CHAPTER 1
State of the Watersheds
Causes and Sources of Impairment

Erosion leading to loss of redwoods along the Van Duzen River. Photo by P. Higgins.

Basin History

The history of the Van Duzen River Basin has not been well documented when compared to the much more abundant information available on the Eel River and its watersheds. However, we do know that the Van Duzen Basin has been characterized by dramatic changes since the introduction of the first European Americans. Since the early days of the white settlers in the area, the Van Duzen River Basin has been used for the grazing of cattle and sheep, dairy, and timber production.

Some of the earliest inhabitants of the Van Duzen Basin were the Lassik and the Nongatl sub-tribes of the Athabascan peoples of the Pacific Northwest (HRC 2009). The Lassik inhabited the upper portions of the VDR and the Nongatl seem to have preferred the areas around Grizzly Creek, Yager Creek, and Larabee Creek (CDWR 1976). Subsistence of the native peoples seems

to have been primarily hunting and gathering, which may have also involved burning of low grassland areas. Naturally, these groups tended to aggregate near good sources of food, especially in those times of the year when and where salmon were plentiful in the streams and when and where deer and other game were plentiful in the hills (Kroeber 1976).

History of the Van Duzen River Fishery

Historian Susie Van Kirk (1996) examined the newspapers of Humboldt County from 1850 to 1955 and captured what was written about fisheries, floods, land use, and the history of changes that have occurred in 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. Citations that follow are excerpts extracted from Van Kirk (1996).

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 a Ferndale Enterprise article of April 17, 1917 article: "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. (HT 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 (HT 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 River, and the Eel River below their 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 stream habitats changed as a result of improper land use. The populations of salmon that made these early runs in August and September have been completely lost, and their genes wiped out due to loss of habitat and inability of the fish to get up the river. The Ferndale Enterprise documented fall Chinook salmon run timing of Eel River entry in years prior to 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 most of the recent years. Consequently, runs only begin when sufficient rain occurs for adequate flows for upstream passage, and the genes of those early moving, typically very big fish, have been lost forever.

Fishing as a 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 1-1). 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).

Figure 1-1. Horse seine catch on the Eel River prior to 1880 in a photo used with permission of the Humboldt Room, HSU Library.

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 ...

The above diatribe was 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.

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, as described by 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 (Hard et al. 1992).

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. 1989). 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. A CDFG (1964) stream

survey on the mainstem of Yager Creek indicated suitable rearing habitat for coho existed and that coho juveniles were abundant:

> 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.

Hallock et al. (1952) did a reconnaissance survey for juvenile coho that included Van Duzen River tributaries and found coho in Cooper Mill Creek, Wolverton Gulch, Hely Creek, Cummings Creek, Fielder Creek, and Grizzly Creek. Brown and Moyle (1991) also verified historic presence of coho in Lawrence Creek, Cuddeback Creek, Root Creek, and Hoagland Creek. CDFG habitat typing surveys of Yager Creek and its tributaries in the 1980's and 1990's showed 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 (USEPA 1999) 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.

In summary, 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. 2005).

NMFS (1997) 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 (NMFS 2001, 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 River and Yager Creek watersheds since 1985 has 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, and is

made higher by extinction or depression of other Eel River sub-populations (Good et al. 2005) as reported in the Van Duzen TMDL (USEPA 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).

Chinook Salmon

Spring Chinook return to basins with substantial snow melt and it is unknown whether the Van Duzen River had some minor component of this population 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 the proportion of that catch that would have been Van Duzen River fish is unknown. Fall Chinook still spawn in the Van Duzen River and Yager Creek sub basins, although runs have obviously 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. Moreover, the carrying capacity of the Eel River estuary as well as the diversity and abundance of species it supports has been greatly diminished due to sedimentation, as reviewed by Higgins (1992). This outcome has had negative consequences for Chinook survival in the Eel River and the Van Duzen River.

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

Steelhead

Both summer and winter steelhead (Figure 1-2) proliferated in the Van Duzen River before European Americans settled in the area.

Figure 1-2. Summer steelhead in the Middle Fork Eel River. 1988. Photo by M. Ward.

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 ‘steelhead.’ 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 1986). 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.

The Van Duzen River TMDL estimated the population of Van Duzen summer steelhead in the year 2007 as 100 or less, although 150 adults were counted in one reach (Steve Cannata (CDFG) personal communication). When adult vertebrate populations drop below 500 individuals, the population (or stock) is at high risk of extirpation (Soulé 1987) particularly from stochastic events, such as floods or droughts (Rieman et al. 1993.

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

Cutthroat Trout (Figure 1-3) are somewhat resistant to habitat degradation from sediment in that it shares late spawn timing ability with the 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.

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). 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 Basin.

Nawa et al. (1990) found that cutthroat juveniles were lost when water temperatures exceeded 70 degrees F and warming likely contributed to their loss. 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.

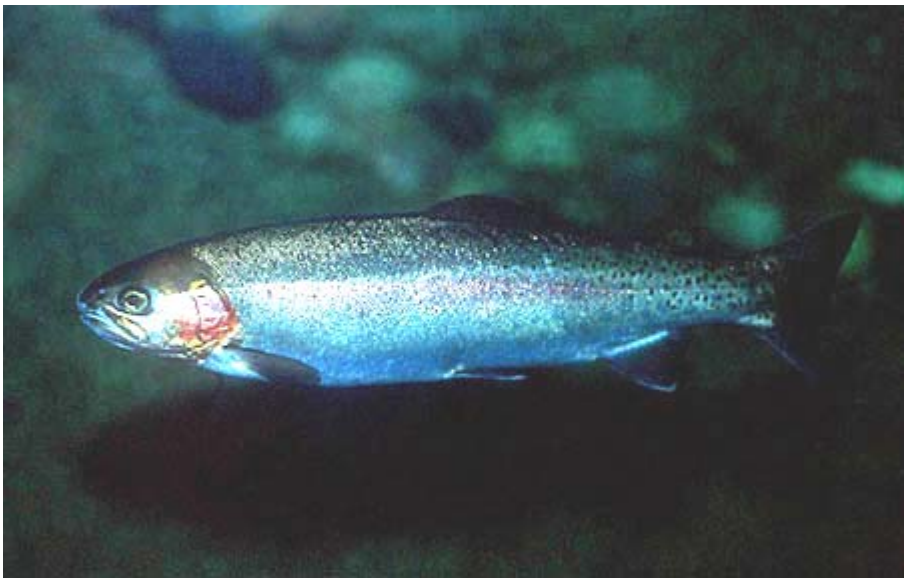

Figure 1-3. Adult cutthroat trout. In the ocean, cutthroat feed near shore to depths of 600 feet. Photo from FishBase website (www.fishbase.org).

Green Sturgeon

The loss of deep pools has severely compromised the carrying capacity of the Van Duzen River and Eel River for green sturgeon. Adults (Figure 1-4) are still occasionally seen in the Eel River in some 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 have hatched before the 1964 flood and could represent 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

In 2003 the Center for Biological Diversity, the Environmental Protection Information Center, and many other organizations petitioned the U.S. Fish and Wildlife Service to consider listing of the Pacific lamprey and three other lamprey species as threatened: “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.”

Pacific lamprey use clean stream gravels for spawning as do salmonids and are susceptible to sediment problems. Pacific lamprey can use their sucking disk to move upstream over waterfalls and, therefore, have an advantage over salmon and steelhead for 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.

Figure 1-4. 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. Photo by Pat Higgins.

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 1-5 shows pikeminnow juveniles in a backwater on the South Fork Eel River.

Figure 1-5. Juvenile northern pikeminnow can be distinguished by the strong, purple lateral line midway down the fish's sides. Photo by Pat Higgins, 1994.

Electrofishing by CDFG in 1991 from the lower mainstem of Yager Creek (Figure 1-6) showed that roach outnumbered 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 basins is not well studied, but there is substantial concern that pikeminnow are a significant limiting factor.

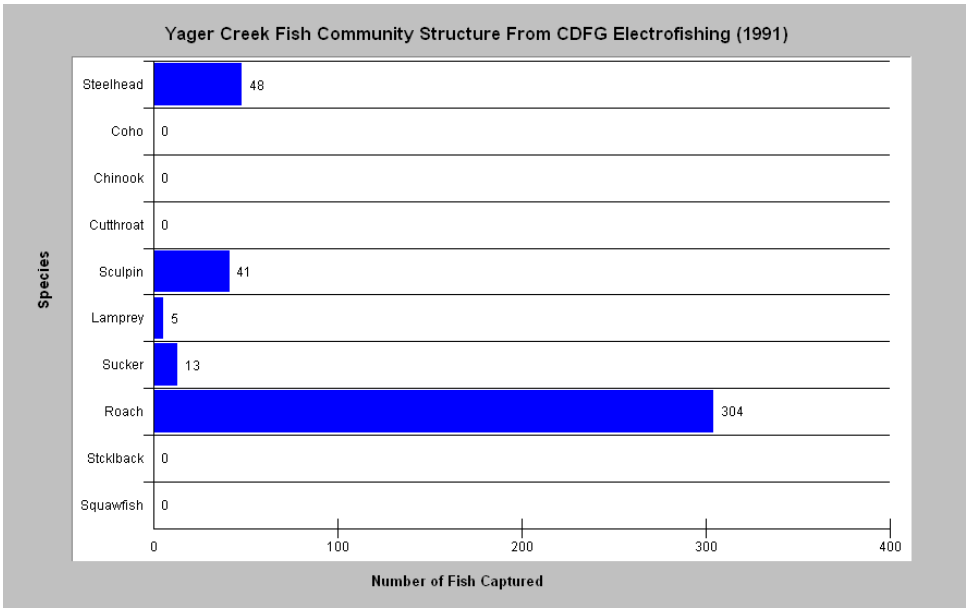

Figure 1-6. Yager Creek electrofishing survey results from 1991 CDFG habitat typing survey. Dominance of warm water adapted California roach shows advanced habitat degradation.

Causes and Sources of Impairment (Element 1)

The Beginning of Logging Culture in the VDR Basin

Since the days when it was first settled by Euro Americans in the middle of the nineteenth century, the Van Duzen River Basin has been used for agriculture, dairy, sheep grazing, and cattle ranching (Moore 1999). As American settlers became landowners and continued to desire more land, they engaged in the lumbering of timber which also served to clear the land for more grazing. Early methods of transportation were inefficient and restricted the amount of profit that could be derived from logging. However, by the early 1900s the arrival of the railroad allowed the cutting and transport of timber to increase to a faster pace, and made logging and timber harvesting much more profitable than before (Tetra Tech 2002b). Greater accessibility of these lands by the railroad allowed large scale timber operations to become established and for the first time, very profitable.

Early in the nineteenth century, there was no awareness of the impacts unrestricted timber harvesting was having on the land and in the streams. Over a period of the last 60 years, there has been a steady decline in the numbers of salmon, steelhead, and cutthroat trout in the streams of the Van Duzen watersheds, as well as those in the entire Eel River Hydrobasin. Anecdotal and statistical data have shown that these declines were associated with the onset of intensive logging activities that began in the early 1900s and flourished in the mid 1900s. Early logging activities generally followed a paradigm known as “cut and run,” which was based on the assumption that logging was a one-shot deal, and would be over after the big trees were gone (Moore 1999).

Logging that was conducted during the early to mid-1900s showed little regard for the ecological balance of the watersheds, and virtually no concern for the impact that logging, especially clear cutting, was having on the land or in the adjacent streams. Through the 1960s it was standard practice to log forests down to the streams. Logging activities resulted in wide spread removal of vegetation from large tracts of land, typically causing severe ground disturbance. Often harvesting was done on steep inner gorges, and provided little to no protection for stream channels or the riparian zone (HRC 2009).

The floods of 1955 and 1964 marked major changes in the hydrology of the Lower Van Duzen River Basin, as well as in the much larger Eel River Basin of which the Van Duzen is a part. Both floods caused major losses of stream habitat, but the 1964 flood was unprecedented in the amount of damage that was incurred to these major rivers and their tributaries. Once characterized by deep channels, most of the deep pools of the major streams were virtually obliterated in a single hydrologic year.

What was it about these floods, especially 1964 that made them so severe and caused such subsequent damage in their wake? Prior to 1964, Van Duzen and Eel River watersheds had been subjected to extensive skid trail and dirt road building, and were commonly stripped clean by

extensive logging, especially clear cutting of their slopes (HRC 2009). One could argue that excessive logging and removal of large amounts of vegetation coupled with "gypo" practices that left behind vast amounts of slash and debris, created the conditions that led to the devastation of the 1964 flood and that as result, the stage was set and primed for the catastrophe that followed. Water flow rates of streams within the lower basin are extremely important with regard to fish and other organisms that live in these streams throughout the year. In a natural situation with healthy, intact watersheds, flow is moderated year round – not too high in the rainy season and not too low in the dry season. Today, we see just the opposite – flash flooding in the winter and streams that run dry in the summer. Harvest methods as recent as 1980 through 2000 have demonstrated the damage to stream integrity that is caused by clear cutting and tractor yarding methods. This more recent era, during the Maxaam-Hurwitz ownership of the Pacific Lumber Company was characterized by a return to extensive clear cutting, almost resembling the cut and run methods of the gypo outfits 40 years earlier.

Clear cutting, especially when deployed with tractor yarding methods, removes all of the protective leaf litter and soil layers that serve to alternately absorb and release water from the hillsides. Ordinarily, thick layers of leaves, leaf litter, and duff (decaying leaf material) cover the soil in a typical forest and absorb water from rainfall throughout the rainy season. Standing trees also shield the soil from direct physical impact of rainfall. Water held in this natural reservoir is then released slowly throughout the rest of the year providing needed water to trees, streams, and fish. Removal of these protective layers by the scraping action of clear cutting and tractor yarding removes the inherent stability of these watersheds, resulting in flash flooding and dramatic release of sediment to the streams during the rainy season, followed by severe dry spells and drought in the summer, both of which are highly undesirable conditions.

The 1964 flood resulted in significant scouring of the stream channels, and transported record amounts of sediment downstream where it was deposited into the lower less steep reaches, leaving aggraded channels and a dramatic loss in the number and depth of pools. Flood waters stripped riparian vegetation and large woody debris from streams and increased stream bank erosion dramatically, thus allowing extreme lateral cutting and loss of large amounts of vegetated stream terrace (HCRCD 2002).

However, this explanation is incomplete. The 1964 flood occurred before no-cut buffer practices were in place. During these years it was standard to log right down to the edge of the streams, to use streams as skid trails, and to cross streams with heavy equipment (e.g., bulldozers) without even the most minimal of crossing structures (HRC 2009). Therefore, much of the vegetation in the riparian zone (when it included harvestable timber) was removed in the logging of these watersheds.

Much of the logging practiced during the mid-1900s, as mentioned earlier, was termed cut and run, where mills were set up and taken down quickly. These operations, harvested an area as fast as possible, giving little or no consideration to the aftermath and ecological destruction that had

occurred. Operators often left an area as fast as they entered, and did not attempt to survey or acknowledge the damage. A quote, supposedly from someone who saw conditions first hand (HCRCD 2002), was as follows:

> When they logged down to the creek, they punched that road in the summer of 1963. They didn't put in any culverts, except where there was running water in the summer. And then where they put the culverts in is where the fill blew out in the winter of 1963. The other thing they did is that they got down to the creek and they pushed the creek over to one side. They had the truck roads and landings, and skidded logs up and down the creek. They had the landings on the gravel bars – it was a nice open spot, everything came downhill, they had skid roads up the two smaller creeks that fed into the large creek. They put a road in at the bottom of this one place. There is a gorge down at the bottom and there is a fairly steep little watercourse that comes down, they just filled that for three years in a row, and it would blow out every winter.

It is unlikely that water alone was responsible for removing the riparian vegetation. Much more likely is that large amounts of debris, including logs and slash that remained after logging, came off the slopes and became part of water column that took out most of the remaining riparian vegetation. It is easy to envision the action of floating logs and debris scouring a channel. During years following the 1964 flood, aggradation of channels led to conditions of chronic floodplain bank erosion and subsequent massive earthflows directly into the streams and rivers, especially during the winter months. In general, forests comprised of large trees serve to hold back processes that result in mass wasting. Thus, removal of most of these large trees released massive amounts of earth in the form of mass wasting, and mud flows and landslides, delivering this additional sediment and silt into the streams, which compounded the severity and secondary effects of the flood (HRC 2009).

Several additional factors exacerbated the severity of the 1964 flood. One of these factors was a change in the tax structure from one that taxed the amount of timber removed from the land to taxing the amount of standing timber on the land (HCRCD 2002). This restructuring of taxation of forest land was a catastrophic mistake that resulted in the immediate acceleration of logging, which reached record levels in the watersheds of the Van Duzen River Basin, and probably everywhere else in which the new law was applied. This acceleration of logging activity and its repercussions occurred just prior to the 1964 flood. A second factor was that winter conditions were much more severe 40 years ago than they are today. The dramatic change in weather conditions from decades past to the present, suggests that a cataclysm the size of the 1964 flood has very little chance of occurring again in this era. Climatic conditions over the last 10 years especially, closely mimic those that would be predicted using global warming models (i.e., increased temperatures and reduction in average rainfall).

Undoubtedly, logging practices have improved since the days of "cut and run" gypo operations of the past. Because of greater regulation and public awareness, lumber companies today probably harvest timber in a more environmentally compatible manner than 60 years ago. Early

logging practices commonly built roads without regard for erosion and delivery of sediment into streams, completely removed protective riparian vegetation, skidded logs downhill, using streams as skid roads, and resulted in massive movement of soil and clay materials directly into streams (HRC 2009). Prior to the 1973 Z'berg-Nejedly Forest Practices Act (FPA) and the California Forest Practice Rules (CFPRs), there were virtually no protective practices employed by logging operations around streams of any kind.

According to the Yager-Lawrence Watershed Analysis (HRC 2009), CFPRs resulted in much greater protection for streams and their associated riparian areas. For example, ground disturbance was significantly reduced and limits were placed on timber removal. They also resulted in the establishment of requirements for reforestation, and the exclusion of heavy equipment operations in stream channels.

However, many local residents noticed a dramatic increase in the clear cutting of old growth redwoods and a significant increase in the acreages harvested beginning around 1985, the year that marked the purchase of the of the Pacific Lumber Company by Maxaam, and continued through 2008 when the company again changed ownership. Many landowners and other members of the communities within the lower basin have provided anecdotal evidence and testimony as to the high level of intensity with which timber was being removed from the Lower Van Duzen Basin during this period of time.

In a letter to the Board of Forestry, the Office of the California Attorney General in 2009 stated that a scientific panel conducted a comprehensive review of the California Forest Practice Rules regarding the potential of these rules for protecting salmonid species. The conclusion of the report filed in 1999 was that these rules and their implementation through the timber harvest plan (THP) process do not ensure for the protection of these species. According to the above letter, the Forest Practices Act only speaks of "giving consideration to" natural resources other than timber products, and thereby questions the intent and commitment of the document toward safeguarding the other equally important parts of the forest ecosystem that could be included as beneficial uses of water and watersheds.

Since the purchase of the lumber company by Mendocino Redwood, which changed the name from PALCO to Humboldt Redwood Company, a new paradigm and new strategies may be in place to better facilitate a more environmentally compatible operation. The adoption of **Best Management Practices (BMPs)** is an important step towards that goal and may help bring about a more sustainable use of our forests and put greater emphasis on the beneficial uses of water.

Geology

Considerable research has contributed to our understanding of the Van Duzen River Basin over the last 40 years, especially with regard to geology. Kelsey (1977) performed the first comprehensive geological study of the basin, which was followed by several subsequent studies

leading to the development of an estimate for Total Maximum Daily Load, or TMDL (PWA 1999, USEPA 1999). A TMDL is defined as the sum of the individual waste load allocations (WLAs) for point sources, and load allocations (LAs) for nonpoint sources and natural background, such that the loading capacity of the receiving water is not exceeded. Therefore, the TMDL for the VDR can be divided into the natural and management-related load allocations:

TMDL = WLAs + LAs (natural and management-related) + Margin of Safety

As there were no previously known point sources of pollution, WLA is equal to 0, and the units for load allocation (LA) were cubic yards sediment per square mile, which can be converted to tons of sediment per square mile using a multiplicative constant of 1.76. All TMDL metrics were considered to be on a 10-year rolling average to account for the very large inter-annual variability and the time frames required for beneficial impacts to be observed. However, it also probably accounts for the intervals between the times that projects of this magnitude can be undertaken for data collection. The method that was used to develop these estimates, called stratified random sampling, required extensive field work and photo interpretation, and identified erosion and sedimentation as the main nonpoint source of pollution affecting beneficial uses of water in the lower basin. Beneficial uses include cold water fisheries and overall water quality (Humboldt County RCD 2002).

Basin stratification in the TMDL, based on Kelsey (1977), identified 5 major types of stratum, including generally stable sandstone, potentially unstable sandstone and active slides, generally stable serpentine and alluvium melange, older slump earthflow melange, and active slump earthflow melange (PWA 1999). PWA divided the Van Duzen Basin into 3 parts, labeled the Upper, Middle, and Lower domains, based largely on differences in geology. However, the three domains are not hydrologically consistent, and the lower basin (or domain) in the PWA TMDL study is not geographically consistent with the Lower Basin in our (VDWP) study. In the TMDL assessment, a major portion of the Yager Creek drainage system (all of which drains into the lower basin) was designated to be part of the middle basin, again, based on geology.

Equally counterintuitive hydrologically, the TMDL study splits the Grizzly Creek drainage system in half, placing the Stevens Creek (a tributary of Grizzly Creek) planning watershed in the lower domain, and the Grizzly Creek planning watershed in the middle domain. The Grizzly Creek planning watershed was included in our lower basin study as part of the Grizzly Creek sub basin. Our study also included Swains Flat (our Rainbow Bridge monitoring site and site of the USGS Discharge Monitoring Station) and Chalk Rock (location of the town of Bridgeville, CA) planning watersheds in our designation of the lower basin, whereas they were placed in the middle domain of the TMDL study.

The major geologic formations that occur within the Lower VDR Basin include Tertiary and Quaternary sedimentary rock and Franciscan graywacke sandstone (HCRCD 2002). This region has been identified as being dominated by stable and unstable sandstone and stable melange

terrace and floodplain deposits (PWA 1999). However, a large portion of the Yager sub basin, which resides in the lower basin study area (current project), was identified as mélange active earthflows and unstable sandstone. Thus, geologic components of the lower basin study area within our VDWP project most likely include stable and unstable sandstone, stable melange, and active earthflows. Sedimentation rates in the basin are considered high due to relatively weak bedrock units causing high stream incision rates and uplift. These processes result in a high frequency of earth and debris flows which are made even more severe by intense land use activities that exacerbate and accelerate the loss of intact structure.

The headwaters of the Van Duzen River originate in Trinity County, although the extent of the lower basin project is confined to Humboldt County. Nestled in California's North Coast Range, the basin is roughly 50 miles from the "triple junction" of the American, Pacific, and Gorda tectonic plates near Cape Mendocino (Pacific Watershed Associates 1999). In the watershed analysis and mass wasting assessment by Humboldt Redwood Company (HRC 2009), the geology of the Lawrence-Yager (Lower VDR Basin) region is described as having a history of tectonic subductions and accretions (basically underlying and overriding plates scraping against each other) dating back to the Cretaceous Period (approximately 100 to 140 million years ago).

Terrain types within the basin include active and dormant earth flows, and Franciscan mélange. This high level of tectonic activity combined with highly erodible and generally unstable terrain, as well as relatively high rainfall, make the Lower Van Duzen River Basin one of the most rapidly eroding watersheds in the United States. As described by Humboldt County RCD (2002), basin landscape is characterized as well dissected terrain with steep canyons and inner gorges, where side slopes are unstable and give rise to dramatic earth flows (Figure 1-7).

The upslope areas of the Yager Creek and Lawrence Creek sub basins as well as the Van Duzen as a whole are moderately rugged with slopes ranging from gentle in the floodplain to steep in the upper reaches of the tributaries. However, the gradient of the main stem within the lower basin is not as steep as in its upper reaches or the upper reaches of its tributaries, and the main channel exhibits severe meandering throughout. Further downstream the channel widens extensively where large volumes of sand, gravel, and other course sediments fill the lower floodplain (Figures 1-8 & 1-9).

The geographic section described as the lower basin has the highest sediment production of the three sections delineated within the Van Duzen River Basin (PWA 1999). The basement rock is formed by the Franciscan complex which is widespread throughout the area. Yager terrane is the dominant bedrock type within the Yager-Lawrence Creek sub basin, and the transition between Yager and the Central belt to the north is characterized by a change in topography and vegetation, from smooth and forested to lumpier prairie (Simpson & Roberts 2008).

Figure 1-7. Earthflow along the mainstem of the Van Duzen River during Summer of 2007. Photo by P. Trichilo.

Figure 1-8. Widening of the Van Duzen River channel, aggradation, and areas of bank failure in the lower basin alluvial flood plain at the mouth of Yager Creek and just upstream from intersection with the Eel River – see Fig 1-9. (Photo by P. Higgins, January 1997).

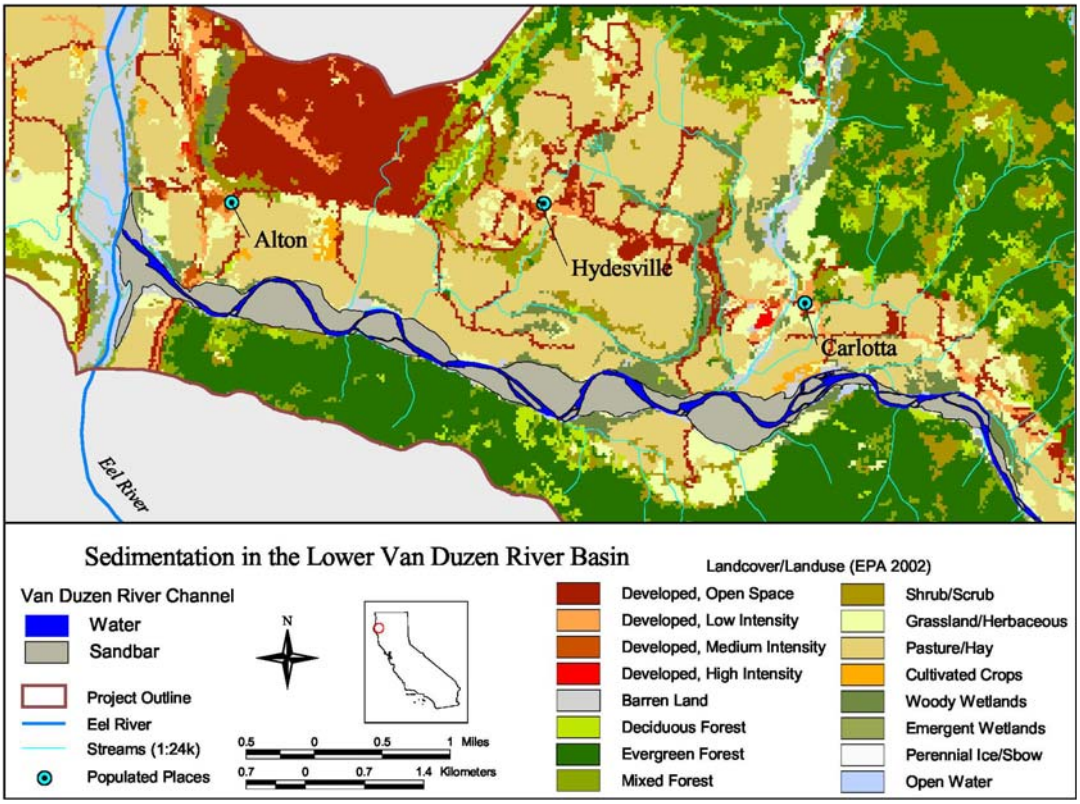

Figure 1-9. Map of the alluvial plain of the lower basin, where the Van Duzen River merges with the Eel River near the town of Alton, CA. Clearly evident is the large aggradation of sediment represented as sandbar in the channel migration zone (CMZ).

Climate and Vegetation

The VDR Basin shares a Mediterranean climate with most of the larger Eel River Basin, which historically at least was characterized by cool, wet winters and warm to hot, dry summers. Heavy rainfall is usually restricted to the months of November through February, becomes lighter in March and April, and is typically absent from May through September. Precipitation used to range between 50 and 100 inches per year, most of which occurs between October and April (HCRCD 2002). However, over the last ten years, rainfall has dropped to as low as 40 inches per year or less, suggesting a reduction in average rainfall for this area. Summer months can become very hot and dry, especially in the upper reaches of the main stem. During the three years spanned by the project (HY07 – HY09) the lower basin, along with all of southern Humboldt County, has been in a drought with progressively less rainfall occurring each consecutive year.

With the exception of Grizzly Creek State Park, virtually 100% of the Lower VDR Basin is in private ownership, within which the dominant vegetation is redwood (*Sequoia sempervirens*) forest (managed for industrial timber production), but species are often found as a mixture of redwood, Douglas Fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), and western hemlock

(*Tsuga heterophylla*) (HRC 2009). Several hardwood species are commonly found in the riparian zones, and include California bay laurel (*Umbellularia californica*), red alder (*Alnus rubra*), big leaf maple (*Acer macrophyllum*), willow (*Salix spp.*), and western cottonwood (*Populus fremontii*). Much of the upper (northeastern) part of the Yager Creek sub basin is characterized by grassland (managed as ranch land supporting beef cattle and sheep grazing), and oak woodland including tan oak (*Lithocarpus densiflora*), madrone (*Arbutus menziesii*), and California black oak (*Quercus kelloggii*) (EPA 1999).

Impact of Management Practices on Aquatic Systems

Some of the wildlife species that have existed historically and are also found today are black bear, mountain lion, black tailed deer, gray fox, bobcat, eagles, (bald and golden), and numerous cold water species, including Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), steelhead trout (*O. mykiss*), and coastal cutthroat trout (*O. clarki*) (HCRCD 2002). However, recently coho salmon have declined to such an extent that they are now considered an endangered species, and populations in the Van Duzen River Basin are virtually undetectable.

Of special concern with respect to the beneficial uses of water in the Van Duzen River Basin must be the plight of fish and other wildlife whose populations have experienced severe declines during the last century. As our understanding improves with regard to the pitfalls and errors made in the past, projects such as ours will contribute to our overall understanding of how these mistakes can be avoided in the future, especially with regard to saving and conserving the highly valued cold water species that have historically existed throughout these watersheds. Today salmon stocks are only remnants of their earlier numbers, and some populations, especially coho Salmon, hover on the brink of extinction. It was the intention and sincere hope of the coordinators of this project that some effort could be made to document the current state of the Van Duzen River and its major tributaries in relation to the declining numbers of salmon and steelhead that were historically present in these areas.

Guidelines have been established for protecting and conserving federally listed salmonid species in California (National Marine Fisheries Service (NMFS) 2000). These guidelines are based on seven areas of concern, which must be included in any approach for the conservation of these species and their habitats. These areas of concern include stream classification, riparian, roads, unstable areas, restoration activities, watershed analysis and assessment of cumulative watershed effects, and monitoring and adaptive management.

Conservation and establishment of healthy salmonid populations requires an understanding of existing and potential refugia in the lower reaches, as well as knowledge of the higher non-fish bearing parts of the streams that influence them. According to NMFS (2000), forest management activities such as logging can cause changes in streams temperatures, increased sediment levels, altered composition and abundance of fish and macro invertebrate species,

destabilized stream banks and streamside areas, reduced in-stream structural complexity, reduced large woody debris recruitment, and altered peak and base flows. Moreover, the presence of roads and their usage can contaminate water, create barriers to migration, reduce stream shading, reduce large wood recruitment to the stream, and increase sediment levels by accelerating the frequency and size of mass wasting events and increasing the amount of sediment delivered to the streams.

Causes and Sources of Impairment

The Van Duzen River (VDR) is a tributary of the Eel River, and the Van Duzen Watershed Project area (lower basin) comprises less than one tenth of the entire Eel River Hydrobasin (Figure 1-10). Topography, geology, and hydrology of the Van Duzen River Basin are similar to that of the Eel River Basin. On a per unit area basis, the Eel River Basin is the highest sediment-producing system in the continental United States, and has been designated a high priority situation under the State of California Water Board Watershed Management Initiative process for nonpoint source water quality planning and improvement efforts (Humboldt County Resource Conservation District [HCRCD] 2002).

Sediment: Natural versus Management-Related

While some proportion of sediment loads in local rivers and streams may be the result of natural (non-management related) causes, the timing of declines of salmonid populations can be closely correlated to the onset of logging activities in these watersheds. The primary natural sources of suspended sediment are earthflow landslides and erosion of melange stream banks, which are more typical of the upper and middle basins than in the lower basin (USEPA 1999). The ratio of suspended sediment to bedload is thus substantially different in the lower basin, which is characterized as having more stable sandstone terrain than in the middle and upper domains (Kelsey 1977).

Therefore, as logging has occurred extensively and continuously throughout the lower basin over the last century (as well as in much of the Eel River Hydrobasin), management-related sediment has undoubtedly contributed to the impairment of these streams and demise of these populations, and has also played a greater role relative to natural sources of sediment than in the middle and upper portions of the basin. Major land uses today (in terms of acreage) include timber harvest (mostly industrial timber), farming (in the lower floodplain), ranching, gravel mining, and residential. The largest land owner in the lower basin is the newly formed Humboldt Redwood Company (formerly PALCO), which purchased the land and timber operations in 2008.

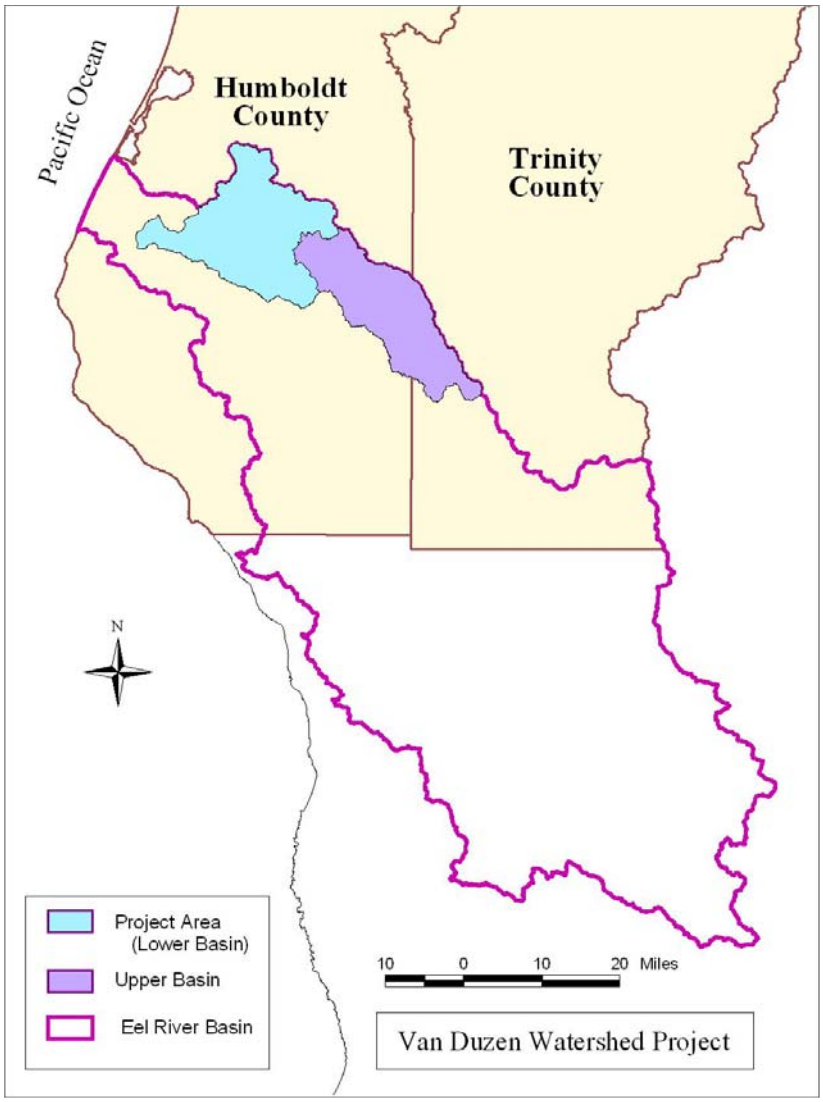

Figure 1-10. Map of the Van Duzen River Basin to the Eel River Basin, which is larger than the Van Duzen Watershed Project area by about 10:1.

Overwhelming evidence indicates that the single most important source of pollution in the Lower Van Duzen River Basin (as well as the Eel River Basin) is sedimentation from the hillsides into the streams which leads to a variety of problems facing cold water species in these waterways. Over the last 50 to 100 years, the relationship between government and the lower Van Duzen River Basin has been predominantly, one of neglect. Due to the recent attention given to the issues of the Headwaters Forest (primarily Freshwater Creek and Elk River Watersheds that are adjacent the Lower Van Duzen Basin to the north), and the HCP/SYP process of Pacific Lumber Company, the Lower Van Duzen Basin has been largely overlooked by regulatory agencies. While it was involved with the challenges and litigation involving the Headwaters issue, the Pacific Lumber Company, on the other hand, seems to have focused attention and timber harvest activities in the Lower Van Duzen River watersheds.

Now, years after the 1964 flood, it is difficult to find visible improvement in the status of cold-water fisheries in the Van Duzen River system. After two years of monitoring turbidity and suspended sediment during our project, virtually all of the streams in the lower basin exhibit a high level of impairment. But the ultimate testimony is that numbers of coho and Chinook salmon continue to reflect a precipitous decline from earlier years of abundance, and in some populations, hover near extinction. This impaired status is substantiated in some streams by high water temperatures in the summer months and in all streams by the progressive decline of returning salmon. While the focus of this project is water quality, one of the primary indices of water quality listed in the original proposal is habitat for cold-water aquatic species, including fish and other vertebrates, and macro invertebrates, such as aquatic insects. The status of the major streams within the lower basin will be described in detail within this document.

Through the work of volunteers who participated in the Citizens Monitoring Group (CMG), Friends of the Van Duzen River (FOVDR) has been monitoring streams of historic significance to salmon populations since 2001. In the Fall of 2006, FOVDR in association with Friends of the Eel River (FOER), was awarded a monetary grant to study water quality conditions in the Lower Van Duzen River Basin. This project was designated the Van Duzen Watershed Project (VDWP). The VDWP represents an expansion of the monitoring activities initiated by FOVDR, plus a comprehensive spatial analysis of upslope conditions that affect water quality within the basin. The monitoring of water quality was aided in large part through the organization of a Citizens Monitoring Group (CMG). These efforts were designed to develop protocol, and to quantify indices of water quality, including levels of suspended sediment and turbidity, as well as to better understand the relationship between water quality and land use within the basin.

This Watershed Management Plan represents the culmination of two and a half years of data collection and analysis, meetings with stakeholders and professionals in the appropriate sciences, and video recordings, website development, and presentations to the public as part of a community outreach program in order to better understand the impact of various factors and their significance with respect to water quality in the lower Van Duzen River Basin. Contained in the following chapters are the results of this study as well as how these results influence and help develop our understanding of the problems and hopefully, solutions that will lead to improved conditions within the lower basin.

While the field work and effort that contributed to the TMDL were impressive, the document failed to adequately address cumulative watershed effects (CWE) including damage to streams, and consequently, fails to set prudent risk limits on future land use in order to prevent these effects and allow aquatic recovery. The advantage of the proposed TMDL research and report (PWA 1999) was the ability 1) to classify and quantify the sources and locations of sediment within the VDR Basin (e.g., earth and debris flows, and channel bank destabilization, etc.), 2) to quantify the rate of accumulation and delivery of sediment to streams, and 3) to differentiate between natural versus management-related (controllable) causes of sedimentation.

The VDWP monitoring program was not intended to fulfill items 1) and 3) above. However, in the TMDL report only processes of mass wasting (e.g., landslides, earth flows, debris flows, channel bank destabilization, etc.) were considered as contributing to sedimentation. Contributions from surface erosion (e.g., from roads, skid trails, and other exposed surfaces) were not considered in the study (PWA 1999). Moreover, the TMDL study did not monitor or quantify actual sediment in the streams.

Sedimentation rates in the lower basin are universally considered the result of non-point source pollution, in a sense, large scale contributors such as landslides and earthflows could be considered point sources. While mass wasting and earth flows are undoubtedly large contributors of sediment to streams, non-point sources such as surface erosion potentially represent major contributions of suspended sediment to streams in the lower basin, although this factor was not addressed in the TMDL.

Problems Related to Sediment

High levels of sedimentation in north coast streams result in several conditions that adversely affect survival and reproduction of cold water species. One of the most obvious effects of excessive sediment is loss of stream habitat. Virtually all of the streams within the lower VDR Basin, including the main stem itself, exhibit a dramatic accumulation of sediment (aggradation), that has resulted in the filling in of deep pools, and loss of depth and channel integrity (Figures 1-11, 1-12).

Habitat

Filling of streams with silt typically results in the loss of clean gravel habitat, which is vital for successful spawning of salmon and steelhead. Annual accumulation of fine sediment and silt in the lower tributaries has resulted in a marked inability of these streams to achieve healthy thresholds for spawning (EPA 1999). A direct relationship has been shown between increased quantities of fine sediment (particles less than 0.85 mm diameter) and a reduction in salmon embryo survival and emergence (Chapman 1988). Silt in the stream beds inundates salmon redds, depriving salmon eggs and fry of necessary oxygen (Burns 1970, Barnard 1992, NMFS 1996, CDFG 2004). Siltation of redds fills the interstitial spaces within spawning gravels, reducing permeability and trapping fry from entering the water column (EPA 1999). Loss of spawning habitat is undoubtedly a major factor in the observed decline of these species.

High sedimentation rates are also associated with high levels of turbidity. Numerous studies have shown a positive relationship between moderate to high chronic turbidity (suspended sediment) and inability of young salmonids to feed effectively (Sigler et al. 1984, Newcombe and McDonald 1991, Trush 2005). Loss of feeding efficacy results in smaller smolt size when these young fish enter the ocean, and thus severely reduces their chances of survival, therefore fewer fish returning to the streams.

Figure 1-11. Grizzly Creek in the summer of 2006, near the where it merges with the Van Duzen River. Note high degree of aggradation, and that the stream is nearly dry (Photo by P. Higgins).

Figure 1-12. Lower Yager Creek in the summer of 2009. Note the high degree of aggradation and that the stream is nearly dry (Photo by P. Trichilo).

The Riparian Zone

Considerable discussion has been devoted to the extreme level of impairment which occurred in the VDR Basin following the 1964 flood (Kelsey 1977, 1980, PWA 1999, EPA 1999, HCRCD 2002). This impairment was most evident as channel aggradation and accumulation of course sediment within the streams. Other signs of damage included channel widening, bank erosion, earth flows, landslides and mass wasting, especially in the inner gorges and steep stream banks. Channel widening and bank erosion was clearly exacerbated by loss and destruction of vegetation species in the "riparian zone," which includes shrubs and trees that immediately buffer the stream and occupy the area within a given distance of the stream. This area is somewhat arbitrary, but can be up to at least 100 meters on either side. Riparian vegetation is often represented by fast growing, water-loving hardwoods, such as willow, cottonwood, and alder, but could technically be any vegetation growing close to the stream. Redwoods are often found growing adjacent or near streams, and in that context, are considered riparian vegetation.

The importance of the riparian zone around streams has been well documented. Vegetation within this zone greatly influences the biological and physical processes that provide freshwater habitat for numerous cold-water species by providing shade and protective cover, increased complexity as observed in aquatic food webs, flow and sediment routing leading to improved water quality and water temperatures, and improved stream channel stability (Beschta, R.L. 1991, Gregory et al. 1991, Naiman et al. 1992, Schlosser 1991). However, often activities such as timber harvest upstream can affect and contribute to sedimentation and alteration of habitats downstream, seriously curtailing the ability of these habitats to sustain salmonid reproduction, growth, and survival (Thornburgh et al. 2000, Welsh et al. 2000).

The riparian zone is especially important to the physical integrity of streams. Trees and shrubs, and their associated root growth provide profoundly stabilizing structures against the erosive forces of moving water, and are capable holding back soil, rock, and debris from being washed into the stream. Beyond the physical presence of the vegetation, leaves, litter, and duff protect the ground and soil, and resist the physical action of wind, rain, and water that would otherwise wash away topsoil and other material.

Benefits that a healthy riparian zone provides include: 1) resistance to erosion, resulting in narrower and deeper channels (e.g., less sandbar and bed load accumulation especially in the lower reaches of the river, 2) reduced quantities of sediment entering the streams, 3) more efficient transport of sediment that does enter the streams, and 4) dissipation of stream flow energy (HCRCD 2002), thereby lessoning the likelihood for mass wasting within the stream channels, which will lead to 5) reduced likelihood of flooding due to more efficient water transport and deeper channels, and less severe conditions when flooding does occur.

According to HCRCD (2002) willows and cottonwoods continue to be "taken out," reflecting periodic failure of vegetated stream banks, high sediment loads in disturbed watersheds, and

fragmentation of what was once a continuous riparian corridor. Riparian vegetation, in general, can become a subject of controversy, as recommendations for no-cut buffers within the riparian zone typically conflict with timber harvest plans. Historically, harvest plans have prescribed leaving a narrow buffer of trees on one side of the stream, usually the south side, while completely harvesting the other side up to the edge of the stream. The argument is that sufficient shade has been left to protect the stream from sun and thus excessive temperatures. However, these prescriptions are severely flawed. No-cut buffer zones serve more than to simply shade a stream, as has already been described for a healthy riparian zone above.

Temperature

For several decades the Eel River system has experienced high summer temperatures that have resulted from excessive sedimentation and the filling of deep pools. These high temperatures have created conditions favorable for blue-green algae. Over the last 2-3 years especially, stories of dogs dying after drinking river water have appeared in local newspapers, and warnings have been issued to avoid the water during late summer months due to toxic levels of algal blooms. During the summer of 2009, for the first time, a warning was issued to avoid the Van Duzen River due to algal blooms, subsequent to an earlier report of dog death due to the drinking of river water.

These occurrences are testimony to the extreme level of impairment of the Eel River system, and the Van Duzen River in particular. These rivers have always provided opportunities for summer activities. Local and visiting youths have been swimming in these rivers for generations, and to now restrict that opportunity sounds an alarm that should be taken seriously. When streams are no longer able to support local cold water species like salmon and steelhead, loss of their ability to support requirements of the human population is not far behind.

High stream temperatures are not just the result of direct sunlight on the water. Water temperature is very much dependent on the ambient temperature of the air above it, which in turn can be directly moderated by refugia in an intact riparian canopy. Intact canopies serve to create a cool and humid microclimate above the stream that is able to keep air temperatures cool, even when outside conditions are hot and dry (Spence et al. 1996, USFS 1998a). Thus, these intact vegetation zones are extremely important for keeping streams cool, and creating suitable and sustainable habitat for fish and other aquatics. When a sufficient frequency of deep pools also exists for fish to retreat to cooler depths, the habitat approaches nearly ideal conditions.

The Channel Migration Zone

A lot of erosion occurs within stream channels themselves, which is an area called the channel migration zone (CMZ). When the action of water and floating debris scours the sides the stream, the CMZ is commonly characterized by erosion of the stream bank (USEPA 1999). However, in the TMDL report (PWA 1999), all CMZ bank erosion estimates were considered to be not

management related. This assumption is an extremely narrow view, as bank erosion is a critical index of stream and also watershed health. Even the EPA report on the TMDL (USEPA 1999) stated that channel bed aggradation can trigger channel migration, which is directly associated with bank erosion, and is at least partly associated with [if not primarily the result of] the cumulative effects of upstream activities such as logging.

Bank erosion results in the loss of topsoil, clay, rock, sand, and gravel (components that comprise sediment), all of which eventually wash into the stream, thus expanding the zone and degrading the value of the surrounding land. The CMZ is not the same as a riparian zone, as adequate riparian vegetation on the sides of the stream would serve to limit the size of the CMZ, and contain the stream into a narrower and deeper channel. Obviously, as land falls away from the stream bank and as sediment and bed load become deposited into the stream, the channel widens and extends the size of the CMZ. Widening of the CMZ thus creates a greater tendency for shallowing, aggradation, and loss of preferred habitat.

In the TMDL (EPA 1999), two major CMZs were identified on the mainstem of the Van Duzen River. One stretch was 8.5 miles long in the upper basin and the other was 16.5 miles long and comprised most of the river within the lower basin to the Eel River convergence. The authors stated that based on unit area, the rate of sediment production (cubic yards per square mile) in the main stem CMZ was higher than for any other terrain type.

Interestingly, erosion associated with the CMZ was considered to be unrelated to management (logging) activities. However, it was also stated that channel bed aggradation, which can trigger channel migration, is associated with the cumulative effects of upstream activities such as logging. Nonetheless, bank erosion in the CMZ incongruously was not considered to be a controllable source of sediment in the TMDL study (PWA 1999). However, logging of the riparian zones would have the effect of making stream banks far more susceptible to erosion than would otherwise have occurred, and the logging in the upper reaches and tributaries would greatly add to the quantities of logs and slash coming down the streams after winter storm events, and would have dramatically increased the amount of physical damage incurred to the stream banks. Certainly logging within the riparian zone and removal of riparian vegetation and soil surface cover would have a direct effect on increasing sediment delivery to the stream.

The Lower Van Duzen River Basin, as designated by the boundaries of the VWMP project is comprised of eight sub basins and 22 planning watersheds (Table 1-1). With the exception of Yager Creek and Grizzly Creek, sub basins are identical in location, size, and shape, to individual planning watersheds that bear the same name. Sub basin terminology was added to categorize the very large drainage system of Yager Creek, which contains 14 planning watersheds, and the substantially smaller drainage system of Grizzly Creek, which contains the two planning watersheds, Grizzly Creek and Stevens Creek.

Table 1-1. Relationship of sub basins to planning watersheds in the Lower VDR Basin.

Sub Basin	Planning Watershed	Summary Statistics - Base Line Data		
		Calwater No.	Calwater Code	AREA (sq. miles)
Barber Creek	Barber Creek	14	1111.110201	12.446
Yager Creek	Wolverton Gulch	15	1111.210002	18.357
	Bell Creek	2	1111.230201	5.763
	Lawrence Creek	3	1111.230205	11.689
	Booths Run	4	1111.230202	10.588
	NF Yager Creek	5	1111.230104	17.018
	Indian Creek	6	1111.230101	8.534
	Shaw Creek	7	1111.230203	5.385
	Corner Creek	8	1111.230204	8.629
	Coyote Valley	9	1111.230106	14.419
	Copper Mill Creek	10	1111.230301	9.443
	Dairy Creek	11	1111.230102	7.044
	Blanton Creek	12	1111.230302	13.590
	MF Yager Creek	13	1111.230103	9.352
	SF Yager Creek	16	1111.230303	10.664
Cummings Creek	Cummings Creek	17	1111.210001	12.596
Hely Creek	Hely Creek	20	1111.210003	10.327
Root Creek	Root Creek	23	1111.220604	13.968
Grizzly Creek	Stevens Creek	18	1111.220603	7.750
	Grizzly Creek	19	1111.220602	11.212
Swains Flat	Swans Flat	22	1111.220601	13.979
Chalk Rock	Chalk Rock	21	1111.220605	10.979
Average >>>				**11.079**

Priorities of the Van Duzen Watershed Project

The completion of this Watershed Management Plan required at least one year of development beyond establishment of the priorities for the Planning Grant. Numerous watershed plans have been produced over many years throughout the State of California, all possessing unique qualities and characteristics. However, useful plans generally contain specific components relative to the development of practical recommendations for recovery of the areas of concern. Many, if not most of these components are outlined in great detail in the EPA handbook designated specifically for the development of watershed plans (USEPA 2005).

Part of the year-long process of developing a project proposal to observe and analyze conditions of the streams and watersheds within the Lower Van Duzen River Basin was devoted to establishing the scope of the project (i.e., how much could we likely accomplish in the roughly two years available through these types of projects), as well as goals, objectives, and the short and long-term outcomes that could be anticipated from such a project. These aspects of the project proposal included the following.

Scope

The Van Duzen Watershed Project was initiated as a result of conversions among members of the Friends of the Van Duzen River (FOVDR) with regard to the observed effects logging was having in local watersheds. The arrival of the Maxaam-Herwitz era seemed to signal an increase in logging intensity within the Van Duzen basin, and a greater impact from logging externalities (e.g., increased sediment, loss of stream habitat, and fewer salmon). One year prior to the submission of our project proposal, members of the group formulated several questions that were posed as a result of these observations. Some of those questions were as follows:

- As residents of the community, how can we become more informed and involved with key environmental issues facing our local rivers and streams, and help resolve problems related to the loss (and feasibly, extinction) of the salmon and steelhead populations that depend on these systems for their survival?

- As water quality is at the heart of the problems facing salmon populations in North Coast CA streams, and in the Van Duzen River Basin in particular, how can we address problems of water quality within local rivers and streams?

- How can we gather diagnostic information in a scientifically valid manner that will provide critical data on the relative health and/or impairment of our local streams and watersheds?

- How can we understand and describe the relationship between water quality in the streams and the conditions on the surrounding hill slopes – is water quality affected by the physical conditions of the watershed and how do human activities such as logging affect water quality?

- How can we accurately quantify the health of the Lower Van Duzen River Basin, develop recommendations for the rehabilitation of watersheds, and bring about the restoration of the salmon and steelhead populations that once were prevalent there? In short, how can we best produce a watershed management plan?

The answer to all of the above questions seemed to be to develop a project that would address the water quality concerns of FOVDR, especially for those individuals concerned about salmon, steelhead, and their habitat. It was therefore proposed to seek funding through a grant proposal to a state or federal agency, and the most appropriate agency appeared to be one geared toward Water Quality issues. We would like to express our gratitude especially to the CA Water Quality Control Board for funding our project for two years of water quality monitoring of the watersheds within the Lower VDR Basin, and the development of the corresponding spatial data base and GIS analyses. This chapter and those that follow describe the extent of that project.

Goals

Questions that were addressed during the preliminary conversations regarding the Van Duzen River, gave rise to three primary goals that the Van Duzen Watershed Project should address. These three goals were as follows:

- Provide information that will lead to improved water quality in the Lower Van Duzen River and its tributaries, and provide for improved habitat for native salmonid species.

- Involve the local community in water quality and biotic sampling activities, in order to increase awareness in the community regarding the conditions of local watersheds.

- Develop a management plan for watershed recovery within the Lower Van Duzen River Basin.

Objectives

Formulation of questions and project goals gave rise to the subsequent development of project objectives – what the project should accomplish. The overall objective of this project was to develop and improve our understanding of the ecological dynamics of the watersheds within the lower basin. Quantifying baseline conditions, as well as specific natural and management related effects both in the streams and on the hillslopes will help to define threats to the integrity of the system and promote development of an effective restoration strategy.

- Establish key locations for monitoring sites along the main stem of the Van Duzen River and its tributaries.

- Train members of the community and students in procedures and protocols for taking turbidity samples during the rainy season, especially during storm events.

- Sample and quantify physical data including turbidity, suspended sediment, temperature, flow rate, and stream habitat, as well as biological data such as macro invertebrates.

- Develop a rigorous ArcView and/or ArcGIS project documenting all stream and upslope conditions, such as vegetation, geology, land use, timber harvest history, etc.

- Distribute information including maps through an official web site (www.fovd.org), and to the Water Quality Control Board, whereby all results will be presented and discussed.

- Bring together staff, stakeholders, and members of the community at regular intervals (bi-annually) for updates and review of project accomplishments, and ultimately to formulate and complete a watershed management plan for the Van Duzen River Basin.

- Describe management measures that promise to provide the most effective outcomes in terms of load reductions and improvement in watershed health.

Restoration strategies will seek to identify load reductions that could reasonably be expected from proposed management measures and Best Management Practices (BMPs). Specific objectives of these strategies are as follows:

- Maintain and enhance water quality to support cold water fisheries, and work toward achieving TMDL targets.

- Improve instream habitat throughout the lower basin, and foster increases in overall numbers of salmonids within each species, and especially support efforts to restore those classified as endangered species (i.e., coho salmon).

- Enhance the function of critical ecosystem processes to increase watershed resiliency and health in order to improve water and habitat quality.

- Promote use of and improvements in Best Management Practices (BMPs) in order to encourage ecologically sound use of forests, and development of greater forest complexity, stability, and sustainability.

- Establish a timeline for reaching milestones and mechanisms for tracking compliance.

- Establish monitoring protocols to adapt watershed management and restoration efforts to most effectively quantify water quality conditions in the lower basin.

- Foster and expand the role and involvement of the community in restoration activities.

- Highlight the economic benefits of a healthy salmonid fishery within the lower basin.

Anticipated Outcomes (Milestones)

As objectives of the project are achieved, outcomes resulting from the pursuit of those objectives are naturally anticipated. Some of the anticipated outcomes of our project are listed below.

- Greater involvement of the local community in water quality issues, and a greater awareness of the problems that affect watersheds and how these impact the beneficial uses of water.

- Recognition of critical conditions and problem areas within the Lower Van Duzen River Basin with respect to turbidity and suspended sediment, and the how the impact of timber harvest and other management-related activities such as clear cutting and tractor yarding affect water quality within the basin.

- Implementation of recommendations for establishing sound, cost-effective strategies to restore water quality within the lower basin that will attain water quality targets and reflect expected load reductions as described in the proposed management measures.

- Reductions in turbidity and sediment that will help restore the lower basin to a naturally functioning ecosystem, and maintain diversity and complexity within the watersheds that will in turn support the native species that originally adapted to these systems.

- Greater communication between local communities, non-profit organizations, agencies, and timber management companies will encourage a more conducive atmosphere of cooperation.

- Greater concern for ecological balance that will promote safer and more efficient management practices that will foster greater stand maturity and increased forest complexity and stability.

- Increased forest ecosystem complexity (multi-aged composition) and stability that will lead to reduced sedimentation, healthier streams, improved beneficial uses of water, increased numbers of salmon, steelhead, and cutthroat trout in the rivers and streams, and a rejuvenation of economic benefit to local areas.