

Efficiency and/or Fairness?  
Understanding the Origins of Prior Appropriation in Early California

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I: Introduction

It is perhaps no surprise to any economist familiar with the system of water law that has grown up in the American West that scholars have vigorously disagreed, and continue to disagree to this day, regarding the positive origins and normative properties of that system of law. The doctrine of prior appropriation, the basis for most of western water law, is incredibly complex, in part because under our federalist system, it was created and evolved in separate jurisdictions responding to a plethora of individual facts, circumstances, and economic pressures. Individual features of the law have been interpreted by scholars in very different ways, in part because there is a considerable body of evidence out there, not all of which seems to point to the same conclusion, even for scholars that start with a broad set of shared assumptions and models. When scholars do not share the same assumptions and models, the interpretive gap can be even wider. Such is the current situation with regard to appropriative law.

Any hopes of making sense out of appropriative law are bolstered by the fact that as complex as the entire body of law happens to be, there are certain key features of the law shared by all jurisdictions, the fundamental lynchpin being first-in-time is first-in right, or *first possession*. For scholars of property law, first possession resembles a bright-line property right placed around a unit of water, until one considers all of the qualifications that exist to the exercise of this right, including reasonable use, beneficial use, use-it-or-lose it, and the no-injury rule [Anderson and Snyder(1997), Smith(2008)]. Scholars who emphasize the first possession rule itself tend to be drawn to an efficiency story that emphasizes security of tenure and all of the attendant salubrious implications for promotion of water development and freedom of water use.

Such scholars tend to view the qualifications imposed on the first possession rule as appendages nefariously detracting from the efficiency of an otherwise pretty good rule, by discouraging investment, narrowing freedom of scope of action, and encouraging wasteful use of water. Other scholars who instead emphasize the qualifications to the first possession rule tend to conclude that the efficiency story has serious holes in it and that other, non-efficiency, explanations must be given serious consideration. For economists accustomed to thinking about issues of efficiency and equity, it is not surprising that the alternative explanations have focused on distributional issues and objectives.

This paper attempts to shed light on these very different interpretations of appropriative water law, what I call the *efficiency* position, and the *fairness* position. It proceeds by viewing our current system of water law for what it is: a path-dependent set of institutions with origins in the distant past, and examines the genesis of those institutions to observe the legal, political, and economic dynamics that gave rise to them.<sup>1</sup> Long prior to current environmental concerns, prior to the federal involvement in large-scale water development that dominated much of the 20<sup>th</sup> century West, and even prior to state support for irrigation development in the late-19<sup>th</sup> century, western appropriative law emerged in response to the demands of placer mining in California in the mid-19<sup>th</sup> century, and subsequently spread to other western states. My explanation takes seriously the claims of some that issues of fairness and distributive justice may have been a key component of the principles that emerged in the mining camps in the Sierra foothills where they originated [Zerbe and Anderson(2001); Schorr(2005)]. However, I argue that those same miners' codes also reflected some overwhelming fundamental economic realities which if ignored by the miners would have seriously hampered the successful prosecution of mining.

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<sup>1</sup> See Libecap(2011).

Key among these economic realities was technological advance resulting in significant economies of scale that strongly encouraged team- and later, large-scale mining that was in direct conflict with the alternative impulse to support individualized, small-scale mining. While the codes did attempt to support broad participation in mining, they also reflected fundamental economic pressures to take advantage of significant economies of scale that were manifesting themselves from very early on in the gold rush.

The rest of this paper develops these arguments. Section II describes existing scholarly accounts of the creation of appropriative rights in the early days of California statehood, focusing on their origins in the mining camps and the scholarly debate over how to interpret these accounts. Section III applies this framework to provide a synthetic treatment of mining and water claims in the early California mining camps to help better understand the specific features of the property rights system that emerged from these camps. A key notion here is potential claim size, which combined the notion of an individual claim size with additional code provisions that permitted the purchase of additional claims and that permitted miners to work in association with each other. Section IV develops the connection between developments in placer mining technologies that occurred during this time period and the temporal progression of provisions in the mining codes governing potential claim size. Section V concludes.

## II: What do we currently know about the origins of appropriative water law?

The dominant tradition regarding the development of appropriative water rights in the western United States correctly focuses on their creation in the mining camps of California in response to the demands of placer miners in the early 1850's.<sup>2</sup> According to this tradition, miners in the camps created rules governing mining that upheld the claims of miners who came

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<sup>2</sup> See, for example, Webb(1931), p. 442; Kinney (1912); Dunbar(1983), p. 61; Pisani(1991).

first in time, and then transferred this so-called *first possession* rule to creation of water rights[Kinney(1912), Dunbar (1983), p. 61; Schorr(2005), pp. 7-8]. This rule supported investment in water development, which became increasingly important as miners began to tap diggings removed from surface sources of water[Anderson and Hill(1975), p. 177]. Thus, the new water rights supported and promoted economic development. This dominant account of the origins of prior appropriation thus has a significant efficiency component in the encouragement of investment through the creation of secure property rights in water.

The traditional story of the creation of appropriative rights outlined above grossly oversimplifies the reality of what actually happened, an occupational hazard of stories that paint with a broad brush. Recent accounts have attempted to paint a more sophisticated picture by pointing to substantive differences among miners concerning their interests regarding development and use of water, and the resolution of disputes over water[Pisani(1991)]. As it turned out, many features of appropriative law later emerged precisely *because of* disputes over water, which were resolved politically in the mining camps and judicially when cases were brought to court. Recently, David Schorr(2005) has posed some fundamental challenges to efficiency stories of the creation of appropriative rights, arguing instead that their emergence was largely governed by the pursuit of distributive justice among the miners. Though Schorr's narrative focuses primarily on Colorado, he also argues that the same forces were operant in California, and indeed, a good deal of evidence for early California suggests similar currents may have been present in both locations. In both cases, mining camps created codes that governed various aspects of mining, including the use of water. The codes that appeared in both cases contained similar provisions, including limits on claim sizes, limitations on the number of claims that could be acquired, work requirements, incentive provisions for new discoveries, and dispute resolution mechanisms.

Schorr argues that appropriative rights appeared not as a means of encouraging investment in water development but rather, to ensure the broadest possible participation among miners consistent with preservation of sufficient water value for individual miners. In Schorr's view, participation was maximized by making claims small and water rights consistent with the small size of those claims, and also by work requirements that ensured that water would not be monopolized by speculators[Schorr(2005), p. 33].

Schorr's critique of the received wisdom on early appropriative law echoes recent scholarship by Andrea McDowell that stresses the individual, broad-based participatory nature of the California gold rush, as well as other gold rushes[McDowell(2002, 2004, 2012)]. Though McDowell does not focus on water, her argument is relevant here because she stresses the constraints that miners imposed on themselves in order to maximize participation and ensure individual access to gold deposits. The restrictions she considers include a lot of the same provisions that Schorr was concerned with, including work requirements, limits on claim size and limits on the number of claims individual miners could hold. Karen Clay and Gavin Wright have also recently examined the California gold rush and concluded in a similar vein that mining camp provisions such as work requirements facilitated turnover on claims, again with the consequence that access to gold by individual miners was maximized[Clay and Wright(2005)].

A central argument of this paper is that all of these accounts that stress broad miner participation and distributively equal claim allocation mechanisms ignore or downplay pressures that were being generated in the gold fields that favored the aggregation of individual claims and team production of gold. The nature of placer mining technologies, along with rapid technological advance, resulted in significant pressures for miners to adopt capital- and water-intensive mining techniques, which raised the minimum efficient scale of the typical placer mining

operation. Indeed, overwhelming evidence suggests that team production, at first with a handful of miners but soon with considerably more, quickly came to dominate the gold fields. The miners' codes, and the origins of appropriative rights, cannot be properly understood without accounting for this major economic factor.

It must be stressed, as I will argue below, that such economic pressures were present from very early in the California gold rush and only became more pronounced over time. There is a persistent stereotypical misconception that gold rushes are comprised of a bunch of solitary individual miners, and that technological advance in the form of more capital- and water-intensive techniques only came along later, after rush conditions had subsided. In fact, as I will argue below, team production was a central component of the California gold rush from very early on. This fact has major implications for how we interpret the provisions regarding both mining and water rights in the early mining codes.

### III. Efficiency and fairness in the mining codes

In this discussion, it should be borne clearly in mind that the attitudes of miners towards fairness and distributive justice were potentially in conflict with the competing goal of maximizing overall gold production. In order to distinguish as clearly as possible the competing hypotheses, I here consider each of the miners to have come to the gold fields with a particular stock of endowments, which included not only their capacity for physical labor, capital(e.g., equipment, firearms), and financial resources, but also certain norms and innate attitudes towards fairness which governed their competitive interactions with each other but which may also have predisposed them in certain ways(or not) to cooperate with others. The miners may be thought of as having been broadly (not literally) homogeneous in terms of overall endowments, though individual endowments certainly varied across miners, including the norms and attitudes that

governed their competitive and cooperative interactions[Zerbe and Anderson(2001)]. Though each miner will be modeled as largely rational and self-interested in the traditional economic sense, fairness considerations may well have entered into their interactions with others. These considerations will be potentially influenced not only by their subjective attitudes but also by the context of their interactions with others, including the history and terms of these interactions.

Both their self-interest and their internalized attitudes toward fairness would have been manifested in decisions made by each miner to participate(or not) in public discussions to negotiate the terms of local rules and regulations governing mining(miners' codes), which he would be bound by as long as he continued to remain in the locality under the jurisdiction of the code. The codes that emerged would have embodied a collective reflection of both the self-interest and fairness attitudes of the miners, tempered by the transaction costs of negotiation. I should stress that when I say "bound by", I do not mean that individual miners would have necessarily perfectly adhered to the local rules, which were enforceable only at some cost. These enforcement costs may have been influenced by the norms and attitudes prevailing in the locality *ex post* which affected the propensity of individual miners to free-ride.

A key determinant of the types of code provisions they would have favored has to do with the way in which they intended to prosecute mining. Each miner had to decide how to use the resources available to him to generate production and income, which included organizational decisions on how, when, and where to mine. The mining company to which each miner belonged may have consisted of one single individual(himself) or some larger number of miners. Their choice of organization would have been influenced by the technological options available to prosecute mining that determined the productivity and cost of operating at different production scales. In this discussion, the distinction between fairness and efficiency will come out most

strongly in the scale of organization supported in the codes and specifically, in the provisions relating to the permissible size of a claim. As we shall see, limits on claim size were virtually universally present in the codes. A crucial question in assessing efficiency vs. fairness was the relationship between the maximum permitted claim size and the minimum efficient scale of a mining operation, where the latter was a function of the technologies available to miners. If the minimum efficient scale exceeded the maximum claim size, then in the absence of other factors, the claim size limitation would have resulted in loss of overall surplus as a result of miners being forced to prosecute mining at an inefficiently small scale. A logical interpretation would then be that efficiency was being sacrificed to promote fair outcomes. Viewed in this light, the question of fairness vs. efficiency depends upon the available mining technologies, the claim size limit, and the extent to which the limit was enforced and/or not compensated for by other code provisions.

Aside from the question of operation scale, efficiency also depended upon the extent to which code provisions protected investments in mining development. Though placer mining is often depicted as a solitary, heavily labor-intensive pursuit, in fact team production emerged in California almost immediately because of initially modest and subsequently significant economies of scale. Without some reasonable security to realize returns from up-front investments, miners would have been discouraged from making those investments, to the detriment of mining production. In the following discussion, we will observe two fundamental types of provisions: ones that can be interpreted as providing fundamental tenure security and broad autonomy to prosecute mining and realize returns on investments, and others that appear to impose restrictions on the free prosecution of mining, an important example being work requirements. These two types of provisions we will term *exclusion* and *governance* provisions, in line with recent deve-



lopments in the property law literature[Smith(2002, 2008)]. The observed pattern of exclusion and governance provisions will reflect a fundamental tension between promotion of mining investment and the resolution of disputes among miners through limitations on their scope of action.

Figure 1 reports the number of new placer codes written annually from 1850 through 1857 that are contained in my sample. Though it reports only two codes that were written in 1850, this may well underestimate the actual number written at the time because earlier codes were more likely to be lost or destroyed. Beginning in 1851, however, a significant number of surviving placer codes were written in every year through 1857, for a total of sixty-four through that year. The following discussion is based on a close reading of these sixty-four codes.<sup>3</sup>

#### *A. River mining operations*

We can see some of the earliest attempts of miners to organize to craft mining codes in the early river mining operations. In river mining, perhaps the most common dispute occurred when a company built a dam that backed water over the dry riverbed claims of a company situated immediately upstream. When there were only one or two or a handful of companies situated on a stretch of river and they were not physically adjacent to each other, they would have been unlikely to interfere with each other's operations and peace and harmony would have reigned, and issues of neither efficiency nor fairness would have arisen. However, when companies organized "along the whole extent of the river, and at every available point it will be dammed and turned"[*Alta Californian*, 5/24/1850], as they apparently did on the Tuolumne River

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<sup>3</sup> I gratefully acknowledge Karen Clay and Gavin Wright for sharing their database of miners' codes with me. This database includes every placer code contained in Clay and Wright's database for this period, plus a few more collected from various additional sources. It excludes codes for camps exclusively devoted to quartz mining. No new placer codes were written in 1858 and 1859, and the five existing codes that were revised in those two years included no substantive modifications of provisions relevant to this study.

in spring of 1850, one can imagine that disputes might well occur, and then attitudes towards efficiency and fairness may have manifested themselves.<sup>4</sup>

Some might reasonably anticipate that river miners placed in this position might resort to taking matters into their own hands by tearing down offending structures, or worse, if they believed they had a superior claim to mine the river. During this period, however, there is little evidence that they pursued such confrontational strategies. On the contrary, there is much more evidence to suggest that river miners tried to resolve matters cooperatively and amicably by establishing guidelines that governed the taking of river claims and disputes that might arise between companies.<sup>5</sup>

For evidence regarding miner attitudes toward efficiency and fairness, consider the codes created by two separate assemblages of river miners on the American and Mokelumne Rivers in the summer of 1851 for resolving disputes over river claims. In the first assemblage, which took place on July 12<sup>th</sup>, damming companies on the Mokelumne River called for the election of two arbitrators to resolve disputes among companies and if needed, a system of jury trial to hear cases. It also attempted to clarify what companies were entitled to; namely, all ground drained or dried by damming in some form[AC, 7/27/51]. Later that month on July 29<sup>th</sup>, a second set of miners convened at Mormon Island on the American River and passed a more extensive set of resolutions specifically enjoining damming companies from backing water over *existing* claims “which do not belong to them”, which constituted an injury to the upstream party “and as such abated”. Furthermore, the injured party was explicitly entitled to damages. It should perhaps be

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<sup>4</sup> For other stories describing extensive river mining occurring in 1849 and 1850, see Alta Californian, 10/1/1849, 4/24/1850, 8/5/1850.

<sup>5</sup> See, for example, Woods(1851), pp. 143-44.

stressed that these resolutions were explicit that temporal priority governed the relative status of damming rights, stating that:

“when claims are held in the bank or river previous to the erection of a dam and so flooded, the company shall be liable for damages.”

The resolutions also required damming companies to clearly establish the limits of their claims by staking them off, and that others were explicitly empowered to work up to those stakes “without any hindrance from the said company”[AC, 8/2/51].

The difference in the approaches taken by the two sets of miners is striking to someone schooled in the modern law-and-economics tradition. Whereas the Mormon Island resolutions may be interpreted as attempts to create bright-line property rights to individual stretches of the river, the Mokelumne River resolutions were considerably more ambiguous, basically leaving the rights in the hands of arbitrators or a jury, and providing no guidance regarding on what basis they should settle disputes. What makes this interesting is that the typical dispute that both of these sets of resolutions were intended to address probably involved low transaction costs. There would have been only two parties involved, and the injury – a dam that backs water over the claims of the adjacent party upstream – would have been easily observable and the identity of the offending company trivial to determine. Under these conditions, efficiency might dictate the creation of clearly-defined property rights, which would facilitate Pareto-improving trades such as a buyout by one company, or consolidation of the two companies accomplished in some other manner. Such property rights were clearly provided by the Mormon Island resolutions and decidedly not by the ones from the Mokelumne River.

It is difficult, of course, to draw definitive conclusions regarding efficiency based merely on these two sets of resolutions. We do not know, for example, how long these resolutions were in effect or how stringently they were enforced. Some evidence, however, suggests that the Mor-

mon Island provisions were probably more broadly reflective of miner preferences in general regarding how to address river mining disputes. The only other surviving set of by-laws that solely governed river mining in the 1850's are those of Lower Humbug Creek, a mining district in Siskiyou County. These by-laws, which were written in 1855, were explicit about the treatment of backwaters in disputes involving adjacent claimants, mandating that the backwaters created by a lower claimant "shall in no case be allowed to interfere with the other" when claims were made "at one and the same time". However, when a claimant arrived first, his backwaters were not "considered an incumbrance(sic) to the one above."(U.S. Mining Laws, p. 284) As in the Mormon Island resolutions, this wording is suggestive of an exclusion right in disputes involving backwaters. And as we shall see, the use of temporal priority in governing such disputes in this manner is broadly consistent with other provisions crafted by miners to resolve disputes over mining claims.

It should be added that river mining operations involved significant economies of scale from a very early date. All such operations required significant up-front investments in dams and diversion canals or flumes, and even the earliest river mining operations involved teams of miners to construct the dam and diversion system.<sup>6</sup> Even as early as 1850, some river mining companies were known to have elaborate corporate structures and procedures.<sup>7</sup> The length of stretch of river designated to be drained of water appears to have depended upon physical features of the local landscape that influenced the ease with which dams could be constructed and diversion canals/ flumes could be dug or constructed. The Mormon Island and Lower Humbug Creek resolutions placed exclusion rights around entire stretches of river, which fully

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<sup>6</sup> Buffum(1966), p. 78; Taylor(1967), pp. 84-85; Woods(1851), pp. 64-65, 133; Gardiner(1970); Derbec(1964), p. 109.

<sup>7</sup> Woods(1851), pp. 145-48.

empowered mining companies to take advantage of economies of scale in gold production, and imposed no constraints regarding the length of stretch of river that could be mined.

*B. Other placer mining operations*

The vast majority of miners' codes available to modern researchers governed diggings not in the beds of rivers but rather, in their bars and banks, or in locations remote from water such as ravines, gulches, flats, and hills. In these settings, the nature of the disputes that could occur over mining claims was not about flooding each others' claims by building dams but rather, was about other forms of interference with mining such as claim jumping and working claims one was not entitled to. The codes governing non-river placer diggings contain several types of provisions that are interpretable in terms of both supporting the general prosecution of mining and expressing distributional concern for justice or fairness. These include limits on claim size, limitations on the number of claims individual miners could hold, work requirements, the ability to associate together to prosecute mining jointly, extra claims for discoveries of new deposits, and formal procedures for resolving disputes over claims. All of these provisions occurred in a significant number of codes, with some, especially work requirements, appearing more regularly than others.

Without exception, the mining codes governing non-river placer diggings sustained the notion of a claim largely as an exclusion right that enjoyed first possession protection against newcomer encroachment. Along rivers, streams, and creeks, claims comprised so many feet of frontage land extending so many feet back from the waterway. In gulches, ravines, flats and hills, surface claims were mostly rectangular, so many feet by so many feet. All provided a perimeter that in principle excluded other miners from interfering with prosecution of mining within the area of the claim. On the surface, defining claims in this way would appear to

promote efficiency to the extent that mining within one's designated claim area inflicted no externalities on other miners.<sup>8</sup> On the other hand, it must be recognized that the creation of an exclusion right in this form effectively imposed a limitation on the permissible size of a claim, which has been interpreted by Schorr and others as reflecting miners' interest in maximizing the number of miners who were able to work the gold, and thus in ensuring allocative fairness.

It turns out that the claim size limitation cannot be correctly interpreted without considering a number of other relevant factors that have been generally overlooked or underemphasized in the scholarly debate over the efficiency and fairness hypotheses. First, the mere fact of a claim size limitation is not in itself sufficient to allow us to conclude that either efficiency or fairness was the decisive operant factor. The reason relates to the question of how the claim size limitation compared to the minimum efficient scale of a placer mining operation during this time period. If the minimum efficient scale was considerably larger than the claim size permitted by a code, then imposing the size limit could have resulted in significant losses in productivity, making it harder to argue that this provision promoted efficiency. If it was not, however, then it is impossible to tell, on the basis of this factor alone, whether efficiency or fairness was the driving factor.

However, even a minimum efficient scale of mining significantly in excess of the claim size limit *in itself* tells us nothing about efficiency vs. fairness unless there were additional proscriptions contained in the code against aggregating individual claims, either by locating or purchasing claims, or working together with other miners. If there were no such proscriptions, then miners could have been free to expand the scale of operations to take advantage of

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<sup>8</sup> The standard efficiency interpretation is bolstered by the additional fact that defining exclusion rights in this manner would have served the additional economizing function of minimizing information costs associated with measuring the various attributes of a property right. See Smith(2002, 2008).

economies of scale by combining claims and resources, laboring together, and prosecuting mining on a larger scale. At the same time, these codes may not have promoted fairness in the egalitarian sense because they would have facilitated, or at the very least done nothing to block, concentrations of resources and wealth in the hands of a few. Enhanced concentration of wealth could have occurred in a variety of ways, the most obvious perhaps being the concentration of Ricardian rents in companies of miners favored by circumstances to mine the most productive placer deposits. Wealth concentration could also occur, however, if technological change was rendering mining more capital-intensive thus increasing the return on labor. Finally, in the instances where miners were hiring others to work for them, they may have been able to gain significant rents as the residual claimant on the revenues of the company, to the extent laborers were risk-averse, or Indian labor was available.<sup>9</sup>

More generally, the appropriate comparison to make is between the minimum efficient scale and the total claim size – what I shall call the *potential* claim size – that reflects the individual claim size limitation but is also adjusted to take into account the possibility of locations or purchases of multiple claims and the possibility of individual miners being permitted to work in association with each other. When one examines the codes in my sample, the potential claim size turns out to be commonly much larger than the individual claim size limitation. For example, of the forty-six codes for which I have specific information on individual claim size limits, twenty-two permitted unlimited purchase of claims, and thirteen explicitly allowed individual

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<sup>9</sup> Most gold rush scholars emphasize the joint stock association model of mining companies, which was probably the dominant company model, especially early on. However, there is also a good deal of evidence of a significant wage labor market at the time. See, for example, Wyman(1945), p. 19; Hill(1966), pp. 37-38; Christman(1930), pp. 143-45; Senter (1938), 3/30/51; Stoddart(1963), p. 61. In addition, a number of scholars have remarked on the use of Indian labor, as well as the use of slaves by transported southerners. See Brands(2002), p. 198; Rohrbough(1997), p. 125.

miners to work in association with each other. Only five of the forty-six codes limited miners to one claim without the explicit possibility of working in association with other miners. All of which means that studies that focus on the individual claim size limitation without considering the possibilities of holding multiple (often unlimited) claims or working in association with other miners provide a misleading picture of the restrictiveness of the individual limit. Since holding multiple claims and working in association with other miners would have promoted the concentration of wealth in companies of miners for the reasons given earlier, the case for fair outcomes, as embodied in egalitarian policies on claim sizes, becomes considerably weakened.

#### IV. Technological change and the evolution of the mining codes

More insight into the relative merits of the efficiency and fairness hypotheses is gained by examining how relevant provisions of the codes evolved over time. The interpretative exercise here is to examine code provisions in connection with what we know of the use of placer technologies and the implications for the likely minimum efficient scale of gold production. Key to the argument is the fact that rapid technological advance occurred during this period in the form of a pronounced movement away from reliance on heavily labor-intensive gold separation technologies to ones that were considerably more capital- and water-intensive. Early exclusive reliance on panning and rockers and cradles gave way to the use of long toms and sluice boxes, which in turn were superseded by ground sluicing and hydraulic mining, all within the span of less than ten years. This fact permits us to better interpret code provisions at different points in time in terms of their connection to the minimum efficient scale of mining, thus providing further evidence on the relative explanatory power of the competing hypotheses.

All of the gold separation technologies used in California during this period were designed to solve one problem: to extract the gold from the otherwise worthless dirt, mud, gravel or



debris in which it naturally occurred. The earliest technologies of *panning* and *rockers-and-cradles* involved one or a handful of miners while requiring minimal up-front capital expenditures and minimal amounts of water. In panning, a single miner placed gold-bearing mud in a pan and swirled it with his arms using a circular motion. The resulting agitation of the water kept the debris suspended while the heavier gold sank to the bottom of the pan. Rockers-and-cradles provided the needed agitation by rocking an oblong box(the cradle) back and forth but unlike panning, optimally involved a small team of miners, who divided up the tasks of rocking, hauling debris, and applying water to the mechanism. Consequently, operations that used rockers-and-cradles operated on a significantly larger scale than ones that used panning, involving as few as three but more commonly six to eight miners. However, both panning and rockers-and cradles were extremely labor-intensive methods which permitted only limited gold production.

The appearance of the *long tom* upped the technical ante, significantly increasing the scale of mining operations while also dramatically increasing mining productivity. The long tom was a long trough roughly twelve feet long through which water was piped in a continuous feed, while miners shoveled debris into the trough, or into wooden troughs feeding water into the tom. The tom itself contained the gold separation mechanism in the form of a perforated iron segment, underneath which was placed a riffle-box. The debris would be fed into the tom and the heavier debris would fall through to the riffle-box, where the gold would be caught and retained by the riffle bars. The essential technology of long toms was reproduced on a larger scale with the subsequent invention of *sluicing*, which involved one or a series of interlocking shallow troughs (sluice boxes) with riffled bottoms, into which water was again continuously fed. Sluicing thus dispensed with the perforated bottoms favored by the long tom, by instead placing riffles in the

troughs themselves, which proved to be more than sufficient to separate out the gold. The long tom and sluicing technologies thus involved considerably more up-front capital investment than did the previous technologies, not merely for building the toms or sluice boxes themselves, but also for building the system that fed in the water. In doing so, they also permitted a significantly larger number of miners to work in concert than previously. It should also be apparent that they used considerably more water as well.

The next key development occurred when miners began to apply water directly to the gold-bearing grounds themselves, rather than merely piping in water to the gold separating mechanism and shoveling in the dirt by hand. In *ground sluicing*, water was conducted to a plot of ground and then turned onto it, while miners worked at the ground with picks and shovels to loosen it and let the water carry it away, at which point it was directed into sluice boxes for gold separation. In *hydraulic mining*(hydraulicking), water would be transported to a diggings and directed in high-pressure jets against a hillside, which would be washed down and the debris again directed into sluice boxes. In dramatically increasing the amount of water used for gold separation, ground sluicing and especially hydraulicking increased the scale requirements of mining even further by expanding the required up-front expenditures for water delivery and application.

In order to correctly interpret the mining code provisions, it will be useful to characterize the time pattern of technological change as precisely as we can, which is summarized in Figure 2. Figure 2 graphs the cumulative number of times each of these technologies is mentioned in news accounts in the Daily Alta Californian from 1849 through 1859.<sup>10</sup> Several important pat-

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<sup>10</sup> The Alta Californian was a San Francisco-based daily newspaper that published numerous news stories on mining based upon accounts of its own correspondents, letters from around the state sent in to the newspaper, and reproductions of local accounts published in

terms emerge from these data. The first is that prior to early 1851, there is virtually no evidence that anything other than the most primitive technologies – panning and rockers-and-cradles – were being used.<sup>11</sup> However, beginning in spring of 1851, the adoption of long toms explodes and indeed, long toms quickly became the dominant technology in the 1851 mining season.<sup>12</sup> Sluicing activity begins to pick up later that season and begins to be even more rapidly adopted than long toms in 1852, so that throughout the 1854 and 1854 mining seasons, long toms and sluicing are comparable in importance. Hydraulicking first appears in early 1853, is adopted gradually over the next three years, and then adoption accelerates dramatically beginning in early 1856.<sup>13</sup> The overall pattern is one of rapid technological advance, toward increasingly capital- and water-intensive production technologies with considerably larger scale requirements.

This overall temporal pattern of technological advance will be exploited to shed light on the mining code provisions, where in addition to the provisions relating to claim size, the holding of multiple claims, and miners working in association, we will also consider work requirements and rules that awarded extra claims for new discoveries. In the following discussion, I will divide the analysis up into what I call the *Early*, *Middle*, and *Late* periods, which provides the basis for characterizing the temporal progression of the provisions in a systematic way. To summarize much of the information quickly in advance, Figure 3 shows the cumulative number

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smaller county newspapers. The sample shown in Figure 2 is based upon almost every single mining-related account that appeared in the paper during this period: roughly 1100 news stories.

<sup>11</sup> This evidence from news accounts is consistent with numerous accounts and histories that conclude that early miners relied almost exclusively on these technologies [Swan(1848), p. 33; Burnett(1880), p. 274; Johnston(1892), pp. 273-74; Paul(1947), pp. 52-53].

<sup>12</sup> The exact timing of the invention of long toms is not entirely certain, though some accounts suggest that they may have been in existence as early as late 1849. See Paul(1947), p. 61. See also Thompson and West, pp. 176-77.

<sup>13</sup> This pattern is also roughly consistent with a number of histories, which suggest that hydraulicking did not begin to make significant inroads for a few years after its initial introduction [May(1970), Greenland(2001)].

of codes over time that contained four key provisions: (a)no limits on purchases of claims(*Unl Claims*), (b)a work requirement to maintain possession (*Work Req*), (c)explicit permission for miners to associate together to work their claims(*Association*), and (d)an extra claim for discovery of a new deposit(*Discovery*).

I. Early Period(1850 – early 1852)

What I call the Early Period up to early 1852 or so roughly coincides with the consensus of numerous studies that call this the *gold rush* period. The codes written during this early period tended to create exclusion rights while imposing very little in the way of governance constraints on the practices of the miners. A good example of this pattern is the previously-mentioned code of Chinese Camp in Tuolumne County, dating from September of 1850, the earliest code in my sample. This code specified that claims would be twenty feet square, which was marked off by making a ditch two feet wide and one foot deep around the claim. It also called for the election of an alcalde who would have “power to decide upon all disputed claims in the vicinity”[Heckendorn and Wilson(1856), p. 83]. Virtually nothing else was deemed necessary to include in the code in order to effectively govern mining within the camp.

The only other 1850 code was that of Gold Mountain in Nevada County, which dates from December of that year. This code specified that claims were to be thirty feet by forty feet and marked by stakes at each corner. In addition, miners were required to have their claims recorded by a locally elected recorder, and transfers of claims from one miner to another were to be recorded as well. But no restrictions were imposed on transfers of claims, and miners were allowed to purchase as many claims as they wished. There was also no explicit work requirement in order not to forfeit one’s claim; indeed, the code explicitly exempted miners from having to put in any work on a claim until the following April, as long as it was properly marked. The

only substantive restrictions imposed on miners, besides forbidding foreigners to hold claims, were proscriptions on stealing tools and throwing dirt or rock onto another's claim[U.S. Mining Laws(1885), p. 331].

The codes of Chinese Camp and Gold Mountain are of interest because they are the only surviving codes from the early period prior to 1851 that was dominated by the primitive technologies of panning and rockers-and-cradles. During this period, of course, the minimum efficient scale of mining was quite small, as only a handful of miners could work together on an operation. The relatively small maximum claim sizes(400 square feet for Chinese Camp and 1200 square feet for Gold Mountain) could be interpreted as local attempts to provide wide access to the gold, perhaps in the interest of fairness. And though the potential claim size was a good deal larger in the case of Gold Mountain, the primitive state of mining technology probably limited the extent to which wealth could be concentrated in the hands of a few miners. At the same time, there was probably little loss of rents through miners being forced to operate at inefficiently small operation scales. Through 1850, then, fairness and efficiency were essentially not at odds with each other, in terms of the permitted scale of operations.

The mining codes written the following year in 1851 continued to impose very few governance constraints on prosecution of mining. Codes written that year for placer mining in Indian Springs, Jefferson Hill, Kentucky Hill and Prospect Hill, all in Nevada County, did little more than establish individual claim sizes and a recording requirement, though it should be noted that they established claim sizes that were a good deal larger than codes of the previous year: sixty feet by sixty feet for Kentucky Hill and Prospect Hill, and eighty feet by eighty feet for Indian Springs and Jefferson Hill. Furthermore, though all restricted miners to one claim by

occupancy, all allowed any miner to purchase as many claims as he wished.<sup>14</sup> One other 1851 code, for Poverty Hill, Yorktown, and Chili Camp, in Tuolumne County, permitted even larger individual claim sizes(100 feet by 100 feet), while also permitting the holding of multiple claims. All of which was coincident with the introduction and rapid spread of the long tom technology, which as we have seen significantly expanded the minimum efficient scale of mining operations. It is in 1851, then, that we start to observe a modest movement toward concentration of wealth in larger mining companies, as operations became larger and codes accommodated this growth by explicitly allowing the purchase of unlimited claims. It should be added that the Poverty Hill code is noteworthy in that it is the first placer code that actually specifies a work requirement in order to maintain a claim, requiring miners to “commenc(e) work thereon” within three days of taking possession. However, the work it required to hold a claim was minimal, only requiring the miner to dig a ditch “two feet wide and one foot deep on two sides of his claim and throw the dirt from said ditch upon it.”<sup>15</sup>

The pattern observed in these early codes is corroborated by Figure 3, where the steepness of the blue line representing unlimited claims into early 1852 indicates that virtually all of the early codes allowed unlimited claims. At the same time, the flatness of the other three lines during this same period indicate that only one code – Poverty Hill – contained work requirements or granted miners extra claims for making new gold discoveries, and none explicitly permitted miners to associate together to work their claims,. In the Early Period, then, the evidence strongly indicates that codes created what were largely pure exclusion rights, imposing very few governance restrictions on the free exercise of this right. In general, potential claim sizes were quite large and miners were not required to work(much) to keep their claims. These rights were

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<sup>14</sup> U.S. Mining Laws(1885), pp. 333, 335, 336.

<sup>15</sup> Article 4, Heckendorn and Wilson(1856), p. 87.

consistent with broad and roughly equal distribution of mining rents in 1850 when virtually all miners were operating on extremely small scales, using only panning and rockers-and-cradles for gold separation. However, in 1851 the rapid adoption of the long tom technology begins to create pressures for miners to amass larger claims, which was fully supported by the codes written in that year.

This evidence provides a more refined picture of the gold rush period than is found in a number of recent scholarly studies, which stress limits on claim sizes, restrictions on holding multiple claims, and work requirements to conclude that miners' codes were crafted to prevent monopolization of claims, to spread the wealth among miners and to facilitate the turnover of claims.<sup>16</sup> The evidence contained in the earliest codes considered here is more consistent with an interest in permitting miners to work claims at their discretion, to exploit what may have been modest but significant economies of scale, and to support production through creation of rights that effectively excluded other miners. The virtual absence of provisions that rewarded miners for gold discoveries also makes sense for this early period: the incentive effects of such provisions were probably largely unnecessary given the relative ease of discovery of gold during the Gold Rush period.

## II. Middle Period(early 1852 – mid- to late-1853)

Beginning in early 1852, however, we observe mining camps imposing significant restrictions on the acquisition of claims and on mining practices on those claims. Some codes written in that year, such as those of Constitution Hill and Washington Hill, continued to permit miners to purchase as many claims as they wished(U.S. Mining Laws, p. 342). Similarly, the mining code of Jackass Gulch also seemed to permit the purchase of multiple claims, but that

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<sup>16</sup> Zerbe and Anderson(2001), Clay and Wright(2005), McDowell(2002, 2004).

purchases needed to be made “in good faith and under a bona fide bill of sale” and certified by two disinterested parties, suggesting that sufficient fraud or confusion had surrounded the selling of claims that the miners considered some procedural guidance to be desirable[Heckendorn and Wilson(1856), p. 80]. Weaver Creek, however, was explicit in limiting “each and every miner” to one claim, “either by purchase or otherwise from this time forth”[U.S. Mining Laws(1885), p. 277]. Rockwell Hill also appeared to limit miners to only one claim when it specified that “No person shall hold more than one claim by location”, though this could be interpreted as leaving open the possibility of holding other claims by purchase, a contingency the code was silent on[U.S. Mining Laws(1885), p. 337]. Similarly, Volcano Hill permitted miners to hold two claims by location, while also not being explicit on purchases.<sup>17</sup> Upper Yuba and East Fork of North Trinity both struck a middle ground by permitting miners to hold one claim by purchase and one claim by location[U.S. Mining Laws(1885), pp. 276-77].<sup>18</sup>

At the same time, however, provisions began to appear in some codes that explicitly permitted miners to associate to work together and pool claims. The code of Volcano Hill, written in 1852, explicitly permitted miners to form joint stock companies which could work “any part of their joint claims as best suits their convenience.” The 1853 code of Columbia, after specifying that each miner within the district was permitted to hold only one claim, went on to say that:

“(N)othing in this article shall be so construed as to prevent miners from associating in companies to carry on mining operations; such companies holding no more than one full claim to each member.”

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<sup>17</sup> Earl v. George, Placer County court case # 125(1855).

<sup>18</sup> For the first time, we also began to observe refinement of the maximum claims provision to allow for special circumstances. The Upper Yuba code specified that miners could successfully bid for the claims of deceased miners, even if they already held other claims.



Since a “full claim” in Columbia(1853) was one hundred feet square, or 10,000 square feet, four miners could in principle pool their claims to amass a total working area of nearly an acre. Similarly, Vallecito(1853) allowed sixty feet square to “each individual, or to each member of any company.” East Fork of North Trinity also explicitly permitted miners to associate together to work their claims.

Referring to Figure 3, the evidence indicates that provisions allowing unlimited claims were still being regularly included in codes, though they were not quite as universal as they had been during the Early Period. At the same time, association provisions were still pretty uncommon, though they were beginning to be included with greater frequency in the latter half of 1853. Overall, however, in most cases the potential claim size remained significantly greater than the individual claim size limit. Twelve of the nineteen codes written in 1852 or 1853, or 63%, either permitted miners unlimited claims or explicitly allowed them to associate to prosecute mining. On the other hand, only three of the codes limited miners to only one claim along with no explicit provision for association.<sup>19</sup> It should be added that the codes that permitted unlimited claims all specified that they could be amassed through purchase (as opposed to location), which would have favored miners with means. The overall thrust of these provisions in the Middle Period still does not support the fairness hypothesis, in any egalitarian sense.

Another significant change that occurred during the Middle Period was the more regular inclusion of work requirements in the codes beginning in early 1852, and then becoming a virtually universal feature of the codes beginning in early 1853(See Figure 3). It should be added that during this period the work requirements became more explicit and binding as the

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<sup>19</sup> In one other case, Upper Yuba, miners were limited to two claims, one by location and one by purchase, along with no explicit right to associate.

period progressed. The 1852 codes of Constitution Hill and Washington Hill imposed no work requirement and indeed, Constitution Hill explicitly permitted claims to be held “without labor done” for an entire year[U.S. Mining Laws(1885), p. 342]. Similarly, the 1852 code of Rockwell Hill only required miners to work one day in sixty[U.S. Mining Laws(1885), p. 337]. The most stringent work requirements found in the 1852 codes were those of Jackass Gulch and Weaver Creek, which required miners to work one day in five and one day in ten in order to hold claims.<sup>20</sup> However, the 1853 codes virtually all imposed relatively strict work requirements. Representative of the 1853 codes were Warren Hill, Empire Hill, and Jamestown, which required miners to work one day in six, and New York Diggings, which required one day in seven.

This evolution in the work requirement is suggestive of generalized growing gold scarcity after 1852, since it is hard to imagine miners forcing each other to work when there is plenty of gold for everyone. To this extent, I agree with existing scholarship that the work requirements helped maximize production by facilitating turnover of claims[Clay and Wright(2005)]. Aside from signaling growing gold scarcity, however, the trend toward universal work requirements also reflected some of the technological advances described earlier that promoted team production. This is seen in the fact that work requirements sometimes complemented the association provisions, as for example, in Brushey Canyon (1853), which stipulated that miners holding contiguous claims could work “one or more of such claims leaving the others unworked.”<sup>21</sup> This provision made it possible for miners associating together to concentrate their efforts on one part of the combined claims without fear of losing the rest. During this period, we also begin to

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<sup>20</sup> Heckendorn and Wilson(1856), p. 80; U.S. Mining Laws(1885), p. 277. The 1852 code of Volcano Hill contained the unusual provision that claims could be held if miners put in more than \$25 worth of labor, “provided it be practicable so to do”, not being explicit about the period of time within which the work needed to be done.

<sup>21</sup> See also Warren Hill(1853).

observe work requirement provisions that reflect the rise of a separate and distinct ditch industry that was in the business of selling water to miners. The work requirements of Columbia (1853), for example, had to be satisfied within three days after water could “be procured at the usual rates”. This tendency would become more pronounced in the next few years.<sup>22</sup>

### III. Late Period(1854 – 1858)

The patterns beginning to emerge in 1852 and 1853 would become more clearly defined over the ensuing years to 1858, and new patterns would begin to emerge as well. With greater regularity, miners’ codes would restrict the number of claims individual miners could hold. The provisions varied across codes and over time, but the modal provision imposed a maximum of anywhere from one to two claims. Similarly, over time we observe fewer codes that permit unlimited purchases of claims, though it needs to be emphasized that such provisions did not disappear from the codes. From 1854 through 1858, ten out of twenty-six codes permitted unlimited purchases. However, as with the previous period, this restrictiveness was partially offset by the inclusion of association provisions, which continued to be written during this period: eight such provisions appeared in new codes written during this period. The result was that fifteen of the twenty-six codes – nearly 58% – written during the Late Period allowed miners either unlimited claims or explicit freedom to associate in mining. Even by mid-decade, the potential claim size well exceeded the individual claim size limit in a majority of mining camps.

As we have seen, work requirement provisions began to be universal in the codes in early 1853. The Late Period witnessed a continuation of the trend that they reflected technological advances in mining that promoted team production of gold. Some codes, such as Smith’s Flat (1855), permitted water development in digging ditches and constructing reservoirs – team acti-

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<sup>22</sup> See also Murphy’s(1857).

vities – to count towards satisfying the work requirement. Some codes that made work requirements conditional on sufficiency of water, for example, based them on the new evolving technologies for water application. The code of Garote(185?), for example, stated that sufficiency meant enough water to “work a (long) tom”, while Smith’s Flat (1855) stipulated that a “sluice-head” was sufficient to work a claim.<sup>23</sup> Still other work requirements clearly reflected a new orientation toward a separate ditch industry that supplied water to miners. Saw Mill Flat(1854), for example, stipulated that miners not working their claims would not forfeit them if water was either not available to work them, or if it was too expensive. French Creek (1854) went even further when it did not require claims to be worked unless water could “be had free of charge” [U.S. Mining Laws(1885), p. 281]. Ohio Flat(1856) specified that claims would be forfeited if not worked within ten days after water was available at a “reasonable” price. The thrust of the work requirement provisions involving water was, of course, to acknowledge not only the technological reality that placer mining was difficult to prosecute without water, but also the economic reality that cheaper water in greater quantities was also important to miners. Miners saw fit to superimpose increasingly sophisticated work requirement restrictions on the basic exclusion right that reflected the importance of water and the new industrial organization that involved separate suppliers of water furnishing water to miners in transactions resembling a market.

As Figure 3 also indicates, one other important development during this period was the emergence in the codes of a provision that gave the discoverer of new deposits the right to an extra claim. Such a provision had appeared sporadically prior to late 1853, appearing in a primitive form in 1851 in the code of Poverty Hill, Yorktown and Chili Camp, which allowed the

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<sup>23</sup> See also Oregon Gulch(1855).

discoverer of a new lead sixty upon the lead. Two other codes that gave discoverers an extra claim were Vallecito and Volcano District in 1852, which stated that the provision was included in the code “in order to encourage industry and diligence within this district”. Beginning with the code of Brushey Canyon in late November of 1853, however, the vast majority of codes written into early 1856 contain such a provision. Granting extra claims to the discoverers of new lodes would appear to have been designed to reward prospecting, which if successful would have led to the enrichment of all. And some evidence suggests that miners would sometimes attempt to free-ride on the prospecting of others, as Frank Marryat described in 1851:

“There are plenty of ‘prospectors’ in the mines, but the profession scarcely pays, for the ‘prospector’ is the jackal who must search for many days, and, when he has found, the lion, in the shape of the old miner, steps in and reaps the benefit. So that there is something to be learnt in the diggings, for undoubtedly one of the first principles in life is to look on while others work, and then step in and cry ‘halves’”. [Marryatt(1962), p. 120]

Additional miners’ accounts confirm that free-riding on the prospecting activity of others was an issue in the 1851 mining season.<sup>24</sup>

To the extent that free-riding was a serious issue, the extra claim provision can be viewed as an attempt to address the problem by providing greater rewards to prospecting activity. However, this explanation by itself is not entirely adequate as it does not explain why the provision did not begin to appear regularly in new miners’ codes until nearly 1854, more than two mining seasons after free riding began to be documented to be an issue in the camps, nor why it largely vanished after 1855. A clue is perhaps provided by Figure 3, which reveals a striking similarity in the time patterns for the association and discovery provisions. My suspicion is that economies of scale, team production, and the search for new placer deposits all intensified in the 1853 season which, perhaps not coincidentally, is when placer mining took a leap upwards in terms of

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<sup>24</sup> See also McDowell(2002), p. 43.

capital- and water-intensity with the invention of hydraulic mining. By 1855, however, larger scale operations had perhaps become regularized and part of industry norms and few new discoveries were being made by small-scale mining operations.

Overall, the evidence presented in this section provides very little evidence for anything like a generalized egalitarian notion of fairness emerging from the miners' codes relating to mining claims. On the contrary, early codes virtually unanimously permitted individual miners to collect as many claims as they had resources to purchase and imposed very little in governance constraints on their behavior in mining their claims. Over time, we observe limits being imposed on unlimited purchase of claims but at the same time, a number of codes compensated by permitting free association of miners and the pooling of claims. The latter association provisions track the likely expansion of the minimum efficient scale of mining through the invention and application of more heavily water- and capital-intensive mining technologies, permitting miners to team up to take advantage of these new technologies. Fairness may well have been an important concern for the minority of miners' codes that explicitly limited miners to one claim apiece, as well as the ones that made their work requirements contingent on the availability of water or being free from illness.<sup>25</sup> The fact that work requirements were largely absent during the Early Period and then became universal after late 1853 seems, however, more consistent with growing scarcities in placer deposits over time than with promoting fairness. The dominant pattern suggests a tracking of the imperatives of gold production: supporting investment security,

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<sup>25</sup> This latter interpretation of fairness is not in the egalitarian sense but rather, in the sense supported in the positive justice literature, that individuals perceive non-egalitarian outcomes to be fair if individuals have "earned" larger rewards through greater effort and also, that fairness demands that individuals not be penalized for circumstances beyond their control. See Hoffman and Spitzer(1985); Konow(2003), pp. 1209-11.

providing exclusion rights, and permitting miners to take advantage of technological advance and growing economies of scale over time.

## V. Conclusions

The debate over the origins of appropriative rights in the 19<sup>th</sup> century American West has suffered from insufficient care paid to the connection between changes in legal doctrine and changing technological and economic imperatives of mining, water development and water use. This study has attempted to forge that connection by examining the time series adoption of key provisions of the miners' codes in light of our best understanding of how water was developed and used during the crucial formative period of early California statehood. The evidence suggests that the miners' codes were strongly shaped by growing scarcity of both placer ore and water, which gave rise to work requirements and provisions granting extra claims to miners who discovered new lodes. At the same time, the codes also attempted to accommodate rapid technological advances that resulted in economies of scale and promoted team production. Without the ability to circumvent individual claim size limitations by purchasing multiple claims and working in association with other miners, miners would have been forced to operate at inefficiently small scales with a resulting loss of surplus. To the extent that fairness concerns generated these limitations on individual claim size, it would then be warranted to conclude that the codes generated an efficiency-fairness tradeoff and came down in favor of fairness. However, a significant portion of the codes did not in fact restrict miners to one claim, especially early on, and many attempted in various ways to facilitate miners working in association with each other. The suggestion is that miners in these camps were not prepared to sacrifice the gains to be had from larger-scale production even if it meant the concentration of gold and wealth in the hands of fewer miners.

## *References*

- Anderson, Terry L. and P.J. Hill. "The Evolution of Property Rights: A Study of the American West," Journal of Law and Economics 18(1975): 163-79.
- Anderson, Terry L. and Pamela Snyder. Water Markets: Priming the Invisible Pump. Washington: Cato, 1997.
- Borthwick, J.D. 3 Years in California. Oakland: Biobooks, 1948.
- Brands, H.W. The Age of Gold. New York: Doubleday, 2002.
- Buffum, Edward G. Six Months in the Gold Mines. Ann Arbor: University Microfilms, 1966.
- Burnett, Peter H. Recollections and Opinions of an Old Pioneer, 1880.
- Christman, Enos. One Man's Gold: The Letters & Journals of a Forty-Niner. New York: McGraw-Hill, 1930.
- Clay, Karen and Gavin Wright. "Order Without Law? Property Rights During the California Gold Rush," Explorations in Economic History 42(April 2005): 155-83.
- Delano, Alonzo. Life on the plains and among the diggings. Auburn: Miller, Orton and Mulligan, 1854.
- Derbec, Etienne. A French journalist in the California gold rush: the letters of Etienne Derbec. A.P. Nasatir(ed.) Georgetown: Talisman, 1964.
- Dunbar, Robert G. Forging New Rights in Western Waters. Lincoln: University of Nebraska Press, 1983.
- Gardiner, Howard C. In Pursuit of the Golden Dream. Stoughton: Western Hemisphere, 1970.
- Greenland, Powell. Hydraulic Mining in California: A Tarnished Legacy. Spokane: Clark, 2000.
- Heckendorn & Wilson. Miners & Businessmen's Directory. Columbia: Clipper, 1856.
- Hill, John Berry. In the gold mines in '50, '51 and '52. Coloma: El Dorado County Historical Society, 1966.
- Hoffman, Elizabeth and Matthew L. Spitzer. "Entitlements, Rights, and Fairness: An Experimental Examination of Subjects' Concepts of Distributive Justice," Journal of Legal Studies 14(June 1985): 259-97.
- Johnston, William Graham. Experiences of a forty-niner. Pittsburgh, 1892.



- Konow, James. "Which Is the Fairest One of All? A Positive Analysis of Justice Theories," Journal of Economic Literature 41(December 2003): 1188-1239.
- Libecap, Gary D. "Institutional Path Dependence in Climate Adaption: Coman's 'Some Unsettled Problems of Irrigation,'" American Economic Review 101(February 2011): 64-80.
- Marryat, Frank. Mountains and Molehills; or Recollections of a Burnt Journal. Philadelphia: Lippincott, 1962.
- May, Philip Ross. Origins of Hydraulic Mining in California. Oakland: Holmes Book Co., 1970.
- McDowell, Andrea G. "Real Property, Spontaneous Order, and Norms in the Gold Mines," Law & Social Inquiry, Vol. 29, No. 4 (Autumn, 2004), pp. 771-818.
- McDowell, Andrea G. "From Commons to Claims: Property Rights in the California Gold Rush," Yale Journal of Law and Humanities(2002): 14.
- Paul, Rodman W. California Gold: The Beginnings of Mining in the Far West. Lincoln: University of Nebraska Press, 1947.
- Pisani, Donald J. "The Origins of Western Water Law: Case Studies from Two California Mining Districts," California History(Fall 1991): 242-57.
- Rohrbough, Malcolm J. Days of Gold. Berkeley: University of California Press, 1997.
- Schorr, David B. "Appropriation as Agrarianism: Distributive Justice in the Creation of Property Rights," Ecology Law Quarterly 32(2005): 3-71.
- Senter, Riley. Crossing the continent to California gold fields. Lemon Cove: Senter, 1938.
- Smith, Henry E. "Governing Water: The Semicommons of Fluid Property Rights," Arizona Law Review 50(2008): 445- 478.
- Smith, Henry E. "Exclusion vs. Governance: Two Strategies for Delineating Property Rights," Journal of Legal Studies 31(2002): S453-487.
- Stoddart, Thomas R. Annals of Tuolumne County. (Carlo M. DeFerrari, ed.) Clovis: Word Dancer, 1963.
- Swan, John Alfred. A trip to the gold mines of California in 1848. John A. Hussey(ed.) San Francisco: Book Club of CA, 1960.
- Taylor, Bayard. El Dorado. Glorieta: Rio Grande Press, 1967.
- Umbeck, John R. "The California Gold Rush: A Study of Emerging Property Rights," Explorations in Economic History 14(1977): 197-226.

Umbeck, John R. A Theory of Property Rights with Application to the California Gold Rush. Ames: Iowa State University Press, 1981.

United States. Department of the Interior. Census Office. The United States Mining Laws and Regulations Thereunder, and State and Territorial Mining Law, to which are appended Local Mining Rules and Regulations. Washington: Government Printing Office, 1885.

Webb, Walter Prescott. The Great Plains. Boston: Ginn, 1931.

Woods, Daniel B. Sixteen months at the gold diggings. London: Sampson Low: New York: Harper & Brothers, 1851.

Wyman, Walker D. "California Emigrant Letters," California Historical Society Quarterly 24(March 1945): 17-46.

Zerbe, R.O. and Anderson, C.L. "Culture and Fairness in the Development of Institutions in the California Gold Fields," Journal of Economic History 61(2001): 114-143.

Figure 1: Number of placer codes written annually, 1850 to 1857

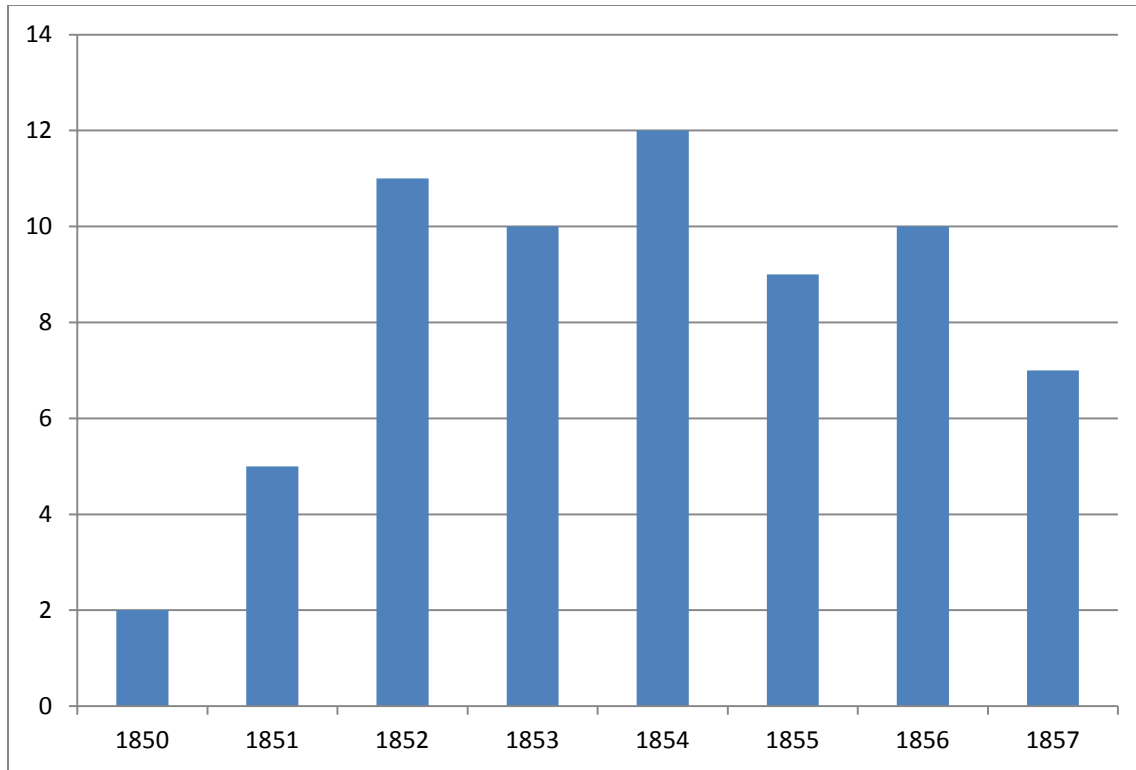


Figure 2: Cumulative Number of News Stories in the Daily Alta California, Various Placer Technologies, 1849-1859

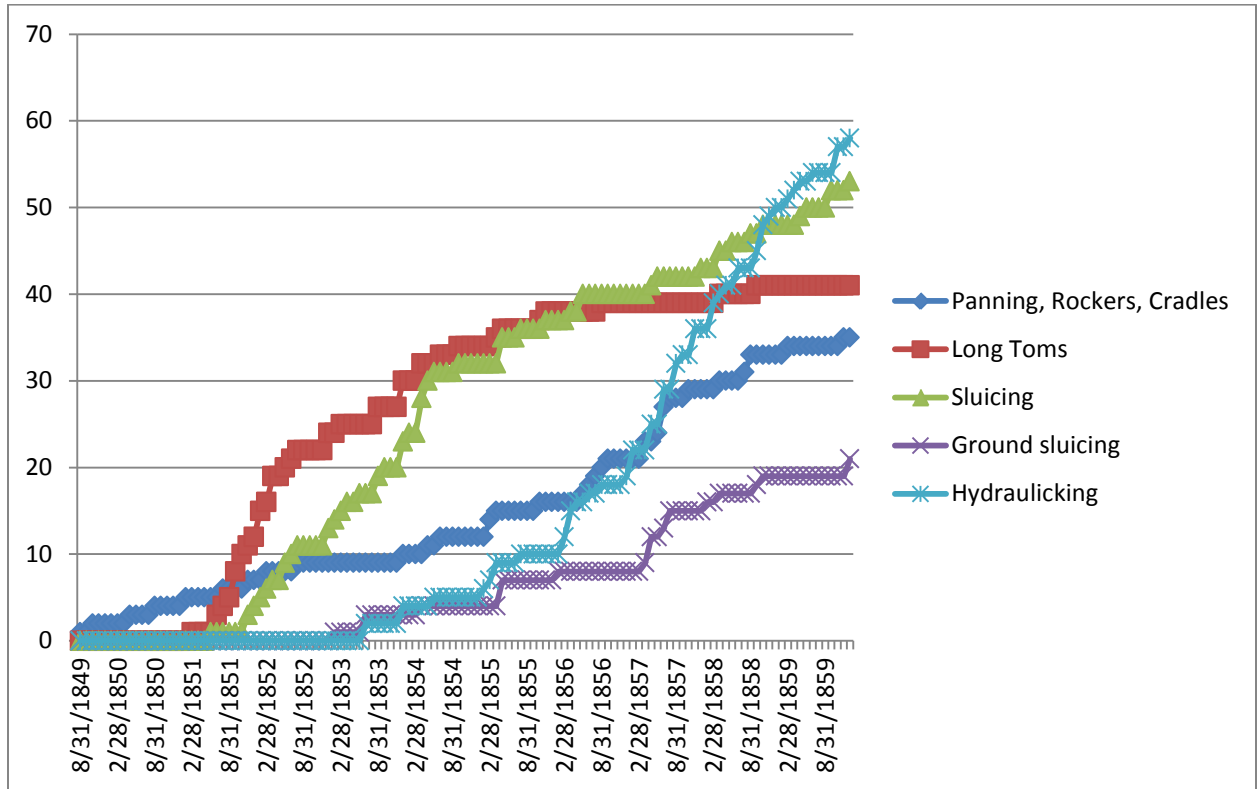


Figure 3: Cumulative number of miners' codes containing various governance provisions, 1850-1858

