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Middle Subbasin

Overview

The Middle Subbasin drains approximately 78 square miles of the Van Duzen Basin and includes seven Calwater 2.2 planning watersheds (Table 1 and Figs. 1 and 2). Virtually all the land in this subbasin (98.5%) is privately owned. Primary land use includes timber production, cattle ranching and rural residential developments. The Middle Subbasin is very sparsely populated and contains only one small town for the entire subbasin. Bridgeville, located along the Van Duzen River near RM 31, provides a school, post office and a community center for residents who live in outlying areas. The Van Duzen River and the Middle Subbasin tributary streams support populations of Chinook salmon and steelhead. Coho salmon have been reported to spawn in Middle Subbasin streams, but due to the lack of focused surveys and overall population decline coho have not been documented in the subbasin since the early 1980s (Reynolds et. al 1981 and Decker and Fuller 1984).

Table 1. Summary of Van Duzen River Middle Subbasin attributes.

Square Miles	78
Total Acreage	50,000
Private Acres	49,250
Federal Acres	600
State Acres	150
Predominant Land Use	Timber Harvests
Predominant Vegetation Type	Douglas fir Forest
Total Stream Miles	162
Stream Miles/Subbasin Miles	2.1
Miles of Anadromous Stream	27

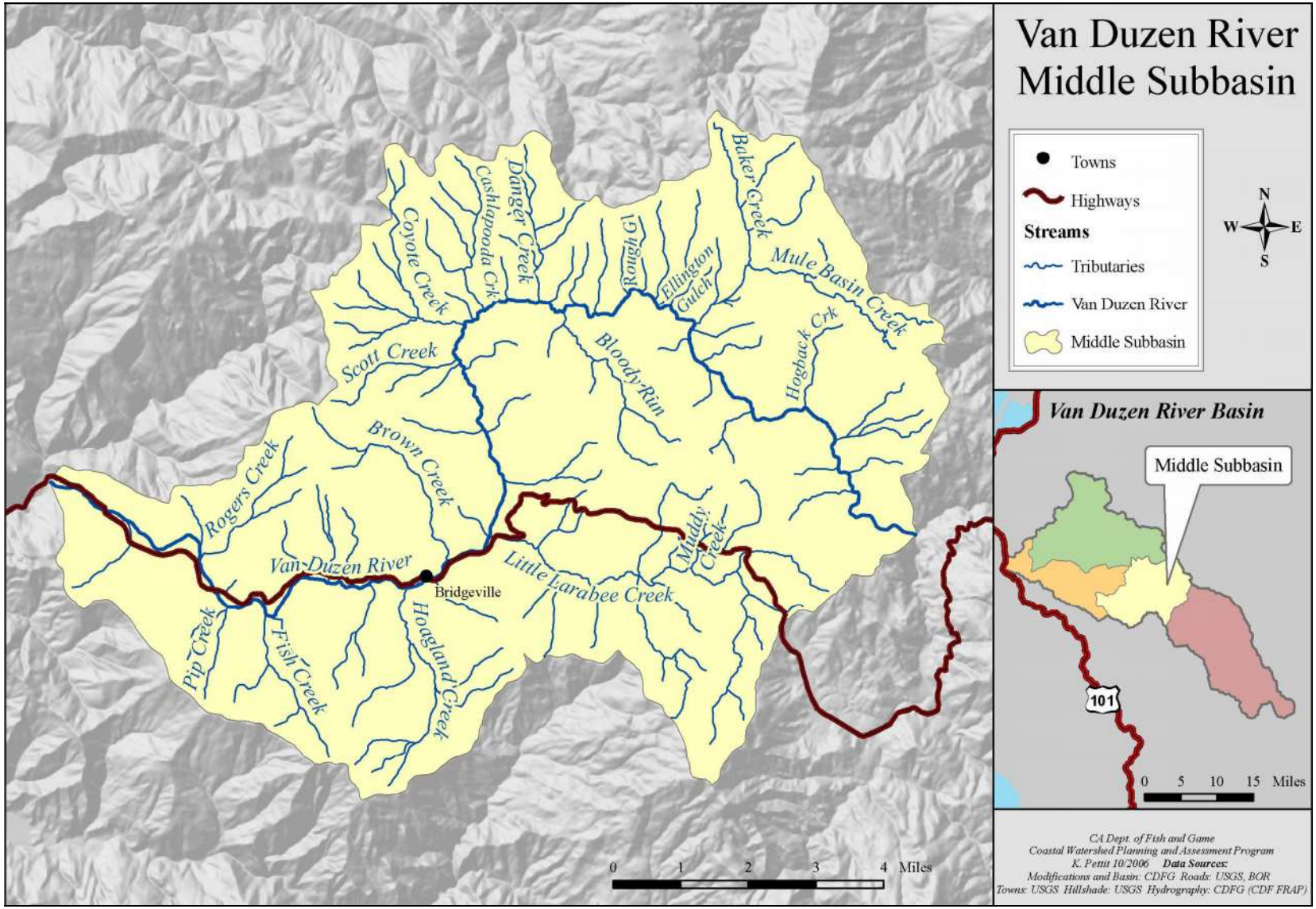

Figure 1. Location and tributaries of the Middle Subbasin of the Van Duzen River.

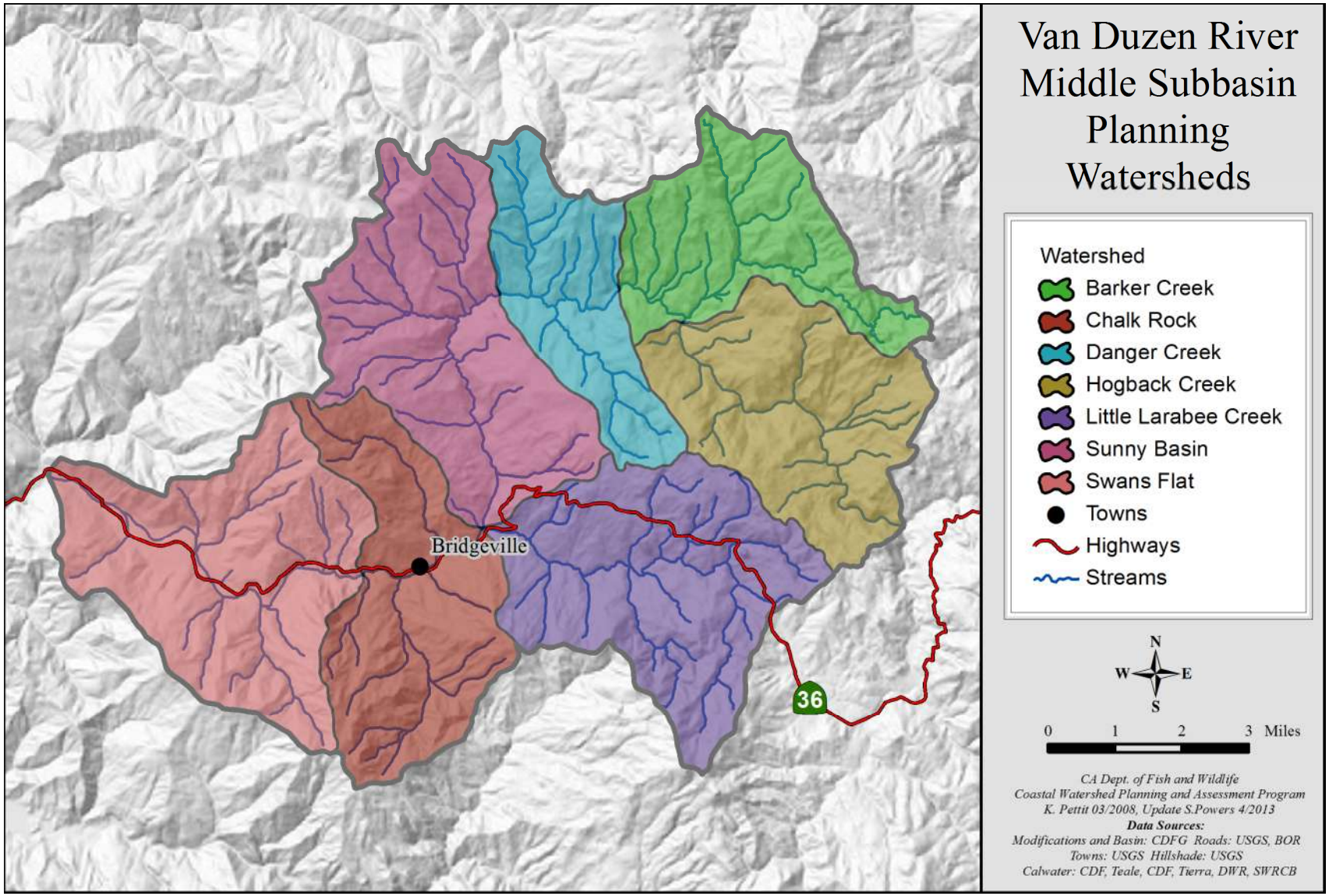

Figure 2. Seven Cal 2.2 planning watershed comprise the Middle Subbasin of the Van Duzen River.

Geology

Bedrock

Central Belt Mélange of the Franciscan Complex is the most abundant bedrock type, occupying 58% of the Middle Subbasin (Figure 3 and Table 2). Mélange of the Central belt formed between 65 million to 200 million years ago in the subduction trench between the Farallon and North American plates as material from the oceanic crust and its overlying sediments were tectonically mixed with sediments washing off the continent (Aalto 1981). This mixture or "mélange" was then scraped off and smashed onto the western edge of the North American continent about 88 million years ago (McLaughlin 2000). Mélange can be described as a mixture of claystone, siltstone, and sandstone that has been metamorphosed, churned, and mixed in a subduction zone to such a degree that its supporting matrix has been completely disrupted by shearing. Because the mélange matrix material is very weak it tends to behave more as an extremely viscous liquid than bedrock, slowly "flowing" over time. The flowing of mélange material over time exposes the more coherent lithologic blocks within the mélange known as "Franciscan Knockers" or "Donakers" (shown in the upper left photo at the beginning of the Middle Subbasin section).

Of all of the lithologies in the Van Duzen River Basin the mélange of the Central Belt is the most susceptible to earthflows and deep-seated landslides (Figure 3). Active and dormant earthflows within the mélange of this subbasin are frequent and sizeable. Active earthflows occur at an average movement of 4 meters/year. Dormant earthflows may reactivate during especially wet seasons, during seismic events, if their toe is worn away by streams, or in response to land use disturbances. Carving roads into earthflows can further destabilize them and initiate subsequent landslides.

Central Belt sandstone of the Franciscan Complex makes up roughly 24% of the surface of this subbasin. The Central Belt sandstone units are described as large blocks of slightly metamorphosed sandstone, greywacke ("dirty" sandstone), and argillite (McLaughlin 2000). They most likely formed 65 to 160 million years ago as sediment eroded from the continent, from sources as far away as Idaho (Underwood and Bachman 1986), and covered the subduction trench. These layers of sediment are not as tectonically mixed as the sediments within the mélange and are preserved relatively intact. Although they were metamorphosed, folded, and sheared to some extent, they are more coherent than the mélange.

The Yager terrane of the Coastal belt makes up 12% of this subbasin. The Yager terrane consists of rather well consolidated sandstone, argillite, and conglomerate. The Yager terrane is relatively stable but contains faulted and/or sheared zones of weakness within the bedrock that are prone to large-scale landsliding. Furthermore, layers of argillite (slightly metamorphosed claystone) within the Yager terrane tend to crumble when exposed repeatedly to water and air leading to sliding along bedding planes and increased sediment delivery to streams.

The Yager terrane was originally deposited around 50 to 34 million years ago from sediments transported by rivers as far as Idaho that accumulated along the continental shelf to the deep ocean floor (Underwood and Bachman 1986, McLaughlin et al. 2000). Quiescent periods of deposition of clay to silt sized particles settling out of suspension were punctuated by large underwater landslide events which deposited sand and gravel. This accumulation of inter-bedded sand, gravel, and mud eventually reached thicknesses of at least 5,000 feet.

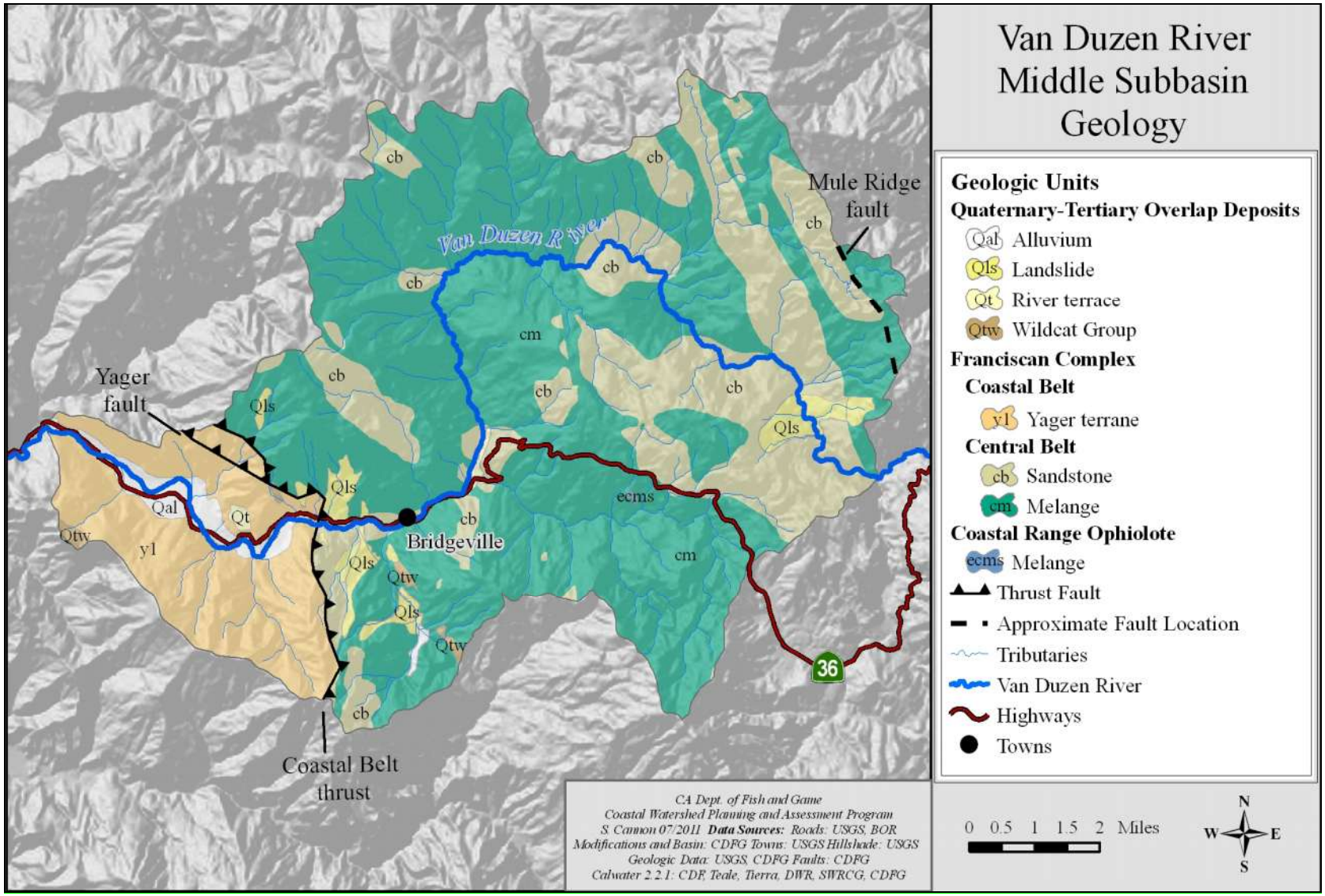

Figure 3. Geologic units of the Middle Subbasin of the Van Duzen River.

Table 2. Lithologic units of the Van Duzen River Middle Subbasin.

GEOLOGIC RELATION AND DESCRIPTION OF MAJOR UNITS WITHIN THE MIDDLE SUBBASIN						
Unit	**Belt/Rock type**	**Formation /terrane**	**Composition**	**Erosion**	**Age ma**	**%**
Overlap Deposits	Alluvium		Unconsolidated river deposits of boulders, gravel, sand, silt, and clay.	Raveling of steep slopes. Transportation of sediments by fluvial and aeolian processes.	0-0.01	2
	River terrace		Unconsolidated river deposits of boulders, gravel, sand, silt, and clay that have been uplifted above the active stream channel.		0.01-2	1
	Landslide		Large, disrupted, clay to boulder debris and broken rock masses.	Shallow debris slides. Rotational slumps on steep slopes or eroding toes. Surface erosion and gullying where vegetation is bare.	0.01-2	3
	Wildcat group		Marine mudstone, siltstone, sandstone grading upwards through nonmarine sandstone and conglomerate.	Shallow landslides, debris slides, rotational slides and slumps, and block slides especially along inward dipping bedding planes between sandstone and mudstone layers. Toppling along joints. Some rock falls and slaking of exposed surfaces.	0.78-11.6	<1
Franciscan Complex	Coastal belt	Yager terrane	Deep marine, interbedded sandstone and argillite, minor lenses of pebble-boulder conglomerate.	Prone to debris slides along stream banks. Translational rock slides, especially on inward dipping bedding planes between sandstone and argillite layers.	33.9-65.5	12
	Central belt	Sandstone	Large blocks of metasandstone and metagraywake, interbedded with meta-argillite.	Generally stable but prone to debris sliding along steep stream banks and in steep headwater drainages.	65.5-161.2	24
		Mélange	Penetratively sheared matrix of argillite with blocks of sandstone, greywacke, argillite, limestone, chert, basalt, blueschist, greenstone, and metachert.	Susceptible to mass movement by large earthflows and subsequent debris flows triggered by saturation.	1.8-65.5	58
Sources: Ogle 1953, Kilbourne 1985, McLauglin et al. 2000. % Data represent an approximation based on GIS mapping.						

Quaternary landslides occupy around 3% of the subbasin (McLaughlin et al. 2000). These areas have been characterized as mostly older landslide features, and therefore have generally been re-vegetated and active movement has been relatively stabilized. However, these areas are still susceptible to enhanced erosion because the coherency of the slide material has been disrupted. The toes of these landslides are typically eroded by stream channels causing subsequent, prevalent small-scale sliding and bleeding of fine sediments into the river system. Furthermore, if the toes of these large landslides erode far enough or if there is a large, local seismic event, these landslides may reactivate.

Alluvium and **river terrace deposits** cover approximately 2% of this subbasin. Alluvium includes any actively moving stream channel sediments as well as unconsolidated bank deposits and floodplain deposits. River terrace deposits consist of unconsolidated cobbles, gravels and fine sediments. These terraces were once river channel and floodplain alluvial deposits but have been raised above the hundred-year-flood level during the last 2 million years by regional tectonic uplift. River terrace deposits tend to form steep channel banks that are prone to dry ravel and slumping.

Prominent river terrace deposits in this subbasin include: Weonme Flat, Swain's Flat, Bar W Ranch, Petty Flat (Little Golden Gate subdivision), and Bridgeville.

Wildcat group, which consists of soft marine sedimentary bedrock, is present within this subbasin but accounts for less than 1% (175 acres) of its surface area. The Wildcat group occurs at two areas within this subbasin: just south of Bridgeville as dislocated, faulted remnant within Central belt mélange, and at the western tip of the subbasin where it overlaps the Yager terrane.

Faults and shear zones

The Yager fault, Coastal belt thrust, and Mule Ridge fault run through the Middle Subbasin disrupting the coherency of the bedrock (Fig 3).

The Yager fault is a low-dipping thrust fault that trends northwest through the lower part of this basin. The Yager fault may be an active offshoot of the Little Salmon fault and occasionally generates earthquakes large enough to trigger landslides.

The Coastal Belt Thrust fault is the major fault that juxtaposes the Coastal belt and the Central belt. It trends north to northwest through the Van Duzen River basin. It is most likely the zone which accommodated movement between the subducting Farallon plate and the North American plate before accretion of the Coastal belt when the active subduction moved west to its present location along the Cascadia Megathrust.

The Mule Ridge fault is a steeply dipping to nearly vertical fault that runs northwest through the eastern edge of this subbasin.

Landslides

Large Quaternary landslide features comprise approximately 3 percent of this subbasin (Table 2). Detailed field investigations may document smaller and/or less obvious landslides. Two notable historical slides include the Donaker Creek earthflow (RM 29) and the Fish Creek debris slide (RM 25).

The Donaker Creek earthflow is the largest within the Van Duzen River basin and has been active since before European settlement, and is perhaps the largest single-point source of fine sediments entering the Van Duzen River. Kelsey (1975) determined an erosion rate for the Donaker earthflow to be 89,000 tons/mi^2/year.

The Fish Creek debris slide (RM 25) was associated with a logging road constructed in the 1950s within the active channel of Fish Creek and initiated by the 1964 flood event (Fig. 4). Debris sliding along the banks of Fish Creek was continuous for over a mile upstream of its confluence with the Van Duzen River. It is estimated that the Fish Creek debris slide flushed 4.9 million cubic feet of alluvium into the Van Duzen River (Kelsey 1975) and was the largest slide associated with the 1964 flood.

Figure 4. Aerial photo of Fish Creek debris slide in the Middle Subbasin of the Van Duzen River.

Slope Inclination

Steep slopes (> 30%) cover 53% of the subbasin's terrain and are distributed throughout the subbasin (Table 3, Fig. 5). Moderate slopes (15-30%) covering a third of the subbasin are also spread throughout of the subbasin.

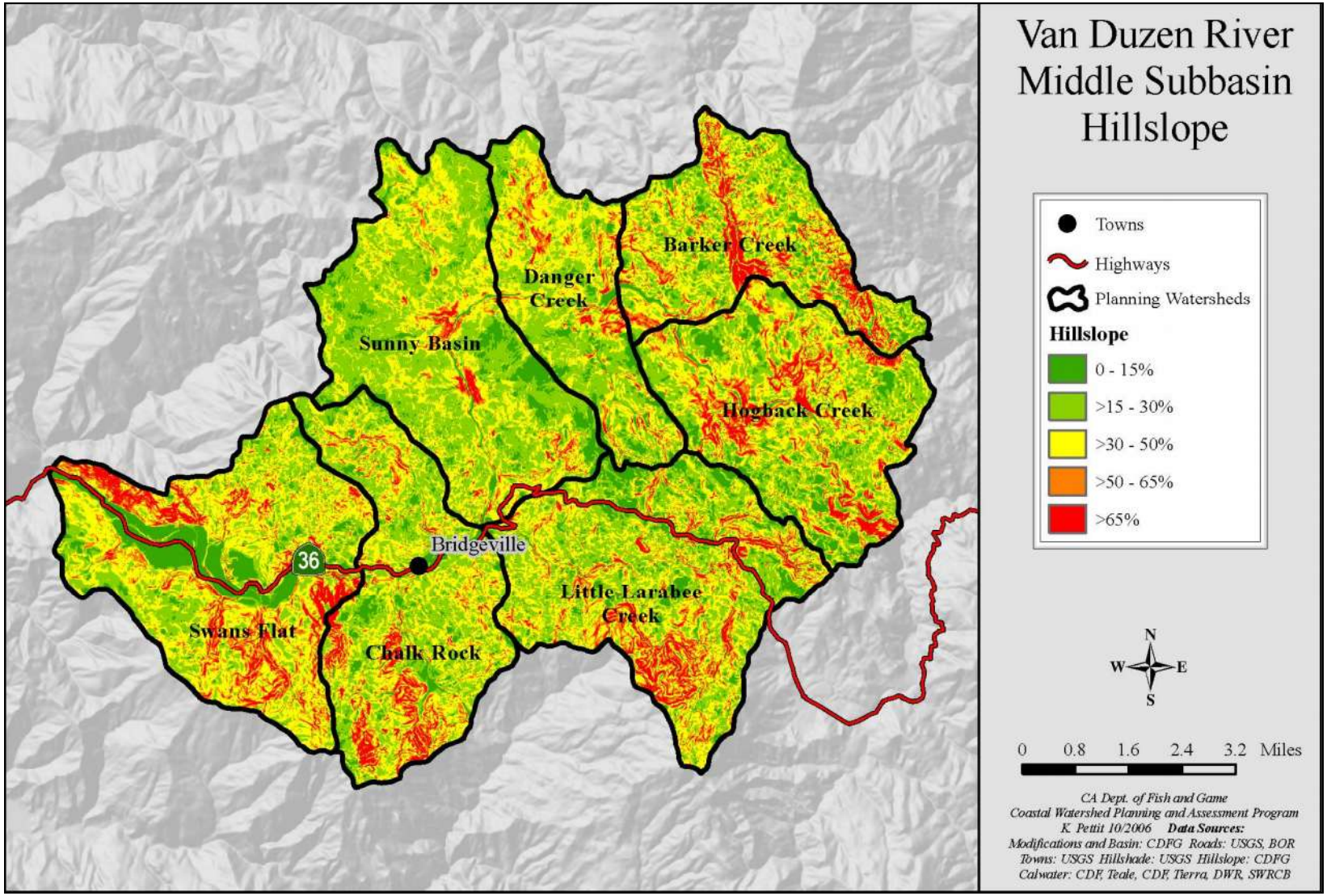

Figure 5. Hillslope classes with planning watersheds depicted in the Middle Subbasin of the Van Duzen River.

Table 3. Hillslope classes and acres associated with each class of the Middle Subbasin of the Van Duzen River.

Slope class	Acres
0 -15% Gentle	5,899 (12%)
>15 - 30% Moderate	17,802 (35%)
>30 - 65% Steep	22,813 (46%)
>65% Very Steep	3,486 (7%)

Regional uplift/basal lowering, offset along local faults, stream power, and nature of bedrock influence the shape of the Van Duzen River's longitudinal profile (Figure 6). In the Middle Subbasin, a prominent knickzone (a locally steep reach separating relatively gently sloped reaches) has developed between RM30 and RM47 within geology of the Central belt. Incision associated with knickzone formation and migration typically leaves relatively steeper canyon walls in the immediately surrounding area which tends to increase the potential for slope failure and surface erosion

Since all the steep hillslope geology of the Middle Subbasin is considered to have high erosion potential, actions such as road construction, intensive timber harvests, and tractor yarding should be mitigated according with Best Management Practices that meet all regulatory agency standards for soil conservation, fish and wildlife values and water quality objectives.

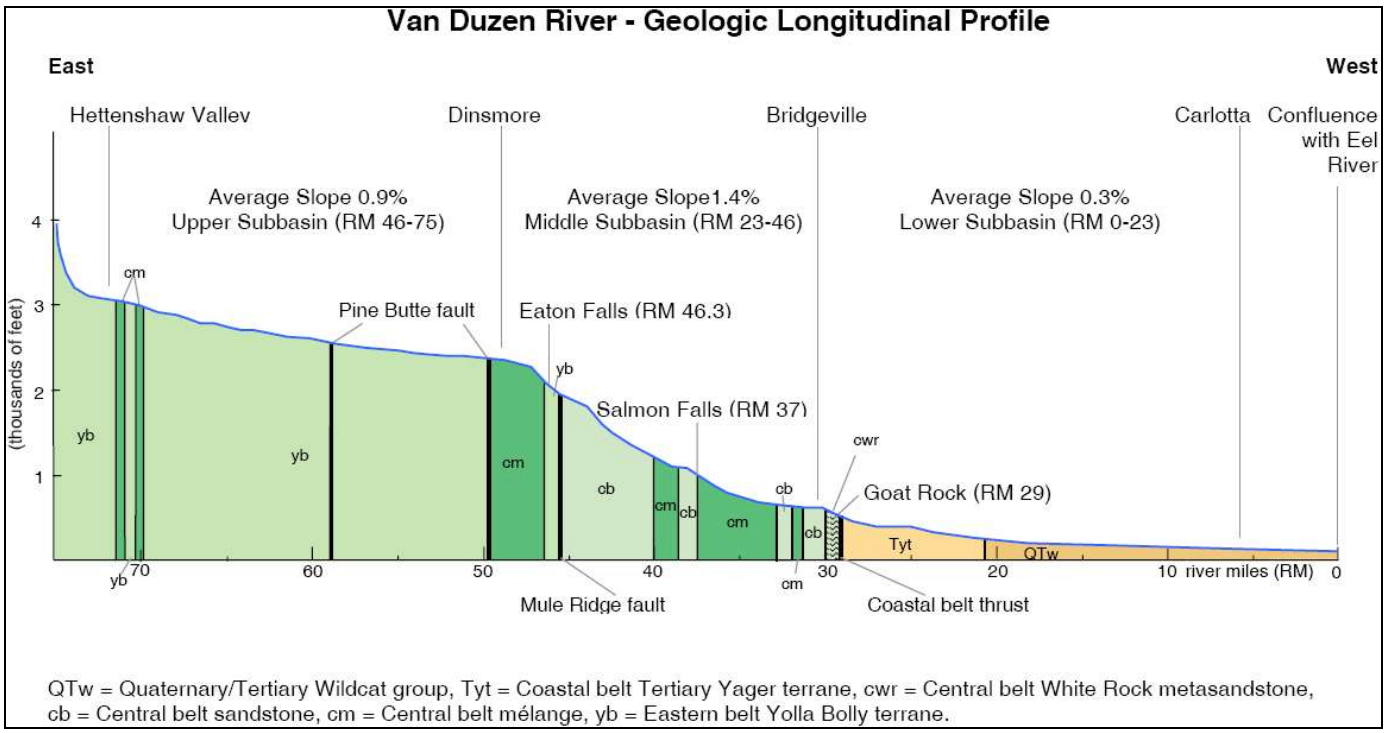

Figure 6. Geologic Longitudinal Profile of Van Duzen River

Hydrology and Sediment Transport

Approximately 23 miles of the mainstem Van Duzen River (a 5th order stream), 53 miles of perennial tributary channels and 86 miles of intermittent tributary stream channels drain the Middle Subbasin according to 1:1000 USGS maps (Figure 6). The Middle Subbasin is a large source of both natural and anthropogenic sediment inputs to the Van Duzen River because it is largely composed of highly unstable mélange terrain. The USEPA (1999) estimated areas of the Middle Subbasin delivers the most sediment to the stream network compared to other subbasins.

Mainstem Van Duzen River

The mainstem Van Duzen River flows within the Middle Subbasin from the confluence with the Grizzly Creek upstream to the confluence with the Little Van Duzen River (RM 23-46). There are both sediment transport and depositional reaches along this length of river channel. The average gradient of the Van Duzen River in the Middle Subbasin is 1.4% with the steepest contiguous sections located above the confluence with Baker Creek (RM 39.2). The lower 15 miles of the river within the Middle Subbasin is generally less than 1% except for a significant rise in gradient along a boulder roughs at Goat Rock (RM 29.5). The Goat Rock roughs may be an obstacle during upstream passage (but not a barrier) to Chinook and coho salmon.

Another significant rise in channel gradient begins near Scott Creek (RM 34.5) where the gradient averages <3% to the confluence with the Little Van Duzen, including a steep section of boulder roughs leading to Salmon Falls (RM 37). It is believed that Salmon Falls typically acts as a barrier to upstream migration of both Chinook and coho salmon, but not steelhead. However, reports of coho salmon in Little Van Duzen River and Butte Creek (Reynolds et al. 1981, Decker and Fuller 1983), suggest that salmon may occasionally migrate past the Salmon Falls.

Streamflow in the mainstem is measured at the USGS stream gauge located approximately one mile upstream of the Grizzly Creek confluence at a site known as Rainbow Bridge (RM 24). The stream gauge measures discharge from the upper half (222 sq. mi.) of the 430 square mile Van Duzen River Basin. Mean annual peak flow from the Bridgeville gauging station is estimated at 22,300 cfs, which is about a two year event or a re-occurrence interval of every two years (Steppen 2002). Additional annual streamflow data from the Rainbow Bridge site is shown/discussed in the Hydrology section of the Van Duzen River Basin Profile (pgs. 18-23).

Tributary Streams

The Middle Subbasin drains approximately 53 miles of perennial tributary channels and 86 miles of intermittent tributary channels (Figure 7). The majority of the tributary channels are characterized as steep (gradient >20%) and are considered sources areas for sediment inputs (Figure 8). A good portion of these steep stream reaches are also intermittent channels and likely do not support anadromous salmonids. However, these tributaries may make critical contributions of flow and sediment to downstream reaches, and their potential contributions should be considered before initiating land use projects that may impact fish, water flow and/or sediment transport.

No stream flow gauging stations exist in the tributaries. Winter flows in the tributaries are generally episodic typified by a rapid rise and fall in flow relative to the intensity and duration of rain events.

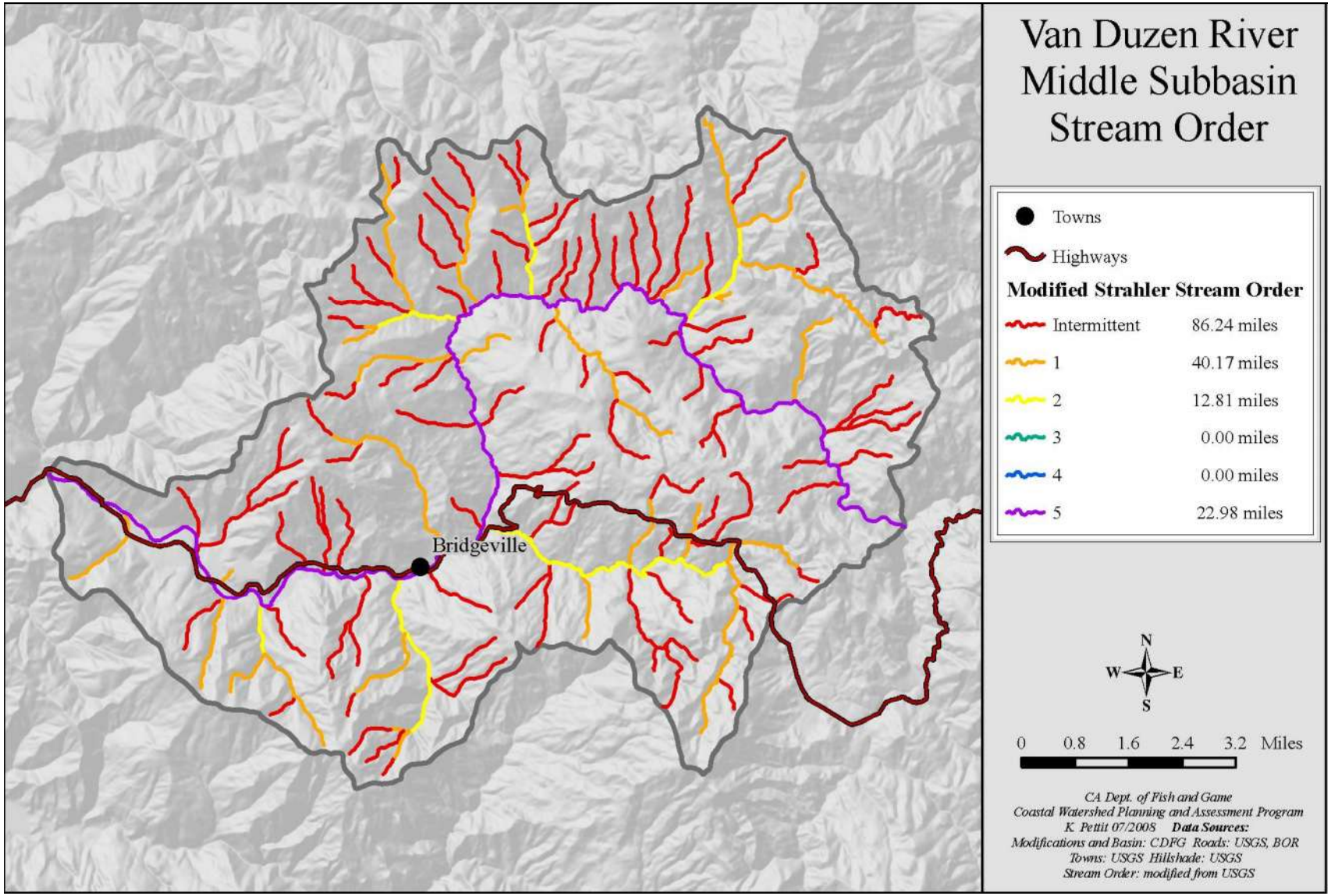

Figure 7. Stream order and intermittent tributaries of the Middle Subbasin of the Van Duzen River.

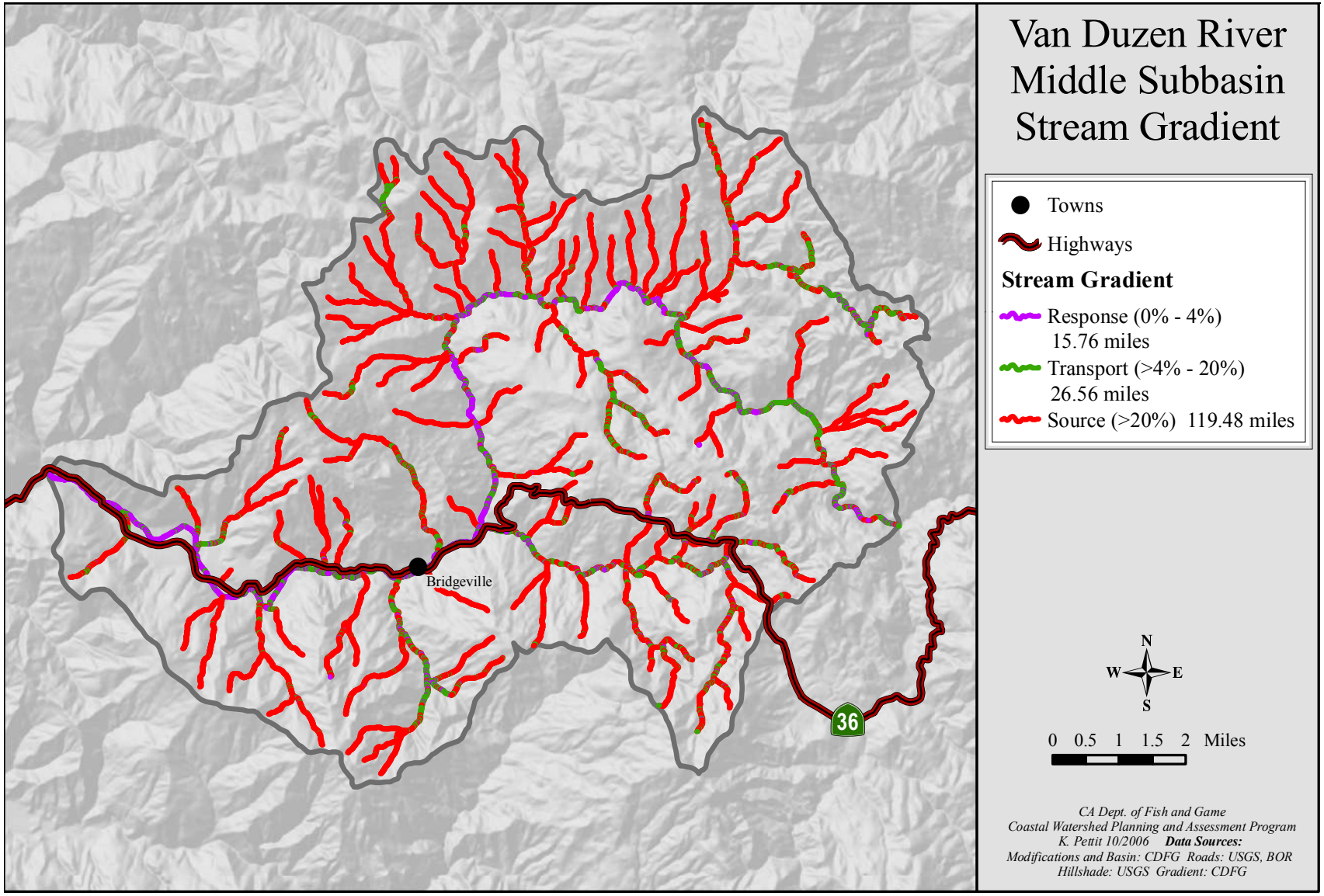

Figure 8. Stream gradient classification for sediment response, transport, and source for Middle Subbasin of the Van Duzen River.

Vegetation

As discussed in the Vegetation section of the Basin Profile (p. 31), the important roles forests play in watershed processes, stream ecosystems and a stream's ability to support viable populations of anadromous salmonids are well documented (Meehan 1991, Murphy 1995, Spence et al. 1996, Lassettre 1999). Douglas fir dominated forests cover approximately 70% of the Middle Subbasin terrain, while grasslands and mixed hardwood forests cover most of the remaining land in the subbasin (Fig. 8). Redwood dominant forest are only found in the western portion of the subbasin as the forest transition into fir dominated forests.

Most tributary stream reaches that support salmonids flow through coniferous forests. However, most of the coniferous forests in the subbasin have been recently logged, leaving early seral stage forest stands predominating the landscape. As discussed in the Basin Profile (pp. 46-47) adverse changes occur to salmonid habitat related to extensive logging of forests (Murphy 1995) and land use that disturbs riparian and near stream forests (Meehan 1991 and Spence et al. 1996).

Land and Resource Use

Land use in the Middle Subbasin is mostly comprised of timber production and livestock grazing (Fig. 9). Rural residential areas occupy land along Highway 36. The only town within the subbasin is the unincorporated community of Bridgeville. With a population of less than 25 people, it consists of a few houses and a post office. Bridgeville has the noted distinction of being the first town in the United States to be auctioned on internet website eBay http://news.bbc.co.uk/2/hi/americas/2605239.stm).

Timber Harvests

A total of 39% of the subbasin's conifer forests were involved in timber harvest activity from 1991 to 2007 (Table 4). During this period, the Swain's Flat and Chalk Rock planning watersheds experienced the highest percentage of harvest activity of their conifer forest with 55% and 52%, respectively, in harvest plans.

Roads

Roads data available from California Department of Forestry (CDF) GIS roads layers show that there is an average of four miles of roads per square mile of land in the Middle Subbasin (Fig. 10). However, the roads layer source data does not cover the full extent of the subbasin, so it underestimates the actual miles of roads on the landscape (ftp.fire.ca.gov/forest). Based on the available data, the road density is above the recommended threshold of 2.5 miles/square mile (Cederholm et al. 1980). Cederholm et al. (1980) suggested the presence of more than 2.5 miles of unpaved roads per square mile of land may increase fine sediment production by approximately 200-400% above natural levels. These fine sediments enter streams from surface erosion and road related landslides.

The highest road densities are in the Chalk Rock, Little Larabee Creek, and Swain's Flat Planning Watersheds. The higher road density in these planning watersheds coincides with a higher percentage of forested land having greater timber harvest activity than compared to planning watersheds containing higher amounts of grasslands (Table 5).

Industrial Marijuana Agriculture

While not displayed in Land Use Figure 10 (p.15), industrial marijuana agricultural operations are locally abundant throughout the rural areas of the Middle Subbasin and are having a significant impact on the landscape and natural resources (including aquatic) of the subbasin and Basin as a whole. The impacts and a discussion of these operations are discussed further in the Basin Profile (pp. as well as in the Lower Subbasin (p. 27).

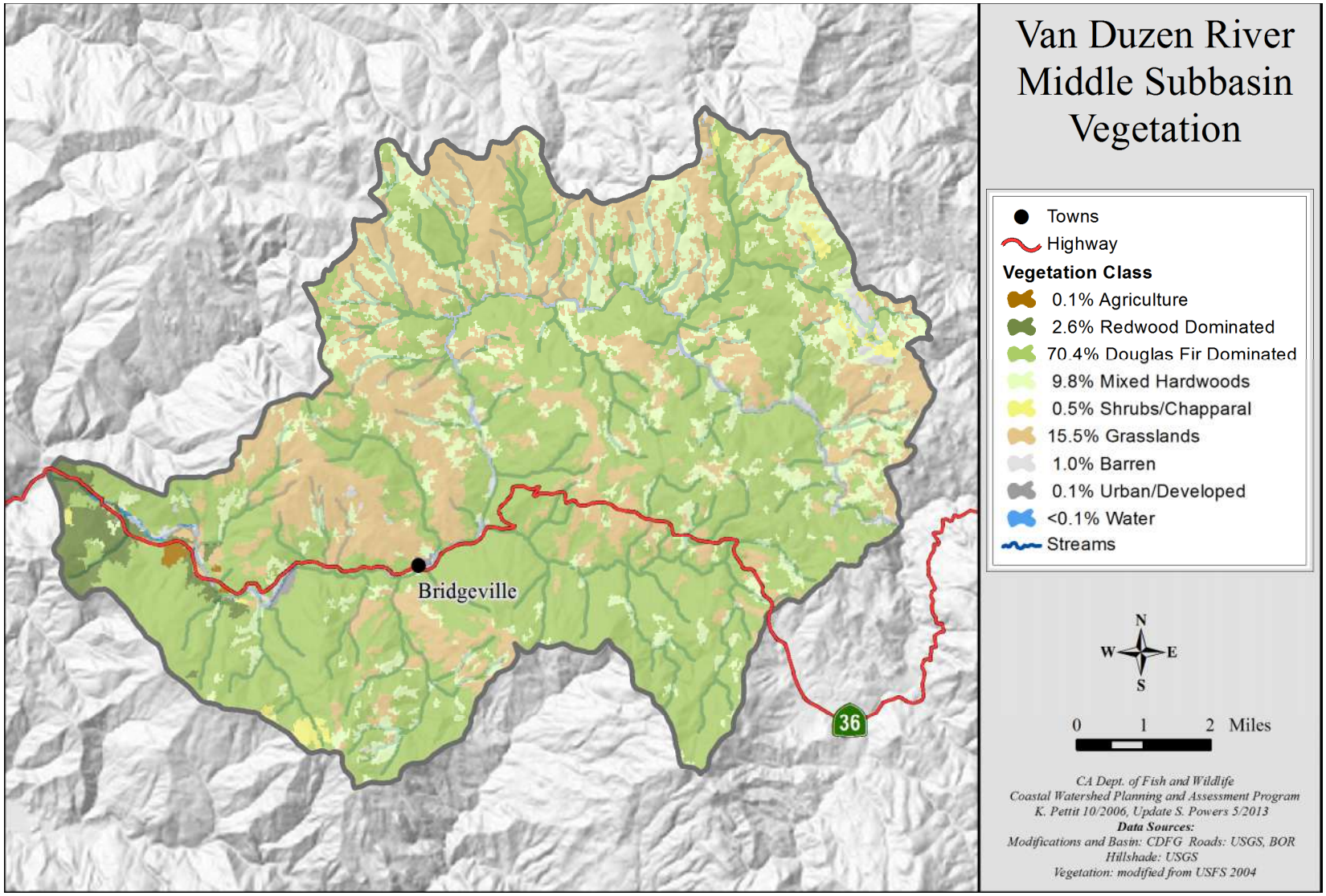

Figure 9. Vegetation classes for the Middle Subbasin of the Van Duzen River.

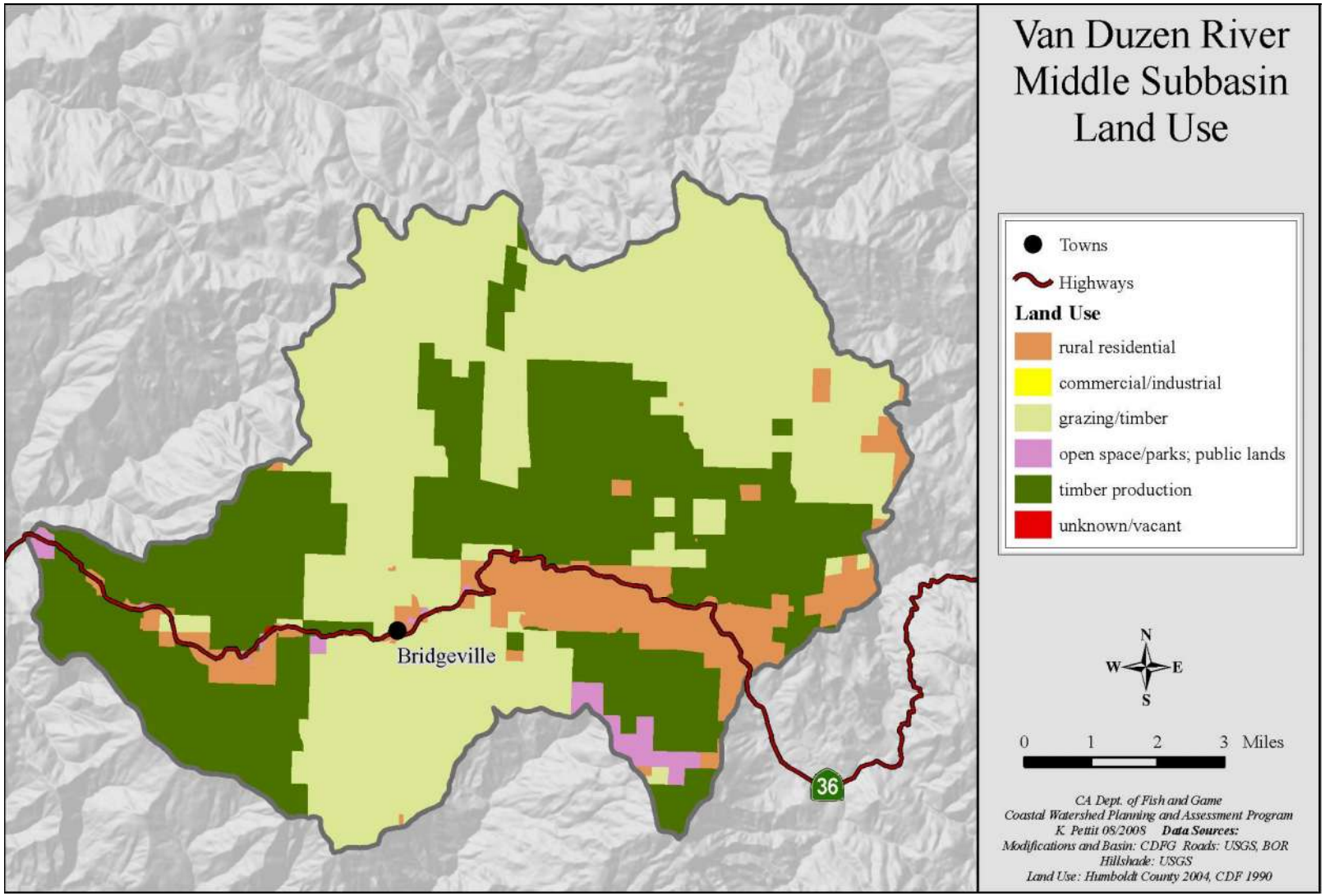

Figure 10. Land use categories in the Middle Subbasin of the Van Duzen River.

Table 4. Middle Subbasin of the Van Duzen River timber harvest plan statistics 1991-2007.

Planning Watershed (PW)	PW Acres	Harvested Acres	% PW Harvested	Conifer Acres	% PW in Conifers	% Conifers Acres Harvested	NCRWQCB* Adjusted %/yr.
Barker Creek	5429	315	6	1911	35	16	0.73
Chalk Rock	7032	2257	32	4329	62	52	2.4
Danger Creek	4590	297	6	2341	51	13	0.5
Hogback Creek	7104	1471	21	3684	52	40	1.1
Little Larabee Creek	8492	2334	27	6776	80	34	1.7
Sunny Basin	8582	1140	13	3571	42	32	1.2
Swain's Flat	8953	3392	38	6218	69	55	2.7
Subbasin Total	50182	11206	22	28830	57	39	1.7

*NCRWQCB = North Coast Region Water Quality Control Board

Table 5. Road miles, square miles and roads per square miles in the Middle Subbasin of the Van Duzen River by planning watersheds.

Planning Watershed	Road Miles	Square Miles	Road Miles per Sq. Mi.
Barker Creek	16.39	8.48	1.93
Chalk Rock	65.37	10.99	5.95
Danger Creek	12.76	7.17	1.78
Hogback Creek	42.61	11.10	3.84
Little Larabee Creek	75.77	13.27	5.71
Sunny Basin	41.50	13.41	3.09
Swans Flat	57.47	13.99	4.11
Totals	**311.9**	**78.4**	**4.0**

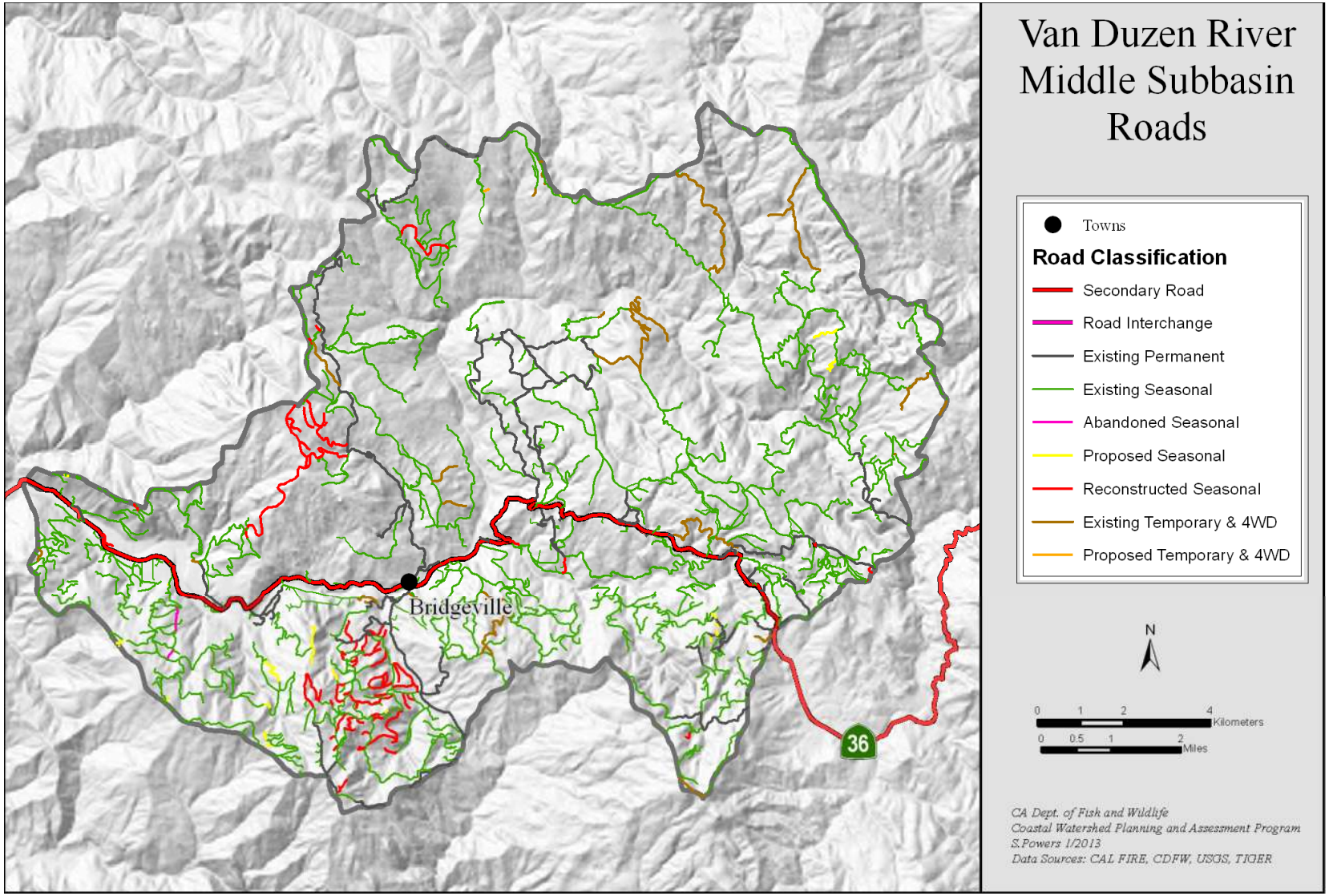

Figure 11. Roads within the Middle Subbasin of the Van Duzen River.

Fish Habitat Relationships

Fishery Resources

The Middle Subbasin supports populations of steelhead, Chinook salmon and possibly coho salmon. Approximately 5 miles of tributaries and 23 miles of mainstem Van Duzen River support steelhead (Table 6, Fig 13) and 15 miles, consisting of mostly mainstem Van Duzen River, are accessible to Chinook salmon (Fig 14). The mainstem Van Duzen is important Chinook salmon spawning habitat and juvenile rearing areas. Salmon and steelhead use the mainstem as an important migration pathways to and from the ocean and as well as for juvenile rearing habitat. The most important tributary streams for salmonids are Fish Creek, Hoagland Creek, and Little Larabee Creek. The tributaries flowing into the Van Duzen from the north are generally too steep and limited by ephemeral flows to provide anadromous salmonid habitat. Figure 14 depicts the passage barrier for Chinook (and coho) salmon at Salmon Falls (RM 37).

Coho salmon prefer small, low gradient tributaries for spawning rather than large mainstem reaches of the Van Duzen used by Chinook salmon. With the exception of the lower mile of Little Larabee Creek, most of the tributaries in the Middle Subbasin are high gradient streams that are unsuitable for coho lifecycle requirements. While coho were historically abundant in the Yager and lower subbasins, reports of coho presence in the Middle Subbasin are limited. A local angler reported catching an adult coho salmon near the confluence of Fish Creek in 2005, and coho salmon have been reported upstream of the Middle Subbasin in the Little Van Duzen (South Fork Van Duzen) (Reynolds et. al 1981) and its tributary Butte Creek (Decker and Fuller 1984). Due to the lack of survey efforts, it is unknown if adult coho currently utilize any of the Middle Subbasin tributaries or mainstem for spawning.

Table 6. Miles of stream accssessable to anadromous salmonids in the Middle Subbasin of the Van Duzen River.

Stream	Steelhead (mi)	Chinook (mi)	Coho (mi)
Brown Creek	0.4		
Hoagland Creek	1.2		
Little Larabee Creek	2.8	1	1
Fish Creek	0.5	0.5	
Winimnome	0.2	0.2	
Van Duzen River	23	14	14

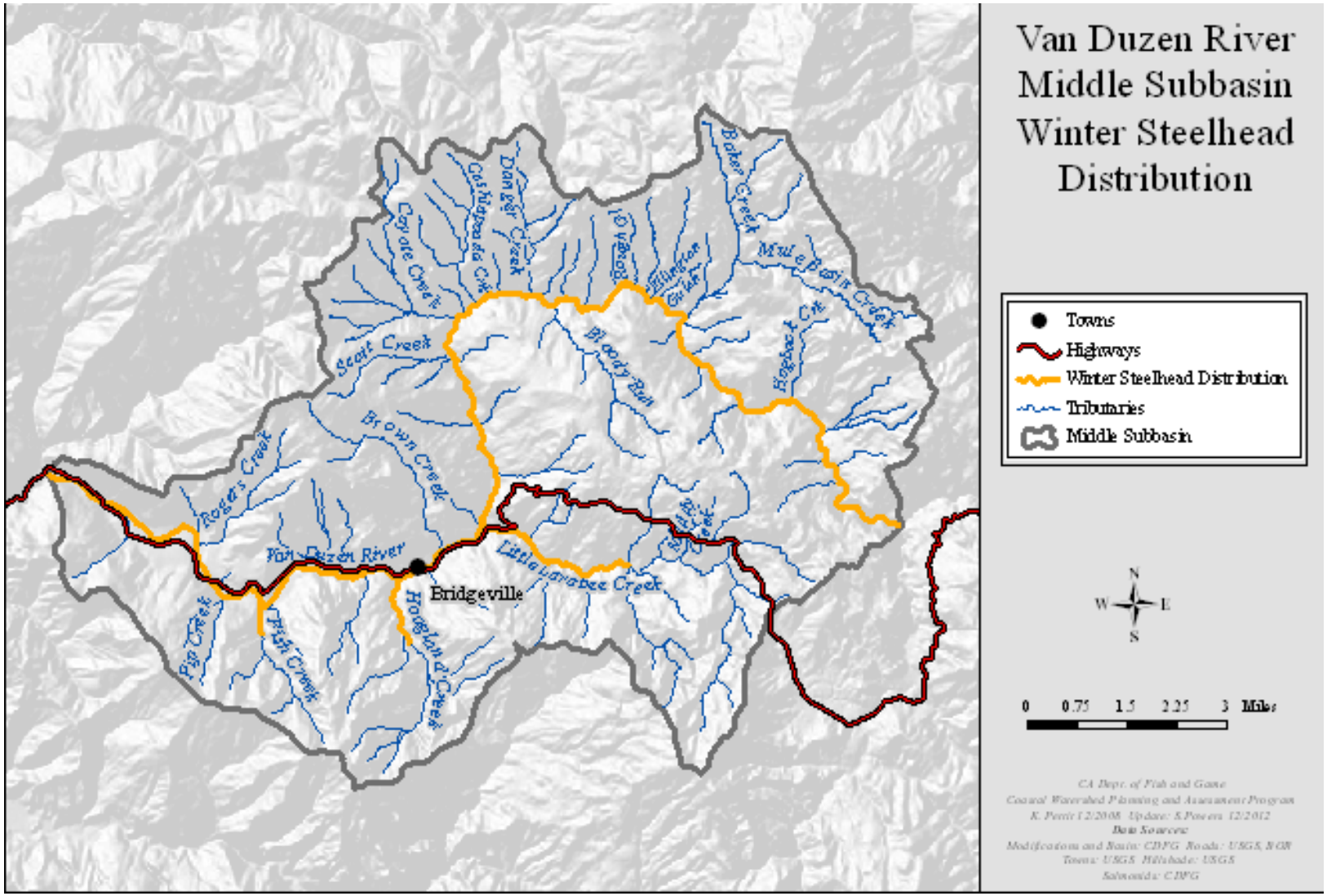

Figure 12. Steelhead migration and spawning habitat within the Middle Subbasin of the Van Duzen River.

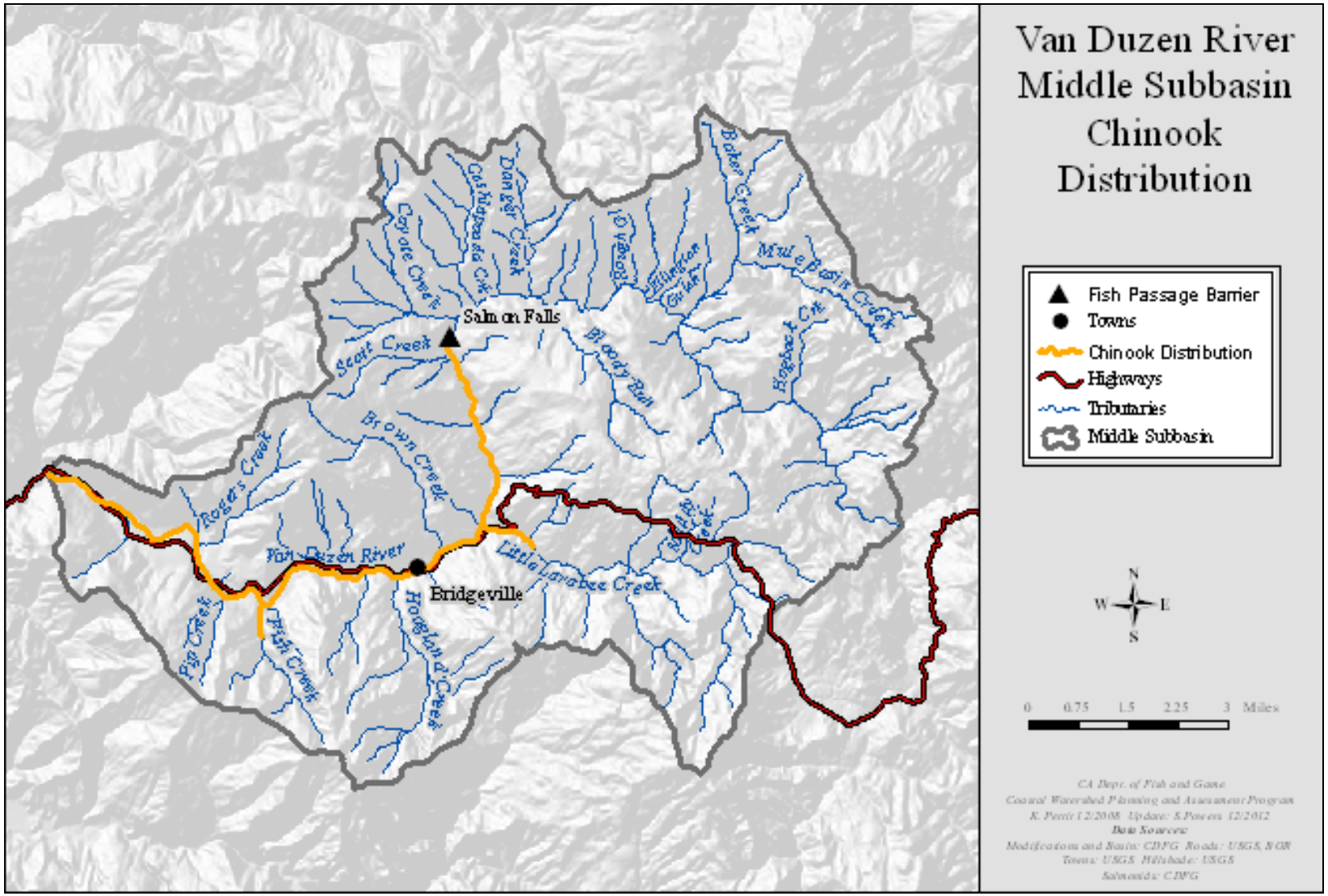

Figure 13. Distribution of Chinook in the Middle Subbasin

Figure 14. Salmon Falls: boulder roughs typically impede Chinook and coho salmon spawning migration, although steelhead are able to pass above the site.

Habitat Overview

Historic Conditions

Most historical CDFG stream surveys within the Middle Subbasin date back into the mid-1960s, with the exception of a 1938 survey in Hoagland Creek (Table 7). These early stream survey efforts were neither specific nor standardized until 1990 when the *California Habitat Restoration Manual* (flosi et al. 1998) was published. Most observations in the historic stream surveys are not quantitative and have limited use in comparative analysis with current habitat inventories. However, data from these stream surveys provide a snapshot of conditions, including barriers limiting fish passage at the time of survey.

Stream	Date Surveyed	Source	Habitat Comments	Barrier Comments
Pip Creek	7/15/1965	CDFG	"Due to the extremely precipitous nature of the stream's mouth region and lack of adequate water flow, the stream was not surveyed beyond the mouth."	"The mouth region was considered to be impassible barrier to anadromous fish due to its extremely precipitous nature."
Hoagland Creek	8/17/1938	CDFG	Fish presence: abundant, steelhead 1½ to 3" Pools: Good Shelter: Good Food: Abundant Spawning area: Good Flow: ⅓ CFS Water Temp: 58F	None observed
	7/25/1963	CDFG	"The habitat is poor in Hoagland Creek. The pools are not deep and shelter area is scarce. Thee stream is shaded about 50%	"About ¾ mile from the mouth, large boulders and some logs form 3 falls 8-10 ft high. These are probable barriers. A

			of the day. Food is available but not plentiful." Fingerling trout observed below barrier and resident trout seen above barrier.	barrier exists 700 yds. from the mouth."
Hoagland Creek	7/20/1965	CDFG	"Numerous small salmonids ranging from 1" to 3" below roughs. In roughs and above there were few fingerling salmonids. Large salmonids, believed to be resident trout, were noted in the pools above the roughs."	Series of roughs and falls to 5 ft high about ¼ of a mile upstream from mouth. Landowner reports anadromous fishes come up Hoagland each year to roughs but never beyond.
	8/12/1975	CDFG	Only lower .25 mile of Hoagland Creek available to anadromous fish as fingerlings were observed in this lower area. Populations of resident trout est. at 90 fish per 100 ft. of stream.	Roughs at 0.25 miles upsteam of mouth prevents upstream migration of anadromous fish. Additional smaller roughs located 0.5 and 1.0 miles upstream from mouth that would prevent upstream migration.
Brown	7/28/1965	CDFG	"Due to the lack of water during the summer months, the precipitous nature of the stream, and evidence of heavy erosion, this stream should not be considered into any fisheries program."	"An impassible barrier was encountered ½ mile upstream from the mouth."
	5/23/1978	CDFG	"Very few salmonids observed. Flow was intermittent for the first 200 yards. Pool to riffle ration was 1:1. Course and fine rubble predominated the stream bottom. Pools formed majority of shelter. Some shelter formed from upperstory vegetation."	"One barrier, considered imapassibe, occurred approximately ½ mile from the mouth."
Little Larabee Creek	7/8/1965	CDFG	"Fisheries habitat far from ideal, but large numbers of fish were seen. Green algae was present in large amounts on the rocks in the stream and aquatic insects were numerous…. Spawning areas contained very coarse gravel and some fine rubble, evidentally suitable for spawning purposes. Cover in the pools was afforded mainly by rocks and undercut banks."	Survey terminated at roughs area approx. 1.5 miles upstrm of mouth. Two waterfalls present in this area. First is 6ft high and unlikely to be barrier. Second is 10ft and probably acts as a complete barrier to migratory fish. No small salmonids were seen beyond this point.
	3/27/1975	CDFG	No fish observed due to turbid water conditions. Additional survey recommended to determine the potential benefits of removal of log jam.	At 1.0 miles upstream of mouth a large log jam, consisting of logs and debris, accumulated in a bend and created a possible barrier to migrating fish.
	5/20/1983	CDFG	Survey inspecting condition of stream after 81 and 82 winter flows. Lower mile was severely damaged by silt deposition due to several active slides caused by adjacent road and its inadequate maintenance and drainage facilities. No fish observed until the end of the survey. One 32mm SH/RT collected and several small salmonids observed (15cm).	Two log jam, partial barriers were observed in the area surveyed (0-2 miles upstream). A slide occurred in the area of the 6 ft fall (1.5 miles) which as diverted some of the stream flow and improved access around the falls. Recommendation to modify 3 log jams.
	6/5/1984	CDFG	Electrofished from mouth to 400 ft. upstream. "Numerous SH/RT were seen, est. at 250 to 300 fish/100' of stream." 35 SH/RT were id and average size was 3.1cm. In addition, 2 SH/RT at 8.0 cm and 7.8 cm.	
Little	12/22/87	CDFG	Surveyed to recover coded wire tags from	"Boulder roughs at 1.5 miles from the

Larabee Creek	and 1/28/88		mouth to 1.5 miles upstream; however, no salmonids were noted on either survey in contrast to previous years carcass surveys. Habitat conditions were generally fair… numerous unstable banks erosion sites contributing fines into stream."	mouth may be barrier to anadromous fish."
Danger	7/27/1965	CDFG	No water in stream channel at time of survey. First 200 yrds of channel was located on a steep gradient. "Due to the lack of water during summer months, the precipitous nature of the stream, and the evidence of heavy erosion, this stream should not be considered into any fisheries program."	

Current Conditions

Recent habitat inventories in the Middle Subbasin are limited to Fish Creek, Hoagland Creek, and Little Larabee Creek. These streams represent the current areas of steelhead and Chinook distribution within the subbasin. Little Larabee was surveyed in 1991 and 1996, while Fish and Hoagland creeks were just surveyed in 1991. Stream habitat inventory methods were conducted according to methods determined in the California Salmonid Stream Habitat Restoration Manual (Flosi, et al. 1998). Analyses of instream habitat conditions include the following:

- Habitat type categories;
- Pools by maximum depth;
- Pool shelter;
- Canopy density;
- Cobble embeddedness.

Habitat Categories

Pool:Riffle:Run Relationships

Significance: Productive anadromous streams are composed of a balance of pool, riffle and runs. Each plays an important role as salmonid and stream community habitat. A pool to riffle ratio of approximately 1:1 has been suggested to provide optimum food production and shelter for juvenile coho salmon (McMahon 1983). Flosi et al. (1998) notes that the length of anadromous salmonid streams should be 40% composed of primary pool habitats.

There are several factors affecting the relationships of pools, runs and riffles. These include channel type, channel gradient, bed and bank materials, sediment inputs, width to depth ratios, scour objects such as boulders and large woody debris (LWD), and the condition of the upstream watershed. Pools in forested mountain streams, such as those in the Middle Subbasin, are often associated with LWD, boulders and rock outcrops that help scour sediments during channel forming flows. A low measure of pool area and aggraded channels are often found when LWD is in low supply and/or when sediments are in excess. Large proportions of run or riffle habitats compared to pools may indicate an aggraded channel.

Findings: Available data shows that the length of pool habitat was generally below suitable levels for salmonid production in tributary streams of the Middle Subbasin. Runs dominated the percent length of habitat types (Table 7). An imbalance in the length of pools and runs is noted in Fish Creek. Fish Creek shows 49% pool occurrence, but only 10% of the stream length is in pools, implying the presence of numerous small pools. Fish Creek has a relatively steep channel gradient which may account for the relatively short length of pools.

Table 7. Pool, riffle and run relationships (% occurrence and % length) from Middle Subbasin tributaries.

Stream Reach	Survey Year	Reach Length (feet)	Pool:Riffle:Run % occurrence	Pool:Riffle:Run % length
Little Larabee	1991	10,450	36:27:37	29:15:46
Little Larabee	1996	15,319	32:29:41	19:20:61
Fish Creek	1991	4,652	49:10:42	10:8:82
Hoagland Creek	1991	6,221	42:29:29	26:27:46

Pool Depth

Significance: Deep pools are important habitats for adult and juvenile salmonids. Deep pools are needed for holding areas by adult salmonids during spawning activities and juveniles use deep pools for year round rearing, escape cover from predators and as shelter from high winter flows. During low summer flows or in streams with intermittent flows, deep pools may provide the only suitable salmonid habitat. A lack of deep pools can limit salmonid production.

The length of deep pool habitat in a stream reach is a geomorphic characteristic commonly used as an indicator of stream conditions. Pool depth and lengths are easily measured without significant observer bias. We use the term primary pool to indicate pools with relatively deep maximum pool depths. The target primary pool depths are scaled relative to the Strahler stream order of the surveyed stream reach. Primary pools are pools with maximum residual depths of at least 2.0 to 2.5 feet for 1st and 2nd order streams, ≥3 feet for 3rd order steams and ≥4 feet deep for 4th order streams (Flosi et al. 1998 and NCWAP 2001). We consider streams with approximately 25-60% of their length consisting of primary pools suitable for salmonids in terms of deep pools. DFG uses these indicator values to assess the pool condition of anadromous salmonid habitat with the Ecological Management Decision Support System (EMDS) and by inspection of maximum pool depth histograms (Table 8, Fig 15).

Findings: Inspection of pool depth data and the EMDS evaluation maps show a general shortage of deep pool habitat with corresponding low habitat suitability in the few surveyed streams of the Middle Subbasin (Fig. 16). For example, Fish Creek shows 49 percent pool occurrence but only 10 percent of the stream length is in pools. This implies numerous small pools in Fish Creek could be enlarged by addition of LWD.

Table 8. Average maximum residual pool depth and length from tributary surveys in the Middle Subbasin of the Van Duzen River.

Stream Reach	Survey Year	Reach Length (feet)	Ave. Max Res. Pool Depth
Little Larabee	1991	10,450	2.1
Little Larabee	1996	15,319	2.4
Fish Creek	1991	4,652	1.5
Hoagland Creek	1991	6,221	1.7

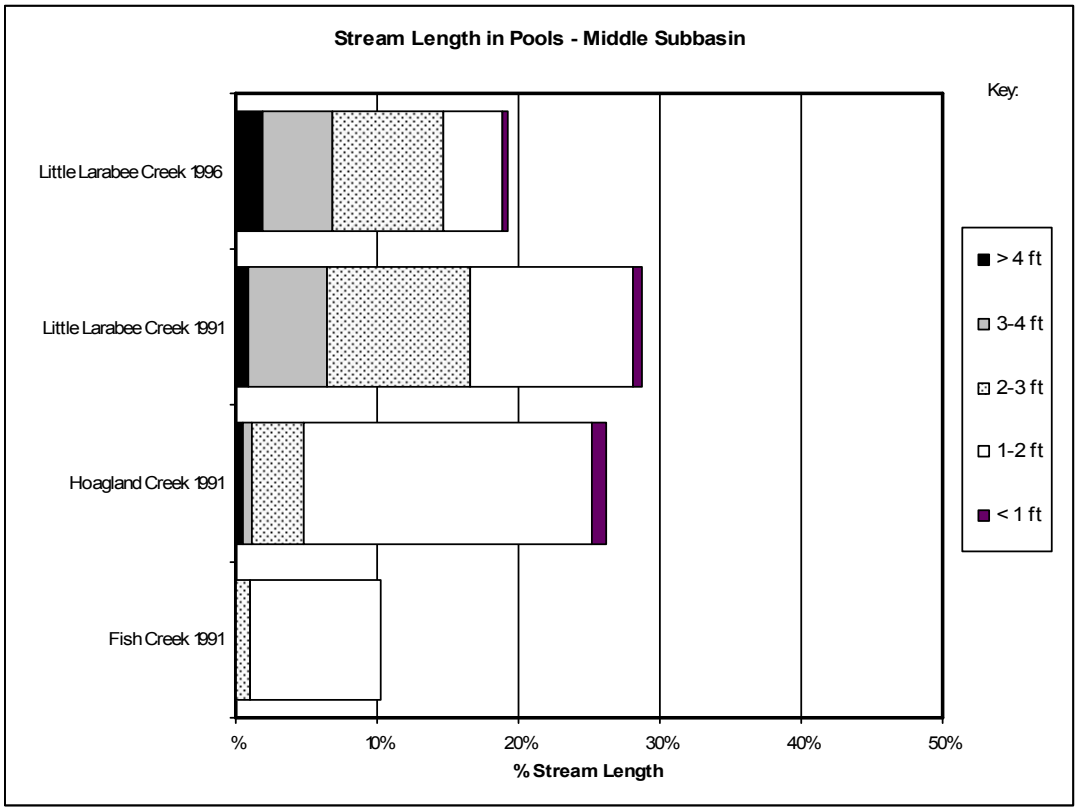

Figure 15. Histogram depicting percentage of stream length that supports four classes of pool depth based on four surveyed streams in the Middle Subbasin of the Van Duzen River.

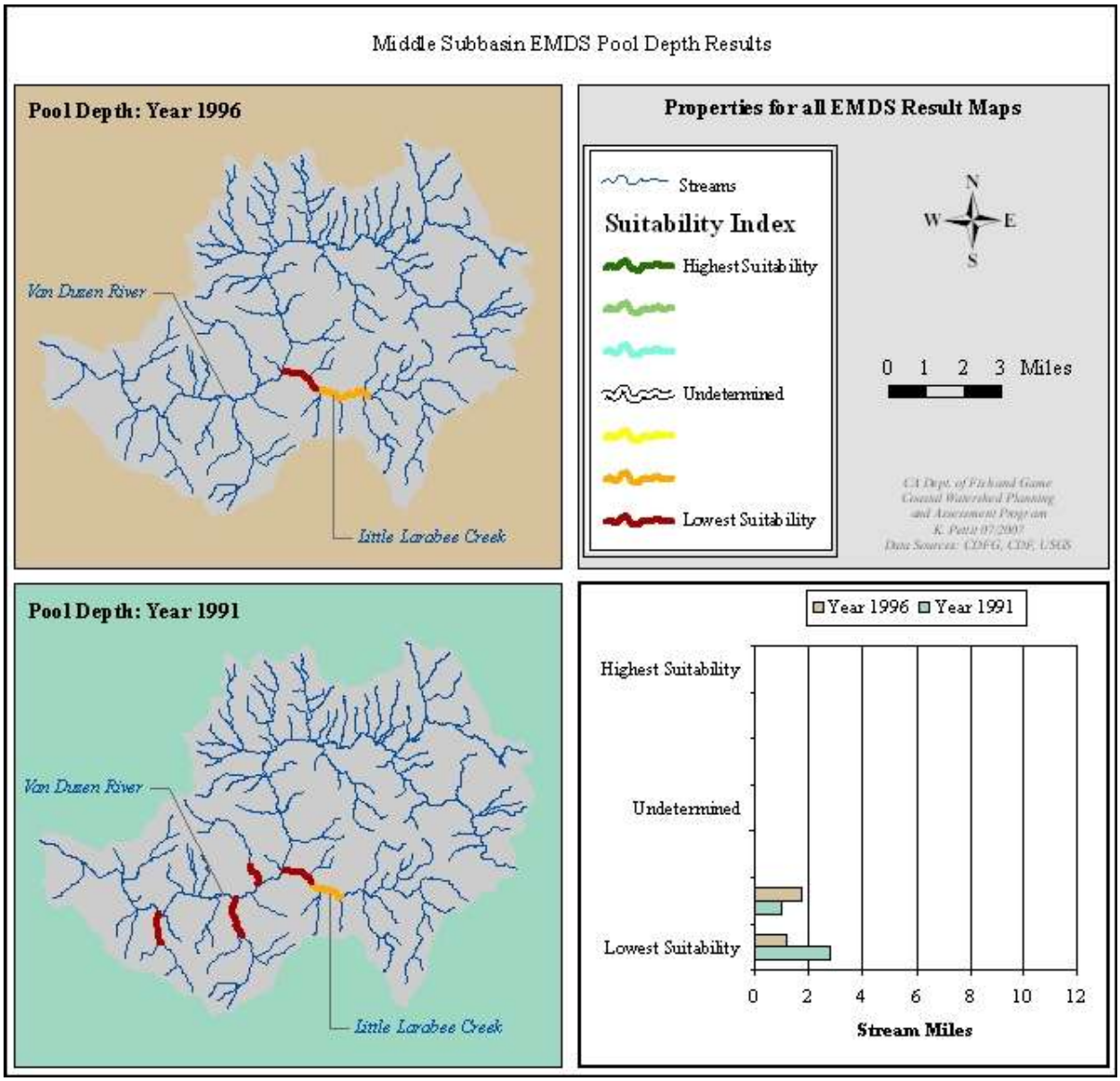

Figure 16. EMDS analysis of habitat suitability for salmonids based on pool depth from stream surveyed in 1991 and 1996.

Pool Shelter

Significance: Salmonid abundance in streams increases with the abundance and quality of shelter of pools (Meehan 1991). Shelter elements create areas of diverse velocity, provide protection from predation, and separate territorial units to reduce density-related competition. CDFG's stream survey protocol (Flosi et al. 1998), evaluates pool shelter complexity by a relative measure of the quantity and composition of LWD, root wads, boulders, undercut banks, bubble curtain, and submersed or overhanging vegetation. The ratings range from 0-300, with ratings of ≥100 considered good shelter values. The ratings do not consider factors related to changes in discharge, such as water depth.

Findings: Pool shelter ratings were far below the 100 target value for all streams and stream reaches indicating a general shortage of instream shelter elements (Figs. 17 and 18). The highest shelter values were observed in Little Larabee Creek; however, the values did decrease slightly from the 1991 survey to the 1996 survey (Figs. 17 and 18).

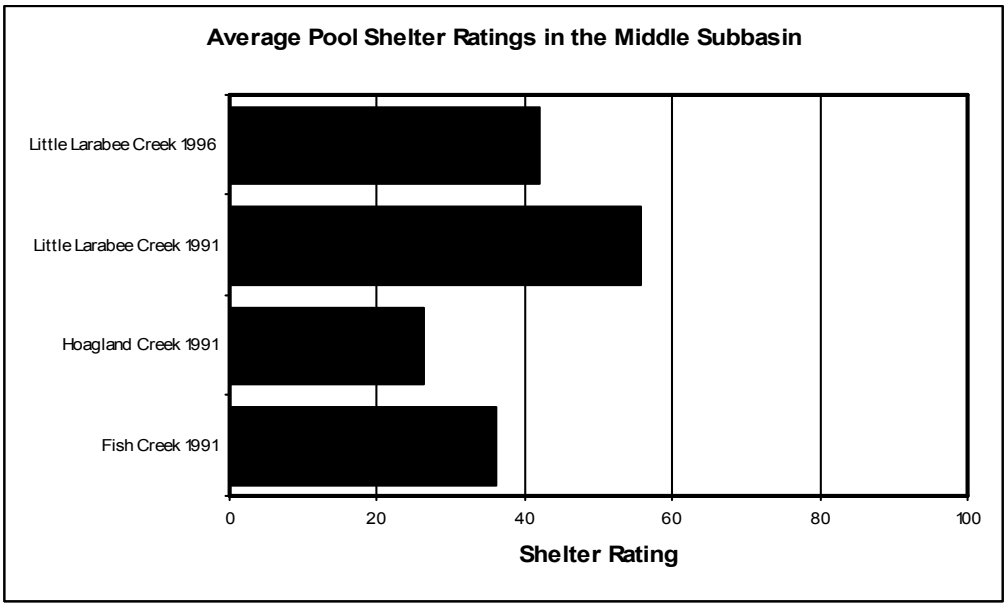

Figure 17. Pool shelter ratings in the Middle Subbasin of the Van Duzen River.

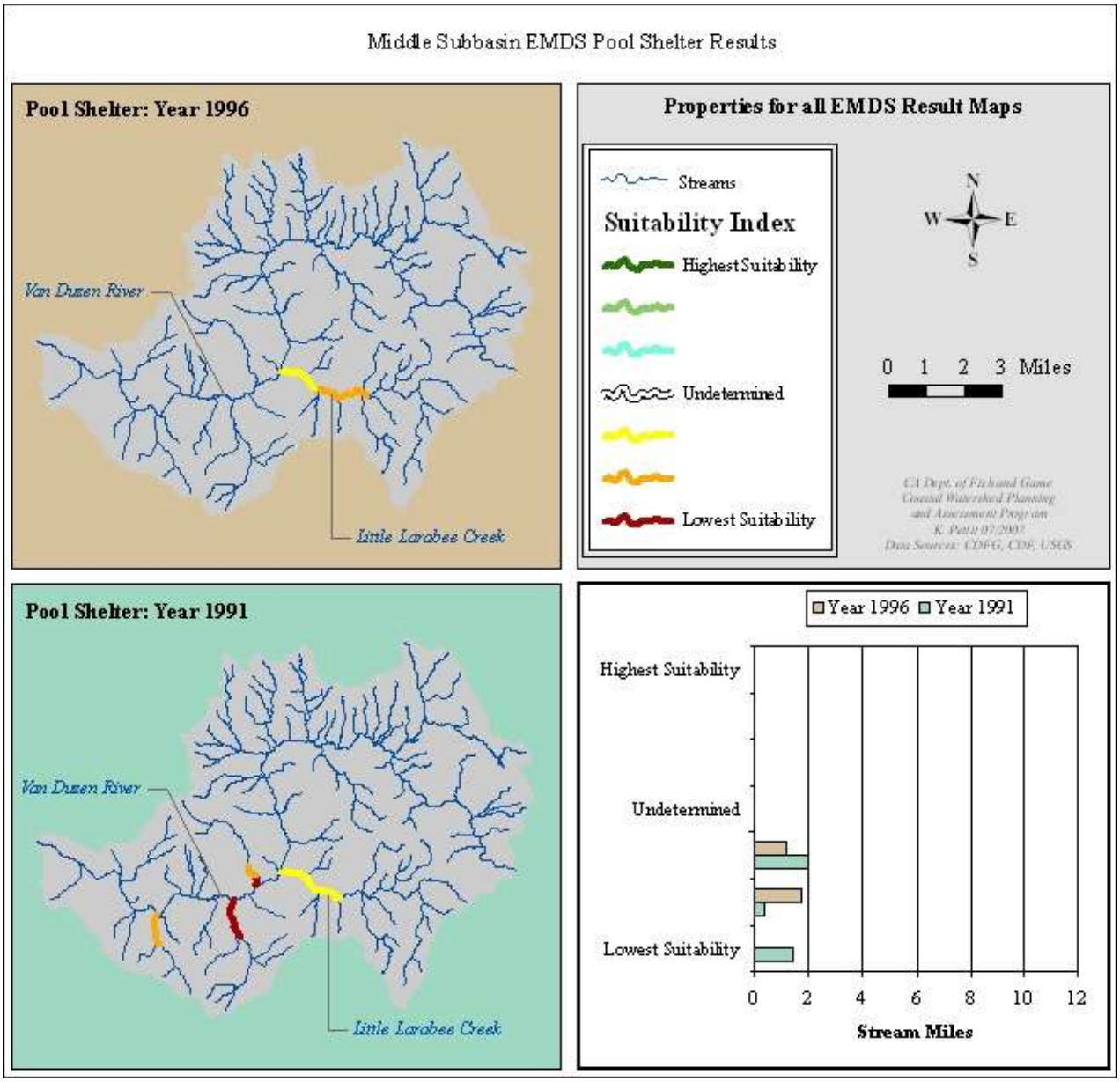

Figure 18. EMDS analysis of habitat suitability for salmonids based on pool shelter from stream surveyed in 1991 and 1996.

Canopy Density

Significance: Streamside canopy density is an estimate of the percentage of stream channel that is shaded by riparian tree canopy. An effective tree canopy provides shade to reduce direct sun light from warming water and contributes to maintaining cool microclimates. The condition of streamside canopy can change relatively rapidly with management that removes trees or alternatively by allowing tree growth. Habitat improvement projects are considered when canopy density is less than 80% (Flosi et al. 1998).

A second measurable attribute of streamside canopy is the percent of coniferous and deciduous tree species providing the shade. The percent coniferous and deciduous component of the stream side canopy influences the potential for LWD loading and can influence microclimate. Streams flowing through mature conifer stands tend to have larger amounts of wood with larger average piece size than streams with younger riparian stands, which often are dominated by smaller deciduous species (Bilby and Bisson 1998). LWD produced by conifers is generally favored over deciduous wood because it tends to be larger and less likely to move downstream, it decays more slowly, and stays longer in stream systems. The overstory shade produced by mature conifer stands also helps form cool microclimates along riparian zones which helps keep streams cool.

Findings: Canopy density in the surveyed stream reaches in the Middle Subbasin are below the target value of 80%; however, Hoagland and Fish creeks with reach values approaching the 80% target still attained suitable EMDS values (Figs. 19 and 20). Although these streams had suitable levels of shade, the amount of overstory shade contributed by conifers is below 50% for all streams. The low amount of overstory conifer shade is indicative of small sized or absence of conifer trees along the riparian zones of surveyed streams. It usually takes approximately 40 years to establish mature conifer forest canopy in these coastal forests.

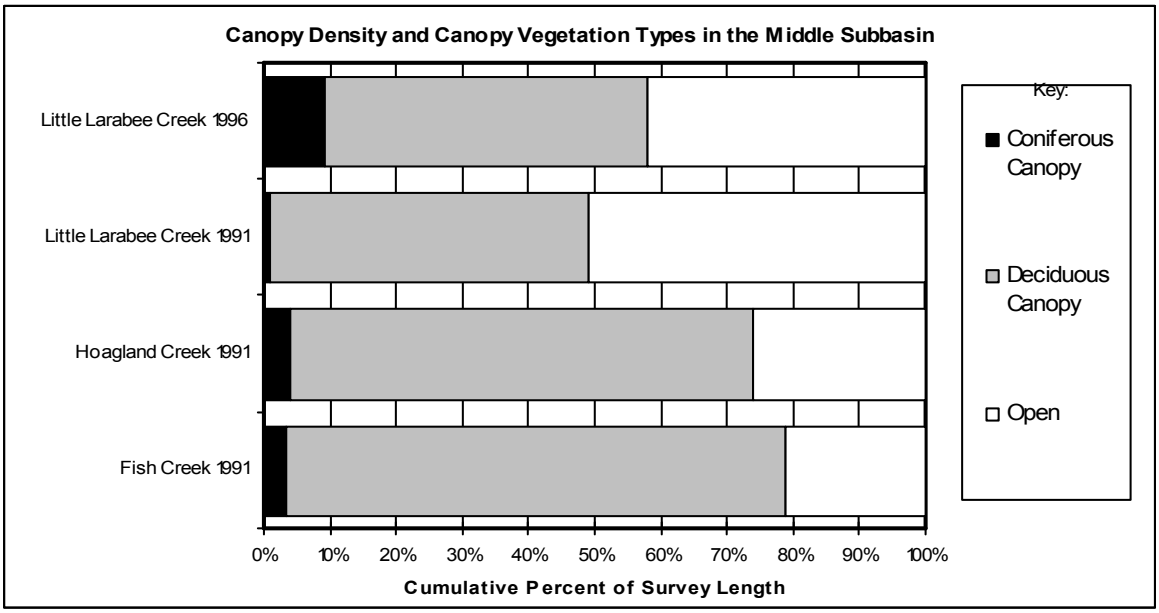

Figure 19. Cumulative percent of canopy density and vegetation types in four surveyed streams in the Middle Subbasin of the Van Duzen River.

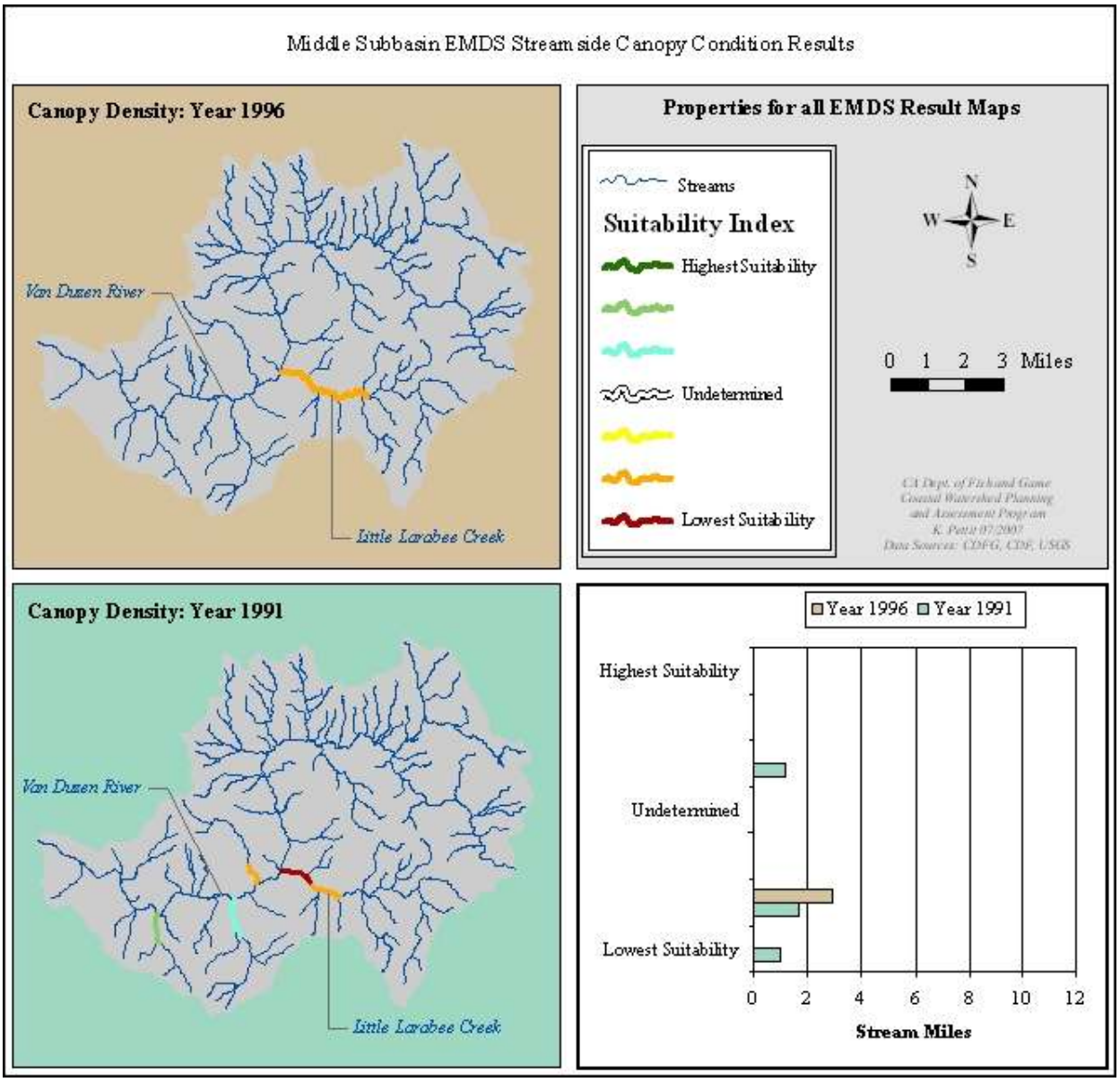

Figure 19. EMDS analysis of habitat suitability for salmonids based on canopy condition from stream surveyed in 1991 and 1996.

Spawning Cobble Embeddedness

Significance: Cobble embeddedness is the percent of an average-sized cobble piece embedded in fine grained sediments observed in pool tails. Pool tails are sampled because they are commonly selected areas for salmonid spawning. Percent cobble embeddedness provides a subjective measure of spawning substrate suitability for salmonid egg incubation, fry emergence and aquatic insect habitat. Embeddedness observations may indicate where excessive accumulations of fine sediments reduce water flow (permeability) through gravels in redds, which may suffocate eggs or developing embryos

High embeddedness ratings may indicate elevated levels of sediment inputs and erosion problems occurring in the watershed. The potential for high levels of fine sediments in streams increases in watersheds of the Middle Subbasin where the unstable geology, high precipitation, steep topography, and land use cumulatively increase erosion potential. Some common land use activities that increases generation of fine sediment are clear cuts, roads, skid trails, and livestock grazing (Cederholm et al. 1981, Duncan and Ward 1985, Swanson et al. 1987, Hicks et al. 1991).

Gravels and cobble that are less than 25% embedded with fine sediments are considered good quality substrate for salmonid spawning and production of stoneflies, mayflies and other aquatic insects. Gravels and cobbles over 50% embedded are viewed as poor quality for salmonid spawning and can impair stonefly and mayfly insect production. At the stream reach scale, spawning cobble embeddedness is considered suitable if at least 50% of all pool tails have embeddedness measures of less than 25%. Pool tails that are covered by wood debris or by fine sediments are considered unspawnable.

Findings: The streams of the Middle Subbasin generally show relatively high levels of cobble embeddedness (Figs. 20 and 21). The high levels of embeddedness are an indication of excessive delivery of fine sediments to most Middle Subbasin streams. Salmonid spawning success is likely limited or impaired by the lack of good quality spawning habitat in these streams.

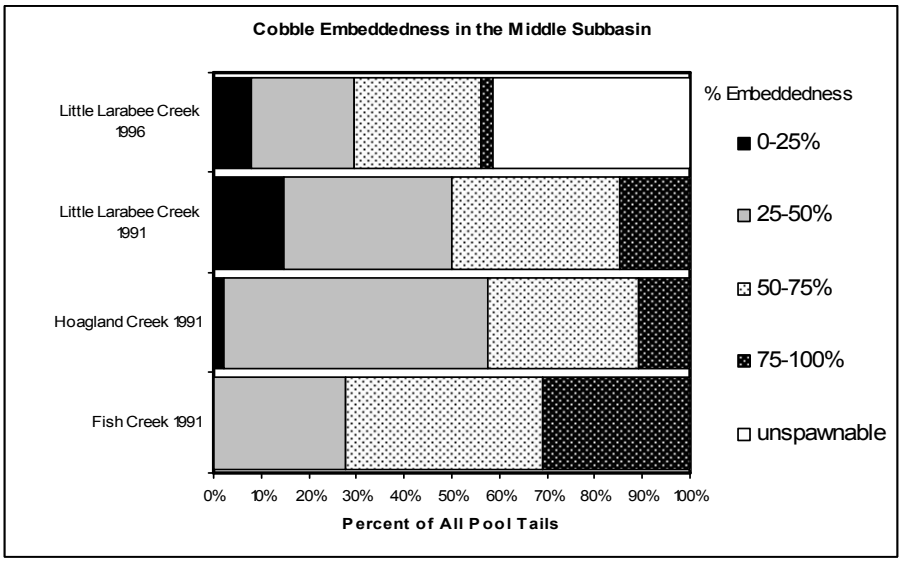

Figure 20. Histogram depicting percent cobble embeddedness in pool tails in four surveyed streams in the Middle Subbasin of the Van Duzen River.

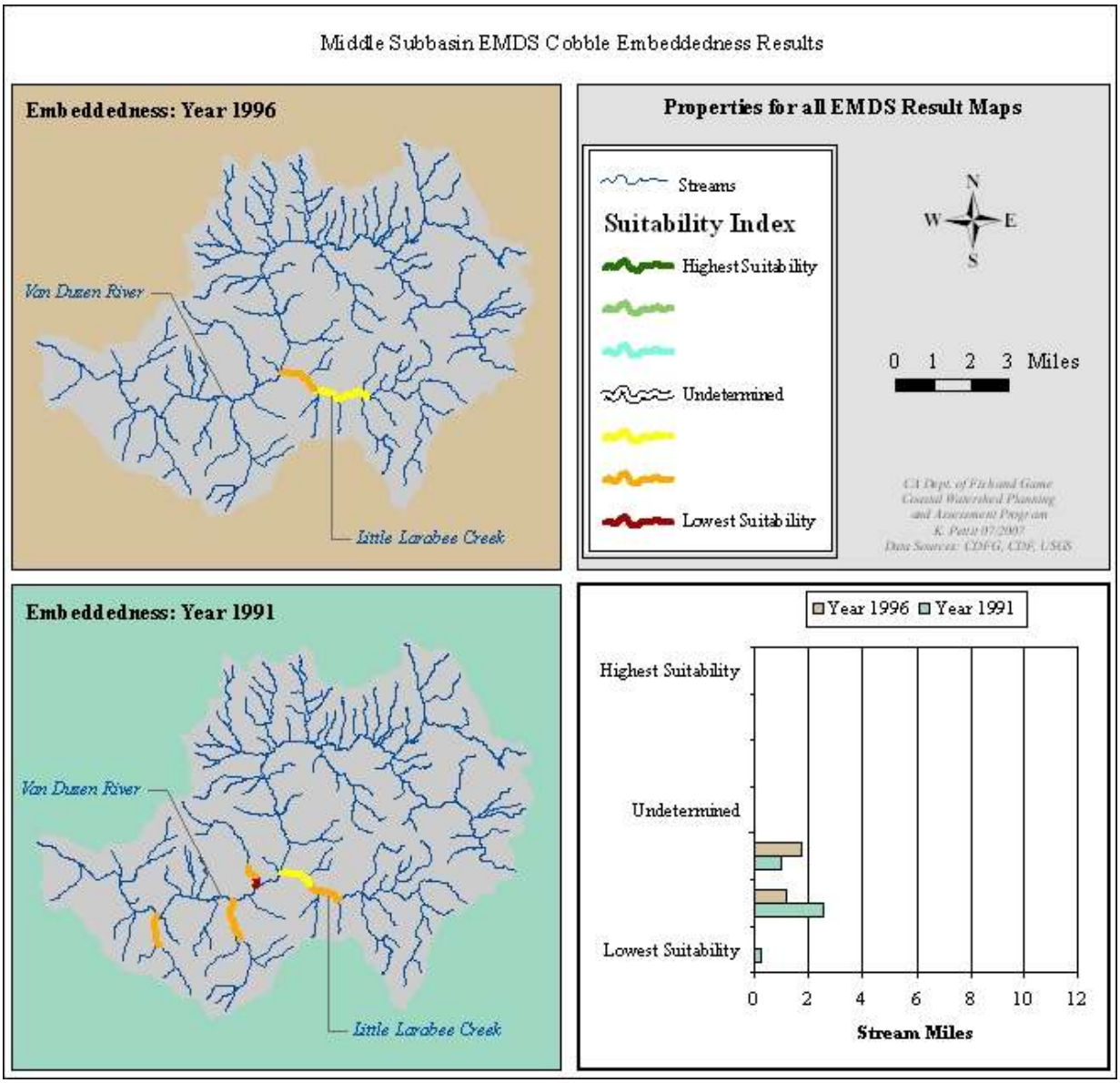

Figure 21. EMDS analysis of habitat suitability for salmonids based on cobble embeddedness from stream surveyed in 1991 and 1996.

Watershed Improvement Projects

A variety of salmonid focused watershed improvement projects have occurred in the Middle Subbasin including instream restoration, riparian restoration, road upgrade/decommission, stream crossing removal/upgrade, and upslope management (Fig. 22). Of these, road upgrade/decommission and stream crossing removal/upgrade have been the most common and spread throughout the watershed. Considered to have the best potential for supporting salmonids of the Middle Subbasin tributaries, Little Larabee Creek has had the greatest extent of restoration projects completed within its watershed.

Some of the first habitat improvement projects in the Middle Subbasin facilitated fish passage along problem sites on the Van Duzen River. Initial improvement projects used explosives to break up passage blocking boulders at Goat Rock, the Salmon Hole, and a site near Baker Creek. The passage problems are attributed to severe hill side erosion and excessive sediment inputs associated with the large flood of December 1964. The flood flows piled boulders across the active channel as well as filled pools needed by steelhead to jump up sections of the river characterized by steep gradients. The passage problems appear to mostly affect upstream migrations of adult summer steelhead (B. Wotherspoon personal communications and CDFG field notes 1965, 1978). In addition to these projects in the mainstem, three log and debris accumulations noted as barriers to migrations were removed in Little Larabee in 1983.

More information on restoration projects such as date and specific location can be found on CalFish (www.calfish.org) or on the Natural Resources Project Inventory online database (www.ice.ucdavis.edu/nrpi/). Recommendations for potential restoration projects are located below in the Subbasin Scale Responses to Assessment Questions (pgs. 35-37).

Figure 22. Adult steelhead caught in the Van Duzen River.

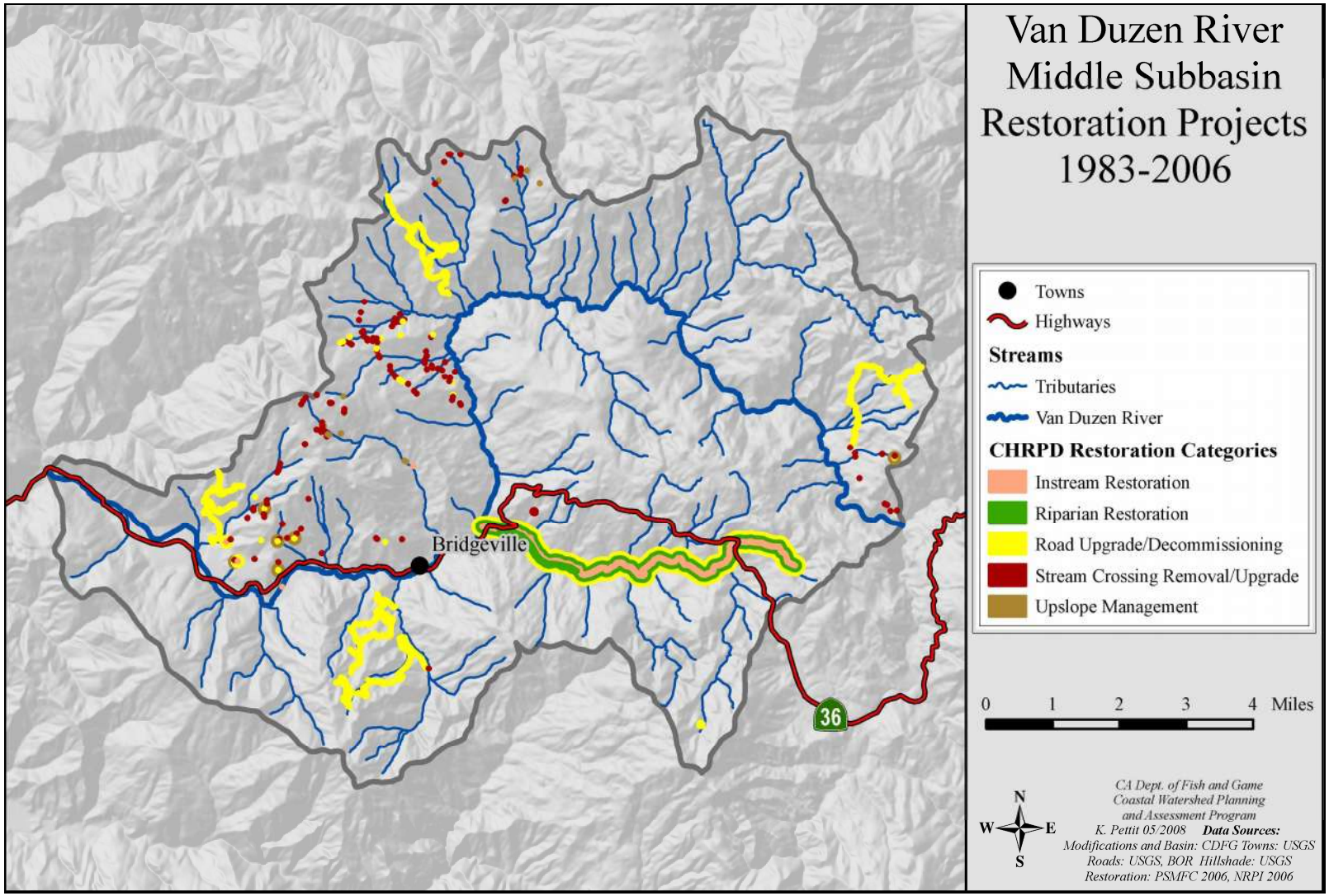

Figure 23. Restoration Projects in the Middle Subbasin 1983-2006.

Subbasin Scale Responses to Assessment Questions

The following discussion of the assessment questions and recommendations for improvement activities are generalized to the subbasin scale.

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations in the Middle Van Duzen Subbasin?

- Historically, large number of Chinook utilized the mainstem Van Duzen River to the barrier at Salmon Falls (RM 37) for spawning and rearing habitat. They also utilized a few tributaries, most notably the lower mile and half of Little Larabee Creek;
- Presently, far few numbers of Chinook utilize the mainstem and have only been observed in three tributaries: Little Larabee, Fish and Hoagland creeks;
- While coho were historically abundant in the Yager and lower subbasins, reports of coho presence in the Middle Subbasin are limited. Stocks have declined to drastically low numbers and may be functionally extirpated from the subbasin;
- Because winter steelhead tolerate a wider range of habitat conditions than the other anadromous species, they are more widely distributed in the subbasin (including above Salmon Falls) and have persisted in streams where other species have declined or are now rarely observed.

What are the current salmonid habitat conditions in the Middle Van Duzen River Subbasin? How do these conditions compare to desired conditions?

- The Van Duzen River and its tributaries exhibit high and prolonged levels of turbidity. The high turbid water make it difficult for fish to find food. This is especially important if newly hatched fish like Chinook salmon cannot feed;
- Even with recent high rainfall years, decreased summer water flows to tributaries is occurring, which in turn, has decreased summer and early fall base flows in the Van Duzen River;
- Increased nutrient, pollution, and sediment input into streams are all leading to impairment of habitat for fish, amphibians, and other wildlife;
- The most important tributary streams for salmonids are Fish Creek, Hoagland Creek, and Little Larabee Creek. The tributaries flowing into the Van Duzen from the north are generally too steep and limited by ephemeral flows to provide anadromous salmonid habitat.

What are the past and present relationships of geologic, vegetative, and fluvial processes to stream habitat conditions?

- Middle Subbasin channel aggradation and sediment storage has been exacerbated by severe erosion in the upstream subbasins;
- Because of the low gradient of the mainstem as well as the lower reaches of several tributaries the Middle Subbasin acts as a sediment deposition as well as a transportation reach depending on flow and the amount of sediment entering the system;

- Unconsolidated sediments perched steeply above the stream are prone to bank erosion and sliding contributing sediment input to the streams;
- Unstable, severely erodable bedrock, frequent seismic movement, high regional uplift rates, high seasonal rainfall, and land use activities recruit vast amounts of sediment into the stream system;
- Soils and bedrock of the Middle Subbasin are easily eroded;
- Uplift has increased the erosion potential of the area;
- Rapid incision rates of the mainstem and its tributaries have left very steep, high banks which increase its likelihood for rockfalls and landslides;
- Multiple faults cut through this area shearing the bedrock and making it less competent;
- Frequent earthflows and deep-seated landslides within the mélange are especially active during heavy storm events and/or seismic events contribute a significant amount of fine sediments to the stream.

How has land use affected these natural processes?

- The present condition of the Middle Subbasin is in part the result of land use activities within the Middle Subbasin and land use that occurs in the watersheds located upstream;
- Primary causes for stream habitat deficiencies can often be traced back to land management actions that reduce stream flow, degrade water quality, increase erosion, and/or activities that alter characteristics of near stream forests;
- Within the past 10 years increasing conversions on private property of large, industrial marijuana agriculture operations have proliferated from the upper portion of the Lower Subbasin throughout the Middle Subbasin and to a lesser extent in the Upper Subbasin. These mostly unregulated operations have decreased summer/early fall stream flows and degraded water quality in Van Duzen River and its tributaries;
- The naturally high potential for erosion of the hill slopes and sediment delivery to stream channels is elevated by land use such as road construction, timber harvest operations and other land use that disturbs top soil or weakens slope stability;
- Some common land use activities that increases generation of fine sediment are clear cut logging operations, roads, skid trails, and livestock grazing.

What habitat improvement and other activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Flow and Water Quality Improvement Activities:

- Instream flows to maintain fish habitat in good condition and channel maintenance flows should be preserved during any existing water diversion activities and considered prior to any new water development projects including riparian diversions, industrial marijuana agriculture operations, small domestic water use and water extraction from near stream wells;

- Consider private landowner water storage and forbearance programs were large capacity storage tanks are operated as part of a seasonal water management program;
- Assess roads and implement road improvement projects to reduce sediment delivery to fish bearing streams;
- Reduce fine sediment inputs by avoiding land use on inner gorge slopes and mitigate to reduce sediment inputs for any land use near streams on slopes greater than 25 percent;
- Intact forests of increasing age structure and complexity will have a greater water holding capacity than impaired watersheds, where forests are of a single dimension and lack complexity.

Erosion and Sediment Delivery Reduction Activities:

- Encourage the use of appropriate Best Management Practices for all land use and development activities to minimize erosion and sediment delivery to streams;
- Review potential for bank stabilization projects along the Van Duzen River.

Riparian and Stream Habitat Improvement Activities:

- Pool enhancement projects should be implemented at select, existing pool habitat units to increase depth and add shelter complexity on Fish, Hoagland, and Little Larabee creeks;
- Consider adding elements to recruit and retain spawning gravels in Fish, Hoagland, and Little Larabee creeks;
- Seek opportunities to increase conifer overstory shade canopy over Little Larabee Creek by plantings and/or thinning hardwoods around small conifers.

Monitoring, Education and Research Activities:

- Perform fish surveys on Fish, Hoagland, and Little Larabee creeks to update current knowledge of presence and distribution of anadromous salmonids;
- Several years of monitoring summer/early fall stream water and air temperatures to detect trends using continuous, 24-hour monitoring thermographs should be done in the Van Duzen River;
- Monitor summer/early fall water quality parameters in the Van Duzen River;
- Conduct community based outreach meetings to discuss approaches that could be implemented to help address the problems created by industrial marijuana agriculture practices;
- Continue outreach and education by local agencies and organizations to rural residents regarding proper road design and maintenance.