5. Human Interaction With the Watershed

5.1 Historic Period Human Interaction With the Watershed

The purpose of this section is to summarize human activities that have had some effect on the Carson River watershed in Alpine County, California. Regional prehistory and ethnography are summarized by Nevers (1976), Elston (1982), d'Azevedo (1986), and Lindstrom et al. (2000). Details of regional history can be found in Maule (1938), Jackson (1964), Dangberg (1972), Clark (1977), Murphy (1982), Marvin (1997), and other sources. A book published by the Centennial Book Committee (1987) contains an excellent selection of historic photographs. Particularly useful is a study on the historical geography of Alpine County by Howatt (1968).

5.1.1 Prehistoric Land Use

Human habitation of the Upper Carson River Watershed extends thousands of years back into antiquity. Archaeological evidence suggests use of the area over at least the last 8,000 to 9,000 years. For most of that time, the land was home to small bands of Native Americans. Their number varied over time, depending on regional environmental conditions. For at least the last 2,000 years, the Washoe occupied the Upper Carson River Watershed.

Ethnographic data provides clues as to past land use and land management practices (see extended discussions in Downs 1966; Blackburn and Anderson 1993; Lindstrom et al. 2000; Rucks 2002). A broad range of aboriginal harvesting and hunting practices, fishing, and camp tending would have affected the landscape and ecology of the study area. Shrubs such as service berry and willow were pruned to enhance growth. Other plants were thinned, aerated, and even replanted either in the same general area or in new locations. Bulbs especially were planted in new locations where they would be needed. Seeds were often recast over the collected area or in new areas.

Women weeded unwanted competitors and replanted smaller specimens and bulbs, producing over time, almost pure stands of one or more targeted species. Other practices such as pruning, coppicing, and burning promoted desired characteristics (straight shoots from new growth for arrow shafts and basket materials) and pest control. These practices were more than by-products of harvesting. Basket makers state that one reason willow from older baskets is superior to willow today is due to traditional practices, "caring for and tending" the plants (Rucks 2002). Willow management included cleansing stands with fire.

Caring for the land and maintaining the health of the resource base was signaled by a clean campsite: milling features were smoothed with oils, trees were well tended, gathering patches were healthy and tended, patches of vegetation were separated by areas cleaned of underbrush, and equipment was cached. Signs of neglect meant others could appropriate an area. Neglect not only signaled an unclaimed place, it was a potentially dangerous place, harboring snakes and spirits. An untended patch would feel the neglect and literally fail or disappear. Women relate that the loss of traditional plants is due not only to direct impacts from development and pollution, but is also due to neglect. Without tending and care, songs, offerings and prayer, the simple company and appreciation of people who know the plants and what they do, they wither and disappear (Rucks 2002).

There is some evidence that the Washoe deliberately set fires to drive animals, to improve forage for both people and game, and to promote fire dependant plants such as tobacco (*Nicotiana attenuata)* (Downs 1966). Heavy brush and old grass in meadows was burn off. Camp areas were periodically cleaned with low intensity fires to burn underbrush, thereby reducing the fire hazard. Fire hazard reduction is also a reason given for cleaning out lower dead branches in wooded areas, and for collecting deadwood in a radius around camping areas. Fuel wood is a major component of occupation, even of an overnight stay, and fire wood collection is an acknowledged means of caring for the land. There are no published data calculating ecological effects of these sustained and systematic fuel reduction activities. However, one can surmise that natural fires would have burned with less intensity, sparing older trees kept free of volatile deadwood, and cleaning out smaller or diseased trees.

Evidence of prehistoric stream or water management in the western Great Basin is limited. In some areas, such as along the Walker River and in Owens Valley, a limited amount of irrigation occurred (Lawton et al. 1993). In some locations these aboriginal practices may have affected "natural" watercourses encountered by Euro-Americans. Such was probably not the case for the Upper Carson River Watershed. Evidence of prehistoric irrigation by the Washoe is scant. Fishing practices at times included the construction of weirs and dams that could have affected watercourses and over time may have contributed to the structure of some reaches along the river. Any evidence of such small-scale modifications would have been eradicated as a result of Euro-American land use patterns during the last half of the Nineteenth Century.

In summary, 9,000 years of sustained and systematic land use by Native Americans would have had an influence on ecologic conditions. However, population densities within western Nevada and the Upper Carson River Watershed were quite low. Archaeological evidence suggests that prehistoric population densities varied over time, reaching a zenith about 1,500 to 3,000 years ago. As of the 1850s, some 4,000 Washoe occupied a homeland that extended from Honey Lake south through Antelope Valley, and from Lake Tahoe east through the Pine Nut Mountains. This equated to a population density of approximately two to three persons per square mile. Their world was a rich mosaic of places that held varying resource and ideological values. People moved between favored places in small bands. Some places were visited more often, some routinely. It is these places where the magnitude of ecological influences would have been most pronounced. In other seldom-visited places the influence of Native American activities would have been far less apparent.

5.1.2 Euro-American Exploration

In May of 1826, Jedediah Smith and a small party of trappers crossed the Sierra Nevada at Ebbetts Pass and traveled along the East Fork of the Carson River (Farquhar 1965:26). The Walker-Leonard trapping party in 1833 and the Bartleson-Bidwell emigrant party in 1841 also may have traversed the county. The best-documented excursion was that of John C. Fremont in 1843-4 (Fremont 1845:229). Fremont began his adventure in central Oregon. He traveled south through Oregon and western Nevada. After passing Pyramid Lake, he crossed the Truckee and Carson rivers before entering the Walker River basin. He continued south as far as the Bridgeport Valley before turning north again. Just after entering the Carson Valley, he turned southwest following Indian Creek through Dutch and Diamond valleys. During February of 1844, he and his party camped for several days at Grover's Hot Springs while searching for a passage over the Sierra Nevada. This exploration afforded the first view by Euro-Americans of Lake Tahoe. Eventually, Fremont and his party located and made their way over the Carson Pass (Gianella 1959:55, Farquhar 1965:53-57). While the direct impact of exploration on the watershed were negligible, the indirect impact was immense in that these parties demonstrated a potential travel route over the Sierra Nevada.

5.1.3 Transportation

The early history of Alpine County derives from its role as a transportation corridor. Most present highways in the county follow historic routes established as thoroughfares between early mining and population centers. Alpine County lies along various paths used by the Carson River Route of the emigrant trail. Most of these routes employed the steep ascent of Carson Canyon between Woodfords and Hope Valley. The main route went up and over Carson Pass. Known as the Carson Pass Route (Emigrant Summit Trail), this main branch of the California Emigrant Trail, went through Hope Valley, along an alignment closely followed by modern U.S. 88 (Franzwa 1999:Ca8). Another route involved continuing through Hope Valley, south over Border Ruffian Pass to Hermit Valley, and then west toward Murphys on what was called the Big-Tree route. A less desirable path was the trail over Luther Pass, which branched off the main trail in Hope Valley and used Johnson Pass to cross the Sierra Crest. Another variant was Ebbetts Pass, which was a more difficult route than Carson Pass.

During most of the 1840s the Carson Pass Route was traversed by pack trains. Wagon traffic began in 1848. In 1849 the road was improved and maintained as a toll road (Howatt 1968:29). The grassland in Hope Valley was prized for its forage. Although it was noted that the grass was often shortened due to grazing, reviewed accounts did not indicate that it was completely devoured. Emigrants camped on the shores of Red Lake before ascending an extremely narrow and steep ascent to Carson Pass called the Devil's Ladder. With each passing team the road became more passable. Toll franchise holders further enhanced the improvements. Despite its steep grades and the need to pass over two major summits, the Carson Pass road had the advantage of requiring only three river crossings compared with 27 on the Truckee Route (Bennyhoff 1982:108). It also did not have the depressing reputation the Donner Party disaster had cast on the route over Donner Pass.

Bennyhoff (1982:108-119) has estimated the volume of traffic over the Carson Pass Route. Only about 400 individuals went overland to California by all routes in 1848. Numbers increased in the following year; some 6,000 immigrants passed over the Carson route alone. In 1850, most of the 45,000 individuals that took to the California Trail selected the Carson River Route. News spread rapidly of hardships endured during the 1850 migration, particularly along the Humboldt River and the 40-mile desert. In 1851, most emigrants went to Oregon and the few (perhaps 1,000) that selected California as a destination preferred other routes, such as the Beckwourth Trail. In contrast, 52,000 people made the journey to California in 1852. By that time, the Carson Route had better support facilities, including a tire-setting shop near Red Lake established by John Studebaker.

> Large numbers of people passed through the Assessment Area in the early years. For example, 40,000 to 50,000 people traversed the Carson Pass in 1850.

Several new trails were available in 1852, including the Big Trees Road. The Hope Valley to Big Tree Road turned southeast from the southern end of Hope Valley rather than ascending Carson Pass (Gudde 1969:97; Nation 1992:16-17). The road passed through Faith and Charity valleys before ascending Border Ruffian Pass on the north side of Hermit Valley. From that point the trail turned southwest toward Murphys and other destinations on the western slope of the Sierras. This was one of the first surveyed roads to cross the Sierra Nevada. Members of the Mormon Battalion improved the summit section of this route in 1848 (Arrington 1979). More important (probably taking effect in 1853) was opening of the Johnson's Pass Cutoff. The number of people that traversed Carson Pass in 1852 is not available, but there were enough for diarists to note extensive camping activity at the base of major grades, and for many other teams to be visible from vista points. Although not the crowded parade of 1850, the trail was far from being a lonely place in 1852. Diaries become rare as the overland trek became commonplace but J.B. Ellis kept a register of immigrants who passed along the Carson Route in 1854, noting passage of 808 wagons, 30,015 cattle, 1,903 horses or mules, and 8,550 sheep. These data also are indicative of the fact that after the first year, the migrants tended to be families with livestock and gear designed to establish farms in California rather than male gold-seekers.

The height and roughness of the Carson Pass Route led to its near abandonment in favor of other routes, some of which incorporated Carson Canyon and Hope Valley. In particular, improvements to the

Big Tree road led it to be the most used route in 1856-1857. With the 1859 discovery of the Comstock Lode, Johnson's Cutoff and more northerly passes (Daggett and Spooner) served to divert traffic from the Carson Canyon and its connection with Johnson's via Luther Pass.

During the early years of the California gold rush Ebbetts Pass was only used by pack animals. The wagon road was built in the 1860s as part of the Big Tree – Carson Valley Turnpike. That trail was not improved until 1862-1864. By then, mining activities at Silver Mountain and Monitor were booming (Hoover et al. 1966:26; Wood 1968). This road follows the East Fork of the Carson River, Silver Creek, and Cascade Creek to Ebbetts Pass, after which it joins the Hope Valley to Big Tree Road (Wood 1968). The route continued to be a privately maintained toll road until 1910 and in 1911 the road became part of the state highway system it was known as the "Alpine Highway."

The Luther Pass Route was used for pack animals starting in 1850. It branched off the main Carson Canyon route in Hope Valley at Picketts Station, headed northwest to Luther Pass, and then along the Little Truckee River before ascending Johnson Pass on the road to Placerville.

Over the latter half of the nineteenth century a number of other roads were developed in Alpine County. In 1863, a toll road was constructed south to Silver Mountain from Markleeville (known as the Carr Grade). The Silver Mountain Toll Road, from Markleeville to Monitor and Mogul, was constructed about the same time (Centennial Book Committee 1987:28, 40). Stage lines operated along these routes, moving both people and freight. A road was also built between Monitor and Silver King. The road was under construction in 1864 (Jackson 1964:44-45) and was in use by 1865 (Maule 1938:18). This road served as part of the mail route between Silver Mountain and Antelope City and Wellington. Freighters provisioning Silver King also used the road, as did lumber companies operating around Silver King (Marvin 1997:21). Another road extended north from Heenan Lake, along Leviathan and Bryant creeks, and eventually connected to the Olds Toll Road near Douds Spring. A road also extended from the south end of Bagley Valley across Grays Landing to the town site of Berry, located along Wolf Creek. A highway was first constructed east over Monitor Pass from Heenan Reservoir in 1954.

Impacts of transportation to local watersheds have varied over the historic period. Impacts were the most pronounced during the immigrant period when large numbers of people and stock moved along established corridors each summer. Trails and wagon roads of the period were only marginally improved (cut and fill grades, wood cribbing, corduroy log paving, dry-laid stone retaining walls, causeways at fords, wooden bridges, etc.). After the 1860s, transportation impacts would have declined substantially and they would have been restricted to more defined corridors. Through the twentieth century, roads were paved, bridges were constructed, and there was a greater emphasis on erosion control.

5.1.4 Settlement

In 1847, Sam Brannan established a trading post along the emigrant trail. The post was located near a prominent spring along the eastern base of the Sierra Nevada. This represented the first settlement of the area by euro-Americans. Daniel Woodford built a hotel and way station at the site in 1849, naming it the "Sign of the Elephant Inn." John Carey built a water-powered sawmill nearby in 1851. From that time to the present, Woodfords has served as a rest stop along one of the region's busiest highways. For a brief period in 1860 and 1861, Pony Express riders used Woodfords as a remount station.

The town of Markleeville is named after Jacob Marklee. Marklee first settled the area in 1861, claiming 160 acres around the present town site. Marklee operated a toll bridge across the East Fork of the Carson River. As mining activities increased in the area, others moved to this central location and Markleeville soon became a regional trading center. Within a short time, the town had nearly 2,500 inhabitants. The town was the center of freighting redistribution since it could be reached by freight wagons all winter, in contrast to the higher mining towns (Howatt 1968:66). As mining declined in the county, so did the population of Markleeville. In 1875, only 1,200 residents remained. But its diversified economy and the presence of hot springs (thought to have curative properties) allowed the town to persist. A fire destroyed much of the town in 1886, but by then its designation as the county seat afforded it the sense of permanence it needed to rebuild and persist.

The earliest mining camp in Alpine County, first occupied in 1863, was known as Kongsberg (named for a silver mining town near Oslo). Located on Silver Creek, the name of the town was soon changed to Silver Mountain (Nadeau 1999: 43). By August of 1863, the town consisted of nearly 100 buildings and a population of some 3,500 people. In 1864, the town became the seat of newly created Alpine County. The town soon had telegraph services, a post office, a variety of hotels and boarding houses, a newspaper (the Alpine Chronicle), a school, and stamp and lumber mills (Murphy 1982:27). The number of residents soon declined, however, as silver deposits played out. Many left for other boomtowns in the county or elsewhere. The post office at Silver Mountain remained open until 1883. By 1885, virtually everyone had moved on. Other mining camps sprang up during the early 1860s as prospectors spread throughout the area. They included Silver King, Monitor, Mt. Bullion (sometimes called Bulliona), Centerville, Diamond Hill, Summit City, Raymond City, and Mogul (Clark 1977).

The town of Monitor sprang into existence in 1863. Prior to that, Monitor Canyon contained three log cabins inhabited by a half-dozen miners (Jackson 1964:40). Development of the town was coincident with increased activities at Silver Mountain. The town was named after the Union gunboat and it "rose in a canyon so narrow there was only room for one street" (Nadeau 1999:44). A road was extended down the canyon to the East Fork of the Carson River where it joined the road from Markleeville to Silver Mountain. The town eventually stretched for a mile along the canyon bottom. By 1864, some 150 buildings were present and 2,500 people lived there. In 1869, ditches were constructed to supply water to the town (Marvin 1997:24). A fire in April 1872 destroyed much of the business district. Within days, construction of new buildings began and soon the burned out section of town was rebuilt. The town began to decline over the 1870s. By 1885 little mining was taking place, as readily available ore deposits were depleted.

In 1864, 11,600 people lived in Alpine County, about seven times the current population.

The camp of Silver King was located at the south end of Silver King Canyon, at the headwaters of the East Fork of the Carson River. The river ran through town, with buildings present on either bank. Industries central to the town's existence included both mining and lumbering. As of 1864 the town consisted of 60 buildings. By the next year, the town was already in decline and by 1874 the town was nearly abandoned (Maule 1938:27).

In summary, European settlement of Alpine County saw a meteoric rise in the early 1860's. The population reached its zenith of about 11,600 persons in 1864. By 1875, the population had declined to about 1,200. Mining activities at the turn of the century kept the population at about 500 people. With the decline of mining in the 1910s and 1920s, the population dropped to below 300, where it stayed through the 1950s (Clark 1977:6). Only in the last several decades has the population increased.

A major stream passes through each of the communities discussed above. Impacts to the watershed due to settlement were focused on those reaches that extended through the town. Stream diversion; the placement of riprap, walls, and dikes to protect towns from flooding; and waste disposal into the waterway were major impacts that occurred to varying degrees in each location.

5.1.5 Mining

The decade from 1848 to 1859 was a period of fundamental change in the Sierra Nevada. With the 1848 discovery of gold in California, miners first rushed to the foothills. As prime locations were claimed or played out, prospectors moved into and back over the mountains into Nevada. In 1859, silver was discovered near Virginia City and miners flocked to the new Comstock mecca. It was during the course of these events that mineral deposits were first located in Alpine County. In November 1860, three prospectors discovered silver ore in the canyon of Carson River's East Fork. The first claims were located in 1861. Others soon joined them. Some 50 men (many Norwegians) stayed on through the winter of 1862-63. During the summer of 1863, Silver Mountain boomed, supported by work at a number of mines located along the Mountain and Scandinavian Ledges. Major mines in the area included the IXL, Exchequer, Lady Franklin, Buckeye, Adolphus, and Pittsburg. Mining proliferated throughout the county. The second-most important mining district was the Monitor District. Mineral deposits were found here soon after their discovery at Silver Mountain and the beginnings of a settlement soon appeared. Major mines in the district were the Tarshish, the Colorado, and the Advance mines. Mineral exploration also occurred in the hills around Silver King. Ore from the Excelsior Lode was milled in an arrastra built near town. There is little to suggest that much came of this endeavor.

Discoveries at and near Silver Mountain resulted in rapid prospecting of the entire county. An 1864 listing (Reed 1864, reproduced by Clark 1977:16) includes no fewer than 227 mines in six districts that encompassed the entire county. Eventually, the number of mining districts increased to 14, some of which saw almost no mineral production.

Over the 1860s, mills were under construction in the Silver Mountain and surrounding areas. It became apparent, however, that ore from local mines did not respond well to milling. The complex sulfide ores had high proportions of base metals that proved difficult to treat using then standard processes. Mills recovered less than half of the assayed value of the ore (Marvin 1997:7). As noted by Jackson (1964:64), the ore was not producing results credible to the mine or to the mill. As these difficulties became more pronounced, many of the original investors began to sell out. It was at this time that English investors became predominant in local affairs. During the 1870s, work at the mines began to wane. By the end of the decade only limited mining activity was still ongoing.

A problem for Alpine County silver miners was the abundance of copper in the ore. This led some to develop copper mines. One of the earliest was the "Uncle Billy" Rogers copper mine in Hope Valley, discovered around 1855. This mine had minimal production, but at least four other mines scattered about the county saw significant production. Both the Leviathan mine east of Markleeville and the Morning Star Mine in the Mogul District produced over 100,000 pounds of copper (Howatt 1968:62). Most of the copper ore was transported to the Comstock, where it was used to make bluestone for use in the mills near Dayton, Nevada.

Mining in the county declined dramatically after the mid-1870s. Following the decline of silver production in about 1880, low grade gold mining became a stable if not very lucrative supplement to the county economy. Mining activities reoccurred sporadically during the 1920s and during the years just before World War II. Tungsten mining occurred during World War Two (Howatt 1968:58). The 1960s saw a brief resurgence with gold mining activities at the Zaca Mine in the Monitor District. Several companies have conducted mineral exploration programs in the district in the last twenty years but no mines are currently active within Alpine County.

Over the years, Alpine County produced substantial amounts of sulfur, gold, silver, copper, tungsten, and rock products (sand and gravel). In addition, small amounts of lead, mercury, selenium, and zinc were produced. The value of all minerals produced is estimated to be about $20 million and may be several million more (Clark 1977:13). Sulfur accounted for more than $14.5 million, while gold and silver accounted for most of the remainder.

The Leviathan Mine showed remarkable resiliency, starting as a Comstock era copper and gold mine, as a copper mine in the 1890s, and as a sulfur mine in the 1930s. Sulfur production was not appreciable until 1953 when the Anaconda Copper Company began extracting sulfur for use at its copper mine near Yerington. This enabled the inexpensive sulfuric acid leaching of the copper ore there. The sulfur ore was transported by truck and by the mid-1950s production figures of over a million dollars a year were reported. This made the Leviathan the largest open-pit sulfur mine in the world until its closure in 1962 (Howatt 1968:72-74).

> The Leviathan Mine was active for over 100 years and for 50 years was the largest sulfur mine in the world.

One of the last mining booms to affect Alpine County was related to tungsten. Tungsten prices, along with improved extraction methods during World War II, led to a widespread boom throughout the West. Tungsten mines were located near Hope Valley and Carson Pass. The ore was concentrated at a plant near Gardnerville. By the late 1950s, the tungsten-mining boom had ended (Howatt 1968:72).

Mining impacts in the watershed can be combined into two primary categories: land disturbance and water quality impacts. Land disturbance came in the form of adits, shafts, waste rock piles, tailings, roads, and innumerable out buildings and support facilities. Mining-related water quality impacts primarily derived from mine drainage and from surface waters leaching through mills and mill tailings. Long term, the water quality impacts have proven more pronounced.

5.1.6 Logging

During the 1840s and 1850s, logging occurred only sporadically in Alpine County. Small, local logging operations and mills were established, of which the mill constructed by Jon Carey at Woodfords is an example. These early mills served local needs.

With establishment of the Comstock mines in 1859, vast amounts of lumber were needed. For the most part, this need was met by lumbering activities in the Lake Tahoe Basin and small canyons along the east flank of the Sierra Nevada. The Pacific Wood, Lumber, and Flume Company was the principal company working along the eastern front of the Sierra Nevada. This and other lumber companies, such as the Carson River Wood Drive Company, the Alpine Wood and Lumber Company, and the Genoa Flume and Lumber Company also produced lumber for use on the Comstock Lode (Howatt 1968:48).

In 1861 there were 13 sawmills and by the mid-1860s more than 45 saw mills were operating in Alpine County. Saw logs destined for the Comstock measured one-foot square by eight feet long. Most of the lumber was cut during the winter, stacked next to the river, and left until high spring and summer stream flows. The lumber was floated down the Carson River to Empire, "Nevada's desert port." From there, it was taken to Virginia City by rail. In 1861 it was reported that 5 million feet of saw logs and 6,000 cords of fire wood were floated down the Carson River. During 1865, in addition to supplying its own needs, Alpine County saw mills delivered six million board feet of saw logs in a single 21-day drive. In preparation for that drive, saw logs were stacked along the river for miles. Up to six such drives could take place in a given season. In 1866, a total of 14 million feet of lumber was run down the river (Howatt 1968:35, 41; Murphy 1982:41-43). Howatt (1968:46) summarized damage along the river from the wood drives:

> In the mid-1860s more than 45 saw mills were operating in Alpine County.

> "Each year, bridges were damaged or washed away, roads were ruined, buildings along the river were often demolished, and the agricultural lands in the Carson Valley were often damaged."

Sawmills were located along canyon bottoms, generally in proximity to a stream. Maule prepared a map of sawmills active from 1860-1880. Eight sawmills were present along the East Fork of the Carson River while five were present along the West Fork. Others were scattered along smaller streams in the area. In later years, with deforestation near the streams, portable sawmills operated further away from streams and rivers. A picture of a typical early 1900s, steam-powered operation is provided by Hattori and King (1985:48). Logging and milling remained an important industry in the region and in Alpine County into the early 1870s when mining began its decline and the market for railroad ties generated by construction of the Central Pacific Railroad disappeared. By the mid-1870s, most of the local forests had been severely reduced. Other more distant markets allowed brief renewals. For example, the Carson Range supplied some milled lumber to the Bodie and Aurora areas through the 1870s (Fletcher 1982:106).

Logging declined markedly in the 1880s as mining continued its decline and as virgin stands of timber were depleted. Those logging operations that did persist into the late 1800s and early 1900s were small, and served local needs rather than the Comstock. In 1880 only two sawmills were left operating in the area. Between 1880 and the turn of the twentieth century, the area continued to deliver an average of 75,000 cords of wood per year. Unrestricted logging was finally eliminated in 1887 when portions of the county were assigned to Forest Reserves and later incorporated into National Forests. The last drive down the Carson River occurred in 1896. By the mid-1960s, these lands yielded about five million board feet of wood annually, all of which was milled outside the county (Howatt 1968:51). Since that time, timber operations have been reduced substantially.

As a result of logging activities, most of the forest in the county is secondary growth. A forestry map produced by the California State Board of Forestry in 1911 shows all of Alpine County as logged over. Woodland and brush were the only merchantable forest products shown on the west slope of the Sierras. In 1921 the California State Mineralogist noted the lack of timber in the county (Howatt 1968:47, 49). The county was described as an area covered by brush and non-marketable woodlands. Logging roads and skid trails would have been common throughout the logged areas. However, it must be noted that most of this logging occurred during an era when logging roads and skid trails were little more than two-track roads. They were not the large, engineered and constructed logging roads required to support trucks and trailers. Unlike many areas, railroads were not constructed in Alpine County to facilitate logging operations.

> Thru the 1920s, the county was described as an area covered by brush and non-marketable woodlands.

As discussed above, wood drives would have had a substantial impact on the East and West forks of the Carson River. Bank erosion would have occurred due to log traffic and this would have been enhanced in areas where logjams occurred. As with many other impacting land use activities, wood drives did not occur after the end of the nineteenth century.

5.1.7 Agriculture

Initially, farming in Alpine County consisted of small-scale operations that supplied meat and produce to local mining communities. When those communities flourished, so did the small farms. These farms were generally limited to valleys below about 5,500 feet, particularly east of Markleeville, in Diamond Valley and east of Woodfords (Howatt 1968:79). However, small amounts of crops were grown as high as Hope Valley and in other upland areas scattered about the county (Howatt 1968:80).

When the mines declined, so did the role of the farmer. The Great Register, a list of voters in the district between 1866 and 1889, noted only six farmers, one rancher, one herder, and one poulterer (Marvin 1997:26). "Stock ranches," intended to service the need for fresh meat, had been established in the 1860s and 1870s at locations near Monitor, Mogul, and several other places throughout the county (Howatt 1968:81; Marvin 1997:26). In the 1860s, Faith, Hope, and Charity valleys were used for summer grazing of dairy cattle. In 1869, Hope Valley supported 700 cattle (Howatt 1968:80).

Natural disasters during the 1860s caused California ranchers to seek winter grazing lands in northern Nevada where public lands were abundant. Also, completion of the Transcontinental Railroad in

1868 provided ranchers with ready access to regional markets. These factors led to the development of small empires ruled by "cattle barons" of the day. Never shy, these cattle barons grazed huge numbers of sheep and cattle on public lands. In the absence of any substantive form of state or federal control, the magnitude of this use was checked only by nature. The late 1870s through the 1890s was a difficult period for small farmers throughout the region (Creel 1964). Many simply faded away or sold out to large-scale operations that could afford to transport products to outside markets (Hattori and King 1985).

By the 1870s, impacts of this shift in the livestock industry were being felt in Alpine County. Large companies moved herds of cattle and sheep onto public lands where they were allowed to range for the summer and fall months. In late fall, the livestock would be relocated back to private lands in nearby Carson Valley, or to more distant home ranches in California lowland valleys. Sheep were the most prominent at first. During the late 1800s and early 1900s, thousands of sheep were trailed into Alpine County where they were pastured over the summer months. In 1870, the number of sheep grazing in the county was placed at 135,000 (Howatt 1968:81). As noted by Nedeau (1999:54):

> "Every June, drovers from San Joaquin Valley herded as many as 100,000 sheep over Ebbetts and Carson Passes to reach the green meadows of Alpine."

Or as noted in the Alpine Chronicle, "our mountains are getting lousy with sheep." Migratory sheep grazing was much resented since it contributed almost nothing to the local economy while stripping the area of its limited forage resources (Howatt 1968:81). References to environmental degradation are found. For example, in 1887 sheepherders set brush fires that spread to timberlands (Howatt 1968:82). The bottom fell out of the wool market in 1920 when the U.S. Government dumped its reserve supplies onto the world market.

> In 1870, 135,000 sheep were grazing in Alpine County.

Beginning around the turn of the century, the grazing of cattle gradually took precedence. The cattle (and sheep) industries boomed during World War I, but declined markedly thereafter. Until World War II, dairy cattle represented the largest part of the county's livestock market. Most dairy herds were based in the Central Valley but spent their summers in Alpine County. Small dairy camps were associated with the dairy herds where butter was produced from the milk. As a subsidiary industry, the skimmed milk was used to feed hogs (Howatt 1968:83, 88).

After World War II, the seasonal grazing of dairy cattle had largely disappeared. By the 1950s beef cattle had become dominant throughout the county. Largely, this reflects the withdrawal of Central Valley livestock from the county. Local beef cattle producers, such as the Dangberg Land and Cattle Company, remained. In the 1960s, some 4,000 cattle and 4,000 sheep, mostly from Carson Valley, were moved into Alpine County each summer to graze (Howatt 1968:86).

Establishment of the Forest Service in 1908 and the Grazing Service in 1934 had a profound effect on public land use for livestock grazing. From the onset, the agencies made a concerted effort to control grazing that took place. They defined allotments and controlled who had access to those allotments. The number of cattle and sheep was controlled, as was the season of use. Rangers monitored use of the land and dealt with violations of prescribed patterns. For the first time, the use of private land was differentiated from that of surrounding federal land. Private holdings were integrated into a more involved system of rotating cattle through specific areas at specific times of the season. Far more than before, the permittee had to be sensitive to land status and conditions placed on the company by the Forest Service. During the first half of the century, then, grazing patterns became more geographically differentiated and fell into a fairly routine pattern from one year to another. Also, the amount of livestock in the area was fairly constant from one year to another.

> By the 1960s, about 4,000 head of cattle and 4,000 sheep were grazed in Alpine County

Present permitted grazing levels represent 30-40 percent of 1960 levels and 1-2 percent of late 1800 levels.

Current data on the number of animals that are permitted to graze on federal lands in Alpine County are provided in Table 5.1. These data, provided by the Forest Service and the Bureau of Land Management, indicate that at the height of the grazing season, some 1,163 cattle, 13 horses, and 1,650 sheep could be present on federal lands. This represents about 30 to 40 percent of the animals grazed in the county in the 1960s, and as little as one to two percent of the animals present during the 1870s and 1880s. Grazing impacts on the watershed were most pronounced during the nineteenth century when uncontrolled grazing by large herds of sheep and cattle occurred throughout the county. Livestock numbers and impacts diminished over the twentieth century as the Forest Service and Bureau of Land Management exerted increased control over the industry.

Table 5.1. Grazing data for Alpine County, 2004.

Allotment	Number of Animals	Class of Livestock	Season of Use
BLM			
Harvey Flat	(37-80)	Cattle	Not Active
Hay Press	50	Cattle	6/16 to 9/30
Barney Riley	70	Cattle	6/1 to 9/30
Forest Service			
Hope Valley	103	Cattle	6/26 to 10/25
Fredericksburg	6	Horses	5/1 to 5/31
Millberry	15	Cattle	6/1 to 7/31
Charity Valley	60	Cattle	7/15 to 10/15
Pleasant Valley	14	Cattle	5/15 to 10/31
Noble Canyon	144	Cattle	6/26 to 9/30, 7/11 to 9/30
	4	Horses	6/1 to 10/10
Bull Canyon	285	Cattle	6/25 to 9/15, 6/16 to 9/30
	3	Horses	7/1 to 9/30
Wolf Creek	90	Cattle	6/16 to 9/30
Murray Canyon	114	Cattle	7/16 to 9/30
Dumont	85	Cattle	7/16 to 9/30
Cottonwood	133	Cattle	6/26 to 10/25, 7/1 to 9/25
Campbell Loope	1650	Sheep	8/16 to 10/10

Source: USFS and BLM file data, 2004.

5.1.8 Irrigation

An essential adjunct to ranching in the Upper Carson River watershed has been irrigation. A series of Nevada ranchers, including the Dressler, Berry, Fay, Wilkerson, Park, Scossa, Dangberg, and Settlemeyer families established water rights starting in the 1880s and proceeded to create a major private irrigation system well in advance of the later federal Newlands Reclamation Project downstream, a situation that was to result in major litigation and a clash of theories concerning upstream versus downstream storage of irrigation water (Dangberg 1975; Howatt 1968:84). A key aspect of this irrigation system was the construction of small reservoirs that were within the technological means of private ranchers. Initially log and earth affairs, early dams were gradually replaced with more permanent stone, earth, and concrete structures. In 1896 the ranchers formed the Alpine Land and Reservoir Company and immediately obtained 15 reservoir sites from individual members (Table 5.2). The company continues to manage the reservoirs to the present.

Irrigation diversions are limited to the West Fork of the Carson River in the Diamond Valley area.

Table 5.2 Reservoirs and lakes in the Alpine County portion of the Carson River watershed.

Name	Location T	R	Sec	Elev.	Capacity (acre-feet)	Source
EAST FORK CARSON RIVER						
Upper Kinney Lake	8	20	7	8,536	328	Silver Creek
Lower Kinney Lake	8	20	7	8,442	920	Silver Creek
Kinney Reservoir	8	20	8	8,333	900	Silver Creek
Wet Meadows	9	19	27	8,030	450	Pleasant Valley Creek
Summit Lake	9	19	27	8,022	31	Pleasant Valley Creek
Raymond Lake	9	19	25	8,980	50	Pleasant Valley Creek
Tamarack Lake	9	19	21	7,890	404	Pleasant Valley Creek
Upper Sunset	9	19	27	7,858	68	Pleasant Valley Creek
Lower Sunset	9	19	22	7,823	860	Pleasant Valley Creek
Heenan Lake	9	21	3	7,084	2,948	Heenan Lake Creek
Indian Creek Reservoir	10	20	4	5,604	3,100	Indian Creek
					10,059	
WEST FORK CARSON RIVER						
Upper or East Lost Lake	9	18	22	8,598	92	Headwater of West Fork
Lower or West Lost Lake	9	18	1	8,546	127	Headwater of West Fork
Crater Lake	10	18	11	8,522	320	Crater Lake Creek
Scotts Lake	10	18	2	8,001	736	Scott Creek
Red Lake	10	18	23	7,867	1,103	Red Lake Creek
					2,378	

Source: Glancy and Katzer (1975, Table 11)

Irrigation impacts on the watershed were limited during much of the nineteenth century but became more pronounced during the twentieth century. Impacts have included modification to flows, either due to impoundment or diversion, and the introduction of nutrients and sediments as part of return flows. Within the assessment area, irrigation diversions are limited to the West Fork of the Carson River in the Diamond Valley area. Diversions include the Snowshoe Thompson Ditches (#1 and #2), the Upper Dressler Ditch, the Upper and Lower Fredericksburg Ditches, and the Falke & Tillman Ditch (Hess and Taylor 1999:6). An extensive photo archive of irrigation-related features is available at the California Division of Water Resources. Many of those photos were reproduced in Dangberg (1975).

5.1.9 Forest Condition and Function

Current conditions in the Sierran landscape of forests and riparian areas have been influenced by many human practices since European settlement. Changes in fire regime are attributed to elimination of the Native American practice of fire as a landscape management tool; fine fuels removal by livestock; alteration of vegetation composition and distribution by irrigation, cultivation, roads, and development; and perhaps most importantly the implementation of a national fire exclusion policy (Arno 2000). Timber harvest has also greatly affected the current forest species composition. The selective harvest of big, pine, and fir trees left shade-tolerant and inferior genetic stock to regenerate on site (SNEP 1996).

> In general, today's forests are over stocked and less healthy, with decreased vigor leading to disease and infestation.

Sierran forests today are denser and exhibit a strong component of shade intolerant species like incense cedar and white fir. In general, forests are over stocked and less healthy, with decreased vigor leading to disease, mistletoe and bark beetle infestation. The herbaceous layer consisting of grasses and forbs is no longer as well represented, with diminished diversity and wildlife habitat values. Accumulated fuels include duff layers that provide substantial ground fuel, downed wood, and ladder fuels in the form of saplings and lower branches on mature trees. The probability of stand replacing fire is high in forest cover types that previously were subject to mixed and ground fire regimes.

In contrast to the pre-settlement landscape consisting of smaller stands of like composition, with various age structures present in both conifer and riparian stands, the landscape today is coarse grained with larger, homogenous areas exhibiting one or two age classes and less species diversity (Arno 2000).

The probability of stand replacing fire is high in forest cover types that previously were subject to mixed and ground fire regimes.

Evidence of forest change was found in historic photo comparisons. The amount of forested area has increased in recent history. For example, in photos of Hope Valley (Figure 5.1), note the treeline on the opposite side of the valley in 1934. Then note the treeline in the current photo. Over the last seventy years, the forest has moved almost all the way to the valley bottom. Figure 5.2 provides a comparison of forest composition over time. The first photograph is of Markleeville in the late 1800s. The hills behind Markleeville are bare; the forest had been completely harvested. Note the absence of disturbance or stumps. Areas comprised of brush and small trees can be seen in the distance at the right of the photo. These data suggest that the forest may not have extended all the way to the Markleeville town site in prehistoric times. In the more recent picture, from about 1955, the forest is encroaching on the town. Figure 5.3 provides a comparison of the Silver City area in the 1860s and at present. In the 1860s photo, stumps are evident in the foreground and downed logs are present on the far right hillside. These data suggest heavy logging activity during the mining era. The few remaining trees are tall and lack limbs at the lower level. Bedrock is evident and low brush cover is present in many areas, including around the cabin in the foreground. The prevalence of brush suggests that the prehistoric forest in this area may have had a higher proportion of brush cover that is present today. The recent photo shows a dense forest of trees with limbs that extend almost to the ground. Also, the forest cover extends onto rocky slopes were brush cover was prevalent in the 1860s photo.

Ecosystem response to fire is variable within broad cover classes of Sierra Nevada vegetation. East side pine forests are influenced by the rain shadow and therefore have slower rates of growth, decay and fuels accumulation. As a result, nutrient cycling and decomposition are slow, and the recovery period after a fire is longer. Chang (1996) suggests that fire suppression and selective logging have caused the shift to forests with high cover contributed by shade tolerant species. Other factors contributing to the current, denser forest composition may include the current wet climactic period and the cessation of sheep grazing. Potential succession in forests following a stand replacing fire would be herbaceous plants to shrubs, to pines and then climaxing with fir. High severity fires may lead to a coarse grained landscape with extensive stands of shrubs like manzanita and *Ceonothus* species as these species are well adapted to fire and require it to regenerate. Soil productivity has decreased, perhaps due to high severity fires and earlier impacts from logging and harsh mechanical practices (Chang 1996). Suppression of fire has also led to stagnant aspen stands encroached upon by shade tolerant conifers. Without disturbance, aspen clones do not regenerate (Arno 2000).

Succession in forests following a stand replacing fire would be herbaceous plants, to shrubs, to pines, and climaxing with fir. High severity fires may lead to a landscape with extensive stands of shrubs.

Subalpine meadows are vegetated by grasses and sedges, with pine forests relegated to the meadow margin. Grazing, fire, and climate have influenced the forest/boundary dynamic. A commonly agreed to theory is that past grazing led to increased runoff and soil erosion, entrenchment of the streams and lowering of the water table. With the elimination of grazing, it is postulated that regeneration of lodgepole pine has occurred in subalpine meadows, as the seedlings are no longer grazed (Chang 1996).

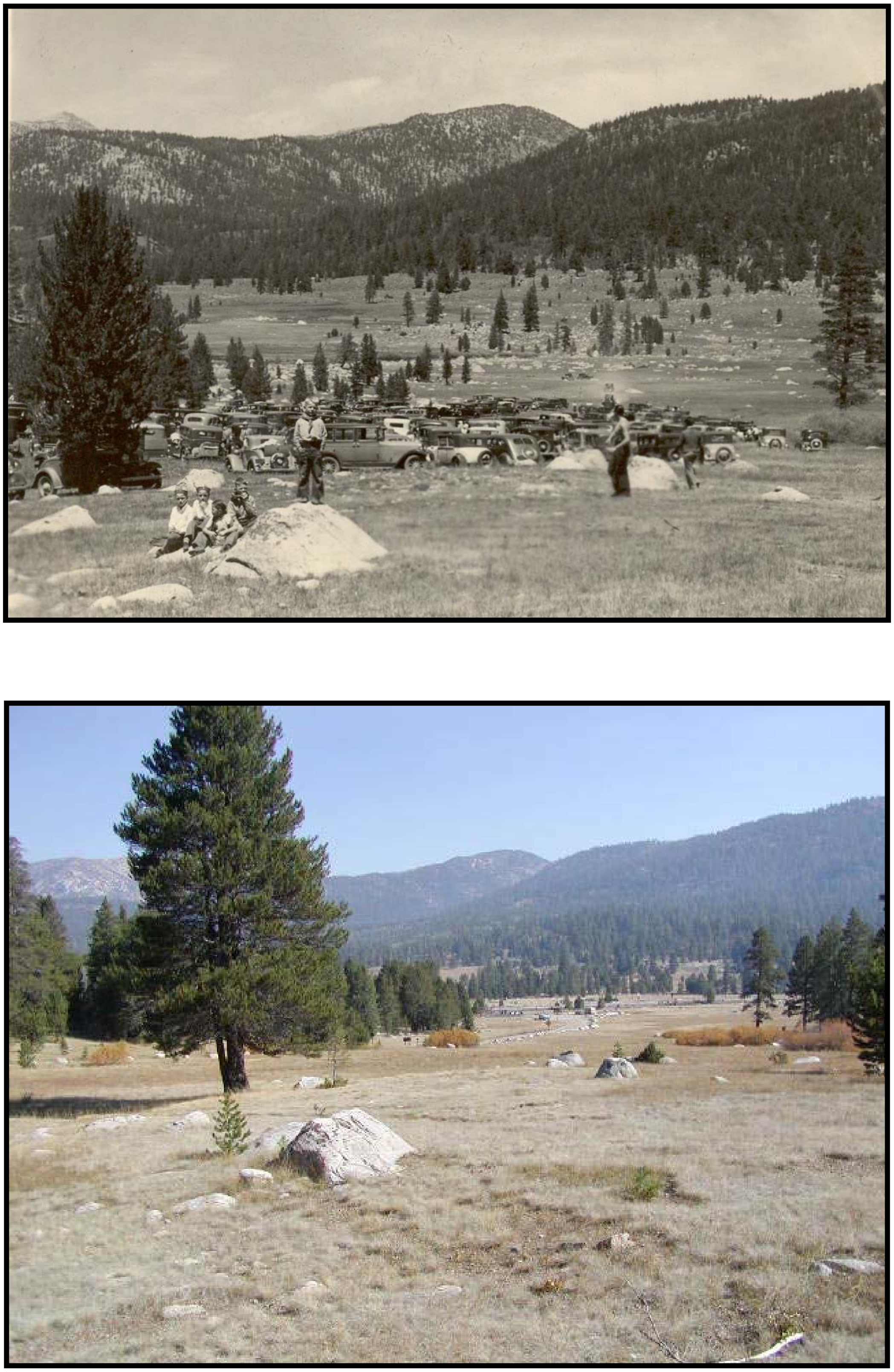

Figure 5.1 Hope Valley in 1934 and 2004.

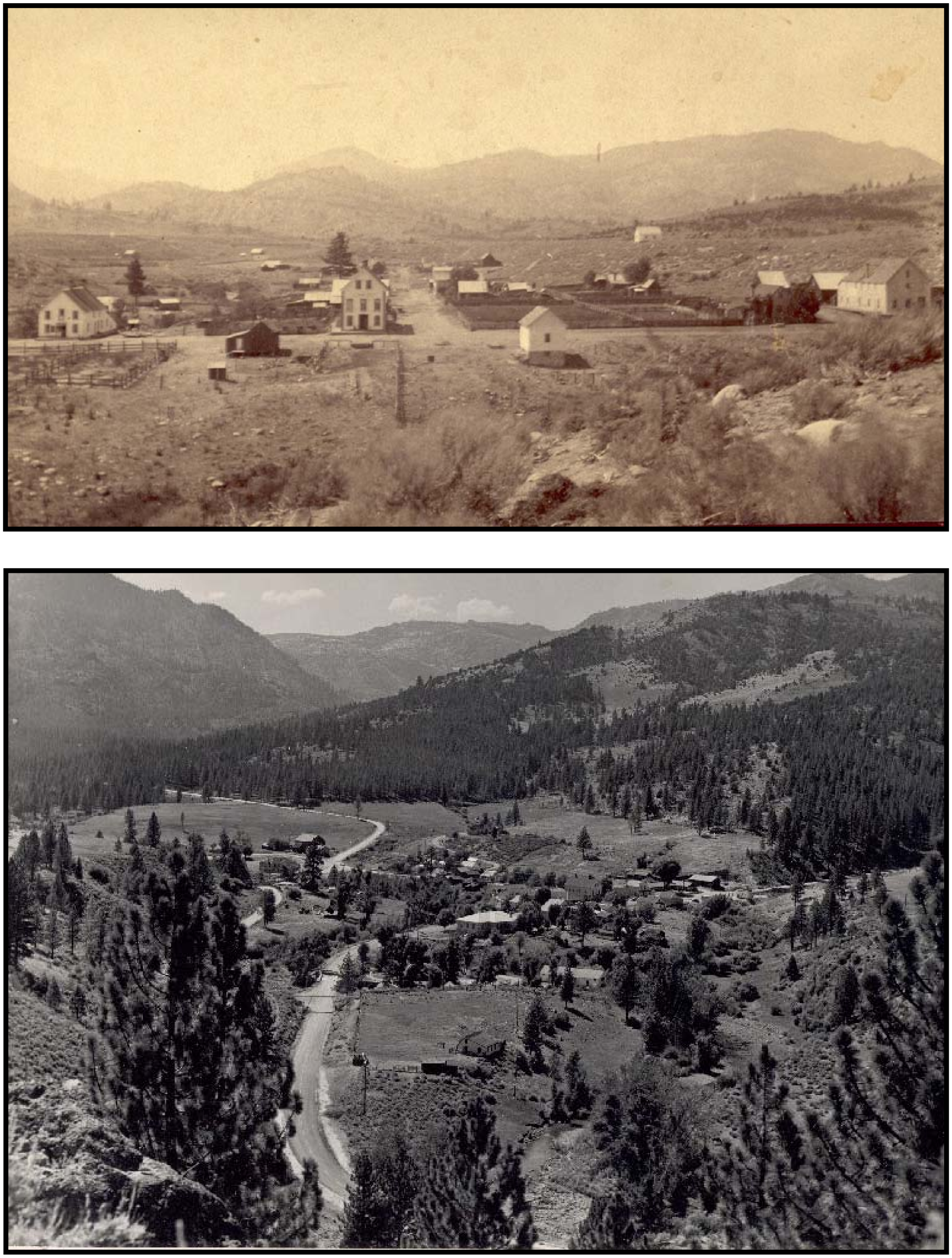

Figure 5.2 Markleeville in about the 1870s and in 1935.

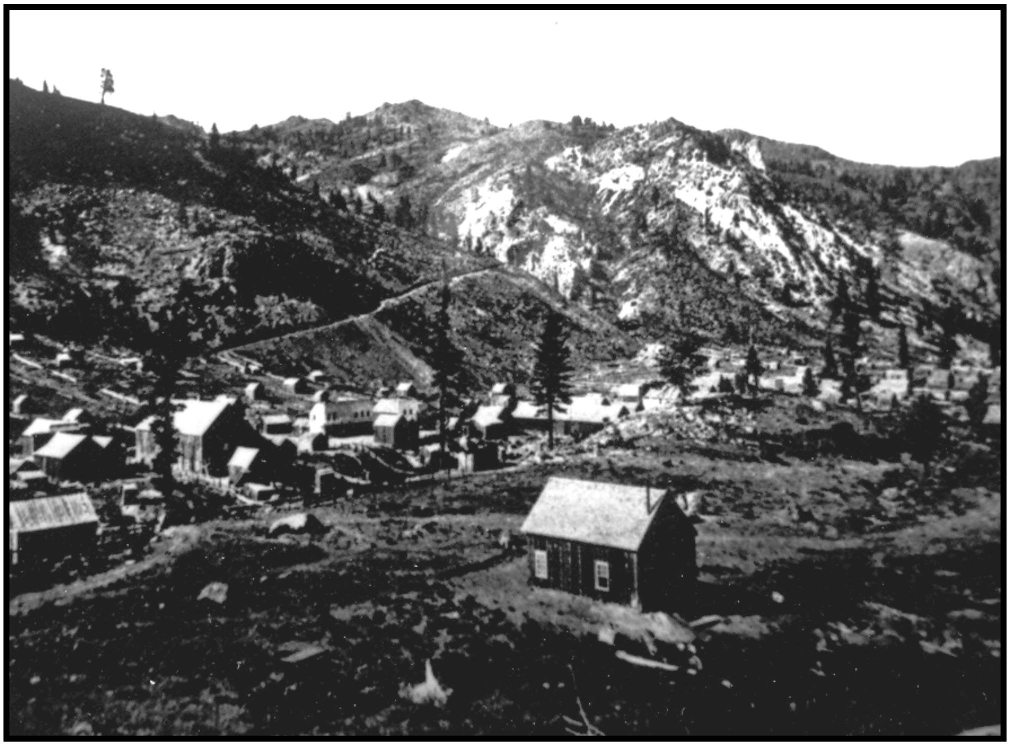

Figure 5.3 Silver City photo pair, the 1860s and 2003.

5.2 Geomorphic Effects of Human Disturbance on Streams

This section describes how, and to what extent, modern human disturbances may have altered the ability of stream systems to maintain equilibrium. Such changes could take place in either of two ways:

- changes in water or sediment supply, rendering floods more capable of promoting change; or,
- a reduction in channel and floodplain inertia to equilibrium change, through decreased channel and floodplain resistance or resilience.

Shifts in any of these factors - the energy of flood events, sediment supply, resistance of the system to change, or resilience of the system from minor change - can set the stage for a threshold shift in channel equilibrium. The greater the increase in these changes, the smaller the magnitude of the event that is needed to trigger a threshold shift in channel equilibrium.

5.2.1 Hydrologic Responses

Two potential hydrologic impacts from cumulative watershed disturbance are increased peak flow response and reduced base flows. Both impacts occur when cumulative watershed disturbance causes a "flashier" response to precipitation. Increased peak flows also mean increased frequency of larger floods such that the channel system cannot, on average, recover. This places an increased frequency and magnitude of erosive stress on the channel, which can induce a threshold change in channel equilibrium.

Overgrazing in the basin headwaters may have increased the peak flow response through decreased infiltration resulting from compaction and erosion (Johnson 1992). Of particular concern was heavy sheep grazing that occurred during the late 1800s and early 1900s. The degree to which conditions were altered is not known. Nor is it clear how much recovery may have occurred in the 60 plus years that have elapsed since heavy grazing occurred. In some portions of the Sierra Nevada late 19th century grazing was thought to be damaging to watersheds (Beesley 1996). The first report issued by the California State Board of Forestry in 1886 contains recommendations to exclude further sheep grazing because of damage it had caused.

Early grazing is thought to have been so damaging because more than one herd often used the same range during the same season. Droughts and floods in the 1860's forced ranchers in other parts of California to drive stock into Sierra Nevada mountain meadows (Kinney 1996). The size of the herd, the number of herds, the timing of their turning out, nor the length of stay was regulated. In the Carson watersheds, use may have been less intensive due to ownership patterns. Nonetheless, grazing may have had significant impacts on peak response. Conditions improved as the level of control by land management agencies (Forest Service and the Bureau of Land Management) increased. Implementation of allotment and permit processes controlled the classes of livestock allowed, the number of animals allowed, their seasons of use, and the locations where that use could occur.

Timber harvest can also increase peak flow response through soil compaction or road construction. Roads can significantly alter hydrology within a watershed (Bowling and Lettenmaier 2001; Luce and Black 2001). Roads increase the amount of impervious surface in a watershed, especially in forested watersheds where canopy cover and dense litter on the forest floor limits overland flow. Harvest patterns were widespread enough within the watershed, particularly in the 1960's and 1970's, to have had some impact on peak flow response. However, this effect probably does not have geomorphic significance today due to subsequent reductions in harvesting activities.

Extensive soil loss in the headwaters may have lead to disclimax conditions or erosion pavement. However, the effect of these conditions on peak flows may have been more muted than might otherwise have occurred. This is because of the prevalence of rain-on-snow events as the cause of major floods. In general, however, it is likely that land use impacts have worked to somewhat increase the magnitude and, potentially, the frequency of floods.

Base flows have been reduced by use of water for irrigation along the West Fork. Diversions downstream of the USGS gage at Woodfords can result in complete dewatering of the lower West Fork in the assessment area during drought years. Base flows and total basin water yield may be increased to some extent by the effects of grazing. This effect occurs through reduction of plant biomass and, therefore, reduced interception and transpiration losses (Heady and Child 1994). Shifts in vegetation species composition from perennials to annuals may also reduce seasonal transpiration losses. Grazing effects are likely to change the timing of water delivery to the channel. Reduced transpiration and infiltration increase and hasten surface runoff, resulting in a more rapid response of streams to rainfall or snowmelt runoff (Spence et al. 1996). More water is delivered to the channel during higher runoff periods, and less is stored in floodplain soils to be delivered during low flow periods.

Low flow can be further reduced by changes in channel geomorphology brought about by grazing and other land use. Channel incision, a lowering of the streambed with respect to the surrounding floodplain, may result in a lower base flow late in the summer (Kattelmann and Embury 1996) because of a loss of water storage in floodplain alluvium. Incision can be caused by a number of factors, but the most important is stream bank instability due to the effects of grazing. Though total water yield may increase due to grazing effects (reduced evapo-transpiration resulting from less plant biomass and lowered water tables), summer stream flow may actually decrease (Spence et al. 1996). This is because the loss of water from gullying outweighs the loss of water due to evapo-transpiration (Elmore and Beschta 1987).

Stream flows in a heavily grazed eastern Oregon stream became intermittent during the summer, while a nearby stream in a similar watershed that was well-vegetated had permanent flow (Li 1994). There is some evidence that channels have incised in portions of the assessment area (see Chapters 2 and 4), which may have resulted in reductions in base flows.

Grazing effects on stream hydrology are correlated with the intensity of grazing. Infiltration may increase somewhat under light grazing (Rauzi and Hanson 1966), and moderate grazing has little effect (Rauzi and Smith 1973). Heavy grazing, however, almost always decreases infiltration (Johnson 1992), which likely results in increased runoff, particularly during snowmelt, leaving less water available for late season base flows. Reduced base flows have several ecological and geomorphic effects. The stability and vigor of riparian plants may be affected by lowering of the water table and reductions in base flow. Bank erosion, channel widening, loss of in stream complexity and pool habitat, and fine sedimentation in substrate may result from base flow reduction (Kattelmann and Embury, 1996).

In portions of the West Fork, base flow may be augmented by storage for irrigation. Water supply reservoirs in the upper portion of the watershed are used for irrigation late in the season (California DWR, 1991). Water that would have passed through the system during spring runoff is held in these reservoirs and passed down the channel for irrigation during the summer months. The net result is a decrease in spring flood flow and an increase in summer base flow. Effects on spring flows are limited because the amount of water stored is low compared to the flow produced during typical snowmelt floods. Because natural base flow is typically low in the watershed, the effect on summer flow is more significant.

5.2.2 Sediment Supply

Grazing in the riparian zone can increase sediment supply to the stream channel by increasing both surface erosion and mass wasting (Spence et al. 1996). The removal of vegetation and exposure of soil makes surface sheet erosion and gullying more likely. Rills and gullies may form in areas where grazing use is heavy, expanding during floods or storms. Mass wasting of sediment occurs along stream banks where livestock trample overhanging cut banks (Fleischner 1994). Stream bank instability resulting from trampling and loss of vegetation on stream banks also tends to result in higher rates of bank erosion and increased sediment supply. Grazing may be a primary cause of channel incision, which greatly increases available sediment. Though channel incision often occurs in response to climate change or other natural factors, heavy livestock grazing has also been shown to be a primary cause (Dietrich et al. 1993; Peacock 1994). Incision results in substantial increases in mass wasting of stream banks and rill and gully erosion on adjacent floodplain surfaces. Surface erosion increases as well due to resulting changes in floodplain and riparian vegetation (Elmore 1992).

Roads alter and concentrate flow paths, and, depending on the quality of construction, can greatly increase sediment supply to the channel. This can occur through the failure of road cuts, fills, or out slope fills. Undersized culverts, built to handle water but not sediment and debris, can clog during peak events resulting in a complete washout of the road, or gully formation when the flow path is altered. Sediment supplied from roads can be grouped into two classes:

- large-scale failures that deliver high volumes of sediment, usually during larger storms; and,
- chronic production of finer sediment at lower rates but over longer periods, which can occur during even brief, low intensity storms.

Sediment from large-scale road failures is delivered to the channel during peak events when the stream flow is high and fine sediment can be transported downstream and coarse sediment can be sorted. This is similar to sediment transport routes for landslides, debris flows, bank erosion, and other natural sources of sediment. An increased supply of sediment generally results in increased channel dynamism (eroding stream banks, channel widening, channel migration, etc.). Fine sediment can erode at lower rates during less intense storms due to shallow flows on road surfaces, ditches, and road cuts. This type of erosion tends to be chronic in nature. During less intense storms, fine sediment from these features is delivered and deposited in stream channels, but stream flow is often too low to transport the supplied material. This results in pool filling and the sedimentation of riffles. The geomorphic impact of this sedimentation may be short-term, as subsequent high flows transport the material downstream, but ecological consequences may be more dramatic (see Chapter 2).

Extensive road development and ground disturbance, both potential sediment sources, have been associated with timber harvest in the watershed. Long abandoned harvest roads may continue to represent a source of erosion within the watershed. Though the modern road system is less dense and was constructed to limit potential erosion, it still represents a potential source of sediment. Many smaller roads or tracks in the watershed were pioneered and are maintained by recreational users.

5.2.2.1 Charity Valley Creek Watershed Sediment Survey

A series of intense thunderstorms occurred in the upper portion of the Carson watershed during July of 2003. They were short duration, high intensity storms that resulted in as much as four inches of rainfall within one half hour. The rainfall created flash flood conditions in localized areas. Runoff plugged existing culverts along roadways and washed material off of undisturbed hillsides. The thunderstorms produced strong evidence of erosion and sediment transport, including rills, gullies and sediment deposits. The assessment team surveyed a part of the Charity Creek watershed to evaluate sources of sediment brought to light by those storms. Since several different land uses (potential sources of sediment) occur in the area, this allowed qualitative evaluation of their sediment contribution potential.

Surveys were conducted over several days in September of 2003. Sediment sources and incidents of sediment transport were photographed (Figure 5.4). UTM coordinates were recorded of all photo locations and notes were made regarding geomorphic conditions at each photo location.

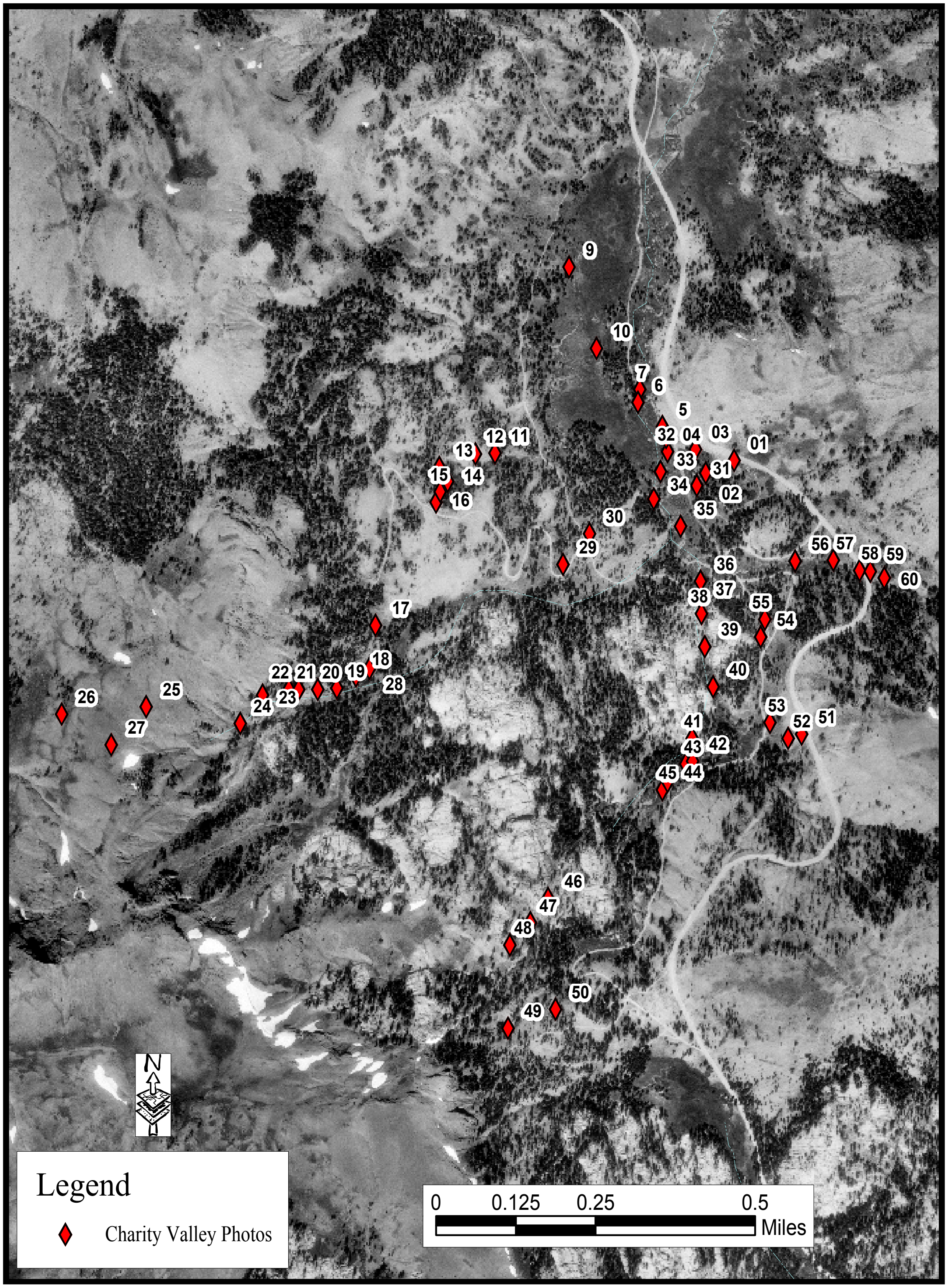

Figure 5.4 Charity Valley Creek photo point locations.

Geology of the upper portions of the watershed consists primarily of extrusive volcanic rock. Slopes are extremely steep. An outcrop of granitic rock dominates the middle portion of the watershed in the assessment area. All drainages are incised through this outcrop in steep, confined channels.

The lower end of the survey area is where Charity Valley Creek first nears the Blue Lake Road. At the time of the storm, road construction, including widening and resurfacing, was underway. Concentrated storm runoff eroded a portion of a newly constructed embankment (Figure 5.5, Photo CV001), which had been reconstructed by the time of this survey. Material from the embankment was transported to the stream channel and channel aggradation was obvious downstream from this point (Figure 5.5, Photo CV004). However, channel aggradation was also apparent upstream of where the material from the road embankment entered. This suggests that sediment supply and transport was also high upstream of the roadway (Figure 5.5, Photo CV032).

A tributary to the main channel is located about 500 feet upstream of where the Blue Lake Road sediment entered the channel. That tributary also transported substantial sediment during the storms (Figure 5.5, Photo CV033). The assessment team surveyed the area to determine the source of the sediment in the tributary. In a few locations, sediment supplied to the tributary exhibited a human influence. A road embankment failure near the middle of the watershed supplied fine and coarse sediment to a gully that enters the tributary (Figure 5.5, Photo CV016). This was the only site located along the tributary that contributed significant quantities of coarse sediment. Other roads or skid trails, generally small and old, had rills and gullies that likely contributed some fine sediment (Figure 5.5, Photo CV017), but no other large-scale failures could be found.

Natural sediment sources within this tributary's watershed were numerous, and contributed both fine and coarse sediment. Well upstream of any human-related land use, this tributary exhibits evidence of sediment transport and deposition that occurred during the storms (Figure 5.6, Photo CV019 and CV020). This material was generated from steep slopes in the upper watershed in volcanic rock geology (Figure 5.6, Photo CV024). Other portions of the upper watershed also showed evidence of sediment derived from natural sources. Based on sediment deposits, debris flows apparently also occurred in an eastern tributary that flows under Blue Lakes road (Figure 5.6, Photo CV059). Less than one thousand feet upstream of the road, this tributary is in a wilderness area, and roads play little part in sediment supply.

Several light duty dirt roads contribute sediment to stream channels in other portions of the watershed. Problems were caused by the concentration of flows. For example, a culvert under the Blue Lakes road contributed to the creation of a gully through concentration of flow on the downstream side (Figure 5.7, Photo CV051). Embankments on Forest Service roads have gullied in several locations due to concentration of flow on road surfaces (Figure 5.7, Photo CV043). The concentration of flow along roads or in ditches also has created erosion along a road in a riparian area (Figure 5.7, Photo CV031). Less substantial rills and gullies are common on both fill and cut slopes throughout the watershed (Figure 5.7, Photo CV042), though similar rills and gullies were observed on many undisturbed slopes.

Road crossings over existing drainages can also be sources of sediment. The gully below the Blue Lakes road culvert (Figure 5.7, Photo CV051) crosses a Forest Service road further down slope (Figure 5.7, Photo CV052). High sediment transport to the crossing from upstream has filled the culvert. As a result, the road itself is susceptible to failure during future flood events.

> Natural sources accounted for the majority of sediment supplied to the stream channel during the intense 2003 summer thunderstorms

In summary, natural sources probably accounted for the majority of sediment supplied to the stream channel in the Charity Valley Creek watershed during intense storms that occurred during the late summer of 2003. Roads generated a substantial quantity of sediment (both coarse and fine). Similar effects from roads are likely in other portions of the assessment area.

CV001

CV004

CV032

CV033

CV016

CV017

Figure 5.5. Charity Valley Creek sediment survey photos.

CV019

CV020

CV024

CV059

Figure 5.6. Charity Valley Creek sediment survey photos.

CV051

CV043

CV031

CV052

CV042

Figure 5.7. Charity Valley Creek sediment survey photos.

In prioritizing projects and making regulatory decisions, it is important to determine, at least in a relative sense, the amount of sediment supplied by man-made versus natural sources. Gaining the most value for your restoration dollar can only be attained by understanding the true impact your restoration activity may have on the watershed. If an expensive project addresses a land use induced impact that generates only 10 percent of the sediment load (because 90 percent is coming from natural sources), then those restoration dollars may be better spent in some other location.

5.2.2.2 Changes in Sediment Supply Potential

As noted in section 5.1.9, forest expanse and structure has changed in the historic period. Historical photographs appear to support these general trends in forest structure. In several locations, the assessment team was able to take modern photographs from the same location as historic photos (see Figures 5.1 through 5.3). These changes in forest structure are likely to increase the intensity of future fires. Forest stands are denser, fuels are more abundant, and the multiple canopies provide ample ladder fuels (Chang 1996). Intense, stand-replacing crown fires are most likely. Erosion rates typically increase substantially after such fires, and more sediment, both coarse and fine, is supplied to channels.

> Changes in forest structure will likely result in high intensity forest fires; burned areas will contribute significant amounts of sediment to the Carson River.

5.2.3 Riparian and Channel Modifications

In many portions of the assessment area, land uses have altered riparian areas or the channel. These modifications are reviewed in the following section.

5.2.3.1 Lower West Fork (Reaches WF1-7)

Several road bridges are located in this area, but the channel is highly stable and most of the crossings have had little effect. The channel shows some dynamism in association with the Highway 89 crossing upstream of Woodfords, and this area was included in our detailed assessment to evaluate the effects of channel modification.

Grazing occurs throughout much of this area. However, the channel is incised and as a result most grazing occurs on meadows well above the elevation of the stream, on surfaces that are geomorphic terraces. Thus, the influence of grazing on the channel has been relatively minor.

The most significant human impact on these reaches is water diversion. All irrigation diversions on the West Fork occur in these sections and reduce flows significantly during dry seasons. Water rights and usage impacts are felt most fully in these reaches. Water rights discussions and management are already occurring in the watershed. Users of the diverted water are meeting to review instream flow issues and discuss possible solutions.

5.2.3.2 Upper West Fork (Reaches WF8-15)

Roads have only a limited impact on the channel and floodplain in this area. However, the Highway 88 bridge in Hope Valley somewhat constricts the channel, and it was therefore selected for detailed assessment to evaluate its potential impact (see Section 4.3.1). A few dirt roads in Faith Valley extend into riparian areas, where they have impacted riparian vegetation.

Grazing has been a prevalent land use throughout both Hope and Faith Valleys. A combination of private and public land once supported livestock grazing in these meadows adjacent to the West Fork of the Carson River. Grazing has not occurred in these areas for the last 20 years (since the late 1980s).

Now, most of this land is state owned and managed without permitted livestock grazing. Current USFS grazing allotments include the Charity Valley allotment, and the Hope Valley allotment, relegated to the high side of the Hope Valley meadow up to Horsethief Canyon, though these allotments are not currently grazed (Walker 2004). Some changes to meadow herbaceous vegetation include the prevalence of "increaser" species that result from livestock preferential grazing habits such as elk thistle, yarrow, *agoseris* and Kentucky bluegrass. Even though grazing has been removed, the channel has not fully recovered, indicating grazing is not the sole issue in these reaches. Recreational impacts and natural processes may also contribute to stream issues.

Recreational use, which is especially high in Faith Valley, has also resulted in impacts. Aerial photographs show the large number of trails and roads on the east side of the valley. Campers are parked almost "hub to hub" on weekends in the summer. A 14 day time limit for camping is imposed. Recreationists are provided guidelines for stock management in these areas that should minimize potential impacts from their activities.

5.2.3.3 Lower East Fork (Reaches EF1-4)

Logs from timbering operations higher up in the watershed were rafted through a portion of the lower Carson in the latter part of the 19th century. Although the team could fine no direct evidence regarding where these drives took place, they may have occurred in the lower portion of the assessment area. These drives took place during high water in the late winter and spring. The scale of the drives may have been quite large (Figure 5.8), and there is evidence that log jams from the drives impacted flooding (California DWR 1991).

Current active BLM cattle grazing allotments on this section of the East Fork are the Hay Press and the Barney-Riley allotments (see Table 5.1). The Hay Press allotment consists of 1440 acres public land and is permitted for 50 cattle. Only a small portion of this allotment borders the Carson River on the east side. The Barney Riley allotment consists of 1985 acres and is permitted for 70 cattle (Suminski 2003). Likewise, only a small portion of this allotment is located within reach EF4 with minimal impacts due to grazing pressure. Impacts on the USFS Cottonwood cattle grazing allotment located farther down stream are also negligible as there is no real access to river for the cattle (Schmidt 2003).

Figure 5.8 Log jam along the East Fork of the Carson River, late 1800s.

Recreational use has also affected riparian vegetation in a few discrete locations, particularly near the hot springs located on the river. Adverse impacts including accelerated erosion, bank instability, and loss of riparian vegetative cover have resulted from the use of off road vehicles (ORV) and camping. To gain access to the hot springs, ORVs have created numerous road crossings through the river, and traveled through the mesic meadows adjacent to the hot springs. During spring float trips, the hot springs area experiences day use and overnight camping from river enthusiasts.

5.2.3.4 Middle and Upper East Fork (Reaches EF 5-10)

At least one small dam, and probably more, was constructed in this portion of the East Fork to provide water for mining in the late 1800's. The Curtz Dam, constructed during the 1860s or 1870s, was located in the canyon of the East Fork of the Carson River just below the confluence of Monitor Creek. The channel was highly modified during construction, and the dam disrupted sediment transport, storing a large volume of material on the upstream side until the dam failed, probably during a large flood event. The release of material from the dam likely caused substantial channel modification downstream as well.

The primary channel modifications in this reach have been through construction and maintenance of State Highway 89. The highway occupies portions of the floodplain, and some meanders were cut off. Where the road occupies part of the former floodplain, the channel has become more dynamic, with less riparian vegetation. The Centerville Flat Bridge may also affect channel form and sediment transport. Detailed study reaches were selected to describe the potential impacts. Other land uses have also affected the floodplain throughout these reaches of the East Fork. The Carson River (East Fork) Resort occupies a former floodplain in a portion of this area, behind the highway. Although floodplain function had already been impacted in this area, recreational use has created some additional impacts to riparian vegetation in spot locations.

This scenic portion of the river is used for fishing, river floats, and camping from spring through the growing season. In areas where the road is in close horizontal proximity to the river, numerous roads and trails are present that have resulted in under vegetated soils and a loss of riparian cover. These recreational impacts have interrupted the regeneration and establishment of woody and herbaceous riparian cover both on newly formed substrates resulting from river deposition as well as impacting the established, existing understory shrub and herbaceous cover. Specifically, soils compaction and loss of riparian cover are present at the unofficial put in point at the "Pebble Beach" gravel bar near the Carson River Resort and at various camping locations located farther upstream within the cottonwood forest canopy.

Human impacts to these reaches have changed over time. Historically, obstructions in the stream channel were the primary impact (dams and log drives) resulting in significant changes to sediment production and riparian vegetation. Today, the channels are improved, but road infrastructure near the river has a continuing impact. Highway 89 / 4 was constructed in the floodplain of the East Fork. When flood conditions occur, flood waters extend up to riprap installed to protect the roadway. This limits natural functioning of the stream by reducing the potential for floodplain development (including vegetation establishment) and by increasing the introduction of roadway related pollutants into the stream. During non-flood conditions, the road allows for ready recreational access to the river. This recreational use along the river bank has a significant impact on vegetation present. Water quality issues are significant, with acid mine drainage in the tributaries and probably some impact from the large concentration of recreational users in the riparian zone. The reaches are recovering from historic conditions. Opportunities for continued restoration exist in road and floodplain mitigation, water quality improvement from mine drainage, and recreation management. Given the large contingent of recreation users, opportunities for public education are also available.

5.2.3.5 Wolf Creek (Reaches WC1-3)

Within the assessment area, the Wolf Creek meadow has been used for grazing for several decades. Riparian vegetation has likely been impacted to some extent, and irrigation works have modified some parts of the channel and meadow. To improve grazing, management activities have been instituted to irrigate the meadow and control the creek. In the 1997 flood, however, the irrigation infrastructure was largely eradicated.

It is clear from aerial photos that flood events have a fundamental impact on the stream with respect to human induced land management issues. After larger flood events, the amount of natural sediment material entering the Wolf Creek meadow from upstream (the Carson Iceberg Wilderness) is tremendous. The wilderness area is mostly undisturbed, and the material released during flood events derives primarily from natural sources. Aerial photos suggest the creek carves a completely new course after each of these events. It is likely that bank erosion, channel changes, and other dynamic behavior occurred prior to human land use and are part of the natural function of the system.

However, it is also likely that the effects of grazing have served to increase natural rates of dynamism. Stream banks may be less resistant to erosion and floods probably capture parts of the irrigation system, resulting in increased erosion. As discussed in Chapter 2, human activities probably serve to magnify the effects of floods, although man's impact on sediment production is likely to be less that in a natural process. Opportunities for restoration and education exist with the single private landowner to help lessen grazing impacts and promote better riparian and geomorphic ideals.

5.2.3.6 Hot Springs and Markleeville Creeks (Reaches MC1-4)

Markleeville Creek has been highly modified through the town of Markleeville due to highway construction, and, downstream of the highway, by floodplain development and construction of a floodwall at the Forest Service administrative site. A couple of bridges are also found upstream of the site, but have had little channel impact except during floods.

Along Hot Springs Creek (Reaches MC2 to MC4), the main county road and other residential roads cross the creek in a few locations, but appear to have little interaction with the channel except during larger floods. Some older dirt roads are found along the creek, probably used during earlier timber harvests. In some locations, these roads may impact riparian vegetation or the channel, but their influence is limited. An irrigation diversion has resulted in some channel modification in one location.

Based on the surrounding road density, timber harvest appears to have been relatively dense in this area, which may have influenced the amount of large wood available to the channel. Some limited residential development also occurs in this drainage, and concerns over flooding probably has led to maintenance or cleaning of the channel, and removal of woody debris.

Human impacts along Markleeville / Hot Springs Creek are significant. However, current land use activities, except for diversion, have little impact on the creek. No active timber harvest occurs, the road is usually not in the floodplain, and much of the surrounding land is public. The prevalence of riparian vegetation is helping to recreate woody debris in some parts of the channel. Restoration projects should seek to enhance and expand this process.

Flooding in Markleeville is well documented. There is no evidence to suggest that modification of the channel or past construction of barriers has been successful in addressing the impacts of flooding. Projects that move facilities out of the floodplain should be a high priority.

5.3 Channel and Riparian Response to Land Use Impacts

To evaluate the response of assessment area channels and riparian areas to impacts described in the previous section, it is necessary to recognize that channels respond to natural variability in climate or sediment supply as well. Natural responses should be separated, to the extent feasible, from response to land use impacts. Information about how the channel has changed through time is useful for this analysis. The analysis of older aerial and ground photographs provides a basis for assessing the impact of land uses, and also identifies natural processes to which channels are constantly adapting.

5.3.1.1 West Fork Carson River

The lower portion of the West Fork (Reaches WF1 through 6) is relatively resistant to channel change induced by land use impacts. This is due to its inherent geomorphic characteristics. In two locations, at bridges near Woodfords and in Diamond Valley, some channel dynamism was noted and is at least partly due to impingement of infrastructure on the floodplain. Channels in lower gradient meadows (Hope and Faith Valleys) in the upstream portion of the West Fork have been more responsive to land use effects. Three discrete meadows are found in this area:

- Lower Hope Valley, which encompasses the area commonly known as Hope Valley, from Picketts Junction upstream to the Highway 88 crossing;
- Upper Hope Valley, about one-half mile upstream of lower Hope, from just downstream of the Blue Lakes Road turnoff to the USFS Hope Valley Campground; and,
- Faith Valley, about two miles upstream of Upper Hope.

These meadows are separated by higher-gradient channels that are incised within glacial deposits and are resilient to land use impacts.

As noted previously, the dominant land use impact in West Fork meadows has been grazing. Figure 5.13 shows a 1866 photo of Hope Valley. It was likely taken near where a gravel pit is now located just upstream of the Highway 88 crossing. The photo looks across the West Fork, and the stream bank on the far side shows very heavy grazing pressure. Cobbles and bare dirt on the floodplain in the background also attest to heavy grazing pressure. Note also the well-developed road in the background, which was probably the immigrant trail. If the date attributed to this photograph is correct, it strongly suggests that grazing and other land uses were impacting the channel not long after initial European settlement of the area. Grazing continued until about 20 years ago in the Hope meadows and until the late 1980s in Faith Valley. Evidence of forest change was found in historic photo comparisons. In Figure 5.9, note the relative size of the trees in the historic photo and the current photo. Trees in the historic photo are much taller, with limbs absent at the bottom, indicating an open, park-like condition (if all the trees were present). Trees in the current photo are much smaller with limbs all the way to the ground, limiting the amount of grass and forbs that can grow under the forest canopy. Substantial recreational use also occurred on the meadows (see Figure 5.1).

Over the last 40 years, the streams in the three meadows have shown different levels of dynamism and change. Between 1963 and 1993, the channel changed fairly dramatically in both Faith Valley and in Upper Hope Valley. In comparison, the channel in Lower Hope Valley changed relatively little. The most change occurred in Faith Valley, where large meanders were cut off and extensive gravel bars developed within the channel. Thus there appears to be a gradient in response, either to climatic change or land use effects, from the upper portion of the watershed to the lower. Differences in the dynamism of the channel in these three locations are partly explained by natural geomorphic factors. Faith Valley, because it is highest in the watershed, is nearer to sediment supply sources. Coarse sediment supplied by debris flow or other mass movement can cause channel dynamism. The lower meadows are less likely to have large inputs of coarse sediment.

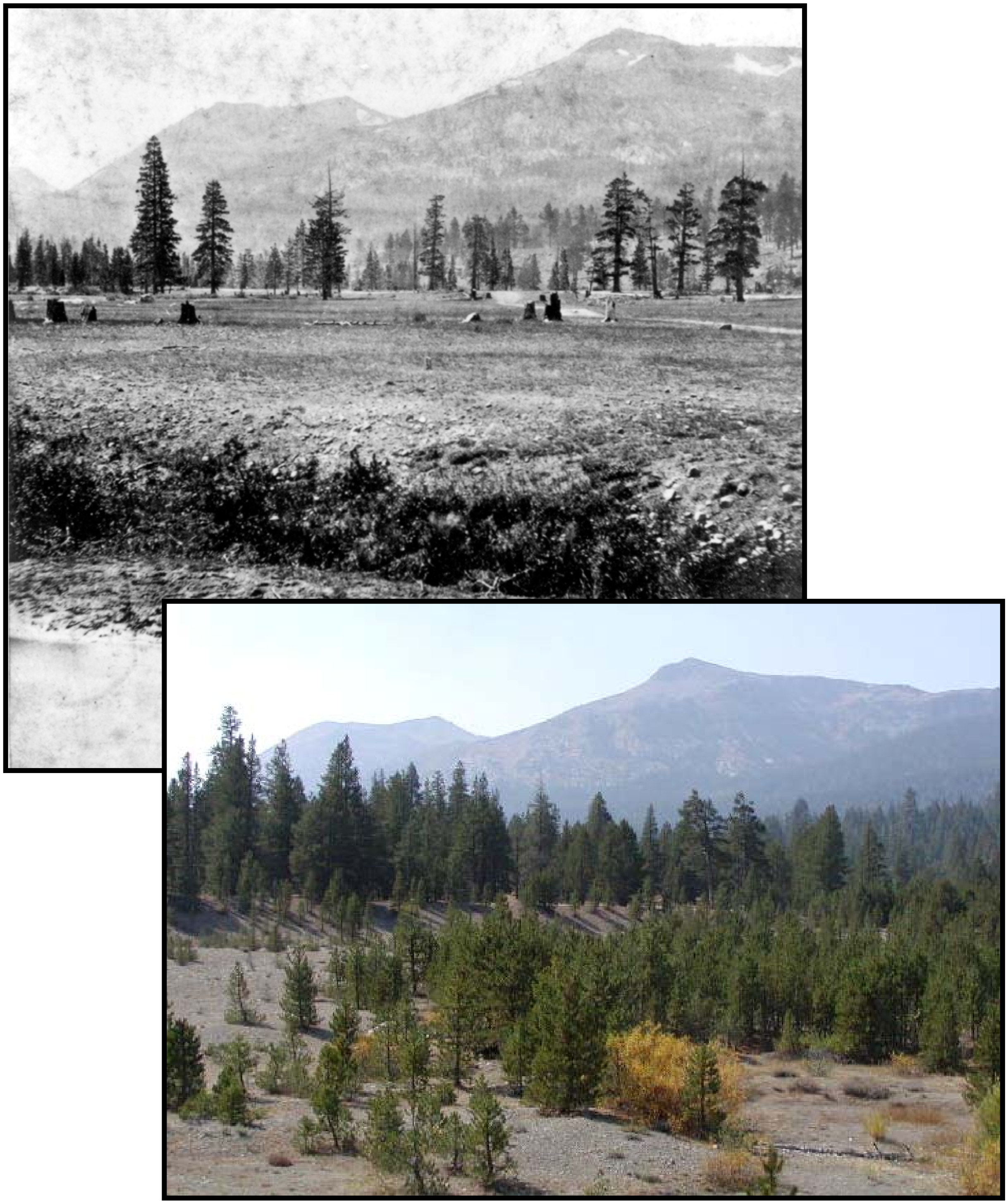

Figure 5.9 Hope Valley gravel pit photo pair, 1866 and 2004.

Also, Faith Valley buffers the downstream meadows in terms of sediment supply. This occurs because a great deal of the sediment supplied to, and generated within, each of the meadows is stored within the meadow. Consider Upper Hope, for example. Coarse bars at the upstream end of the meadow likely represent material transported to the area from upstream (including Faith). There bars have resulted in substantial channel dynamism in the upstream part of the meadow, but a great deal of the sediment generated in this portion of the meadow is stored throughout Upper Hope Valley in large bars. As a result, coarse bars at the upstream end of Lower Hope are smaller than those in the upper end of Upper Hope.

The Upper Hope Valley channel is far more dynamic and is more incised than the channel in Lower Hope Valley. This is due in part to the natural geomorphic gradient described above. Upper Hope represents a very strong, abrupt change in geomorphic conditions, as the steep, confined channel upstream transitions to the meadow in the valley. Reduction in stream energy at this transition results in deposition of sediment, and consequently high dynamism. Thus, natural geomorphic factors have some role in the dynamism inherent in the West Fork meadows.

Human disturbance may also contribute to dynamism in Upper Hope Valley. Several potential channel impacts were evaluated, including construction of a gravel pit and potential effects of the Highway 88 crossing. The highway bridge somewhat constricts the channel, but little evidence was found that these activities had a substantial system-wide effect (see Section 4.3.1). Nonetheless, our detailed site studies (Section 4.2.2) suggest that the channel is incised with respect to the floodplain. Early aerial photos (about 1963) show that the stream may have had fewer gravel bars (although bars were evident in the 1963 photos), indicating that the stream was less dynamic. This evidence indicates that the cumulative effects of land use have impacted the channel.

Aerial photos provide evidence that other land uses may have had impacts on the West Fork. Evidence is best developed in Faith Valley. It was noted that between 1963 and 1993 the stream was dynamic in both the Upper Hope and Faith meadows. The channel in Faith meadow, however, appears to have been relatively stable prior to 1963 (Figure 5.10), whereas the Upper Hope channel, based on large gravel bars apparent in the 1963 photos, was highly dynamic prior to 1963. While it is possible that the Faith channel may have changed equilibrium between 1963 and 1993 due to natural factors, it is not likely. Land use impacts, such as reduction of stream bank stability through grazing or roads on the adjacent floodplain, were probably an important factor. Note the large number of roads on the meadow in the 1963 photo, evidence of fairly extensive land use.

Other aspects of channel change in Faith Valley suggest that land use between 1963 and 1993 may have played a role in channel destabilization. A channel split is apparent in the 1963 photo, and the channel to the right (looking downstream) is dominant in the 1993 photo (see Figure 5.10). This split appears to have occurred not long before 1963, as the meander geometry develops substantially by 1993. Note that the new channel is abnormally straight and nearly devoid of riparian vegetation, suggesting that it may have been an irrigation ditch, road or other man-made feature captured by the stream, possibly in a large rain-on-snow flood (1955 or 1963). At least one meander was cut off in the 1997 flood. The reduction of stream length caused by these cut offs likely increased gradient. That has subsequently resulted in incision in much of Faith Valley.

It is also important to recognize the potential role of beaver in Faith Valley dynamism. We found little evidence of recent beaver activity within either of the Hope Valley meadows, but beaver have been active relatively recently in Faith Valley. The lack of beaver activity in the lower meadows is probably due both to the larger size of the stream and because there are few willows and other riparian shrubs, which provide both food and material for dam construction.

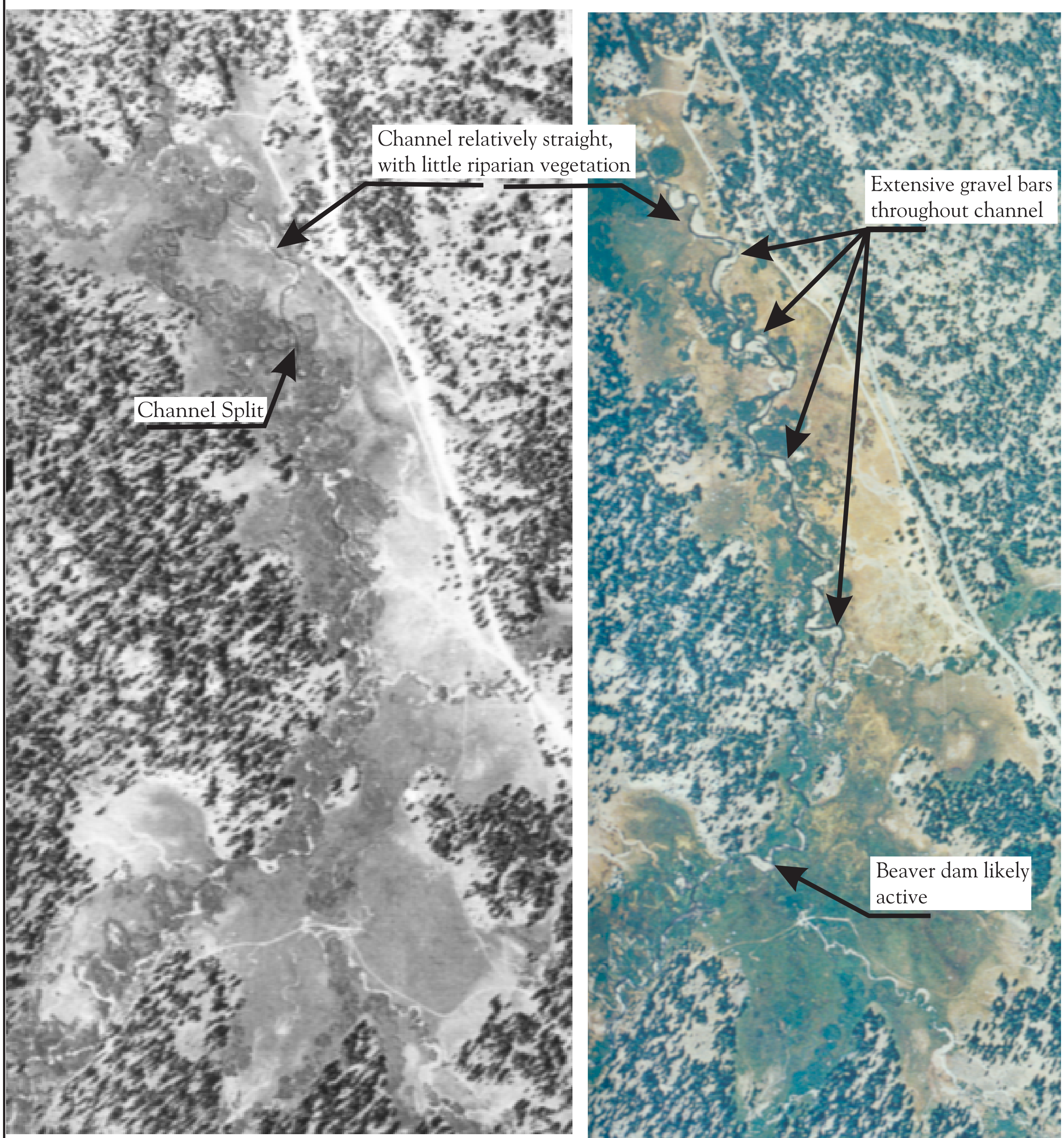

Figure 5.10. The West Fork Carson River in Faith Valley in 1963 (left) and 1993.

Where beavers are active, and maintain dams, channels tends to remain relatively stable. The animals check erosion around the ends of the dam, and control flow through adjacent channels (Muller-Schwarze and Sun 2003). When dams are abandoned, however, their failure can increase stream dynamism and sediment supply (Naiman et al. 1988). The assessment team found the remains of several failed dams throughout the Faith meadow. It is possible that the abandonment of beaver dams in Faith Valley contributed to meander cut-offs, by diverting flow, particularly during large floods, and subsequently contributed to dynamism as they failed in response to stream incision.

One large beaver dam still remains at the upstream end of Faith Valley (see Figure 5.10). No fresh beaver sign was found during our survey and the site appears to have been abandoned. This dam was in place during the 1997 flood, and holds several feet of gravel and sediment behind it. It has checked channel incision at its base, with a drop of five to six feet over the crest. Water has started to divert around the structure during floods forming small gully channels. This structure appears to be the last of a series of dams that were constructed throughout Faith Valley. All of the downstream dams have failed, and the channel has incised several feet.

It is not known if the channel was incised prior to dam construction in Faith Valley. In this case, beaver may have played a beneficial role, and dams raised base level throughout the valley. It is also possible that beaver dam failure caused the incision. The history of beaver in Faith Valley may represent a boom-and-bust cycle of establishment in the Sierra, in which colonies and dams are established rapidly in an area of new colonization, and subsequently abandoned when food supplies have been exploited.

Beaver typically abandon a dam or colony site when they run out of food or dam material. Yet food sources and dam materials appear to be well-distributed through Faith Valley, which is relatively high-quality habitat. We suspect that elimination of beaver by humans may also be important in this area. Beaver are often eliminated because of perceived negative impacts.

5.3.1.2 East Fork

Several photographs were located of the Curtz Dam and another small diversion dam located slightly downstream. Both are about one mile downstream of the Monitor Creek confluence. In each case, it was possible to retake the photograph, allowing for a comparison of historic and current conditions (Figure 5.11). In the 1880 photo, infrastructure, either a road or a diversion ditch, is flooded in the foreground. A diversion dam is clearly visible in the background. This area is the location of our current reference reach along the East Fork (Section 3.2). Sediment transport was obviously quite pronounced when the historic photos were taken. Substantial land use had already occurred by that time, so some of the sediment may have been derived from sources impacted previously by mining or grazing. However, high sediment transport in the river at this time suggests that substantial sediment production is a natural feature of the watershed. Although discharge is obviously high in the 1920s photo of the lower diversion dam, there is some evidence, including bars seen in the foreground of the photos and the level of water on the bank to the right, that the streambed is substantially aggraded with respect to today. The photo shows the dam and flume washing out in a flood. Gravels bars are well scoured in areas where riparian vegetation is not extensive, suggesting that floods regularly move and scour bed load.

Riparian vegetation communities in the early photos appear similar to those present today. Willows are present on the lower bars and larger cottonwoods are present on some of the older bars and stream banks. However, there is substantial colonization of riparian vegetation on all of the bars in the historic photographs. Although similar development of riparian vegetation is found today in portions of the channel that are not impacted by the highway, areas where the highway or other land use occupy former floodplain appear to have less developed riparian vegetation (see Section 3.2). This is likely due to increased dynamism, a channel response to floodplain encroachment.

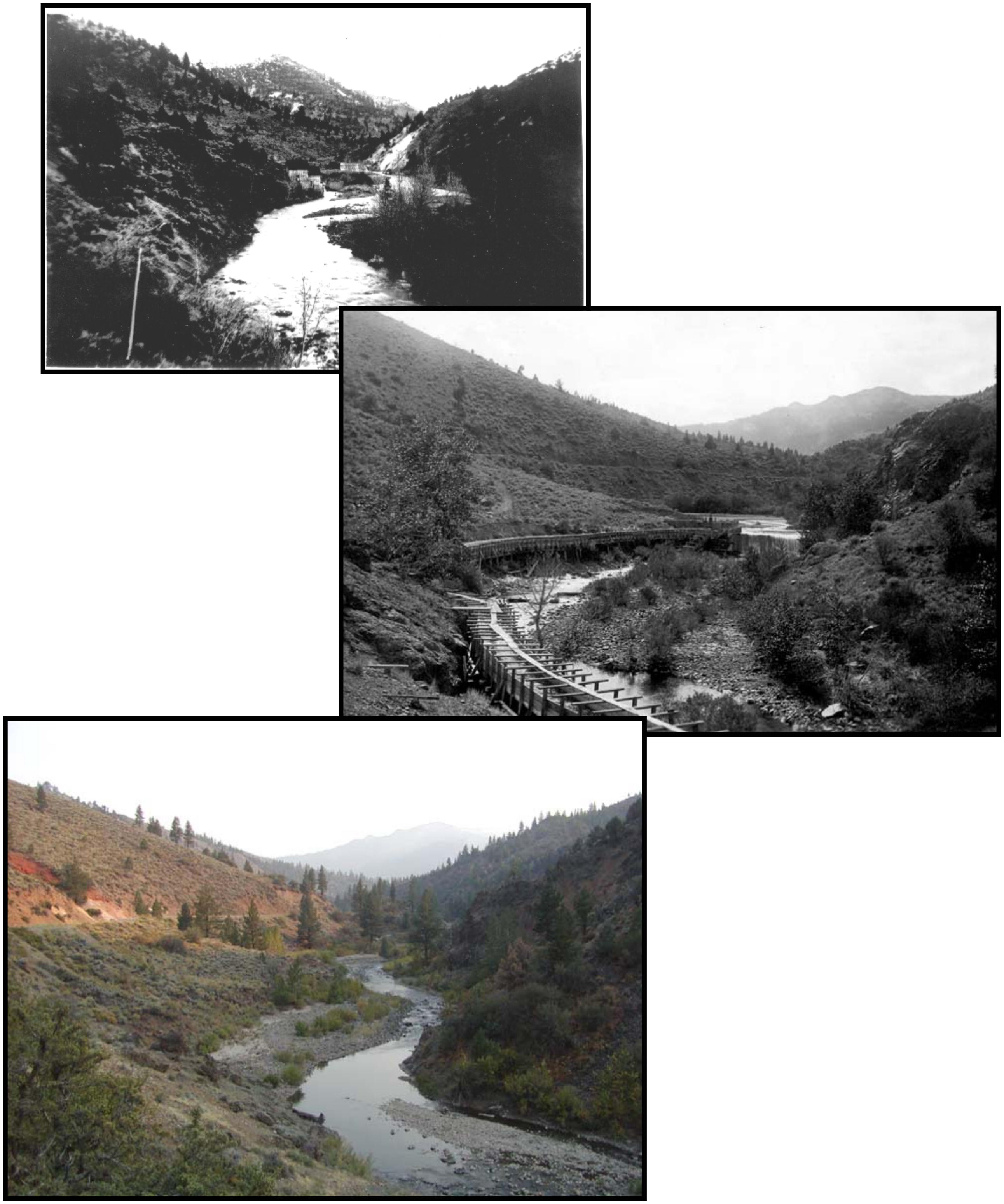

Figure 5.11 Curtz Dam photo pairs, 1880, 1920, and 2004.

It is also interesting to note that our reference reach was located in an area that in the early 1900's had included a diversion dam and was highly altered by land use. This suggests that the channel is highly resilient to land use impacts. The dams and other structures were destroyed by larger floods, which left behind large gravel bars. Riparian vegetation quickly colonized these surfaces. A similar process is now occurring on bars left by the 1997 floods. The channel has also had a substantial impact on Highway 89. Historic photographs were located that show the highway being eroded during floods in 1937 and 1955 (Figure 5.12), and in 1964 and 1997. Constriction by nearby valley walls precluded moving the highway away from the river, and it has been repeatedly reconstructed in the same location.

Aerial photos show that high dynamism has been a dominant feature of channel behavior since 1963 (see Figure 2.12). Rain-on-snow events scour bars and cause shifts in channel location. During subsequent years, riparian vegetation colonizes bars, especially shrubs like willow, which promote some channel stabilization and narrowing. Land use may have affected, to some extent, the magnitude or rate of these changes. Selected uses have certainly affected channel morphology in some discrete locations through impingement on the floodplain. Overall, however, available evidence suggests that much of the dynamism in the system is natural and inherent.

5.3.1.3 Wolf Creek

The Wolf Creek meadow (Reach WC2) also exhibits high rates of dynamism and, like the East Fork, appears to change substantially with each rain-on-snow event (see Figure 2.11). As discussed in Chapter 2, the high supply of coarse sediment from sources just upstream of the meadow likely explains part of this dynamism.

However, it is important to note that the Wolf Creek channel and floodplain are quite different from the Carson River. The Wolf Creek floodplain is wide, substantially reducing energy during large floods by allowing water to spread out. Well-developed meadow sod, which covers much of the floodplain, can only develop over long periods of relative stability (very few floodplain surfaces in the East Fork canyon develop sod because the bars are all regularly scoured). Also, many meander scars visible on aerial photographs are much tighter than those present today. Tighter bends tend to be produced in less dynamic, erosive environments.

Thus, evidence suggests that the geomorphic environment of Wolf Creek should be significantly less dynamic than that of the East Fork. Yet each large rain-on-snow event causes wide-spread bank erosion along Wolf Creek and leaves behind large, unvegetated gravel bars similar to those in the East Fork. Land use impacts are probably at least partially responsible for the observed dynamism. Trampling of stream banks, the loss of native riparian plants, and modification of the area to accommodate irrigation have all decreased the ability of the channel to resist erosion and changes in equilibrium. While there is no doubt that bank erosion and channel change occurred regularly in the meadow prior to human land use (note extensive old channels in aerial photographs), land use impacts have likely served to increase the dynamics inherent in the natural system.

5.3.1.4 Markleeville and Hot Springs Creeks

Encroachment on the Markleeville Creek floodplain downstream of the Highway 89 bridge has resulted in the loss of some riparian habitat and function. Loss of floodplain has most likely increased flood energy, and may contribute to stream bank erosion along a hill slope just downstream of the bridge. Bank erosion at the toe of the hill slope threatens a sewage pipeline.

Rain-on-snow events also regularly affect the nearby infrastructure. Figure 5.13 shows the area being flooded in 1937 and 1955. It was also flooded in 1964 and 1997, and will continue to be flooded during most rain-on-snow events.

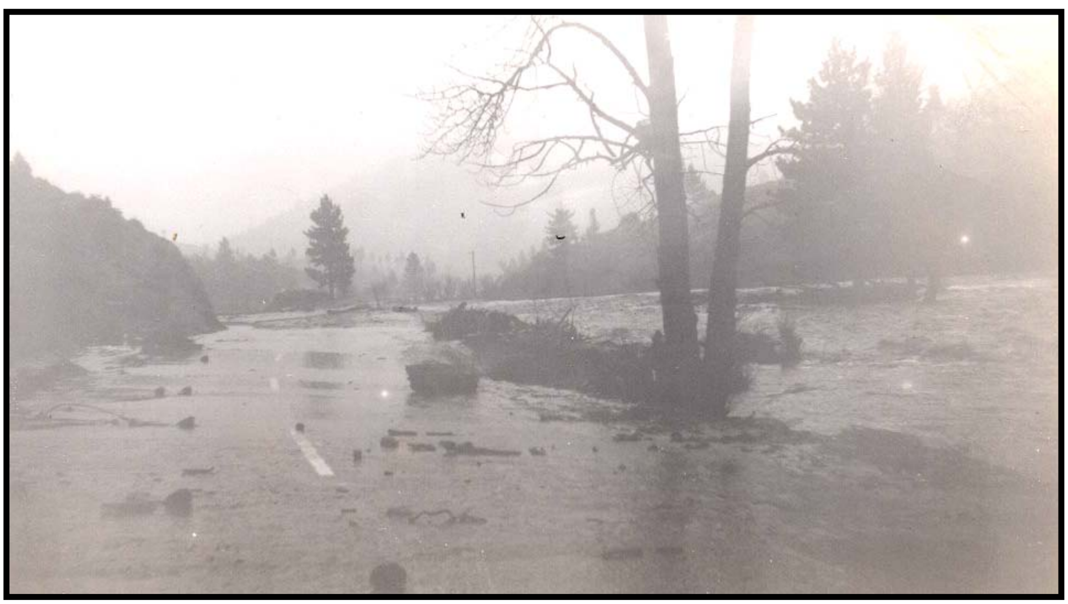

Figure 5.12 Highway 89 flood photo pairs, 1937 and 1955.

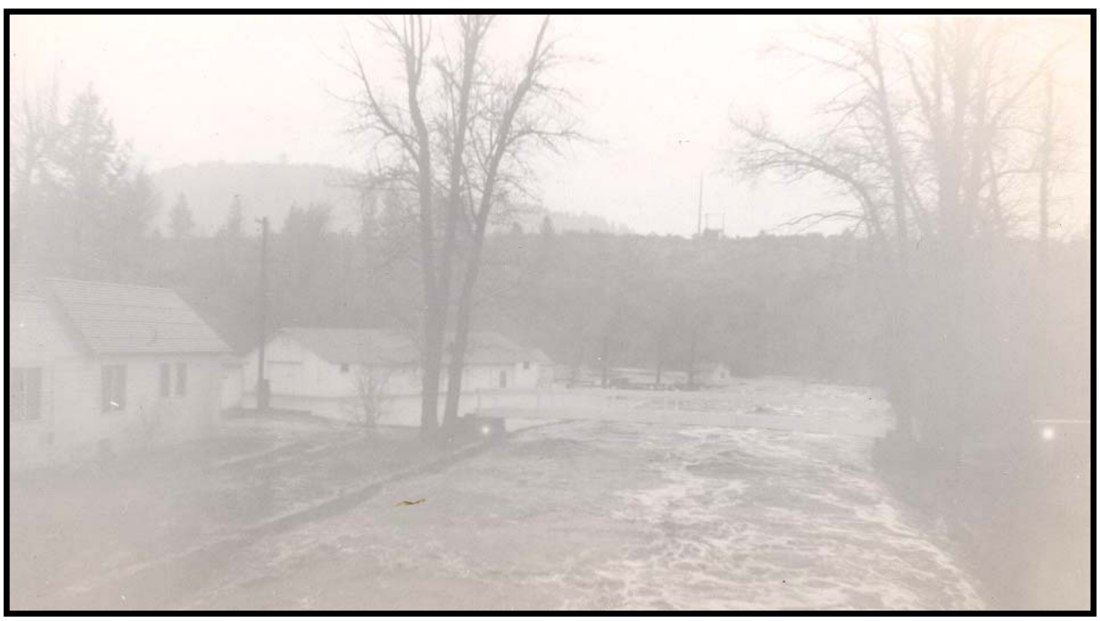

Figure 5.13 Markleeville flood photo pairs, 1937 and 1955.

Through the town of Markleeville, and up to near the confluence with Pleasant Valley Creek, the stream is incised in outwash or morainal deposits. The channel contains large bed substrate and is relatively resistant to changes from land use practices. Upstream of the Pleasant Valley Creek confluence to Grover Hot Springs, Hot Springs Creek exhibits the cut-and-fill morphology and erosional processes described in Chapter 2. Land use practices have likely had more influence on the channel in this reach, including impacts of timber harvest and road construction.

Perhaps the most significant influence may have been changes in woody debris availability or in-stream abundance. As noted earlier, it is likely that wood was removed from the channel, and that current riparian forests deliver less large wood. Because in-stream wood serves to stabilize channels and store sediment, this reach is probably more dynamic than in the past. Stream bank erosion during the 1997 flood was extremely high in some portions of the channel.

5.4 Aquatic Biology and Water Quality

As discussed in previous sections, general effects of land use throughout the watershed have probably included an increase in channel dynamism, increased erosion, and a reduction in the distribution and density of native riparian and floodplain vegetation. Although the main objective of this assessment was to provide an analysis of fluvial geomorphology, the assessment team reviewed habitat conditions at detailed assessment sites. Available data on effects of land use to aquatic biology and water quality also were reviewed, and a qualitative summary of available information and biological effects was provided.

5.4.1 Existing Data and Studies

The California Department of Fish and Game (CDFG) is currently preparing an administrative report on the status and distribution of fish resources within the East and West Forks of the Carson River (personal communication, Dave Lens, CDFG). Expected to be complete in 2004, these reports will summarize the results of fish population surveys in the 1980's and 1990's. Fish populations will be the primary focus, although habitat within study reaches will be assessed in some cases.

Macro-invertebrate populations, important indicators of stream health, are currently being analyzed throughout much of the watershed under a project funded by the Lahontan Regional Water Quality Control Board (RWQCB) (personal communication, Dave Herbst, Sierra Nevada Aquatic Lab). Several locations are being sampled throughout the watershed (Table 5.3). Some habitat analysis will also be conducted at these sites. The final report for this project may be available by the end of the year.

5.4.2 Water Quality Impairment

The California Water Quality Control Board is required to produce a list of impaired waters in the state. Called the 303(d) list, the summary of impaired waters is updated every four years. The last update occurred in 2002 (CRWQCB 2001, see also a similar report prepared for Nevada [NDEP 2002]). Development of the list and other activities of the Lahontan Regional Water Quality Control Board, the regional board responsible for the Carson River watershed in the assessment area, can be found on their website. Several stream segments in the assessment area are listed as water quality limited. These are summarized below.

5.4.2.1 West Fork

Upstream of Woodfords, the West Fork is listed as impaired for high concentrations of nitrogen, phosphorus, and sodium. High concentrations of all of these constituents may be partly related to natural sources, including high concentrations in rocks or high rates of erosion. Sources related to human impacts include higher rates of erosion, storm water runoff, septic systems, or road maintenance (sodium may be related to road sanding).

Table 5.3 Macroinvertebrate sampling sites in the Upper Carson River Watershed.

Site Tag	Site Name	Reference Site	Year 1999	2000	2001	2002
West Fork						
63WCR1	West Fork, lower BLM	No	X			
633WCR3	West Fork, Upper Faith	Yes	X			
633WIL1	Willow Cr., lower	Yes	X			
633FRD1	Forestdale Cr., upper	No	X			
633RDL1	Red Lake Cr., below hwy	Yes	X			
East Fork						
632LEV4	Leviathan Cr., upper	Yes	X			
632HEN1	Heenan Cr., Company Meadow	Yes	X			
632IDN1	Indian Cr., upper	No	X			
632NOB1	Noble Creek, lower	Yes	X			
632SVR1	Silver Cr., above Silver Mtn. City	Yes	X			
632BGV1	Bagley Valley Cr., control	No	X			X
632BGV2	Bagley Valley Cr., meadow	No	X			
632BGV3	Bagley Valley Cr., restoration project	Yes				X
632SVK1	Silver King Cr., above valley	Yes		X		
632SVK2	Tributary above Silver King Cr.	Yes		X		X
632WLF1	Wolf Cr., above trail	Yes		X		
632SPT1	Spatt Cr., above road crossing	Yes		X		
632ECR6	East Fork, above Bagley Cr.	Yes		X		
632HOS1	Hot Springs Cr., above Grovers	Yes			X	
632DIX1	Dixon Cr., lower, above trail	Yes				X

From Woodfords to Paynesville, the West Fork is listed for sodium, nitrogen, and percent pathogens. The potential human sources of these pollutants, as in the upstream reach, are higher rates of erosion, storm water runoff; septic systems; or road maintenance. Based on available data, the high loading of pathogens, which are fecal coliform bacteria, appear to be the result of cattle grazing practices (CRWQCB 2001, LRWQCB 2003).

5.4.2.2 East Fork

The East Fork itself, which was previously listed for nutrients, has been removed based on additional data analysis. Several tributaries, however, are listed. Both the Monitor Creek drainage and the Leviathan drainage have been listed for metal pollutants resulting from the effects of mining and acid mine drainage.

Indian Creek and the Indian Creek reservoir are both listed. Indian Creek reservoir is listed due to phosphorous loading resulting from past wastewater export. Indian Creek is listed for habitat alterations and for pathogens. The creek has been highly modified for irrigation and for the construction of reservoirs to store exported effluent. High pathogen loads appear to be the result of grazing operations and are not from effluent export (CRWQCB 2001).

Wolf Creek is listed for sedimentation/siltation. As noted in the previous assessment, a substantial portion of the high sediment load is delivered due to natural processes. However, grazing and irrigation practices have likely reduced stream bank stability, contributing additional sediment.

5.5 Summary

This chapter has focused on a review of human development in the watershed, and its potential effects on geomorphic and ecosystem processes. Clearly, human impacts on the Upper Carson Watershed have been significant. Though no photo record exists, some of these impacts extend into the time before Euro-Americans inhabited this area. Some historic photos of early Euro-American development show the landscape denuded of vegetation and infrastructure built right into the river. This evidence suggests a population that was transient, utilizing all possible resources before moving to the next watershed.

Today, stark evidence of our impacts on the watershed remains. The road systems along the East and West Forks are well developed and heavily traveled. Homes are constructed near and sometimes in the river corridor. Large numbers of people recreate in the watershed annually. However, relative to the impacts of the mid to late 1800's, our presence here is much less dramatic. In the 1860s, as many as thirty thousand cattle passed through Hope Valley in any given year. In the last 20 years there have been none. The hills around Markleeville were once completely bare of timber, now forest stockings are at all time highs. There were 45 sawmills in Alpine County at one time, now there are none. Thirty-five hundred people lived in a single town in the East Fork watershed, now less than 1500 live in the entire County. The Carson watershed is still recovering from dramatic impacts of the Nineteenth Century.

Based on what we know of the severity of the impacts that occurred during the second half of the Nineteenth Century, watershed conditions have likely been improving since that time. This assessment indicates that the management actions and resource utilization of 150 years ago probably had a greater impact on the geomorphology of our streams today than grazing or other land uses that have occurred over the last 20 years. This said, it is important to understand that even the effects of resource extraction of 150 years ago probably resulted in less sediment production than occurred due to landslides, thunderstorms, and other forces of nature. One must keep this interrelationship natural and man made impacts in mind when considering management objective and restoration projects.

Nonetheless, current land use activities inevitably have some negative impacts on stream and watershed function. These include:

- ***Decrease in meadow stream bank stability.*** Impacted areas include larger meadows in Hope and Faith Valleys, Wolf Creek meadow, Hot Springs meadow, and smaller meadows on Hot Springs, Markleeville, and possibly Pleasant Valley Creeks. A number of land uses likely contributed to this impact, but the primary cause has likely been past grazing practices. This is not to suggest that the channel was completely stable prior to human influence. The Carson watershed is highly dynamic naturally, with high rates of erosion in upper portions of the watershed and the climactic potential for large floods. The primary influence of human development in the meadow systems has been to increase rates of bank erosion, which in turn provides more sediment to the system.

- ***Increased watershed sediment delivery.*** Increases in both fine and coarse sediment delivery to the channel from the surrounding watershed have occurred as a result of land uses. Most of the assessment area has been affected by increased sediment supply to channels. Roads are likely the primary land use responsible for an increase in sediment supply. Both paved and unpaved roads contribute. Although pavement reduces erosion of the road surface and bed, sand and other materials used to provide traction during the winter accumulates along road shoulders. This accumulated material is then transported into adjacent stream channels during snowmelt or rainstorms, as occurred during the August rainstorms in the West Fork drainage. Also, pavement tends to increase and concentrate runoff. During storms that produce intense precipitation, concentrated runoff can erode road fill in discrete locations.

During the survey of Upper Charity Valley following the August thunderstorms, several locations were identified where runoff produced gullies or rills in road embankments or surfaces. Sediment produced from these sources, especially fine sediment, can degrade aquatic habitat when it enters stream channels.

- ***Modifications to channels.*** Stream channels in the watershed have been highly modified for flood control in two locations - Markleeville Creek downstream of the highway bridge in Markleeville and the East Fork along Highway 88. While these modifications have been necessary to protect nearby infrastructure (roads, buildings), they have resulted in impacts to stream and riparian habitat. Much of Indian Creek has been highly altered to facilitate irrigation and the construction of facilities for effluent export.

- ***Lowered in-stream flows.*** Several water diversions occur in the lower portion of the West Fork within the assessment area. As a result, flow in the stream is usually very low during the irrigation season. During drought years, the channel may go dry resulting in impacts on fish and other aquatic species.

- ***Impacted water quality and riparian habitat.*** While mining has occurred throughout the watershed, most mining activity has taken place along the East Fork and its tributaries. Mining has been especially concentrated in the Monitor Creek drainage. Although none of these mines are currently active, old shafts and adits have filled with water. Resulting drainage can be acidic depending on the chemical and mineral composition of the rocks. Acid mine drainage, with associated heavy metal load, has impacted aquatic habitat in Monitor Creek, and may impact areas downstream as well.

  Wastewater exports have led to increased phosphorus loading in Indian Creek Reservoir. Wastewater effluent use for grazing is monitored by the RWQCB and no adverse effects are known in the assessment area.