Comments on Van Duzen River and Yager Creek Sediment TMDL with Recommendations for Implementation Action and Monitoring

Performed for the:
Van Duzen Watershed Project

Funded by:

Friends of Eel River
California State Water Resources Control Board

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January 2008

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Cover Photo: Van Duzen River looking downstream from the mouth of Grizzly Creek at a pool that was formerly popular for swimming and diving but is now too shallow. Photo by Pat Higgins. July 2003.

Executive Summary

The *Van Duzen River and Yager Creek Total Maximum Daily Load for Sediment* (*Van Duzen TMDL*) (U.S. EPA, 1999) set quite modest goals:

> "A primary mission of the TMDL program is to protect the health of impaired aquatic ecosystems by ensuring attainment of water quality standards, including beneficial uses (EPA 1998). The development of this TMDL provides a unique and valuable opportunity to look at the entire Van Duzen River basin, not just discrete projects or ownership specific projects, to determine the major sediment delivery mechanisms which influence the attainment of applicable state water quality standards (WQS). The results of this TMDL provide a basin-wide framework from which to establish sediment reduction measures to attain WQS."

The following is a summary of attributes and short comings of the *Van Duzen TMDL*:

- Fisheries discussions are thorough and the decline of salmon and steelhead acknowledged, but extinction risk for species such as coho and cutthroat trout has increased since 1999 due continued intensive land use.
- Targets for attainment of water quality are scientifically derived and suitable for gauging long term recovery of salmon and steelhead habitat, but no systematic monitoring has followed to determine trends.
- There is no projected trajectory for recovery of fisheries or water quality or schedule for compliance.
- The TMDL upland sediment reduction strategy is insufficient and lacks discussion of prudent risk limits for watershed disturbance to reverse water pollution and to prevent damaging cumulative effects.
- The narrative tone emphasizes "past land use" practices as yielding the most sediment, and downplays the significance of logging-related damage since 1985 on Middle and Lower Van Duzen tributaries, including Yager Creek.
- Changes in flow caused by roads and logging is ignored despite potential for more frequent damaging floods and decreased summer base flows.
- Elevated water temperature is not addressed despite the known relationship of excess sediment, channel changes and stream warming.
- The EPA makes clear that it has no authority to create an implementation plan, but nearly a decade after the technical TMDL the State has not yet created one.

The *Van Duzen TMDL* calls for road related erosion control and quite a bit of work on recommended projects has likely been carried out since 1999, however additional roads have been built and extensive timber harvest conducted. The real prospects for recovery of Pacific salmon in the Van Duzen River relies on slowing the rate of logging and reducing road networks and crossings, not just improving road drainage.

This report assesses all fisheries, aquatic habitat and upland data. Sources of information include historic press accounts, the Pacific Lumber Company (PL, 1998) *Habitat Conservation Plan* (HCP), California Department of Fish and Game (CDFG) file reports, California Department of Forestry (CDF) timber harvest planning data, and the Humboldt County Resource Conservation District (RCD) Eel River temperature monitoring project (Friedrichsen, 1996; HCRCD, 1999; 2000; 2002; 2003).

The Van Duzen Watershed Project monitoring efforts (FOER, 2007) are a good start on trend monitoring that would be useful under a TMDL implementation plan. With the bankruptcy of the Pacific Lumber Company, there is a specter of a major shift in land ownership. The Van Duzen Watershed Project should consider joining in the movement for implementing a community forest management model on PL's holdings in the Van Duzen River watershed to attain Clean Water Act objectives. In the event of a take-over by another large private owner, the Van Duzen Watershed Project should consider offering to augment the company's monitoring capacity through cooperative efforts, including the use of volunteers.

TMDL Sediment Budget for Van Duzen Sub-Basins

Pacific Watershed Associates (PWA, 1999) estimated sediment sources and a sediment budget for the *Van Duzen TMDL* (U.S. EPA, 1999). The sediment analysis, however, did not include estimates of surface erosion and bank erosion triggered by cumulative effects, which is likely significant. Discussion of PWA findings is followed by a narrative on potential for surface erosion as a major overlooked source. Cumulative effects driven bank erosion is covered in a later section.

Pacific Watershed Associates (1999) analyzed land slides and sediment delivery by terrain type (Figure 1) and found that the greatest source areas were underlain by unstable sandstone assemblages (4265 yds.^{3}/mi^2), followed by active earthflows (3937 yds.^{3}/mi^2), and dormant earthflows (2368 yds.^{3}/mi^2). Stable sandstones yielded the lowest sediment (190 yds.^{3}/mi^2), which is just slightly less than that coming from stable mélange terrain.

The Upper and Middle Van Duzen River basins have much more mélange and earthflow terrain and deliver more sediment per square mile than the Lower basin. The Upper basin (98 mi^2) encompasses the headwaters of the mainstem Van Duzen River, upper South Fork and West Fork Van Duzen River. The Middle basin is defined as the mainstem Van Duzen from Grizzly Creek to the South Fork, the lower South Fork, and the upper North, Middle and South Forks of Yager Creek.

Although the large size of the Middle basin (202 mi^2) partly explains its ranking as the top sediment producer, huge inner gorge failures along the mainstem in this reach are the largest source in the entire Van Duzen watershed. The Lower basin (129 mi^2) extends from Grizzly Creek to the Eel River with the addition of lower Yager Creek and Lawrence Creek. Figure 2 shows the gross estimate of sediment coming from each of the three sub-basins with the relative amount coming from five different source categories: 1) undisturbed watershed areas, 2) mature second growth landscapes, 3) road related, 4) skid trail related, 5) tractor clearcut, 6) cable clearcut, and 7) partial cut. The Lower basin has the highest component of management related sediment with the most landslides triggered by tractor clearcuts.

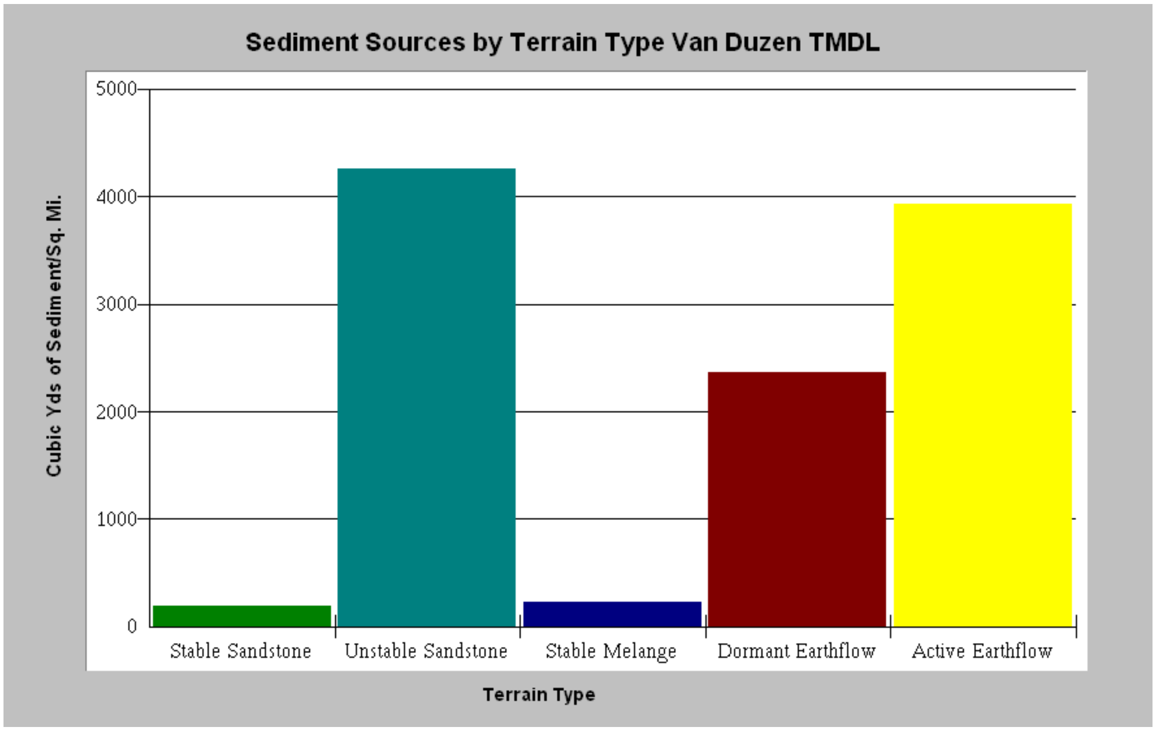

Figure 1. According to PWA (1999), the largest contribution of sediment from landslides in the Van Duzen River watershed is from unstable sandstone terrain, followed by active and dormant earthflows, stable mélange and stable sandstones, respectively.

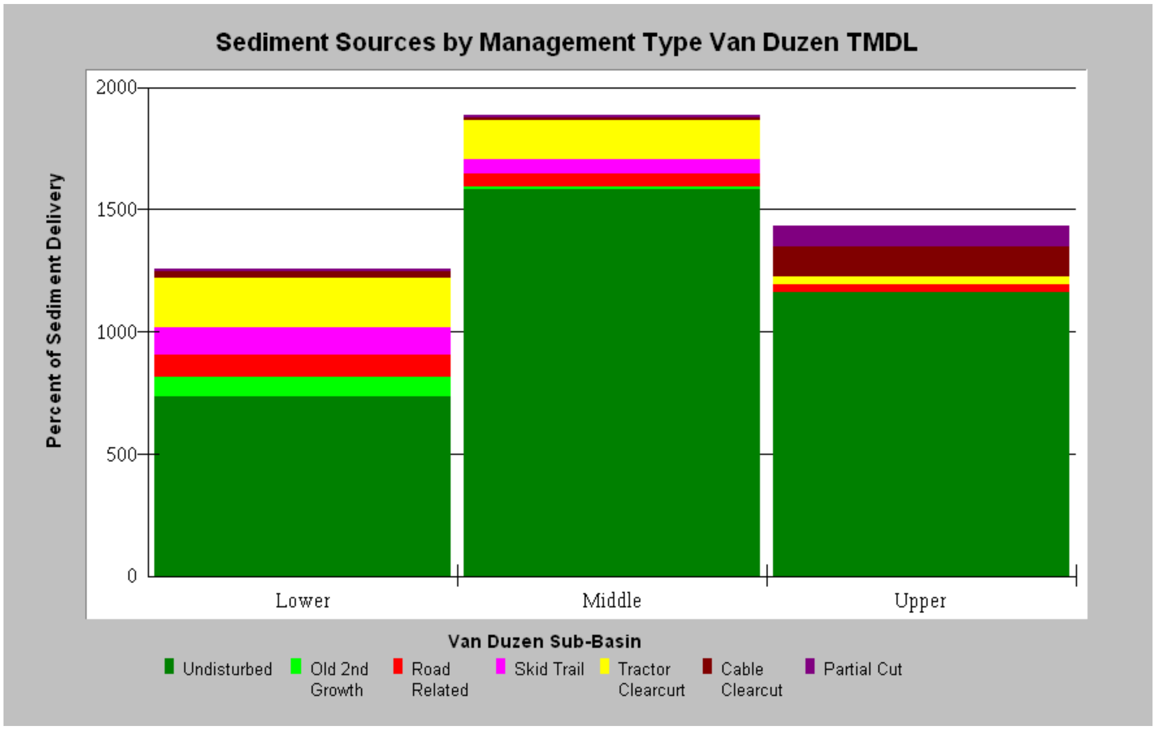

Figure 2. The Middle Van Duzen sub-basin had the highest overall sediment yield, followed by the Upper basin, but management related sediment from landslides was highest in the Lower basin. Data from PWA (1999) and the *VD TMDL* (EPA, 1999).

There are questions regarding the PWA (1999) methods, which used 80 forty-acre plots (3200 acres) taken as representative of the whole watershed (274,560 acres or just over 1%). Methodologies between various northwestern California TMDLs vary greatly. Studies for the Noyo, Big and Ten Mile Rivers (GMA, 1998; 1999; 2000) include a complete history of road construction and timber harvests to better understand the relationship of land use to sediment yield. This approach would have gotten much more accurate results had it been applied in the *Van Duzen TMDL*.

"Estimates of surface erosion and sediment yield along roads and their cutbanks (i.e. road and skid trail surface lowering) were not quantified within the 80 field sample plots due to time constraints and, therefore, are not included" (U.S. EPA, 1999). The omission of data or discussion of surface erosion is a major problem when judging land use impacts on recently logged lands of the Lower Van Duzen River basin, including Yager Creek. Elsewhere in the *TMDL* it states that "approximately 22% of timberland road miles presently are hydrologically connected in lower basin." This means they are pumping fine sediment.

Extensive logging roads, temporary roads and skid trails create pathways for sediment to enter streams from clear cut areas on Pacific Lumber Company lands in Yager Creek, Lawrence Creek and a number of Lower Van Duzen basin tributaries. The Corner Creek watershed (Figure 3), which is within the Lawrence Creek and Yager Creek basins, is exemplary of the potential for sediment delivery through surface erosion. The increased fine sediment in Lawrence Creek and other Van Duzen River tributaries certainly reflects this land use (see WQ Fine Sediment). PWA (1999) also fails to properly calculate bank failures triggered by increased peak flows and sediment transport (see Cumulative Watershed Effects).

Figure 3. Logging roads and skid trails in the Corner Creek basin, including red arrows that point out unprotected stream course. Photo by Doug Thron. April 1995.

TMDL Upland Targets for Sediment Reduction Insufficient

While the Van Duzen TMDL chooses appropriate instream targets, those chosen for hillslope and watershed protection are insufficient and have been ineffective. While measures called for are worthwhile steps, they do not represent a comprehensive nor adequate approach. Table 1 is a sub-set of Table 3.2 in the TMDL and includes indicator targets, a bullet on existing conditions and another on needed action. We have added a column with a note on sufficiency of the action to abate sediment pollution.

The targets for instream indicators in the TMDL are quantitative and measurable, while those for hillslope targets are not. For example, the target of eliminating diversion potential at stream crossings would reduce catastrophic failures and sediment yield, but there are no data for 2/3 of the basin and the Lower Basin is at an extreme level of risk with 63% of crossings having potential for diversion. There is neither timeline for completing an inventory nor a mechanism for tracking compliance.

Collison et al. (2003) noted that the concept of hydrologic disconnection is theoretical and that no monitoring results have demonstrated the effectiveness of these methods. They had particular reservations when land use remained active with expanding road networks and continued timber harvest, which is exactly the case with the Van Duzen River since the TMDL.

While reducing fill failures on the hundreds of miles of logging roads would reduce sediment yield, the cumulative effects from roads will continue as long as road densities are too high and roads cross unstable slopes. Even the TMDL measure to increase culvert size is insufficient in that pipes should be capable of handling 100 year frequency interval storms.

The Van Duzen TMDL recommends that roads no longer be built on unstable slopes and that existing road segments on such slopes be decommissioned, there is no mechanism to carry this out. Disturbance of unstable slopes has likely continued with extensive harvests in the Van Duzen River since 1998 (see Cumulative Watershed Effects), yet timber harvest gets very little discussion and potential logging limits are never broached. The Van Duzen TMDL says monitoring called for under the PL Habitat Conservation Plan will "provide information on the effectiveness of management actions to reduce sediment delivery ……in the future." If such monitoring has taken place, it has not been shared with the public.

Cumulative Watershed Effects: Land Use Components

The *Van Duzen TMDL* does a very poor job of dealing with cumulative watershed effects (CWE) damage to streams and, consequently, fails to set prudent risk limits on future land use to prevent them and allow aquatic recovery. Cumulative effects problems include increased bank failure, increased bedload mobility, depletion of large wood and destructive impacts to watershed hydrology.

Table 1. *Van Duzen TMDL* upland indicators and comments on sufficiency.

Indicator Target	**Existing Condition**	**Improvement Needed**	**Sufficiency**
No stream crossings with diversion potential	Roads in lower basin have 63% diversion potential at stream crossings. Upper and middle basins unknown.	Reduction of 100% of existing stream diversion potentials along roads. Inventories needed on middle and upper basin to determine reduction needs.	Good to prevent catastrophic road failures, but no mechanism for tracking or compliance. All crossings should be fixed regardless of location.
Less than <5% of road surfaces and ditches are connected to streams	Approximately 22% of timberland road miles presently are hydrologically connected in lower basin. No upper and middle .	95% reduction from existing level baseline inventories needed on middle and upper to determine reduction needs	Experimental (Collison et al., 2003). Not a substitute for quantitative limits to road densities. Substantial variability in implementation. PL has not followed up on implementation and monitoring and professional oversight from PWA is limited since 1998.
Reduced fill failures from roads, skid trails and landings	60% of road-related sediment delivery in the Lower Eel Study was associated with fill failures (PWA 1998)	Lower: 90% reduction from existing level. middle and upper: 80%	Even if you treat 1,000 cutbanks with potential fill failure, the cumulative disturbance is too great to mitigate. Need to reduce road miles and densities.
Reduced stream crossing failure/washout	12% of road-related sediment in the Lower Eel Study was associated with crossing failures (PWA 1998)	Lower: 90% reduction from existing level. middle and upper: 80%	Should have recommended that all culverts be sized for 100 year flood events. Why wouldn't you want to prevent all failures?
Reduction in management associated mass wasting from inner gorges, steep slopes and unstable areas	Roads located on inner gorges, stream side slopes (>50%), and headwall swales accounted for 43% of the total road-related sediment delivery in the lower basin (PWA, 1998).	Lower: 90% reduction from existing level. middle and upper: 80%	TMDL did not suggest use of SHLSTAB model or any method to limit further disturbance on unstable slopes. Known huge problem in Lower Eel (PWA, 1998).

Land use activities that contribute to these problems in the Van Duzen River watershed are principally timber harvest and road building. Ranchland management, gravel mining and rural residential development also have the potential to add to cumulative effects, but are largely beyond the scope of this discussion.

Dunne et al. (2001) evaluated the adequacy of California Forest Practice Rules (FPR) and the relationship of timber management and cumulative watershed effects, which they described as follows:

> "Generally speaking, the larger the proportion of the land surface that is disturbed at any time, and the larger the proportion of the land that is sensitive to severe disturbance, the larger is the downstream impact. These land-surface and channel changes can: increase runoff, degrade water quality, and alter channel and riparian conditions to make them less favorable for a large number of species that are valued by society. The impacts are typically most severe along channels immediately downstream of land surface disturbances and at the junctions of tributaries, where the effects of disturbances on many upstream sites can interact."

The photo of the junction of Yager Creek and the Van Duzen River (Figure 4) clearly shows cumulative effects of increased sediment from the tributary manifest in a very wide gravel bar. Dunne et al. (2001) also point out that destructive cumulative effects cannot be managed without first minimizing risk:

> "Inevitably, the institutional aspects involve decisions about how much environmental and other risks are acceptable in a project. Before the institutional evaluation can be made, however, the risks of cumulative watershed effects need to be identified in some transparent manner."

The Van Duzen TMDL fails to properly characterize risk factors. Individual contributors will be analyzed independently below, and discussion of aquatic ecosystem response to cumulative effects follows.

Timber Harvest

The *Van Duzen TMDL* (U.S. EPA, 1999) does not quantify timber harvest and, while acknowledging that logging caused increased sediment yield, the contributions of logging to cumulative effects are ignored.

Reeves et al. (1993) studied eight Oregon Coastal basins that were less than 25% timber harvested and compared them to adjacent watersheds with greater harvest levels. They found that streams draining watersheds cut in over 25% of their area within a 30 year period were usually dominated by one Pacific salmon species, while basins with less disturbance maintained several species. Swanson et al. (1998) noted that logging in 20-30 percent of an Oregon Cascade watershed caused catastrophic channel changes and was "substantially influenced by vegetation conditions in watersheds at the time of the flood." The latter study was conducted on U.S. Forest Service lands where some intact sub-

Figure 4. Widening of the mainstem Van Duzen River channel and major areas of bank failure in the Lower basin at the convergence with Yager Creek. Channel migration is exacerbated by increased bedload and peak flows due to cumulative watershed effects. Photo by Pat Higgins. January 1997.

basins remain, while all of PL's holdings in the Lower Van Duzen basin are homogenously disturbed with logging rates as high as 80% in some sub-basins (Figure 5).

Dunne et al. (2001) point out problems that arise when timber harvests are looked at individually and not in conjunction with all activities in a watershed:

> "The concern about cumulative effects arises because it is increasingly acknowledged that, when reviewed on one parcel of terrain at a time, land use may appear to have little impact on plant and animal resources. But a multitude of independently reviewed land transformations may have a combined effect, which stresses and eventually destroys a biological population in the long run."

This is an apt description of the process of timber harvest oversight in the Van Duzen River basin, with timber harvests still continuing despite overwhelming signals of cumulative effects problems for over a decade (Higgins, 1995a; 1995b, 1995c; 1996). Coho salmon are one of the casualties of this failure (see Fish Population).

Timber harvest plan (THP) data were not available for a quantitative analysis by PWA (1999) and U.S. EPA (1999), but harvests since 1991 have since been mapped by the California Department of Forestry (CDF). This still does not take into account relatively recent THP's in the period from 1980 to 1990 that could still be contributing to cumulative effects. Even with a restricted window on approved timber harvest plans

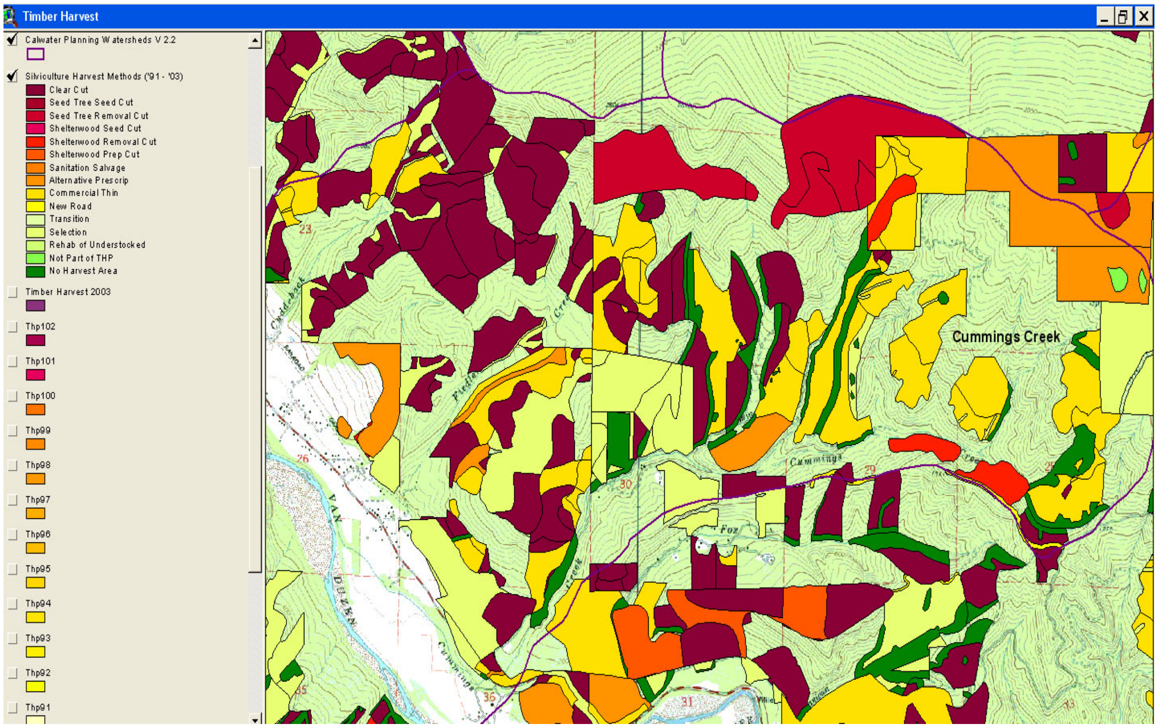

Figure 5. Timber harvest plans (THP) permitted by the California Department of Forestry from 1991-2003. Data from CDF.

(THP) of 1991-2003, one can see that prudent risk limit of 25% over 30 years noted by Reeves at al. (1993) have been greatly exceeded at a sub-basin scale such as in Cummings Creek, Cuddyback, Fox and Fielder Creeks in the Lower basin (Figure 5).

Accelerated logging began in the Yager sub-basin in 1985 and potential for cumulative watershed effects from logging were already well advanced by 1994 (Figure 6). Changes in downstream channels from this level of disturbance were apparent in early 1990's habitat typing reports (see WQ Pool Frequency, Pool Depth, Embeddedness). Although PL's logging in the Lower Van Duzen basin is the most extensive, the rate of harvest in other sub-basin areas are high enough to warrant concern (Figure 7).

Historic press accounts describe an increase in logging in Yager Creek in 1940 (HT, Oct. 4, 1940). Subsequent angler reports note increased turbidity: "All we know is that the Van Duzen was about olive drab Wednesday at the 101 Highway Bridge, but that may have come from Yager creek logging" (HT, Jan. 6, 1949). However, problems with cumulative effects in the 1955 and 1964 floods were not as catastrophic in the Yager sub-basin as they were in the upper Van Duzen River (Kelsey, 1977). Logging in Yager and Lawrence Creek in the 1940's included construction of 23 miles of railroad and extensive use of cables, similar to logging in Freshwater Creek in the period just prior. Because road networks were less extensive in this prior logging period, watershed and stream recovery may have been relatively rapid (Higgins, 2003).

Figure 6. Lawrence Creek watershed with extensive clear cutting, road networks and skid trails on PL lands in fall 1994. Lawrence Creek is in the center of the photo (red arrow) and is flowing toward Yager Creek. Photo by Doug Thron.

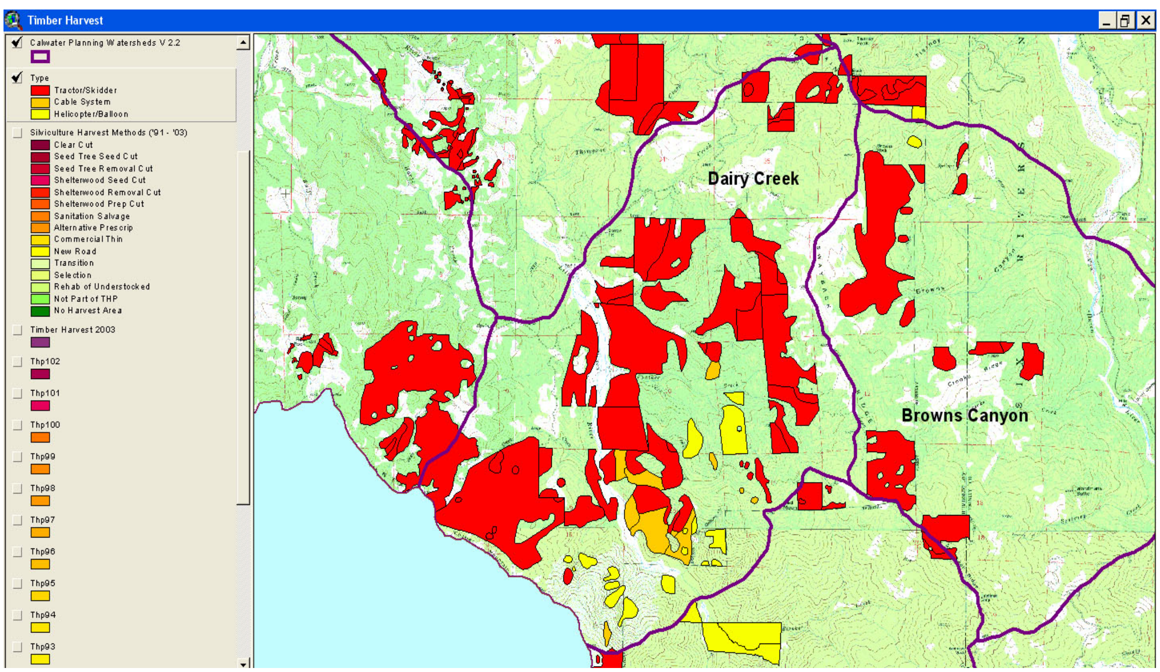

Figure 7. Middle reach of the South Fork Van Duzen River (also known as the Little VD) with yarding techniques from THPs approved between 1991 and 2003. Approximately half this Calwater Planning Watershed was logged with tractors during that period. Data from CDF, Santa Rosa.

The *Van Duzen TMDL* does not express concern over riparian logging or its cumulative effects potential (see Large Wood). Spence et al. (1996) described the effects of streamside logging on salmonids as follows:

> "Riparian logging depletes large woody debris (LWD), changes nutrient cycling and disrupts the stream channel. Loss of LWD, combined with alteration of hydrology and sediment transport, reduces complexity of stream micro- and macrohabitats and causes loss of pools and channel sinuosity. These alterations may persist for decades or centuries. Changes in habitat conditions may affect fish assemblages and diversity."

The prevention of timber harvest on steep unstable ground is advised against in the *Van Duzen TMDL*, but no mechanism to prevent it was put in place. Reeves et al. (2004) point out that more wood is delivered by landslides in unstable headwater and inner gorge areas than from areas immediately adjacent to streams (see Large Wood).

Roads

Hagans et al. (1986) estimated that 50 to 80% of the sediment that enters northwestern California streams stems from road-related erosion. Roads that parallel streams have the highest chronic sediment delivery (Spence et al., 1996), but road-stream crossing failure during large storm events yields more sediment volume episodically (Hagans et al., 1986). High road densities are also recognized as altering the hydrology of watersheds, by essentially extending stream networks and intercepting ground water flows (Jones and Grant, 1996) (see Altered Hydrology).

The *Van Duzen TMDL* (U.S. EPA, 1999) acknowledges "high road and skid trail densities and high road mileage located directly adjacent to streams in Yager Creek and Lawrence Creek." Their estimate of road densities includes only main haul roads and not temporary roads and extensive skid trail systems (Figure 8), but passages regarding PWA (1999) findings clearly indicate high cumulative effects risk:

- 63% of stream crossings had diversion potential,
- 22% of the road ditch length was poorly constructed resulting in sediment delivery to streams (9 mi. out of 43 mi.),
- 60% of the total sediment delivery from roads came from fill failures, and
- 27% stream crossings had a history of actively eroding.

As noted above, surface erosion from road surfaces, road cuts and road fills were not calculated for the TMDL. The TMDL also noted that :"Roads located on inner gorges, stream side slopes (>50%), and headwall swales accounted for 43% of the total road-related sediment delivery in the lower basin (PWA 1998)."

Road Density: Armentrout et al. (1999) used a reference of 2.5 miles of roads per square mile of watershed area (mi./mi.^{2}) as a watershed management objective to maintain hydrologic integrity in Lassen National Forest watersheds harboring anadromous fish. Regional studies from the interior Columbia River basin (USFS, 1996) show that bull

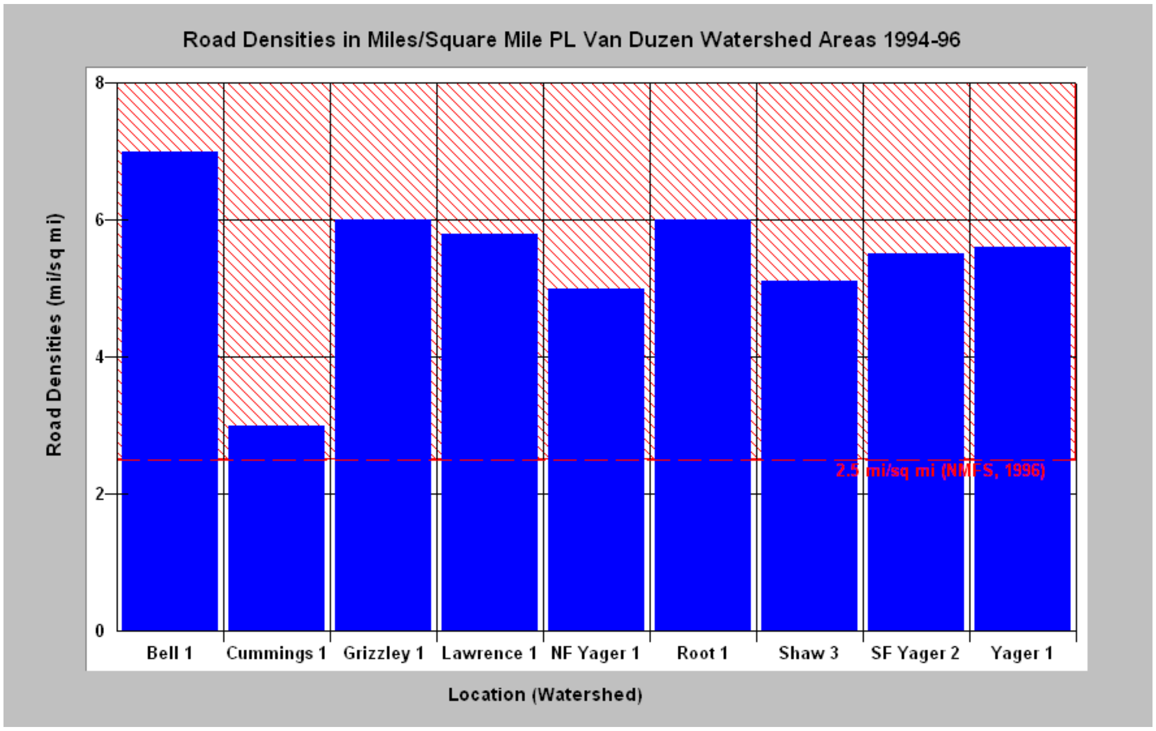

Figure 8. Road densities as calculated for the PL (1998) *HCP* show that road densities are all above levels recognized as properly functioning watershed condition even though they do not include temporary roads or skid trails.

trout do not occur in watersheds with more than 1.7 mi./mi.^{2}. The road density ranking system shown in Figure 9 was developed based on the Columbia basin findings.

NMFS (1995) required that road mileage be reduced with an emphasis on "road closure, obliteration, and re-vegetation" where road densities exceed 2 mi/mi^2 on USFS and BLM land in the interior Columbia River basin in order to protect Pacific salmon species. Other National Marine Fisheries Service (1996b) guidelines for salmon habitat characterize watersheds with road densities greater than 3 mi./mi.^{2} as "not properly functioning" while "properly functioning condition" was defined as less than or equal to 2 mi./mi.^{2}, with few or no streamside roads. Major haul roads parallel many streams in the Lower Van Duzen River basin, such as Yager and Lawrence Creeks. Figure 10 shows a close up of a near stream road and crossing in a headwater stream of Lawrence Creek, just one example of an epidemic problem with chronic surface erosion as well as potential for failure.

<u>Road Stream Crossings:</u> Failure of road-stream crossings poses a major risk of catastrophic sediment yield to streams. Although the *Van Duzen TMDL* categorized many crossings as at risk for failure, it did not recommend reducing the number or restricting their future construction associated with logging. Armentrout et al. (1999) recommended a limit of 1.5 crossings per stream mile to reduce risk of catastrophic cumulative effects damage related to failure of multiple crossings on one stream.

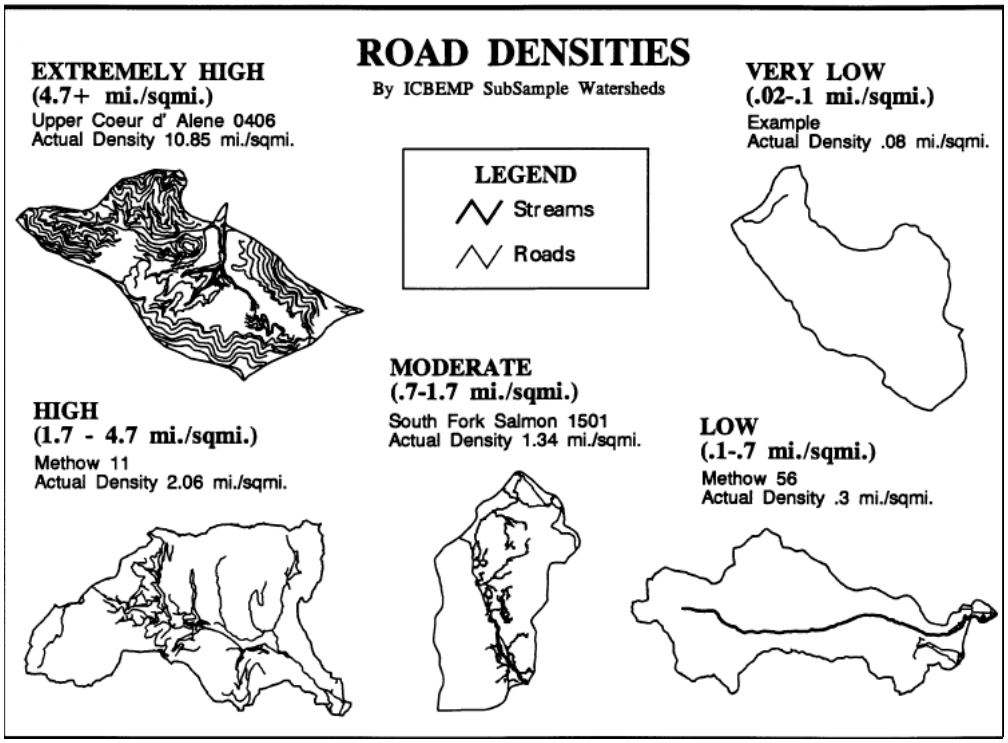

Figure 9. The USFS (1996) Interior Columbia River basin criteria for ecological and hydraulic risk from road densities are displayed here. Most Lower Van Duzen sub-basins fall into the Extremely High (>4.6 mi/mi^2) category.

Figure 10. PL logging road crossing a Lawrence Creek ephemeral tributary. The road provides a direct pathway for sediment. Notice also that logging and equipment operation has taken place up to the active channel. Photo by Doug Thron. January 1997.

Changes in Flow Regimes

Jones and Grant (1996) estimated that, when 25% of the area of a basin was impacted by timber harvest and roads, flow increases of 50% resulted. They explained this phenomenon as resulting from interception of subsurface ground water flows by road cuts. This causes roads to act as extension of stream courses and can result in major flow increases that can be very damaging to stream channels. Groundwater interception also decreases sub-surface storage that supports summer baseflows (Montgomery and Buffington, 1993). McCammon (1993) and Satterland and Adams (1992), as cited in Spence et al. (1996), had similar findings that showed increased peak flows resulting from alteration of 15-30% of a watershed's vegetation and concluded "that no more than 15-20% of a watershed should be in a hydrologically immature state at any given time."

Increased peak flows flatten channel profiles, reduce pool frequencies, blow out large woody debris, increase scouring of redds and cause bank erosion and inner gorge failure (Spence et al., 1996). While the *Van Duzen TMDL* treats most bank erosion as natural, it is likely that increased peak flows and sediment transport are contributing to the frequency and magnitude of these failures (Figure 11 & 12).

The combination of reduced base flows and extreme aggradation has actually caused many basin streams like Yager Creek to lose surface flow entirely in later summer and fall, the worst case scenario for fish. This includes the lower mainstem Van Duzen River just upstream of its convergence with the Eel River.

Large Wood Recruitment

Large trees that fall into coastal streams play a dominant role in forming pools, metering sediment, trapping spawning gravels and creating a more complex stream environment that promotes use by multiple salmonid species (Sedell et al., 1988). Redwoods are particularly valuable because a large tree may not decay for several hundred years (Kelly et al., 1995). The *Van Duzen TMDL* made the following statement regarding large wood in the Lower basin: "PL (1998) acknowledges that historic logging of streamside trees in the Yager Creek watershed has led to low canopy levels and consequently LWD recruitment problems in the near term." In fact, PL logged extensively in the riparian zones of all streams within its holdings in the Lower Van Duzen basin, including tributaries of Yager and Lawrence Creek (Figure 13 and 14).

Large quantities of wood may also be contributed to streams from unstable inner gorge areas or steep headwater swales that periodically fail naturally (Reeves et al., 2003). Reeves et al. (2003) studied a fourth order Oregon coastal stream and found that "about 65% of the number of pieces and 46% of the estimated volume of wood were from upslope sources." If these unstable areas are logged, failure rates increase but no large wood is delivered with sediment, as would normally be the case. PWA (1998) found that lack of large wood in debris torrents on logged hillslopes of Bear Creek in the Lower Eel River allowed much greater "runout" distance and; therefore, much greater length of damaged stream habitat.

Figure 11. Yager Creek 1997 aerial photo shows streamside landslide likely triggered by high flows and excess sediment transport at bend at upper center of photo. Other arrows denote CWE from timber harvest activity in riparian zones. Photo by Doug Thron from KRIS Coho.

Figure 12. Mainstem Van Duzen bank failure at County park is a symptom of aggradation.

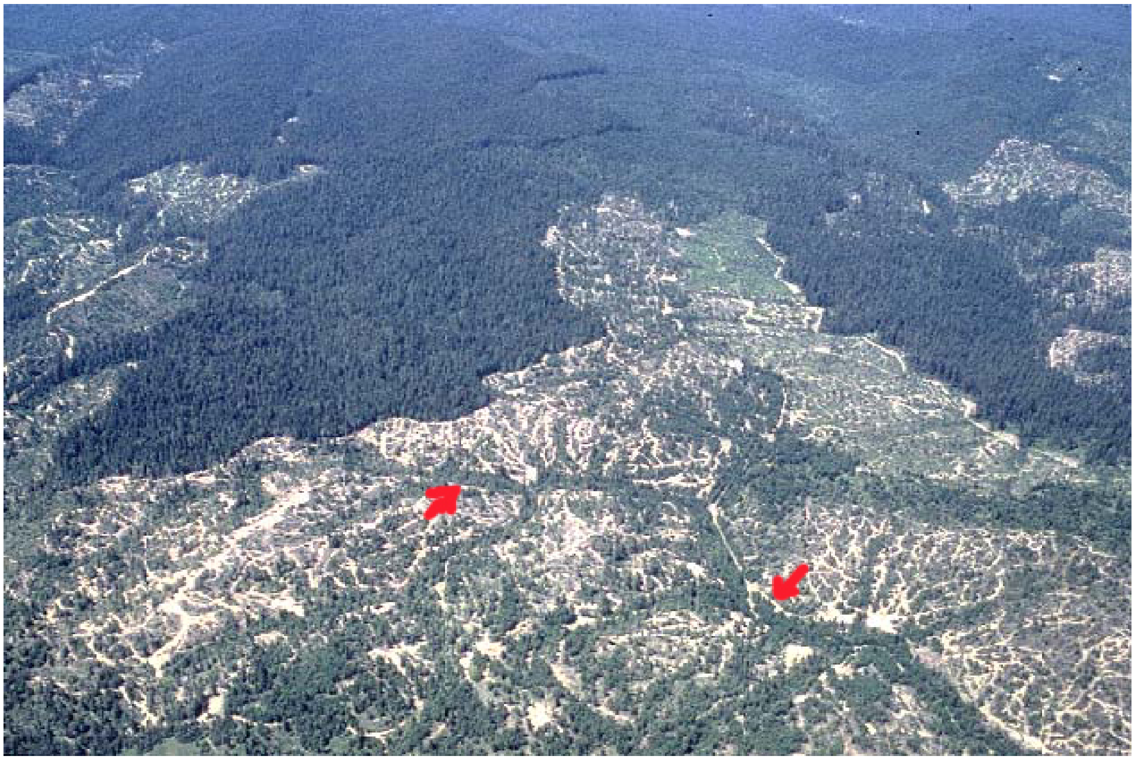

Figure 13. Headwaters Forest at top is over the divide in Elk River, but Corner Creek, tributary of Lawrence Creek, is in the foreground. Red arrows show almost no large tree retention in the riparian zones greatly reducing potential large wood recruitment and sediment buffer capacity. Photo by Doug Thron from KRIS Coho. Summer 1994.

Figure 14. Timber harvest has removed almost all large conifers from the riparian zone of the lower North Fork Yager Creek on PL ownership, thus reducing large wood recruitment for at least 50 years. Harvest extends upslope in inner gorge areas where landsliding might deliver whole trees to the stream. This type of harvest would not be permitted on Federal lands (FEMAT, 1993)

Removal of streamside trees at the streams edge and within two site potential tree heights leaves the stream open to direct sun and opens up airflow over the stream, making it subject to warming (FEMAT, 1993; Poole and Berman, 2001). The red arrows highlight streamside landslide, which typify features triggered by cumulative effects. Photo courtesy of Doug Thron. June 1997.

Changes in Channel Conditions Due to CWE

The CDFG approach to restoration of placing instream structures in Lower Van Duzen River tributaries has not met with success because cumulative watershed effects have caused shifting bedload and increased peak flows that dislodge them or bury structures in place. Hopelain (unpublished) found that only 23% of Grizzly Creek structures remained intact after storm damage and failure rates on Hely and Stevens creeks were over 40% (Figure 15).

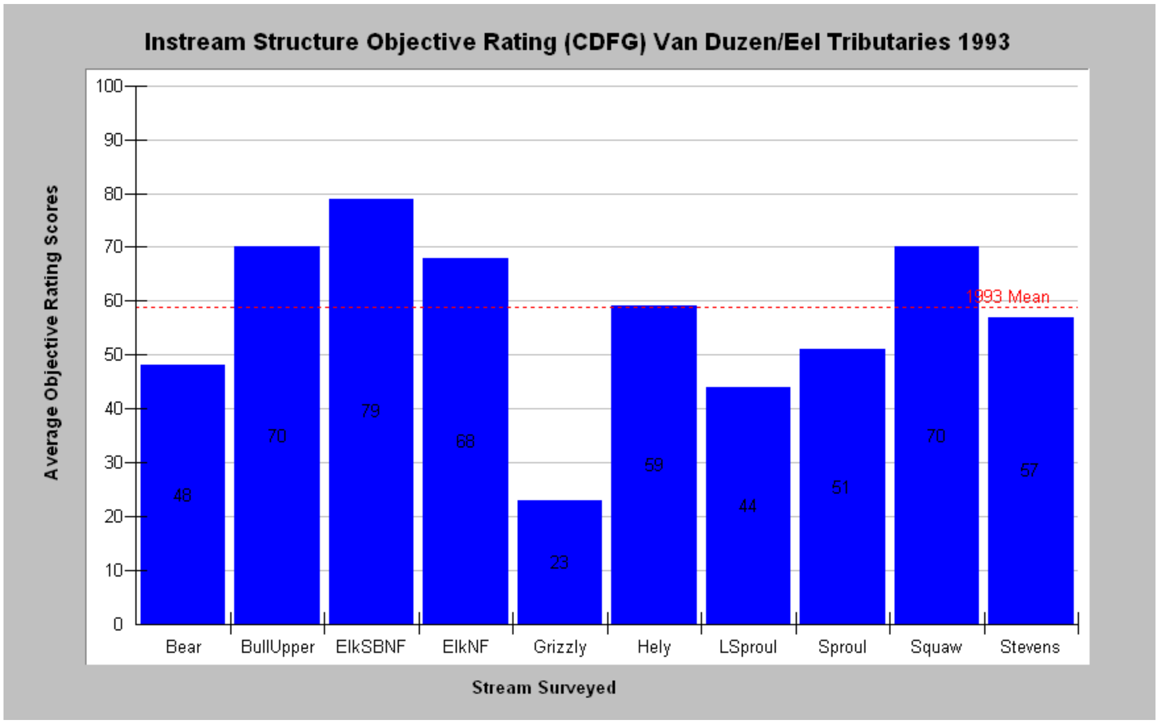

Figure 15. CDFG surveys of failure rates of instream structures in the early 1990's showed a very high failure rate for Lower Van Duzen basin tributaries (Hopelain, unpublished.

Aquatic Habitat Conditions

The *Van Duzen TMDL* did an adequate job of characterizing aquatic habitat. Targets set for water quality are scientifically defensible and appropriate as long term implementation goals. Aquatic habitat data from all sources are reviewed below with greater explanation of how these values reflect land use as well as their implications for Pacific salmon recovery. New data from the Van Duzen Watershed Project (VDWP) (FOER, 2007; Lee, 2007) are also discussed.

Although the *Van Duzen TMDL* does not deal with temperature issues, the temperature pollution in the basin is driven by cumulative effects from logging and is fully discussed below. Turbidity is not in the TMDL, but the science of turbidity and relationships to land use has advanced considerably since the TMDL was written (Klein, 2003) and data have been collected by the VDWP. This parameter has significant potential in on-going trend monitoring related to TMDL implementation and adaptive management.

Habitat Typing Data

The California Department of Fish and Game (CDFG) conducted extensive habitat typing surveys (CDFG, 2004) in the Lower Van Duzen basin that provide valuable stream inventory data. Pool frequency, pool depth and embeddedness are three metrics chosen for analysis here and also in the *Van Duzen TMDL*.

<u>Pool Frequency</u>: Coho salmon juveniles prefer pool habitat formed by large wood (Reeves et al., 1988), and yearling and older age steelhead juveniles also reside in pools (Barnhart, 1986). Murphy et al. (1984) found that natural pool frequencies in unmanaged streams ranged between 39-67%. Peterson et al. (1992) used 50% pool frequency by length as a reference for good salmonid habitat and recognized streams with less than 38% as impaired. CDFG (2004) recognizes having greater than 40% primary pools by length as a benchmark for healthy salmonid habitat. Surveys of Yager Creek and Lower Van Duzen tributaries (Figure 16) show pool frequencies ranging from 9-34% by length indicating severe to moderate impairment.

Reeves et al. (1993) found that pools diminished in Oregon coastal streams as the extent of timber harvest increased. Basins with less than 25% of their watershed area harvested over 30 years had 10-47% more pools than did streams in high harvest basins (>25%). The flattening of stream profiles and loss of pools in the Lower basin is consistent with cumulative watershed effects resulting from the widespread disturbance from logging and extensive road networks in these watersheds.

<u>Pool Depth</u>: Greater pool depth provides more cover and rearing space for juvenile salmonids and better shelter for migrating or spawning adults (Spence et al., 1996). Pool depths of three feet or one meter are commonly used as a reference for fully functional salmonid habitat (Overton et al., 1993; USFS, 1998; Bauer and Ralph, 1999; Brown et al., 1994). Lower Van Duzen River and Yager Creek tributary pools (Figure 17) are almost all less than three feet as a result of advanced cumulative effects and are, consequently, very poor salmonid rearing habitat. Tributaries that are small are cool enough for salmonids, but lack depth and while larger tributaries have deeper pools they are too warm in summer for rearing juveniles.

<u>Embeddedness</u>: The degree to which cobble or gravel at pool tail crests is buried in fine sediment or sand is known as embeddedness, a measurement made routinely in habitat typing surveys (CDGF, 2004). Pool tail crests are often chosen as locations for salmon and steelhead redd construction so embeddedness is a measure of spawning habitat quality. Elevated embeddedness is indicative of high fine sediment supply that makes redd excavation more difficult and decreases egg and alevin survival. Juvenile salmon and steelhead may hide within interstitial spaces of a cobble-bedded stream; therefore, embeddedness is also an inverse index for available cover. CDFG (2004) rates

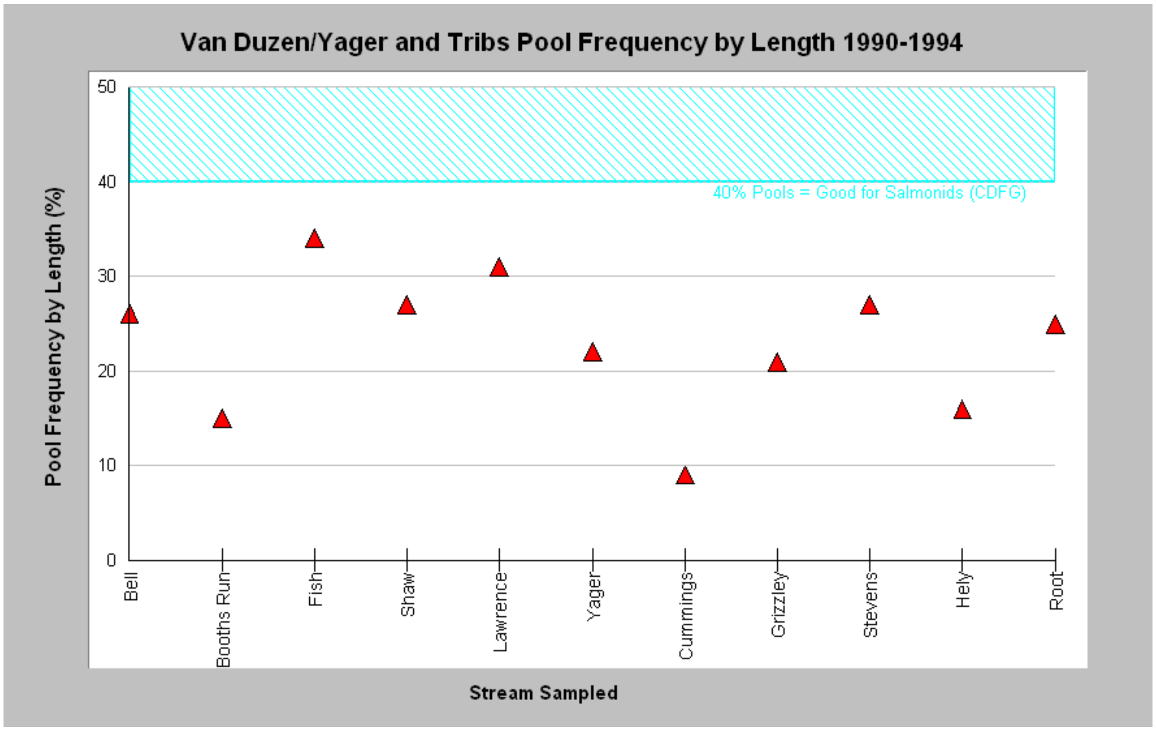

Figure 16. Pool frequency in lower Van Duzen River and Yager Creek tributaries show a very low pool frequency reflecting advanced cumulative watershed effects and significantly compromised habitat for salmonids. Data from CDFG.

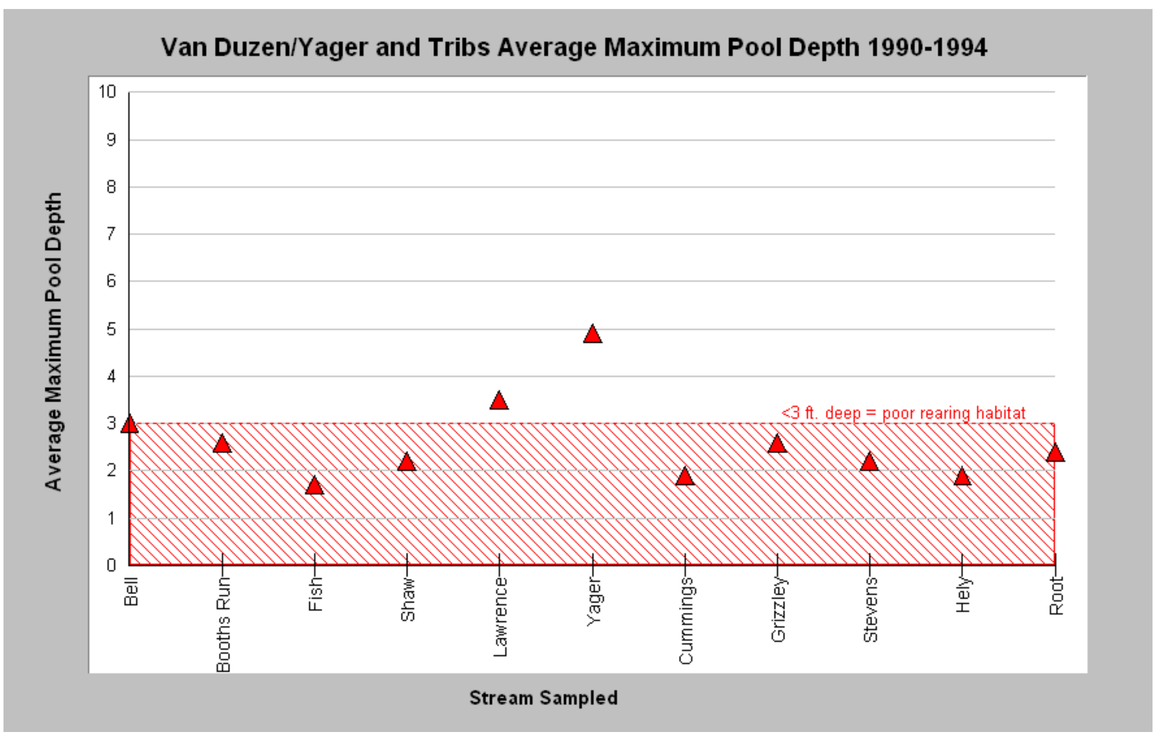

Figure 17. Pool depth in lower Van Duzen River and Yager Creek tributaries falls below 3 feet in all but the largest tributaries indicating significant limiting factors for coho and steelhead juvenile production. Data from CDFG.

embeddedness scores of less than 25% as good, while NMFS (1996) rated anything greater than 20% as not properly functioning.

Embeddedness in lower Van Duzen River and Yager Creek tributary pool tail crests ranged from an average of 40% in Stevens Creek to a high of 83% for the mainstem Yager, according to CDFG habitat typing surveys (Figure 18). These values reflect significant impairment with regard to supporting Pacific salmon spawning, which is a specifically recognized beneficial use under the Clean Water Act. High embeddedness is a reflection of an excess supply of sediment and cumulative effects processes described above.

PL *Habitat Conservation Plan* Data and Updates

The Pacific Lumber Company *Habitat Conservation Plan* (PL, 1998) supplied a wealth of data on aquatic habitat that are analyzed below, including aquatic macroinvertebrates, bulk gravel samples, and median particle size (D50) distribution of the stream bed. The *Van Duzen River TMDL* used fine sediment but not macroinvertebrates or D50. Macroinvertebrate data collected since the *TMDL* completion by the VDWG (Lee, 2007) is included in discussions.

<u>Aquatic Macroinvertebrates</u>: The *Van Duzen TMDL* did not use aquatic macroinvertebrate data to interpret aquatic health, despite their recognized power for evaluating water quality (Barbour et al., 1999). Since these animals inhabit stream gravels, their diversity and abundance can be significantly impacted if fine sediment or bedload mobility increases due to cumulative effects. Aquatic macroinvertebrates are also an important food source for salmonid fry, juveniles and smolts. PL collected aquatic macroinvertebrate data in lower Van Duzen River and Yager Creek tributaries from 1994-1996 following California RAPID Bioassessment protocols (CDFG, 1998).

The EPT Index is the number of species from the pollution intolerant orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). The presence of more than 25 taxa is indicative of high water quality, while fewer than 15 species signify an impaired condition (Kier Associates and NMFS, 2007). The Richness Index is simply the number of macroinvertebrate species present in a sample, with very good health equating with 40 or greater species. Impaired conditions are reflected by values lower than 25. Van Duzen tributary EPT Index values range from moderate health to impaired (Figure 19) and the Richness Index varies similarly (Fig 20). Reference values for relative aquatic health of southern Oregon and northern California streams were set for two diversity indices of macroinvertebrate diversity by Kier Associates and NMFS (2007) as part of coho recovery planning, which are adopted for this analysis.

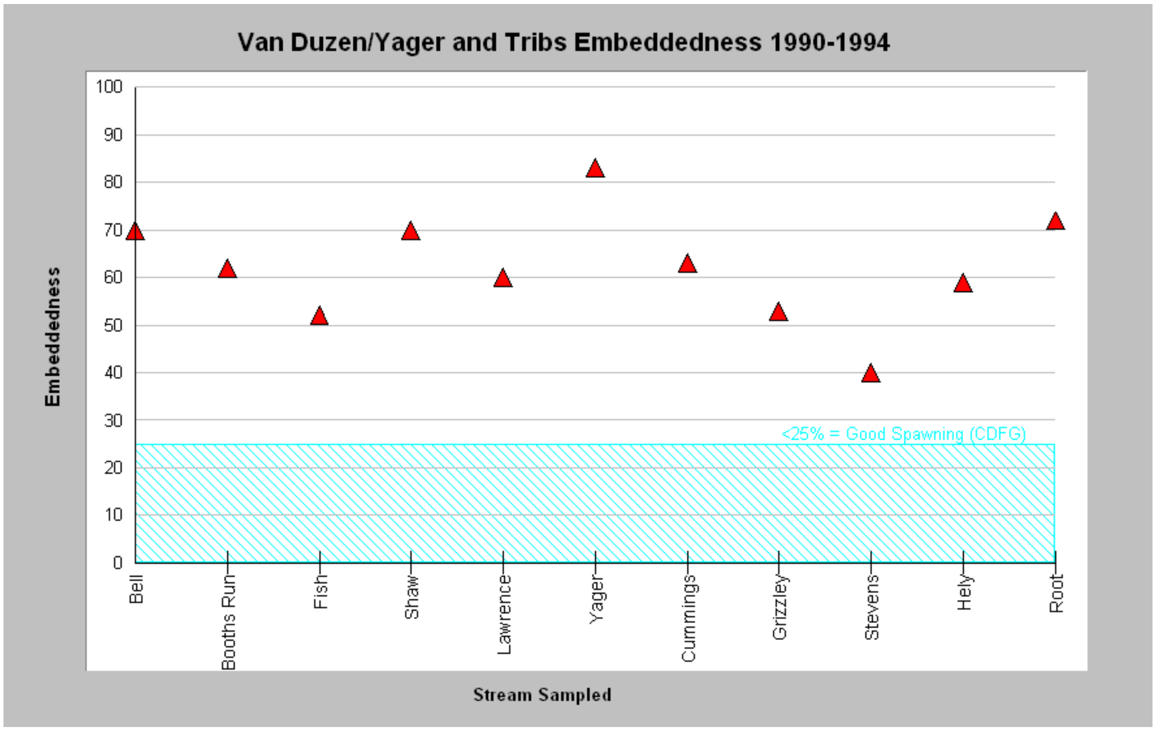

Figure 18. Embeddedness in lower Van Duzen River and Yager Creek tributaries shows very poor spawning conditions for salmonids according to CDFG standards. Data from CDFG.

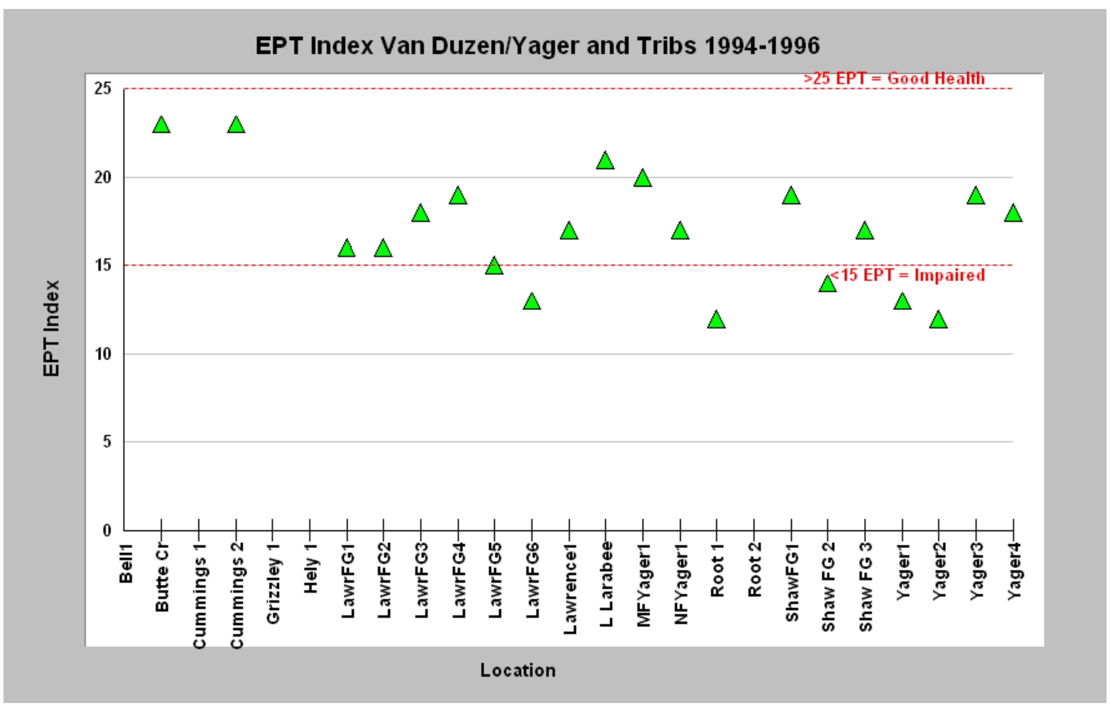

Figure 19. EPT Index values range from 12 to 23 indicating that most streams were in moderate health at the time of the surveys in 1994-1996, however, Lawrence, Root, Shaw and Yager creeks were impaired at that time. Data from PL HCP.

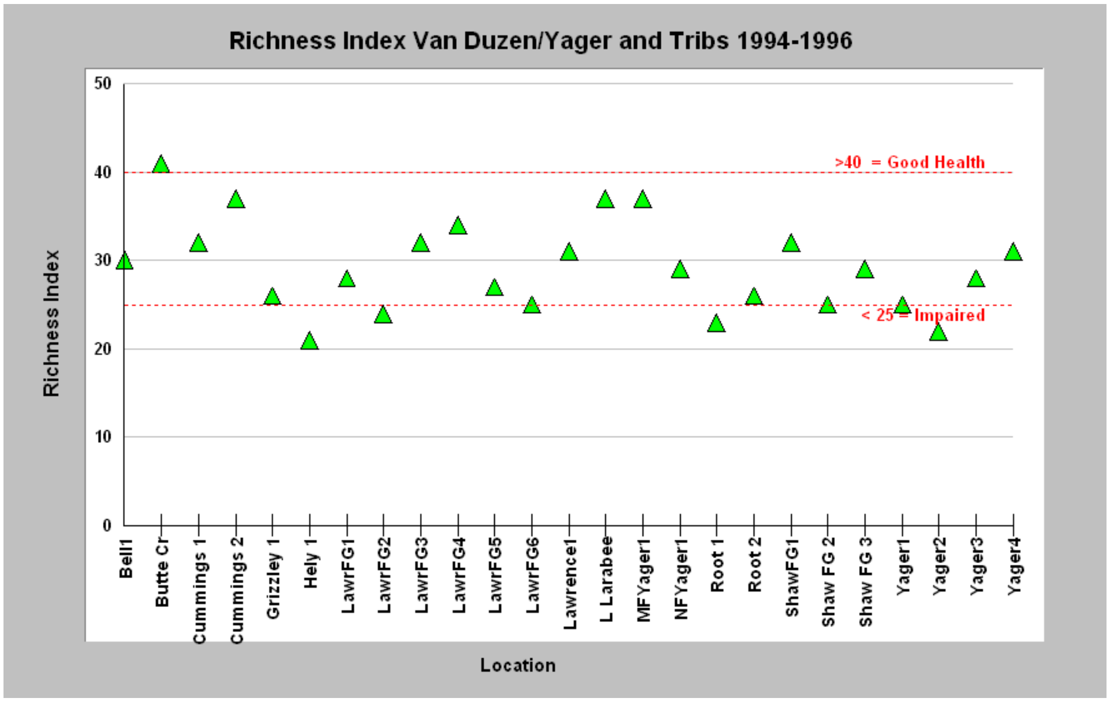

Figure 20. Richness Index values range from 21 to 41, indicating good stream health for Butte Creek (41 taxa) at the time of the survey, moderate health for many, but impaired conditions at some stations in Hely, Lawrence, Root and Yager creeks. Data from PL HCP.

Lee (2007) collected aquatic macroinvertebrates for the VDWG and Figure 21 shows results of Fall 2006 sampling at two mainstem Van Duzen River locations and in several lower river tributaries. Scores show extremely impaired conditions, with Wolverton Gulch (Figure 22) showing the least diversity of these pollution intolerant taxa (6 taxa). Lee (2007) notes that Wolverton Gulches smaller size would naturally lead to slightly fewer species than larger streams to which it is compared. Cummings Creek (Figure 23) is in slightly more advanced recovery from sediment impacts and shows slightly better health (10 taxa).

Results of macroinvertebrate diversity scores for the Van Duzen and Yager tributaries show striking similarity to changes in Freshwater Creek analyzed by Higgins (2003) as part of the PL Freshwater Creek Watershed Analysis. Years of sampling extended from 1994 to 1999 in Freshwater Creek and showed significant reduction in EPT and Richness as well as increased fine sediment levels following logging.

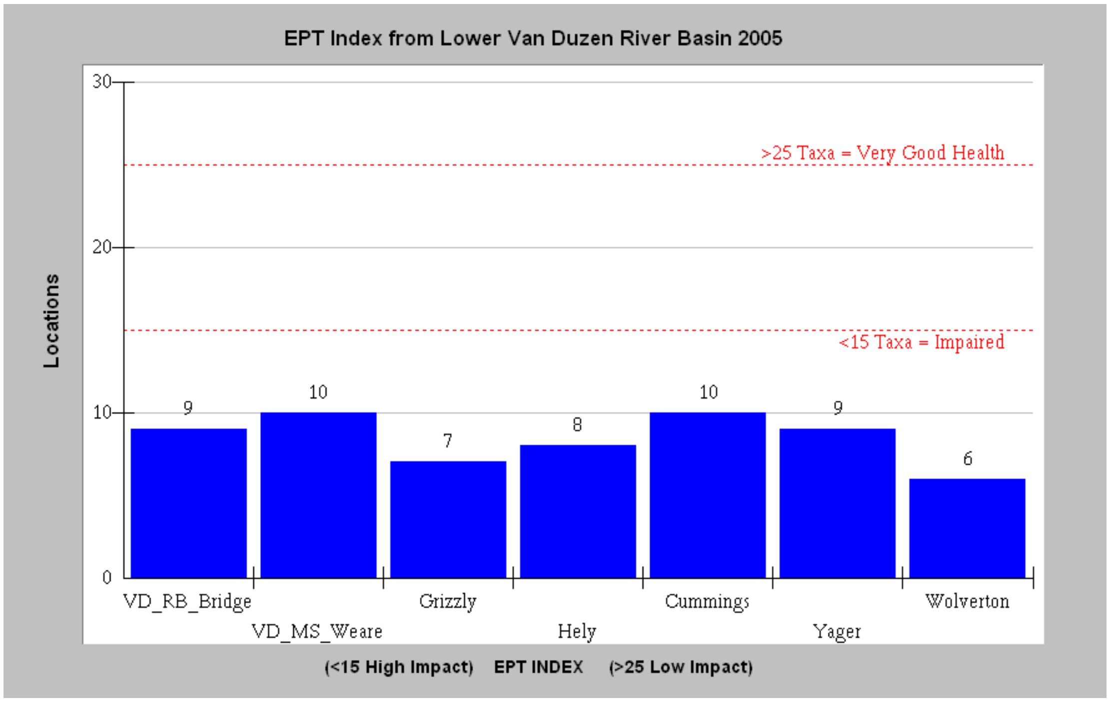

Figure 21. Samples from the mainstem Van Duzen (VD) and tributaries have very few pollution intolerant EPT taxa reflecting a high degree of impairment with regard to sediment. Data from Lee (2007).

Figure 22. Wolverton Gulch has very low macroinvertebrate diversity and shows signs of sediment impairment in this April 2007 photo. Photo from Van Duzen Watershed Group.

Figure 23. Lower Cummings Creek during winter flows in 2006. Note that bed is cobble and boulders, not fine sediment indicating early recovery. Photo from VDWG.

Fine Sediment

PL collected bulk gravel samples from Van Duzen and Yager Creek tributaries and published results as part of their HCP. Samples were analyzed for particles smaller than 0.85 mm, which are known to infiltrate salmon and steelhead nests (McNeil and Ahnell, 1964). PL also supplied data for sediment less than 4.7 mm, which represents sand sized particles and tiny gravel that may infiltrate substrate above redds and lead to capping that prevents fry emergence (Kondolf, 2003).

The *Van Duzen TMDL* sets targets of less than 14% fine sediment less than 0.85 mm and 30% for sediment smaller than 6.4 mm. McHenry et al. (1994) found that, when fine sediment (<0.85 mm) comprised 13% or greater of the substrate inside redds, it caused nearly 100% mortality of steelhead and coho salmon eggs. Kondolf (2003) found that 30% fine sediment 6.4 mm caused 50% mortality of salmonid eggs.

PL shovel sample results are displayed in Figure 24 and 25, with fine sediment less than 0.85 mm and less than 4.7 mm shown, respectively. Figure 26 combines Winzler and Kelly (1981) data for fines less than 0.85 mm and PL shovel samples for Lawrence Creek. Data show a major increase following logging and road building from approximately 10% to nearly double that between 1980 and 1994. No data are available since that time.

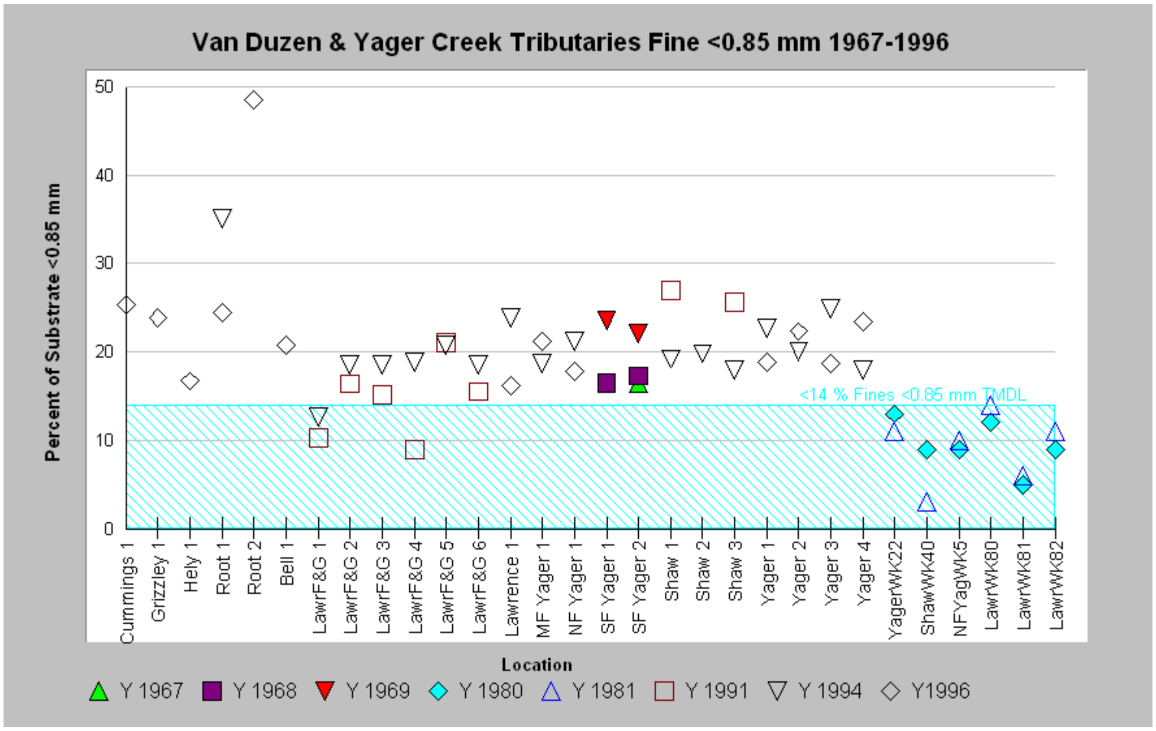

Figure 24. Fine sediment less than 0.85 mm is well over TMDL targets of less than 14% except in early 1990's and earlier samples. Data from PL HCP.

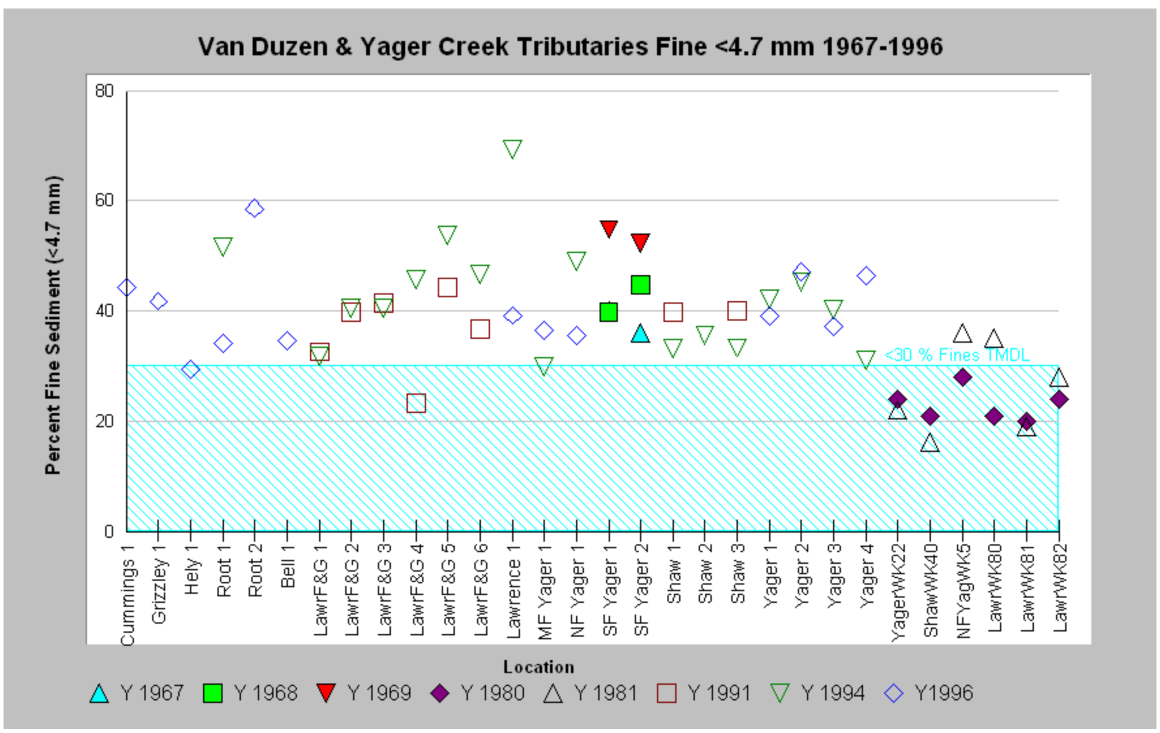

Figure 25. Sand and fine gravels (<4.7 mm) at PL sampling sites show levels well above those recommended by EPA and known to cause decreased salmon survival. Note that historic samples, except for the South Fork Yager, show much less sediment than recent ones. Data from PL HCP.

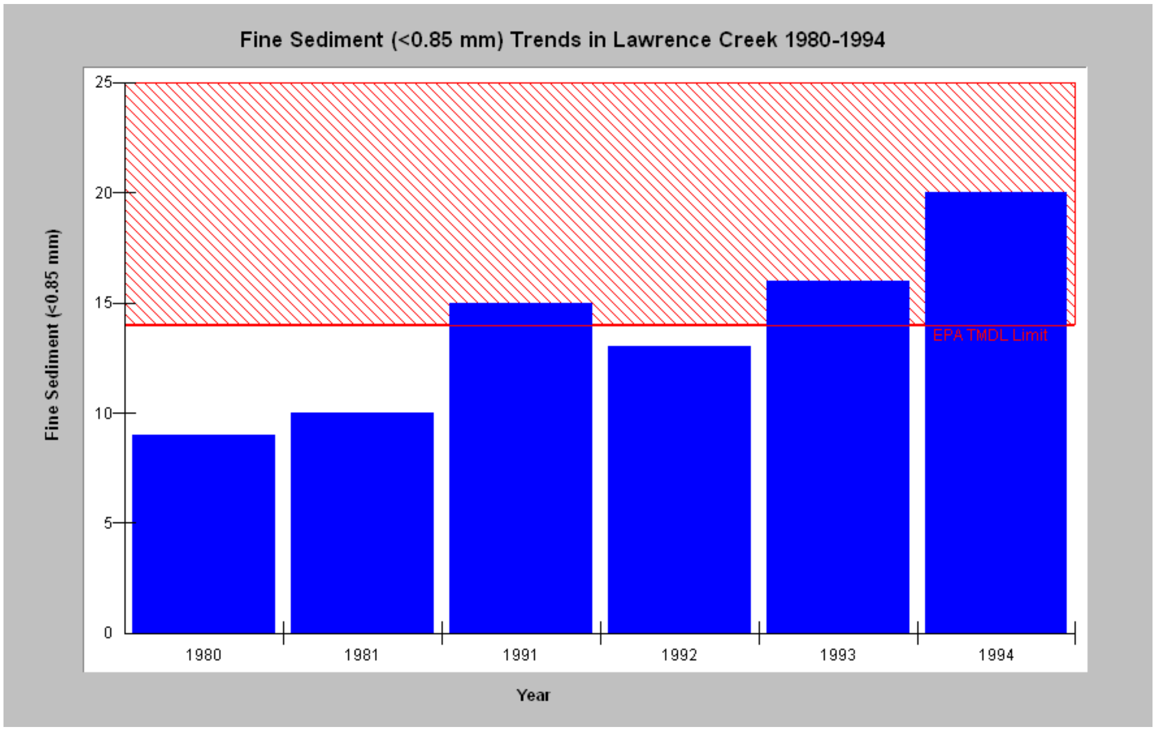

Figure 26. Fine sediment less than 0.85 mm was measured by Winzler and Kelly (1981) and by PL in more recent years (1991-1994). Fines rose from approximately 10% in 1980-81 to nearly 20%.

Results of fine sediment scores for the Van Duzen and Yager tributaries show striking similarity to those in Freshwater Creek analyzed by Higgins (2003) as part of the PL *Freshwater Creek Watershed Analysis* (PL, 2001). Barnard (1991) collected baseline information before recent wave of logging activity in Freshwater Creek using freeze core sampling. He found fines <1 mm in 1988, after about 40 years watershed rest from logging, ranged from 6-10% at mainstem locations. The overall average was 13% fine sediment outside redds and 7% inside redds due to cleaning action of salmon.

After logging, Higgins (2003) found a doubling or tripling of fines sediment of both size classes, which is very similar to the patterns shown above in Van Duzen and Yager Creek samples. SF Yager Creek samples collected from 1967-1969 (CDFG, 1966) also supply data cited in the *Van Duzen TMDL*, with levels noted as over optimal for both fines less than 0.85 mm (16-22%) and 6.4 mm (39-55%). This likely shows influence from the antecedent 1964 flood. Barnard found indications of lingering problems from previous land use in Freshwater Creek tributaries, with the South Fork Freshwater having 16% fines and Little Freshwater 26% fines less than 1 mm.

Median Streambed Particle Size

Knopp (1993) studied 60 northwestern California streams and found a relationship between the median particle size (D50) of a stream bed and watershed conditions. Control watersheds, or those that had recovered from disturbance, had a D50 of 52-88 mm. Values of less than 38 mm were correlated with recent, intensive watershed management. Reduced median particle size often indicates increased fine sediment contributions (Montgomery and Buffington, 1993) and increases likelihood of bedload mobility that can cause egg and alevin mortality (Nawa et al., 1990).

If peak flows are elevated due to cumulative watershed effects, then shear stress may also lead to an increase in median particle size. The U.S. Forest Service (Gallo et al, 2001), as part of aquatic and riparian assessment under the Northwest Forest Plan, uses median particle size for judging stream health through their EMDS model. Figure 27 shows the model rating curve where +1 is optimal habitat and -1 is completely unsuitable. The range of optimal gravel size for salmonid spawning is 65-95 mm and useable gravels extend from 45-128 mm.

Van Duzen and Yager Creek tributaries (Figure 28) show a high degree of variability of D50, although many fall within healthy ranges defined by EMDS. Root and Hely Creeks and Yager Creek (Site #1) all show impairment recognized by Knopp (1993) as coincident with intensively logged landscapes (<42 mm), with values also often well below the threshold for salmonid spawning (<45 mm). Indication of increased peak flows can be seen in larger stream channels like Yager Creek (#1 & #2) and Lawrence Creek (Site #1), with mean particle size showing extreme variability and sometimes considerably larger than can be used by salmonids for spawning (>128 mm).

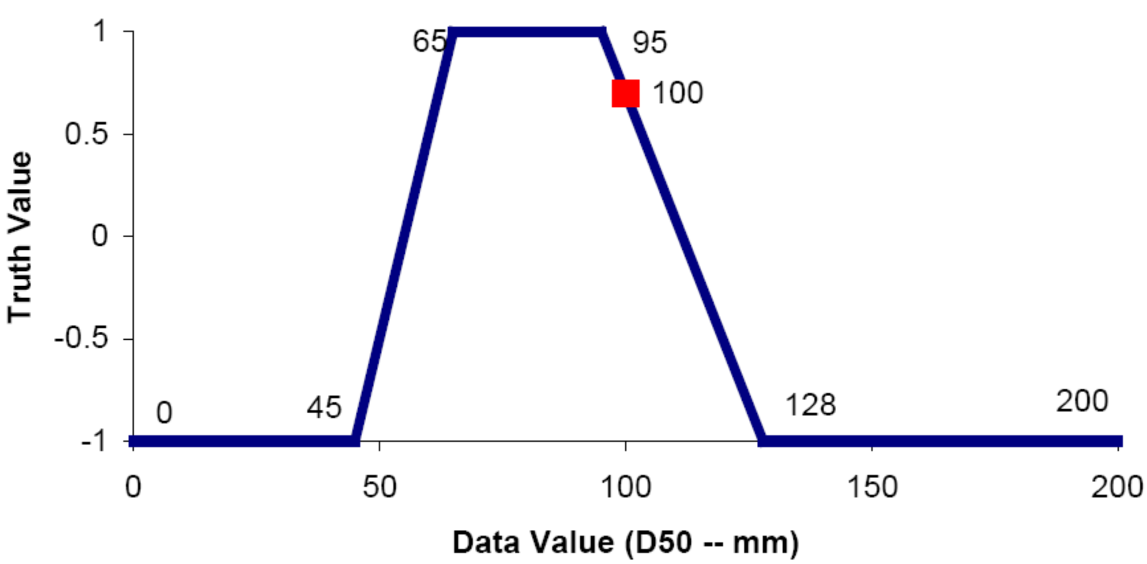

Figure 27. EMDS rating curve for D50 with optimal for salmonids between 65-95 mm and unusable below 45 mm and above 128 mm.

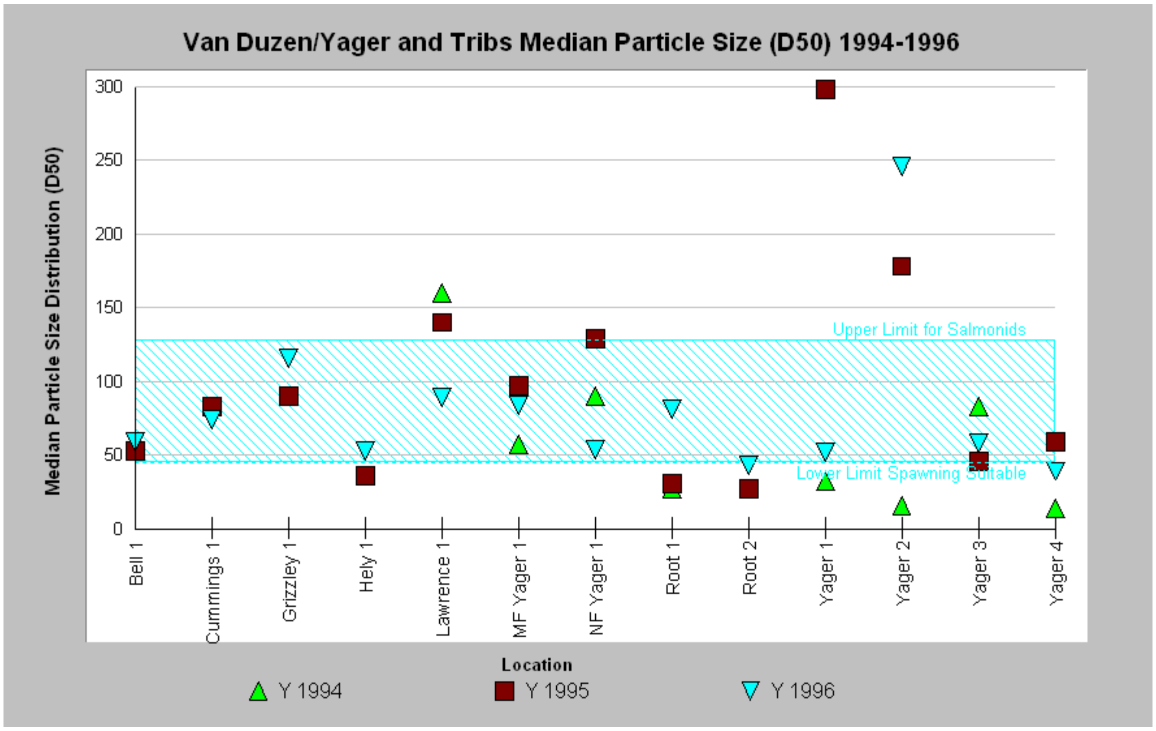

Figure 28. While many D50 values from Van Duzen and Yager Creek tributaries fall within the optimal range for salmonid spawning, values from Hely, Lawrence, Root and Yager Creek showing indications of impairment. Data from PL HCP.

Turbidity Data from the Van Duzen Watershed Group

The *Van Duzen TMDL* does not address turbidity, but regional studies of land use and turbidity (Klein, 2003) have made this parameter much more useful for understanding cumulative effects and the rate of recovery of sediment impairment. The Van Duzen Watershed Group has monitored turbidity (FOER, 2007) in a partnership with Salmon Forever, a non-governmental organization with experience in this field.

Turbidity is a measure of the ability of light to pass through water and the data are reported in nephlometric turbidity units (ntu). Turbidity affects the ability of juvenile salmonids to find food; consequently it can reduce growth rates and survival (Sigler et al., 1984). Higher levels of turbidity can be directly injurious to coho at all life stages (Newcombe and McDonald, 1991). The Oregon Department of Environmental Quality's (ODEQ, 2005) exhaustive review of literature on turbidity concurs with Newcombe (2003) that while the duration of exposure is important, 25 ntu should be a benchmark for impairment of salmonids:

"This is not out of line with Newcombe's (2003) assessment model regarding clear water fishes which predicts that a long-term turbidity level of 25 NTUs would be at the threshold for 'severely impaired' or 'poor' water quality conditions."

Klein (2003) demonstrated a strong relationship between watershed disturbance rates and the level and duration of turbidity in northwestern California streams (Figure 29). He

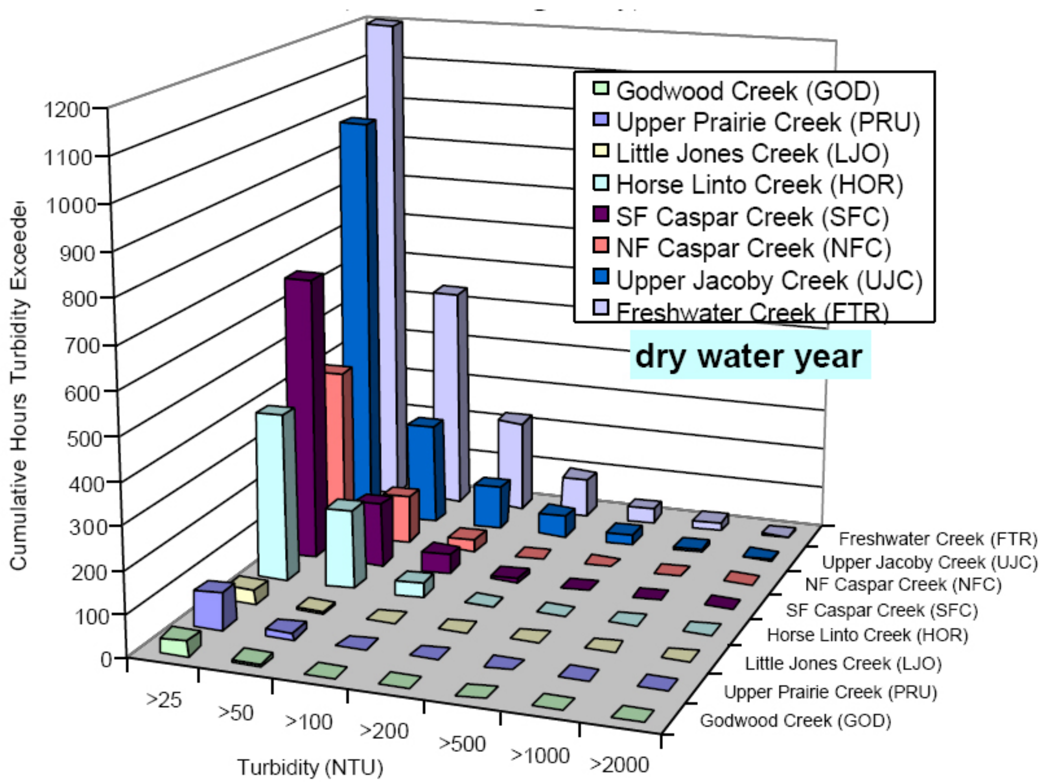

Figure 29. Taken from Klein (2003) Figure 7 entitled Turbidity Durations for Eight Northcoast Streams: WY2002 (October through May). Freshwater Creek is most heavily logged and Little Jones, upper Prairie and Godwood are control streams.

analyzed data from undisturbed watersheds and those with varying timber harvest rates and road densities and found logrhythmic increases as timber harvest rates rose from 1% of inventory (1% of a watershed per year or 25% in 25 years) to 2% and 3% POI, respectively.

Friends of Eel River (2007) found the highest turbidity and most prolonged periods of levels greater than 25 ntu in Wolverton Gulch. Relatively rapid decreases of turbidity in Cummings Creek indicate that sediment sources have healed as logging has gone into a period of inactivity. Recovery of pool frequency and depth and optimal sediment levels in the stream bed will require longer periods of time and biological response will follow.

Temperature

For the most part, the *Van Duzen TMDL* avoids the subject of water temperature, despite the fact that sediment from logging and roads is linked to recent major water temperature rises in the Lower basin, including Yager Creek and its tributaries. The *Van Duzen TMDL* acknowledges this historic linkage (post-1964), but not changes since 1985 resulting from recent logging:

> "Aggradation from the 1964 event resulted in the filling of formerly incised channels, channel widening, loss of riparian vegetation, increased bank erosion, loss of deep pools, and consequently increased water temperatures."

Coho juveniles are only found in northwestern California streams where the maximum floating weekly average water temperature (MWAT) is less than 16.8^{o} Celsius (C) (Welsh et al., 2001; Hines and Ambrose, 1998). Optimal growth for steelhead occurs in the range between 10-16^{o} C (Sullivan et al., 2001). Temperature data are those collected by PL, CDFG and the Humboldt County Resource Conservation District as part of the *Eel River Temperature Study* (Friedrichsen, 1998; HCRCD, 1999; 2000; 2003). When all Van Duzen basin sites are analyzed for MWAT (Figure 30), major problems for coho salmon and other salmonids are apparent. All mainstem Van Duzen and Yager Creek locations are in the range of stressful to highly stressful for salmonids. Larger tributaries that used to support coho salmon (Hallock et al., 1952) are now too warm to do so, including Yager, Lawrence, and Grizzly creeks. Very small tributaries still maintain water temperatures suitable for coho, but they lack sufficient pool frequency, pool depth, and spawning gravel quality to support them. This is very similar to the North Fork Gualala River (Higgins, 2007).

Welsh et al. (2001) noted that while using MWAT provides a good cumulative stress index, it may mask transitory peaks that indicate severely stressful or lethal conditions for salmonids. Sullivan et al. (2000) considered 25^{o} C the lethal temperature for all Pacific salmon species and Figure 31 shows that the mainstem Van Duzen River now routinely attains this temperature during summer. As a consequence, the mainstem Van Duzen River is dominated by invasive warm-adapted species like the California roach and the Sacramento pikeminnow (see Fisheries below).

Fish Population History, Status, Trends and Extinction Risk

The U.S. EPA and California State Water Resources Control Board both recognize salmon, steelhead and trout as beneficial uses (COLD), and their spawning habitats are afforded specific beneficial use protection (SPAWN) under the Clean Water Act. The following review of historical fisheries of the Van Duzen River, recent population trends and risk of extinction are all relevant to the TMDL process.

The Van Duzen has long been famous for its sport fishing, particularly its runs of salmon and steelhead. While there are no hard data on historic or recent fish run trends, it is clear from early press accounts and recent surveys that what was once a fabulous fishery has collapsed and that some species have disappeared. In its undisturbed condition, the Van Duzen River was teaming with anadromous fish species, including coho salmon (Oncorhynchus kisutch), chinook salmon (Oncorhynchus tshawytscha), coastal cutthroat trout (Oncorhynchus clarkii), summer and winter steelhead (Oncorhynchus mykiss), green sturgeon (Ascipenser medirostris) and the Pacific lamprey (Lampetra tridentata). All these fish spawn in freshwater and reach maturity in the ocean. Historical information is presented below followed by a description of what is known regarding the present status of each species and relative risk of extinction.

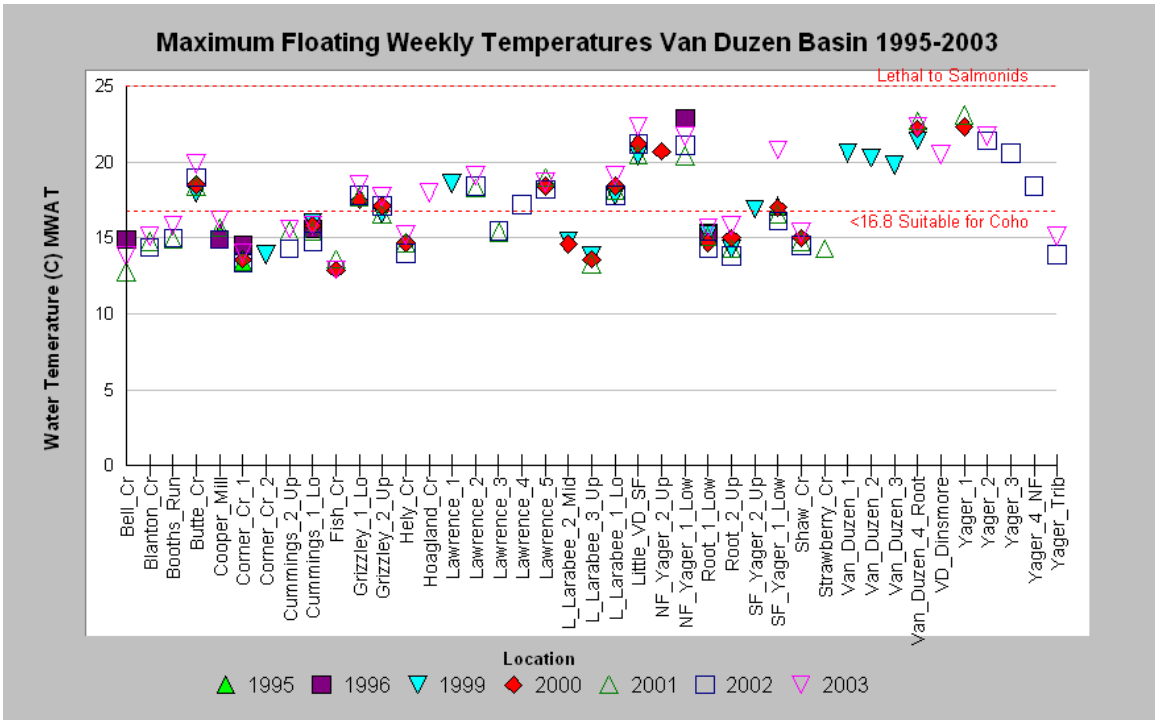

Figure 30. The maximum floating weekly average water temperature (MWAT) was calculated from continuous data for a number of Van Duzen River tributaries. Streams with MWAT's cooler than 16.8 C are suitable for coho, while those with an MWAT over 20 C are stressful or lethal for salmonids.

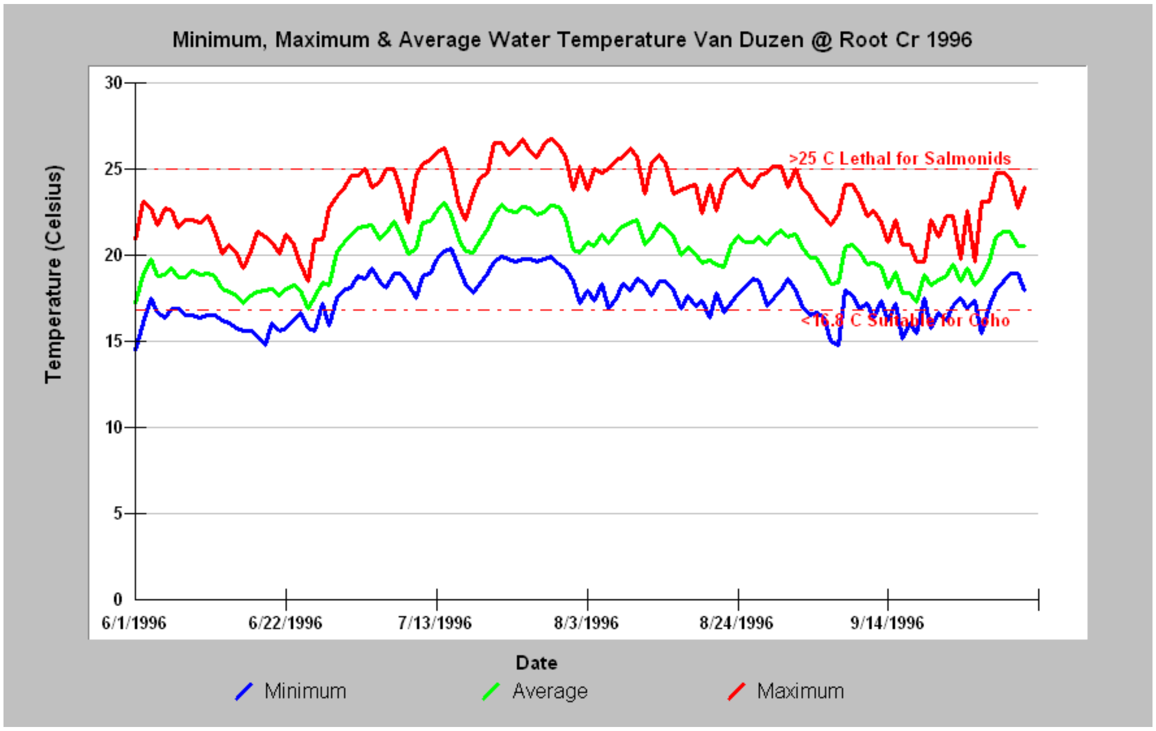

Figure 31. The daily minimum, average and maximum water temperature of the Van Duzen River above Root Creek shows that highs exceed lethal for salmonids.

History of the Van Duzen River Fishery

Historian Susie Van Kirk examined all the newspapers of Humboldt County from 1850 to 1955 and captured what was written about fisheries, floods, land use and the history of changes of Humboldt County rivers. Numerous illuminating passages provide insight into the glory days of the Van Duzen River, but also the biology of its fish and their use of habitat. Newspapers include the Humboldt Times (HT), which began publication in 1854, and became the Times Standard in 1967, and the Ferndale Enterprise (FE) that began publication in 1878.

On June 9, 1877 the Humboldt Times noted that “Indians, said to be from Hoopa, are fishing in Van Duzen, not far from the bridge. They are successful and the salmon trout they catch are a splendid fish, fat and in fine condition.” This is the first press account of summer steelhead on the Van Duzen, although the possibility exists that spring Chinook salmon were present as a sub-dominant summer-run species.

Summer steelhead seem to be confirmed in Yager Creek by an April 17, 1917 article (FE): "The annual run of steelhead salmon is on in Yager and the same conditions prevail as in the past as in regard to the barrier opposite the Porter place. The fish unable to get over the falls gather in great numbers at the foot of the falls.”

Green sturgeon were documented in the Humboldt Times in and below the Van Duzen River:

- James Smith caught a sturgeon in the Van Duzen which weighed 125 pounds and was 6 feet 2 inches long. (April 7, 1883).

- “More than one hundred large sturgeon have been killed in one deep place in Eel River, near the mouth of Van Duzen, in the last month (August 6, 1877).”

This indicates that the Van Duzen had deep holes suitable for these six-foot long creatures, before extensive watershed disturbance.

Good fishing conditions for smolts and adult summer steelhead made the Van Duzen, and the Eel River below its convergence, Humboldt County’s main summer fishing attractions from the 1850’s through the 1940’s. “Fly fishing in Eel river near the mouth of the Van Duzen is reported very good this week, and local sportsmen have been making some fine catches” noted the Ferndale Enterprise of July 27, 1906. Adult summer steelhead were still known to hold in the lower Van Duzen River and downstream in the mainstem Eel River all through summer as recently as the 1940’s and 1950’s (HT, 7/11/41; Murphy and DeWitt, 1952). These reports suggests much different conditions than today where pools are too shallow and water too warm for salmonids after May or early June.

The Ferndale Enterprise of November 8, 1895 stated that:

> "the upper Eel river and the Van Duzen have been visited by quite a run of fish this fall, owing to the rise in the river from the September rains. These fish have spawned and will help considerably in keeping up the fish supply."

This quote suggests that run timing and spawning were likely much different before aquatic habitat changes resulting from land use. The same paper (FE) documented fall Chinook salmon run timing of Eel River entry just before the 1955 and 1964 floods (Aug 26, 1949):

> "Salmon heading for their spawning grounds came into the Eel River Tuesday evening like jet propelled torpedoes, according to witnesses at the river, and were the first major run of the great sporting fish to make the entrance this season. Records kept by John Brazil and other sports fishermen of this section show the run to be on schedule, their data showing the first run can be expected in the Eel between August 24 and 27 each year.

Runs today in the Eel and Van Duzen usually start in late October or November. The lower Van Duzen River loses surface flow in August, when runs would have traditionally begun, and the mainstem Eel River has exhibited dry reaches in late summer in some recent years. Consequently, runs only begin when sufficient rain occurs for adequate flows for upstream passage.

Side Notes on Fishing as the Limiting Factor

The *Van Duzen TMDL* does not take into account depletion of fish populations related to fishing, but there is evidence that initial Eel River stock declines were caused by fishing (Figure 32). While Indians who inhabited Humboldt County for thousands of years did not over-exploit the fisheries of the Van Duzen and Eel Rivers, the same is not true of white settlers:

> "Fishermen are sweeping the river with seines from its mouth to the Van Duzen. It looks to us as though salmon would be scarce, if not entirely extinct, in Eel River in a few years, with the present way of fishing." (HT, November 8, 1879).

The wanton over-fishing depleted fish populations on the Eel River as early as 1888, as indicated by a precipitous decline in commercial net catches. Spearing salmon and steelhead on the spawning beds was common practice by white settlers and one that was defended in the press (FE, February 5, 1917):

> "Never before in the history of California, since the establishment of the Fish and Game Commission, has there been such an uprising against the hoggish sportsmen who want everything for themselves. They have overstepped the boundary line in attempting to stop spearing…."

Figure 32. Horse seine catch on the Eel River prior to 1880 in a photo from the Keir Collection used with permission of the Humboldt Room, HSU Library.

That diatribe is directed at sportsman who lobbied for legislation to protect the Eel River. They had come on the railroad beginning in the late 1880’s and were appalled at the commercial harvest of fish in the river using nets. They were joined by Humboldt County residents in calling for legislation to ban netting in rivers (FE, February 16, 1917):

> “We, the undersigned, residents of Humboldt county respectfully petition your honorable body to pass such legislation as necessary to prohibit the seining and netting of fish in Eel river, Mad river and their tributaries. The petition is signed by more than three thousand resident voters of the county and is the largest and most representative of any petition ever presented by the people of the county on any proposition. A great percent of those living along the river and familiar with the conditions and know what they ask for, have signed this petition.”

Netting and spearing were banned by 1922 and fisheries rebounded until about 1950, when habitat changes began to cause their decline.

A Note in Historic Hatchery Supplementation of the Van Duzen River

Artificial culture of salmon, trout and steelhead can often have major unanticipated consequences and cause harm to native fish populations (Higgins et al., 1992). It is likely that over-exploitation of fish stocks caused increased pressure to use hatcheries (FE, 1893): “That salmon are woefully scarce in Eel river is apparent to all and that the river should have a hatchery cannot successfully be disputed.”

Planting of salmon, steelhead and trout also took place in the Van Duzen:

> "Beginning as early as 1928, records show where hundreds of thousands of steelhead were planted yearly in such streams as Bear River, the Mattole, Butte creek, Russ Creek both the Van Duzens, upper Mad River and a host of others. This was kept up for several years" (FE, August 15, 1941).

Many scientific studies now show that transplanting of salmon and steelhead stocks to non-native waters leads to no sustaining benefits and instead cause a decline in local stock fitness to the degree that breeding between native and non-native hatchery fish occurs (PWA, 1994).

The most recent attempts at artificial culture were on Yager Creek at a small scale hatchery on Cooper Mill Gulch aimed at using native salmon and steelhead stock. The failure of this project was caused by problems with water quality after extensive logging upstream in the Cooper Mill Gulch watershed. Future restoration efforts on the Van Duzen should avoid use of culture and focus on protection of aquatic habitat and accelerating recovery of streams.

Status of Van Duzen River Anadromous Fish

Coho Salmon**:** Coho salmon co-evolved with the giant coniferous forests of the Pacific Northwest and are adapted to streams that are cold (10-15 C) and have an abundance of pools formed by downed wood (Groot and Margolis, 1991). Juveniles must spend a full year in freshwater to attain maturity and strongly favor pools formed by large wood as rearing habitat (Reeves et al., 1988). Northern California coho are absent from streams with a maximum floating weekly average in excess of 16.8^{o} C (Welsh et al., 2001; Hines and Ambrose, 1998).

Coho salmon would have been the dominant species in the small and intermediate sized low gradient tributaries of the mainstem Van Duzen and Yager Creek. CDFG (1964) stream surveys in late August on the mainstem of Yager Creek indicate suitable rearing habitat for coho existed throughout summer:

> "Seining was done near the mouth and the species identified were stickleback, rainbow trout, and silver salmon. The fish ranged in size from 2 inches to 12 inches. The most abundant were the 5-6 inch fish."

Figure 33. Coho salmon spawning in the Elk River in 1998. Note the red color of fish at furthest left, which is characteristic of male coho salmon.

Hallock et al. (1952) did a reconnaissance survey for juvenile coho that included Van Duzen River tributaries and found coho in Cooper Mill Gulch and Wolverton Gulch and Hely, Cummings, Fielder and Grizzly creeks. Brown and Moyle (1991) also verified historic presence of coho in Lawrence, Cuddeback, Root and Hoagland creeks. CDFG surveys of Yager Creek and its tributaries in the 1980's and 1990's show widespread presence in tributaries, but diminishing trends in both counts of adult coho carcasses and redds and in juvenile abundance during summer electrofishing surveys. CDFG surveys prior to the *Van Duzen TMDL* found coho juveniles only in Shaw Creek:

> "Recent field surveys have confirmed the presence of coho salmon in the Eel River and in tributaries such as the Van Duzen River (and its tributary Shaw Creek), Howe Creek, the South Fork Eel River, and in tributaries to Outlet Creek. Within the Van Duzen River sub-basin, another 14 tributaries were recently surveyed in which no coho salmon were observed: Wolverton Gulch (tributary to Barber Creek), Yager Creek and its tributaries Cooper Mill and Lawrence creeks, Cuddeback Creek, Fiedler Creek, Cummings Creek, Hely Creek, Root Creek, Wilson Creek, Grizzly Creek and its tributary Stevens Creek, Hoagland Creek, and Little Larabee Creek." U.S. EPA (1999).

In sum, the *TMDL* noted that : "Coho salmon were noticeably absent during recent surveys of many of the tributaries to the Van Duzen River, in contrast to older surveys conducted on those same streams." They did not mention the potential elevated extinction risk that this suggests (Rieman et al, 1993; Good et al., 2007).

NMFS (1996) listed the Southern Oregon Northern California Coastal coho salmon ESU populations as threatened under the Endangered Species Act (ESA) and more recently affirmed that level of risk (Good et al., 2005). CDFG (2002) found coho salmon in need of protection under the California ESA and they were subsequently listed as Threatened in northern California in 2004, including coho of the Van Duzen River basin.

The widespread disturbance of lower Van Duzen and Yager Creek watersheds since 1985 have created a homogenous and simultaneous degradation of streams suitable for coho. Smaller tributaries with suitable water temperature have insufficient pool frequency and depth to support coho juveniles and mainstem environments, where pools are deeper, have become too warm for coho rearing (i.e. Lawrence Creek). The risk of coho extinction in the Van Duzen is high, made higher by extinction or depression of other Eel River sub-populations (Good et al., 2007) as reported in the *Van Duzen TMDL* (U.S. EPA, 1999):

> "Similarly, recent surveys failed to find coho salmon in many of the smaller tributaries to the Eel River where coho salmon had been reported historically. Although coho salmon were recently confirmed in many of the South Fork Eel River tributaries, there were nearly as many streams in which coho salmon were not observed….. Coho salmon in the North Fork and Middle Fork Eel are now believed to be extirpated (Brown and Moyle 1991; CDFG 1994a).

<u>Chinook Salmon</u>: Spring Chinook return to basins with substantial snow melt and it is unknown whether the Van Duzen River had some minor component of this race prior to white settlement. If spring Chinook did occur in the Van Duzen, they would have been very vulnerable to exploitation due to their likely confinement in lower reaches. If present historically at any level, they likely went extinct early in the period of white settlement and before press accounts of catches.

Fall chinook were the dominant Pacific salmon species of the Eel River, with hundreds of miles of mainstem and large tributary habitat suitable for their spawning (USFWS, 1960). Records from canneries suggest that hundreds of thousands of salmon were caught, canned and shipped, although what portion of that catch would have been Van Duzen River fish is unknown. Fall Chinook still spawn in the Van Duzen and Yager Creek basins, although runs have undoubtedly declined in response to habitat loss.

Chinook have a competitive advantage over coho salmon in that their juveniles can migrate downstream as young of the year and do not require cold summer freshwater habitat for rearing. However, chinook survival in the ocean is greatly enhanced if they are able to grow to larger size in estuarine environments before ocean entry. Higgins (1992) noted that the habitat carrying capacity of the Eel River estuary, and the diversity and abundance of fish species it supports, have been greatly diminished due to sedimentation. This likely has negative consequences for Eel River and Van Duzen River Chinook survival.

The California Coastal Chinook salmon ESU, which includes the Eel and Van Duzen River, was recognized as Threatened in 1999 (NMFS, 1999) and their status confirmed in 2006 (NMFS, 2006). Their risk of extinction is likely lower than that of coho salmon, summer steelhead and cutthroat trout, but greater than that of winter steelhead.

<u>Steelhead</u>: Both summer and winter steelhead proliferated in the Van Duzen before white settlement, although information on summer steelhead distribution, behavior and abundance is greater. This is owing to the substantial interest of Humboldt County fishermen and associated press coverage. In 1917 H.E. Wilder of Carlotta sent an adult summer steelhead to the California Fish and Game Commission for analysis (FE, January 26, 1917). The fish had spent two years in freshwater and two years in the ocean and was

sexually immature when taken in June of the previous year, confirming the summer steelhead life history. This race of fish was thought to spawn with the first rains in fall and then return to the ocean (FE, 1917; HT, 1940).

After lower river netting and poaching were reduced, summer steelhead were still fairly abundant in the Van Duzen River (HT, March 11, 1941):

> "On the Van Duzen above Bridgeville….hundreds of steelhead concentrate in the deep holes of that stretch known as Eaton Roughs. There are falls there also, but the fish get through and go far up into the Little Van Duzen. They are able to go far up the main Van Duzen, but for some unknown reason, apparently do not."

Although there was no estimates of Eel River steelhead in early times, there were many fish to catch and the fall and winter run of steelhead began their entry into freshwater in August, similar to adult fall Chinook (FE, Aug. 6, 1907):

> "The steelheads fresh from the ocean are strong and vigorous and the fight they put up before yielding to the angler's wiles is worth a long journey to experience. These fish run all the way from one-half pound to twenty-pound in weight, the smaller being denominated 'half pounders,' the larger 'steehead.' Fly fishermen have been known to catch in a day's sport from eight to ten steelhead and twenty to sixty half-pounders, the latter varying from one-half pound to one and one-half pounds."

Steelhead that exhibit early entry into freshwater, after less than a year in the ocean, are known as half-pounders and are unique to the Rogue, Klamath-Trinity, Mad and Eel rivers (Barnhart, 1989). These fish feed as sub-adults off the continental shelf from the Eel River to the Rogue River. The half pounder life history is strongly linked to summer steelhead, with over 80% of Klamath and Trinity River summer steelhead exhibiting a half-pounder life history.

Figure 34. George Koortboojian holds up summer steelhead caught on April 1, 1988 at the mouth of Yager Creek. Photo by Pat Higgins.

Figure 35. Summer steelhead in the Middle Fork Eel River. 1988. Photo by Mike Ward.

The *Van Duzen River TMDL* estimated the population of Van Duzen summer steelhead as 100 or less, although 150 adults were counted in one reach in 2007 (Steve Canatta, personal communication). When adult vertebrate populations drop below 500 individuals, the population (or stock) is at high risk of extirpation (Gilpin and Soule, 1990) particularly from stochastic events, such as floods or droughts.

Winter steelhead are more resistant to habitat degradation than summer steelhead or coho salmon. Juvenile steelhead are better able to cope with stream warming and adults may leap further upstream to less impacted reaches than can be accessed by coho. Their ability to spawn in April and May allows their eggs and alevin to avoid mortality caused by shifting bedload, whereas chinook and coho salmon do spawn later than January.

The mainstem Van Duzen, Yager Creek and major tributaries like Lawrence Creek once had very high carrying capacity for two year old steelhead juveniles, but today their temperatures are stressful or lethal during summer. Loss of pool depth and frequency also compromised habitat for yearling and older steelhead (see Habitat Typing). Consequently, lack of older age rearing habitat is likely inhibiting winter steelhead recruitment and causing population declines.

Steelhead were listed as Threatened in the North Coast and Central Coast California ESU by the National Marine Fisheries Service (1998) and listing was upheld and reconfirmed in 2005 (NMFS, 2005).

Coastal Cutthroat: The Eel River is the furthest southern extension of the range of the coastal cutthroat trout and this species was known to occur in some lower tributaries such as Wolverton Gulch (CDFG, 1980). Cutthroat (Figure 36) are somewhat resistant to habitat degradation from sediment in that it shares late spawn timing ability with the

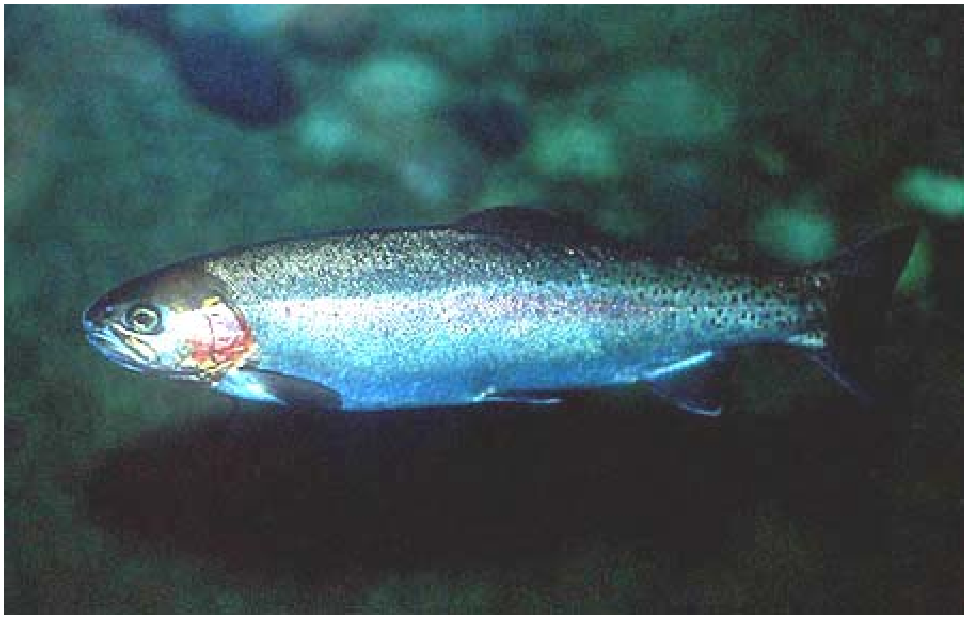

Figure 36. Adult cutthroat trout underwater. In the ocean cutthroat feed near shore to depths of 600 feet. Photo from FishBase website (www.fishbase.org).

steelhead. Additionally, the cutthroat has smaller egg diameter, which confers an advantage for tiny emerging fry because they can wriggle through small interstitial spaces in a sediment impacted stream. Conversely, Nawa et al. (1990) found that cutthroat juveniles were lost when water temperatures exceeded 70 degrees F. Older age juvenile cutthroat also prefer pools (Groot and Margolis, 1991) and decreased pool frequency and depth have likely contributed to their loss or decline in the Van Duzen River and its tributaries. No specimens have been collected in any CDFG electrofishing surveys since 1980, and this species may have already been lost from the Van Duzen River.

Green Sturgeon: The loss of deep pools has almost completely compromised the green sturgeon carrying capacity of the Van Duzen and Eel Rivers. Adult green sturgeon (Figure 37) are still occasionally seen in the Eel River in deep pools, but loss of habitat after the 1964 flood has all but eliminated them. Because these fish can live in excess of 60 years, those sited recently in the Eel River may hatched before the 1964 flood and could represents a senescent population. These fish do not have a protected status at the State or federal level, but protection under ESA has been requested by conservation groups.

Pacific Lamprey: The Center for Conservation of Biodiversity has recently petitioned the U.S. Fish and Wildlife Service to consider listing of the Pacific lamprey and three other lamprey species: "Pacific lamprey are still present in most of their native areas, but the large runs described as great 'wriggling masses of lampreys' seen ascending barriers and fish ladders in early spring, once characterizing streams such as northern California's Eel River, have largely disappeared" (CCB, 2007).

Pacific lamprey use clean stream gravels for spawning as do salmonids and are susceptible to sediment problems. Pacific lamprey formerly manifest both spring and

Figure 37. Green sturgeon can attain a length of greater than six feet and weight of over 500 pounds. They use barbels under their snout to sense electromagnetic fields of shellfish that they consume. Picture by Pat Higgins.

Pacific lamprey can use their sucking disk to move upstream over water falls and, therefore, have the advantage over salmon and steelhead of access to headwaters that have less cumulative effects damage. Lamprey juveniles or ammocetes lack eyes and spend from 4 years living in fine sediment along river margins. While fine sediment increases in the Van Duzen River might seem to augment ammocetes habitat, increased peak flows and associated bedload movement would increase juvenile mortality. Implications of high water temperatures and potential for predation by exotic predators are unknown.

Invasive Species: The California roach (Hesperoleucus symmetricus) and Sacramento pikeminnow (Ptychocheilus grandis) are both minnow species and both were introduced to the Eel River system. While the roach is relatively benign, the pikeminnow is a voracious predator of salmonids and other fish species and out-competes salmonids in the Eel River system due to its ability to thrive in warm water. The warming of the Eel River and its tributaries after the 1964 flood (Kubicek, 1973) has lead to a widespread reduction in salmonids and allowed a competitive release and increased numbers of roach and more recently pikeminnow. Figure 38 shows pikeminnow juveniles in a backwater on the South Fork Eel River.

Electrofishing sample by CDFG in 1991 from the lower mainstem of Yager Creek (Figure 39) showed that roach outnumber steelhead and that coho salmon were absent, reflecting warming associated with major aggradation. Pikeminnow are highly migratory and now dominate the mainstem Van Duzen River during summer low flow periods. The impact of predation on salmonids in the Eel River and Van Duzen River basin is not well studied, but there is substantial concern that pikeminnow are a significant limiting factor.

Figure 38. Juvenile northern pikeminnows can be distinguished by the strong, purple lateral line midway down the fish's sides. Photo by Pat Higgins, 1994.

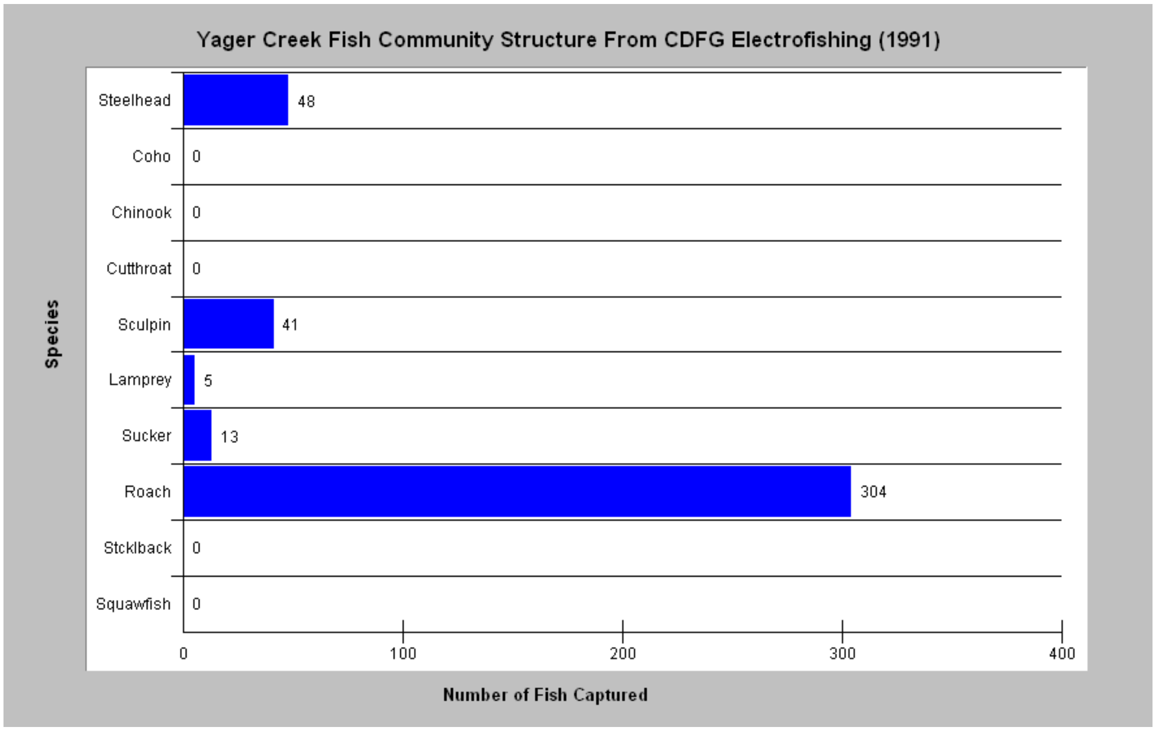

Figure 39. Yager Creek electrofishing survey results from 1991 CDFG habitat typing survey. Dominance of warm water adapted California roach shows advanced habitat degradation.

Pacific Decadal Oscillation Cycle and Potential for Salmonid Recovery

The *Van Duzen TMDL* preceded by four years the final report of the Independent Scientific Review Panel (Collison et al., 2003) for the North Coast Regional Water Quality Control Board, which found that if freshwater habitat is not restored when ocean conditions become less favorable and dry on-land climatic cycles return sometime between 2015 and 2025, the prospect for extinction of species like coho salmon will be very high. There is a need for prompt action, if the salmon and steelhead of the Van Duzen River are to survive into the future and Van Duzen River TMDL implementation should reflect this urgency.

Implementation/Restoration/Monitoring

The *Van Duzen TMDL* provides the following on implementation and restoration:

> “The overriding implementation need throughout the basin is for resource managers and agencies to conduct assessments to identify and prioritize controllable sediment sources, particularly road networks, and to implement appropriate prevention and control measures in a timely manner. Ideally, implementation of prevention and restoration activities will be prioritized by sub watersheds containing the greatest biological (fisheries) benefit, in accordance with strategies described by Bradbury (1995) and others.”

The *Van Duzen TMDL* fails to capture needed actions for implementation that achieves sediment pollution abatement because it ignores cumulative watershed effects. Sediment cannot be abated nor can water quality and fisheries be recovered unless anthropogenic sources of stress on habitat are lessened or abated (Kaufmann et al.,1999; Rieman et al., 1993), yet logging and road building has continued since completion of the *Van Duzen TMDL*. Despite recommendations to follow Bradbury et al. (1995), the TMDL does not specify the need to protect less impacted existing watersheds. Bradbury et al. (1995) recommend that the best intact habitats or refugia be protected as a priority and then watersheds adjacent are next in line for restoration investment.

<u>Prudent Risk Limits to Land Management</u>: TMDL implementation needs instead to set prudent risk limits for watershed disturbance (Table 2), which includes watershed rest as well as extensive decommissioning of roads to allow sediment reduction and restoration of a normal hydrologic function. These limits should include reduction of road density, road stream crossings and near stream roads. Timber harvest rates should never exceed 25% of a watershed in any 30 year period (1% POI). No timber harvest should be allowed in buffer widths similar to those recommended by FEMAT (1993) and Spence et al. (1996), which is a minimum of two site potential tree heights or 400 feet in redwood forests. Similarly, no timber harvest should be allowed or roads constructed within inner gorges, headwater swales or zones at high risk of landsliding (Dietrich and Montgomery, 1994; Dietrich et al., 1998).

Table 2. Recommended targets for watershed condition.

Parameter	**Upland Target Conditions**	**References**
Road Densities	<2.5 mi./sq. mi.	USFS (1996), NMFS (1995), Armentrout, (1998)
Road-Stream Crossings	<1.5 road crossings per mile of stream	Armentrout et al. (1998)
Streamside Roads	De-construct streamside roads and relocate haul roads to ridge tops	Bradbury et al. (1995)
Timber Harvest	<25% of a watershed in 30 years (1% POI)	Reeves et al. (1993)
Unstable areas	No disturbance in SHALSTAB high risk zones or inner gorges	Dietrich et al. (1998), FEMAT (1993)

The Van Duzen Watershed Group should continue to assemble a geographic information system GIS for TMDL implementation and adaptive management support as suggested by Dietrich et al. (2001). This should include 10 meter DEM based shallow landslide stability (SHALSTAB) model. This tool should be used to explore where disturbance, such as road building and timber harvest, has occurred and whether such areas yielded excess sediment through landsliding subsequent to management.

Electronic timber harvest data from CDF should continue to be updated and PL timber harvest back to 1985 should be captured from the National Geographic Redwood Transect project and used in CWE assessment. Studies in the future should also use hydrologic models to judge changes in flow regimes and the likely period for recovery. Grant's (1988) RAPID CWE technique should be employed in response reaches to gauge channel recovery and continuing problems with high flows and excess sediment yield.

Monitoring: Monitoring under TMDL implementation should adopt those parameters for which U.S. EPA numeric targets or to which standards above could be applied (Table 3).

The *Van Duzen TMDL* made the following recommendation regarding monitoring:

> "The development of a basin-wide monitoring plan would likely improve the efficiency between entities conducting monitoring and render the results of an agreed upon monitoring strategy more meaningful. A vital step in the development of a comprehensive monitoring strategy for the VDR is for a local agency (such as DFG or NCRWQCB) or group to play a leadership role in pulling together all the interested parties to develop a monitoring plan for the VDR. A comprehensive monitoring program will provide the basis for adaptive management.

Table 3. Recommended TMDL Implementation Trend Monitoring Methods and Locations

Method	**Reference**	**Target**	**Location**
Benthic Macroinvertebrates	Kier Associates and NMFS (2007)	EPT >25 species Richness > 40 species Percent Dominance < 20%	Repeat at previously monitored locations every five years or after major storm event
Large Woody Debris	Schuett-Hames et al. (1999)	Key Pieces > 3 per mile	Coho salmon tributaries lower than fourth order
Embeddedness	CDFG (2004)	< 25%	All stream sizes. Not necessary if more quantitative fine sediment data are collected.
Pool Distribution and Depth	US EPA (1998b)	> 3 ft.	Use habitat typing data or directly measure pool depths to gauge trends in all sizes of streams
Percent fines (<0.85 mm, 6.4 mm)	*Van Duzen TMDL*	Less than 14% < 0.85 mm fines Less than 30% <6.4 mm sand-sized	Same locations as PL but add tributary locations where fine sediments are a problem (Wolverton Gl.) or to gauge trends after restoration
Cross Sections	Kelsey (1974)	Recovery Trends (degradation)	Wherever there are previous monumented cross sections
Volume of Sediment in Pools (V*)	Lisle and Hilton (1992) and Knopp (1993)	<0.21 V* or roughly 21% of pools filled with sediment	Begin monitoring in as many creeks with low gradient reaches as possible.
Median Particle Size (D50)	Knopp (1993), Gallo (2002)	>42 mm <85 mm	PL monitoring locations and add stations since cost is low.
Turbidity	Klein (2004)	<25 ntu	Continue trend monitoring
Water Temperature	Welsh et al. (2001)	< 16.8 degrees C MWAT for tributaries	Continue monitoring at previously sampled locations and add.

Since no other agency or entity seems interested or willing to take a lead on monitoring pursuant to TMDL implementation, the VDWG should continue filling the niche of trend monitoring to support adaptive management.

Although most monitoring tools suggested for implementation support and adaptive management are discussed above, the volume of sediment in pools (V*) (Hilton and Lisle, 1993) was not. Pool volume is a good surrogate for juvenile coho rearing space and stream carrying capacity because of the species' recognized preference for pools (Reeves et al., 1988). Hilton and Lisle (1993) devised a method to quickly assess the ratio of the volume of sediment and water in a pool to the volume of sediment alone, to determine the residual volume of pools, and termed the measure V-star or V*. Knopp (1993) found a high correlation in northwestern California between the intensity of land use and residual pool volume as reflected by V*, with highly disturbed watersheds having values greater than 0.21. Regional TMDLs (U.S. EPA, 1998) and the NCRWQCB (2006) both use a V* score of 0.21 as a target for fully functional conditions.

Using a plumb line to test depth of mainstem Van Duzen River pools may be amuch less expensive method of gauging channel recovery than cross sections, although use of both for trend monitoring would be optimal. The VDWG should also consider excersises similar to those conducted in the Elk River in Oregon (USFS, 1998), where projected riparian regrowth and temperature recovery were modeled.

Conclusion

The Van Duzen Watershed Group should continue its trend monitoring activities and to work cooperatively with the North Coast Regional Water Quality Control Board and the U.S. EPA to make meaningful progress toward abatement of sediment and temperature pollution. The VDWG should also continue with public education to inform their neighbors and Van Duzen River stakeholders about the need for further action. The current extremely low ebb of Pacific salmon populations should be emphasized along with the urgent need for action before 2015-2025 due the PDO.

If Pacific Lumber Company is sold to new ownership, the VDWG needs to engage the new managers immediately to let them know the challenges of land management need to include salmon recovery and a return to more normal hydrologic function.

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