

IRRIGATED AGRICULTURE IN SETTLER ECONOMIES

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The usual view of settler economies is one of land abundant areas where a few people have moved to exploit plentiful unoccupied land. That is pretty much a definition of a settler economy. Superficially, at least, it would therefore seem anomalous that in some settler economies there should have been an early resort to irrigation. That implies a substantial capital investment to supplement the abundance of land. How should one account for this? How is it that settlers felt the need to shift to a more capital intensive agriculture when moving into an area whose foremost characteristic was the abundance of land? In this paper I try to address this seeming anomaly by examining the early history of irrigated agriculture in the western United States and in Australia, two archetypical settler economies. I also briefly take into account the Canadian experience where irrigation was unimportant.

A Brief History of Irrigation in the United States and in Australia

The United States

By the middle of the nineteenth century people in the United States looked westward from the Mississippi river to a vast extent of land available for settlement. The first section of this, between the Mississippi and Missouri rivers (Iowa and eastern Kansas) was extremely promising to farmers, but beyond that lay the "Great American Desert"¹. There was a huge area of land, but it was questionable whether it was arable.

At about the same time attention shifted to the Pacific coast. California had been added to the United States and it, too, represented a large area of unsettled land. The main intrusion of European settlement into these areas was a classic movement of settlers into a region with an abundance of unoccupied land.² The northern part of the Central Valley of California became a wheat growing region which, despite the great distance from Britain, was able profitably to flood

Britain with American wheat. By 1870 California had attracted a substantial population. San Francisco had become a major city and several areas of the state had filled with agricultural settlers. Still there were large areas yet to be cultivated. Nevertheless, this seemingly land-abundant region had begun at an early date to turn to capital intensive irrigation to support further development of farming. Given the large area of land in the state, why did the early settlers not simply leave aside the arid districts and concentrate settlement in the areas, still with abundant lands, that could be brought under cultivation with conventional farming? If there were really an abundance of land, why worry about the dry lands?

Further to the east, as Americans pushed westward from the Mississippi onto the plains they had also resorted to capital investment in irrigation. The earliest development of irrigated farming was associated with the Mormon settlement in Utah, although it is noted that, further to the southwest, there had been limited areas of rather primitive irrigated farming in the region that had been under Spanish rule. Even before Spanish contact the indigenous population had used controlled water supplies for growing crops. These were small scale and fairly primitive precursors of irrigated farming and, with usual European arrogance, it is common to think of the Mormons as having pioneered irrigated farming in the American west. When the Mormons moved out to settle the shores of the Great Salt Lake they knew that water would be a problem and that irrigation would be necessary. What they did not know was anything much about irrigation. With no experience, and little more than some “book learning”, the early Mormon settlers successfully established irrigated agriculture on a small scale. It was a communal effort and it was accomplished by trial and error. The motivation was wholly ideological. The Mormons explicitly wanted to establish their colony in a remote and isolated area. From the outset they knew that irrigation would be a necessity in that region.

This was the pioneer experience with irrigated agriculture in the American west, but it was a peculiar one. From the outset non-economic considerations prevailed. The Mormons knew before the trek west that they would have to irrigate but they had deliberately chosen to settle in

an isolated, remote, but arid region. What the Mormons provided was a demonstration project. They showed that with irrigation, arable farming was possible in the Great American Desert.

The next development involving irrigation also had an ideological dimension. In the lee of the Rocky Mountains, in northern Colorado, an agricultural colony was established in the early 1870s, again with the clear understanding that irrigation would be necessary. The arid western plains had, in general, posed a barrier. Some had perceived, however, that with water management, agricultural settlement might be possible. Furthermore, the integrated communal effort required by an irrigation project would, as the Mormons had shown, give cohesion to the settlement. The Union Colony of 1870 was a well organized venture to establish farming, using irrigation, just east of the Rocky Mountains in north-central Colorado. It began as a communal, ideologically imbued venture that was eagerly promoted by New York journalist Horace Greeley.³ The community was called Greeley in his name, and from the outset it prospered.

The Greeley settlement was imitated in several other nearby developments. These were relatively large scale, privately financed ventures, organized in corporate form. They abandoned the communal ideology and were, in essence, projects to sell land to prospective farmers who were eager to settle in the west. They utilized the water of small rivers running down the east slope of the Rocky Mountains to flow into the South Platte River. The capital investments were not really great — rather primitive weirs and some ditching sufficed, the whole thing working with gravity flow. The only problem was that there was a limited number of streams that could be exploited in that way. Similar developments were carried out in southeastern Colorado in the upper Arkansas River valley. Also in the 1870s private irrigation ventures were tried in western Colorado, on the other side of the Rocky Mountains. Where sufficient water combined with local conditions of climate and soil to support high valued crops such as tree fruits or potatoes, these developments were reasonably successful. Elsewhere, though, many of the projects were short lived and foundered. By 1880 the largest extent of cultivated land on the high plains was on the very western edge, in Colorado, in the lee of the Rocky Mountains, and one half of that land was irrigated. In 1890 Colorado was second only to California among the states in area of irrigated

land. By 1900 it had displaced California to become the leading state in irrigated acres. In Colorado, though, irrigated acres amounted to almost one half of all improved farm land. Areas of irrigated land in the western states are summarized in Table 1.

At about the same time as irrigated agriculture was getting underway in Colorado some beginnings were being made in California. These began on a small and quite unsophisticated way in Anaheim and Riverside in the Los Angeles district. What made them outstanding was the introduction at Riverside of a high quality navel orange that could be made to thrive in California. Small irrigated plots to grow citrus fruit were a profitable way to use the land of southern California. The brothers George and William Chaffey solved two problems and in so doing greatly fostered the expansion of irrigated agriculture in southern California. First off, in their projects at Etiwanda and then at Ontario, they showed that the limited supplies of water in the small streams coming down the western side of the San Bernardino mountains could be substantially augmented by tapping the greater volume of underground water running beneath those streams. They also solved an important “law and economics” issue by pioneering the implementation of the mutual land and water company whereby the purchaser of land acquired a proportional interest in the firm that controlled the water supply. The farmer of irrigated land then avoided the risk of being at the mercy of whomever controlled the water. The Chaffey colonies at Etiwanda and Ontario, established in 1880 and 1882 respectively, were notably successful. Irrigated citrus growing expanded along similar lines at Pasadena, Pomona and Riverside and other locations in the Los Angeles region.

Even before those developments much more extensive irrigation works were being constructed in the Central Valley of California. These too were private initiatives, undertaken by the owners of large tracts of land from Bakersfield north to Fresno. They were projects of a different sort, intended mainly to flood lands on which hay and alfalfa could be grown to feed large herds of cattle. This was low intensity irrigated agriculture which, at least at the beginning, did not involve the sale of small farms to large numbers of new settlers. It did, however, involve a large area of land, considerably greater than the more intensive irrigated farming further to the

south. It was this area that made California the leading state in irrigated acreage as reported in the census of 1890.⁴

By 1890 smaller projects had begun in several other western states but they were patterned on the earlier examples of Colorado and California. There were, in effect, three different pioneer irrigation schemes in the western United States, one in Colorado and two in California. All were private enterprise, without subsidy of any sort. In Colorado there were extensive ventures that provided for small mixed farms to engage especially in vegetable and fruit growing. In California a few large land holders in the central valley provided irrigation water to augment the feed for their cattle herds, Closer to the coast smaller irrigation projects laid the foundation for the California citrus industry. This last involved the smallest number of acres of the three but probably generated the greatest value of output and attracted the widest attention.

Much grander and more extensive irrigation projects, involving large dams and reservoirs, would come in the early 20th century. That was when government got involved in the planning, financing, and carrying out of the grand projects. It was then that the promotion of irrigation became a matter of public policy. The pioneer ventures had been private initiatives. Not all had been profitable. Many of the imitators of the Union Colony at Greeley in Colorado got low returns on their investment and some went bankrupt. The central valley irrigators in California made good returns only when, late in the nineteenth century, they shifted their strategy to selling or renting small plots of land to farmers who could use the land more intensively. The Chaffey brothers sold their “model” colony at Ontario, California for a meager gain just before the boom in southern California land values in the late 1880s. What the pioneer ventures had done was to demonstrate the conditional feasibility of irrigated agriculture and to draw attention to the possibilities of a more capital intensive alternative to the settlement of new territory. They laid a foundation for a movement and an ideology by which large scale irrigation projects were promoted. The pioneer developments had shown that farming was feasible, even if not always profitable, on arid lands. Men could master the environment. If land was arid, just add water. It

became an obligation, a duty. With some engineering, and a lot of capital, the limitations of so much of the territory of a great nation could be overcome.

Irrigation in Australia

In Australia, in the colony of Victoria, the desirability of irrigated agriculture became a topic of widespread and vigorous discussion in the early 1880s. In an extensive part of the colony the lack of rainfall was proving to be a serious limitation to further agricultural settlement. A few individual farmers had undertaken small irrigation projects and reported favourably on them. In true British parliamentary fashion the government of Victoria struck a royal commission to investigate the issue. Its report, leaning strongly to the promotion of irrigation, was extensively discussed in the legislature. No one seemed to doubt the desirability of irrigation; what was disputed mostly was the question of public subsidy. Even that was focused on whether private developers would get subsidized loans. There was really no thought that irrigation projects should be planned, financed and carried out by the government. Commissioner and member of parliament Alfred Deakin traveled to the United States and in an informative volume reported on the irrigation works in California and Colorado (Deakin, 1885). In California Deakin met the Chaffey brothers. He evidently inspired them to consider a project in Australia. George Chaffey traveled to Australia, convinced himself that he could do great things there, and instructed brother William to sell out in California and to move “down under”. The lure to Chaffey was to develop on a larger scale than he did in California. There was the prospect of a large grant of land which he could supply with water and then sell at a profit. Deakin expected that irrigation works would be done on private initiative although he fully realized that some form of subsidy and government support would be required.

The deal negotiated between the Chaffeyes and the government of Victoria was a complex one. George Chaffey purchased a barren sheep station on the Murray river, Australia’s grandest inland waterway, in the northwest corner of Victoria. He was to be granted land in stages, each contingent upon his making a substantial investment in irrigation works. There was also a somewhat vague promise of a railway to be built by the government of Victoria since Mildura

was far remote from any market. The Victoria parliament was slow to enact the enabling legislation and so the Chaffeys worked out a similar deal, on a somewhat smaller scale, down river at Renmark in South Australia. The government of that colony had suddenly become eager to get the jump on Victoria in the matter of irrigation. By 1888 the Chaffeys, and Australia, had underway two ambitious irrigation projects. These were in a region where there had been almost no prior settlement, a region where rainfall was indeed scanty. Even grazing sheep had been of doubtful viability. Irrigation could be made to pay only if farms could produce high value crops such as fruit, yet transport was slow, by river steamer or overland by bullock team 500 kilometers to Melbourne. Furthermore, the irrigation works would have to be more capital intensive than the gravity systems developed in the United States. Water had to be pumped almost thirty meters up from the Murray River. For that purpose George Chaffey designed, and had built in England, huge steam engines of a revolutionary but controversial new type. The engines worked. Water flowed. Settlers were attracted, the majority from overseas, and by 1891 the first great Australian experiments with irrigated agriculture were well underway.

For all the effort made, Mildura and Renmark did not initially work out. Distance to market was a serious problem. The government of Victoria made no move to build the railway. Settlers were unable to meet their payments for land and water. By 1893 the entire Australian economy was crumbling in a major financial crisis. The Chaffey enterprise faced bankruptcy and George returned to the United States. Eventually, in the twentieth century, Mildura and Renmark prospered and grew. They came to be looked upon with pride as examples of how the desert could be made to bloom (and how muddy Murray water could be turned into wine). The initial impact, however, cannot be said to have contributed to the success of agricultural settlement in Australia.

At the same time the Chaffeys were developing Renmark and Mildura another pioneer irrigation project was underway in Australia. The Goulburn Weir was constructed as a “national project” by the government of Victoria. Its purpose was to act as the headgate for an irrigation system in north central Victoria, using water from the Goulburn River, a tributary to the Murray.

Principal canals running north and west towards the Murray were projected, also to be built as a “national project”. The weir was completed in 1891 and a few close by farmers began irrigating. A few years later the Rodney Irrigation Trust inaugurated a somewhat larger project using Goulburn water. The Trust ran up a large debt that eventually was absorbed by the Government of Victoria. It was not, however, until well into the first decade of the twentieth century that any substantial acreage came under irrigation in the area fed by the Goulburn Weir. This was, initially, no more successful an irrigation venture than that of the Chaffey brothers at Mildura.⁵

Australian interest in irrigated farming came when Victoria still had a population of fewer than 500,000 people. It came before the long period of drought that set in by the 1890s, although it was always recognized that an outstanding feature of Australia is that it had a vast area of land that was seemingly too dry to farm.⁶ Rational calculation clearly indicated that irrigation was not worthwhile.⁷ Still, the challenge of taming the desert was there. It was not a matter of necessity, though, at the time when the first projects were begun.

Irrigation in Alberta, Canada

A brief account can be given here of the case of Canada, essentially as “the dog which did not bark.” Irrigation played only a very small role in the settlement of western Canada, and then only belatedly. The Canadian plains were dry but not altogether so arid as the western United States or the interior of Australia.⁸ They could be conquered by techniques of dryland farming to grow wheat, or used to graze beef cattle. They were settled very quickly in the early years of the twentieth century. There were irrigation projects in southwestern Alberta, drawing on mountain streams coming down from the glaciers and the snowbanks of the Rockies. There was no shortage of water but only weak and limited interest in the sort of intensive farming called for by irrigation. As much as anything what precipitated irrigation development in Alberta was the immigration of Mormon farmers from Utah who had experience with irrigation. They formed an association with the Northwestern Coal and Navigation Company which had built a railway to ship coal from deposits it owned near Lethbridge, Alberta. As government subsidy to the railway the company had received a substantial grant of land, but it was land in the dry belt. The

company thought that it could sell its land only if it provided water for irrigated agriculture. Under the name of the Alberta Railway and Irrigation Company, formed in 1891, it laid out a plan for a relatively ambitious irrigation project. It entered into a contract with the leaders of the Mormon immigrants from Utah who had experience with irrigated farming. The project proceeded slowly and actual construction of the irrigation works began only in 1898 (Hedges, 1939: 172). By 1900 184 kilometers of irrigation canals had been constructed along the St. Mary river above Lethbridge. There was still little land actually being farmed with irrigation water. Under the shelter of a protective tariff a beet sugar refinery was established in 1903 and a market established for the sort of product that intensive irrigated agriculture required. Potatoes were grown and some alfalfa but, mainly for climatic reasons there was no development of orchards or vineyards and other such intensive crops that usually make irrigation worthwhile. The feasibility of a limited form of irrigated agriculture in western Canada was being demonstrated, yet only a few thousand acres were actually being irrigated.⁹

At about this time (1903) the Canadian Pacific Railway got interested in irrigation development as an aid to selling the large amount of grant land it owned in southwestern Alberta. That railway had run its main line right through the dry belt of southern Alberta but only in 1903 did it agree to accept land there as part of its massive land grant subsidy.¹⁰ It launched an ambitious irrigation project into which it threw a lot of resources.¹¹ Harnessing water of the Bow River, the Bassano Dam and Brooks Aqueduct were completed in 1914, but by that time agricultural settlement in Alberta was just about completed. Irrigation allowed this larger area to produce alfalfa for cattle feed, and irrigation water was used from time to time on cereal crops, but the whole thing added up to a small element in the settlement history of western Canada. The main point is that the Canadian settler economy pretty much did without irrigation.

By Way of Explanation

With some of the basic facts before us we can look to the factors that might account for the apparent anomaly of capital intensive irrigated agriculture in land abundant settler economies. Several possibilities present themselves.

One point should be made explicit. My interest is in the reasons why people turned to irrigated agriculture relatively early in the settlement process. In the United States, in the twentieth century, after settlement was essentially completed, there was a heightened interest in irrigation.¹² Large projects were promoted and carried out, mostly as government ventures. The rationale for these differed from the earlier projects carried out by private enterprise. The larger, twentieth century developments now account for the greater part of the land under irrigation and they get most of the attention in contemporary writing about irrigation. These projects were not, however, an integral part of the settlement process. I leave the consideration of how they came about to other authors. The concern here is with the early projects, carried out at a time when land was still abundantly available. Similarly, in Australia there was a substantial augmentation of land under irrigation in the twentieth century, mostly after 1920. That too involved government planned, promoted, and carried out projects. It also accounts for the greater part of the land under irrigation in Australia in recent years. The question with which I am concerned is why, in some but not all settlement economies, people resorted at a quite early stage of settlement to capital intensive irrigation. The issue is whether there were good and understandable economic reasons for that, or was it just misguided urge to have mastery over the desert.

In my examination of the situation in the settler regions of the United States and Australia I focus on three main points. One concerns demand. Irrigation may have been pursued because with it farmers could respond to demands for products that could not otherwise have been raised and for which there was an established demand. Another way of putting this is to ask whether irrigation involves a completely different way of farming, suitable only to a select set of products. The second point is to question whether it was really the case that land was abundant in some of the settler economies. We should perhaps not characterize all settler economies as having an abundance of land. Some of them may have had to create usable land through capital investment in water supply. Thirdly, I ask whether the early forms of irrigation were really so capital intensive as we might think. All cultivated land might be thought of as part of the capital stock, created through a process of investment. Land as a pure gift of nature, in some costless sense, is a myth. The question to be asked then concerns the relative cost of making land usable

through irrigation compared to other processes of land preparation, particularly the clearing of forests. Each of these points is considered in order.

Demand for the Products of Intensive Agriculture

A starting point is to recognize that irrigation rarely, if ever, pays when used to raise low unit value products such as wheat or corn. If land is going to be irrigated it has to be used to grow products of much higher value per acre. Citrus fruit and grapes are near the top of the list, but other orchard fruit does well as do vegetables and beets for sugar. The farmers of coastal California were able to prosper on 10 or 20 acres of irrigated orange grove. At Fresno in the Central Valley grapes quickly became the leading crop. Cattle can be grazed on dry pasture land but finishing them to market weight on irrigated alfalfa is sometimes profitable. In southeastern Colorado and on the western slopes of the Rockies peaches and other orchard fruits were the specialty of irrigated farming. In the Greeley area of Colorado it was potatoes and cabbages. In Australia the irrigation districts that were eventually successful were those with vineyards and citrus orchards.

To produce those intensive products profitably there has to be access to a sufficient market. That, in turn, presupposes either a substantial nearby population or cheap and rapid enough transport to more distant markets. Both factors turn out to have an important bearing on the early irrigation developments in the United States. Neither California nor Colorado were being settled *de novo* as agricultural areas. Both had mining developments that had drawn in relatively large populations. Hence there was a pre-existing market for fruit, vegetables and meat. The early irrigators could serve the mining camps and the cities such as San Francisco, Denver, and Melbourne that had been built upon mining wealth. It was also the case that both northern Colorado and southern California were served by railways before the irrigators arrived. Products could be marketed beyond the local mining camps. That was especially important to the citrus growers of southern California.

The products that made early California irrigation viable were citrus fruits, grapes and beef. The climate of southern California was especially suitable to oranges. At an early date a variety of orange was introduced that was especially suitable, and railways were already in place to transport the oranges throughout the country. A similar story can be told about grapes. The Fresno area of the Central Valley of California quickly became the important supplier of table grapes to the nation. Grapes could also be dried and sold as raisins, a product for which there was a substantial demand in the cookery of the nineteenth century. With established rail connections it was possible to ship fruit to the eastern parts of the United States. Dried fruit could be shipped even more widely and California had become, by the late years of the nineteenth century, a major world supplier of raisins. The greatest area of irrigated agriculture in the Central Valley of California, though, was given over to produce cattle feed. There was a large demand for beef nearby. San Francisco had already, by 1860, become one of the large cities of the United States, and there were a good number of other urban centers created by the mining boom. The existing market made fattening beef for market a potentially profitable business in nineteenth century California.

The earliest irrigation district in northern Colorado had ready access to the transcontinental railway main line and, more importantly, there was a substantial market for vegetables nearby in Denver and in the mining communities. Again, alfalfa to feed cattle was a principal product of the irrigation district. On the western slope of the Rockies, the pioneer irrigation district around Grand Junction, Colorado was favoured by an usually mild climate and the area became noted for its peaches. In southeastern Colorado sugar beets were introduced at an early date and the district became a prominent producer of beet sugar. Beet sugar developed in the United States behind a high level of tariff protection. That, however, had been brought into place by pressures from producers further east. Protected beet sugar meant that irrigation farmers had just the sort of high value, intensive yield product that warranted irrigation.

In Australia the colony of Victoria had gone through a great gold mining boom that had drawn in a relatively large population. Melbourne had grown to a large city and there were

numerous subsidiary urban places as well. There also a market existed in advance of much agricultural settlement, and a market for the whole range of farm products, including those best turned out by more intensive use of land. An important difference from California, however, is that the region to be developed through irrigation was far distant from the market and the much needed railway transport did not materialize. The irrigation colonies at Mildura and Renmark could not compete with districts closer to Melbourne, Ballarat and Bendigo to supply beef and vegetables. They were dependent upon the production of wine grapes and dried fruit for distant markets. It was, if anything, a limited basis for development. At most it could support only a small area of irrigated farming. The region struggled greatly for many years before finally getting railway connections in the early twentieth century and eventually gaining access to substantial enough markets. The early irrigation experience in Australia was a bold experiment but hardly justified by sufficient demand for the products that can be profitable with irrigation.

The pioneer settlers in western Canada were cereal producers and, to a lesser extent, grazers of beef cattle. They quite understood that these products did not warrant investment in irrigation. They expressed little or no interest in irrigation and the whole region was settled and developed without much controlled surface water. The Canadian climate did not permit the growing of grapes or citrus or orchard fruit. The small area of southern Alberta where irrigation was developed was a very modest component of the newly-settled region. There sugar beets and table vegetables were produced but for a quite limited market. The railway companies which invested in irrigation works potentially had a large area which they could supply with abundantly available water. Still, they found it difficult to sell land to irrigation farmers and ended up selling most of their land in the irrigable areas to dryland farmers (Hedges, 1939).¹³

There is one other aspect of prior settlement for non-economic reasons that should be considered. The miners and others who had come to support the mining economy had to find a source of support when the mines ran out and boom was over. Some moved on to other destinations but many remained in the region. In a predominantly agricultural era those who remained were looking for land to farm. In these previously populated mining regions, then, there

was a relatively larger demand for land. In these seemingly land abundant areas many individuals expected to settle on farms. The government authority, partly to maintain a stable social order, was also concerned to find land upon which people could settle. Compared to other settler economies these ex-mining regions exhibited an unusually strong demand for farm land. That leads us to question whether in some of the settler economies, after the mining booms had passed, land was after all really so abundant.

Was Land Really So Abundant?

The common perception of settler economies is that they had lots of vacant land unto which settlers could move. From the foregoing review of the irrigation experience of Australia and the United States, however, we might question whether the settlement areas that early turned to irrigation were really so land abundant. People commonly think of the American west as a region with a vast abundance of land. What really counts, however, is usable land. There was a lot of territory in the western United States, but once settlement had reached the edge of the high plains there appeared to be relatively little land that could support arable farming. Most of the area was what was referred to as “the Great American Desert” (Webb, 1931; Ganoe, 1938). Around 1870 prospects for further agricultural settlement did not look so good. We know that, eventually, techniques of dryland farming were developed that opened a greater area for possible cultivation, but until then supplying surface water for irrigation appeared to be the only way that the high plains could be brought under cultivation. Irrigated agriculture in Colorado preceded the advent of dryland farming. As late as 1890 almost one half of cultivated land in Colorado was irrigated land (see Table 1); a decade earlier the proportion had been even higher. The situation was similar in other western states. In Idaho, Montana, and Nevada most early farming took place only on irrigated land. The big expansion of conventional, or dryland, farming onto the plains in western Kansas and in the Dakotas came after farming with irrigation had begun in districts further west.

Similarly, California did not actually have much land suitable to conventional farming. The northern half of the Central Valley did well in producing wheat and barley but the cultivable

land there was all taken up by the mid-1860s. Elsewhere in the state the lack of rainfall restricted agricultural settlement to extensive grazing. The resort to investment in irrigation in the 1870s and 1880s was, at least in part, an indication that the era of land abundance was past. The situation was further exacerbated by the fact that most of the land had already passed into private ownership. From an early date a relatively small number of owners of large tracts of land controlled most of California. There was little land left to be alienated from the public domain. Nevertheless, with an already large population, there was a continuous interest in settling “small farmers”. Something was needed to absorb much of the population left over from the gold rush era. With sufficient demand for farmsteads, usable land could be created through investment in irrigation. The abundance of streams coming down the west slope of the Sierra mountains made that appear to be a promising solution. Overall, California had little land to offer settlers but the owners of a substantial part of that land could envision profits in producing land for settlers through investment in irrigation works.

The story that can be told of Australia has many similarities. The gold rush of the 1850s had brought a large increase in population, especially in Victoria. After the gold played out people turned to farming for their livelihood but it did not take long for the land in areas with adequate rainfall all to be taken up. Furthermore, it was again the case that most of the territory had already passed into the hands of a relatively small number of individuals. In fact, most of the land in Australia had come under the control of the graziers, the so-called squatters.¹⁴ There was growing public pressure to provide land to small farmers. The conflict of interest between “selectors” and “squatters” was a prominent theme of later nineteenth century Australian history. Where so much of the territory was arid, and where there had been substantial prior settlement for non-agricultural purposes, a superficial appearance of land abundance may not accord with the actual situation.

In Canada there was almost no settlement in the plains region before the cultivators began to arrive. When conditions finally made it attractive to farm the area there were many millions of acres of publically owned land available as virtually free homesteads, and millions more acres

offered for sale by the railways at quite reasonable prices. Here was a situation where land was truly abundant. Thinking that in the most arid part of the country irrigated farms would be attractive, the railway companies promoted irrigation and invested in facilities. They found it difficult to sell land with water rights. So long as there was land for dryland farming available, settlers preferred it.

Was the Capital Investment Really So Large?

One thinks of irrigated agriculture as contrasting with conventional farming, especially grain farming, in substituting capital for land. Irrigated farms typically apply a lot of capital and a lot of labour to a small parcel of land. While there is an element of truth to that, one should be wary of overstating the capital intensity. The experience of the western United States underscores that. Many of the early irrigation projects, the ones carried out as private initiatives, did not actually involve great amounts of capital. The really big projects with high dams, large water impoundments, and extensive networks of canals came later, as government projects. In the American west of the 1870s and 1880s irrigation was almost always by gravity feed. Modest streams rather than great rivers were tapped. The headworks were rudimentary, in many cases just temporary, having to be replaced annually. Simple brushwork weirs whereby humans did a half-way job of emulating beavers sufficed. In Riverside California, Matthew Gage filled a modest ditch from a spring-fed water supply and thereby opened up a major area of orange production. In the Central Valley of California the most extensive area of irrigation in the state was watered from rudimentary obstructions to intermittently-flowing streams.

In some cases the capital invested was more substantial. At Ontario, California the Chaffey brothers tunneled 3000 feet into rock at the base of Mount San Antonio to tap the underground stream that flowed there, and they moved the water through concrete pipes. Still, the investment required was within the capabilities of individual entrepreneurs. Where citrus growing land was involved quite substantial capital investments could be justified. In Colorado the main investment was in ditches, fed by gravity from tributary streams to the South Platte and

Arkansas rivers. It does not seem to have been difficult for individual promoters to raise the needed capital.¹⁵

In Australia the capital requirements were greater. Water had to be pumped from the river and that called for large steam engines. The scale of the project was considerably larger than most of the earlier American projects. Not surprisingly, perhaps, the projects at Mildura and Renmark were not profitable. It was not large capital expenditure that pushed the Chaffey brothers into bankruptcy in Australia but the failure of revenues from land sales to materialize when the purchasers of their land defaulted on payments. The farmers, in turn, lacked revenues because they did not have sufficient markets for their products and the railway promised by the railway did not materialize. The Renmark and Mildura projects had just got underway when Australia, and the colony of Victoria especially, was hit by a severe financial crisis.¹⁶

Only after the communities inherited the works from a bankrupt firm did irrigated agriculture flourish at those pioneer Australian sites. Many of the more ambitious, second-round projects in the United States, especially ones in Colorado, were failures as profit making enterprises. They changed ownership frequently as new management optimistically thought it could make a return on partially completed works, purchased at a discount. Even that typically did not pan out. Over time the operation of irrigation works came increasingly under the management of governmental institutions. States established water boards and irrigation districts backed by the power to tax and the public purse at large.

Large irrigation projects involving huge amounts of capital expenditure were features of a later age, in the twentieth century, when economies were well past the settler stage. These were government projects, mostly of questionable worth on economic grounds. They were carried forward with an ideology of “taming the desert” and making “waste lands bloom”, coupled with political motivation to make small farms available to deserving people who wished to be farmers. In short, in the twentieth century, in post-settlement years, irrigation became a more complicated matter. It is well beyond the intention of this paper to attempt to sort out and evaluate the motivation for these grander irrigation projects of more recent times.

Our mental image of the high costs and great capital intensity of irrigation is largely formed by the big, dramatic projects of more recent times. The early irrigation projects in the United States were evidently not such costly ventures. There are quite numerous records of investment costs but they have a wide range and they are hard to interpret. It is often not clear what all is included in the stated costs. There are two common ways of stating costs: per volume of water that could be delivered, and per acre of land irrigated. Only the latter are helpful for our present purpose and even those often are expressed in terms of the acres that might potentially be irrigated rather than the area actually irrigated.¹⁷ It is important to have the particulars of each cost estimate.

Two features of the available evidence are significant. One is that costs for nineteenth century developments were substantially lower than those for twentieth century projects. That is very evident in the diagram in which Colin Clark summarizes the data he has assembled on costs (Clark, 1970; Fig.6, p. 61). The second point is that costs were relatively low for the pioneer projects carried out by individual entrepreneurs in the nineteenth century. Again, Clark emphasizes that point when he remarks that “simple diversion from a flowing stream can be very cheap indeed” (Clark, 1970: p. 58). For projects in the United States in the 1870s and 1880s a figure of \$10 per acre of land irrigated would probably not be too low. That is an amount quoted several times by developers in the Central Valley of California (recounted in Pisani, 1984; 114, 145) and accords well with an estimate from the Arkansas River Valley in Colorado (Sherow, 1990; 24). Some developers were evidently able to do much better than that. Costs per acre of headgates and ditching that are well below \$10 per acre that can be found. Pisani (1984; 261) gives a firmly based figure of \$4.81 for a development in the Sacramento Valley, and it included both projected legal costs and the price of acquiring raw land. In southern California the Chaffey brothers were able to make a profit selling land at \$12-\$15 per acre which they had purchased and supplied with irrigation water which they obtained through a deep tunnel into the mountainside and piped through concrete conduits. Newell (in U.S. Department of the Interior, 1894; p. 8) estimated the average capital outlay for irrigation works in the United States up to

1890 to be \$8.15 per acre, and Clark (1970; p. 61) puts the average cost of projects developed before 1900 to be \$12.12 per acre.¹⁸

In Australia costs were higher and a pessimistic early report on irrigation prospects (by Gordon and Black, reported in Davidson, 1981; 160) was convinced that irrigation works would cost £10 per acre or more. However, the Chaffey brothers at Mildura spent less than one half that and still had a lot of unutilized pumping capacity. The Mildura development was a relatively sophisticated and costly project for its time. It required specially designed giant steam engines for pumping but it did not use artificially constructed reservoirs to store water.¹⁹ Like many other of the early irrigation works, the investment involved was not beyond the means of an individual or small consortium of entrepreneurs to finance.

The main point is that the costs of building irrigation works were far from astronomical. So long as large dams and reservoirs were not required the main cost was that of cutting the primary ditches and that was not greatly different from the costs of road building. A further consideration is that we should not think of unsettled land without irrigation as being costless to bring into production. In eastern North America the forest had to be cleared before land could be used for farming. That was a far from costless matter. In the Ohio and Mississippi valleys in the 1850s it appears to have cost about \$10 per acre to clear forested land, and that did not include the later cost of pulling the stumps (Primack, 1962; 486).²⁰ In the following two decades farmers on prairie land west of the Mississippi had the benefit of being able to create farms at considerably lower cost. That had been one of the great attractions of the untreed prairies. Unsettled land of that sort, however, had pretty much run out by the 1870s. In the experience of many farmers and prospective farmers there was a significant cost to farm making. Clearing unsettled land of trees was a long and arduous process. Land may have been unsettled and abundant but it could not be utilized without considerable investment.

In the Victoria colony of Australia, by the 1880s, added farm land could be found either by investing in irrigation facilities in the Murray River valley or by clearing the heavy forest of

the Gippsland. The per acre costs for that area quoted by Ian Mclean (1971, p. 156) would make irrigation in the Murray Valley the lower cost alternative.²¹ The average per acre clearing cost in Victoria of £5 given by Mclean can be compared with costs of no more than double that incurred by the Chaffeys. Another early irrigation project of that time in Australia, the Rodney Irrigation Trust, spent £11.40 to irrigate 12,226 acres (Martin, 1955; pp. 65-66) but that does not include the costs of the weir to provide an assured water supply. On the other hand the investment was made with the intention of providing water to many more acres than were being irrigated at the time of the evaluation. It appears, then, that even under Australian conditions, some modest scale irrigation could be done at costs that were not greatly different from the capital costs of creating non-irrigated farms.

Conclusion

We began with the observation that, at least at first glance, it seemed anomalous that at relatively early dates people should have turned to more capital intensive irrigated agriculture in some parts of economies that were thought to be characterized primarily by an abundance of land. It is not enough just to say that some of that land was arid and could not be utilized without water management. If land was so abundant why were not the arid districts just bypassed and left unsettled?

In the foregoing examination of the history and nature of early irrigation projects in Australia and the United States it was seen that the picture was not so simple. There were several good reasons for turning to the investment of capital in irrigation. On some of the land involved climate and location were such that, with irrigation, commodities could be produced that yielded much higher revenues per acre and thereby justified the investments. Where grapes and tree fruits, potatoes, cantaloupes, and sugar beets — even perhaps alfalfa — could not be grown and marketed, irrigated agriculture was not warranted and, with only a few exceptions, was not pursued. To some extent the markets came from relatively large pre-existing populations. These were not “agricultural” settler economies but ones where initial settlement, or at least a great augmentation of population, had come for other reasons. Both California and Victoria had drawn

large non-agricultural populations to mine gold. After the mines played out there were sufficiently large populations that we cannot say so glibly that these regions were characterized by “land abundance”. It was also the case that there was little public land to be offered up to prospective farmers as an essentially free good. In both California and Australia the uncultivated land had already passed into the hands of a relatively few owners of vast tracts. In western Canada there was a true abundance of land available as virtually free homesteads, in a region where high yield, high value products could not be grown. Not surprisingly, there was little investment in irrigation.

While they may have been parts of settler economies, which we think of as land abundant, California, Colorado and Victoria were all regions which were not actually “land abundant”. The greater part of these jurisdictions were mostly arid and not suited to conventional agriculture. They attracted people because of their mineral wealth, not because of their land. That is, they were not really land-abundant territories. They were a different sort of “settler economy”. Other gold rush regions, such as the interior of British Columbia and, somewhat later on, the Yukon, offered no reasonable agricultural prospects. When the mining rush was over the people it had attracted simply left. California and Victoria differed in two respects. In the first place they attracted a lot more people. Secondly, they had climate, soils and potential markets that, if only they had water, would make farming potentially profitable.

Finally, in settings that were otherwise propitious, the costs of irrigating, especially compared to the costs that were incurred in clearing forested land, were not really so great. Individual private entrepreneurs thought that irrigation would pay off and they were able to finance the projects. In some cases they turned out to be right, others misjudged. There were lots of failures among the early irrigation projects, but that has been so in most lines of business endeavour. Later writers, influenced no doubt by the excesses of grand irrigation projects in the twentieth century, have made a lot out of the failures. What they have overlooked is the message from the successful ventures that, especially in California, but also to some extent in Colorado and eventually in Australia, some irrigation projects were economically justified. At least to a

limited extent there was a rational place for investment in irrigation in some of the settler economies. This underscores a final point and that is that we should be wary of making sweeping generalizations about the nature of settler economies. There were many variations in circumstances and those should be fully taken into account.

Table 1
Irrigated Agriculture in the United States, 1890 and 1900

State	acres irrigated 1890	per cent of all cultivated acres, 1890	acres irrigated 1900
California	1,004,233	8.2	1,445,872
Colorado	890,735	48.8	1,611,271
Montana	350,592	38.3	951,154
Utah	263,473	48.1	629,293
Wyoming	229,676	48.2	605,878
Nevada	224,403	31.0	
Idaho	217,005	35.8	602,568

Endnotes

1. This perception, its origins and persistence, is discussed in Morris (1926).
2. Of course there is the question of whether these lands should be thought of as truly unoccupied, even if the aboriginal populations were sparse. European settlers looked upon them as unoccupied lands.
3. Greeley had traveled west in 1858 and had enthusiastically observed the success of the Mormons in Utah.
4. The date 1890 is a particularly useful one upon which to focus. It comes near the end of what we might call the pioneering phase of irrigation development in the United States, before governments got involved in the planning and building of irrigation works. It is also the case that the census of 1890 carried a special report (US Census Office, 1894) on irrigation in the western part of the United States that is a major source of evidence.
5. A very detailed account of the early phase of irrigation development in north central Victoria is given by Martin (1955). A summary version can be found in Davidson (1967).
6. This characterization is questioned by Davidson (1967) who claims that rainfall is neither less on average nor more variable from year to year in extensive areas of Australia, especially of Victoria, than in other parts of the world where dry land cereal farming is successfully carried on. He claims that with careful use of then known techniques a large population of farmers could have been settled on the land.
7. This is the principal message offered by Colin Clark (1970) in his little monograph on the economics of irrigation. Clark began with his appraisal of the Australian experience and went on to general to the international situation.
8. There is a large area in southwestern Saskatchewan and southern Alberta, famously known as Palliser's Triangle, after the person who first clearly identified it. Much of that area is too arid for successful cereal culture and it is not really surprising that what irrigation was carried out was in the western segment of Palliser's Triangle.
9. The land grant to the railway and irrigation company was in the vicinity of one million acres. It is difficult to determine just how much land actually was farmed with irrigation in Canada. The Canadian census of agriculture began asking about irrigated acres only in 1921 and even then did not publish the figures. I have as yet been unable to determine whether they were even tabulated. The railway companies which were carrying out the irrigation projects reported how many acres of their lands were classed as "irrigable" (i.e. therefore sold at a higher price) but not all lands classed as "irrigable" ever got served with water and farmers on irrigable lands with access to water more often than not did not draw on the water. All that is indicative of how little irrigation meant to western Canadian agricultural development.
10. The millions of acres of land granted to the Canadian Pacific Railway were to be lands "fairly fit for cultivation". The railway got to choose the areas in which it claimed its land. This was a process drawn out over time. Only in 1903 did it agree to accept a large block of land along its main line between Medicine Hat and Calgary, Alberta. The railway had chosen to run its main line right through the dry belt. The actions of the Alberta Railway and Irrigation Company in developing irrigation works to the south of the CPR main line were a factor in the decision by the CPR to accept granted land in the dry belt and to embark upon its own ambitious irrigation projects. In 1912 the Canadian Pacific Railway bought out the Alberta Railway and Irrigation Company.
11. The details of the CPR's experience with irrigation agriculture are given by Hedges (1939, esp. Ch. 7). Ever concerned with the settlement and development of agriculture that would generate the freight to carry on its rails the

company did far more than just build dams and irrigation canals. It hired experts on irrigation farming, it printed manuals and instructions, it set up demonstration farms. This was probably the most intensively developed and thoroughly organized irrigation carried out anywhere. The railway company, as both initial land owner and provider of transport services, spared no expense in carrying out its project. It is not quite true to say “all for naught” yet , despite the heavy investment and careful attention by the company this was hardly a successful irrigation development. In the larger picture of Canadian western settlement it played a minor, if not to say minuscule, role.

12. This is usually discussed under the title of the Reclamation Movement.

13. In its endeavour to sell irrigated land the Canadian Pacific Railway mounted a large and expensive marketing programme. At least one quarter of the per acre cost of providing irrigated farm land consisted of marketing costs (Hedges, 1939). That company spent almost as much per acre trying to sell land with irrigation water as the early developers in California and Colorado invested in irrigation facilities.

14. The precise legal nature of their claim to land is a bit nebulous. In one sense the squatters were renting the use of the land from the crown but their hold was tenuous. Their claims could be marketed and they were not easily displaced unless they abandoned their sheep runs.

15. Local banks, railway companies and insurance firms were all willing to lend to irrigation promoters. When the irrigators overbuilt and overtaxed the limited water supply the Travellers Insurance Company appears to have got stuck with a lot of the assets of bankrupt irrigation firms (MacDonnell, 1999).

16. The last straw for the Chaffey brothers may have been the insolvency in 1893 of the bank with which they mainly dealt. At the same time at Mildura they faced a refusal by protesting farmers to pay the annual water charges.

17. Projects were often planned to irrigate many more acres than actually got supplied with water. Costs related to potential area would appear to entail a downward bias as developers were frequently over-optimistic about the area their projects could serve. On the other hand capital costs were dictated by the planned or intended size of the projects. If fewer users actually took up water, relating costs to actual use implies an upward bias. A further complication is that in some projects not all farmers would draw water every year so that one sees wide variations in the stated acres actually irrigated. It should also be noted that there were projects that, for want of sufficiently abundant source water, were never able to deliver as much water as they had been built to provide. The main point is that one must evaluate cost estimates with great caution.

18. Converting his per hectare figure to dollars per acre and deflating his 1964 dollars to 1890 on the trend of the Consumer Price Index.

19. Water was pumped a total of 90 feet from the Murray River, in two stages. The first stage pumped into a pre-existing natural reservoir; a second engine pumped from there into the main irrigation canal. This avoided the cost of having to dam the river or to construct a man-made reservoir. On the other hand it added operating costs for fuel and engine maintenance.

20. In commenting on Primack’s work, Gallman (1962, p.) notes that mid-nineteenth century contemporary writer Ezra Seaman had put the average cost at \$11.

21. But the Gippsland district was much closer to Melbourne and could be developed to produce dairy products for the urban market. Its high clearing costs were offset by better prospective revenues.

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