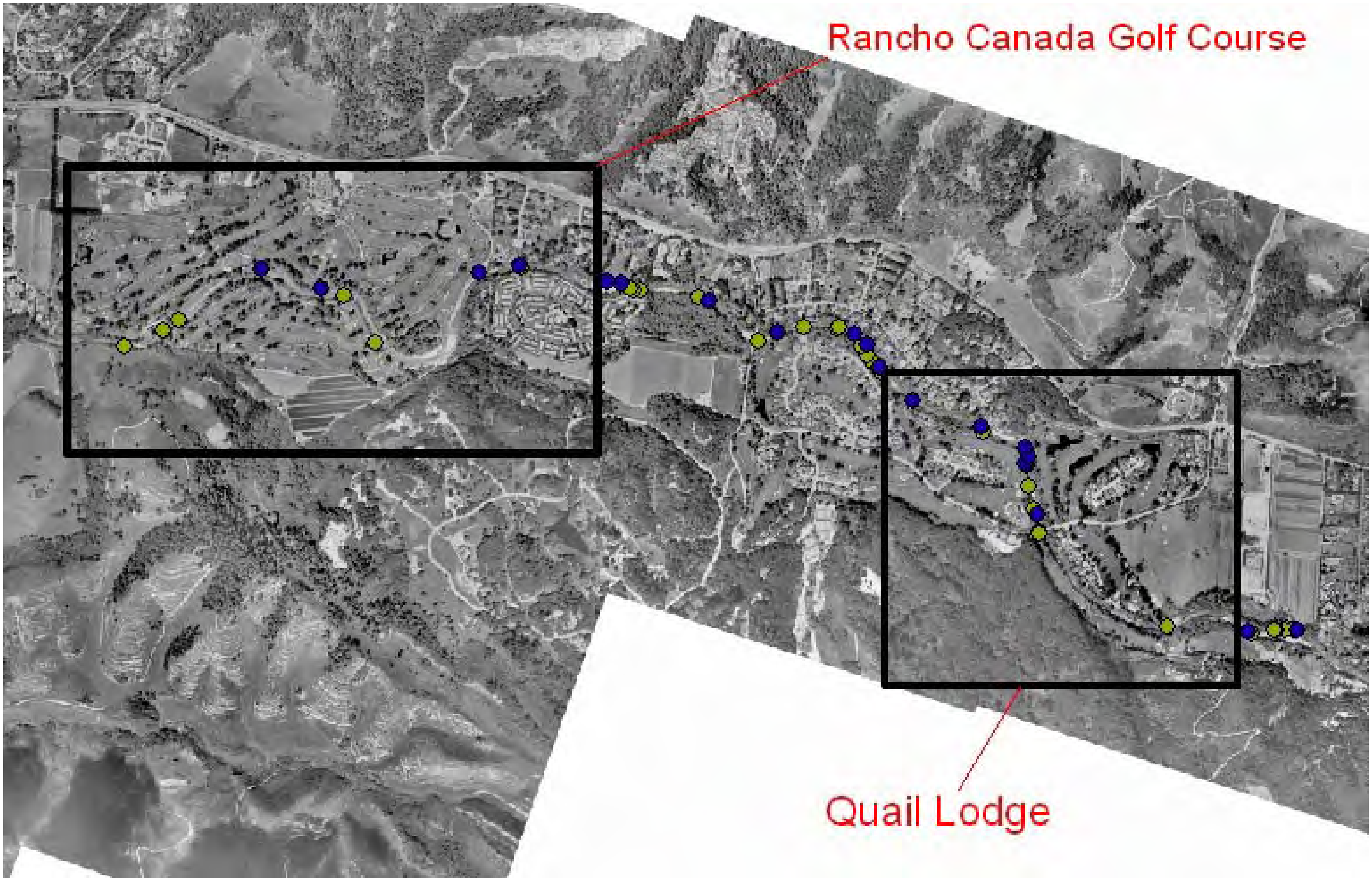


Figure 6: Low LWD concentrations along two golf courses.



To see how average conditions change from upstream to downstream on the river, we divided the study site roughly into thirds (Fig 7).

Figure 7: Reach A,B,C definitions for following figures

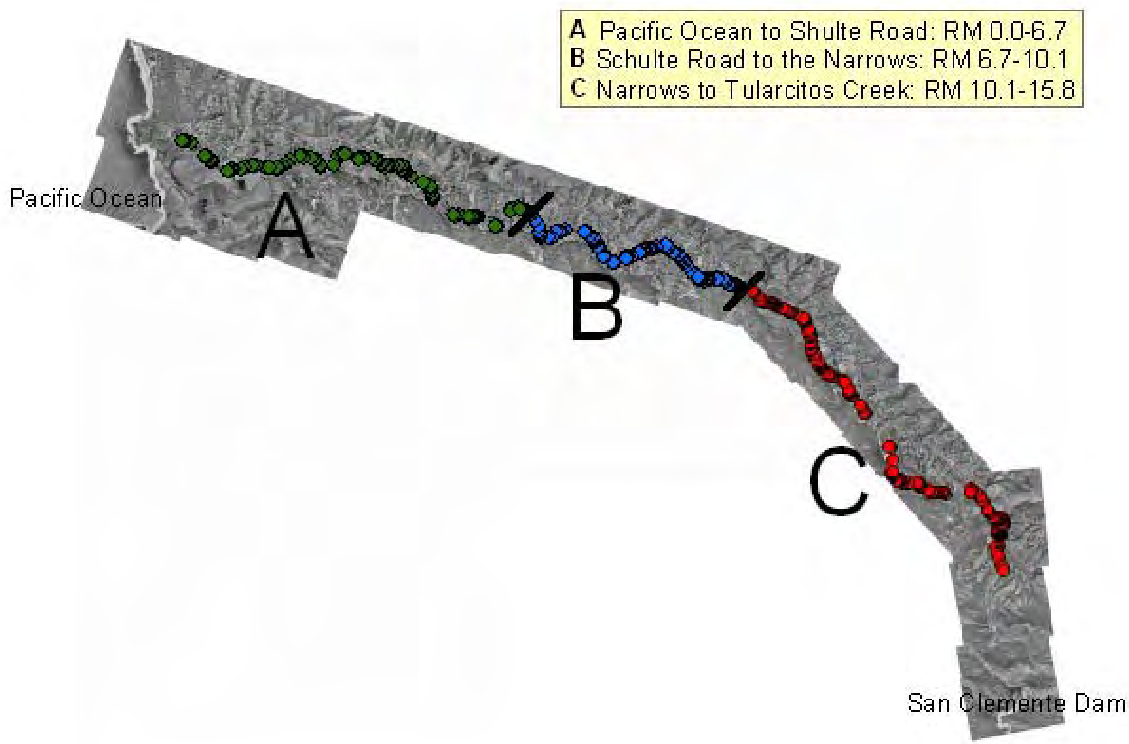


Figure 8 shows that upstream sites have a higher proportion of LWD accumulations that gradually disintegrate into single pieces of LWD downstream. Likewise single pieces with associated with rootballs appear to lose their rootballs as they move downstream. These inferences can be tested as future studies track the tagged wood as it moves downstream.

We assessed the apparent mobility of each LWD occurrence by noting the kind of event that would initiate movement (Appendices A and C). The mobility did not change much along the river (Fig. 9) except for the lowest reach where the wood appeared to have a more stable geometry and larger pieces on average.

Thirty-five pieces of LWD (7%) in the survey were placed for river management purposes. We have been visually monitoring five large redwood logs placed near the deDampierre baseball park (Fig. 10). The logs were placed, angled upstream, to maintain a deep efficient channel and provide pool habitat. This reach has historically been the location of high sediment load that periodically fills and destabilizes the channel. Since installation of the log structures (2002) there have been several minor flood flows. The installations are structurally sound and are providing significant pool habitat through forced hydraulic scour. The channel has developed and maintained a relatively low width/depth geometry as planned. This geometry provides a large hydraulic radius that is best for transporting sediment that might otherwise cause instability.

Figure 8: LWD type variation along the Carmel River. See Figure 7 for reference.

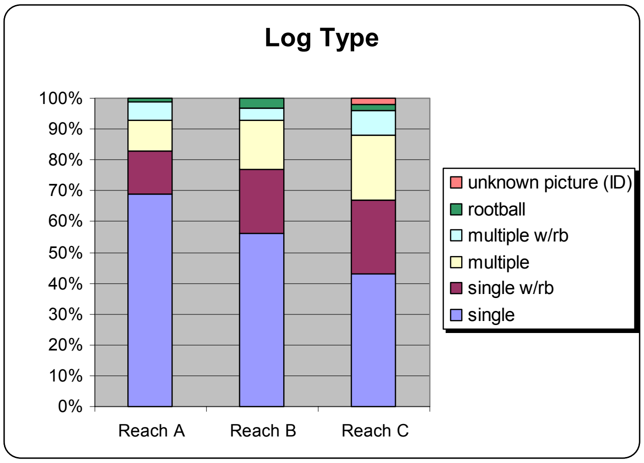


Figure 9: LWD Mobility along the Carmel River. See Figure 7 for reference.

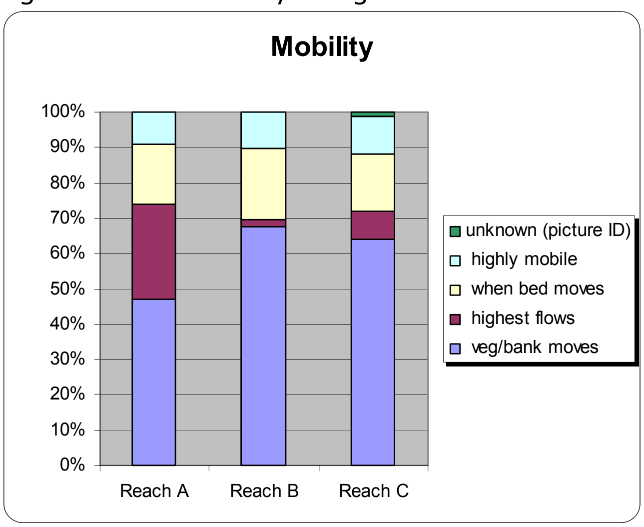
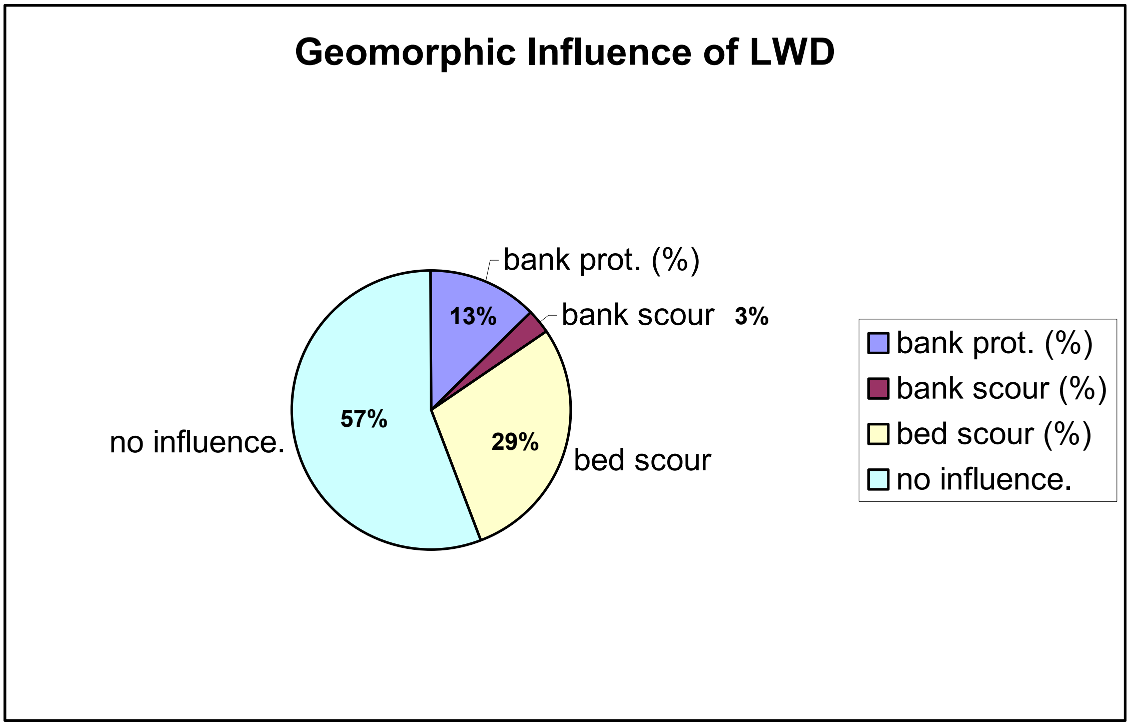


Figure 10: One of five large redwood logs placed near deDampierre ballpark. View upstream.

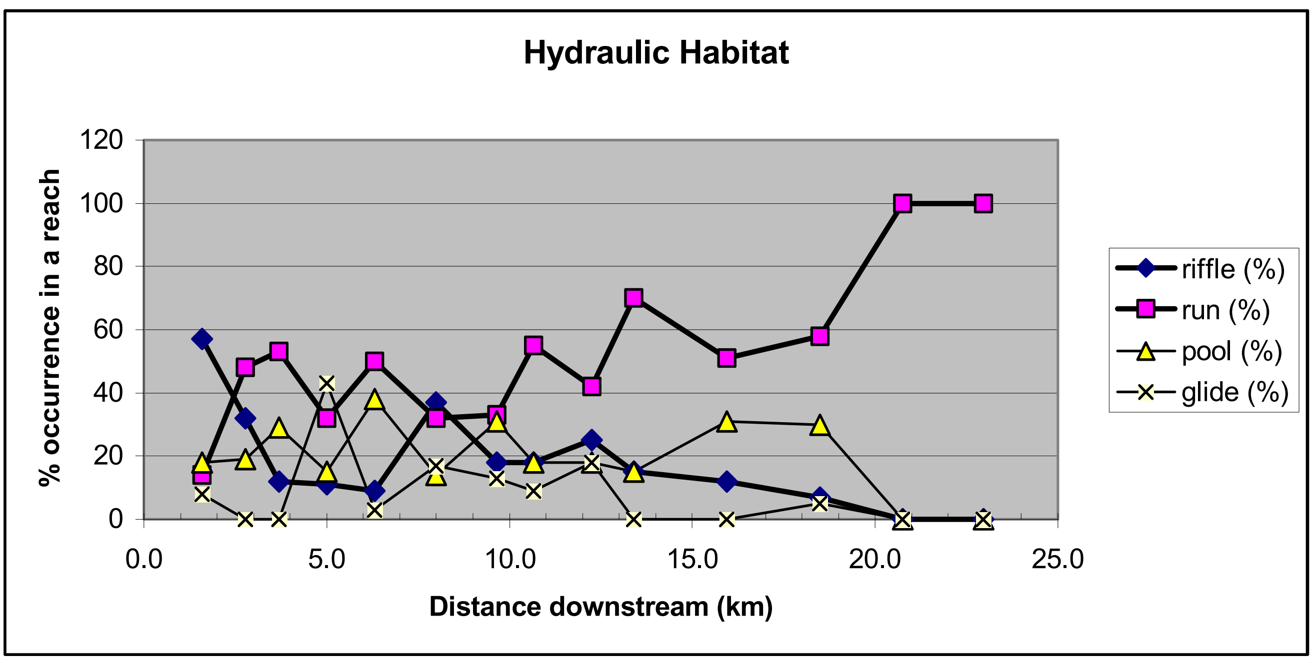
Of the approximately 470 occurrences of LWD, 57% appeared to have no morphological impact on the bank or bed (Fig. 11). 42% of the LWD pieces were providing benefits to the morphology by either providing bed scour for pool habitat or armoring the bank from erosion. Only 3% were inducing bank scour. The majority of LWD providing bank protection was oriented parallel to the flow or pointing downstream, in roughly equal amounts. In general, the overall data set indicates, that wood naturally accumulates parallel to the bank or with the stem pointing downstream (Appendix C). There is no clear relationship between the positive or negative influence on the bank and LWD orientation or angle from the bank (Appendix C). Of the 17 occurrences of LWD that were clearly causing bank scour, 9 (47 %) were multiple piece accumulations. Of the remaining 8 occurrences, half were oriented parallel to flow and half were oriented downstream, which is the same orientation as wood that was protecting the banks.

Figure 11: Geomorphic influence of LWD.



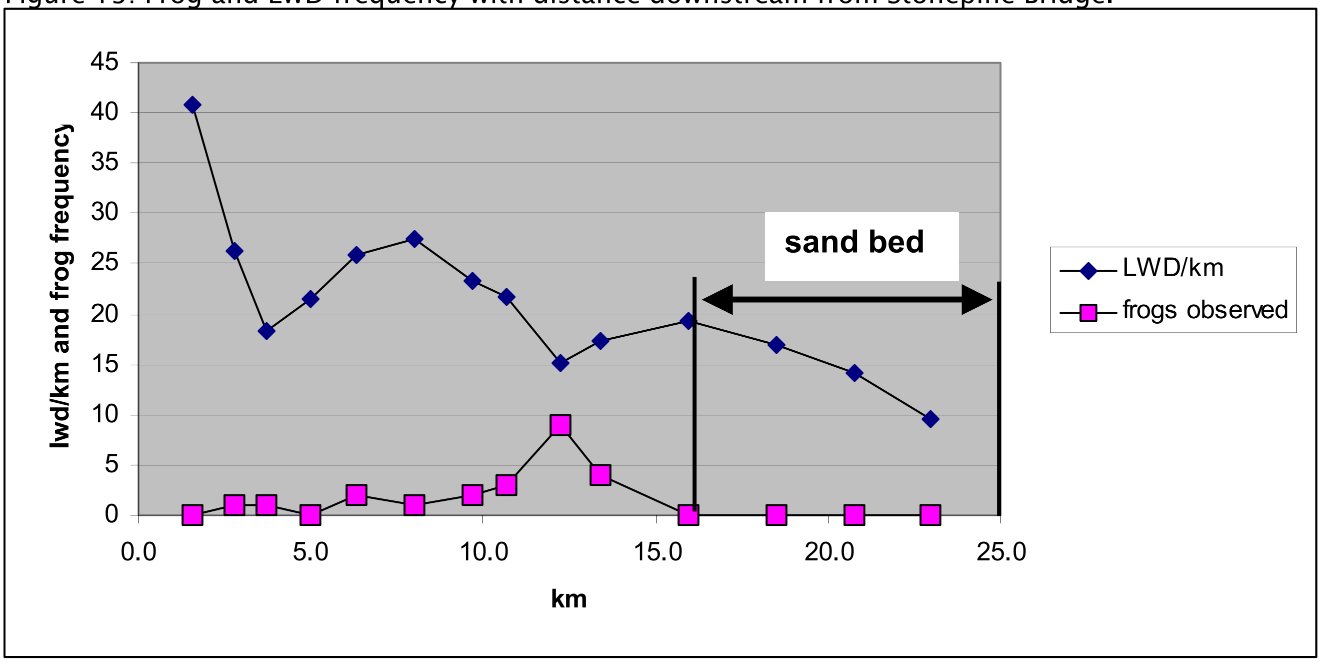
Riffle habitat becomes less prevalent downstream as cobble and gravel substrates give way to sand. Run habitat takes the place of riffle in the river , especially after sand becomes the dominant substrate at 16 km (Fig. 12). The proportion of pools remains relatively constant.

Figure 12: Changes in river hydraulic habitat with distance downstream from Stonepine Bridge.



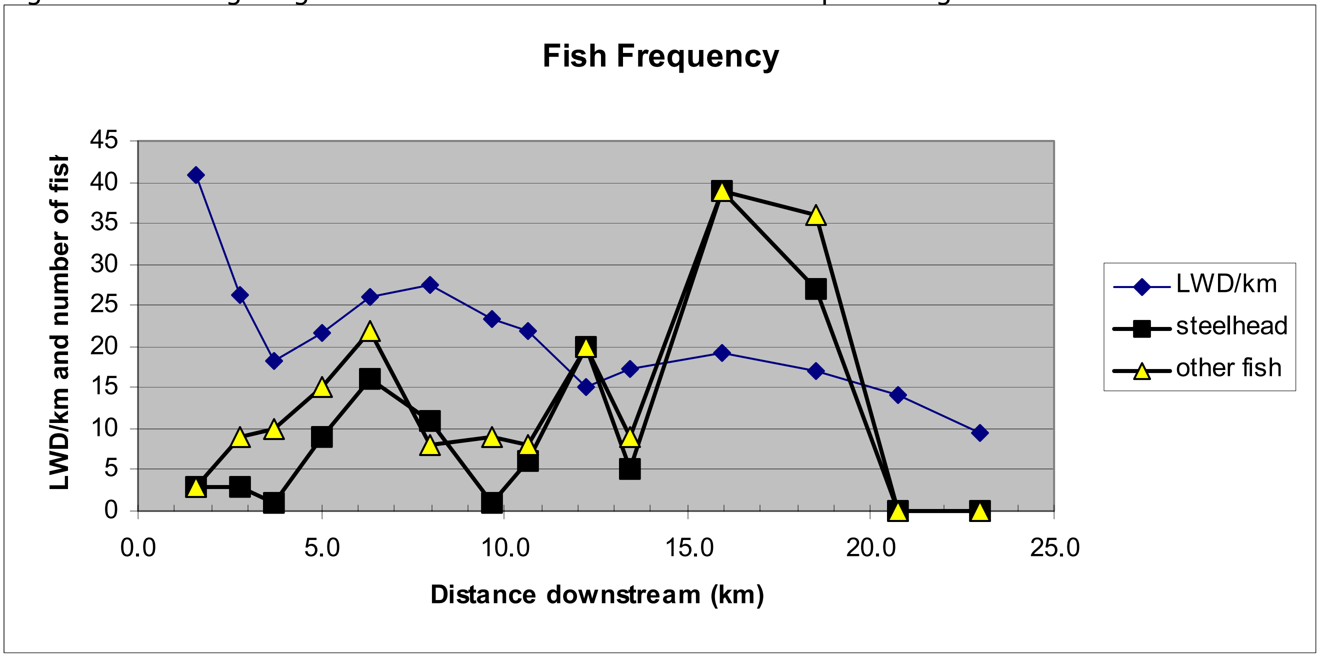
Fauna were noted on first approach to each LWD site (Appendix A). These biological data provide only anecdotal evidence of how the LWD is being used. The percentage of LWD bearing frogs increases markedly where there is a sudden decrease in available logs, suggesting that the population may be impacted by the paucity of LWD in that reach of the river (Fig. 13); however we note that there is not a similar increase in frog sightings where LWD decreases at 3.5 kilometers along the river. The sudden drop in frog sightings at a position of 16 km corresponds to the point at which the bed of the Carmel River turns to sand. The number of crayfish also plummets at 16 km. The lower two reaches of river were dry, eliminating the chance of finding aquatic fauna

Figure 13: Frog and LWD frequency with distance downstream from Stonepine Bridge.



Fish, including juvenile steelhead and stickleback, were commonly seen near LWD, attesting to the biological importance of the resource (Fig. 14).

Figure 14: Fish sightings at LWD sites with distance from Stonepine Bridge.



5 Discussion

As is true in the Aptos watershed (Conrad, 2003), we note that streamside urbanization and development tend to reduce the density of LWD in the stream. This relationship may reflect a lower number of local recruitable trees or a tendency for landowners to periodically clear their reach of stream. During our survey we noted several occurrences of landowners cutting LWD to increase its mobility.

According to Fox (2004) unmanaged watersheds in Washington have a wide range of LWD densities. Based upon their data, a stream with 21 pieces per km (average Carmel River density) has half as much LWD as the minimum acceptable amount for salmonid-bearing streams. We do not suggest that the Washington data be directly used as an index of LWD density in the Carmel River, but we could find no other references for west coast streams.

Although it is clear that more LWD was present in the 2003 survey than in the pilot study of 2002, a rigorous comparison of 2002 LWD (Smith et al., 2003) and the present 2003 LWD density is not advisable owing to possible differences in observer skills between the two surveys.

6 GIS Project

Accompanying this report is an ArcMap 8.2 GIS project and electronic dataset. The electronic data associated with this study include the following data.

Data	Files	FileType	Report element
this report	1	doc/pdf	all
photgraphs of LWD	93	jpg	
list of photographed sites	1	xls	
list of tagged wood	1	xls	
LWD data by reach	15	xls	App C & D
summary statistics	1	xls	Tables 2 & 3
LWD sites located without GPS	1	xls	

7 References

Conrad, M.T., 2003, Large Woody Material Recruitment in Aptos Creek Watershed (Including Valencia Creek): unpublished Coastal Watershed Council Report, P.O. Box 1459, Santa Cruz, CA 95061, 16 pp.

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins, 1998, California Salmonid Stream Habitat Restoration Manual: The Resources Agency, California Department of Fish and Game, Inland Fisheries Division.

Fox, M., 2004, Large Woody Debris, How Much is Enough?: Center for Water and Watershed Studies January 2004 Fact Sheet, University of Washington, Seattle, 2 pp.

Franklin, J., Cromack, K., Jr., Denison, W., McKee, A., Maser, C., Sedell, J., Swanson, F., and Juday, G., 1981, Ecological characteristics of old-growth Douglas fir forests: USDA Forest Service General Technical Report PNW-188.

Harmon, J., Franklin, J., Swanson, F., Sollins, P., Gregory, S., Lattin, J., Anderson, N., Cline, S., Aumen, N., Sedell, J., Lienkaemper, G., Cromack, K., Jr., and Cummins, K., 1986, Ecology of coarse woody debris in temperate ecosystems:" Advances in Ecological Research, V. 15, p. 133-302.

Harvey, B.C., Nakamoto, R.J., and White, J.L., 1999, Influence of large woody debris and bankfull flood on movement of adult resident coastal cutthroat trout (Oncorhynchus clarki) during fall and winter: Canadian Journal of Fish and Aquatic Science, V. 56, p. 2161-2166.

Maser, C. and Sedell, J., 1994, From the forest to the sea: the ecology of wood in streams, rivers, estuaries, and oceans: St. Lucie Press, Delray Beach, FL.

Montgomery, D.R., Massong, T.M., Hawley, S.C.S., 2002, Influence of debris flows and log jams on the location of pools and alluvial channel reaches, Oregon Coast Range: Geological Society of America Bulletin: V. 115, p. 78-88.

Mussetter Engineering, Inc., 2002, Carmel River Dam Removal Study, Monterey County California for California Department of Water Resources: Mussetter Engineering, Inc., Fort Collins Colorado.

Smith, D.P., Huntington, P, and Harter, K., 2003, Carmel River Large Woody Debris Inventory from San Clemente Dam to the Lagoon Fall 2002: Watershed Institute, California State University Monterey Bay, Publication No. WI-2003-13, 38 pp.
http://home.csumb.edu/s/smithdouglas/world/Doug/html/2002_carmel_lwd.html

Triska, F., and Cromack, K., Jr., 1980, The role of wood debris in forests and streams; in Waring, R., ed., Forests: fresh perspectives from ecosystem analysis: Oregon State Press, Corvallis, OR., p. 171-190.