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Upper Subbasin

The Upper Subbasin drains approximately 143 square miles of mountainous terrain located above the confluence of the mainstem Van Duzen River with the Little Van Duzen River (also known as South Fork Van Duzen River (Figure 1). Approximately half the land is located in each of Humboldt (73 sq. mi.) and Trinity (70 sq. mi.) counties. The upper half of the subbasin is within Trinity County where the majority of land is in Six Rivers National Forest (Table 1). The lower half is mostly in private ownership. Coniferous forest is the dominate type of vegetation. Timber production is the major land use, but in recent years the proliferation of large-scale industrial marijuana grow operations has occurred throughout the upper watershed. Several small rural developments and several large private land ownerships are located near the towns of Dinsmore and Mad River.

This California Department of Fish and Wildlife (CDFW) assessment is focused on anadromous salmonid habitat which is thought to be limited on the mainstem Van Duzen River by Eaton Falls. Eaton Falls, (RM 46) located about two miles downstream of Dinsmore is considered a natural barrier to upstream salmonid migrations, although there have been anecdotal reports of large salmonids (possibly steelhead) above the falls. The Van Duzen mainstem and its tributaries above Eaton Falls is populated by resident trout populations. Winter and summer run steelhead migrate to tributaries and upper reaches of the Little Van Duzen River. Passage of Chinook and coho to the Upper Subbasin is typically blocked at Salmon Falls in the Middle Subbasin, but reports of coho salmon have been made in the Little Van Duzen River and its tributary, Butte Creek (Reynolds et al. 1981 and Decker and Fuller 1983).

The Upper Subbasin is made up of 11 CalWater 2.2.1 Planning Watersheds (Figure 2) which are utilized to delineate tributary drainages.

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

Square Miles	143
Total Acreage	91,520
Private Acres	43,423
Federal Acres	48,084
State Acres	13
Predominant Land Use	Timber Harvests
Predominant Vegetation Type	Mixed coniferous forest
Stream Miles	296
Miles of Anadromous Stream	28
Road Miles/Subbasin Miles	3.5
Low Elevation (feet)	1,540
High Elevation (feet)	5,900

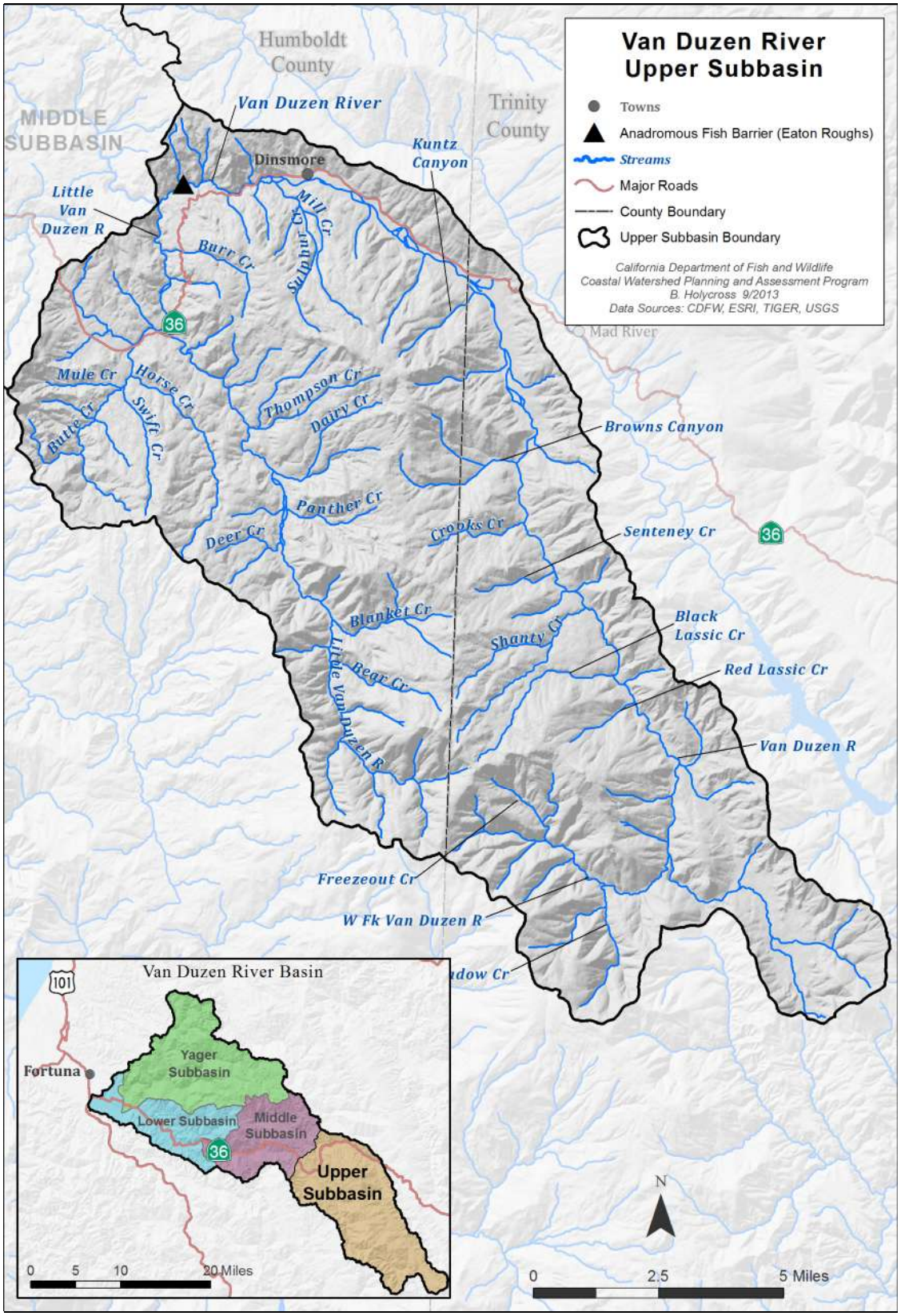

Figure 1. Location and tributaries of the Upper Subbasin of the Van Duzen River

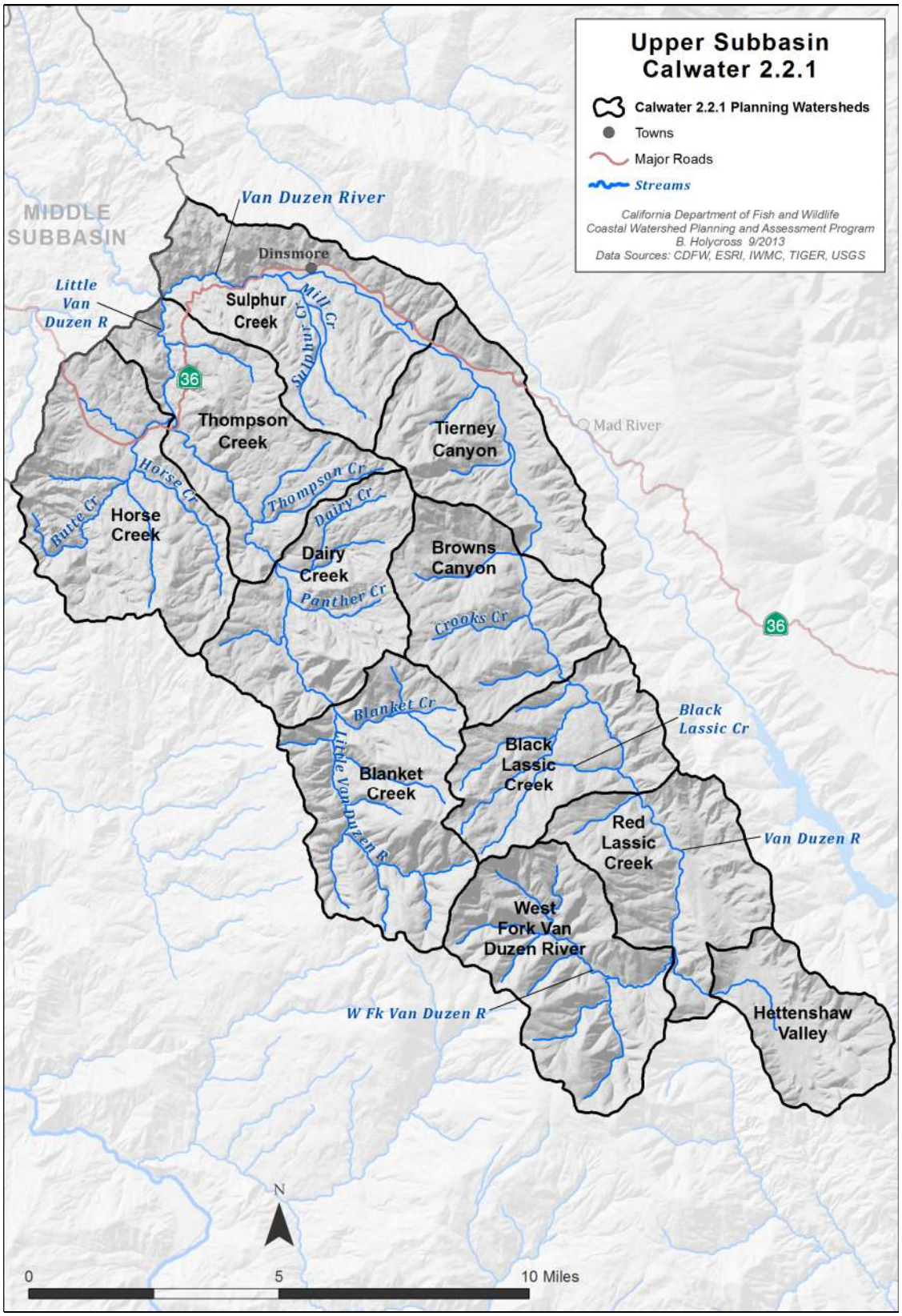

Figure 2. Eleven Cal 2.2 watersheds compose the Upper Subbasin of the Van Duzen River

Geology

Bedrock

The Yolla Bolly terrane dominates this subbasin at about 41% of the surface geology (Figure 3). The Yolla Bolly terrane is predominantly metagraywacke, meta-argillite, conglomerate, and mélange made up of a sheared matrix of the aforementioned rock types. This terrane contains mappable blocks of greenstone, metachert, metagraywacke, and phyllite (a metamorphic rock type between slate and schist in metamorphic grade).

The Yolla Bolly terrane most probably formed 100 million through 175 million years ago as sediments washed off of the continent and blanketed the subduction trench. The segments of Yolla Bolly terrane are considered to be part of the Eastern Belt that has been translated to their current position by movement along the Mule Ridge and Grogan-Red Mountain fault zones (McLaughlin, 2000).

Central Belt Mélange of the Franciscan Complex makes up approximately 35% of this subbasin. Melange can be described as a mixture of claystone, siltstone, and sandstone that has been metamorphosed churned and mixed in a subduction zone to such a degree that its supporting matrix has been completely disrupted by shearing.

This mixture or "melange" was then scraped off and smashed onto the western edge of the North American continent after about 88 million years ago (McLaughlin 2000). Of all of the lithologies in the Van Duzen River Basin the melange of the Central Belt is the most susceptible to earthflows and deep-seated landslides. There are very large, active earthflows (moving several meters per season) as well as dormant earthflows with in the melange of this subbasin. Dormant earthflows may reactivate during especially wet seasons, during seismic events, or if their toe is worn away by streams.

Central Belt sandstone of the Franciscan Complex makes up roughly 6% of the bedrock of this subbasin. The Central Belt sandstone units are large blocks of slightly metamorphosed sandstone, greywacke ("dirty" sandstone), and argillite (McLaughlin 2000). Although they have been metamorphosed, folded, and sheared to some extent they are more coherent than the mélange and tend to form steeper valleys and sharper ridges.

Quaternary landslides occupy around 7% of the subbasin (mapped as of 2000 – McLaughlin et al). Since the mapped landslides have already, at some point, slid, they have less potential for continued sliding; however, they are sensitive to land use because the coherency of the slide material has been disrupted. The toes of these landslides are typically eroded by stream channels causing subsequent, prevalent small-scale sliding and bleeding of fine sediments into the river system. Furthermore, if the toes of these large landslides erode far enough, if they become saturated by heavy seasonal rain, or if there is a large, local seismic event these landslides may reactivate.

Several large, active earthflows have been mapped and studied by Kelsey (1977) along the Van Duzen River mainstem (Figure 4) within the upper basin which contribute large amounts of sediment. These earthflows typically form in mélange due to its very low shear strength. Even though large scale GIS mapping shows only 7 percent of this subbasin as landslides it is estimated based upon topographic diversity that on the order of 70 percent shows evidence of past movement (Ellen et al. 2007).

Alluvium which are the active channel sediments being transported downstream over time, include bed, bank, and floodplain deposits and to some extent low-lying river terrace deposits occupy about 4% of this subbasin.

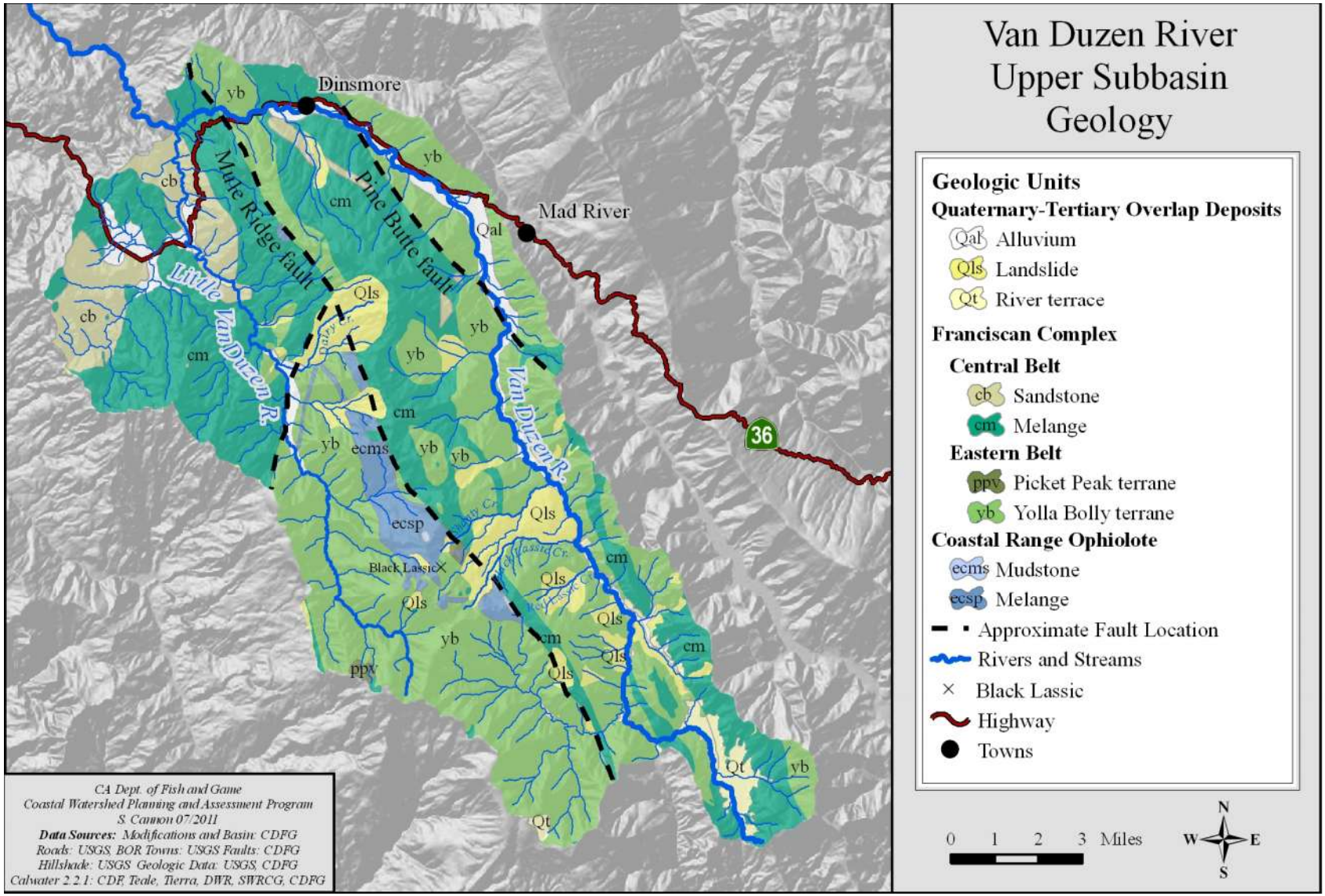

Figure 3. Geology of the Upper Subbasin

River terrace deposits occupy 2 percent of this subbasin. River terrace deposits consist of unconsolidated through poorly consolidated cobbles, gravels and fine sediments. These terraces were once river channel and flood-plane alluvial deposits but have been raised above the hundred-year-flood level during the last 2 million years by regional tectonic uplift. River terrace deposits tend to form steep channel banks that are prone to dry ravel and slumping. Prominent river terrace deposits in this subbasin include: Hettenshaw Valley, Larabee Valley, and Dinsmore.

The Great valley/Coastal Range melange unit makes up about 3% of this subbasin. The Great Valley/Coastal Range melange consists of a disassociated, ophilolitic serpentinite mélange containing blocks of basalt, diabase, gabbro, and ophiolitic breccia (McLaughlin, 2000).

An Ophiolite may be thought of as a sequence of rock types that comprises a cross section through the oceanic crust. Sediments deposited on the ocean floor, pillow basalts, sheeted dykes, gabbro, and peridotite usually represent this sequence. The Great Valley/Coastal Range Ophiolite has been disassociated by tectonic accretion and faulting and translation to its current location leaving the crustal sequence scattered and non-distinct.

The Great valley/Coastal Range mudstone unit comprises around 1% of this subbasin and consists of thinly bedded, fractured mudstone with minor amounts of sandstone and siltstone. These sediments were deposited atop of the Great Valley/Coastal Range Ophiolite from 100 million to 145 million years ago.

The Pickett Peak terrane associated with the Eastern belt of the Franciscan Complex accounts for less than 1% of this subbasin. The Pickett Peak terrane is made up of metamorphosed sedimentary and volcanic rock types including; schist, metabasalt, metagraywacke, mudstone, conglomerate, and metachert that are approximately 100 million to 145 million years old (McLaughlin, 2000).

Figure 4. Halloween Earthflow complex on the right-bank of the Van Duzen River near the confluence of the Little Van Duzen River.

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

GEOLOGIC RELATION AND DESCRIPTION OF MAJOR UNITS WITHIN THE MIDDLE SUBBASIN						
Unit	**Belt/Rock type**	**Formation /terrane**	**Composition**	**Erosion**	**Age ma**	**%**
Overlap Deposits	Alluvium		Unconsolidated river deposits of boulders, gravel, sand, silt, and clay.	Raveling of steep slopes. Transportation of sediments by fluvial and aeolian processes.	0-0.01	4
	River terrace		Unconsolidated river deposits of boulders, gravel, sand, silt, and clay that have been uplifted above the active stream channel.		0.01-2	2
	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	7
Franciscan Complex	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	6
		Mélange	Penetratively sheared matrix of argillite with blocks of sandstone, greywacke, argillite, limestone, chert, basalt, blueschist, greenstone, & metachert.	Susceptible to mass movement by large earthflows and subsequent debris flows triggered by saturation.	1.8-65.5	35
	Eastern belt	Pickett Peak terrane	Schistose metasedimentary and metavolcanic rocks.	Generally stable but prone to debris sliding along steep stream banks and in steep headwater drainages.	1.8-65.5	<1
		Yolla Bolly terrane	Predominantly Semi-schistose metagraywacke, meta-argillite, conglomerate, and mélange made up of a sheared matrix of the aforementioned rock types with minor metachert and metavolcanic rocks.	Susceptible to mass movement by large earthflows and subsequent debris flows triggered by saturation.	99.6-199.6	41
Great Valley Sequence	Coastal Range Ophiolite	Mudstone	Thin-bedded mudstone, arkosic siltstone and sandstone.	Prone to debris sliding along steep stream banks and in steep headwater drainages.	65.5-251	1
		Mélange	Sheared matrix of serpentinized dunite containing blocks of basalt, diabase, gabbro, and ophiolitic breccia.	Susceptible to mass movement by large earthflows and subsequent debris flows triggered by saturation.	65.5-251	3
Sources: Kilbourne, 1985, Ogle, 1953, McLauglin, 2000. % Data represent an approximation based on GIS mapping.						

Faults and Shear Zones

The Mule Ridge fault and Pine Butte fault (Table 3) as well as several smaller faults and shear zones cut across this subbasin disrupting the coherency of the bed rock and increasing the local erosion potential. Uplift of this subbasin associated with northward migration of the Mendocino Triple Junction has increased the potential energy of the streams allowing them to incise and erode the landscape at high rates. Uplift in the area of Hettenshaw Valley has allowed the West Fork of the Van Duzen to capture the headwaters of the East Fork of the North Fork of the Eel River in the recent geologic past.

Table 3. Faults located in the Upper Subbasin of the Van Duzen River watershed.

Fault Name	Displacement	Description
Mule Ridge fault	Vertical/Dextral	The Mule Ridge fault is another steeply dipping to nearly vertical fault that runs northwest. It is believed to be similar to the Grogan-Red Mountain fault zone.
Pine Butte fault (Grogan-Red Mountain fault zone)	Vertical/Dextral	The Pine Ridge fault is considered part of the Grogan-Red Mountain fault zone which is a steeply dipping fault zone that runs northwest within the Upper subbasin. This fault zone separates the Central belt from the Eastern Belt of the Franciscan Complex. It probably marks the zone of active subduction before the Coastal Belt Thrust.
Sources: U.S.G.S. 2011, McLauglin 2000		

Landslides

Seven percent of this subbasin has been mapped with large Quaternary landslide features. These landslides reflect only what has been mapped on a large scale without detailed field investigation. Many smaller and/or less obvious landslides most likely exist that have not been mapped or have been mapped as part of landslide inventories at a much more detailed scale.

Earthflows some of which are very large (≈ 1 mile^2) are prevalent in the Central Belt mélange as well as mélange units of the Yolla Bolly terrane and contribute significant amounts of fine sediment to the river system. Dormant earthflows may become reactivated during large storm/stream flow events and/or seismic events.

Debris avalanches especially in the headwaters region are significant in terms of erosion and delivering sediment to the streams (Kelsey 1982).

Three of the largest mapped landslides in this subbasin occur in the vicinity of Black Lassic, Red Lassic, and Buck Mountain. On the east flank of Black Lassic the landslide encompasses the area of Black Lassic Creek (Figure 5) and Shanty Creek and is in geology of the Yolla Bolly terrane and Central belt mélange. Red Lassic Creek drains the debris avalanche complex on the eastern flank of Red Lassic which is made up of geology of the Yolla Bolly terrane. On the western flank of Buck Mountain, Dairy Creek (tributary to the Little Van Duzen) drains the large mapped landslide within the geology of the Yolla Bolly terrane.

Slope Inclination

Steep slopes (> 30%) cover 54% of the subbasin's terrain and are distributed throughout the subbasin (Table 3, Fig. 7). Moderate slopes (15-30%) covering almost third of the subbasin are also spread throughout of the subbasin.

Table 4. Slope classes and acres associated with the slope classes in the Upper Subbasin.

Slope class	Acres
0-15% Gentle	13817 (15%)
>15 -30% Moderate	27756 (30%)
>30 -65% Steep	34515 (48%)
>65% Very Steep	5703 (6%)

Figure 5. Pseudo-aerial view looking west of the Black Lassic landslide into the Van Duzen River.

Figure 6. View of older landslide (on right side of photo) in the Upper Van Duzen River near Eaton Falls (RM 46).

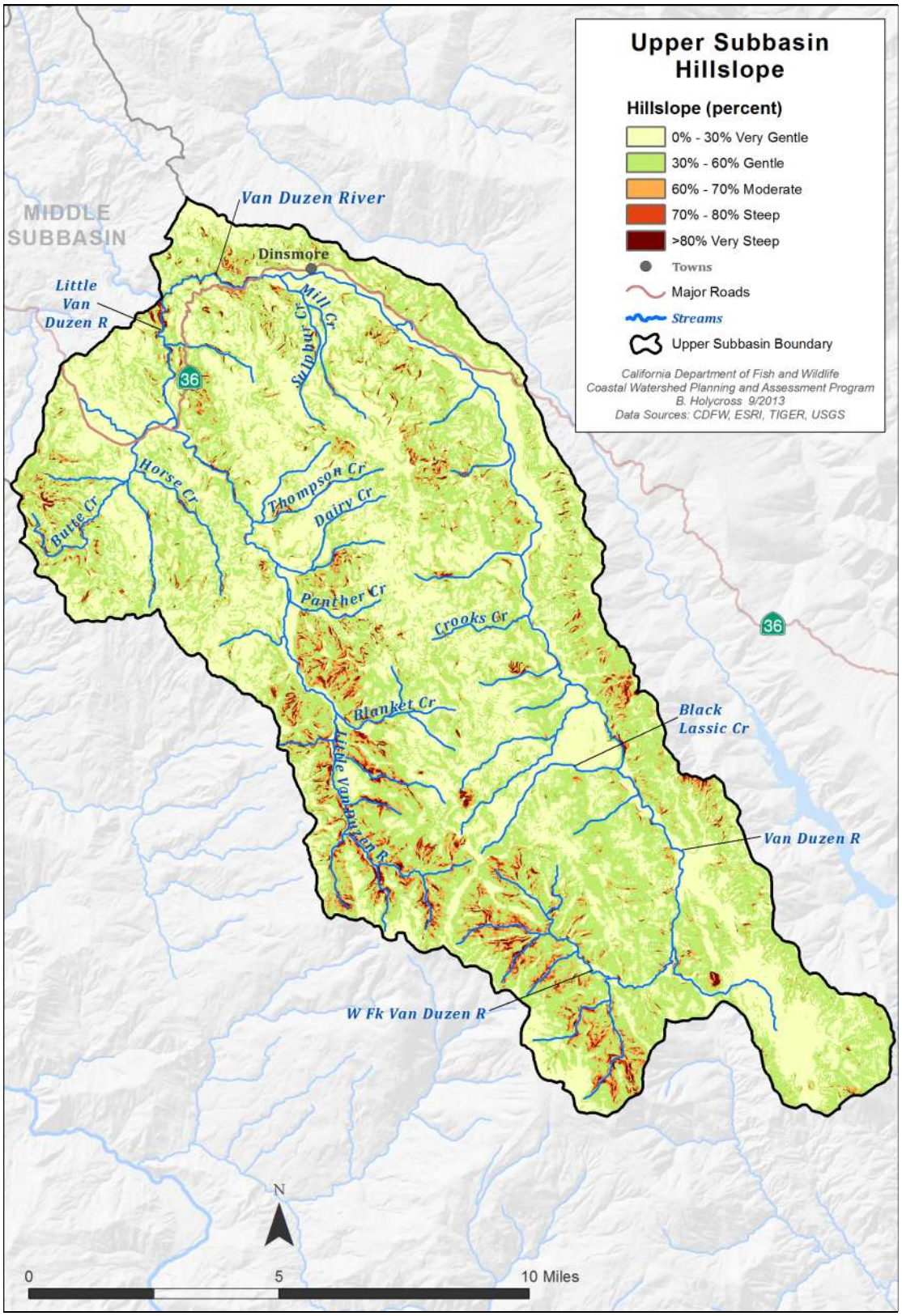

Figure 7. Upper Subbasin hillslope classes.

Hydrology, Fluvial Processes and Sediment Transport

The mainstem Van Duzen River (Figure 8) flows approximately 30 miles from its headwaters in the Six Rivers National Forest down through the Upper Subbasin. There are approximately 121 miles of perennial tributary channels and 149 miles of intermittent channels that flow into the mainstem (Figure 9). The majority of the perennial tributaries (83 miles) are classified as first order streams according to the modified Strahler Stream Order (Strahler 1957). The largest tributary in the subbasin is Little Van Duzen River (also known as South Fork Van Duzen River), which is a 4rth order stream (in its lower reach) that flows 18 miles before joining the mainstem at RM 45.5.

Many of the intermittent stream channels are steep and are considered as sources areas for sediment (Montgomery and Buffington, 1997) delivered to the Van Duzen River (Figure 10). While the Van Duzen River and the Little Van Duzen River are low gradient streams until their headwaters. The average mainstem channel gradient is approximately 1.5 %. The average Little Van Duzen channel gradient is approximately 4.5%.

Figure 8. Upper Van Duzen River at Eaton Falls (RM 46).

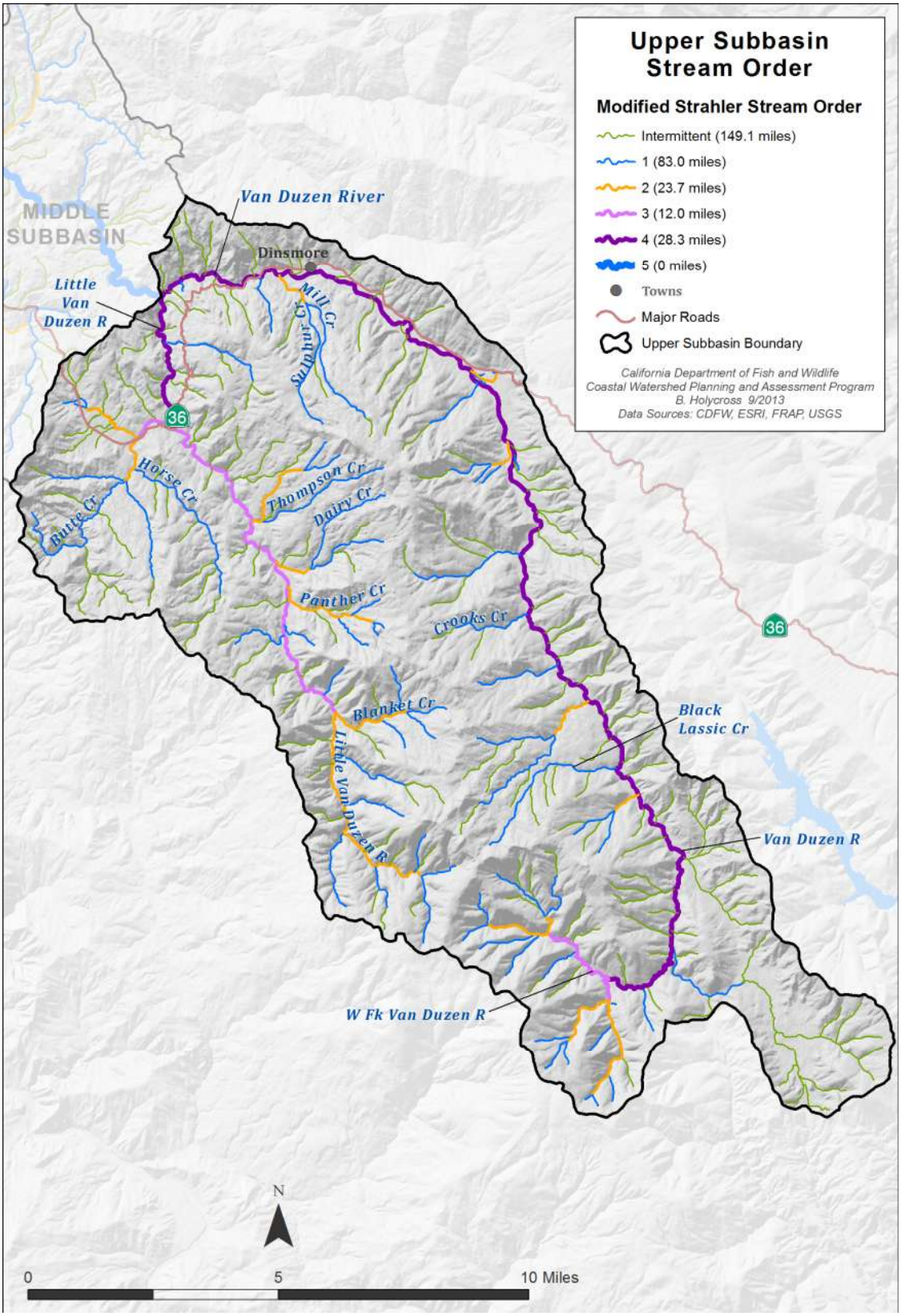

Figure 9. Stream order and intermittent tributaries of the Upper Subbasin

Figure 10. Stream gradient classification for sediment response, transport, and source for Middle Subbasin of the Van Duzen River.

Vegetation

Douglas fir dominated forests and mixed conifer and hardwood forests are the most common vegetation types in the Upper Subbasin composing 39.7% and 32.2%, respectively, of the landscape (Figure 11). The subbasin's complex geology and diverse soils support a rich herbaceous flora (Reynolds et al. 1981), including patchy stands of white fur (7.3%) and pine forests (2%) that do not grow elsewhere in the basin.

Most tributary stream reaches that support salmonids flow through coniferous forests. The important roles forests play in watershed processes, stream ecosystems and a stream's ability to support viable populations of anadromous salmonids have are documented (Meehan 1991, Murphy 1995, Spence et al. 1996, Lassettre 1999) and discussed in the Basin Profile section of the assessment report. Most of the coniferous forests of the Middle Subbasin have been recently logged and now early seral stage forests stands predominate. The adverse changes to salmonid habitat related to extensive logging of forests (Murphy 1995) and land use that disturbs riparian and near stream forests (Meehan 1991 and Spence et al. 1996) also are well documented and discussed in the Basin Profile.

Figure 11. View of the upper Van Duzen watershed.

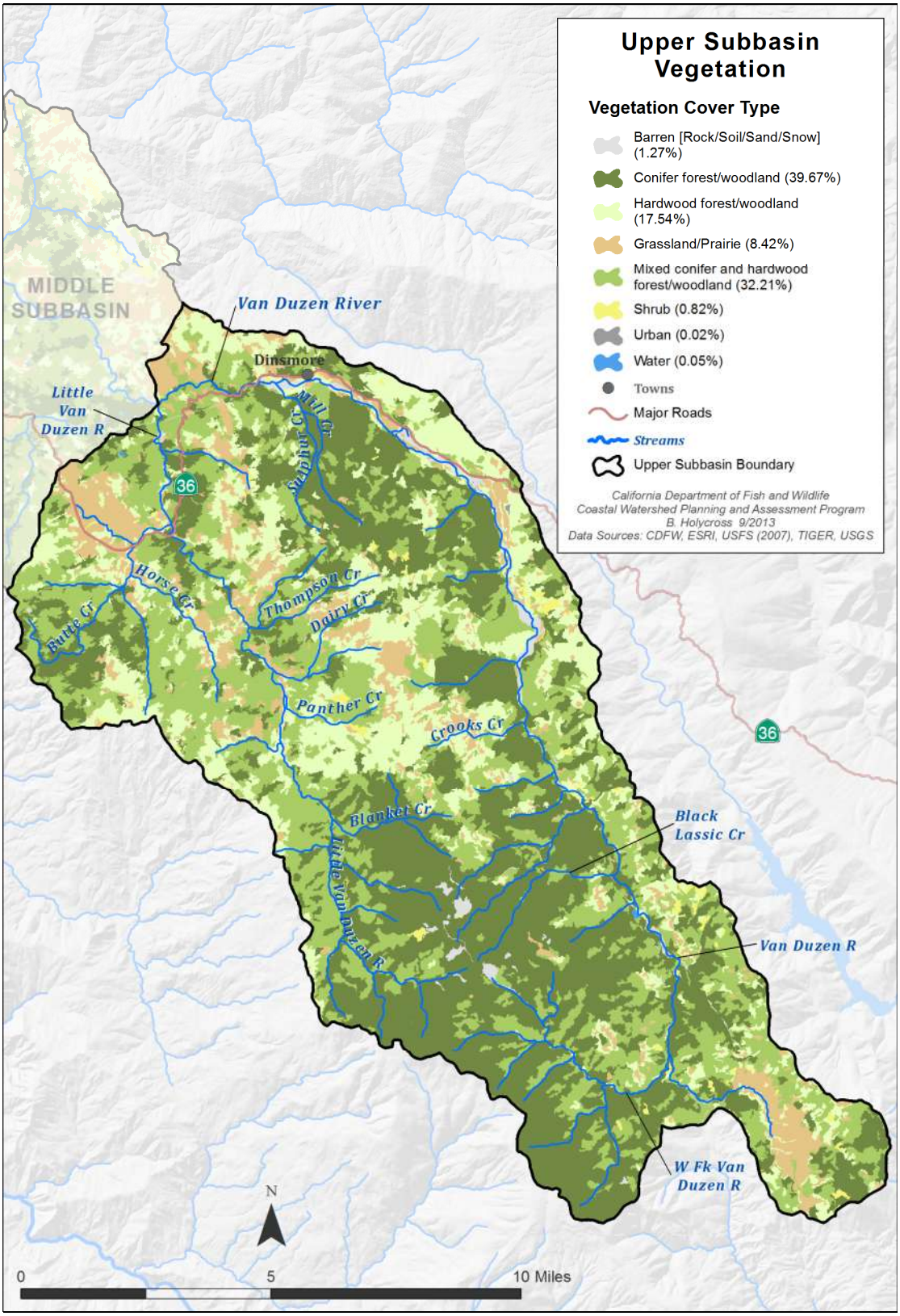

Figure 12. Vegetation classes of the Upper Subbasin

Land Use

Approximately half (50%) of the Upper Subbasin's land area is managed as National Forest by the Six Rivers Forest Service. Timber harvests, livestock grazing and public recreation are the major land use on these public lands (Figure 12). Timber production from private timber companies occupies a large majority of the northwest portion of the Upper Subbasin and composes 21.4% of the land use in the subbasin. For the past several decades, most of the private lands were managed for timber production or used for rural residences and ranchlands; however, in recent years the proliferation of large-scale industrial marijuana grow operations has occurred throughout the upper watershed.

Timber Harvests

A total of 25 percent of the subbasin's conifer forests were involved in timber harvest activity from 1991 to 2008. The majority of the timber harvest activity occurred in the lower to middle portion of the subbasin. The Dairy Creek Planning Watershed (PL) experienced the greatest amount of timber harvest activity with 2,800 acres or 76 percent of its conifer forest lands involved in timber harvest activity. Thompson Creek (2,466 acres harvested) and Browns Canyon (1,255 acres harvested) PWs also had substantial rates of timber harvest activity (Table 5). Appropriately, these three PWs (along with Sulpher PW) also contained the highest number of roads per square miles within the Upper Subbasin (Table 6).

Table 5. Upper Subbasin timber harvest statistics from 1991 to 2008.

Planning Watershed (PW)	PW Acres	Harvested Acres	% PW Harvested	Conifer Acres	% PW in Conifers	% Conifers Acres Harvested
Black Lassic Creek	7109	62	1	4953	70	1
Blanket Creek	9807	516	5	7197	73	7
Browns Canyon	7781	1255	16	2882	37	42
Dairy Creek (Upper)	8106	2800	35	3745	46	76
Hettenshaw Valley	5010	266	5	1873	37	14
Horse Creek	10779	1916	17	6482	60	29
Sulphur Creek	9788	835	9	5867	60	14
Thompson Creek	8507	2466	29	5326	63	46
Tierney Canyon	7894	622	8	3853	49	16
Totals	**74782**	**10738**	**14.4%**	**42176**	**56.4%**	**25.5%**

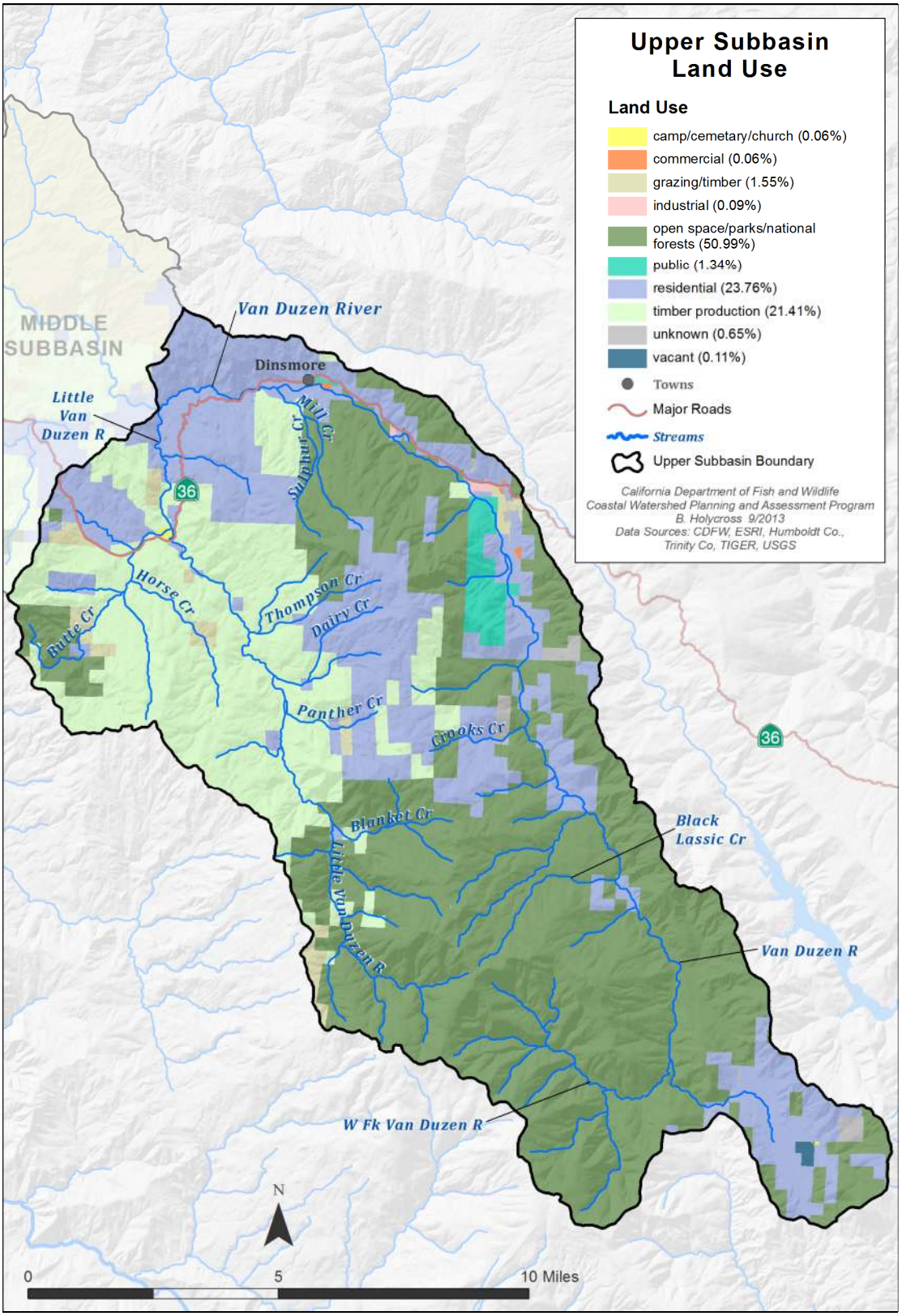

Figure 13. Land use categories in the Upper Subbasin

Roads

Roads data available from California Department of Fire (CDF) GIS roads layers show that there is an average of 3.6 miles of roads per square mile of the Upper Subbasin (Table 6 and Figure 13). The roads data provided by CDF likely underestimates the actual mileage of roads. The majority of these roads are considered existing seasonal roads that are generally utilized during the dry summer and early fall. There are, however, a large number of miles of existing permanent roads as well. The highest road densities are in the Sulpher (5.3 mi/sq. mi.), Thompson (5.1 mi/sq. mi.) and Dairy (4.8 mi/sq mi) creeks Planning Watersheds (Table 6).

Industrial Marijuana Agriculture

While not displayed in Land Use Map (Figure 12, p.17), industrial marijuana agricultural operations are locally abundant throughout the rural areas of the Upper Subbasin and are having a significant impact on the landscape and natural resources (including aquatic) of the subbasin and basin as a whole. The impacts and a discussion of these operations are discussed further in the Basin Profile's Land Use section (pp.47-48) as well as in the Lower Subbasin (p.27).

Table 6. Road miles in the Upper Subbasin planning watersheds.

CDFPWS NAME	Square Miles	Road Miles	Road Miles per Sq.Mi.
Black Lassic Creek	11.1	30.1	2.7
Blanket Creek	15.3	22.6	1.5
Browns Canyon	12.2	46.2	3.8
Dairy Creek (Upper)	12.7	60.3	4.8
Hettenshaw Valley	7.8	25.7	3.3
Horse Creek	16.8	60.6	3.6
Red Lassic Creek	12.0	38.4	3.2
Sulphur Creek	15.3	80.5	5.3
Thompson Creek	13.3	68.1	5.1
Tierney Canyon	12.3	43.1	3.5
South Fork Van Duzen River	14.6	38.8	2.7
Total	143.5	514.3	3.6

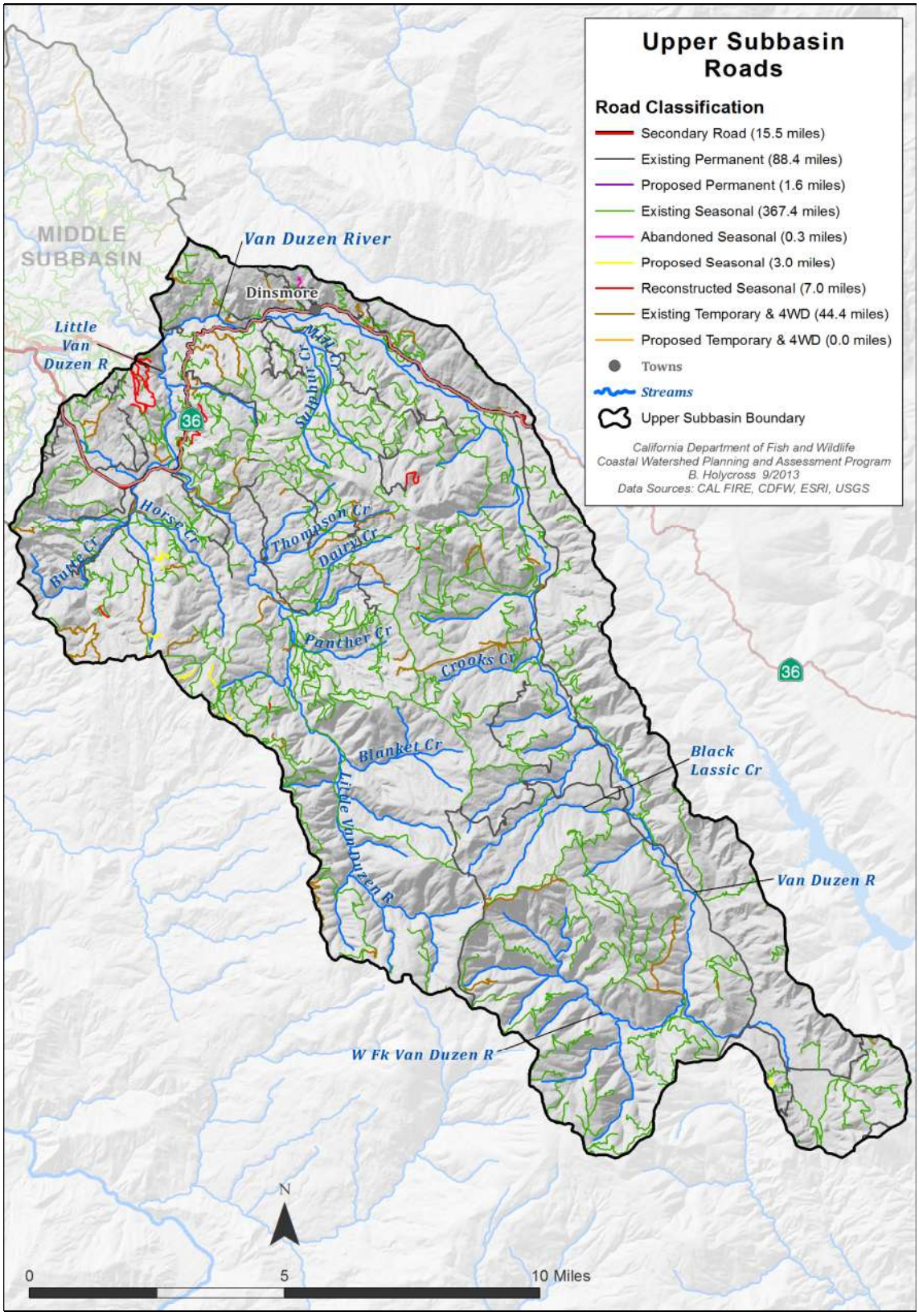

Figure 14. Upper Subbasin roads.

Fish Habitat Relationships

The stream habitat data collected from Upper Subbasin streams is twenty years old and may not be representative of current conditions. However, CDFW staff performed reconnaissance level surveys in reaches of the Little Van Duzen and Butte Creek in 2006 and 2007. These recent surveys found the streams in a generally good condition to support anadromous salmonids with a few habitat discrepancies. The reconnaissance survey summaries are located in Appendix III.

Fishery Resources

Salmon Falls in the Middle Subbasin blocks the passage of Chinook and coho salmon into the Upper Subbasin; therefore, the Upper Subbasin only supports populations of steelhead and resident rainbow trout. With the anadromous fish barrier of Eaton Falls located near RM 46 in the lower portion of the Upper Subbasin, potential steelhead distribution is almost entirely limited to the Little Van Duzen sub-watershed area. The Little Van Duzen River (Figure 14) flows into the Van Duzen River at RM 45 and contains approximately 13 miles of mainstem habitat and an additional 15 miles of tributary habitat available to support steelhead (Table 7 & 8). The most important tributary streams for salmonids are Butte Creek, Dairy Creek, Blanket Creek, and Lost Canyon Creek.

Table 7. Miles of stream accessible to anadromous salmonids in the Upper Subbasin of the Van Duzen River.

Stream	Steelhead	Chinook	Coho
Little Van Duzen River	13		
Butte Creek	6		
Horse Creek	1.1		
Swift Creek	0.4		
Thompson Creek	0.8		
Dairy Creek	1.3		
Panther Creek	0.96		
Dolores Creek	0.04		
Blanket Creek	1.3		
Bear Creek	1.0		
Lost Canyon Creek	1.4		

Figure 15. View of the lower Little Van Duzen River (SF Van Duzen).

Habitat Categories

Pool:Riffle:Run Relationships

Productive anadromous streams are composed of a balance of pool, riffle and runs. Each plays an important role as salmonid and stream community habitat. Flosi et al. (1998) suggests that the length of anadromous salmonid streams should be forty percent composed by pool habitats. In contrast, an over abundance of riffles can indicate an aggraded stream channel which often contributes to a reduction in pool occurrence, pool length, and depth.

Table 8. Habitat conditions in surveyed streams in the Upper Van Duzen River Subbasin

Stream Reach	Survey Year	Reach Length (feet)	Ave. Max Pool Depth	Pool:Riffle:Run % occurrence	Pool:Riffle:Run % length	%Length Dry
Little Van Duzen River	1992	71,890	2.5	33:37:30	23:41:35	1
Butte Creek	1992	31,817	2.5	35:30:35	35:21:44	0
Horse Creek	1992	5,861	1.9	34:11:23	28:11:38	24
Swift Creek	1992	2,235	0.6	13:25:13	4:2:3	92
Thompson Creek	1992	4,301	1.6	27:34:36	17:35:46	2
Dairy Creek	1992	6,817	1.8	22:38:29*	8:31:21	40
Panther Creek	1994	5,058	1.4	38:3:38	9:2:37	52
Dolores Creek	1992	226	N/A	33:66:1	7:93:0	0
Blanket Creek	1992	6,625	2.8	32:40:26	22:55:21	2
Bear Creek	1992	5,671		34:42:18*	5:37:16	42
Lost Canyon Creek	1992	7,511	1.4	25:36:36	9:44:37	10

*10% units dry in Dairy Creek and 6% dry in Bear Creek
N/A: no analysis performed because only 1 pool was observed.

Pool Depth

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

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

Findings: Inspection of pool depth data and the EMDS evaluation maps show a general shortage of deep pool habitat with corresponding low habitat suitability in the few surveyed streams of the Upper Subbasin (Fig. 15). For example, Panther Creek shows 38 percent pool occurrence but only 9 percent of the stream length is in pools, and the average maximum pool depth is only 1.4 feet. This implies numerous small pools in Fish Creek could be enlarged by addition of LWD.

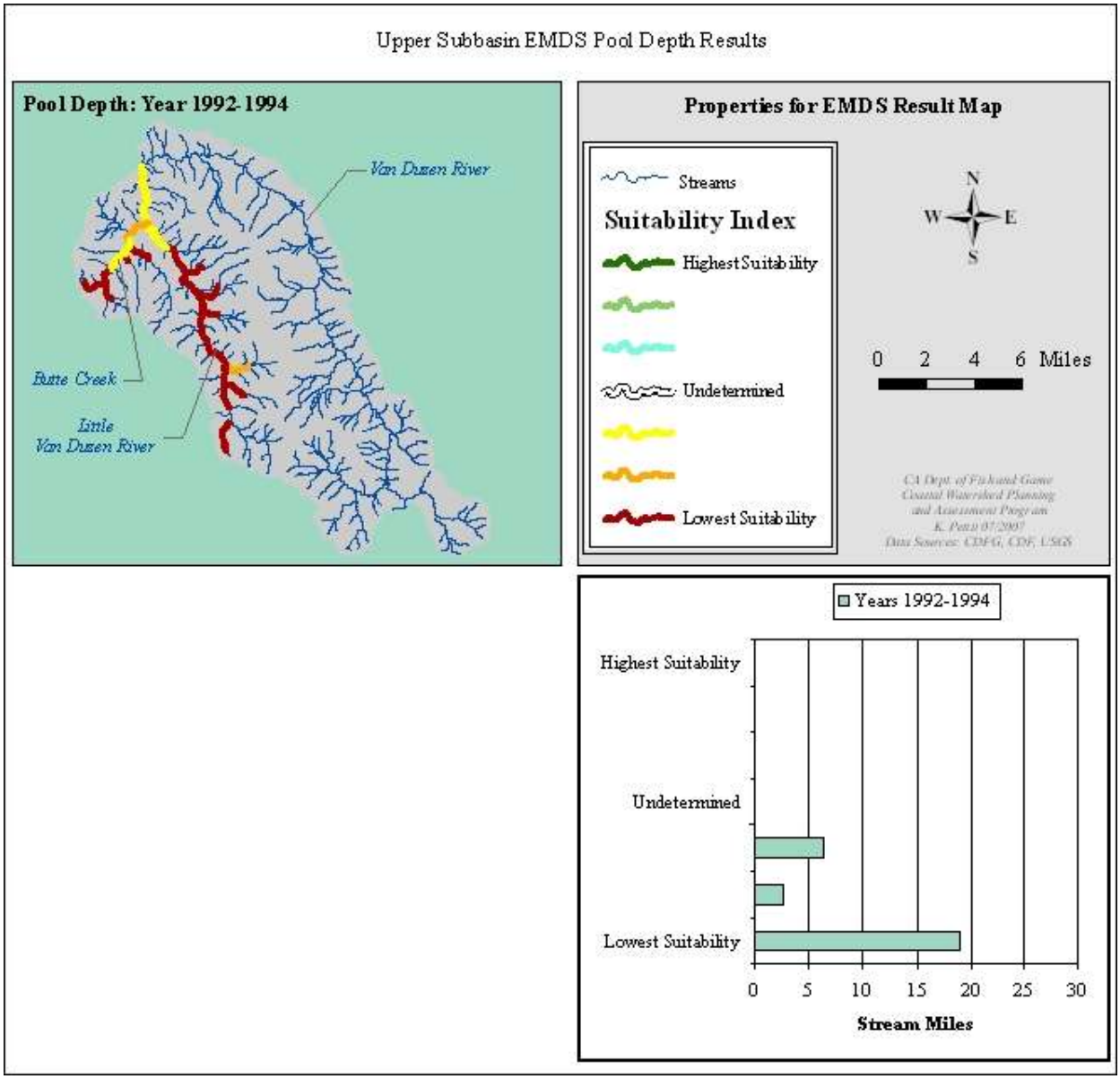

Figure 16. EMDS analysis of habitat suitability for salmonids based on pool depth from stream surveyed in 1992 and 1994.

Pool Shelter

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

Findings: Pool shelter ratings were far below the 100 target value for all streams and stream reaches indicating a general shortage of instream shelter elements (Figs. 16 and 17). The highest shelter values were observed in small tributaries of the Little Van Duzen.

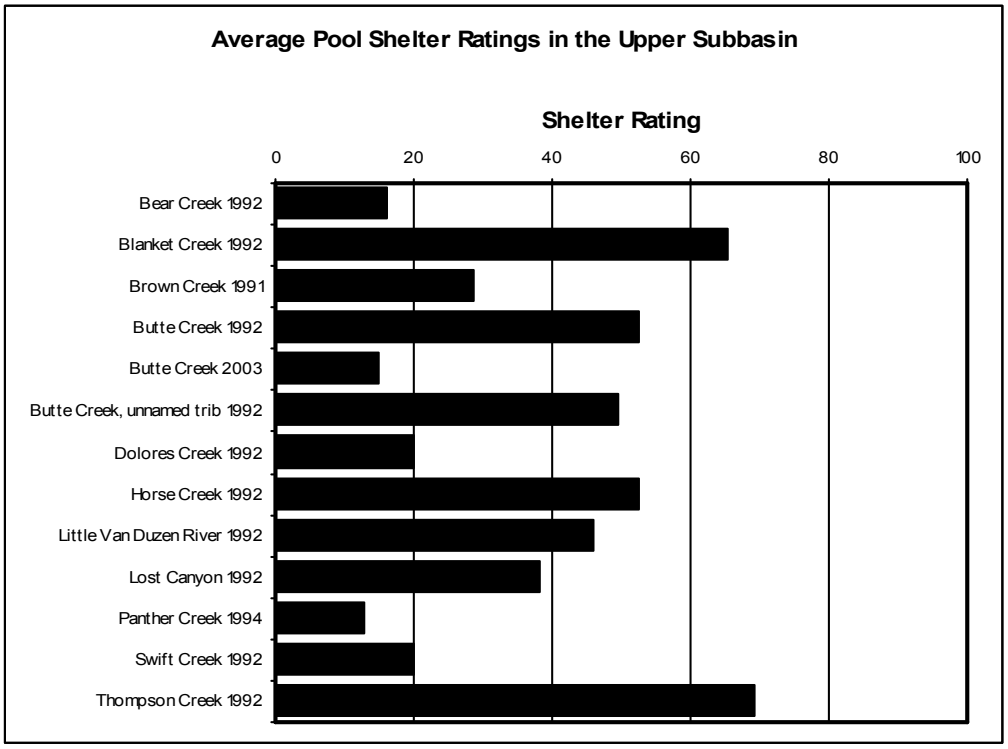

Figure 17. Average pool shelter rating in surveyed streams of the Upper Subbasin 1992-1994.

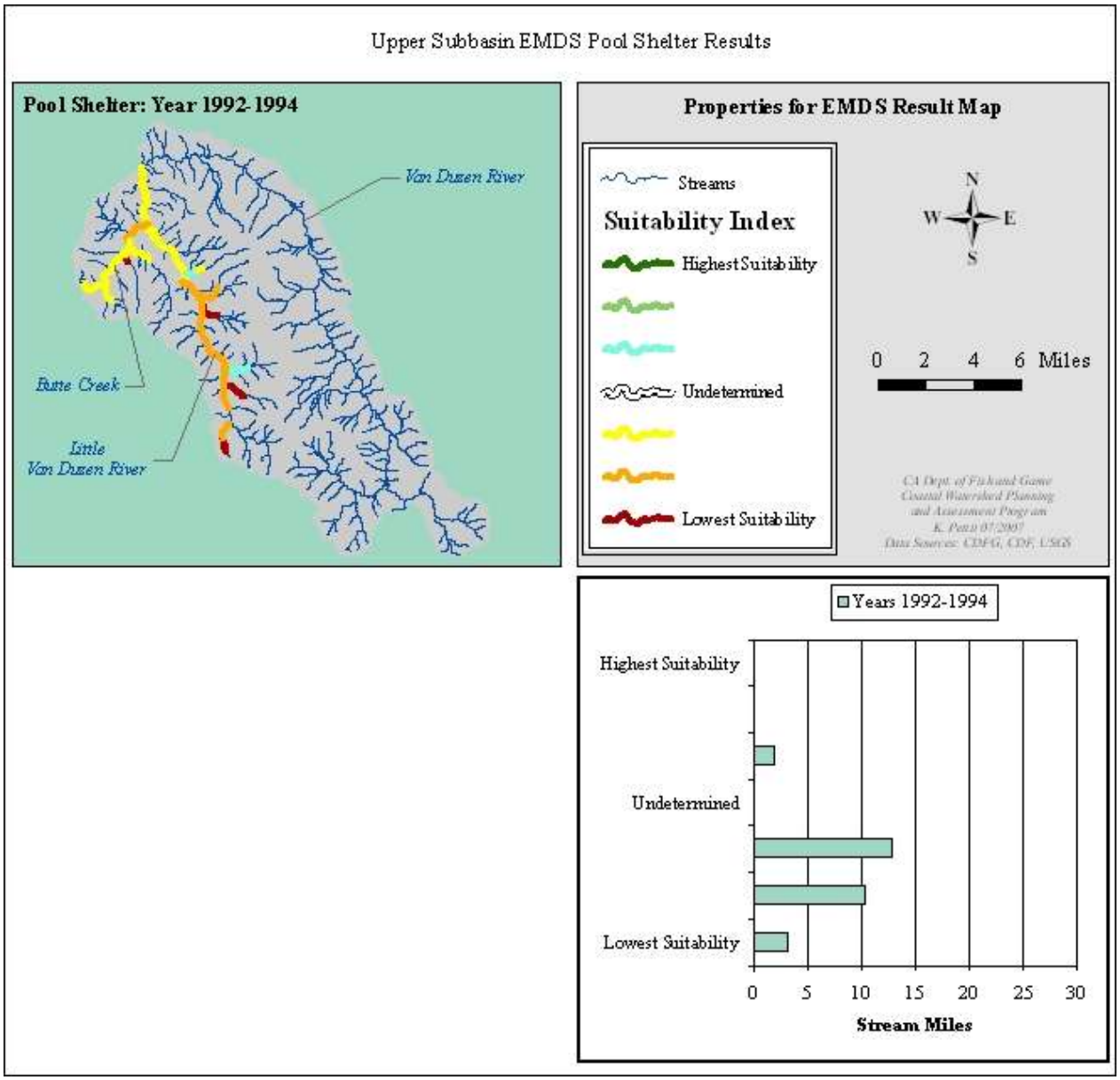

Figure 18. EMDS analysis of habitat suitability for salmonids based on pool shelter from streams surveyed in 1992 and 1994.

Spawning Cobble Embeddedness

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

High embeddedness ratings may indicate elevated levels of sediment inputs and erosion problems occurring in the watershed. The potential for high levels of fine sediments in streams increases in watersheds of the Middle Subbasin where the unstable geology, high precipitation, steep

topography, and land use cumulatively increase erosion potential. Some common land use activities that increases generation of fine sediment are clear cuts, roads, skid trails, and livestock grazing (Cederholm et al. 1981, Duncan and Ward 1985, Swanson et al. 1987, Hicks et al. 1991).

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

Findings: The streams of the Upper Subbasin generally show relatively high levels of cobble embeddedness (Figs. 18 and 19). The high levels of embeddedness are an indication of excessive delivery of fine sediments to most Upper Subbasin streams. Salmonid spawning success is likely limited or impaired by the lack of good quality spawning habitat in these streams.

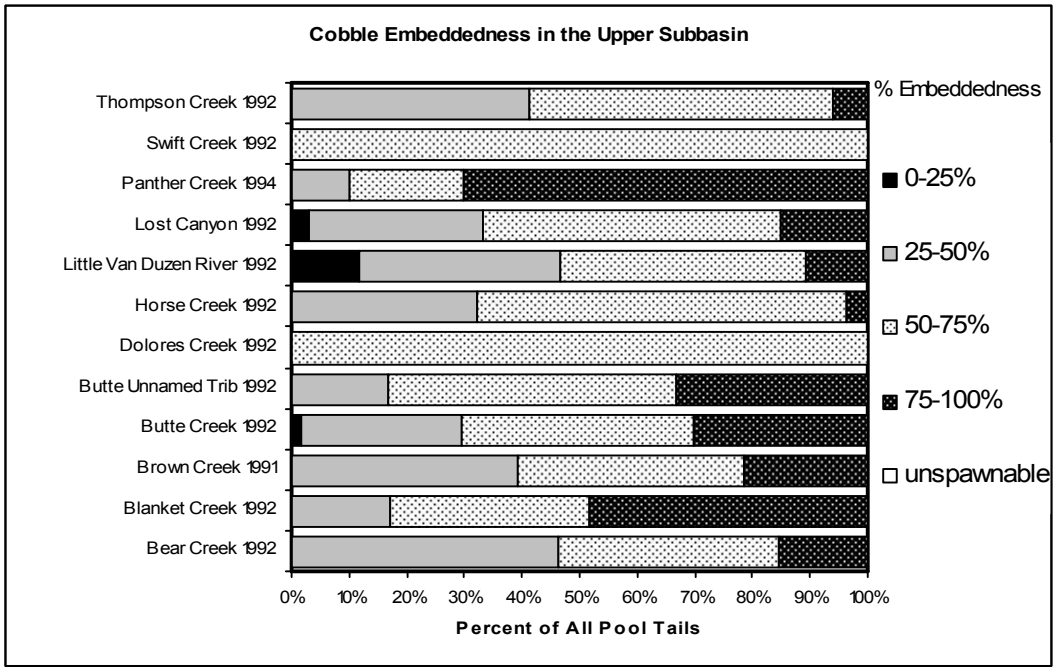

Figure 19. Cobble embeddedness in surveyed streams of the Upper Subbasin in 1992 and 1994.

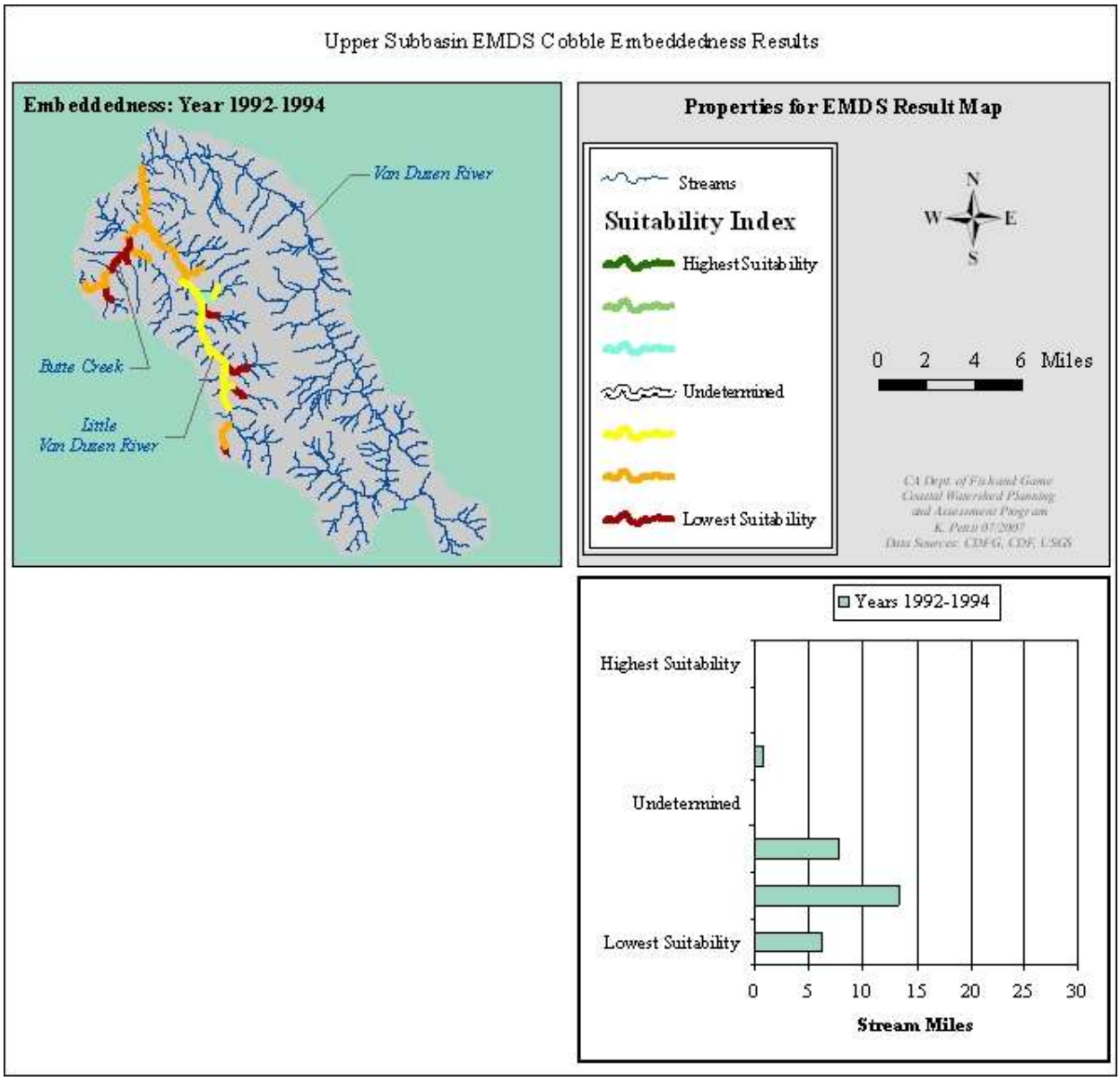

Figure 20. EMDS analysis of habitat suitability for salmonids based on cobble embeddedness from streams surveyed in 1992 and 1994.

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: While canopy density was below the target value of 80% in most of the Little Van Duzen River, most of the small tributaries as well as Butte Creek had suitable canopy density values (Figs. 20 and 21). Although these streams had suitable levels of shade, the amount of overstory shade contributed by conifers is below 50% for all but two of the streams surveyed. The Little Van Duzen River had less than 20% shade contributed by conifers. The low amount of overstory conifer shade is indicative of small sized or absence of conifer trees along the riparian zones of surveyed streams. It usually takes approximately 40 years to establish mature conifer forest canopy in these coastal forests.

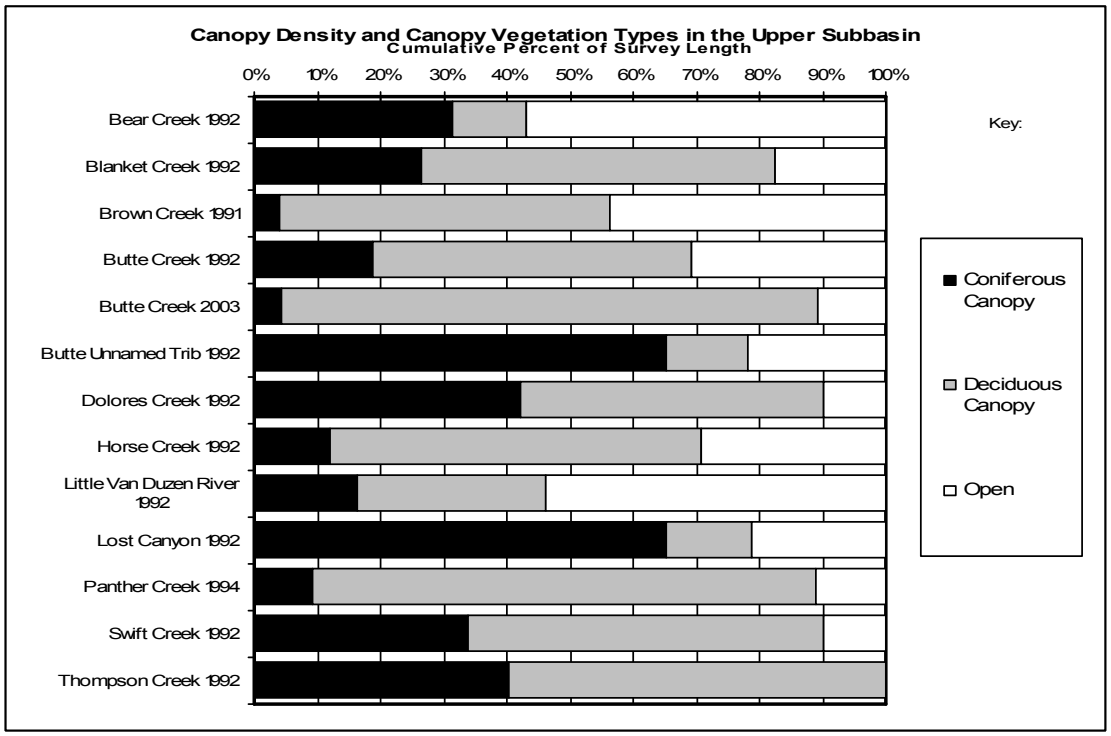

Figure 21. Canopy density and canopy vegetation types in the Upper Subbasin from surveyed in 1992 and 1994.

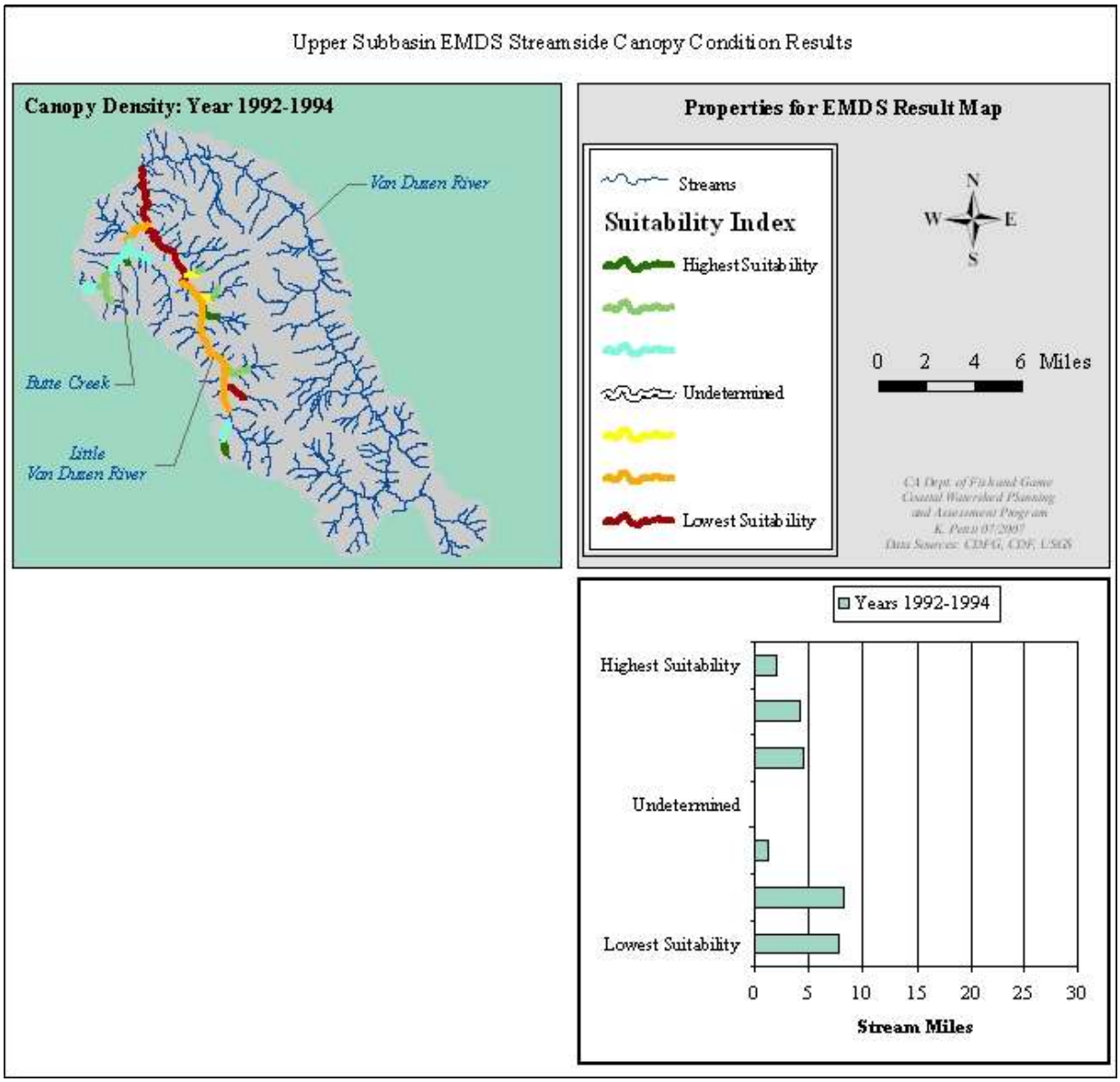

Figure 22. EMDS analysis of habitat suitability for salmonids based on streamside canopy from streams surveyed in 1992 and 1994.

Watershed Improvement Projects

A small sampling of salmonid focused watershed improvement projects have occurred in the Upper Subbasin including road upgrade/decommission, stream crossing removal/upgrade, and upslope management (Fig. 22). The fish passage project consisted of the placement of a series of boulder weirs in Butte Creek to help facilitate fish passage at a multiple culvert stream crossing. Bank stabilization projects were completed in Burr Creek and along the mainstem Van Duzen River. Road improvements/decommissions occurred in the very lower and very upper portions of the subbasin.

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. 30-33).

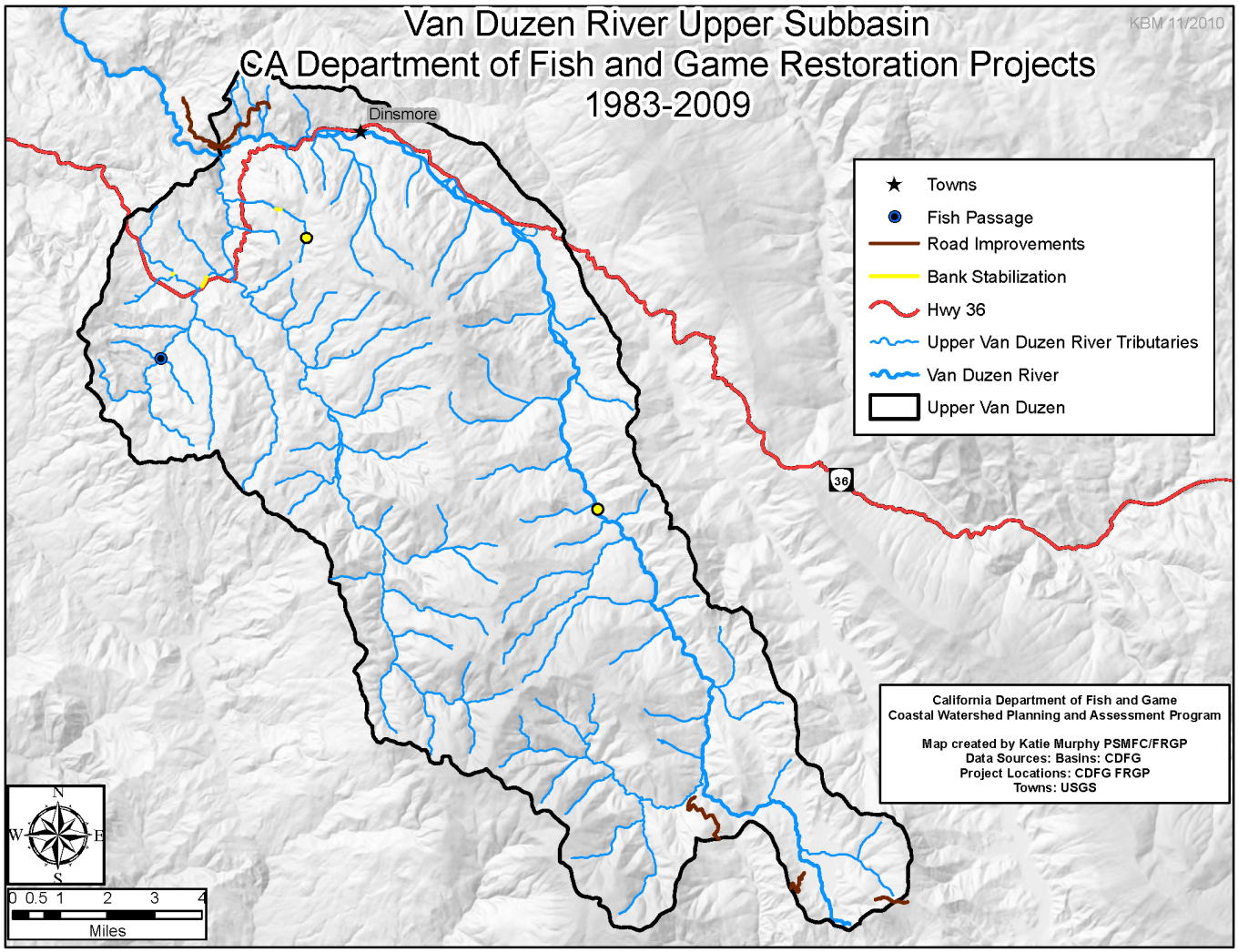

Figure 23. California Department of Fish and Game completed restoration projects in the Upper Subbasin from 1983 to 2009.

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 Upper Van Duzen Subbasin?

- Historically, it is unknown if Chinook and coho salmon were ever able to access the Upper Subbasin due to the presence of the barrier at Salmon Falls (RM 37). The channel configuration at the falls may have been different then its present form; however, there are no reported sightings or anecdotal records of either of these species within the subbasin;
- During periods of suitable stream flow conditions that are conducive to passage at Salmon Falls, winter steelhead have been able to access the Upper Subbasin. Eaton Falls, located in the lower portion of the Upper Subbasin at RM 46 prevents the further upstream migration of steelhead in the subbasin, therefore, anadromous steelhead distribution is limited to the Little Van Duzen River and its tributaries;
- Historically, the Little Van Duzen River had a small run of summer steelhead as far up as Panther Creek, approximately RM 7.5 (CDFG 1981). Summer surveys are no longer conducted in the Little Van Duzen River as it is believed that summer steelhead are no longer distributed in the Little Van Duzen;

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

- 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 and in the Little Van Duzen River;
- Increased nutrient, pollution, and sediment input into streams are all leading to impairment of habitat for fish, amphibians, and other wildlife;
- The Little Van Duzen River provides 13 miles of potential habitat for steelhead and rainbow trout;
- In addition to the Little Van Duzen River mainstem, the most important tributary streams for steelhead are Butte Creek, Dairy Creek, Blanket Creek, and Lost Canyon Creek. These and a few other tributaries provide an addition 15 miles of potential steelhead spawning and rearing habitat;

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

- The Upper Subbasin is naturally prone to earthflows, landslides, and erosion during high winter flows;
- Unconsolidated sediment stored in terrace deposits and gravel bars by previous large flow events is easily mobilized and redistributed during high winter river flows;
- Unstable, erodable bedrock, frequent seismic movement, high regional uplift rates, high seasonal rainfall, and land use activities recruit large amounts of sediment into the stream system;
- Large flow events play a major role in aggradation, degradation, as well as other changes in channel morphology;

- Middle Subbasin channel aggradation and sediment storage has been exacerbated by severe erosion in the upstream subbasins;
- Because of the low gradient of the mainstem as well as the lower reaches of several tributaries the Middle Subbasin acts as a sediment deposition as well as a transportation reach depending on flow and the amount of sediment entering the system;
- Unconsolidated sediments perched steeply above the stream are prone to bank erosion and sliding contributing sediment input to the streams;
- Unstable, severely erodable bedrock, frequent seismic movement, high regional uplift rates, high seasonal rainfall, and land use activities recruit vast amounts of sediment into the stream system;
- Soils and bedrock of the Upper Subbasin are easily eroded;
- Uplift has increased the erosion potential of the area;
- Rapid incision rates of the mainstem and its tributaries have left very steep, high banks which increase its likelihood for rockfalls and landslides;
- Multiple faults cut through this area shearing the bedrock and making it less competent;
- Frequent earthflows and deep-seated landslides within the mélange are especially active during heavy storm events and/or seismic events contribute a significant amount of fine sediments to the stream.

How has land use affected these natural processes?

- The present condition of the Upper Subbasin is in part the result of land use activities occurring within the subbasin;
- 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 in the Upper Subbasin. These mostly unregulated operations have decreased summer/early fall stream flows and degraded water quality in Van Duzen River, the Little Van Duzen River and its tributaries;
- A total of 25 percent of the subbasin's conifer forests were involved in timber harvest activity from 1991 to 2008. The majority of the timber harvest activity occurred in the lower to middle portion of the subbasin;
- The naturally high potential for erosion of the hill slopes and sediment delivery to stream channels is elevated by land use such as road construction, timber harvest operations and other land use that disturbs top soil or weakens slope stability;
- Some common land use activities that increases generation of fine sediment are clear cut logging operations, roads, skid trails, and livestock grazing.

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

Flow and Water Quality Improvement Activities:

- Instream flows to maintain fish habitat in good condition and channel maintenance flows should be preserved during any existing water diversion activities and considered prior to any new water development projects including riparian diversions, industrial marijuana agriculture operations, small domestic water use and water extraction from near stream wells;
- Consider private landowner water storage and forbearance programs were large capacity storage tanks are operated as part of a seasonal water management program;
- Assess roads and implement road improvement projects to reduce sediment delivery to fish bearing streams, especially in watersheds with high road densities and higher rates of timber harvest, such as Thompson Creek, Dairy Creek, and Panther Creek;
- Reduce fine sediment inputs by avoiding land use on inner gorge slopes and mitigate to reduce sediment inputs for any land use near streams on slopes greater than 25 percent;
- Intact forests of increasing age structure and complexity will have a greater water holding capacity than impaired watersheds, where forests are of a single dimension and lack complexity.

Erosion and Sediment Delivery Reduction Activities:

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

Riparian and Stream Habitat Improvement Activities:

- Pool enhancement projects should be implemented at select, existing pool habitat units to increase depth and add shelter complexity on the middle to upper reaches of the Little Van Duzen River as well as Butte Creek;
- Consider adding elements to recruit and retain spawning gravels in the lower Little Van Duzen River and Butte Creek;
- In order to decrease summer and fall high water temperatures in the Little Van Duzen River seek opportunities to increase coniferous tree overstory shade canopy along the Little Van Duzen River by plantings and/or thinning hardwoods around small conifers.

Monitoring, Education and Research Activities:

- Perform fish surveys on the Little Van Duzen River and some of its tributaries, such as Butte Creek, Dairy Creek, Blanket Creek, and Lost Canyon Creek to update current knowledge of presence and distribution of anadromous salmonids;
- Several years of monitoring summer/early fall stream water and air temperatures to detect trends using continuous, 24-hour monitoring thermographs should be done in the Little Van Duzen River;

- Monitor summer/early fall water quality parameters in the Van Duzen River and the Little Van Duzen River;
- Conduct community based outreach meetings to discuss approaches that could be implemented to help address the problems created by industrial marijuana agriculture practices;
- Continue outreach and education by local agencies and organizations to rural residents regarding proper road design and maintenance.