Table of Contents

LIST OF FIGURES ..... **i**
LIST OF TABLES ..... **ii**
LOWER SUBBASIN **1**
OVERVIEW 1
GEOLOGY 4
Bedrock 4
Faults and Shear Zones 8
Landslides 10
SLOPE INCLINATION 11
HYDROLOGY, FLUVIAL PROCESSES AND SEDIMENT TRANSPORT 11
Mainstem Van Duzen River 13
Tributary Streams 14
VEGETATION 16
LAND AND RESOURCE USE 19
Industrial Marjuana Agriculture 18
Timber Harvests 19
Roads 25
Gravel Mining 25
FISH HABITAT RELATIONSHIPS 28
Fishery Resources 28
Water Temperature 32
Turbidity 33
STREAM HABITAT CHARACTERISTICs 33
Pool:Riffle:Run Relationships 33
Pool Depth 35
Pool Shelter 37
Spawning Cobble Embeddedness 40
Streamside Canopy Density 43
Habitat Conclusions 43
Restoration Projects 44
Refugia Areas 46
SUBBASIN SCALE RESPONSES TO ASSESSMENT QUESTIONS 48

List of Figures

Figure 1. Location and tributaries of the Van Duzen River Lower Subbasin. 2
Figure 2. Six Cal 2.2 planning watershed comprise the Van Duzen River Lower Subbasin. 3
Figure 3. Geologic units of the Van Duzen River Lower Subbasin. 5
Figure 4. River Terrace deposit overlays wildcat group along bank of the Van Duzen River near Root Creek. Note Large Woody Debris which provides pool and habitat complexity for fish. 7
Figure 5. a) Fine sediments of the Wildcat formation erode from hill slope to Hely Creek, b) fine sediment from the Wildcat formation accumulate in Hely Creek. 7
Figure 6. Toe of streamside landslide on steep slope actively eroded and undercut by Grizzly Creek destabilizing the deposit as well as persistently contributing fine sediments to the creek. 10
Figure 7. Persistent streamside landslide in undifferentiated Wildcat contributing fine sediments to the Van Duzen River near Cheathum Grove. 11
Figure 8. Pseudo-aerial view looking northeast of an Earthflow in the headwaters of Steven's Creek. 11
Figure 9. Van Duzen River Lower Subbasin hillslope classes valuable pools and reduce the quality of spawning substrate. 12
Figure 10. Confluence of Yager Creek with Van Duzen River. Note channel widening and bank erosion in the Van Duzen River linked to sediment inputs and high flows from Yager Creek. Photo courtesy of Kris Coho. 13
Figure 11. Van Duzen River plane bed channel caused fish stranding at low flows. Photo taken near dry channel confluence with Eel River. 14
Figure 12. Excavated channel with exclusion culverts (top) looking upstream and looking downstream with culverts removed (bottom) to allow fish passage into Van Duzen River at flows of ~160 cfs. 14
Figure 13. Stream order and intermittent streams in the Van Duzen River Lower Subbasin. 15
Figure 14. Channel gradient of Van Duzen River Lower Subbasin streams. 16
Figure 15. Vegetation classes by percentage in the Van Duzen River Lower Subbasin. 17
Figure 16. The lower Van Duzen River. 18
Figure 17. Van Duzen River Lower Subbasin land use classes 20
Figure 18. Debris torrent buries Hely Creek with logging debris near Redwood House Road in 1983. 22
Figure 19. After wood salvage and clean up from debris flow in Hely Creek 1983. Large sediment accumulation remains. 22
Figure 20. Hely Creek 2006. While large wood occupies the bank and channel providing cover and habitat for salmonids and potential spawning cobble has replaced some fine sediment, the recovery of Hely Creek remains ongoing. A dense growth of young willow resides in the active, braided channel. 23
Figure 21. Van Duzen River Lower Subbasin timber harvest activity 1991-2008. 24
Figure 22. Road network of the Van Duzen River Lower Subbasin. 26
Figure 23. Adult steelhead caught on the lower Van Duzen River. 29
Figure 24. Lower Subbasin winter steelhead distribution. 30
Figure 25. Chinook distribution in the Lower Subbasin. 31
Figure 26. Pool depth suitability based on EMDS for the Lower Subbasin Van Duzen River. 36
Figure 27. Pool depths for streams of the Lower Subbasin of the Van Duzen River. 37

Figure 28. Average pool shelter ratings from CDFG sample reaches in Van Duzen River Lower Subbasin streams. Average pool shelter ratings exceeding 100 are considered fully suitable and average pool shelter ratings less than 30 are below desirable values for contributing shelter elements to salmonids. 38

Figure 29. Pools shelter evaluations by EMDS for Lower Subbasin of the Van Duzen River tributaries. 39

Figure 30. Percent cobble embeddedness in Lower Subbasin streams. Spawning cobble embeddedness is considered suitable if at least 50% of all pool tails are less than 25% embedded in fine sediments. 41

Figure 31. Spawning cobble embeddedness evaluations by EMDS for Lower Subbasin of the Van Duzen River tributaries. 42

Figure 32. EMDS streamside canopy condition results for the Lower Subbasin of the Van Duzen River. 44

List of Tables

Table 1. Attributes of the of the Van Duzen River Lower Subbasin. 1

Table 2. Lithologic units of the Van Duzen River Lower Subbasin. 6

Table 3. Faults within or influencing the Van Duzen River Lower Subbasin. 8

Table 4. Acres of the Van Duzen River Lower Subbasin Slope classes. 11

Table 5. Vegetation cover types in Van Duzen River Lower Subbasin planning watershed (shown in acres). 18

Table 6. Lower Subbasin of the Van Duzen River timber harvest plan statistics 1991-2008 23

Table 7. Road miles in planning watersheds of the Van Duzen River Lower Subbasin 25

Table 8. Van Duzen River Lower Subbasin Extraction 1997-2007 (CHERT 2008) 27

Table 9. Salmonid streams of the Lower Subbasin Van Duzen River. 29

Table 10. Seven-day maximum average water temperature (°F) from Van Duzen River Lower Subbasin streams 1996-1998 32

Table 11. Seven-day maximum average water temperature (°F) from Van Duzen River Lower Subbasin streams 1999-2005 33

Table 12. Pool, riffle and run relationships from Van Duzen River Lower Subbasin streams. 34

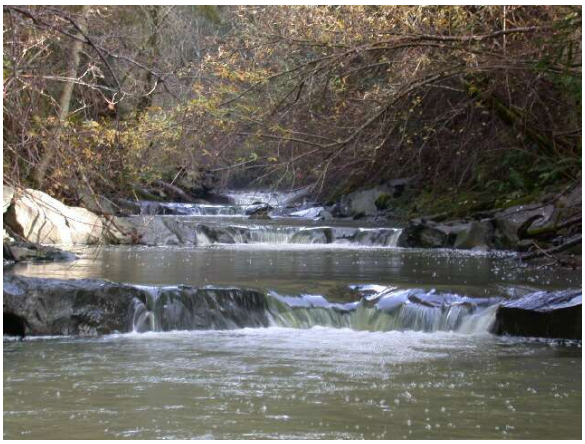
Table 13. Average maximum pool depth in tributaries in the Lower Basin of the Van Duzen River. 37

Table 14. Pool shelter elements for Van Duzen River Lower Subbasin streams. The percent contribution for each shelter element is shown. 38

Table 15. Habitat factors that limit (L) or support (S) production of anadromous salmonids in streams of the Van Duzen River Lower Subbasin. 45

Table 16. Refugia category ratings of streams in the Lower Subbasin 45

Lower Subbasin



Overview

The Lower Subbasin drains approximately 69 square miles of the southwestern portion of the Van Duzen River Basin, including approximately 23 miles of the mainstem Van Duzen River, 54 miles of perennial tributary channels and 85 miles of intermittent tributary stream channels according to 1:1000 USGS maps (Table 1 and Figure 1). This subbasin consists of six Calwater 2.2 planning watersheds (Fig. 2). Grizzly Creek is the eastern most planning watershed in the subbasin, marked by the approximate eastern extent of the coastal fog zone and distribution of redwood forests. Nearly all the land in this subbasin (97.7%) is privately owned, and the remaining 2.3% is owned by the state. Primary land uses include timber production, dairy and cattle ranching, gravel

Table 1. Attributes of the Van Duzen River Lower Subbasin.

Square Miles	69
Total Acreage	44,159
Private Acres	43,144
Federal Acres	0
State Acres	1,015
Predominant Land Use	Timber Harvests and rural developments
Predominant Vegetation	Redwood Forest
Total Stream Miles	162
Miles of Anadromous Stream	45
Low Elevation (feet)	60
High Elevation (feet)	3,440

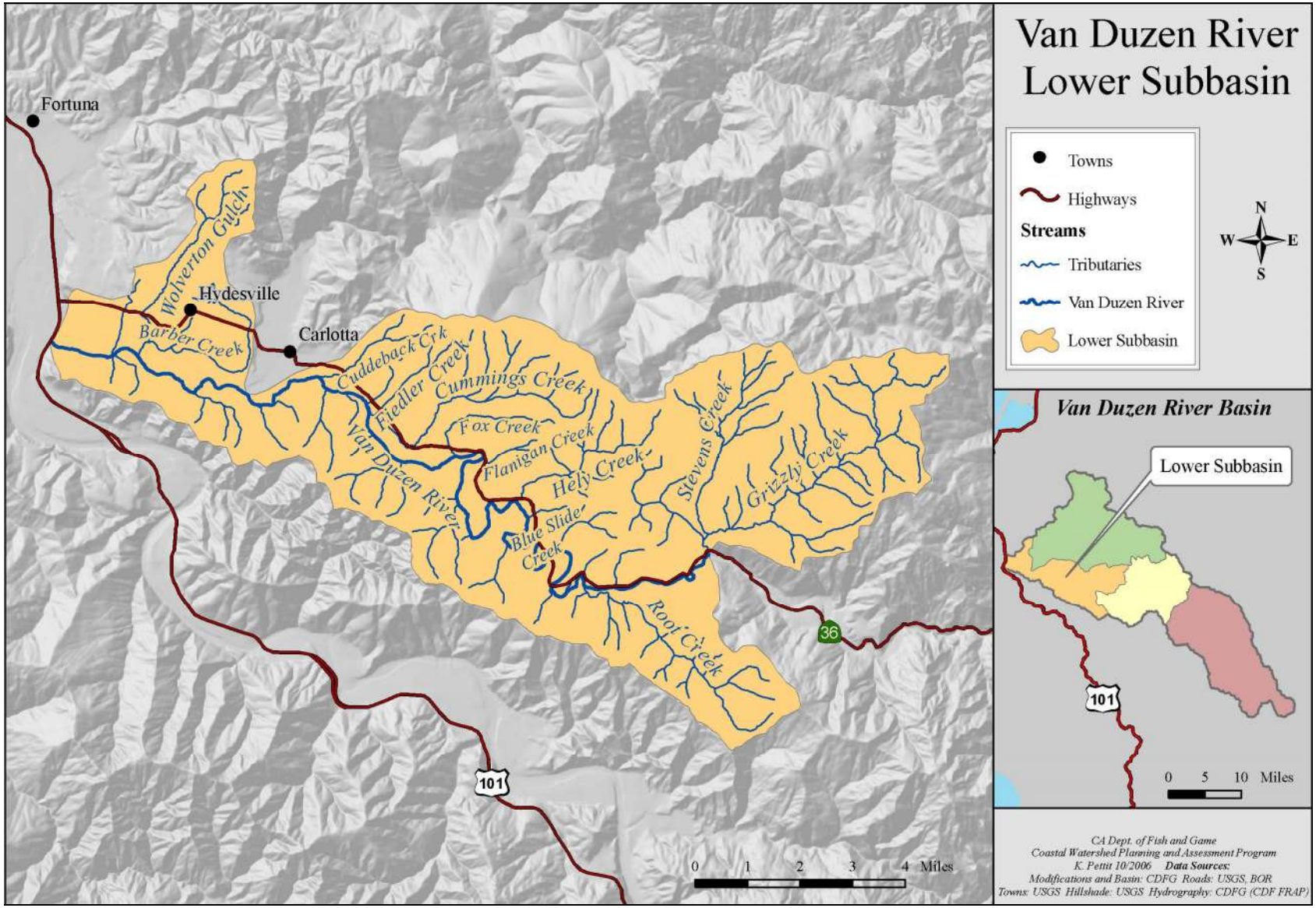


Figure 1. Location and tributaries of the Van Duzen River Lower Subbasin.

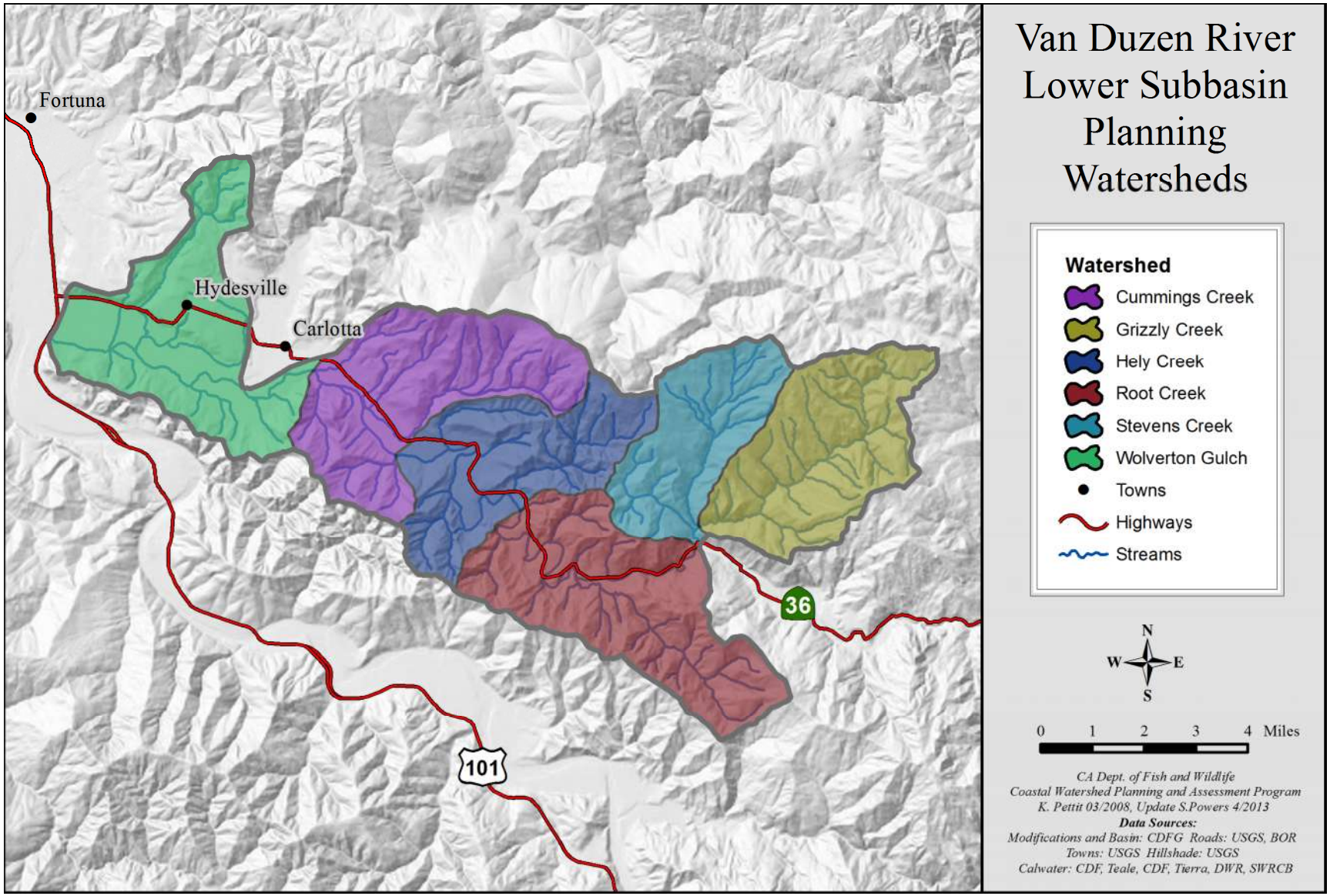


Figure 2. Six Cal 2.2 planning watershed comprise the Van Duzen River Lower Subbasin.

mining and residential developments. The towns of Hydesville and Carlotta are centers for residential developments located in the lower river valley. There are two county parks (Swimmers Delight and Pamplin Grove) and Grizzly Creek State Park in the Lower Subbasin designed to conserve natural resources and provide recreational opportunities to the public.

Streams of the Lower Subbasin support populations of Chinook salmon, coho salmon, steelhead, and coastal cutthroat trout. The largest tributaries in this subbasin are among the most important salmonid producing streams in the Van Duzen River Basin, including Grizzly Creek, Root Creek, Hely Creek, and Cummings Creek (Fig. 1).

Geology

The geology of the Lower Subbasin of the Van Duzen River is complex and characterized by active faults and land movement that have important implications for watershed health, planning, and restoration. The Basin Profile of the Van Duzen provides a review of the important processes, terrain types, and references. In this section, we present the geologic units at the tributary scale within the Lower Subbasin.

Bedrock

The Lower Subbasin is composed of seven different rock types: the Wildcat group (50%), Yager terrain (19%), Central Belt Franciscan Mélange (11%), alluvium deposits (11%), river terrace deposits (6%), landslide deposits (2%), and Central Belt sandstone (1%) (Fig. 3 and Table 2). Lower Subbasin streams have down cut into erodible bedrock during extensive tectonic uplift of this region leaving very steep bank-slopes and terraces, which are susceptible to small-scale, frequent slope failure (Reynolds et al. 1981). The naturally high potential for erosion is elevated on steep slopes (>30%) and dormant landslides where land use has disturbed top soil or reduced slope stability.

The Wildcat Group is the most abundant bedrock type in the subbasin, occupying 50% of the Lower Subbasin. The Wildcat Group consists of moderately to poorly indurated marine – nonmarine sedimentary bedrock. Along the lower Van Duzen River valley, the Wildcat Group is often covered by alluvium and river terrace deposits (Fig. 4).

The bedrock of the Wildcat Group is one of the most unstable in the subbasin. Consequently, very high erosion potential exists where the Wildcat underlies Cummings Creek, Hely Creek, and Root Creek planning watersheds. Erosion of the soft, sedimentary rock types of the Wildcat contributes fine sediments to stream channels (Fig. 5). These properties of the Wildcat bedrock allow it to shed large amounts of fine sediment into the streams causing heavy levels of turbidity that can fill in spawning gravels. The clay content within the bedrock is easily suspended in the water column, and erosion near the surface tends to stabilize as cohesion between grains increases. In areas where Wildcat bedrock goes through repeated wet and dry cycles, the surface tends to crumble and slough off allowing fine sediment input to the streams. Streams within Wildcat bedrock tend to form steep to vertical canyon walls, which are prone to undercutting and rock sliding. The Wildcat bedrock is also prone to sliding in areas where bedding dips inward towards the stream canyon. Slide planes tend to develop along bedding between sandstone and mudstone layers. While the sediments that make up the Wildcat are considered bedrock, they are rather loosely cemented and friable making them susceptible to crumbling under light pressure. The size of the grains within the Wildcat are composed of small, clay-sized fine sand particles.

The Yager terrane consists of well-consolidated marine, interbedded sandstone, argillite (metamorphically hardened mudstone), and conglomerate deposits occupying 19% of the Lower Subbasin. Most of the Yager terrane is exposed in the Steven's and Grizzly Creek planning watersheds. The sandstone interbeds represent the deposits of large, drawn-out submarine sediment flows collectively termed turbidites that careen down the Continental slope

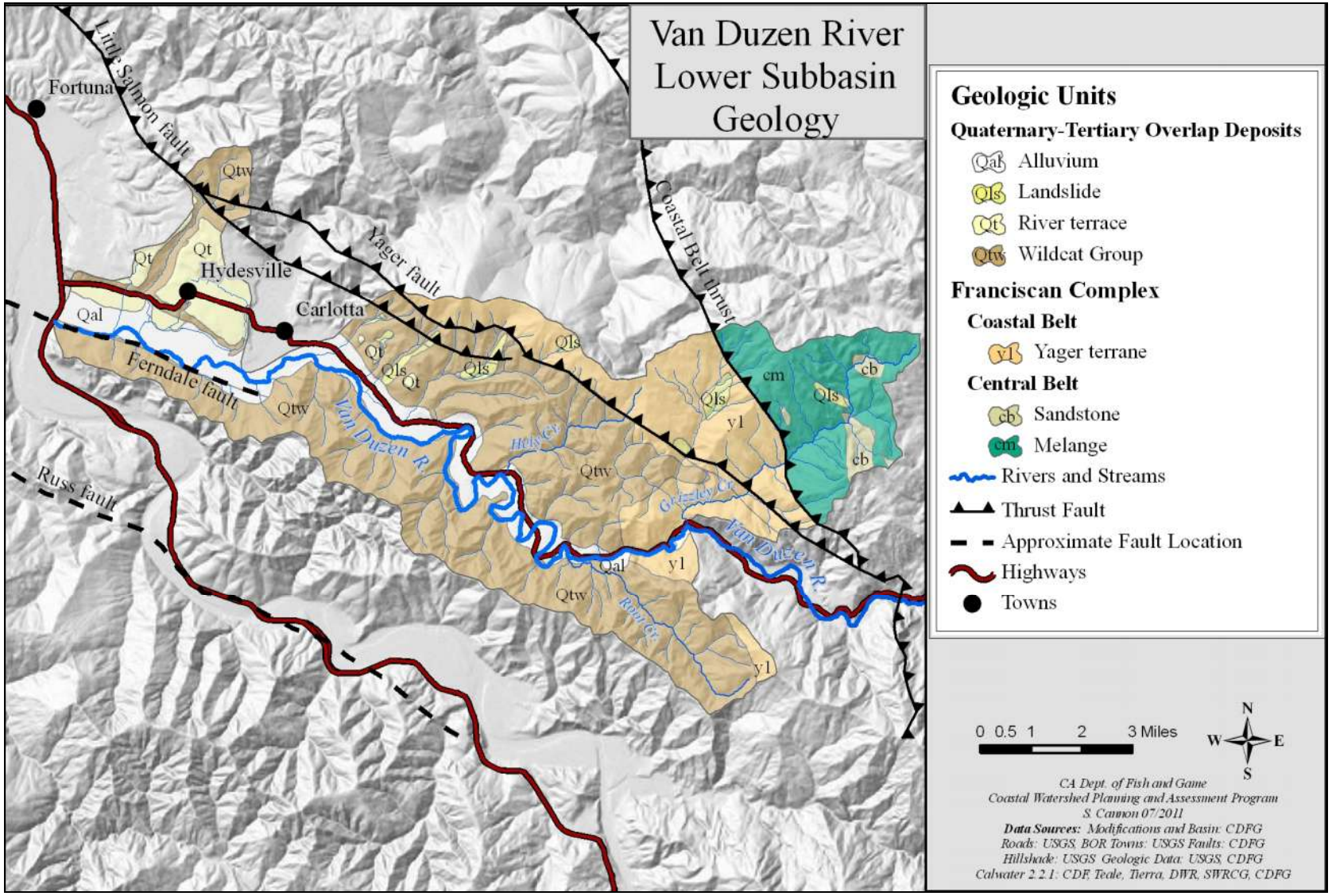


Figure 3. Geologic units of the Van Duzen River Lower Subbasin.

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

GEOLOGIC RELATION AND DESCRIPTION OF MAJOR UNITS WITHIN THE LOWER SUBBASIN						
Unit	**Belt/Rock type**	**Formation/ terrane**	**Composition**	**Erosion**	**Years 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	11
	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	2
	River terrace		Unconsolidated river deposits of boulders, gravel, sand, silt, and clay that have been uplifted above the active stream channel/flood-plane.	Raveling of steep slopes. Transportation of sediments by fluvial and aeolian processes, gullying, and debris slides.	0.01-2	6
		Hookton				
		Rohnerville				
	Wildcat group (undifferentiated)	Carlotta	Partially indurated, nonmarine conglomerate, sandstone, and clay. Minor lenses of marine siltstone and clay.	Shallow landslides, debris slides, and block slides along inward dipping bedding planes. Toppling along joints. Some rock-falls and ravel.	0.78-1.8	50
		Scotia Bluffs	Shallow marine sandstone and conglomerate	Friable, typically fails in numerous small debris slides.	1.8-3.6	
		Rio Dell	Marine mudstone, siltstone, and sandstone	Of the Wildcat group the Rio Dell formation is one of the most susceptible to landsliding. Landsliding is most common in zones between mudstone and sandstone beds with inward dip during saturation.	1.8-3.6	
		Eel River	Marine mudstone, siltstone, and sandstone	Debris slides/flows, slaking.	3.6-5.3	
		Pullen	Marine mudstone, siltstone, and sandstone	Debris slides/flows, rotational slides, slumps, slaking.	5.3-11.6	
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	19
	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	1
		Mélange	Penetratively sheared matrix of argillite with blocks of sandstone, greywacke, argillite, limestone, chert, basalt, blueschist, greenstone, metachert,	Susceptible to mass movement by large earth flows and subsequent debris flows triggered by saturation.	1.8-65.5	11
Sources: Ogle 1953, Kilbourne 1985, McLauglin et al. 2000. % Data represent an approximation based on GIS mapping.						

Figure 4. River Terrace deposit overlays wildcat group along bank of the Van Duzen River near Root Creek. Note Large Woody Debris which provides pool and habitat complexity for fish.

a)

b)

Figure 5. a) Fine sediments of the Wildcat formation erode from hill slope to Hely Creek, b) fine sediment from the Wildcat formation accumulate in Hely Creek.

periodically. The argillitic layers represent calm deposition of mud and clay that have settled out of suspension. This sequence of turbidites and argillitic interbeds is up to 5,000 feet thick and was deposited between 34 and 65 million years ago.

Yager terrane is relatively stable if left undisturbed, however many areas where it is faulted and/or sheared are prone to large-scale landsliding. In addition, argillaceous interbeds of the Yager terrane tend to crumble when exposed to water and air leading to some sliding along bedding planes especially if they dip inward towards the stream valley. This erosion contributes small to fine sediments into the stream. Further erosion is linked to land use activities occurring in the Yager terrane such as road construction and timber harvest. These activities constitute over 35% of sediment delivery to streams which is well above natural levels (USEPA 1999).

Mélange of the Central Belt represents 11% of the Lower Subbasin and is found mostly in the Grizzly Creek planning watershed. The Central Belt Mélange can be described as a completely sheared matrix of argillite and sandstone deposits containing very small (pebble sized) to mappable blocks (acres) of sandstone, blue schist, greenstone, basalt, and chert. The mélange matrix material is very weak and tends to slowly flow over time exposing the more coherent rock blocks known as "Franciscan Knockers". Mélange is often vegetated by grasses that are susceptible to surface erosion, headword erosion, and gullying. The Mélange is easily disturbed by land use activities that may increase the rate of erosion and sediment delivery to streams.

Alluvium in the river floodplain and Van Duzen River valley covers approximately 11% of the subbasin. Alluvium includes active stream channel sediments as well as stored floodplain and low lying terrace deposits.

River terrace deposits, including the Rohnerville and Hookton formations, occupy 6% of this subbasin. River terrace deposits consist of unconsolidated and poorly consolidated cobbles, gravels and fine sediments. River channel and flood plain deposits have been raised during the last 2 million years by regional tectonic uplift above the 100-year flood level and may form steep channel banks that are prone to dry ravel and slumping.

Faults and Shear Zones

Faults and shear zones tend to weaken the bedrock making it more prone to erosion. Active faults may also seismically trigger landslides during earthquakes. The combination of active faults located near dormant landslides adds to the potential for hillslope erosion. In light of the high erosion potential on these sites, avoidance and/or careful planning involving a geologic study should be considered with future land use actions. Table 3 shows the faults within or influencing the Van Duzen River basin.

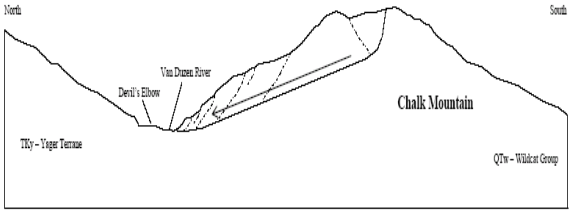
The Little Salmon fault is an active, northeast-dipping thrust fault that trends northwest coming onshore near Eureka and terminating approximately at Cummings Creek. The onshore extent of the Little Salmon fault zone is about 50 miles in length.

Table 3. Faults within or influencing the Van Duzen River Lower Subbasin.

FAULTS WITHIN OR INFLUENCING THE VAN DUZEN RIVER BASIN			
Active Faults:	**Fault Type**	**Possible Magnitude**	**Recurrence Interval**
Cascadia Megathrust	Thrust	9	500-600
Little Salmon fault	Thrust	7.2	400-800
Yager fault	Thrust	unknown	unknown
Goose Lake fault	Thrust	unknown	unknown
San Andreas fault (Northern segment)	Dextral	7.3	200-300
Faults:			
Coastal Belt Thrust	Thrust		
Ferndale fault	Reverse		

A prehistoric seismic event associated with the Little Salmon fault zone likely triggered the Chalk Mountain landslide which was a large (640 acre) deep-seated landslide located just downstream of Grizzly Creek on the left bank of the mainstem of the Van Duzen. This slide likely dammed the mainstem of the Van Duzen for a time until the river was able to rework the sediment (Oswald 2006). The landslide dam may have existed for a period of time sufficient to impede water upstream and initiate widespread sliding of the banks allowing the impounding of massive amounts of sediment upstream of the landslide dam. It is possible that the low-lying terraces from downstream of Grizzly Creek State Park to approximately six miles upstream near "Goat Rock" are a result of this event. The outwash of sediments was flushed downstream when the dam was breached and deposited the terrace on top of the Wildcat bedrock near Root Creek.

Erosion of the toe of this landslide is still supplying sediments into the river in a series of smaller, subsequent stream-bank landslides and ravel. Encroachment of the landslide has narrowed and increased the steepness of the canyon along this stretch.



Depiction of the Chalk Mountain landslide.

The Yager fault is a low-dipping thrust fault that trends northwest through the basin. The Yager fault may be an active offshoot of the Little Salmon fault and share similar characteristics. The Northeastern draining tributaries of the Lower Subbasin cut across the Little Salmon and Yager faults and into the Yager terrane (Box 1).

The Goose Lake fault is an active, northwest trending thrust fault associated with the Little Salmon and Yager faults. It is mapped within the lower subbasin in the vicinity of Hydesville and bounds the southern limb of a synclinal down-warp that historically held "Goose Lake". This fault disrupts river terraces of Yager Creek and Van Duzen River deposition. The upper portion of Barber Creek runs along this fault and drains this area.

The Ferndale fault runs into the Lower subbasin on its western edge. The Ferndale fault is a steeply dipping reverse fault that trends west by northwest and bounds the southern edge of the Van Duzen River valley floor in the area from Alton to Carlotta.

The Coastal Belt Thrust fault trends north by northwest through the Lower Subbasin near Steven's Creek and Grizzly Creek, and many of their tributaries cut across this fault.

The Coastal Belt Thrust juxtaposes the Coastal Belt with the Central Belt. It is most likely the zone that accommodated movement between the subducting Farallon slab 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 Cascadia Megathrust allows subductive movement of the Gorda plate beneath the North American plate. This fault is capable of generating very large earthquakes (~M9) and usually produces associated uplift or subsidence of the coastal area adjacent to the Van Duzen River basin. The last major event on the Cascadia was on January 26, 1700 and was estimated to be between a magnitude of 8.7 and 9.2. Although not within the basin this fault can produce strong ground-shaking and trigger widespread landsliding. It is possible that a large seismic event on the Cascadia Megathrust could trigger movement on faults within the basin.

The San Andreas fault (Northern segment) is an active, right-lateral fault that runs just offshore, southwest of the Van Duzen River basin. It is capable of large earthquakes (~M 7) that can significantly affect the basin by seismic shaking, and wide-spread landsliding. The earthquake of 1906 (the San Francisco earthquake) caused significant damage to the surrounding communities, triggered multiple

landslides, and caused liquefaction of low-lying, saturated sediments.

The Mendocino Triple Junction is located just offshore between Cape Mendocino and Petrolia. It juxtaposes the Gorda, Pacific, and North American plate in a complex tectonic regime. The Mendocino triple Junction has been migrating northward, relative to the North American plate, over geologic time increasing the seismic activity and deformation of this region. Tectonic stresses inherent to the complex interactions of the Mendocino Triple Junction are predominately responsible for driving fault movement and land deformation within this basin.

Coseismic Landsliding. Strong ground shaking by local earthquakes tends to trigger landslides in areas of unstable geology especially during the rainy season when the hill slopes are saturated with water.

Landslides

Large Quaternary landslides occupy only ~ 2% of the Lower Subbasin at the scale and limited detail of the geology map used in this report. Large mapped landslides infer features that can readily be seen at a basin-wide scale and are usually on the order of square miles in aerial extent. The designation of Quaternary infers that these landslides moved sometime within the last 2 million years. There are undoubtedly many more landslides than what is reflected within our mapping. Detailed landslide maps covering the areas of Rohnerville, Hydesville, Carlotta, and Chalk Mountain show a much higher density of landslide features. The largest mapped landslides in the Lower Subbasin occur in Steven's Creek, Cumming's Creek, and Fiedler Creek. The local effect of landslides on the stream network include persistent contribution of fine sediments and are particulary prevalent in areas where faults occur (Fig. 6 and 7).

In the headwaters of Steven's Creek (tributary to Grizzly Creek), a large earthflow exists in the geology of the Central belt mélange and the Coastal belt Yager terrane of the Franciscan Complex (Fig. 8). The Coastal Belt Thrust dissects this area juxtaposing these two belts.

Cumming's Creek drains a large earthflow within Wildcat Group geology that is situated in an area cut by the Little Salmon and Yager faults. Fiedler Creek drains an earthflow that initiates in the Wildcat Group geology (Eel River, Rio Dell, Scotia Bluffs, and Carlotta formations) in the area of the Little Salmon and Yager Faults.

These landslides may have been initiated by their proximity to nearby faults, either from strong ground shaking during seismic events on the Little Salmon and/or Yager faults or by weakening of the bedrock by fault disruption and shearing.

Figure 6. Toe of streamside landslide on steep slope actively eroded and undercut by Grizzly Creek destabilizing the deposit as well as persistently contributing fine sediments to the creek.

Figure 7. Persistent streamside landslide in undifferentiated Wildcat contributing fine sediments to the Van Duzen River near Cheathum Grove.

Figure 8. Pseudo-aerial view looking northeast of an Earthflow in the headwaters of Steven's Creek.

Slope Inclination

Steep slopes (>30%) comprise 51% of the Lower Subbasin terrain (Table 4 and Fig. 9). The steepest slopes are often located in headwater areas of streams that are not fish bearing, and therefore may receive the least protection from land use regulations. However, these sizeable headwater areas with steep slopes and unstable geology have contributed to excessive and persistent erosion and sediment inputs to fish bearing stream reaches. Since all the steep hillslope geology of the Lower Subbasin is considered high for erosion potential, actions such as road construction, timber harvesting, and yarding should be mitigated according to best management practices that meet or exceed all regulatory agency standards for soil conservation, water quality concerns, and protection of fish and wildlife.

Table 4. Acres of Van Duzen River Lower Subbasin Slope classes.

Slope class	Acres
0-15% Gentle	10, 130 (23%)
>15 -30% Moderate	11, 260 (25%)
>30 -65% Steep	20,500 (46%)
>65% Very Steep	2262 (6%)

Hydrology, Fluvial Processes and Sediment Transport

Streamflow in the Van Duzen River is measured at the USGS Bridgeville stream gauge located approximately one mile upstream of Grizzly Creek at RM 24. However, the highest flows occur downstream the confluence with Yager Creek (RM 5). Yager Creek drains approximately 33% (140 sq. mi.) of the Van Duzen River basin, and therefore adds substantial flow and sediments to the Lower Van Duzen River. Annual streamflow data from the Bridgeville site is shown in the Hydrology section of the Basin Profile (page 23).

The Lower Subbasin has the highest density of streams per square mile (2.3 mi/mi^2) in the Van Duzen River basin. The high stream density produces rapid runoff from the mountainous

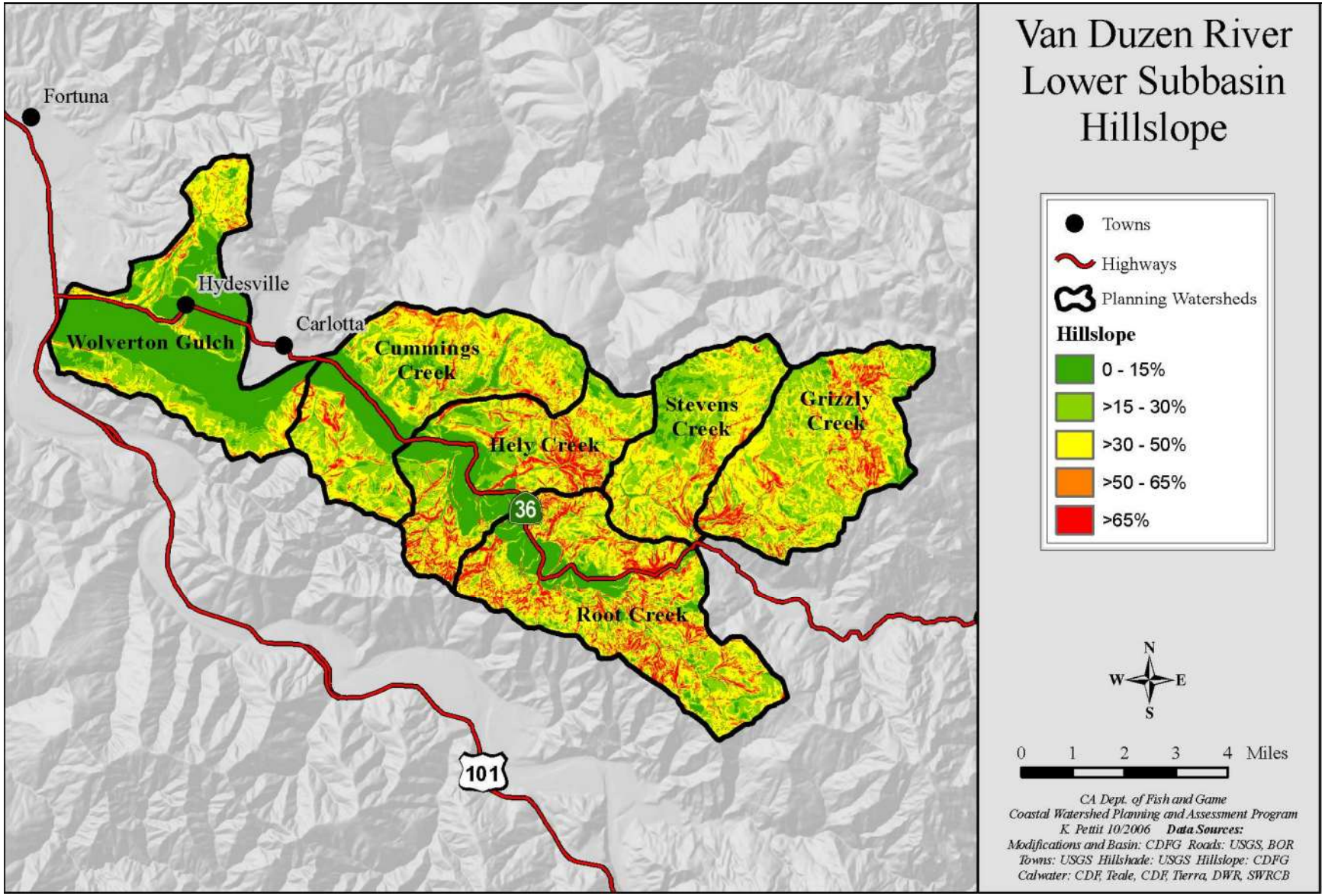


Figure 9. Van Duzen River Lower Subbasin hillslope classes valuable pools and reduce the quality of spawning substrate.

terrain during winter storms, which can lead to flooding on portions of Highway 36 and other areas. Attributed to the relative instability of hillslopes, large amounts of sediments can be eroded and enter streams during strong winter storms. The sediments are transported or stored within the stream channels or floodplain depending on several factors including stream flow, particle size, channel gradient, channel confinement and presence of scour elements. The excessive sediment accumulations tend to aggrade channels, fill valuable pools, and reduce the quality of spawning substrate.

Extended and excessively high turbidity levels occur when fine sediments continually enter the stream and remain suspended in the water column. Many of the Lower Subbasin tributary streams display highly turbid flows during and after rain events. Flow of prolonged, excessive turbid water can impair the ability of juvenile salmonids to feed and grow.

Mainstem Van Duzen River

The mainstem Van Duzen River flows approximately 23 miles (RM 23-0) through the Lower Subbasin from Grizzly Creek to the Eel River. Within this river segment there are three distinct reaches: 1) from the confluence of Grizzly Creek to Root Creek where the river flows at an average 4% gradient for approximately three miles though a narrow boulder laden gorge; 2) the 12 miles between Root Creek to near Cummings Creek (~RM8) where the channel gradient is approximately 1% and the river flows through entrenched meanders confined by bedrock banks; and 3) from RM 8 near Cummings Creek to the Eel River where the channel widens to a largely unconfined, alluvial plain bed channel. Low gradient alluvial channels are characterized as having lower sediment transport capacity to supply ratios and thus tend to accumulate sediments delivered from upstream sources (Montgomery and Buffington 1997). Sediment deposition and storage occurs in the wide and unconfined sections of the lower river. The amount of stored sediments is noticeably larger downstream of the confluence with Yager Creek (Figure 10).

Figure 10. Confluence of Yager Creek with Van Duzen River. Note channel widening and bank erosion in the Van Duzen River linked to sediment inputs and high flows from Yager Creek. Photo courtesy of Kris Coho.

Many of the wide sections along the lower Van Duzen River, such as the area below the Yager Creek confluence, have experienced stream bank erosion in response to flood flows and channel aggradation. The process of channel widening and associated sediment accumulation contribute to detrimental impacts to both land owners and to aquatic habitats. Landowners lose potentially valuable land and may have to invest in bank protection methods to reduce or minimize channel erosion along their property. While in addition to a loss of valuable riparian land from erosion, channel widening and excessive lower sediment accumulations have reduced the quality of fisheries habitat by filling in valuable pool habitats and increasing width to depth ratios resulting in a wide, shallow channel. Wide shallow reaches without a shade canopy allows sunlight to heat the water to stressful or levels lethal to salmonids during warm summer months. These wide, shallow channel reaches and such conditions are common along the Van Duzen River in the Lower Subbasin. An increase in sediment deposition also occurs in the lowest river segment where the current velocity slows as it pushes into the larger Eel River, also known as a “delta effect” (Figure 11). The slowing current reduces the river’s ability to transport sediments along the lowermost reach of the Van Duzen.

The wide, shallow river condition creates a reoccurring problem for fish passage into the

Van Duzen River from the Eel River. After the first rains of fall, this reach forms wide, braided shallows that impede upstream passage of fall migrating Chinook salmon. In the fall of 1996 approximately 20 adult Chinook salmon stranded and died on braided riffles as they attempted to migrate up the Van Duzen River from the Eel River during intermittent flows. A similar stranding event occurred in the fall of 2002 when over 130 adult Chinook salmon were stranded in the shallows and died along the lower mile of river. Every fall season since the incident, the river bed has been modified by local gravel miners excavating a single thread channel, up to one-half mile through the streambed. The passage channel is controlled at the lower end by three exclusion culverts that prevent migrating fish from entering the Van Duzen River from the Eel River during low flows (Fig. 12). When flows in reach 160 cfs, (gauged when the three 36 inch exclusion culverts are at their full capacity) the exclusion culverts are removed allowing salmon to move upstream into the Van Duzen River (Fig. 12). There is a high risk of a repeat stranding of salmon and mortality if the channel modifications are not made on an annual basis. Details regarding the gravel mining extraction methods are included in the section "Gravel Mining" (pgs 26-27).

Figure 11. Van Duzen River plane bed channel caused fish stranding at low flows. Photo taken near dry channel confluence with Eel River.

Figure 12. Excavated channel with exclusion culverts (top) looking upstream and looking downstream with culverts removed (bottom) to allow fish passage into Van Duzen River at flows of ~160 cfs.

Tributary Streams

The Lower Subbasin drains approximately 54 miles of perennial tributary channels and 85 miles of intermittent tributary channels (Fig. 13). Approximately 91 miles of the tributary channels are characterized as steep (gradient >20%) and are considered sources areas for sediment inputs (Fig. 14). Most of these steep stream reaches are also intermittent channels and likely do not support anadromous salmonids, but may provide habitat for resident trout. 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. Observations indicate that summer base flows usually occur by August. Fox, Cummings, Fielder, Wolverton, Root, and Grizzly creeks

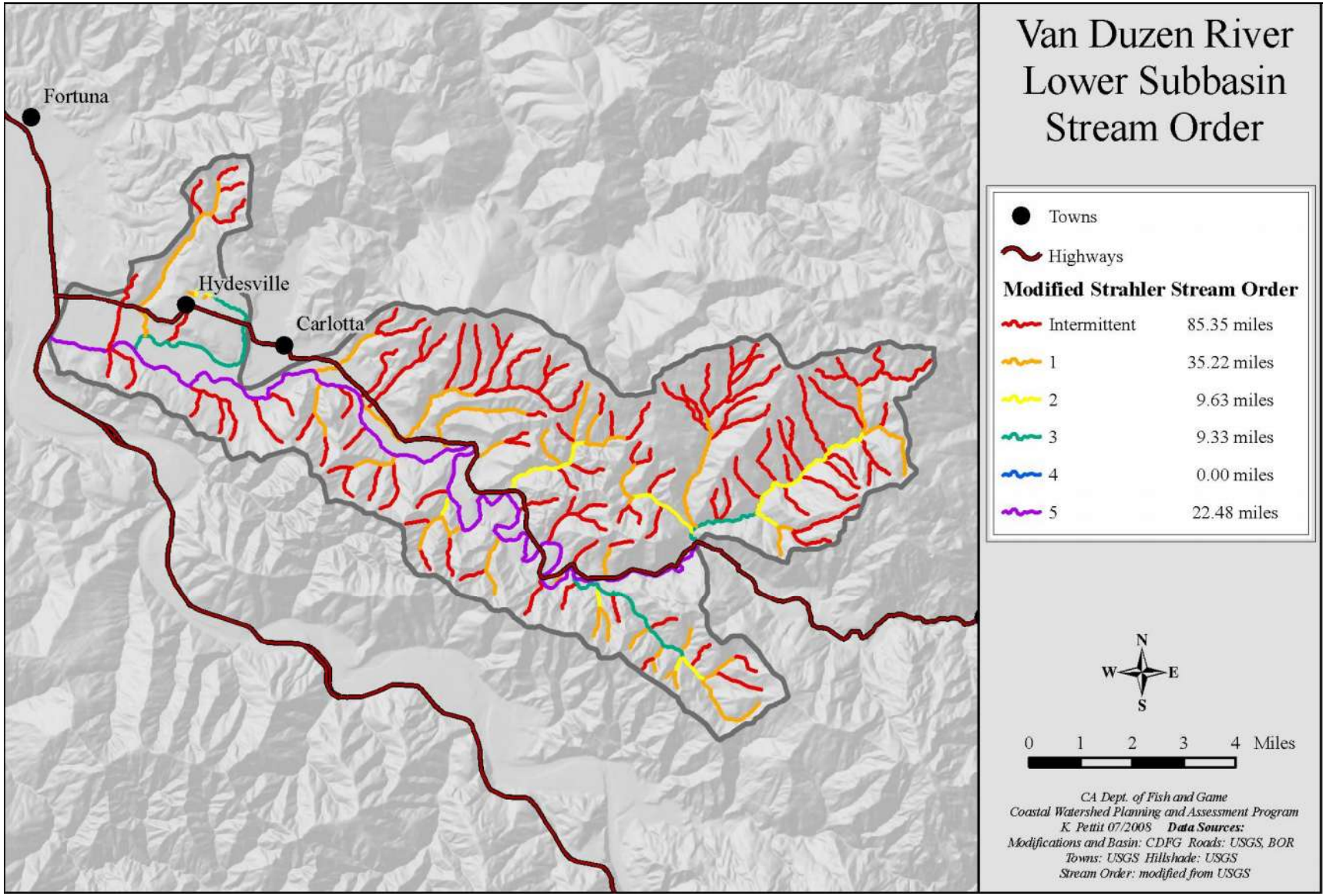


Figure 13. Stream order and intermittent streams in the Van Duzen River Lower Subbasin.

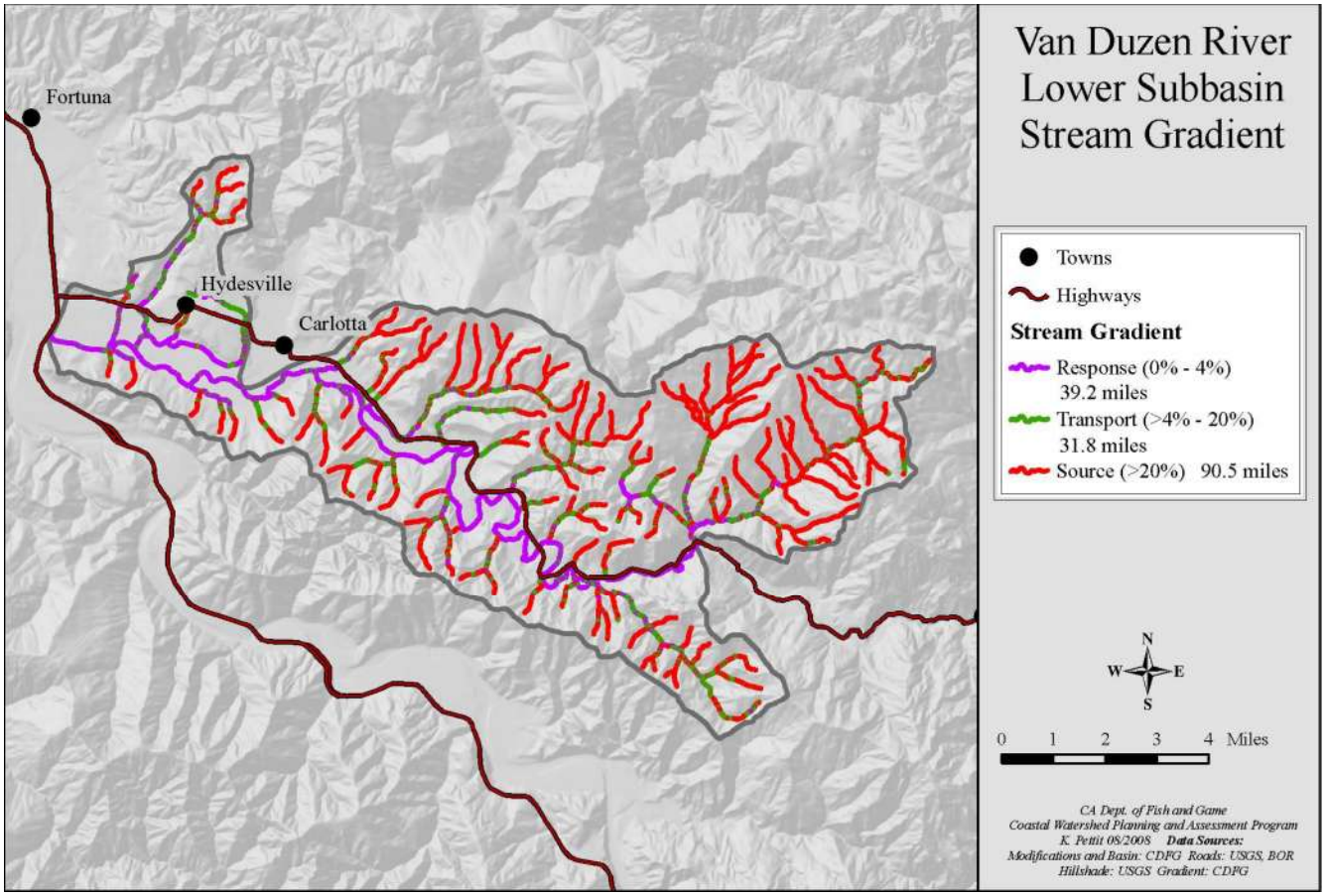


Figure 14. Channel gradient of Van Duzen River Lower Subbasin streams.

typically lose an active surface connection with the mainstem in summer due to intermittent flow and/or from sediment accumulations that raise the channel bed above the mainstem river base flow elevation. During summer the lack of water in stream reaches limits fish movements and likely reduces salmonid production. Any management actions that increase summer flows in the tributaries should receive consideration as they benefit fish habitat.

Vegetation

Coniferous forests cover 85% of the Lower Subbasin terrain. Redwood dominated forest is the most common vegetation class, covering approximately 70% of the terrain (Fig. 15, Table 5). Douglas fir dominates the remainder of conifer forests. Patches of mixed hardwoods (alder, willow, cottonwood, bay laurel) grow in the lower river valley, and patches of oaks grow in the uplands of the eastern most region of the Lower Subbasin.

Grasslands occur in the lower river valley and in patches and prairies spread across the Lower Subbasin. Agricultural vegetation composed of mostly pasture grasses occupies much of the lower river valley and the area around Hydesville. Much of the pasture land used for livestock grazing was converted from hardwood or coniferous forests.

Most of the coniferous forests of the Lower Subbasin have been recently logged, and are subsequently dominated by early stage seral forests stands. The adverse changes to salmonid habitat related to extensive logging of forests and land use that disturbs riparian and near stream forests are discussed in the "Role of Riparian and Nearstream Forests in Stream Ecosystems" section in the Basin Profile.

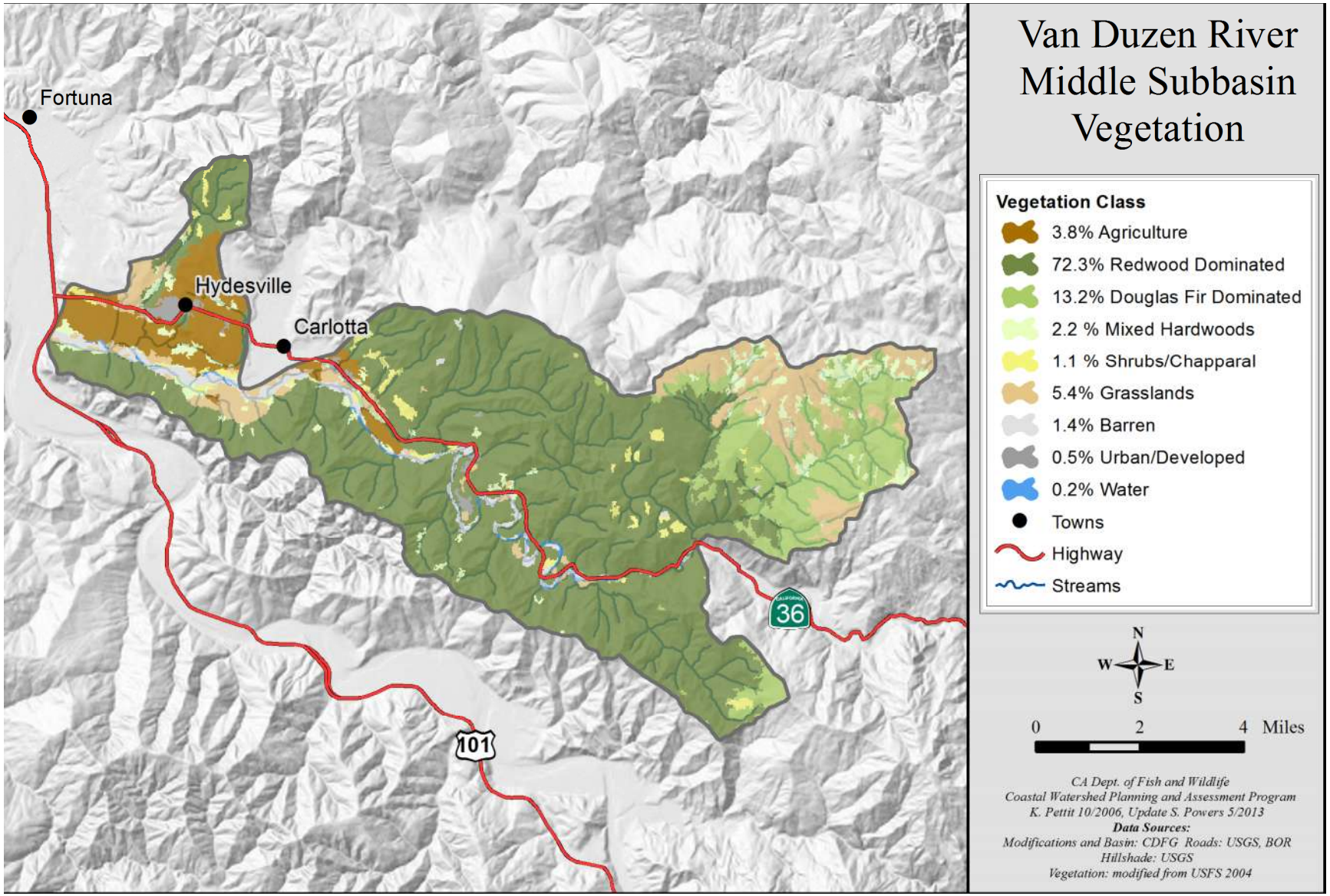


Figure 15. Vegetation classes by percentage in the Van Duzen River Lower Subbasin.

Table 5. Vegetation cover types in Van Duzen River Lower Subbasin planning watershed (shown in acres).

Planning Watershed	Cover Type								
	Redwood Dominated	Douglas Fir Dominated	Grass Lands	Hard wood	Shrubs	Agriculture	Developed	Barren	Total Acres
Cummings Creek	6,937	2	195	117	208	3,020	92	121	7,997
Grizzly Creek	781	3879	1,783	710	21	0	0	6	7,180
Hely Creek	6,035	35	72	115	39	4	94	210	6,613
Root Creek	8,027	402	79	32	87	0	0	230	8,945
Stevens Creek	2,748	769	1,014	237	183	0	0	10	4,963
Wolverton Gulch	3,325	0	1,029	447	271	2,628	227	487	8,451

Figure 16. The lower Van Duzen River.

Land and Resource Use

Principle land uses in the Lower Subbasin are industrial and non-industrial timber harvests, livestock grazing, gravel mining, rural residential developments, and roads (Fig. 16). Timber harvesting is the dominant land use, especially upstream of the Carlotta area, involving approximately 79% (35,000 acres) of the land in the Lower Subbasin. Rural residential developments occupy 8% (3,405 acres) of the land use and are mostly located around the town of Hydesville and along Highway 36 east of Carlotta. Other land uses in the Lower Subbasin, most prevalent in the lower river valley area west of Carlotta, include livestock grazing (7%; 3142 acres) and dairy production and growing agricultural crops (4%; 1625 acres). Remaining land uses are classified as public lands such as parks and open space (<2%, 622 acres), gravel mining (<1%, 147 acres), and commercial/industrial (<1%, 72 acres). Gravel mining sites are located in the lower Van Duzen River channel near the confluence with the Eel River.

Timber Harvests

Commercial timber harvest began in the Lower Subbasin shortly after the arrival of first white settlers around the mid 1800s. These early harvests involved both clearing forests to open up rangeland for livestock grazing and cutting and milling trees for wood products (Moore 1999).

Early timber harvest rates were minimal until the late 1800s as harvest methods relied on horses or oxen were used to pull logs over skid trails. Harvest rates experienced a gradual increase with the use of the steam donkey cable yarding and railroad hauling in the late 1800s and early 1900s. However, with the implementation of tractor yarding and truck hauling in the mid-1940s combined with the boom for building products that occurred after World War II timber harvest rates had accelerated rapidly as large tracts of forest were being cut and processed in numerous local mills. By the end of the 1970s, most of the forests had been clear cut harvested at least once and were supported by a dense network of haul roads to truck logs from the forests to mills. Tractors dragged, or "skidded", the logs to landings where they were loaded on trucks. The tractors carved up skid trail across the landscape and through creek channels. At times, high line cable systems were also utilized to move trees. Between the large expanse of clear cuts, skid trails and logging roads the mountain landscape were exposed to forces of unnatural occurring erosion. The heavy rains and floods of 1955 and 1964 were the first documented large storms to hit the area after these numerous consecutive years of heavy-handed harvests.

The cumulative impacts from these intensive land use activities and severe rain associated with winter storms and snow resulted in widespread flooding, severe erosion from landslides, and debris torrents forming large debris accumulations. Excessive erosion caused aggradation of stream channels and channel widening. Timber harvest activities that occurred during the 20th century were likely the most significant detrimental land use to salmonid stream habitats, and the resulting legacy impacts are still apparent today in some areas. After these two large floods, problems associated with timber logging continued to develop. For example, in 1974 a CDFG field note from Hely Creek states, "during past logging activities it is apparent little regard was given the stream. Much slash and standing timber is sliding into the creek, and many debris jams are silted in and are barriers to fish passage" (CDFG 1974). In 1983, after heavy rains a debris torrent flooded Hely Creek with large cull logs, slash and sediment (Figs. 17 and 18). The probable source of the debris torrent was noted as a tributary that was part of timber harvest activities that occurred shortly before the event. Despite fledgling timber harvest rules instituted in 1973 and further rule development regulating harvest methods, salmonid habitats continued to suffer from loss of shade from large stream side conifers, loss of input of large wood and excessive sediment inputs.

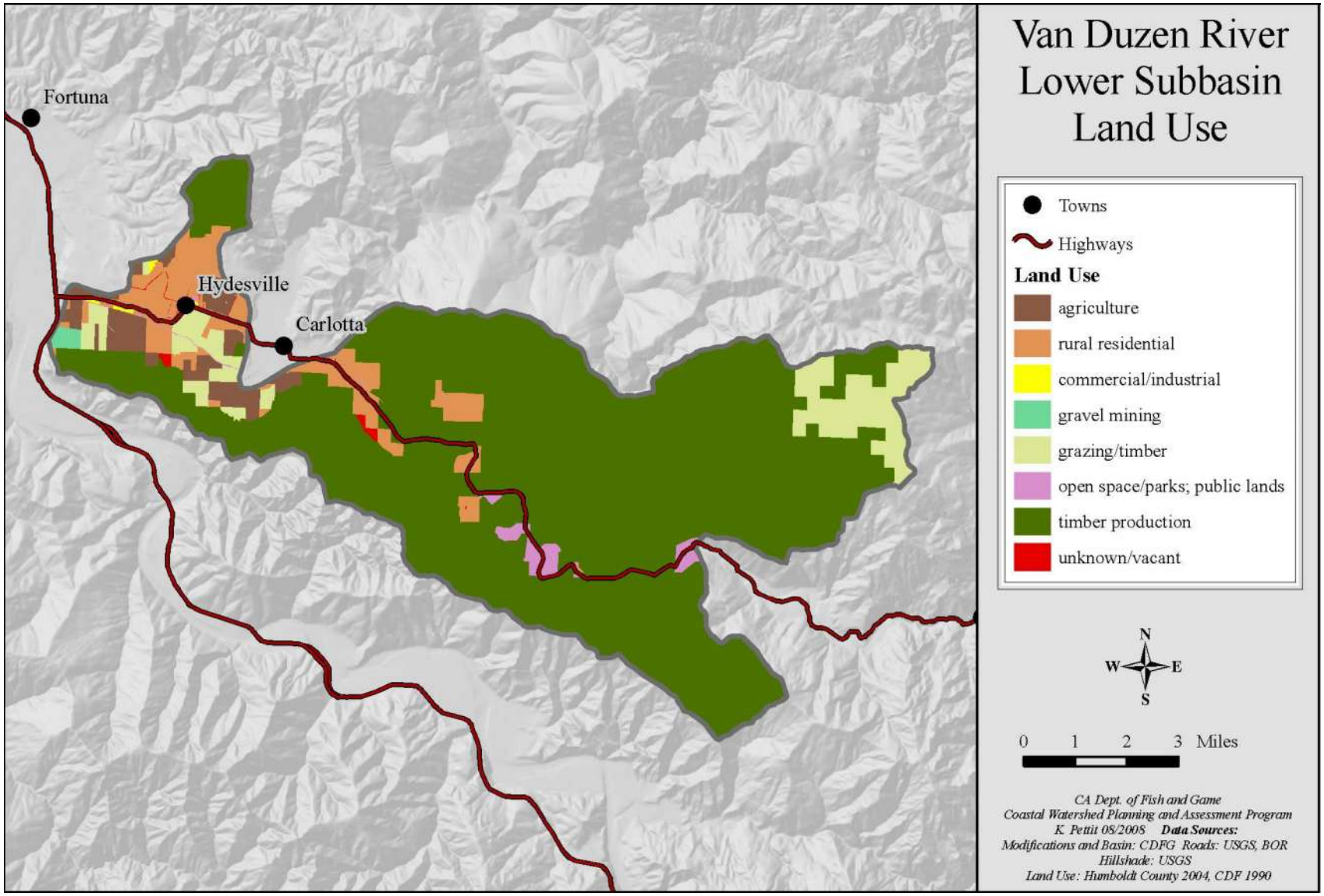


Figure 17. Van Duzen River Lower Subbasin land use classes

Based on analyses of more recent timber harvests impacts, the issue of harvest rates appear to be as important to manage as the harvest methods themselves. Approximately 40% of the Lower Subbasin area (54% of conifer forests) was part of timber harvest plans from 1991-2008 (Table 6, Fig. 20). Timber harvest prescriptions included primarily clear cuts (5,780 acres), selection cuts (5,678 acres), commercial thinning (5,450 acres), seed tree removal (1,550 acres). Over the 17-year period, Cummings Creek, Stevens Creek, and Hely Creek planning watersheds had the most timber harvest related activity in the subbasin with 70%, 66%, and 60%, respectively, of the coniferous forests involved in timber harvest respectively not including multiple harvests on the same acres.

To assess water quality impacts from timber harvests, the Regional Water Quality Control Board developed a series of adjustment factors that rated impacts from various silvilcultural prescriptions (RWQCB 2006). According to the adjustment system, clear cuts are the most detrimental to the forest landscape and water quality parameters. Seed tree removal impacts are considered 75% as disruptive as clear cuts, and selection cuts are considered 50% as disruptive relative to clear cuts. Several other prescriptions are evaluated, including yarding and tractor yarding methods. Yarding methods vary in their contribution to land disturbance. Tractor yarding typically generates the most erosion of top soils compared to other yarding methods.

Klein et al. (2008) suggests using the adjustment factors for a relative measure of timber harvest rates to compare with a maximum watershed harvest rate of 1.5% per year (~ 65 year rotation) to mitigate for erosion and associated sediment inputs to streams. Using silvilculture area adjustment factors and 1991-2008 harvest plan data, the Lower Subbasin forest has been cut at a rate of approximately 2.7% per year representing a 37-year rotation. The recommended harvest rate of 1.5% and 65 year rotation was exceeded in all planning watersheds except for Grizzly Creek. The highest annual adjusted harvest rates were in Stevens Creek (4.1%/yr) Cummings Creek (3.6%/yr), and Hely Creek (3.1%/yr) planning watersheds. For comparison, if not adjusted for silvilcultural methods, 3.2% per year of the forest area was involved in timber harvests, representing a 31-year rotation through the Lower Subbasin forests. The high harvest rates likely contribute to a continuous impairment to stream ecosystem recovery needed to improve status of State and/or Federally listed threatened salmonid populations.

Figure 18. Debris torrent buries Hely Creek with logging debris near Redwood House Road in 1983.

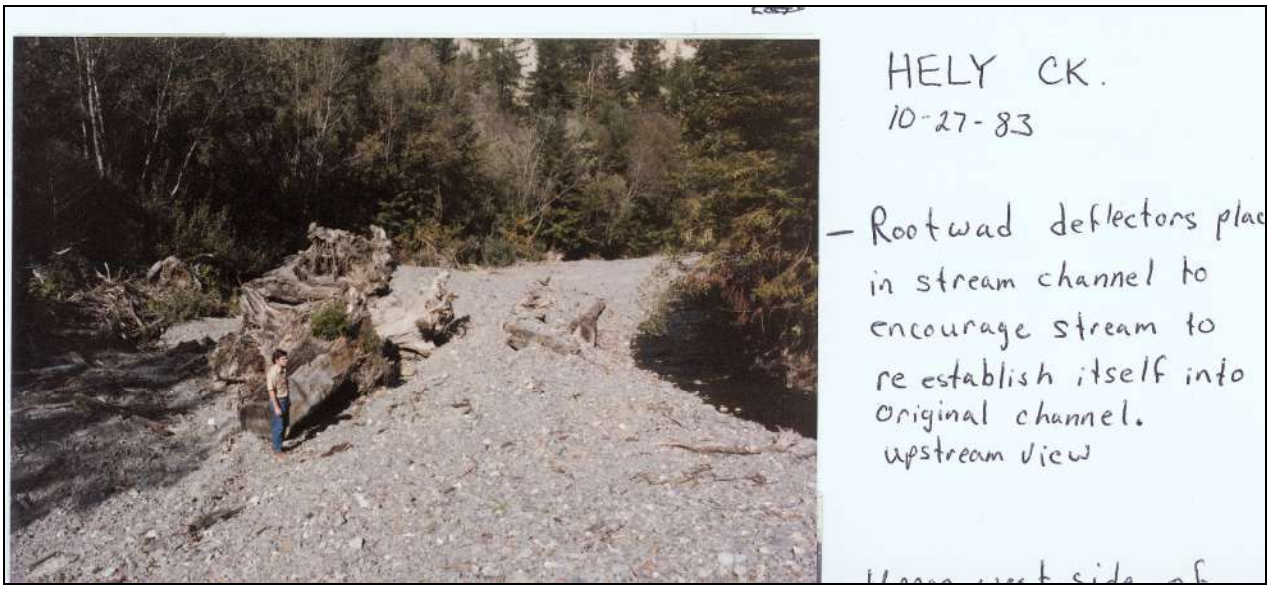


Figure 19. After wood salvage and clean up from debris flow in Hely Creek 1983. Large sediment accumulation remains.

Figure 20. Hely Creek 2006. While large wood occupies the bank and channel providing cover and habitat for salmonids and potential spawning cobble has replaced some fine sediment, the recovery of Hely Creek remains ongoing. A dense growth of young willow resides in the active, braided channel.

Table 6. Lower Subbasin of the Van Duzen River timber harvest plan statistics 1991-2008. This table does not reflect 382 acres of pending THPs in 2008. Harvest rates exceed the recommended 1.5% per year harvest rate (Klein et al. 2008) in all planning watersheds except for Grizzly Creek.

Planning Watershed (PW)	PW Acres	Conifer Forest Acres	THP Harvest Acres	% PW Harvested	% PW in Conifers	% Conifer Acres in THP	Conifer Harvest Rate Adjusted for Prescription
Cummings Creek	7997	6938	4832	60	87	70	3.6%/yr
Grizzly Creek	7180	4660	1797	25	65	39	1.4%/yr
Hely Creek	6613	6070	3645	55	92	60	3.1%/yr
Root Creek	8946	8429	4152	46	94	49	2.1%/yr
Stevens Creek	4963	3517	3191	47	71	90	4.1%/yr
Wolverton Gulch	8451	3325	1131	13	39	34	1.9%/yr
Subbasin Total	44,150	32941	17,875	41	75	57	2.7%/yr

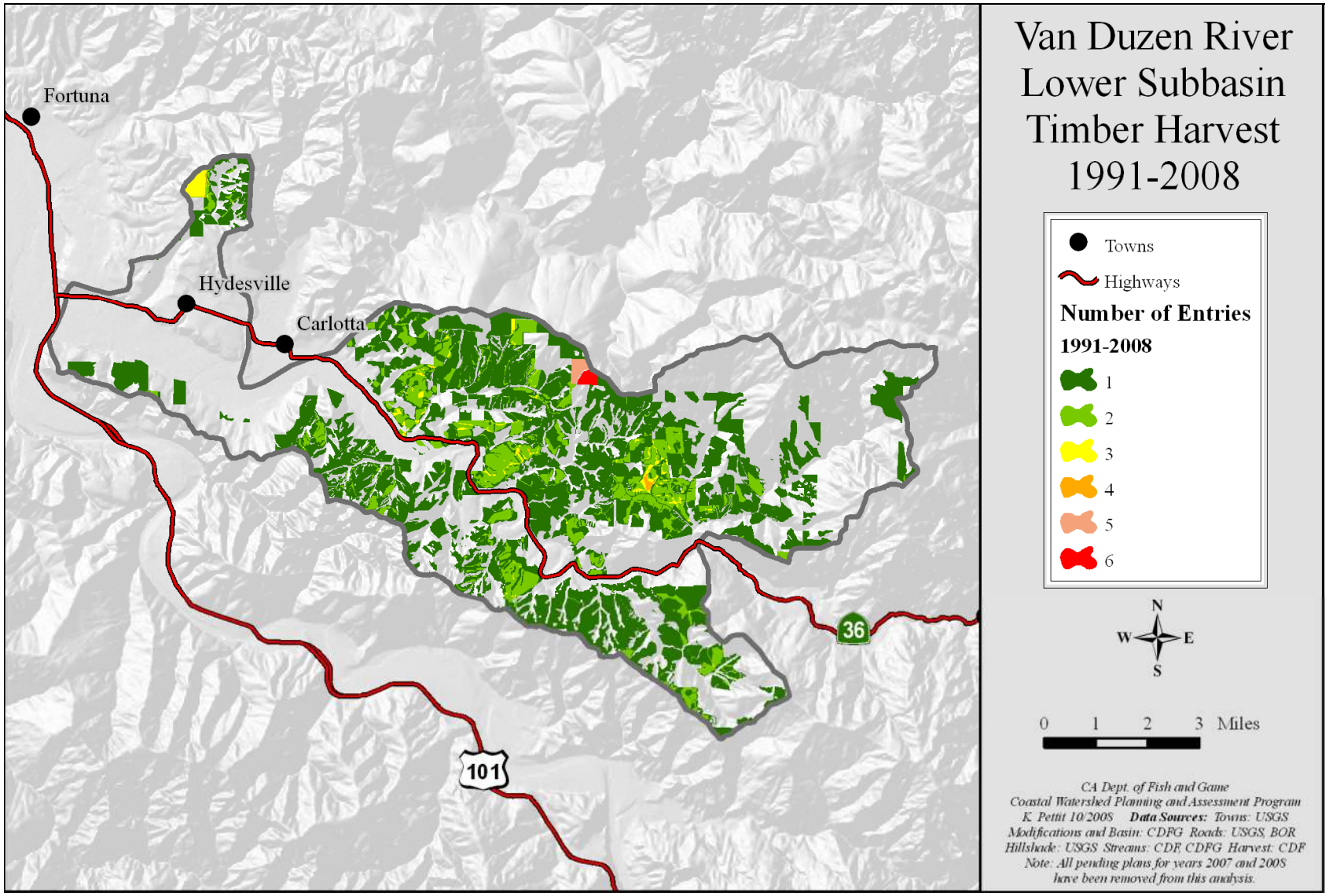


Figure 21. Van Duzen River Lower Subbasin timber harvest activity 1991-2008.

Roads

Roads data available from CDF GIS roads layers show that there is an average of six miles of roads per square mile of area in the Lower Subbasin (Table 7, Fig. 21). This large number is an underestimate because 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) and does not consider skid trails. Using the available data, the highest road densities are in the Cummings Creek, Root Creek, and Hely Creek planning watersheds where road densities exceed 7 mi/sq. mi (Table 7). More than 2.5 miles of roads per square mile of watershed is considered to produce excessive surface erosion and excessive sediment inputs to stream channels (Cederholm 1981, NMFS 1995). The high road density in the Lower Subbasin is well above recommended levels.

In order to reduce the impacts from the high road density, recent efforts in the Lower Subbasin include road decommissioning and road improvement projects. Approximately 118 miles of roads located on Humboldt Redwoods Company lands within the Lower Subbasin have been improved with culvert upgrades, rolling dips, outsloping, or other treatments intended to reduce road related erosion (HRC, written communication). Most of the work on HRC lands is in compliance with their Habitat Conservation Plan (HCP). Other road projects were completed with support funding from CDFG's grants program (see Watershed Restoration section below). With the high density of roads in the Lower Subbasin, more road decommissioning and improvement projects are likely and should be implemented. New road construction should be minimized. Any new road construction plans should be reviewed by a certified geologist, carefully located, designed and built using best management practices.

Table 7. Road miles in planning watersheds of the Van Duzen River Lower Subbasin.

Planning Watershed	Road Miles	Square Miles	Road Miles per Sq Mi	Improved Road Miles
Cummings Creek (Lower)	89.2	12.50	7.14	21.5
Grizzly Creek	53.3	11.22	4.75	9.4
Hely Creek	72.5	10.33	7.01	31
Root Creek	99.9	13.98	7.15	38.1
Stevens Creek	50.0	7.75	6.45	13.5
Wolverton Gulch (Lower)	52.0	13.20	3.94	4.5
Total	417	69	6	118

Gravel Mining

Gravel mining occurs in the lower Van Duzen River from the confluence with the mainstem Eel River to approximately one mile above the confluence with Yager Creek (RM 6). Gravel mining activities may potentially impact salmonid spawning and rearing habitat through alteration of channel morphology, sediment routing processes and impairment of the development and maturation of woody riparian vegetation (Meehan 1991; Brown et al. 1998; ACOE 2003; McBain and Trush 2009). Surface gravel mining should therefore be conducted in a prudent and cautious manner, especially in known salmonid bearing rivers like the Van Duzen River. The United States Army Corps of Engineers (USACOE), State of California and Humboldt County, among others, provide oversight to the surface gravel mining industry through annual collaborative planning sessions.

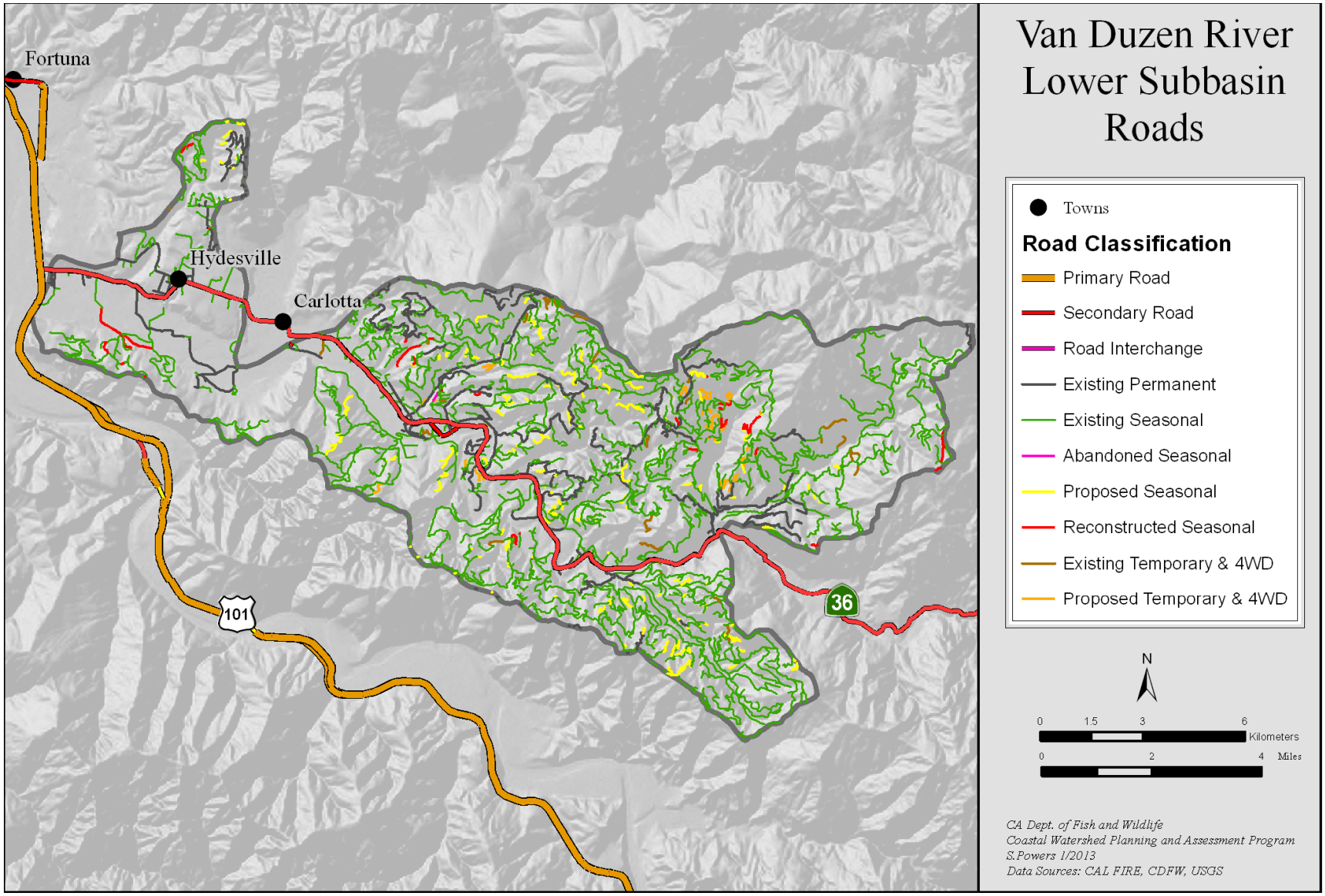


Figure 22. Road network of the Van Duzen River Lower Subbasin.

The County of Humboldt Extraction Review Team (CHERT) monitors and makes recommendations on sites that extract over 5,000 cubic yards annually. For each harvest site, CHERT estimates the mean annual recruitment (MAR) of bedload in relation to the surrounding instream mining operations. Based on the MAR, the CHERT sets limits on the maximum volume of aggregate available for harvest each year, recommending extraction should not exceed 75% of MAR in salmonid-bearing rivers and streams; and only after analysis has determined the MAR for a particular mining reach. Without specific reach analysis, 25% of MAR should be the guideline (Laird et al. 2000). From 1997 through 2007, the average volume extracted from the lower reach of the Van Duzen River was 111,347 cubic yards, or about 70% of the maximum volume permitted by CHERT (Table 8).

Table 8. Van Duzen River Lower Subbasin Extraction 1997-2007 (CHERT 2008).

Year	Max Volume (cy)	Extracted Volume (cy)	Percent Extracted
1997	120,000	81,600	68%
1998	119,100	103,700	87%
1999	159,900	108,800	68%
2000	194,800	121,300	62%
2001	161,700	85,600	53%
2002	202,500	167,400	83%
2003	175,100	123,000	70%
2004	179,045	92,610	52%
2005	159,090	123,170	77%
2006	134,910	104,750	78%
2007	152,773	113,184	74%
Totals	1,758,918	1,225,114	70%
Averages	159,902	111,374	70%

Channel bed elevation changes in the Van Duzen River have been measured in three separate studies. Kesley (1977) found that the upper Van Duzen River had aggraded during the time period from 1941 to the post-1955, and 1964 floods. Given the magnitude of those system reset events, this conclusion was not surprising. Fifteen years later (1992) and in the lower Van Duzen River, Humboldt County determined that a river cross-section near Highway 101 had downgraded 10 feet (Humboldt County 1992). However, the USACOE measured channel aggradations in the lower Van Duzen River from 1968 to 1999, and concluded that these measurements were not evidence of gravel mining impacts (ACOE 1999).

Legacy effects of aggradation in the Van Duzen River due to the large-scale erosion of the basin during major floods, and resultant deposition in the lower reaches have left the lower five miles of the active river channel extremely wide; of which has led to the current shallow, braided, and even sub-surface flows common in late summer and early fall prior to seasonal rains. This condition has posed a significant adverse impact to early fall Chinook spawners in the Van Duzen River and lower Eel River just upstream of the confluence with the Van Duzen River. As described in the "Mainstem Van Duzen River" section (pg.14), stranding events occurred in 1996 and 2002 when adult Chinook salmon died in the wide, shallow, braided channel as they tried to migrate upstream to spawn.

Following the major stranding event in 2002, and annually since, the construction of a single thread, low flow channel has been included in gravel mining operations in the lower one mile of the river. In the USACOE Letter of Permission, bar-skimming as a technique is no longer approved in the lower two miles of the river, and preferred alternative methods are trench, alcove, or wetland pit mining (ACOE 2003). By utilizing these preferred methods, in coordination with CDFG and NMFS personnel, current gravel mining operations have improved the lower Van Duzen River's channel shape and functionality and curtailed early Chinook salmon migration mortalities.

Industrial Marijuana Agriculture

What is not displayed/categorized in Land Use Fig. 16 (p. 19) is the recent proliferation of industrial marijuana agricultural operations. Since the passage of Proposition 215 in 1996 and SB420 in 2003 in California, CDFG field staff has discovered increasing numbers of large marijuana grows on private lands, presumably for medical purposes. These operations are having a significant impact on the landscape and natural resources of the Basin (including the Lower Subbasin).

Unlike other regulated land use activities such as legal timber harvesting and/or mining operations, there are no standards for "best practices management" or any review by agencies like CDFG and the state Water Quality Control Board; therefore, a wide range of impacts to watercourses and their aquatic resources can be associated with these industrial marijuana agricultural operations. These impacts may include the following (T. LaBanca, CDFG, personnel communication 2012):

- Illegal water diversions that draw directly from the streams without screens or bypass, so juvenile fish and amphibian can be pulled from their habitat and die;
- Decrease in stream flows due to these water diversions;
- A wide range of pollutants may be used, including fuel, fertilizers, herbicides, pesticides, rodenticides, and construction debris. These chemicals and debris may go directly into watercourses or could leach into the soil, eventually releasing into the water throughout the year;
- Human wastes from camps that could also directly enter or leach into watercourses;
- Improperly constructed roads and construction around the site that contributed to sediment production that enters watercourses throughout the rainy season;
- Unpermitted timber harvests that may occur when an area is cleared for an agricultural grow operation.

Fish Habitat Relationships

Fishery Resources

The Lower Subbasin supports populations of Chinook and coho salmon, steelhead and coastal cutthroat trout (Table 9). Winter steelhead are the most widely distributed and abundant anadromous salmonid in the subbasin utilizing approximately 45 miles of stream habitat in the Van Duzen River and its tributaries (Fig 22). Approximately 30 miles of the available stream miles are used by coho and Chinook salmon with about half of these miles in the tributaries and the other half in the mainstem. Chinook salmon spawn in both the mainstem Van Duzen River and its tributaries (Fig. 23), whereas coho and steelhead typically spawn in the tributaries. Some of the streams not currently displayed as fish bearing streams in Figures 22 and 23 (non-highlighted) may be utilized by juvenile steelhead for rearing or adults for spawning, but due to limited staff and funding these streams were not surveyed during this assessment.

Currently, the most important tributary streams for salmonid spawning and rearing are Cummings Creek, Hely Creek, Root Creek, and Grizzly Creek. These streams (along with several others) in the Lower Subbasin once supported robust populations of Chinook and coho salmon, steelhead and possibly coastal cutthroat trout. A review of recent CDFG spawner survey results (Appendix B) reveals the present number of Chinook and coho salmon returning to spawn in the Lower Subbasin have declined significantly compared to the substantially larger runs reported prior to 1965 (CDFG 1965). Moreover, coho salmon stocks have declined to drastically low numbers and may be functionally extirpated from the subbasin.

CDFG stream field notes are located in Appendix B of the Van Duzen River Assessment report. These field notes describe anecdotal historical stream conditions and presence/

absence observations. Additionally, Appendix B contains results of CDFG spawner surveys conducted in the mid-eighties to 2008 for the following streams: Cummings, Root, and Grizzly creeks.

Table 9. Salmonid streams of the Lower Subbasin Van Duzen River.

Stream	Anadromous Miles	Steelhead	Chinook	Coho	Cutthroat
Barber Creek	**1.0**	**X**			
Wolverton Gulch	**2.4**	**X**		**X**[1]	**X**
Cuddeback Creek	**0.8**	**X**	**X**	**X**[1]	
Fielder Creek	**1.0**	**X**	**X**	**X**[1]	
Cummings Creek	**3.1**	**X**	**X**	**X**[1]	
Fox Creek	**0.4**	**X**[2]			**X**
Flanigan Creek	**0.5**				
Hely Creek	**1.8**	**X**	**X**	**X**	
Root Creek	**2.6**	**X**	**X**	**X**[1]	
Grizzly Creek	**3.0**	**X**	**X**	**X**	
Stevens Creek	**0.9**	**X**	**X**	**X**[1]	

[1] *Sites to re-establish coho salmon population;* [2]*resident rainbow steelhead/trout*

Figure 23. Adult steelhead caught on the lower Van Duzen River.

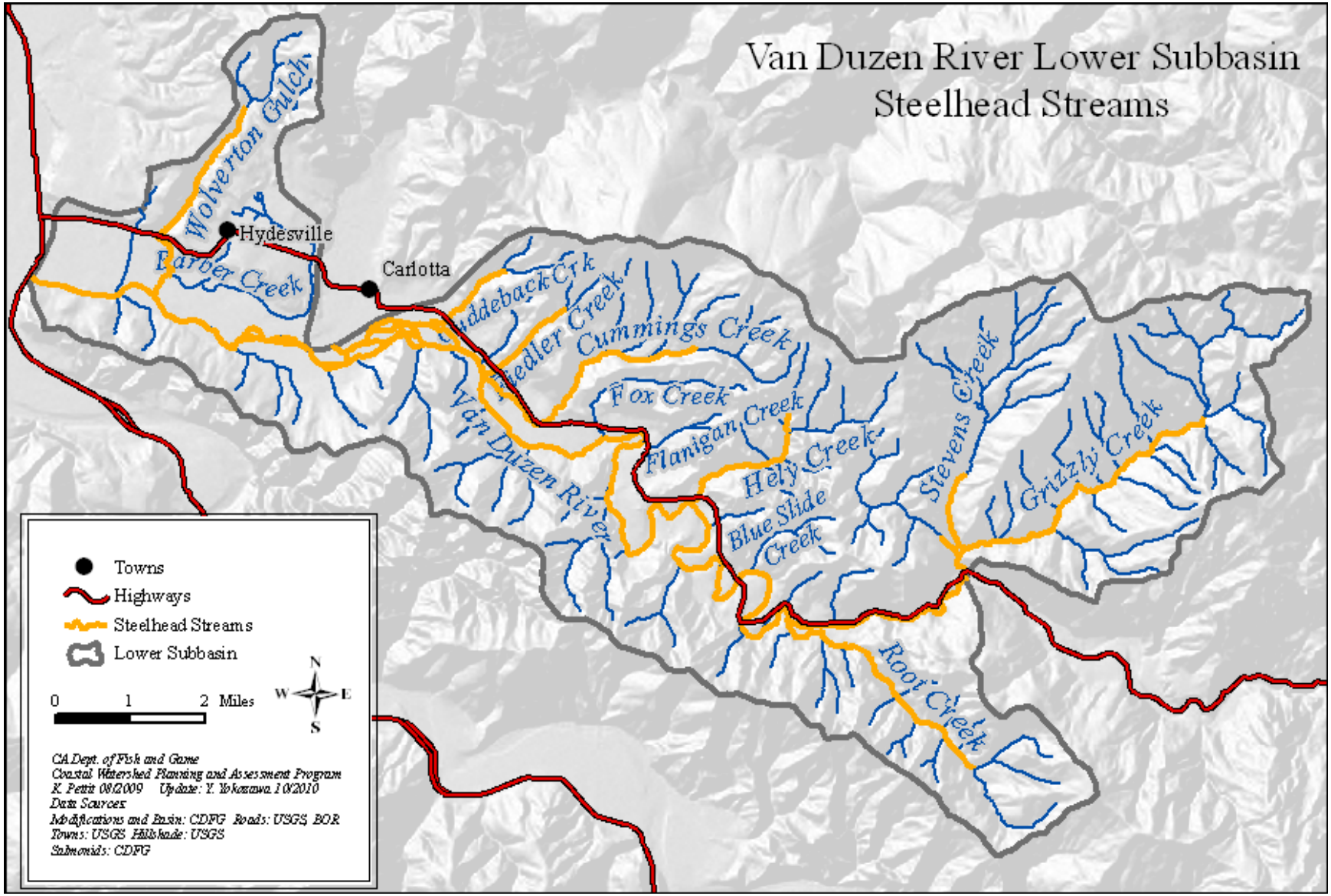


Figure 24. Lower Subbasin winter steelhead distribution

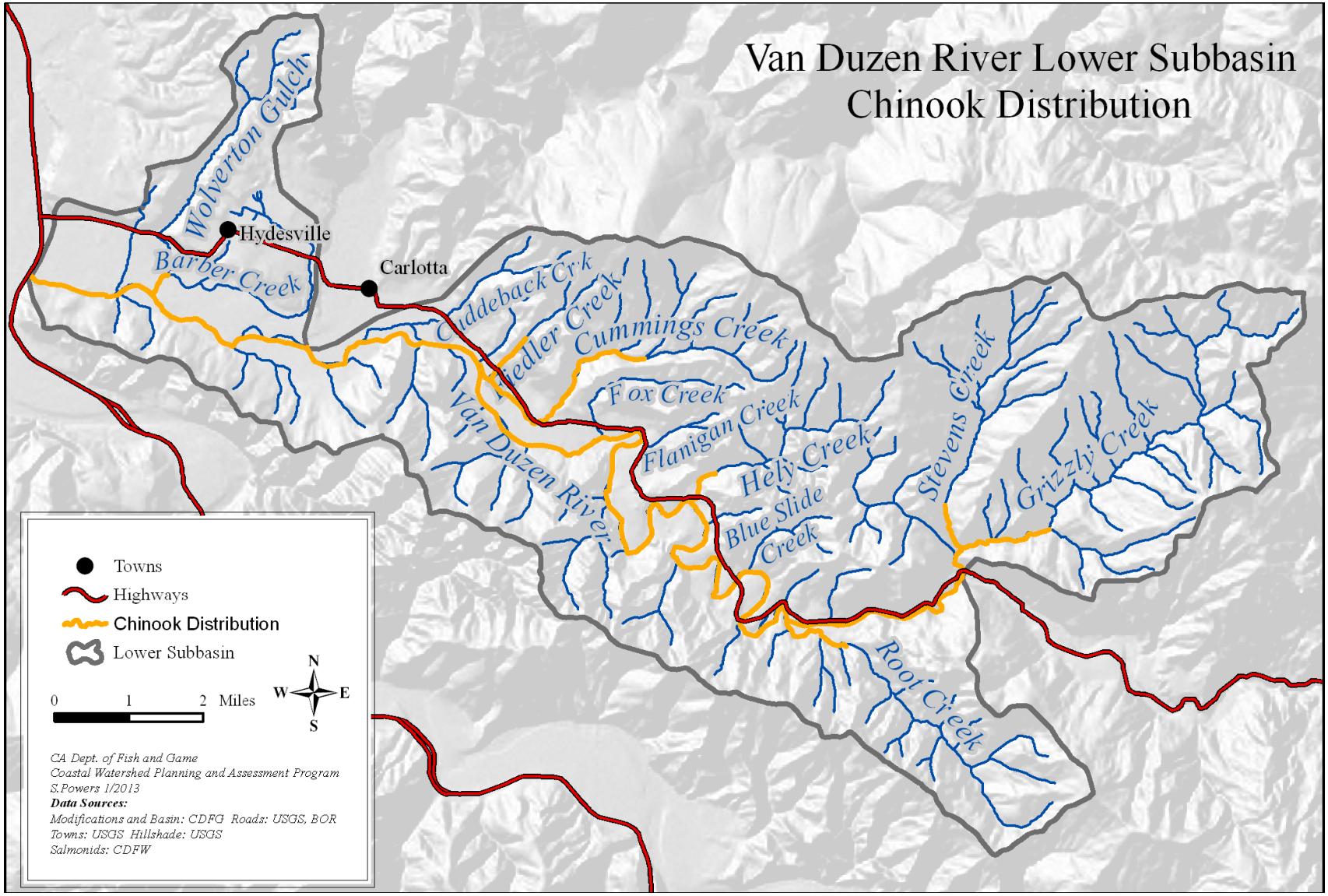


Figure 25. Chinook distribution in the Lower Subbasin.

Habitat Overview

Water Temperature

Water temperature data for streams in the Lower Subbasin are available from the Humboldt County Resource Conservation District (HCRCD) 1996-1998 (Table 10) and from PALCO 1999-2005 (Table 11). Overall, the stream temperature data indicates unsuitable salmonid water temperatures in the mainstem Van Duzen River, but suitable water temperatures in the Lower Subbasin tributaries (except in Grizzly Creek for coho, see below). The 1996-1998 data (Table 10) show that the 7-day average maximum temperature in the Van Duzen River is often above 68°F (20°C), for several hours each day, which is well above the average maximum temperature thresholds suggested as an upper limit for coho salmon presence of 63.7°F (17.6°C) (Hines and Ambrose 2001). Moreover, the averages above 68°F (20°C) is considered to stress all salmonids during the warm summer months of mid-July through early September. The water temperature data also show a general trend of decreasing temperature as the Van Duzen River flows from warmer inland areas (near Root Creek) to the cooler coastal climate (near Alton). Small patches of cool water refugia have also been observed adjacent to Grizzly Creek, Root Creek, Hely Creek and possibly at other locations where tributary seeps bring cool flows to the mainstem river.

Persistently or intermittently flowing tributaries, springs or seeps may add cool water near the confluence with the mainstem Van Duzen River resulting in localized patches of cool salmonid refugia during summer months, especially in side channel pools and alcoves. These cool water habitats may be particularly important for juvenile coho salmon compared to Chinook salmon because Chinook juveniles are more likely to leave their natal streams by early summer and migrate to the estuary before temperatures reach stressful or lethal levels.

Water temperatures recorded in Lower Subbasin tributary streams from 1999-2005 (Table 11) are generally suitable for year round rearing of all salmonids, except for Grizzly Creek where the summer season 7-day average maximum temperature from 2001-2005 averaged 65°F (18.3°C). Even though these temperature values exceed suggested coho salmon thresholds and recent detection of coho salmon in Grizzly Creek has been limited to very small numbers, it was historically considered a good coho-bearing stream (CDFG 2004) and still has potential to be so once again. In September 2007 and August 2008, juvenile salmonids were observed holding in small patches of cool water refugia in the mainstem Van Duzen River near the Grizzly Creek confluence, which may be attributed to the importance of patches of cool water refugia during summer months.

Table 10. Seven-day maximum average water temperature (°F) in the Van Duzen River and Lower Subbasin streams 1996-1998. Source: HCRCD.

Year	**1996**	**1997**	**1998**
Site	**7-day Ave Max**	**7-day Ave Max**	**7-day Ave Max**
VDR near Root Cr.		79.7	77.9
VDR near Cummings		78.3	75.7
VDR near Alton	75.6	74.5	73.8
Cuddeback Creek 969			58.8
Cummings 1530	64.0	65.1	64.0
Cummings 1531	62.6		
Cummings 969			58.8
Root Creek 1203	61.3	63.1	61.2
Root Creek 1404	62.1	61.7	61.5

Table 11. Seven-day maximum average water temperature (°F) from Van Duzen River Lower Subbasin streams 1999-2005. Source: PALCO.

Station Location / Year	1999	2000	2001	2002	2003	2004	2005
Grizzly Creek			63.8	64.1	65.3	66.7	65.0
Root Creek	59.4	58.4	59.2	57.7	60.3	61.4	
Hely Creek		58.5	58.4	57.2		60.4	58.5
Cummings Creek			59.9	57.7	60.0	60.7	59.0

Turbidity

Turbidity was monitored in Lower Subbasin streams during the 2007 and 2008 water years by Friends of the Van Duzen River, a local volunteer watershed group. Analysis of collected data showed a strong positive relationship between discharge and turbidity levels for all sample sites. Highest turbidity levels were observed during the highest stream flows, and extended periods of high turbidity occur following rain events indicating prolonged inputs of fine sediment inputs to stream channels. Among the sample sites, Flanigan Creek, Fox Creek, and Wolverton Gulch consistently ranked highest in turbidity levels while Grizzly Creek had the lowest turbidity levels during the study (Friends of the Van Duzen 2010).

Stream Habitat Characteristics

CDFG measures a set of stream habitat characteristics to help assess stream condition in terms of suitability for anadromous salmonid production through the expression of several watershed factors and geomorphic processes acting together on spatial and temporal scales. The resulting channel geomorphology and riparian functions influence overall stream ecosystem conditions.

Within the Lower Subbasin, CDFG inventoried 7 tributaries between the years of 1991 and 2006 (Table 12). The data collected during these inventories are compared to the target values defined in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998) to determine if habitat conditions within the streams are limiting to salmonid production. Data collected during these habitat inventories describe the canopy density, cobble embeddedness of pool tails, length of primary pools, and mean pool shelter coverage along surveyed reaches within the Lower Subbasin. Additionally, the CWPAP evaluates these habitat data using the Ecological Management Decision Support (EMDS) system software. The EMDS system can evaluate stream reach conditions for salmonids based on water temperature, riparian vegetation, stream flow, and in channel characteristics. More details of how the EMDS functions are in NCWAP Methods Manual (2003), located on the CWPAP website (http://coastalwatersheds.ca.gov/AboutAssessment/AssessmentTools). Habitat data collected in the Lower Subbasin that can be used in the EMDS are: canopy, pool quality, pool depth, pool shelter, and embeddedness (Figures 25, 28, 30, and 31). Calculations and conclusions made in the EMDS are pertinent to surveyed streams and are based on conditions existing at the time of survey.

Pool:Riffle:Run Relationships

Significance: Productive anadromous streams are composed of a balance of pool, riffle and runs; each playing an important functional role in stream habitat ecology. 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), and the length of anadromous salmonid streams composed of primary pool habitats should be 40% (Flosi et al. 1998).

There are a variety factors affecting the relationships of pools, riffles, and runs, including channel type, channel gradient, bed and bank materials, sediment inputs, width to depth ratios, scour objects such as boulders and LWD, and the condition of the upstream watershed. Pools in forested mountain streams, common in the Lower Subbasin, are often associated with LWD 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.

Pool, riffle and run relationships for Lower Subbasin streams are shown in Table 12. Using the most recent data available (for streams with multiple surveys), the mean percent stream length considering all streams of the Lower Subbasin is 30% pools (95% CI ±10%). Root Creek had the highest percent of surveyed stream length in pools in 2006 (45%) followed by Stevens Creek (38%). There are likely some quality pools in Root Creek, however field measurements may be biased because of the following factors: long sections of standing water that went dry soon after the stream survey was conducted; a large fish bearing section of Root Creek that was not surveyed in 2006 due to logging activity that posed a safety hazard to surveyors; and because of the limited survey period. Wilson Creek had the lowest amount of pools at 4% of the surveyed stream length. It should also be noted that Grizzly, Stevens, and Cummings creeks received improvement projects in the 1990s and early 2000s, often resulting in increased pool area.

Generally, the percent occurrence of pools and riffles are greater than their corresponding percent length of a stream in Lower Subbasin streams, indicating pools and riffles are relatively shorter in length than run habitats. In excessively aggraded channels, runs may develop as pools fill. Because pools are generally below desired lengths, habitat improvement projects should consider strategic placement of LWD in existing pools to enhance scouring and result in greater pool depths and increased pool lengths within the tributary streams.

Table 12. Pool, riffle and run relationships from Van Duzen River Lower Subbasin streams.

Stream Reach	Survey Year	Survey length	Pool:Riffle:Run % occurrence	Pool:Riffle:Run % length
Cummings Creek	1991	17,823	35:41:24	11:36:25
Cummings Creek	1996	10,572	33:33:34	18:24:58
Cummings Creek	2006	16,164	44:34:22	35:36:29
Grizzly	1991	12,962	30:36:34	21:31:47
Grizzly	2006	15,849	34:44:21	31:47:22
Hely Creek	1991	8,220	31:39:30	16:55:29
Hely Creek	2006	9,892	32:34:34	23:39:38
Root Creek	1991	13,824	39:23:38	25:21:54
Root Creek	2006	6,830	53:25:22	45:30:25
Stevens Creek	1991	5,063	49:27:24	27:33:40
Stevens Creek	2006	5,131	46:32:20	38:31:31
Wilson Creek	1991	2,481	19:50:31	4:86:10
Wolverton Gulch	1997	6,224	51:6:43	32:2:66

Pool Depth

Significance: Deep pools are important habitats for adult and juvenile salmonids. They are used as holding areas by adult salmonids during spawning activities, and by juveniles for year round rearing and refuge from both predation and high winter flows. During low summer flows or in streams with intermittent flows, deep pools may provide the only suitable salmonid habitat.

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 length 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, such that primary pools are considered to have maximum residual depths of at least 2.0-2.5 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, NCWAP 2003). We consider streams with approximately 25-60% of their length consisting of primary pools suitable for salmonids in terms of deep pools. These indicator values are then used to assess the pool condition of anadromous salmonid habitat with the EMDS and by inspection of maximum pool depth histograms. However, shallow pool conditions can occur in low gradient reaches within small watersheds that lack sufficient discharge to deeply scour the channel. Therefore, some of the smaller streams may not meet the general target values, but still provide important fish habitat.

Despite the increasing amount of pool habitat noted above, surveyed Lower Subbasin streams do not meet target criteria for the length of primary pool habitat according to EMDS evaluations (Fig. 24). Based on the most current survey data, the mean maximum residual depth for 1st and 2nd order reaches is 1.6 feet, and 2.4 feet for 3rd order reaches. A low measure of pool area and pool depth is often found in stream channels that are in low supply of LWD and over supplied with sediments, which may indicate a disruption to channel forming processes and/or elevated levels of sediments stored in the stream channel. However, there appears to be a trend of increasing pool depth in streams that were surveyed in 1991 and then again in 2006 (Table 13), which may indicate improving conditions in these streams.

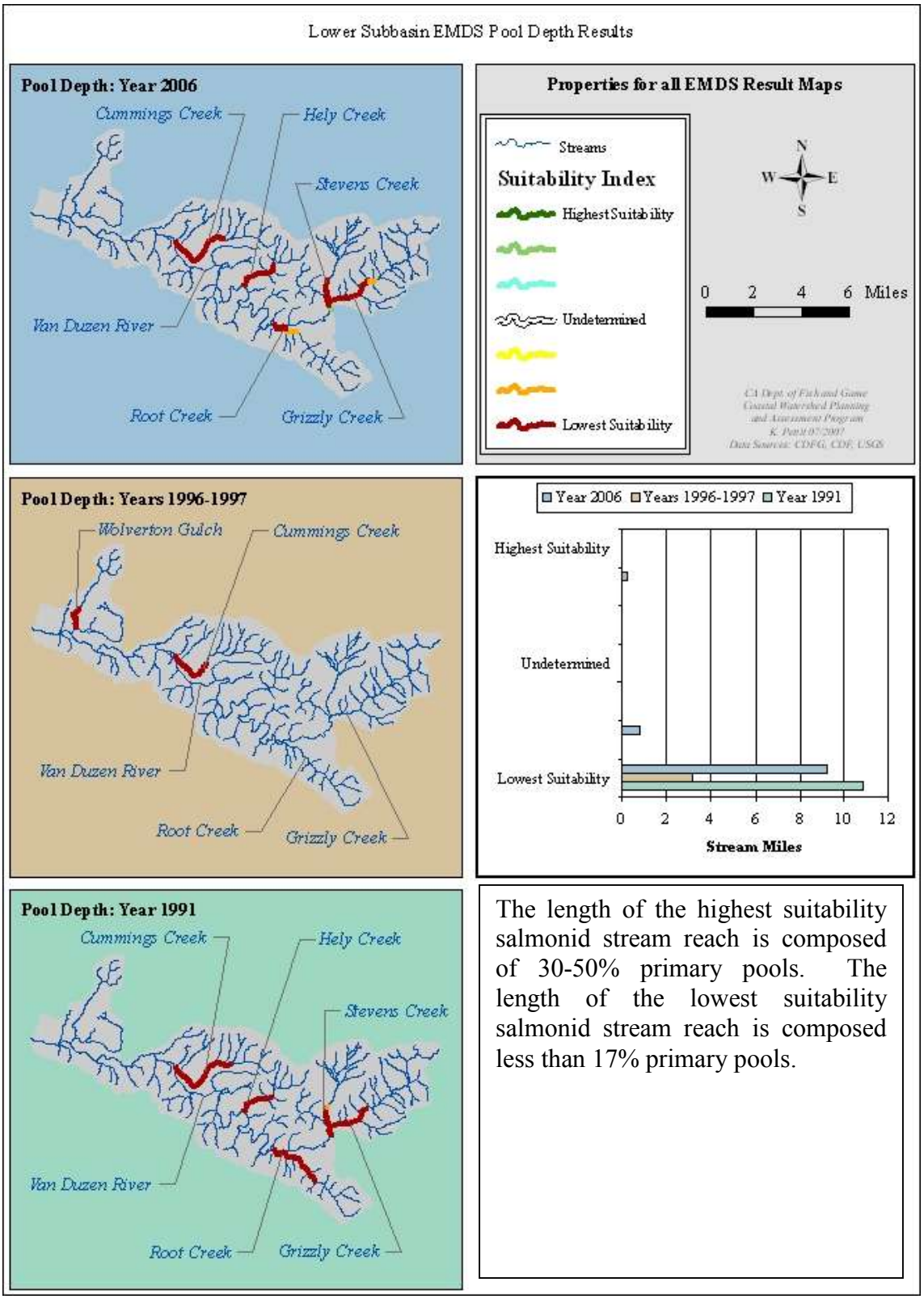


Figure 26. Pool depth suitability based on EMDS for the Lower Subbasin Van Duzen River.

Table 13. Average maximum pool depth in tributaries in the Lower Basin of the Van Duzen River.

Stream Reach	Survey Year	Ave. Max Pool Depth
Cummings Creek	1991	1.6
	1996	1.3
	2006	1.8
Grizzly	1991	2.1
	2006	2.5
Hely Creek	1991	1.4
	2006	1.8
Root Creek	1991	2.0
	2006	2.3
Stevens Creek	1991	1.8
	2006	1.9
Wilson Creek	1991	1.1
Wolverton Gulch	1997	1.6

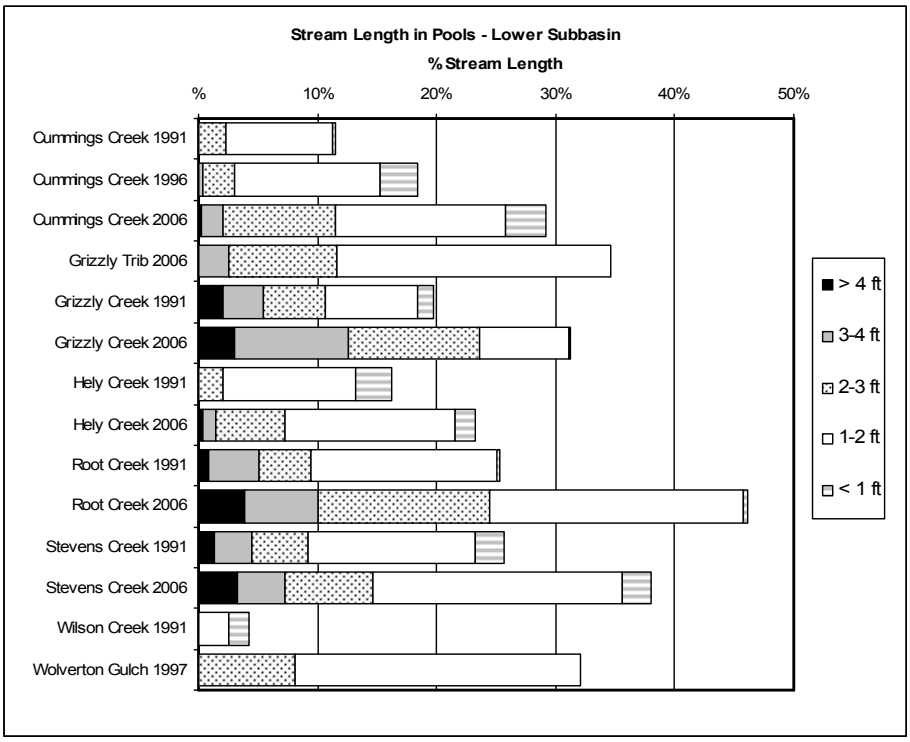


Figure 27. Pool depths for streams of the Lower Subbasin of the Van Duzen River.

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 below the 100 target value for all streams and stream reaches indicating a general shortage of instream shelter elements (Fig. 26 and Table 14). The highest shelter values were observed in Hely Creek. Although generally in short supply, woody debris makes the largest contribution to pool shelter in Lower Subbasin streams (Table 14). No discernible trends are indicated in each individual stream or the overall set of Lower Subbasin streams as the stream survey data shows some stream shelter ratings have decreased in subsequent surveys while others have increased in more recent surveys (Fig. 27).

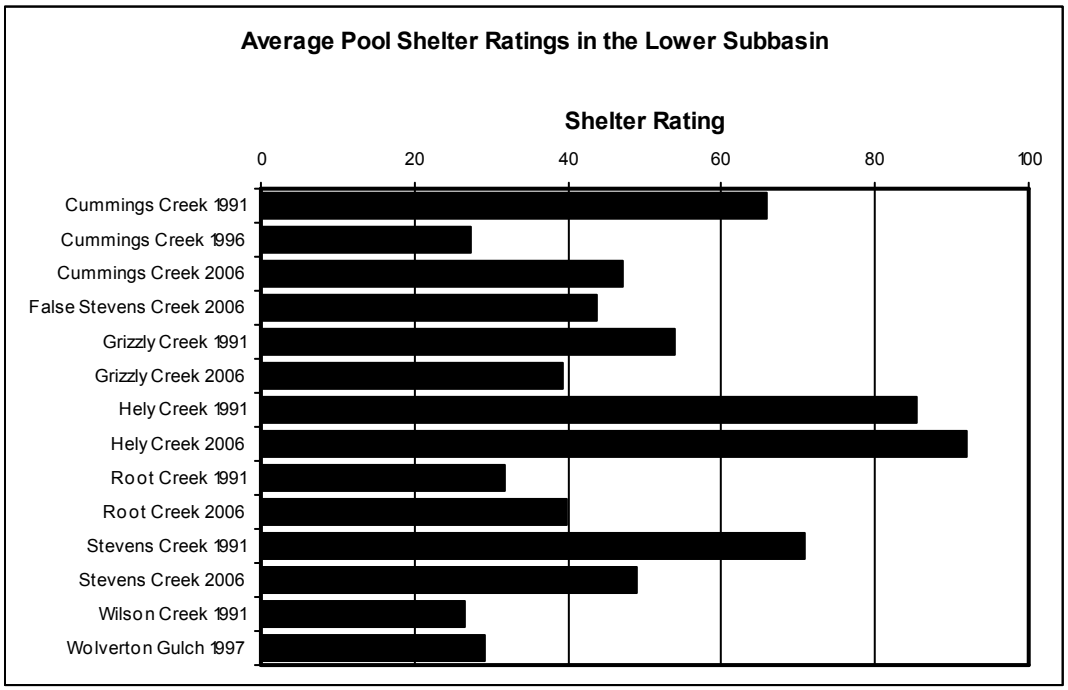


Figure 28. Average pool shelter ratings from CDFG sample reaches in Van Duzen River Lower Subbasin streams. Average pool shelter ratings exceeding 100 are considered fully suitable and average pool shelter ratings less than 30 are below desirable values for contributing shelter elements to salmonids.

Table 14. Pool shelter elements for Van Duzen River Lower Subbasin streams. The percent contribution for each shelter element is shown.

Stream / year	Undercut Banks	Woody Debris	Terrestrial Vegetation	Aquatic Vegetation	White-water	Boulders	Bedrock Ledges
Cummings/ 2006	13	67	2	1	1	11	
False Stevens/2006	11	17	1		10	63	
Grizzly/2006	2	33	6		8	45	2
Hely/2006	7	66	14		14	22	1
Root/2006	18	54	3		4	22	
Stevens/2006	5	61	2		5	24	2

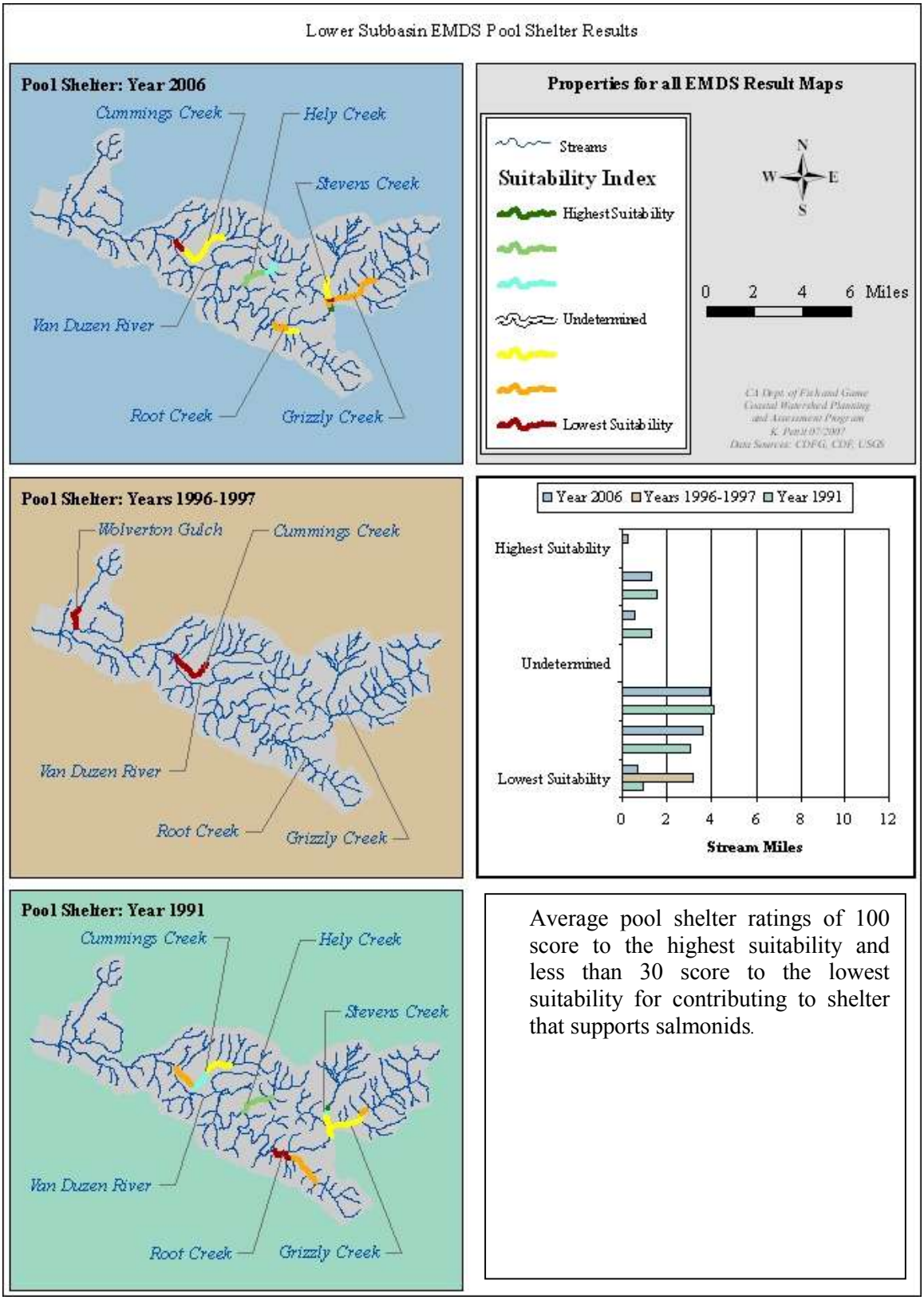


Figure 29. Pools shelter evaluations by EMDS for Lower Subbasin of the Van Duzen River tributaries.

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. Excessive levels of fine sediment accumulations within gravel and cobble substrate may also alter aquatic insect species composition and reduce connectivity of flow between surface and subsurface stream flows needed to moderate water temperature.

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 Lower 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 Lower Subbasin generally show relatively high levels of cobble embeddedness (Figs. 28 and 29). Stevens Creek, sampled in 2006, was the exception with just over 50% of the 43 pool tails measured showing less than 25% cobbled embeddedness. However that is a decline from the 65% category measured in the 1991 survey. EMDS evaluations showed that 2006 surveyed reaches in Hely and Root creeks were poorest of the Lower Subbasin streams for salmonid spawning habitat. The high levels of embeddedness are an indication of excessive delivery of fine sediments to most Lower Subbasin streams. Salmonid spawning success is likely limited or impaired by the lack of good quality spawning habitat in these streams.

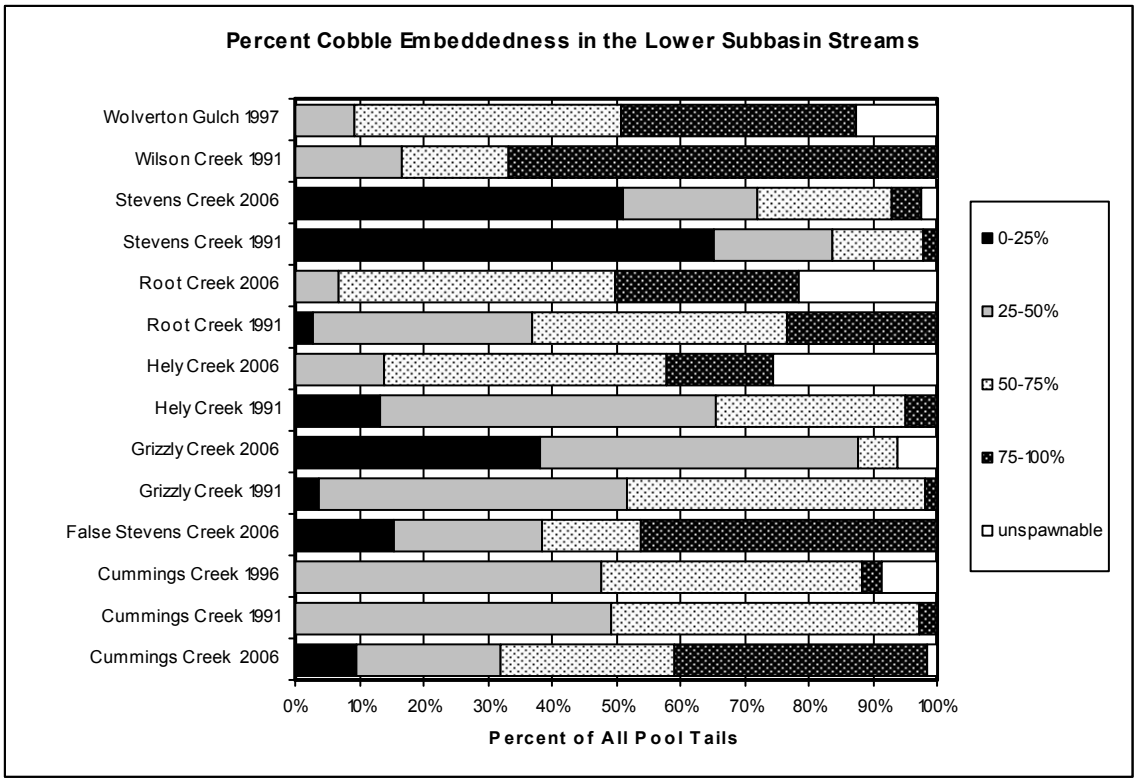


Figure 30. Percent cobble embeddedness in Lower Subbasin streams. Spawning cobble embeddedness is considered suitable if at least 50% of all pool tails are less than 25% embedded in fine sediments.

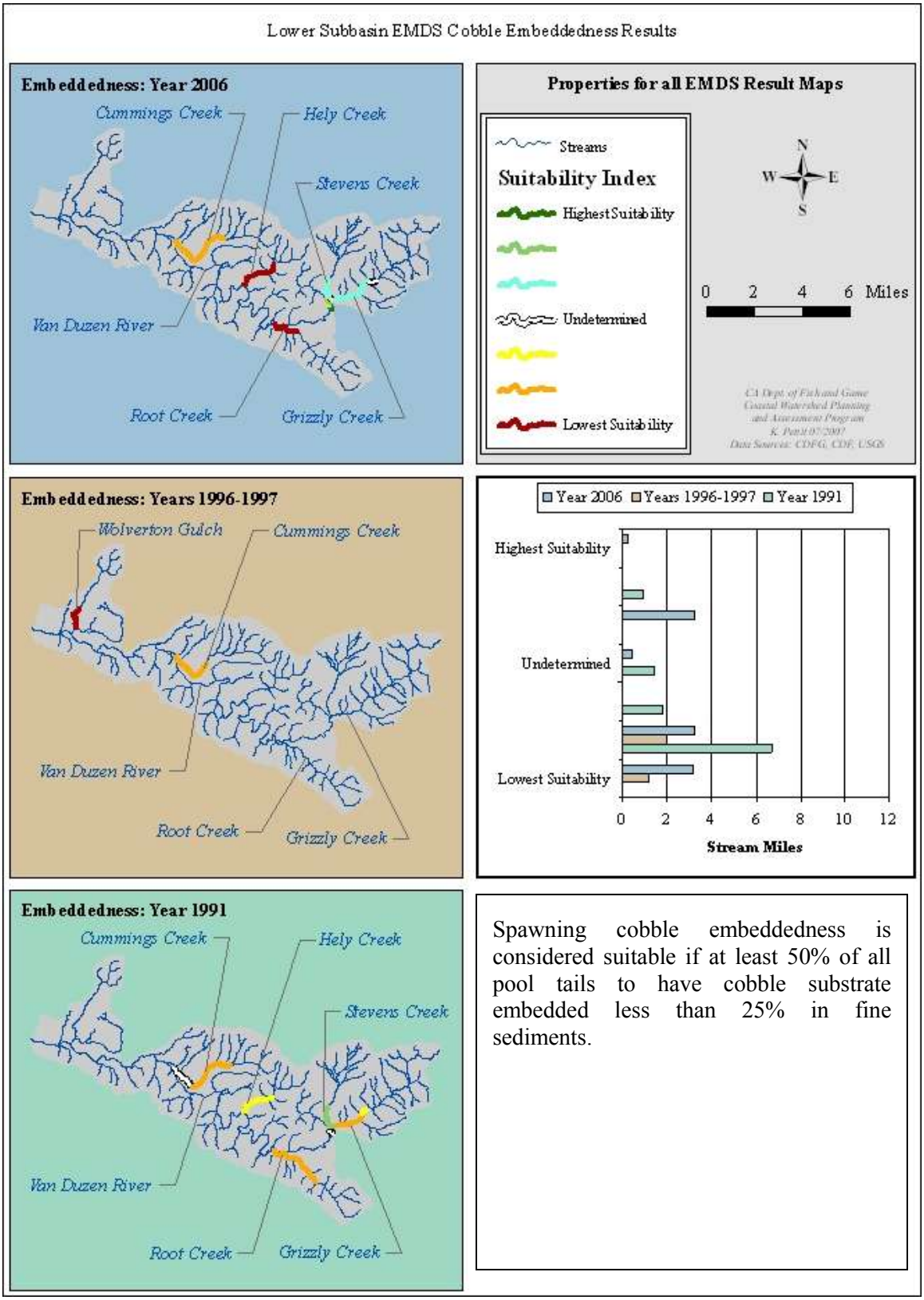


Figure 31. Spawning cobble embeddedness evaluations by EMDS for Lower Subbasin of the Van Duzen River tributaries.

Streamside 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: The majority of surveyed stream reaches in the Lower Subbasin had streamside canopy density values above 80%, indicating good direct shade cover over the water (Fig. 30). Although most 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. Multiple years of surveys show increasing coniferous canopy on Cummings, Stevens, Grizzly, Hely, and Root creeks. The desirable increase in coniferous canopy is due to re-growth of redwood or Douglas firs that were removed from riparian zones during past timber harvests or bank erosion. Wolverton Gulch had the lowest streamside shade contribution from coniferous trees. Redwood trees were recently planted by students of Hydesville School to help address the lack conifers on Wolverton Gulch.

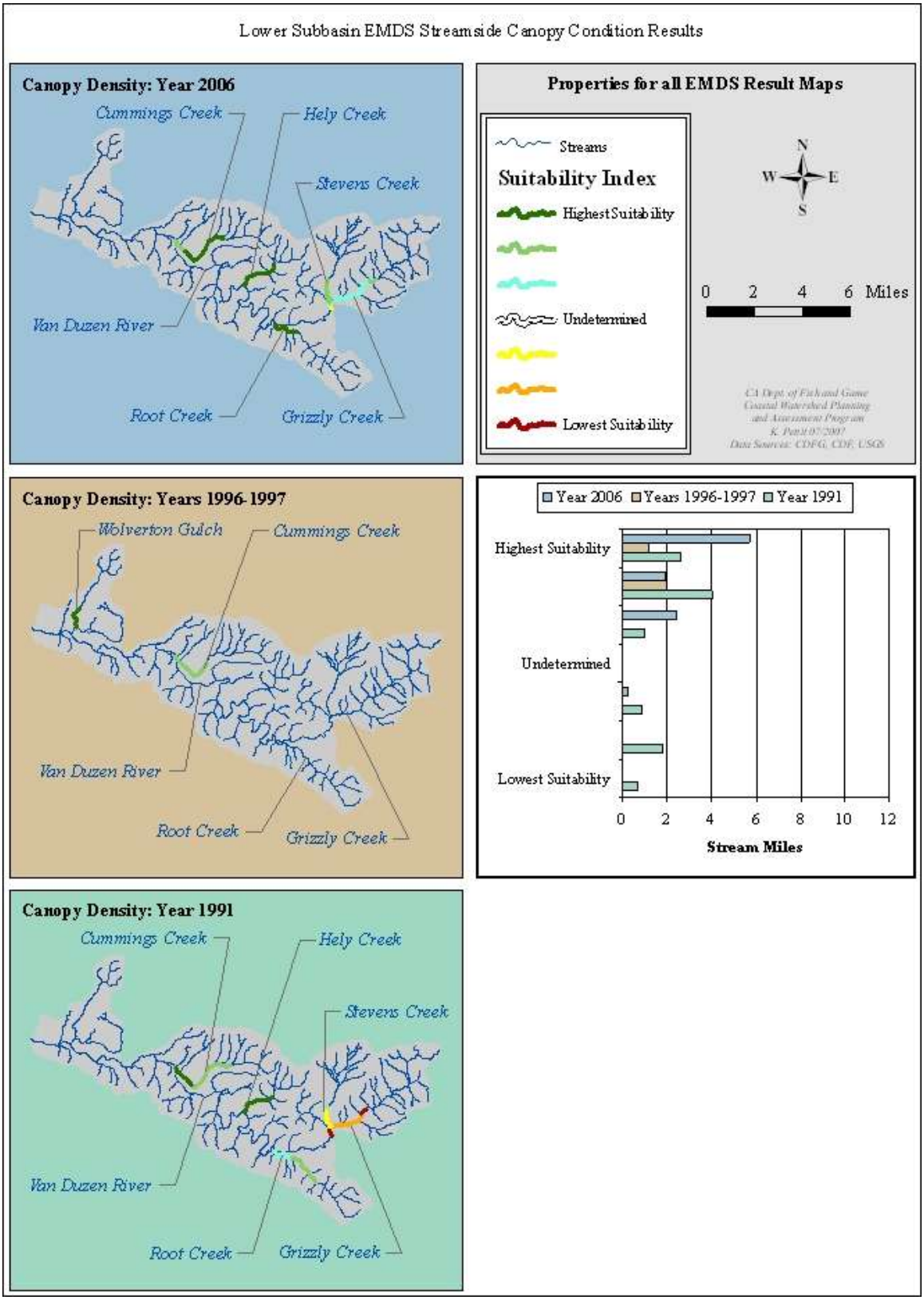


Figure 32. EMDS streamside canopy condition results for the Lower Subbasin of the Van Duzen River.

Habitat Conclusions

Within the Lower Subbasin, CDFG inventoried 6 tributaries between the years of 1991 and 2006 (Table 15). Considering relatively the same reaches were surveyed in Cummings, Hely, Root, Stevens and Grizzly creeks in 1991 as in 2006 two data sets can be compared to show general trends.

Where habitat data were available from both older stream surveys and recent stream inventories it appeared that habitat conditions generally remained the same or showed slight improvement in some habitat categories. However, in a few reaches habitat conditions actually decreased from the 1991 surveys to the 2006 surveys. The percentage of pool occurrence and pool length improved in almost every stream surveyed. Canopy density also improved in some stream reaches, most noticeably in Grizzly Creek. Spawning habitat (embeddedness) improved in some reaches (Grizzly Creek) but decreased in others (Hely and Root creeks). Similarly, pool shelter improved in some reaches but decreased in others within the same stream, such was the case in Root and Cummings creeks.

Canopy density was suitable on all surveyed stream, except for one reach on Grizzly Creek. Aside from Grizzly Creek, water temperatures were found to be suitable for salmonids in on all streams where data was collected. Water temperature is likely a limiting factor for coho in Grizzly Creek. It is important to note that current canopy density measurements do not take into account differences between smaller, younger riparian vegetation versus the larger microclimate controls that are provided by old and second growth forest canopy conditions.

Overall instream habitat conditions were generally poor to moderate in this subbasin at the time of more recent CDFG surveys (late 1990s and mid 2000s). Surveyed reaches fell below target values and were evaluated as unsuitable for salmonids by EMDS for the majority of habitat characteristics, except canopy density and percentage of pool occurrence.

These habitat factors are likely limiting factors to the salmonid populations in nearly all the surveyed streams within the subbasin. High sediment loads in these streams results in decreased pool size, shallow pool depths and highly embedded spawning areas. The lack of pool shelter in all surveyed streams except for Hely Creek could also be considered a limiting factor.

Table 15. Habitat factors that limit (L) or support (S) production of anadromous salmonids in streams of the Lower Subbasin.

Stream	Stream flow	Passage Barriers	Stream temp	Water quality	Spawning substrate	Pool depth	Pool area	Pool Shelter	LWD	Canopy
Wolverton Gulch	S	L	ND*	ND*	L	L	L	L	L	S
Cummings	S	L	S	L	L	L	L	L	S	S
Hely	S	S	S	S	L	L	L	S	L	S
Root	S	L	S	S	L	L	S	L	L	S
Stevens	S	S	ND*	L	S	L	S	L	S	S
Grizzly	S	S	L	L	S	L	L	L	L	S

*ND is no data available

Restoration Projects

Road and instream habitat improvements are the most common watershed restoration projects implemented in the Lower Subbasin (Fig. 31). Goals of road projects are to reduce road related erosion and reduce sediment delivery to streams. Instream projects typically add wood and boulders to channels to build pools or recruit spawning substrate (Fig. 30). Grizzly Creek has received the most CDFG funded instream, road improvement, and stream crossing removal/upgrade work within the subbasin as nearly its entire stream length has benefited from some type of restoration improvement projects. A large amount of restoration work involving instream, riparian, stream crossing removal, and road improvement projects have also been completed in the Cummings Creek watershed.

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. 48-49).

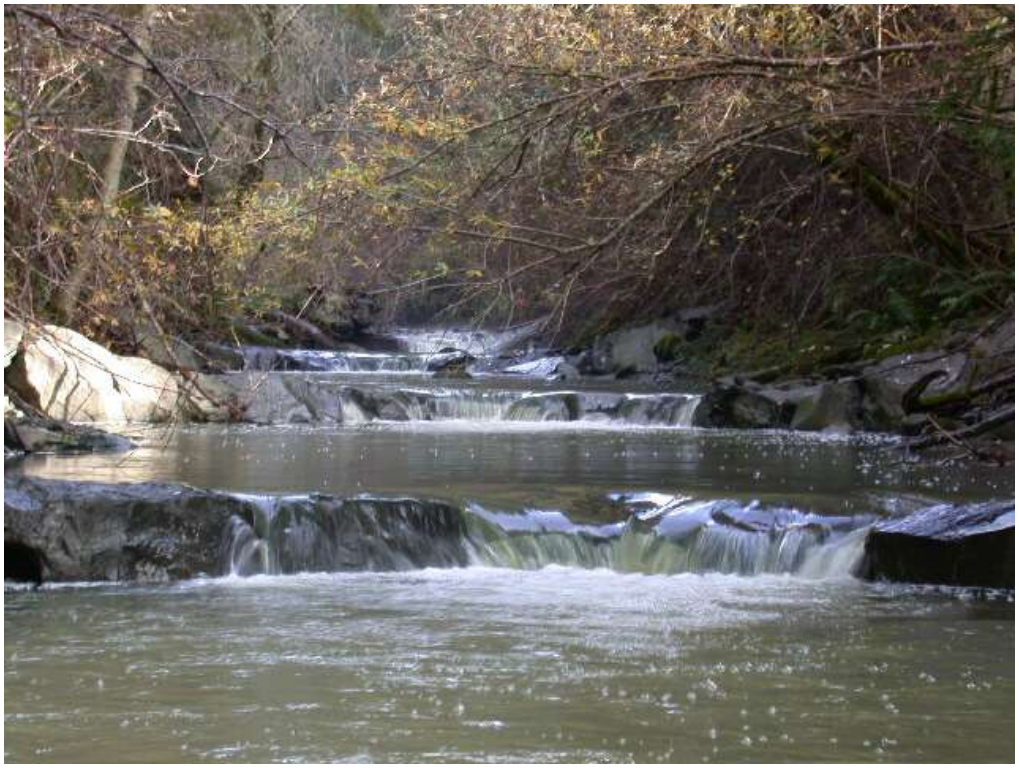


Figure 30. Step pool instream improvement project on Grizzly Creek.

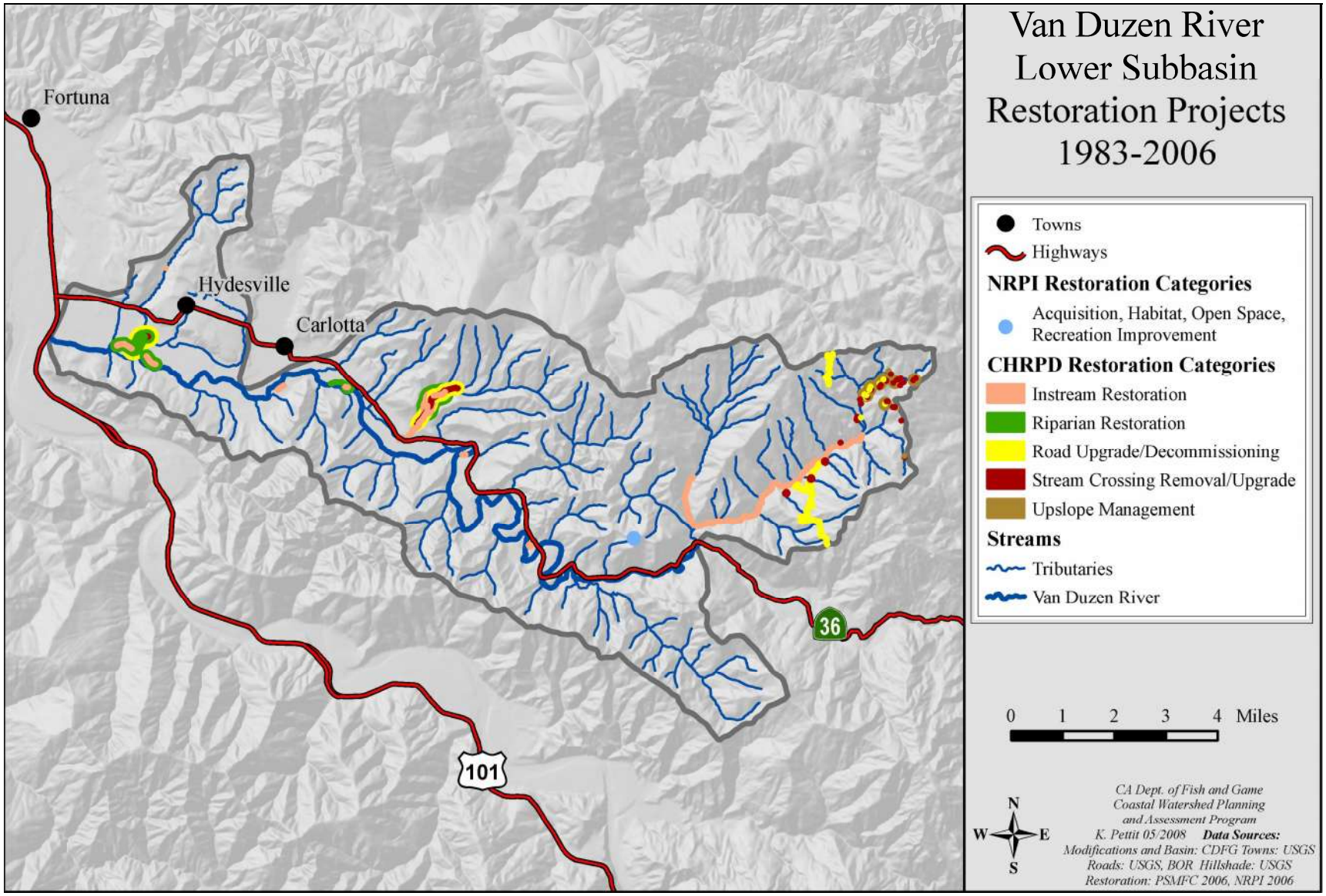


Figure 31. Lower Subbasin restoration projects delineated by the California Habitat Restoration Project Database (CHRPD) and the Natural Resources Project Inventory (NRPI) from 1983 to 2006.

Refugia Areas

The interdisciplinary team identified and characterized refugia habitat in the Lower Subbasin by using professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by the EMDS at the stream reach scale.

The most complete data available in the Lower Subbasin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered. Salmonid habitat conditions in the Lower Subbasin on surveyed streams are almost split between a low quality refugia rating and a medium potential refugia rating with there being a few more streams rated as medium potential (Table 16). While the Van Duzen River (mainstem) has medium potential, current conditions reflect a low quality rating. Hely Creek was the only creek to receive a high quality and high potential refugia ranking. Considering the amount of restoration projects that have occurred in the Grizzly Creek watershed, it could be upgraded to a high potential refugia rating in the near future. About 40% of the streams were considered data limited.

Table 16. Refugia category ratings of streams of Lower Subbasin.

Stream	Refugia Categories				
	High Quality	**High Potential**	**Medium Potential**	**Low Quality**	**Data Limited**
Van Duzen River (mainstem)			x	x	
Van Duzen Tributaries					
Barber Creek				x	x
Wolverton Gulch			x		
Wilson Creek			x		
Cuddeback Creek				x	x
Fiedler Creek			x		x
Cummings Creek			x		
Fox Creek				x	x
Flanigan Creek				x	x
Hely Creek	x	x			
Root Creek			x		
Grizzly Creek			x		
Stevens Creek			x		

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 Lower Van Duzen Subbasin?

- A review of recent CDFG spawner survey results (Appendix B) reveals the present number of Chinook and coho salmon returning to spawn in the Lower Subbasin have declined significantly compared to the substantially larger runs reported prior to 1965 (CDFG 1965);
- Coho salmon 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 and have persisted in streams where other species have declined or are now rarely observed.

What are the current salmonid habitat conditions in the Lower 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 causing impairment of habitat for fish, amphibians, and other wildlife;
- Hely Creek has a small but continuous stream flow year round with water temperature cool enough to support coho salmon. While the lower reaches of Cummings and Root Creek dry up during the summer season the mid to upper reaches provide continuous stream flow with suitable water temperatures for year round juvenile salmonid rearing habitat.

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

- All of the bedock types in the Lower Subbasin are considered highly prone to landsliding and surface erosion;
- Streams have down cut into the erosive bedrock of the Lower Subbasin during extensive tectonic uplift leaving very steep bank-slopes and terraces which are susceptible to small-scale, frequent slope failure;
- Frequent landslides especially during heavy storm events and/or seismic events contribute a significant amount of sediments to the stream;
- The sediment supply to streams may be easily increased to excessive levels by land management activities;

- 85 miles of intermittent tributary channels drain the Lower Subbasin are sediment source reaches. Most of these stream miles receive minimal protection (class 3) from timber harvests or other land use and may generate excessive amounts of sediments to downstream fish bearing reaches;
- Low gradient reaches of the mainstem as well as the lower reaches of several tributaries are storing sediments;
- Excessive sediment accumulations at the mouths Hely and Root creeks impair fish passage during spawning migrations;
- Recent studies show Wolverton Gulch,, Grizzly Creek, Cummings Creek and other creeks of the Lower Subbasin have extended periods of high turbidity after rain events indicating persistent, high levels of fine sediment inputs to stream channels;
- The original forest stands were integral to stream ecosystem and salmonid production;
- The present forest condition does not provide the same beneficial levels of shade, microclimate, soil stability and supply of organic materials to streams as the old growth forests of the past;
- The lowermost two miles of Van Duzen River is a very wide and shallow reach with a simplified channel lacking in bed form diversity. The lowermost reach requires annual channel maintenance to facilitate fish passage during spawning migrations from the Eel River into the Van Duzen River;
- Since the Lower Subbasin receives runoff from the entire Van Duzen River Basin, it is susceptible to cumulative watershed effects that influence water temperature rates of sediment deposition, and channel morphology;
- Large flow events play a major role in aggradation, degradation, as well as other changes in channel morphology.

How has land use affected these natural processes?

- The present condition of the Lower Subbasin is in part the result of land use activities within the Lower 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.

Based upon these conditions, trends and relationships, are there factors considered to limit salmon and steelhead production?

- Decreased summer/early fall stream flows, potentially higher summer/early fall water temperatures and degraded water quality in the Van Duzen River;
- Spawning substrate embedded in fine sediments likely impairs reproductive success in Grizzly, Stevens, Root, Hely, Cummings and portions of the mainstem;
- Perched sediment deltas may impede spawning fish passage to tributaries in Healy, Cummings, Root creeks and other tributaries;
- A lack of deep, complex, pools needed for critical habitats limits salmonid production in all Lower Subbasin tributaries;
- High levels and prolonged duration of turbid water impairs juvenile salmonid feeding and growth;
- Inputs of LWD and SWD are needed for fish shelter elements, spawning substrate recruitment, and scouring pools on all Lower Subbasin tributraries.

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

Barriers to Fish Passage

- Annual channel maintenance is required to facilitate fish passage into the lower Van Duzen River from Eel River;
- Inspect fish passage into Wolverton Gulch and at culverts located on HWY 36 and Rohnerville Road;
- Fish access into Cummings and Fiedler creeks should be improved by channel reconfiguration in their lowermost reaches;
- Review options for improving salmonid spawner access through sediment deltas into Root and Hely creeks.

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.

Erosion and Sediment Delivery Reduction Activities:

- Consider stabilization of hillslope failure at Hely Creek 1440 feet above HWY 36; 1100 feet up Redwood House Road. Insure stormwater runoff from Redwood House Road is diverted away from this site;
- 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 Grizzly Creek and Cummings Creek.

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 Cummings, Hely, and Grizzly creeks;
- Consider adding elements to recruit and retain spawning gravels in Grizzly;
- Seek opportunities to increase conifer overstory shade canopy over Grizzly Creek by plantings and/or thinning hardwoods around small conifers.

Monitoring, Education and Research Activities:

- Collect genetic samples from any coho salmon found in the Subbasin;
- Consider methods to re-introduce coho stocks into appropriate streams of the Lower Subbasin such as Healy, Cummings, Fielder, Root, Grizzly and Stevens creeks;
- Perform fish surveys on Fox Creek to identify presence and distribution of coastal cutthroat and resident rainbow trout;
- Perform fish surveys on Flanigan Creek to identify 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.