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美国加州早期淘金技术以及其对环境的影响（1850–1900）

Early Mining Technologies and their Environmental Impact in California, 1850-1900

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摘　要：本文讨论了1850年至1900年加州淘金热时期沙盘淘金、“长汤姆”，特别是水力淘金对环境的影响。通过对日记、回忆录、法律诉讼的分析，文章认为在化石燃料广泛应用之前人类就已经开始破坏环境。这与环境史学家John F. Richards和John McNeill的观点不同。他们认为产生污染的化石燃料在二十世纪才被广泛使用，所以人类对环境的破坏始于二十世纪初。其次，通过对矿工和农民之间诉讼的考察，文章认为，在企业、政府、知识分子之外，普通公民在环境保护中同样发挥重要作用。当环境问题侵害到农民利益时，农民自觉组成环保的公民社会，从保护个人利益出发，客观上为保护环境做出努力。最后，文章讨论了淘金技术向农业生产的转移，分析了传统工业绿色发展的可能性与现实意义。

关键词：沙盘淘金　长汤姆　水力淘金　环境污染　公民社会

Abstract: This article examines the environmental impact of early mining technologies including panning, long toms, and most importantly, hydraulic mining in the California Gold Rush between 1850 and 1900. Using diaries, memoirs, and lawsuits of the day, this research, first of all, shows that human beings were able to make profound and longstanding environmental impact in the early times before fossil fuels were used. The argument is different from what environmental historians such as John F. Richards and John McNeill have argued that environmental degradation intensified in the twentieth century because of the wide application of fossil fuels. Secondly, by investigating the controversy between miners and farmers at the turn of the century, the article argues that in addition to the state, government, and intellectuals, ordinary people played an equally important role in environmental protection. When farmers' interest was harmed by environmental devastation, they organized themselves into a civil society, pushing the government to pass and implement environmental protection acts, though their original intention was pragmatic and self-centered. Finally, the article discusses the possibility and the meanings of technological transfers between industries in the process of regulating pollution.

Key Words: Panning; Long toms; Hydraulic mining; Environmental degradation; Civil society

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As China is growing into the second largest economy in the world, it encounters serious environmental crises due to the rapid development of technology, industrialization, and urbanization. In the recent several decades, China's environmental issues such as air, water, and earth pollution became particularly daunting that it reminds people of environmental disasters like the great smog of London and the dust bowl in the United States half a century ago. Many environmental historians believe

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that environmental degradation has been accelerated by human activities in the twentieth century. For example, John F. Richards pointed out that before the twentieth century human beings had an unending frontier, because land at that time was abundant and natural resources remained plentiful. However, in the twentieth-first century the frontier is no longer unending. [1]John McNeill agreed with Richards that "the twentieth century has been unusual for the intensity of environmental change and the centrality of human effort in provoking it." [2]McNeill argued that "in the very long view of biological evolution, humans were rat-like insofar as they pursue survival strategies of adaptability. In the twentieth century, however, human societies appeared to be more shark-like. That is, adopting strategies of supreme adaptation to existing circumstances."([2], p.xxii) In the chapter "engines of change," McNeill particularly pointed out that the use of fossil fuels, which were the main energy source in the modern times, was responsible for environmental degradation in the twentieth century and the present. ([2], p.xxii)

McNeill's argument is correct, at least in the light of China's current experience, because fossil fuels such as coal were the main source of pollution in contemporary China. However, by studying how the Atlantic Forest in Brazil was destructed by local farmers with broad axes and firebrands, Warren Dean found that environmental devastation is not necessarily a result of industrialization and burning of fossil fuels. In contrast, environmental degradation has already started in the agricultural society in a much earlier time when human technology remained primitive. [3]Fortunately, the Atlantic Forest in Brazil could be slowly recovered after farmers stopped to chop down trees for farming land and housing, but environmental destruction in the other parts of the world such as the damage made by mining in California in the Gold Rush period was not easy to restore. As a matter of fact, before using heavy machine powered by fossil fuels to excavate deep-seated quartz deposits for gold, early mining techniques working on shallow alluvial deposits in the nineteenth century, such as digging dirt with axes and shovels and washing gold with buckets and flumes, had already made a long-term and irreversible impact on the environment.

Using the Gold Rush in California in the nineteenth century as a case study, this article agrees with Warren Dean that environmental degradation has already been serious in the nineteenth century, a period before fossil fuels and advanced technologies were applied. The article focuses on early mining technologies including panning, long toms, and most importantly, hydraulic mining, which were completely operated by manual labor instead of modern machine. It shows that simple technologies without burning fossil fuels can make longstanding impact on the environment and the society. Furthermore, by discussing the controversy between farmers and miners at the turn of the century, the study reveals that environmental impact is a subjective matter that relates to economy, politics, and culture of the society and environmental issues does not become a problem until some people's interest is threatened. In the scholarship of environmental history, Richards believed that nation states should take the responsibility on the environmental change and protection. Dean blamed that "the empire's inability to control public lands—its willingness to connive in their private expropriation at no cost to the expropriators—was a major cause of rapid deforestation," and in the same time he championed scientists and scholars as heroes in the process of environmental protection. ([3], p.151) This research, however, attempts to show that ordinary people and groups, such as farmers in the California gold rush, formed as a civil society and played an equally important role in protecting public interest and the environment.

I. Gold Rush and the Earliest Mining Technologies in California

California has abundant gold mines, which "commences at the south in Tulare and Kern counties, nearly under the parallel of 35°, and extends northwards through the whole range of counties of the State to the Oregon line, the parallel of 42°." [4] Gold locked in deep veins is called hard rock or quartz mines, which requires huge capital and advanced technologies to excavate. Gold that dislodges from rocky bonds and deposits downstream at beds of ravines and gulches and sand bars in rivers is called placer or alluvial mines, which is easily to be found and excavated. Gold discovered and excavated in nineteenth-century California belongs to the second category, the alluvial deposits, which were the mines that this article focuses. California's gold rush started with an American carpenter named John Marshall who found gold at Coloma County on the American river in 1848. The earliest and the easiest mining method at that time was using a pan "with a diameter of twelve inches and the sides six inches high, rising from the bottom at an angle of about forth-five degrees." ([4], pp.129–130) Miners filled pans with dirt and held them under water. With gentle shakings, dirt dissolved and carried away by clear running water, leaving gold dust and pebbles sink to the bottom where mercury was placed. Gold was then retained by amalgamation while stones were thrown out. ([4], pp.129–130)

An improvement of the mining pan was a tool called rocker. It was an oblong box, several feet in length, without a top. It mounted with one side higher than the other and operated like a children's cradle with one person shoveling dirt and throwing out stones and the other person pumping or baling water through the holes on the one side of the rocker with buckets and meanwhile rocking the box. A few years later, a larger rocker called "long tom" was invented. Its productivity was twice higher than the former rocker, able to wash 400 to 500 buckets of dirt every day. Driven by the desire for gold, mining technology developed fast. About a year later, "long tom" was developed into a sluice, "a whole series of riffle boxes fitted together into a continuous string, sometimes as much as several hundred feet in length." [5] In the sluice a stream of water diverted from nearby rivers constantly run. When dirt was shoveled in, soil dissolved and carried away by water, and gold detained by riffles and mercury sank at the bottom.[5] ([4], p.156)

Using these early mining technologies, every miner on average was able to move about 1 to 1.5 cubic yards of dirt every day. The most efficient miners worked faster, but even with their biggest effort, every person could not move more than 10 cubic yards every day.[6] However, when hundreds and thousands of people coming and digging gold in California, the impact on the environment became huge. Between 1849 and 1850, there were more than 40,000 gold seekers came to California by sea and 80,000 came overland.[7] As soon as miners arrived, trees were cut for housing, cooking, and heating. When long toms and sluices were developed, more trees were chopped for building these mining facilities. Deforestation was in such a large scale that one contemporary writer lived in Nevada City, one of the mining towns, commented that "it was beautifully situated by a forest of magnificent pine trees, which however, had been made to become useful instead of ornamental, and nothing now (in 1851) remained to show that they had existed but the number of stumps all over the hillside." [8] John David Borthwick, a Scottish journalist who travelled to California between 1851 and 1854 observed the tremendous change of the landscape in the town of Placerville, or Hangrown as it was commonly called. [9] He noted that "the number of bare stumps of what had once been gigantic pine trees, dotted over the naked hill-sides surrounding the town, showed how freely the axe had been used, and to what purpose was apparent in the extent of the town itself, and in the numerous log cabins scattered over the hills, in situations apparently chosen at the caprice of the owners, but in reality with a view to be near to their diggings, and at the same time to be within a convenient distance of water and firewood." ([9], pp.112–113) Unfortunately, deforestation was not the only threat to the environment; a bigger threat was mining debris. Although comparing to later technologies, debris produced by panning, long toms, and sluices was little, it was enough to make a profound impact on the environment as what Borthwick observed in the 1850s:

"The bed of the numerous ravines which wrinkle the faces of the hills, the bed of the creek, and all the little flats alongside of it, were a confused mass of heaps of dirt and piles of stones lying around the innumerable holes, about six feet square and five or six feet deep, from which they had been thrown out. The original course of the creek was completely obliterated, its waters being distributed into numberless little ditches, and from them conducted into the 'long toms' of the miners through canvass hoses, looking like immensely long slimy sea-serpents." ([9], pp.112–113)

II. Hydraulic Mining in California

As more and more gold seekers came to California, shallow placer mines closed to rivers were quickly exhausted. When people were moving to places far away from water courses to look for gold, they found they could barely make a rich return, because they had to build extended and costly sluices to transport water from faraway. A man from Downieville town said one of his friends bought a share in a mining company, and after working hard for six weeks, had not, as he expected it, made enough to pay for his grub. ([9], pp.203–204) Since then mining towns near rivers started to decline and many of them ultimately disappeared. However, people's desire to make a fortune in California kept them working hard and looking for new methods to obtain the precious metal. While some people went to places far away from rivers to look for gold, others dug deeper on river banks and the nearby to take their chances. Fortunately, by shafts and tunnels, they found that the most valuable deposits were in strata deeper than those they could readily reach, but unfortunately, working with shovels and spades their productivity was too low to make profit. ([4], p.157)

The productivity problem was not solved until the spring of 1852 when a miner innovatively put up a machine on his mining claim at Yankee Jim at the Placer County, and this device was regarded as the origin of hydraulic mining. The structure of the device was not very complicated: "a flume was built towards the ravine where the mine was opened from a small ditch on the hillside. The flume gained height above the ground as the ravine was approached until finally the vertical height of forty feet was reached. At this point the water was discharged into a barrel, from the bottom of which depended a hose, about six inches in diameter, made of common cowhide, and ending in a tin tube, about four feet long, and the latter tapering down to a final opening or nozzle of one inch." ([4], p.157) This use of hydraulic power not only saved manual labor to dig shafts and tunnels for deeper mines, but significantly increased productivity.

A year later, two miners, E. E. Matteson and Eli Miller who was a tinsmith, improved the device by joining forces with ground-sluicing to construct a larger canvas hose affixed with a tapered nozzle of sheet iron. They directed the stream of water from mountaintops through extended ditches and sluices to a movable nozzle at the end. Gravity produced gigantic hydraulic power that was large enough to move Tertiary deposits (deeper placer mines).[10] The force was so powerful that "large boulders and lumps of pipe-clay were slowly washed down to the bedrock, and rocks two feet in diameter flew like chaff when struck by the stream. The actual work of tearing down the cliff was hard to see, for there was a cloud of red foam hanging over the spot. People heard little rattling and slipping noises through the incessant roar, and a stream which was ten times greater than could come out of the pipe flew down the dripping pile, and so into the rock-channels which led to the tunnel." [11] Hydraulic mining enabled gold miners to excavate deeper placer mines, and the high return of this new mining method offset the high construction cost. The amount of gravel washed off in a season in a hydraulic mine was measured by acres, and by so many millions of cubic yards. Take the Miocene mine near Oroville for example, in a period of forty days in 1883, miners "removed 300,000 cubic yards of earth, which yielded 1,000 dollars every day, equaling to 13.33 cents per cubic yard." [12]

The whole hydraulic mining project could cover a hundred, sometimes a thousand acres, forming a complicated and extensive hydraulic water system. The large amount of water required by hydraulic mining was mostly supplied by perpetual alpine snow, which was then directed by ditches and flumes to the operation sites. In the period of hydraulic mining in California, it was common to see "miners around the Sierra Nevada mines entered into a joint association for turning the river between the island and the shore, and then engaged in cutting the new channel, expecting to derive extraordinary profits from the undertaking. [13]

Ditches cut along the mountain sides and around the heads of ravines were used to divert water from mountaintops into flumes. In the first few years of construction, artificial ditches encountered many problems, as they often leaked because of the loose soil and holes dug by rodents. However, as time went by, the earth under and around the ditches compacted and squirrel and rabbit holes were filled. Seeds of trees and bushes blown by wind or lodged by water took roots and grew into fine plants and thus firmly grabbed the earth and formed a perfect hedge. Years after years, artificial ditches finally turned into a permanent landscape that changed the water distribution and ultimately, as what will discuss later in the article, benefited agricultural irrigation in California. By 1855 "there were 303 canals with a total length of 4,493 miles, whilst a further 112 canals and ditches were under construction." [14]Eureka Lake and Yuba Canal Company was one of the companies that built extensive water system for hydraulic mines in California. By 1875 the company owned 300 miles of ditches and $1.5 million of mining ground and facility. During the dry season in fall and winter, the company was able to supply mines within the range of its water system with water of 3,000 miner's inches ①every day. The South Yuba Canal Company was another canal company in California, the size of which was similar to Eureka Lake and Yuba Canal Company, and it had a water system worth of $2 million. Some big mines developed their own water systems. For example, the North Bloomfield Mine had its ditches, dams, and reservoirs extending over 150 miles to supply gigantic hydraulic power. The Excelsior Mine at Smartsville constructed ditches over 110 miles, costing a total of $1 million. By 1882 the construction cost of all ditches to feed the hydraulic mines in California approximated $30 million. ([10], p.349)

Wooden flumes connecting ditches and mining sites could be extensive, especially in places where a canyon was encountered, in which it was impossible to find room along the precipitous sides of the great cliffs for miles to rest a flume. In this situation, a sustaining work was built much like a railroad bridge in nearly a level position, and some high flumes could be more than two hundred feet above the gorge below. ([4], p. 92) The Miocene mine had a flume suspended by iron slings and brackets from the face of the perpendicular cliff. A visitor at that time found difficult to believe that "the white shaft of water which he saw emerged from the muzzle at work had been carried along precipitous cliffs, over deep gorges, and along the flanks of Sierra spurs, a distance of fifty or more miles." ([12], p.330) Wooden flumes were easily broken and rotten, and thus needed regular reparation. One flume under the most favorable circumstances would last only about ten years, and must be renewed. ([4], p.93)

Another expensive construction project in the hydraulic mining system was artificial reservoirs which enabled hydraulic mining operated all the year round including the dry season from July to the next spring. There were abundant valleys near the summit of the Sierra and within the line of perpetual snow, which were perfect for storage of water. When a valley

① The miner's inch was derived from the amount of water that would flow through the hole of a given area at a given pressure. Historically, the unit lacked a firm definition or equivalent measurement, and varied by location. In 1905, its usage in California was standardized. Today, the standard in California is between 1/50 ft^3/s (566 mL/s) and 1/40 ft^3/s (708 mL/s).

was selected, huge dames were built across the gorges at the mouth of the valley. These reservoirs not only changed the landscape fundamentally, but also altered the water routes of melting snows, the main source of water supply which otherwise escaped into the beds of the natural streams and was thus "stored until the natural streams have dried up or run down so low that they were no longer of any service to the hydraulic miners." ([12], p.333) Reservoirs built for hydraulic mining usually took up a huge area. The Bowman or the Big Cafion reservoir, one of the biggest artificial mining lakes in the Sierra area, covers a mountain valley of 5,450 feet above the sea level, and of an area of 530 acres, which was formerly owned by a man named Bowman. The English reservoir, a property of the Milton Company, covers an area of 400 acres blocked by a dam of 87 feet high. The Silver Lake, an enlarged natural lake, covers about 1,200 acres. ([12], p.333)

III. The Flourishing of Hydraulic Mining and Deforestation

Constructing a hydraulic mining system was expensive, but it was much more lucrative than the early mining methods. Washing a cubic yard of gravel by a pan cost $15. Washing the same amount of gravel cost $4 by a rocker, $1 by a long tom, $0.34 by a sluice, and only $0.06 by hydraulic washing. [15]Meanwhile, as mining methods improved, production of gold increased every year, especially after the wide application of hydraulic mining beginning with 1850. At the peak of hydraulic mining, the yearly amount of gold and silver production could be more than 60 million dollars. (Table 1)([4], p.43) The quantity of gravel washed off in a season in a hydraulic mine was measured by acres, and by so many millions of cubic yards. In the 1880s, a state engineer, William Hammond Hall, estimated that 15,122,000 miner's inches of water was used in hydraulic mining every day in the Sacramento basin, and 53,404,000 cubic yards of material was washed off by it into the Cafion, and 22,326,500 cubic yards being dumped into the Yuba and its tributaries.([12], p.335)

Table 1 Production of Gold in California Between 1848 and 1875

Year	Production of gold and silver (million dollars)
1848	$ 5 million
1850	59
1853	68
1857	64
1860	52
1863	50
1864	35
1866	26
1869	21
1873	20
1875	26
Total	$1,153 million

The extensive hydraulic mining system caused huge and longstanding impact on the environment in California. In addition to housing, cooking, and heating, hydraulic mining needed much more lumber for construction and maintenance of its infrastructure, which caused even worse deforestation in California. Over a 30 year period, the Comstock Lode consumed 800 million cubic feet lumber, which was enough to build 50,000 ranch-type houses, each with two baths and a double garage. ([8], p.127) Because of the big and lucrative lumber market, some lumber mills started to specialize in producing wooden blocks for sluice bottoms and deliver lumber by watercourses for easy transportation. Every spring gigantic drives of lumber and cordwood, up to four miles or more long, took place on the Carson River and more than 150,000 cords of wood were floated down the Carson in a typical season. To facilitate the lumber transportation from watercourses to mills, V-shaped flumes, sometimes a dozen miles long, were built in the 1870s. At the peak season, there were more than 700 cords (500,000 ft) of mining timber were transported down through the flumes of the Carson and Tahoe Lumber Company every day. ([8], p.127)

Deforestation was also caused by the construction of artificial reservoirs, which commonly submerged a large area of forest. The reservoirs of the South Yuba Hydraulic Mining Company had a storage capacity of 1.8 billion cubic feet; the Eureka Lake Hydraulic

Mining Company had 1.13 billion cubic feet; the North Bloomfield Company had 1.05 billion cubic feet; the El Dorado and Deep Gravel Mining Company had 1.07 billion cubic feet; the Milton Company had 650 million cubic feet; the California Water Company had 600 million cubic feet; the Spring Valley had 300 million cubic feet; the Omega and Blue Tent united had 300 million cubic feet. ([12], p.334) During the construction, hydraulic mining companies simply flooded the whole valley, leaving forest trees to wither and die as water rising up.

Vegetation could be recovered when mining stopped, but it does not mean that the environmental degradation was small and temporary. Hydraulic mining removed deep soil, creating an open cut of huge dimensions and exposing the bedrock of a large area, which made vegetation take longer time to recover. In some localities, hydraulic mining cut back hill slopes for considerable distance, creating a long vertical cliff. The landscape was covered with great masses of white limestones in bizarre shapes and "the earth, torn up everywhere, resembled a battlefield of the antediluvian giants and monsters."([8], p.131) Although many hydraulic mining ceased in the middle of the 1880s, vegetation in the bottoms of some mine pits has not been fully recovered to the present. Revegetation started even slower on the slopes of hydraulic pits, because the slopes were too steep to hold seeds. As time went by, erosion reduced the steepness of the slopes to some degree, but its help on revegetation was too small to notice. ([8], p.128) Even if vegetation could be slowly recovered in a half century after hydraulic mining was ended, the mining impact on the change of the distribution of plant species was permanent. Dense ponderosa pine forest, the original plant of many places in California, was destroyed and replaced by Chaparral and Digger pine trees, which originally occupied a narrow zone at the base of the Sierra foothills but spread upward rapidly as a result of the complete removal of timber during the mining period. Mining debris washed down from hydraulic mining sites, destroying much of the original vegetation; in the same time it brought seeds of Chaparral and Digger pine downstream, which quickly established themselves in the new territory. ([8], p.129) It is hard to tell whether the change of plant species affected the local ecosystem, but it is clear that the forest cover today in California "have reached down to the 1,000 foot level." ([14], p.134)

IV. Hydraulic Mining Debris and the Conflict Between Miners and Farmers

Hydraulic mining washed acres of gravel downstream, producing millions of cubic yards of mining debris, which turned out to be the most serious environmental problem in California in the late nineteenth century. The state engineer, William Hammond Hall, estimated that "every day approximately 15.122 million miner's inches of water was used for hydraulic mining, and 53.4 million cubic yards of materials was washed off into the Cafions, 22.326 million cubic yards of debris being dumped into the Yuba River and its tributaries—namely, the steams draining 'the ridge'." ([12], p.327) The total amount of debris dumped into the tributaries of Sacramento over the years was about 1.3 billion cubic yards. ([8], p.132) Mining debris in California was in such an extraordinary volume that William W. Harts, a member of the Commission of California Debris pointed out that "the lower water plane of the Yuba River at Marysville was raised 15 feet between the years 1849 and 1881. Between the years 1881 and 1905 there was an additional raise of three feet, making a total raise in the low water plane of 18 feet (the actual fill in the main channel being 26 feet). The depth of fill of mining debris in the Yuba River averaged from 7 ½ feet at Marysville to 26 feet at Daguerre Point and 84 feet at Smartsville. A short distance east from Marysville, the bed of the Yuba River was 13 feet above the level of the surrounding farms..."[16] Although the quantity of material lodged in the river due to mining had been variously estimated, it was safe to conclude that in 1905 there were more than 333 million cubic yards in the bed of the lower Yuba and in a distance of about 8 miles above Marysville. The condition of other rivers in the mining area including the Feather, the Bear, and the American River was no better than the Yuba River. The bed of the Bear River was filled with a depth of nearly 8 feet of mining debris in the center. The surrounding pine trees, formerly were far above the stream, were gradually engulfed by rising water and in 1870 only the top branches were still above the water. ([8], p.132) By 1911, "there were 300 million cubic yards of debris in the Feather and American river systems which had yet to move out to the bay." [17]

The overloading of streams by mining debris caused formation of numerous sand bars, sometimes even islands, and streams "spreading at will in many shifting channels." Some streams expanded as much as five to six times of their original width, and some chocked by mining debris cut new channels, sometimes shifting as much as half a mile. ([8], p.133) Slickens invaded every nook and corner of the land and the rivers, which presented a scene of desolation wherever direction eyes were turned. Mining debris converted clear and high-banked streams in the old days into sluggish, turbid, and erratic watercourses, flowing on elevated beds between artificial banks, and turned formerly fertile land into a barren desert. ([12], p.337) The environmental impact of mining debris was so great that it not only polluted local watercourses and obstructed navigation, but also caused flood and destroyed agricultural land, which ultimately led to a fierce and protracted conflict between hydraulic miners and farmers.

Before railroads came, rivers were the major means of transportation in nineteenth-century California. River navigation, which was cheap and reliable and had a big carrying capacity, was particularly important for farmers who transported and sold their agricultural products outside their hometowns or even as far as to the east coast of the country. In the early days, the Feather River in California was "a handsome stream, with bold, rapid current and navigable to Oroville, about 141 miles from the mouth of the Sacramento River, for streamers of a small size at all seasons of the year. Its bottoms in many places were wide, and contained some excellent farming land, and were also well adapted to grazing and pasturage, producing the year round a luxuriant coat of grass." [18] The Sacramento River, another main river in California, was "navigable to Red Bluff, about 250 miles from the mouth of that river." ([16], p. 272) In the 1850s when hydraulic mining was not yet running in a full swing, steamboats drawing 13 feet were able to ply the Sacramento River through the northern delta to the port of Sacramento.

Beginning with 1866, however, boats were unable to reach the port of Sacramento, and efforts to dredge the channel proved inadequate. In the 1880s, the streambed at Sacramento was 6.5 feet higher than it had been in 1849. [19] The rising streambeds, sand bars, and islands made sailing on these rivers particularly dangerous. After several steamboat companies had accidents on the rivers, losing their steamers and barges with full cargoes of freight, many transporters who did not want to take the risk ceased their water transportation business. Insurance companies such as Marine Insurance Company also refused to issue any more policies on either the steamers or their cargoes. ([16], p. 94) As the traditional and cheap water transportation was no longer a reliable option, farmers had to turn to the newly constructed railroads to transport agricultural products, though it meant much higher freight rates. Meanwhile, the bays of California, which used to be ideal places for trade, had also been impeded by the deltas from these polluted mountain streams, and "in a comparatively brief period the greater portion of these bays would be useless for the purpose of commerce." ([4], p. 160)

Thanks to the fast development of the railroad system since the turn of the century, the navigation issue was not too serious to fatally jeopardize agriculture and other local economy. However, frequent and widespread floods caused by the growing riverbeds inundated hundreds and thousands of farming land, giving really a heavy blow to agriculture. As more mining debris deposited in rivers, the capacity of the channels to convey flood flows was reduced and levees were more likely to fail due to the increased hydrostatic pressure. Although great floods were periodical natural phenomena of Californian rivers every year despite of prevention measures were taken, the filling-up of the riverbeds increased the tendency of overflow and the denudation of forest and mountains increased the rapidity of the drainage. After flood waters receded, agricultural plants were destroyed. "Slimy deposited sediment drained off, hardened, and turned into a creamy-colored substance, yielding no vegetation, where lying large quantities, except willows; a flake of dry slickens looked very much like brick-dust, such as is used by every housewife for burnishing cutlery." ([12], p.337)

Furthermore, the debris increased turbidity and diminished water quality for livestock and human use. [19] Before the widespread application of hydraulic mining, California used to have abundant natural resources that pioneers in the Westward Movement in the U.S. history thought that the natural resources were inexhaustible. At the annual fair of the agricultural society of northern California in 1865, General John Bidwell addressed that the conflict of abundant natural resources and insufficient human labor and technology impeded the development of California. [20] Travelers who came to California in the early times were often surprised at California's rich fisheries and aquaculture resources. William Kelly, a traveler of the day, surprisingly found that there were "great numbers of enormous salmon and trout in the clear water below, in the Sacramento, San Joaquim, and all their tributaries, in all of which there were countless favorable places for erecting weirs, where any amount of fish might be taken, which always commanded an exorbitant price in the Sacramento and Francisco markets; but no one seemed to give the matter any attention, though most other projects, which presented a profitable aspect, were jumped into avidity." ([13], p.45) A letter of 1853 from an Indian agent, E.A. Stevenson, to the superintendent of Indian Affairs, Thomas J. Henley, also described the affluent salmon resources in California: "I saw them at Salmon Falls on the American River in the year 1851, and also Indians taking barrels of these beautiful fish and drying them from winter." ([8], p.110). However, as soon as hydraulic mining launched, the same Indian agent, E.A. Stevenson unfolded a completely different picture in his letter of 1853: "the American River became so thick with mud that it would scarcely run it returns to its natural channel and with it the soil from a thousand hills, which had driven almost every kind of fish to seek new places of resort where they could enjoy a purer and more natural element."([8], p.110)

Hydraulic miners dumping a great amount of debris into rivers severely damaged farmers' property. Beginning in the 1870s, farmers, especially people lived in river towns such as Marysville and Yuba City, aired their complaints and protested hydraulic mining in open meetings. They formed the Anti-Debris Association of the Sacramento Valley and later the State Anti-Debris Society as a counterweight of the Hydraulic Miners Association formed in 1878. The farmers "repeatedly urged Congress and the state legislature to outlaw the dumping of mining tailings on behalf of the public interest, and when these methods seemed fruitless, resorted to legal action." [21] Farmers accused hydraulic miners that mine tailings and frequent floods turned their once fertile farmland into a barren desert. They claimed that "the loss to the state by the ruin of farming lands, and the destruction of the improvements had reached many millions of dollars that the transient gain from the mines had been far less than constant returns from the lands would have been had they not been rendered valueless." ([4], p.160) The society pointed out that deforestation in mining areas made soil easily erode and wash away to the bedrock, which not only destroyed river navigation but also turned the vast land useless for all purposes. On the other side of the controversy, hydraulic miners emphasized their priority over the use of the land and their contribution to local economy. They argued that miners came to California earlier than farmers and mining industry had and would continue to massively promote the economy of the golden state. Since fine gold has been deposited in the alluvial bottoms, they should been considered rather as minerals than farming lands. Moreover, the cost of prohibiting the dumping of mining tailings was not only great to the state but also enormous to mining companies, because those expensive ditches, flumes, reservoirs, and many other structures would become useless. ([4], p.161)

As the conflict between miners and farmers on hydraulic mining escalated into a lawsuit, engineers and senators started to conduct a number of surveys on the environmental impact of hydraulic mining in a hope to find an ideal way to solve the controversy, that is, to keep the hydraulic mining industry but meanwhile reduce its damage to agriculture and the environment. Dredging debris out of the rivers perhaps was the easiest way to fix the problem, but the unbelievable vast amount of the debris in the rivers proofed that dredging was impractical at all. A more feasible solution was financing and building of dams and levees to limit debris damage, which was elaborated in a compromise act, the Drainage Act of 1880, but the effect of the dams and the levees was small. Small dams were not big enough to contain debris. Large dams could keep debris for a short time, but as time went by, they were either full with debris or collapsed because of the high pressure. In addition, these dams needed regular maintenance, which was too costly to be compensated by agriculture, navigation, or other business. Building levees to prevent debris from encroaching farming land encountered a similar dilemma between the cost and the reward. In 1868 people in Marysville found it was necessary to build levees around the city as well as the north bank of the Yuba River to protect the land from the rapid encroachment of mining debris coming down the river. Soon later, it had been found necessary to increase these levees in height and thickness from year to year ever since. [22] Since 1868 Marysville had developed a large levee system that "consisted of thirteen miles of levees and seven miles of levees surrounded the city proper and encircled an area of 1,418 acres of land. The remaining six miles of levees easterly, on the north side of the Yuba River ended at the Kupser Ranch, and were constructed to prevent the Yuba River overflowing at flood periods and joining with the Feather River on the north side of the City, which it used to do in the early days. The cost of the construction of levees was huge. Between 1881 and 1938, Marysville spent more than $1 million on levees construction and maintenance. (Table 2)① The number of the cost in the state of California was even larger. A report of major U.S. grant, 3rd, document no. 3, 69th congress showed that "the estimated expenditures by local interests both for flood control and reclamation since 1850 and up to 1925 amounted to $86.6 million, and in addition the state of California had advanced the sum of $4.48 million, making a total of $91 million." ([16], pp.272–273)

Table 2 Annual cost of construction and maintenance on the levee system in Marysville, California, 1881-1938

Year	Cost（$）	Year	Cost（$）	Year	Cost（$）
1881	35,952.24	1901	9,175.39	1919	2,070.79
1882	38,292.37	1902	4,773.99	1920	1,659.90
1883	22,845.67	1903	4,192.93	1921	3,450.76
1884	33,031.80	1904	21,170.72	1922	2,548.77
1885	19,825.26	1904 (County Tax)	5,000.00	1923	2,679.84
1886	8,367.79	1905	12,395.29	1924	1,803.96
1887	10,847.54	1906	6,195.78	1925	2,587.94
1888	10,471.50	1907	79,248.43	1926	2,707.29
1889	5,767.95	1908 (County Tax)	5,000.00	1927	2,745.70
1890	16,215.54	1908	13,798.93	1928	10,666.34
1891	12,912.23	1909	37,572.65	1929	14,497.16
1892	6,329.56	1910	22,852.60	1930	4,385.21
1893	12,417.30	1912	1,793.27	1931	4,226.21
1894	5,339.07	1912	3,644.40	1932	4,049.00
1895	5,088.45	1913	3,543.39	1933	4,071.00
1896	8,962.99	1914	3,563.50	1934	7,260.54
1897	9,527.40	1915	0.00	1935	7,260.54
1898	6,873.98	1916	3,625.03	1936	6,225.71
1899	12,794.07	1917	1,851.19	1937	4,778.77
1900	9,478.74	1918	0.00	1938	20,188.04
Total			1,037,132.14		

The Drainage Act of 1880 satisfied few people and farmers believed only the abolition of hydraulic mining would solve the problem once for all. After a protracted battle between farmers and miners in

① The city spent a total of $1 million on levees over 57 years.

the state legislature, hydraulic mining in California was ended by Judge Lorenzo Sawyer in *Woodruff vs. North Bloomfield, et al.* of 1884. ① The Sawyer Decision was one of the first environmental decisions in the United States and it was also among the first Supreme Court decisions to define a concept of a general public interest. As a result of strong resistance from the miners, hydraulic mining revived to some extent in the 1890s due to the Caminetti Act of 1893, by which hydraulic mining was controlled and supervised by the California Debris Commission with broad powers to license hydraulic operations under severe restrictions. The Caminetti Act, the end product of the conflict between miners and farmers, started "river management in California, with its complex of dams, canals, and government commissions." [23] Hydraulic mining was not completely ended until the early twentieth century when mining industry was no longer as important as it had been in the state's economy. San Francisco Bulletin thus commented that mining was a transitory industry, while "the wheat field produced year after year, and wine and oil and wool were perennial." [24] When hydraulic mining declined, the industry's water systems as well as the river management skills and experience became valuable in facilitating the development of agriculture in California. Mining ditches, dams, and artificial reservoirs were integrated into the complicated irrigation systems that contributed to abundant harvest in California year after year.

Although hydraulic mining was ceased at the turn of the century, the mining debris has a constant impact on the environment. Immense deposits of sand and gravel remained stored in the river channels and continued to be reworked by floods. Much of the sediment has been lodged in narrow valleys from the mining districts downstream to the Van Geisen Dam at the Combie Reservoir and in wide, flat valleys of the lower basin from the Camp Far West Dam to the mouth of the Feather River. The storage has been most extensive in the mining regions and at sites corresponding with low gradients. Data collected by L. Allan James on the Bear River in 1985 showed that large deposits of hydraulic gold mining sediments remained in the main channels of the Bear River for more than one hundred years after the end of mining. [25] The data was collected from four transects of the lower Bear River, which were indicated in the map as A, B, C, and D. The study compared variables such as "the cross section area," "top width," "mean depth," "surface area," and "volume" in the 1900s, the historical era, and the 1980s, the present time, and concluded that the transport of the sediments was very slow under the nature force. From the end of hydraulic mining till 1985, for almost one hundred years, the volume of sediments did not change significantly. Put it more precisely, the percentage of eroding in the lower Bear River was less than ten percent.

V. Conclusion

In the early nineteenth century when people came to California with axes and shovels for gold, they have already adopted McNeill's shark-like strategy to maximum the profit at the cost of destroying the environment. Early gold seekers excavating gold with primitive mining technologies caused considerable deforestation and pollution, which indicated that individuals can make big damages to environment even in the period before fossil fuels were used. Hydraulic mining companies excavating gold with the help of extensive water systems made the environmental damage even more serious. Supported by abundant capital and advanced technologies, mining companies colonized the nature to a factory-like system, in which forests, rivers, and mines were connected and integrated into a capitalist system, functioning like a big organic machine producing for

① North Bloomfield Gravel Mining Company established in 1866 was a major hydraulic gold-mining operation at the Malakoff Mine in California subsequent to the California Gold Rush. *Woodruff vs. North Bloomfield, et al*. was a lawsuit from 1882 to 1884, in which Edwards Woodruff, a farmland owner in Marysville brought an anti-debris suit in *Woodruff v. North Bloomfield Gravel Mining Company.*

gold. Although hydraulic mining was ended at the turn of the century, its environmental impact was profound and longstanding: the landscape is irreversibly changed by artificial reservoirs, dams, and ditches; vegetation has been recovering extremely slowly on steep slopes of hydraulic pits; and mining debris has continuously impacted river courses for more than a century. The longtime impact of the mining debris and the difficulty of removing of them afterwards warned us that environmental protection is much more important than fixing it afterwards.

However, the story of the wax and wane of hydraulic mining in California shows that environmental problems, to some degree, are a subjective matter, because it does not become a problem until somebody realizes their interest is harmed. Before farmers came to California, water pollution and mining debris was not a serious problem, except for some estheticians lamenting on the loss of the beauty of nature. But when agriculture gradually became an important economy in California, the environmental devastation caused by hydraulic mining grew into a social and economic problem that activated a fierce and protracted conflict between farmers and miners. In the book *Gold vs. Grain: the Hydraulic Mining Controversy in California's Sacramento Valley,* Robert Kelley elaborated the conflict and argued that "what is recounted in these pages is the history of the first successful attempts in modern American history to use the concept of general welfare to limit free capitalism." ([23], p. 13) This article, in contrast, tries to reveal the social mechanism of environmental problems. In other words, it examines what after all turned environmental change a problem and who were the promoters and activists.

In the studies of environmental history, it is commonly agreed that scientists, scholars, government and non-government organizations (NGOs) played a crucial role in education and legislation regarding to environmental protection. Take the history of environmental protection in the United States for example, influential environmentalists such as Aldo Leopold, John Muir, and Gifford Pinchot, were all intellectuals who served either in the state government or NGOs. This article, on the other hand, indicates that ordinary people and social groups such as farmers in California also played an important role in environmental protection, though their intentions were somehow self-centered and pragmatic. In fact, that ordinary people, out of pragmatic purposes, organized into a civil society to urge the government to enforce laws to protection environment was nothing new in the U.S. history. In the early 1980s, housewives who were particularly concerned for the health of their families organized themselves into antitoxic groups to protest against ground water contamination and air pollution, which was also known as "movement of housewives." Social groups spontaneously organized to protest environmental issues also appeared in other countries like China. The rising Chinese middle class, who care about their family health and life quality, are particularly concerned about the environmental problems in their country. They speak in the public and impose pressure to the state to take immediate actions. A well-known case recently was a famous public figure, Chai Jing, who worked for China Central Television (CCTV) and then resigned from her job to take care of her sick daughter, produced a widely circulated documentary on the issue of the smog in China. In the documentary Chai claimed that her daughter's tumor, to a great degree, was caused by the air pollution in Beijing, and urged the government to take actions immediately. Her argument received wide response from the middle class in China. Although the documentary is somewhat controversial, it once again confirms that social groups and civil societies, like the farmers in California, are one of the important forces in environmental protection.

Finally, the fact that the water systems constructed by hydraulic mining companies were used for agricultural irrigation after the mining was ended reveals that technology is transferrable in industries and society. In the heyday of hydraulic mining, companies invested a considerable amount of capital in construction of the infrastructure of hydraulic water systems, which was one of the important reasons that these companies refused to shut down their business in the farmers vs. miners dispute. The economic cost is also the main reasons for many highly polluting industries refusing to cooperate with the state regulations in the past and the present in many countries including China. However, the result of farmers vs. miners controversy in California shows that the economic cost could be minimized by transferring technology from one field to the other, though it is usually difficult and taking a very long time.

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