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An Equity Autopsy: Exploring the Role of Water Rights in Water Allocations and Impacts for the Central Valley Project during the 2012–2016 California Drought

Zachary P. Sugg [1,2]

[1] Martin Daniel Gould Center for Conflict Resolution, Stanford Law School, Stanford University, Stanford, CA 94305, USA; zachary.sugg@stanford.edu

[2] Water in the West Program, Woods Institute for the Environment , Stanford University, Stanford, CA 94305, USA

Received: 27 November 2017; Accepted: 6 February 2018; Published: 13 February 2018

Abstract: Entrenched Western water rights regimes may appear to function relatively well in wet years, but extreme drought events can expose the kinds of harsh ecological and socio-economic outcomes that the hard edges of prior appropriation inherently generate. During the 2012–2016 California drought some irrigators received little or no water at all in consecutive years while others received comparatively large allocations. This paper focuses on the role that California's water rights priority system and its administration via Central Valley Project contracts have played in generating disproportionate water allocations and impacts during the drought. The analysis is structured around two key questions: (a) in what ways does strict adherence to a priority system of water allocations produce inequitable socio-ecological outcomes during severe drought? (b) how might the system be changed to foster outcomes that are more equitable and fair, and with less costly and less serious conflicts in a non-stationary climate future marked by extreme events? Using an equity perspective, I draw from the doctrine of equitable apportionment to imagine a water rights regime that is better able to create a fairer distribution of drought impacts while meaningfully elevating the importance of future generations and increasing adaptive capacity.

Keywords: water law; California; drought; equity; Central Valley Project; water rights; prior appropriation

1. Introduction

From 2012–2016 California experienced the most severe drought—including the driest single year, 2014—in the last 1200 years [1]. Statewide costs to California's agricultural sector in 2015 were estimated at $2.7 billion, along with some 21,000 workers impacted by either direct or indirect job losses [2]. Agriculture largely rode out the drought by continuing to deplete the already vastly overdrafted groundwater, but at a cost of $590 million in that year alone. Statewide figures mask the uneven socioeconomic impacts of the drought, which fell disproportionately on agricultural areas south of the Sacramento/San Joaquin Bay Delta in the San Joaquin Valley [3–5].

An important factor affecting these impacts was curtailment of surface water supplies from federal managers, with many growers receiving 0–5% of their contracted maximum allocation for three consecutive years [6]. Much of California's surface water is managed by the federal Central Valley Project (CVP), an expansive system of 20 reservoirs, 11 powerplants, and over 500 miles of canals that facilitates interbasin transfers from the Sacramento River Basin south into certain parts of the relatively drier San Joaquin Basin [7]. USBR administers CVP water supply contracts totaling to some 9.5 million acre-feet (AF), though average actual deliveries are about 7 million AF [8]. About 5 million AF is used

to irrigate about one-third of all the agricultural land in the state, with the rest divided up between municipal and industrial (M&I) uses, in-stream flows, and wildlife refuges and wetlands [8]

CVP allocations are shaped by the underlying state water rights system which, while a hybrid system of riparian and prior appropriation rights, has a defined hierarchy based largely on chronology of right establishment [9]. CVP contracts reflect this hierarchy and dictate to some extent how the negative impacts of shortages are distributed among different groups of contract holders [9,10].

While water rights are only one factor affecting "acquisitions and allocations" within the universe of CVP contractors, they take on especially significant importance during times of relative scarcity [10]. This particular drought was severe enough that observers began broaching the sacrosanct third rail of Western water: the prior appropriation system [11–18].

Although this drought was unprecedented in the last millennium, tree ring records show that there have been longer and more severe natural droughts within the climate system [1]. Given robust modeling estimates of increasingly higher mean and extreme temperatures [19], reduced snowpack [20], and increased risk of droughts that are both hot and dry [21], it would be a mistake to fail to attempt to learn from it.

Western states like California must adapt to new climate realities in ways that do not exacerbate already existing inequities or create new ones. Recent studies of equity and drought in California have focused on the uneven access to domestic water supplies in marginalized communities [22,23]. In this analysis I seek to expand such analyses by turning the equity lens to the state's water rights system and how it dictates uneven outcomes for communities of water users who receive water from the CVP. I ask two questions: (1) in what ways does strict adherence to a priority system of water allocations produce inequitable socio-ecological outcomes during severe drought? (2) how might the system be changed to foster outcomes that are more equitable and fair, and with less costly and less serious conflicts in a non-stationary climate future marked by extreme events?

I argue that evidence from the drought supports critiques of the fairness of the priority system of water allocation and that the equitable apportionment approach would be an alternative system more conducive to meaningfully incorporating equity dimensions of drought response. I focus in particular on how severe curtailments to CVP allocations exacerbate the groundwater overdraft problem in the Central Valley. The paper is organized in the following sections: (1) introduction; (2) short review of literature on water resource equity; (3) historical and legal background for CVP contracts; (4) analysis of the 2012–2016 drought and impacts for the CVP contractors; (5) discussion (6) conclusion.

2. Equity and Water Resources in the West and Beyond

In the context of the Western U.S., the "equity perspective" arose amid the broader shift from large water storage projects to water transfers in the 1980s after federal support for dams and diversions tapered off during and after the Carter administration [24]. Some scholars recognized in the 1980s that subjecting control and access to surface water supplies to a market economy had strong potential to exacerbate already unfair water access among Indian tribes and traditional Hispano communities throughout the Southwest for whom treating water as a tradable commodity has been considered morally unacceptable [25].

How can the equity perspective be characterized in the context of water resources? Ingram et al. [26] (p. 6) contend that equity has no single universal objective definition, but rather is more properly understood as

> " . . . *complex and contingent on circumstances, varied and nuanced, and cannot be fully understood until put back into the life cycle of living things. Consequently, there is no simple principle or set of principles, like those guiding efficiency, which can be set out as rules and universally applied in all places and circumstances. Instead, equity is a complex and protean idea*."

Many western water observers know that in the West, equity is meted out very differently within states compared to among states. Within states, the seniority system dominates, while interstate

agreements usually rest on the doctrine of equitable apportionment [27,28]. Similarly, water markets may be seen by officials as a fair allocation mechanism to use within states, but unacceptable at the interstate level [29].

Because equity is a somewhat nebulous concept, scholars have investigated empirically how equity has been operationalized and acted out by communities of water users in a range of contexts, including poor water access in indigenous and Hispano communities in the U.S. Southwest [25]; a wide variety of case studies across Mexico, Spain, the American Southwest, and Pacific Northwest [30]; and the Global South [31–35]. Recent work has also explored the "climate gap" between disadvantaged and more affluent communities in relation to the degree of vulnerability to climate change and resources for mitigation and adaptation in communities near the Arizona and New Mexico border [36]. Much of this recent work weaves equity concerns into broader discourses about water justice and climate justice.

During the 1990s the Australian government funded a series of seven social scientific studies spanning a decade to determine what exactly people think constitutes equity and fairness in water allocation. The researchers found that " . . . people have universal fairness criteria for judging the overall fairness of water allocation systems at a general level, and these are useful for systematic derivation of accountable solutions at a local or situational level," though may shift towards greater emphasis on situation-specific fairness criteria depending on the perceived urgency of a problem [37] (p. 67).

More empirical work is needed to elicit social understandings of equity in different water user communities in the Western U.S.; a long-term study like the Australian one just mentioned to systematically determine the understandings of water allocation equity across the various stakeholder and user groups connected to the CVP would be particularly valuable. However, in the absence of such a study, an operational definition of equity is needed for the sake of argument and clarity. I borrow Dunning's [38] (p. 77) definition of equity as "an attempt to fairly share limited water resources, often by taking into considerations many factors".

More definitional specificity is required to meaningfully evaluate a given case study using the lens of equity, but this is challenging for at least two reasons: (1) equity is always situation-specific to some extent, and (2) there is not just one kind of equity but rather multiple forms or types (socioeconomic, procedural, intergenerational, etc.). Rather than argue for a single definition, scholars have specified the meaning of equity in terms of sets of principles [39,40]. Constitutive principles can be understood as necessary and sufficient conditions, a qualitative balancing test for evaluating equity in water policy [40] (p. 186).

To further clarify the operational meaning of equity for this analysis I draw from the five equity principles articulated by Ingram et al. [40] in their analysis of the allocation of the Colorado River.

1. *Reciprocity* means "distributive advantages and costs should be shared by all members of the relevant community" [40] (p. 186). It is a balancing principle that recognizes the fairness of prior appropriation in its original 19th century setting, while also recognizing that in certain conditions it can result in intolerable effects, such as waste and inefficiency resulting from the "use it or lose it" provision, or harm to the rights of third parties.
2. *Value pluralism* means "users' rights to employ water to pursue whatever values they consider legitimate should be respected, provided use does not degrade the resource or harm others" [40] (p. 187). Ingram et al. recognize that the conditions of no degradation and no harm could restrict certain activities and uses of water and thus must be balanced by the principle of reciprocity.
3. Principle 3 is *ensuring the accommodation of multiple value claims in resource allocation and decision processes*. This principle entails widening the diversity of communities involved in decisions and rejects sacrificing participation in the pursuit of technically efficient decisions, even if it makes deliberation and decision-making messier and more complicated. For Ingram et al., such inconveniences ought to be tolerated because the alternatives are even less likely to satisfy the public interest in water resource decisions.
4. Principle 4 is to *obey promises agreed to in good faith.* Past negotiated agreements about the apportionment of water resources should be respected to the extent possible. Two special

problems with this principle are that (a) promises can conflict with each other, and (b) the circumstances under which promises were made can change over time to such an extent that the original agreements become highly problematic. Since there is no single "unambiguous rule of equity" for resolving such conflicts, flexibility, adaptation, and the acceptance of unavoidable ambiguity in decision making are especially important [40] (pp. 188–189). Any renegotiation of contracts in light of changed circumstances must be qualified by the other four equity principles.

5. *Intergenerational equity* is the principle that "the present use of water resources should take account of future generations" [40] (p. 189). Importantly, because water is fundamentally a social good, intergenerational equity is an inherently value-laden, ethical idea and thus cannot be satisfied by relying only on economic logics which rationalize the risks that short-term depletion and degradation may pose to future generations [39–42]. Intergenerational inequity is inextricably tied to sustainability [43–46] and is especially elevated in importance by climate change, as the most pronounced effects will be visited upon generations not yet born.

3. Background: How the Priority System is Embedded in Central Valley Project Water Supply Contracts

Understanding water impacts of drought in California requires also understanding the contracts water users have with the federal government through the CVP. In the 1920s, a basic issue for the state was that none of the then-recent actions (e.g., regulating post-1914 water rights, adjudications, creating irrigation districts) had generated any "new" water [47]. Political support had grown for a large storage project to significantly expand agriculture on the fertile but unirrigated soils of the Central Valley. Originally a state project approved by California voters, the state could not sell the bonds it needed to fund construction of the CVP during the Depression and it was taken over by the U.S. Bureau of Reclamation (USBR).

The project involved a complex system of dams and canals to store and divert water from the relatively water-rich Sacramento River Valley south to the drier San Joaquin Valley, and from the San Joaquin headwaters mainly to growers in the southern part of the Valley. A huge volume of water rights was needed to make the two massive transfers possible but both rivers were already grossly over-appropriated and the water rights to those rivers were largely very senior, monopolized, and unregulated. A major problem, therefore, was how to get adequate and secure rights to make the project legally and operationally feasible.

Two main things occurred to make it work. First, the state made major filings for new water rights for itself in 1927 and assigned them to USBR. However, since a priority date of 1927 was far junior to the existing users who collectively already had rights to more than twice the natural flows of both rivers, they also had to do something to make their rights more secure. Rather than push the state for adjudications of the San Joaquin and Sacramento Rivers, USBR opted to negotiate with the senior rights holders in both basins.

There are three main groups of CVP irrigation contractors–San Joaquin River Exchange Contractors, Sacramento River Settlement Contractors, and water service contracts, with each falling somewhere in the larger hierarchy of state water rights and CVP contracts in this general order:

(1) Riparian rights (includes Settlement and Exchange Contractors)
(2) Pre-1914 appropriation rights (rights acquired before state regulation)
(3) Post-1914 appropriation rights (rights acquired after state regulation, including USBR's rights for the CVP storage)
(4) CVP water service contracts

The geographic locations of the different CVP divisions and user groups are shown in Figure 1.

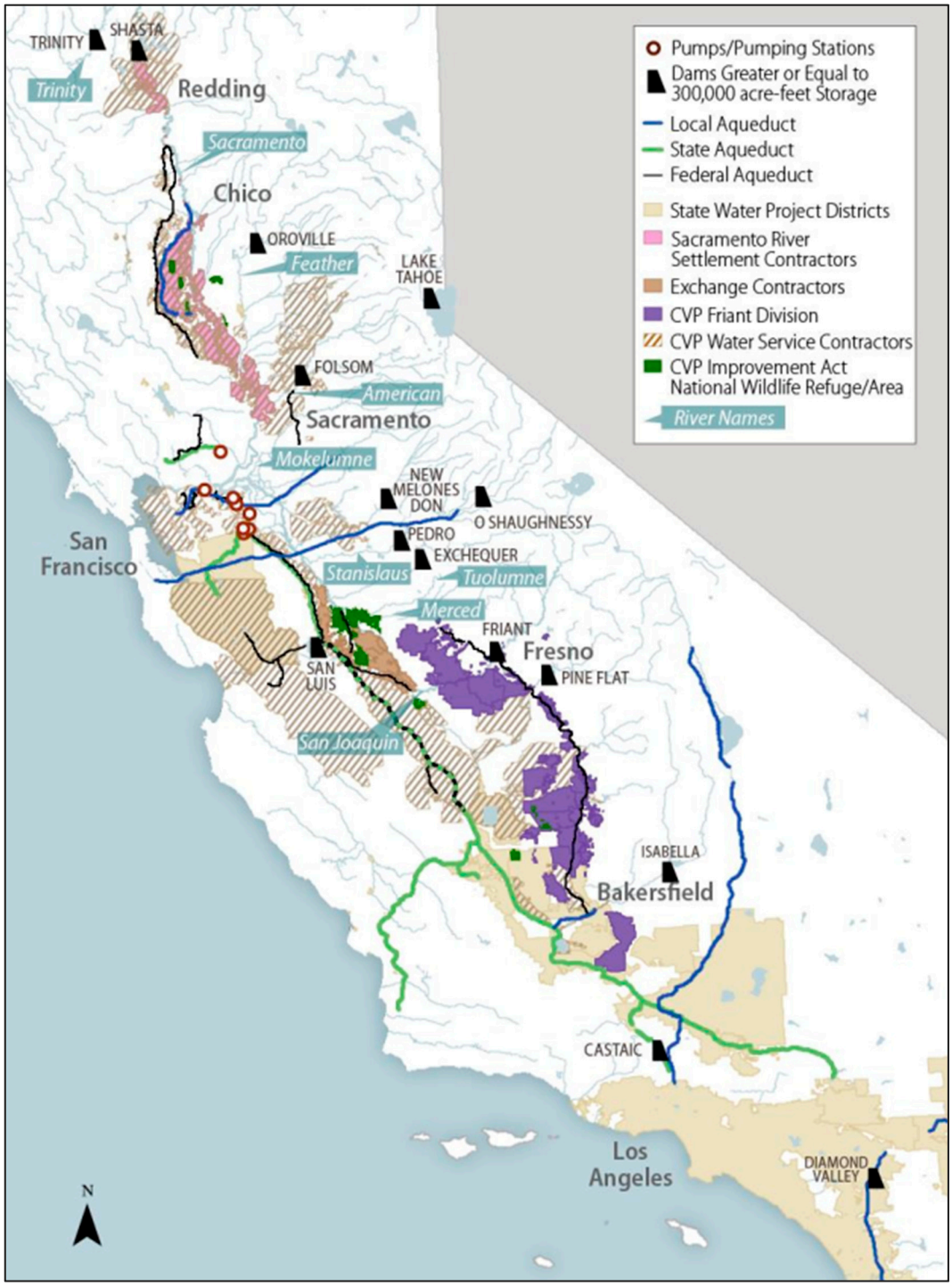

Figure 1. Geographical distribution of CVP and State Water Project infrastructure and water supply contractor divisions. Map modified from Cody et al. [10] (p. 36).

3.1. San Joaquin River Purchase and Exchange Contracts

The most senior water users within the CVP universe are the so-called Exchange Contractors who are the corporate descendants of the old Miller & Lux cattle company. The CVP plan entailed damming and diverting practically the entire flow of the San Joaquin River north and south along the Madera and Friant-Kern Canals (Figure 1), but this could not be done without infringing on the downstream riparian rights of Miller & Lux. Rather than pursue a water rights adjudication, USBR

opted to strike an agreement to provide the senior San Joaquin diverters with a substitute supply from the Sacramento River in exchange for permission to store and divert the water they would otherwise use at Friant Dam.

In a Purchase Agreement signed in 1939, USBR acquired outright 623,000 AF from Miller & Lux, a mixture of riparian flood flows and pre-1914 appropriation rights to waters that flow through grasslands. This water would go to farmers along the Madera and Friant-Kern Canals to the north and south of Millerton Lake near the headwaters of the San Joaquin River. USBR also executed a separate Exchange Contract [48] in 1939 for 840,000 AF of cropland water rights that had originally belonged to Miller & Lux, but which had since been bequeathed to the four private canal companies that were created as Miller & Lux was waning: Central California Irrigation District, Columbia Canal Company, San Luis Canal Company, and Firebaugh Canal Company. The Exchange Contract lays out the substitution agreement under which these users agreed to forego diversion of San Joaquin River water in exchange for substitute supplies from the Sacramento River stored at Shasta Dam. Importantly, the agreement did not require the Exchange Contractors to relinquish possession of their water rights.

According to the contract, in a "typical" year, the Exchange Contractors are to receive 100% allocation (840,000 AF). In a critical dry year, the substitute Sacramento River water deliveries can be reduced to 650,000 AF (about 78% of the maximum allocation) [48]. In the event of a shortage severe enough that USBR is unable to send the exchange contractors at least that amount from the Sacramento River, the Exchange Contractors may request that the deficit be made up with water from their original source, which is stored in Millerton Lake. When this happens, CVP contractors with more junior rights may lose access to water that would otherwise come to them. This is how the priority system can come into play, and why it is possible for the Exchange Contractors to receive most of their contracted water while many other irrigators go completely without.

Stroshane [47] (p. 16) likens the purchase and exchange contracts to the way the U.S. Constitution relates to the union of states: "[t]he contracts provide a framework and a point of departure for water project operations every single year. Their effect is nothing if not constitutional and foundational for the Central Valley Project." The Exchange Contract enshrines the priority system and specifically the old Miller & Lux monopoly's control over San Joaquin River basin land and water in perpetuity.

3.2. Sacramento River Settlement Contracts

The Purchase and Exchange Contracts made it possible to distribute water stored at Millerton Lake to contractors in the Friant Division and along the Madera Canal, but USBR still had a major problem, which was that they had no way to protect "their" water in the Sacramento River from being intercepted by the several hundred diverters along the mainstem after it was released from Shasta Reservoir but before it could reach the pumps in the Delta that move the water to the Exchange Contractors.

Again, rather than pursue an adjudication of Sacramento River rights, USBR opted to negotiate some 145 Settlement Contracts, altogether totaling some 2.2 million AF of face water [49]. As with the Exchange Contract, these contracts preserve seniority. They divide up water allocation between "base supply" and "Project water." Base supply is the amount of water the contractor is allowed to divert for free, in deference to these users' senior rights. Project water is an amount over and above the base supply that can be purchased from USBR. Glen-Colusa Irrigation District, for example, is allowed to divert 720,000 AF a year of base supply for free and also are entitled to purchase 105,000 additional AF of "Project water," for a total of 825,000 AF per year, doled out in monthly maximums specified in the contract [50].

The Settlement Contracts have the same critical year trigger criteria as the Exchange Contract but the shortage provisions are different. The Settlement Contracts simply state that in a critical year, their total water will be reduced by up to 25%. This reduction is assessed monthly from April to October.

3.3. Water Service Contracts

At the bottom of the CVP hierarchy are the Friant Division contractors and those south and north of the Sacramento/San Joaquin Delta with regular water service contracts. Water service contracts comprise 16% of the total contracted volume of water in the North-of-Delta (NOD) CVP users, dwarfed in volume by the Settlement Contractors (Figure 2). In the South-of-Delta (SOD) section, the water service contracts comprise 71% of the SOD grand total, with the Exchange Contractors having rights to 28% of the total contracted SOD volume. SOD group of water service contracts includes the Westlands Water District, the biggest irrigation district in the U.S.

Water service contracts may be for agricultural or municipal and industrial (M&I) uses. There are clear rules about what happens to the M&I contracts in the event of a "condition of shortage" [51]. When a contractor has both agricultural and M&I uses, irrigation has to decrease by 25% before any M&I reductions are required.

The Friant Division of the CVP includes irrigators withdrawing water from either the Madera or Friant-Kern Canals, stored at Millerton Lake. The Friant Division's contracts were started in 1951 when Friant Dam and Madera Canal were finished and have a term of 40 years [28] (p. 779). Their water is divided into Class 1 and Class 2, the former being more reliably available than the latter.

Most of these contractors receive water from the Friant-Kern Canal; the Madera group is just two districts, Chowchilla Water District and Madera Irrigation District. However, these two districts have contracts for 18% of the total Friant Division Class 1 water. The other 83% is distributed among some 30 other entities with contracts for water for M&I, agriculture, or both. Most of the water either belonged or still technically belongs to the four Exchange Contractors.

Allocations for the Friant Division are based on a formula specified in their contracts (see, for example, the water service contract for Tulare Irrigation District [52]). The maximum contracted volume of Class 1 water is reduced by the ratio of actually available water divided by the total claims for that water. In times of shortage, however, the junior status of the Friant Division and the NOD and SOD water service contractors means they can be reduced even to 0%.

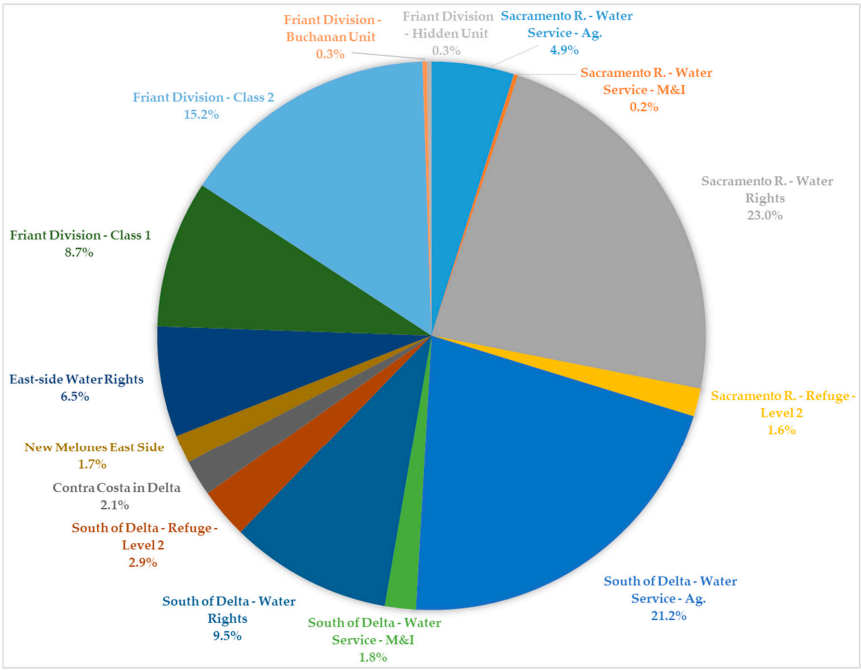

Figure 2. The proportional distribution of CVP's 9.5 MAF of total maximum contracted water supplies among the different user groups. Percentages derived from data reported by U.S. Bureau of Reclamation for 2016 [53].

4. Impacts and Outcomes for CVP Contractors during the 2012–2016 Drought

In their 2016 Drought Contingency Plan for the CVP and State Water Project (SWP), USBR and California Department of Water Resources took stock of the unprecedented nature of the drought up to that point:

> "*California has just ended its fourth consecutive year of below-average rainfall and snowpack, and Water Year (WY) 2015 was the eighth of nine years with below-average runoff. This extended drought has produced chronic and significant shortages to municipal and industrial, environmental, agricultural, and wildlife refuge water supplies and led to historically low groundwater levels. This recent dry hydrology has set many new statewide records, including the driest four-year period of statewide precipitation (2012–2015). In calendar year 2013, many communities recorded their lowest-ever levels of annual precipitation; calendar year 2014 saw record-low water allocations for the Central Valley Project (CVP) and State Water Project (SWP) contractors; and January 2015 was the driest January on record for precipitation Statewide. WY 2015 also produced by far the lowest snowpack in the Sierra Nevada since records have been kept, and by some estimates based on tree-ring analysis, was the lowest over the past five centuries*". [54] (p. 4)

In this section, I unpack how these impacts were distributed through the CVP's user groups and how they were mediated by the underlying system of water rights and contracts.

4.1. Allocations and Curtailments for Central Valley Project Water Users, 2012–2016

Although I focus here on CVP allocations, it should be noted that thousands of water rights were simultaneously curtailed by the California State Water Resources Control Board (SWRCB) based on §1058.5 of the California Water Code which allows SWRCB to implement temporary emergency water regulations [55]. This is noteworthy because these senior rights had not been curtailed since the 1976–1977 drought [56].

The hierarchy of state water rights embedded in the CVP contracts is evident from the allocations made to various user groups during the drought years. Table 1 presents water allocations to the various CVP water user groups by Project division during the drought years 2012–2016 based on data reported by USBR [6].

Table 1. Drought year allocations to CVP water user groups by region. Allocations are reported as percentages supplied out of total contracted volumes. Allocations are averaged for February–May and June–August except for 2015, in which no changes to the initial February 27 allocation were reported.

CVP Region	Water User Group	2012		2013		2014		2015		2016	
		Feb.–May	June–Aug.	Feb.–May	June–Aug.	Feb.–May	June–Aug.	Feb.–May	June–Aug.	Feb.–May	June–Aug.
North of Delta	Agricultural water service contractors	77%	100%	75%	75%	0%	0%	0%	0%	100%	100%
	Urban contractors (M&I)	92%	100%	100%	100%	50%	50%	25%	25%	100%	100%
	Wildlife refuges	92%	100%	100%	100%	63%	75%	75%	75%	100%	100%
	Settlement Contractors/Water Rights	92%	100%	100%	100%	63%	75%	75%	75%	100%	100%
	American River contractors (M&I)	*	*	75%	75%	50%	50%	25%	25%	100%	100%
	Contra Costa	*	*	75%	75%	50%	50%	25%	25%	100%	100%
South of Delta	Agricultural water service contractors	37%	40%	21%	20%	0%	0%	0%	0%	5%	5%
	Urban contractors (M&I)	75%	75%	71%	70%	50%	50%	25%	25%	55%	55%
	Wildlife refuges	92%	100%	100%	100%	48%	65%	75%	75%	100%	100%
	Settlement Contractors/Water Rights	92%	100%	100%	100%	48%	65%	75%	75%	100%	100%
Friant Division	Friant (Class 1 water)	43%	50%	56%	56%	0%	0%	0%	0%	40%	70%
Eastside Division Contractors		100%	100%	100%	100%	55%	55%	0%	0%	0%	*

Allocation color code:

75–100%;	50–74%;	25–49%;	0–24%

* No value reported.

In the first two years of the drought, the Settlement and Exchange Contractors received full or nearly full allocations. In 2012, the first official year of the drought, all NOD users received full allocations while South of the Delta, agricultural service contracts were reduced to 40%; the Friant Division received 50% of Class 1 water and zero Class 2 water; and the Exchange Contractors received full allocations.

The next year, NOD agricultural water service contracts were curtailed to leave water for urban uses, wildlife refuges, and the Settlement Contractors, which all received full allocations. The agricultural water service contractors were reduced by 25% for all of 2013. SOD agricultural contractors were also cut back to around 20% for all of 2013. Friant Division curtailments varied from 45–65% from early late February to mid-July, with an average of 56% allocation, while the Exchange Contractors received 100% allocations.

2014 is notable for being the first time in history that SOD senior rights holders received allocations less than 75%. When USBR was unable to provide the Exchange Contractors with the minimum contracted amount from the Sacramento River, the Contractors exercised their rights to the San Joaquin River. With the exception of 2014, the Exchange Contractors received at least 75% allocations in every other year of the drought. Both the Friant Division and SOD agricultural water service contractors received no water two years in a row (2014–2015), and the latter group only received a 5% allocation in 2016 even as hydrologic conditions improved relative to the previous years. The NOD agricultural water service contractors also received 0% allocations during 2014–2015 while the Sacramento River Settlement Contractors generally received their contracted 25% maximum reductions.

In 2016, hydrologic conditions improved in the Sacramento Valley and starting April 1 all NOD users received full allocations. However, conditions remained severe for most SOD users who received only 5% for agricultural water service contracts, 55% for M&I, and 30% for the Friant Division. In reaction to this disparity between north and south, the director of the California Farm Water Coalition said in spring 2016: "you've got Lake Shasta at 90 percent capacity and probably going to be full by the summer, and Folsom reservoir filling up, and south of the Delta farmers are getting almost no water–it's a screaming headline that the system is broken" [11], a sentiment echoed by a representative of the Westlands Irrigation District [57].

These disproportionate allocations and impacts are not because Friant Division has much larger acreage and thus a much larger water allocation in a maximum year. On a per-acre basis, senior water rights holders' maximum allocations are much larger than the Friant Division. Settlement Contractors are entitled to about 4.7 AF/ac (2.12 million AF for 450,000 acres) and the Exchange Contractors 3.5 AF/ac (840,000 AF for about 240,000 acres), while the Friant Division contracts are for between 1.9 and 0.71 AF/ac depending on whether the unreliable Class 2 water is counted (much of which is used for groundwater replenishment rather than field crops). In other words, the baseline of maximum allocations is uneven. As explained earlier, this is related to the relatively late addition of these acres in time relative to the senior rights holders elsewhere in the San Joaquin Valley.

4.2. Socioeconomic Impacts of CVP Curtailments

The California agricultural economy survived the drought in relatively good shape overall [58], but not without serious costs. Estimates of the total direct costs drought-induced water shortages on the statewide agricultural economy ranged from an estimated $1.5 billion in 2014 to $1.8 billion in 2015, to $550 million in 2016 [2,4,59].

However, the statewide metrics mask the geographical unevenness of the negative impacts of the drought. The worst impacts among CVP contractors were visited most heavily upon people in certain parts of the San Joaquin Valley (Table 1) [3,4]. In each of the years 2014, 2015, and 2016, among the three CVP basins (Sacramento, San Joaquin, and Tulare Lake) the 0% allocations had the greatest effect in the Tulare Basin where the Friant Division is located. The effects of fallowing and lost crop revenues were most severe in that region, where surface water losses were 3 million AF [59]. In 2014, fallowing was somewhat evenly distributed across the basins, with the Sacramento basin having the most at

151,000 acres fallowed compared to average; Tulare Lake Basin growers removed 133,000 acres from production. However, in the Tulare Lake Basin where fruit and nut trees are prevalent, crop revenue losses were greater than in the Sacramento Valley, Delta, and East of Delta regions at $373,400,000 [59].

The disparities increased in 2015; over half of all the fallowed acres in the Central Valley were in the Tulare Lake Basin (an estimated 80,000 acres relative to average water supply conditions), along with 67% of the total crop revenue losses for the entire state [2]. This is less than 1% of all irrigated land in California, but about 90% of the drought-induced fallowing is in the Central Valley south of the Delta. In 2016, 100% of the fallowing in the Central Valley occurred in the Tulare Lake Basin [4].

Fallowing is associated with unemployment and underemployment. Agricultural job losses in 2014 were estimated to be over 17,000, significantly greater than in the 2009 drought; in fact, 2014 drought impacts were estimated to be up to 50% more severe than 2009, which has been attributed to the much lower water supplied by CVP and the SWP, notably the Friant Division's 0% allocation [59]. In 2015 there were more job losses in the Sacramento Basin than Tulare Basin (5480 compared to 3850). In 2016 an estimated 1815 full and part-time agriculture-related jobs were lost in the Central Valley (4700 when indirect effects on other sectors are included), with about 75% in the Tulare Basin. Medellin et al. (2016) reported that 57% of the $6.5 million in direct assistance provided through the state's Drought Emergency Assistance Program (DEAP) went to farm-related workers in the San Joaquin and Tulare basins in 2016. This is unfortunate given that it is already one of the poorest regions of the state. Kern, Tulare, Kings, and Fresno Counties (as well as Merced and Madera) all have poverty rates between 20–25% [60].

4.3. Groundwater Impacts of CVP Curtailments

Surface water deficits experienced by some irrigators were largely made up for by increasing groundwater pumping [61]. Groundwater substitution appears to have been greatest in South of Delta regions (Tulare Lake Basin in particular) with the greatest surface water deficits to make up as a result of severe surface water curtailments. In fact, new wells proliferated during the drought in areas with major surface water reductions; over 5000 were drilled in the San Joaquin Valley between 2012–2015, more than in the previous 12 years combined [62]. In 2015, the most wells went in in Tulare county (904) and Fresno county (627), followed by Merced county with 304 [62].

Negative impacts of groundwater overdraft include increased pumping costs, land subsidence, and permanent loss of storage capacity. Exacerbating declines in local water tables may contribute to dry domestic wells in marginalized unincorporated communities such as East Porterville and Woodville [62].

4.4. Conflict over CVP Operations during the Drought

The 2012–2016 drought is notable for the ways in which distribution of CVP water generated informal tensions between senior and junior growers within the system [63]. One formal conflict stemmed from the release of water from Millerton Lake in May 2014 to fill the rights of the Exchange Contractors when USBR could not provide them with their contracted minimum substitute supply from the Sacramento River [64]. This occurred while Friant Division received 0% allocations.

In May 2014, Friant Water Authority led 21 plaintiffs in legal action to stop USBR from releasing water from Friant Dam to wildlife refuges and the Exchange Contractors but were denied [65]. The plaintiffs contended that in allocating water to the Exchange Contractors and wildlife refuges but not to them, USBR breached their water service contacts, in addition to taking property (water rights) without compensation in violation of the 5th Amendment of the U.S. Constitution [66]. Intervening in the case on the side of USBR were not just the refuge management organization, but also the San Joaquin River Exchange Contractors Water Authority, the San Luis and Delta-Mendota Water Authority, and the Westlands Water District [67].

After this, the case was dropped [67] but re-filed in 2016 [68]. The revised complaint did not specifically question the USBR's interpretation of the Exchange Contract; rather, it requested $350 million in compensation for the alleged taking of their property under the 5th Amendment [69].

How did the Friant Division respond to the outcomes of the drought? The Friant Water Authority identified protection of water rights and agreements and the development of a sustainable water supply as their primary goal [70]. The protection of existing water rights and supplies included the resolution of " . . . issues caused by the Bureau of Reclamation's (Reclamation) interpretation of the Exchange Contract" which the Authority listed as one of several threats to their water supply, particularly to their ability to ensure some minimum surface water allocation during drought periods [70] (p. 4). The legal conflict and internal response by Friant Water Authority is evidence of the drought and the priority system embedded in the contracts causing tension between not just environmentalists and agriculture, but between different groups of irrigation communities.

5. Discussion

Based on the foregoing analysis, we can see the important role that water rights play in dictating uneven water allocations and their ripple effects. While water rights are not the only factor affecting allocations, they are an especially important one during shortages. Because there is a definite hierarchy based on chronological order of rights and contracts acquisition strongly affecting CVP drought allocations, it is worth revisiting earlier critiques of the equity dimensions of prior appropriation before considering a more equitable alternative.

5.1. Fairness Critiques of Priority in Relation to the CVP Drought Allocations

On its face, priority (in time) is not an unfair basis for allocating water resources. It arguably provided a greater degree of certainty to the individual making risky investments of money and labor to irrigate the desert than did the correlative rights of the riparian doctrine. As water law scholar Samuel Wiel wrote, "the pioneer gambles for high stakes, and unless those large stakes are secure to him after he succeeds, he will not gamble, and there would be no pioneering" [71] (p. 534). Dunning [38] reminds us that the priority principle was described as a "maxim of equity" in *Irwin v. Phillips* (1855), the influential early California case of competing appropriation and riparian rights claims.

Today, even junior rights holders see the priority system as a generally fair one. For example, when the Friant Water Authority took action to block USBR from sending water from Millerton Lake to the Exchange Contractors and wildlife refuges in May 2014, an Authority spokesperson was careful to clarify that they were not attacking the priority system itself or the Exchange Contractors, but rather USBR's decision-making [66].

However, critiques of California's water rights system proliferated during the drought [12–15,17,72], echoing a long history of critiques of the fairness of the priority system of allocation and curtailment. Late 18th and early 19th century critics of reliance on the relatively narrow criterion of chronology of rights establishment for determining winners and losers included Elwood Mead, Frederick Newell, John Wesley Powell, as well as a number of western judges, scientists, and engineers [24,73]. A minority of 20th century scholars have carried forward these earlier critiques of the equity and fairness aspects of seniority as a water allocation scheme (e.g., [73–75]).

Samuel Wiel argued that the fairness of the priority system was conditional on whether a basin was (a) not fully appropriated and there was considerable risk to a pioneering individual in attempting irrigation development versus; (b) a system long after the pioneer times which is fully appropriated [71]. In the case of the latter, he argued, curtailments cannot be distributed without gross disparities based on historical happenstances of priority dates.

The CVP and the rivers it draws from are fully appropriated and have been for decades, yet shortages are managed largely based on deference to 19th-century water rights. Even though the California water rights system contains riparian rights, the evidence presented above from the

2012–2016 drought illustrates how the priority system underpins CVP allocations during drought, supporting critiques of the fairness of seniority systems in fully allocated surface water bodies.

The critique of priority can be extended by drawing from Ingram et al.'s five principles to consider how the evidence presented may amount to an inequitable situation. Like the Colorado River Compact, the bedrock of CVP system operations is a complex set of different promises (water rights and permits granted, agreements entered, contracts signed) which must be respected. However, if equity is understood as a balancing exercise, the effects of enforcing these promises must be weighed against other criteria. If satisfying one of the five principles causes an imbalance in the other constituent principles, then it is safe to conclude that equity is not being satisfied.

In this case, one of the bigger balancing challenges is weighing the principles of honoring past promises with reciprocity (a condition of fair sharing of distributive advantages and costs by all members of the relevant community). The evidence presented above suggests that, overall, the drought curtailment system is uneven enough as to fail this test. One element of reciprocity is that those who use more water should expect to have to sacrifice more under conditions of scarcity [40]. In the San Joaquin basin, the Friant Division's maximum allocation of Class 1 water is less than the Exchange Contractors' total water rights and on a per-acre basis is comparatively almost half as much, yet during severe drought the Contractors are entitled to receive San Joaquin water to satisfy their demands before the Friant growers receive anything. As discussed above, the USBR's enforcement of this rule was a point of formal conflict during the drought.

This raises a key question: at what point do conditions become sufficiently different from those that existed when promises and contracts were originally made as to warrant renegotiation? In line with Wiel's argument, Ingram et al. [40] note that negative effects are generated when the priority system is pushed to an extreme. In this case, the serious negative social and ecologic impacts that resulted during the 2012–2016 drought stemmed in large part from the conditions Wiel described almost a century ago (full allocation of surface water). This situation, combined with robust predictions about the hydrologic impacts of climate change on the Sacramento and San Joaquin Rivers, amounts to a sufficiently changed set of conditions relative to the mid-20th century as to justify a reordering of water right priorities. However, any reordering should be done in balance with the other four equity principles.

5.2. The Connection between CVP Allocations and the Intergenerational Inequity of Long-Term Central Valley Groundwater Depletion

This analysis has focused so far on the fairness of drought allocations and their impacts, but this is only one of potentially numerous factors that may be relevant to overhauling water rights and allocations for CVP users. A small sample might include such things as the degradation of ecosystems and extirpation of endemic species; injustices to indigenous tribes; the widely disproportionate subsidies and costs of water between agricultural and M&I users; even the fraudulent acquisition of land and water rights under both riparian and appropriation doctrines during the laissez faire era by Miller & Lux and others.

In the case of the CVP, one of the important ripple effects of 5% or less water allocations is increased groundwater pumping. Increasing groundwater pumping to make up for a lack of surface water during a drought is a form of conjunctive use that can, under certain conditions, be a valuable adaptive strategy to socioecological disturbances [76]. In the San Joaquin Valley, however, where natural replenishment rates are often very slow and regional groundwater basins have been in continual decline for nearly a century, using groundwater as a drought buffer exacerbates a longstanding problem [61], further inhibiting the realization of the principle of intergenerational equity.

There is an important historical dimension to this problem. While drought impacts are most severe in the Tulare Lake Basin, it is also true that groundwater depletion has continued overall and has been concentrated in the same area [77]. Growers in the region who contracted for CVP supplies in some cases used them to develop new lands instead of to replace groundwater pumping for watering

existing acreage as was intended by the Project's proponents [74] (pp. 277–278). All of the basins in the area have been designated as being in critical overdraft since 1980, yet cumulative groundwater depletion of the Central Valley aquifer has only increased as depletion has accelerated [61] and storage capacity has decreased [78,79]. The additional storage created by the CVP and SWP ended up doing relatively little to address the problem, which has only gotten worse with time.

The benefits of groundwater pumping during drought are mostly individual and short-term but the aggregate costs are mostly socially distributed and deferred to future generations in the form of permanently reduced aquifer storage capacity, land subsidence, and increased costs of pumping from chasing the water table further and further down.

Adaptive solutions for the Central Valley overdraft problem are somewhat limited. Recharge can be increased through water storage, but major new reservoirs are not usually considered politically realistic. Depletion can be slowed by increasing irrigation efficiency instead of continuing to flood irrigate, but this is also a problematic option because (a) inefficient irrigation replenishes streams and aquifers to some extent and (b) saved water is often just used to irrigate more acreage or more high value but water-intensive crops (as has happened with the proliferation of almonds and other thirsty nut trees in parts of the Tulare Basin) [77]. Aquifer recharge by irrigation districts when floodwater is available to capture may mitigate the overdraft problem to some extent in certain areas, but on its own it seems unlikely to bring critically overdrafted basins into some state of long-term sustainable yield without significant concomitant reductions in pumping.

Given this limited set of options, maintaining the status quo of rights and contracts in which 0% surface allocations are highly likely for the most groundwater-reliant CVP customers seems likely to generate the same outcomes over and over, worsening the overdraft problem. This raises considerable questions about the ability of communities of junior CVP contractors in the San Joaquin Valley to adapt to a changed climate characterized by reduced snowpack and runoff and more frequent and severe drought episodes. The supply problem may only become more difficult if Groundwater Sustainability Agencies pass meaningful pumping constraints under the Sustainable Groundwater Management Act of 2014 which reduce growers' ability to continually rely on groundwater as a drought buffer when they are cut off from surface supplies.

This raises some very difficult choices. The main options are to (1) reallocate some surface water from senior users such as the Exchange Contractors to more evenly distribute the water that is available in Millerton Lake during drought in order to help mitigate groundwater overdraft in the Central Valley, or (2) substantially shrink the overall water footprint of agriculture in the San Joaquin Valley in general to reduce the total demand for both groundwater and CVP water. With regard to option (1), what degree of responsibility for resolving the problem can be placed on CVP contractors in the San Joaquin Valley who used their surface water supplies to irrigate new land instead of using it to reduce groundwater overdraft as was the original intent of the Project? This is also a potential point of conflict, since addressing the groundwater problem may require making more surface water available for recharge, at least some of which would likely come from the senior entitlements of other users.

At a minimum, in order to rebalance equity principles so that intergenerational equity is more properly weighted, a 50–100 year planning horizon must be adopted [42]. Depending on how it is implemented, the requirements of the 2014 Sustainable Groundwater Management Act may be instrumental in eventually achieving such a long-term vision. Additionally, long-term declines would have to be halted and eventually reversed through natural and artificial recharge. This would involve more strictly operating the Friant Division as the conjunctive use project it was intended to be, such that temporary withdrawals from groundwater reserves in dry years are later replenished instead of contributing to continued net depletion.

I do not propose to answer the difficult questions raised by the need for equitable adaptation to the hydrologic impacts of climate change. Instead, I argue that surface water allocations cannot be understood as disconnected from groundwater usage, and thus any reordering of surface water priorities within the CVP universe of contractors to reduce distributional inequities of socioeconomic

suffering during drought must be balanced with the need to address the intergenerational inequity of long-term groundwater mining.

As Gleeson et al. [41] (p. 379) point out, "the social and economic benefits of large aquifer withdrawals may not compensate for the significant depletion of aquifers that are effectively non-renewable on human timescales" (this applies also to alluvial unconfined aquifers and groundwater quality [42]). The capital generated by industrialized agriculture in the Central Valley cannot alone be used to justify current patterns of groundwater extraction on equity grounds if those patterns substantially reduce the capacity of future generations to adapt to a climate with more frequent and severe drought episodes and shrinking snowpack.

5.3. Equitable Apportionment as a Fairer Alternative to Priority

What legal doctrine might one apply if the system could be torn down and rebuilt in order to strike a better balance between the five equity principles? I suggest equitable apportionment is one hypothetical alternative to the current system which is more conducive than priority to a broadly fair and sustainable water management regime.

The doctrine of equitable apportionment dates back to the first interstate surface water dispute that resulted in *Kansas v. Colorado* (1907) and has since developed primarily within that subcategory of water resource law [28,80]. In its decision for *Nebraska v. Wyoming* in 1945, the U.S. Supreme Court affirmed that "[e]quitable apportionment among appropriation States does not require a literal application of the priority rule" [81]. Further, the court identified several categories of relevant criteria beyond priority, including

> " . . . physical and climatic conditions; the consumptive use of water in the several sections of the river; the character and rate of return flows; the extent of established uses; the availability of storage water; the practical effect of wasteful uses on downstream areas; the damage to upstream areas as compared to the benefits to downstream areas if a limitation is imposed on the former. The decree of equitable apportionment to be entered in this case must deal with conditions *as they exist at present and must be based on the dependable flow of the river* which is not greater than the average condition which has prevailed since 1930". [81] (emphasis added)

Although the development of equitable apportionment has happened primarily within interstate water law, different forms of it have been applied at times in California for both groundwater and surface water. For example, Dunning [38] has argued that under a strict priority rule, SWRCB should have imposed Sacramento-San Joaquin Bay-Delta salinity control requirements disproportionately on the junior appropriator, which would have placed the greater or perhaps sole burden of maintaining outflows for salt flushing on the SWP and little or no responsibility on the CVP. Instead, a sharing rule was adopted which " . . . reflects a form of state equitable apportionment of water resources [38] (p. 109)," a fairer arrangement in light of the total body of relevant facts and evidence than priority would have dictated.

From an equity standpoint, then, one advantage equitable apportionment has over priority is that it allows for a variety of non-priority criteria to be brought to bear on court decisions. Ruhl [82] (p. 52) concluded that " . . . equitable apportionment encompasses whatever seems relevant to a fair division of the resource between the states. This means equitable apportionment is a flexible doctrine, able to incorporate new knowledge not only about water demands and uses, but also about the ecology of water in general."

Further, because equitable apportionment allows for priority to be used as a guiding principle, it does not require an *equal* apportionment. This is another reason why it would be appropriate for overhauling CVP allocations and shortage provisions, which I submit are inequitable in certain ways but not *unjust*. One key difference between justice and equity is that they correspond with different kinds of remedies. In some cases equality is what is needed, e.g., uniform national water quality

standards and equal protection from water-related hazards for all economic and ethnic groups [27] (p. 80). Other cases such as fair access to water resources, compensation for injury, a minimum supply, and procedural justice, may be more suited to an equity-driven approach that "may secure remedies that are deemed fair by many but not equal for all" [27] (p. 76). This is the appropriate kind of remedy needed in the case of the CVP.

5.4. Anticipated Opposition to Water Rights Reform for the CVP

In the case of the CVP, re-tooling the system to achieve a more even balance of equity principles would likely entail revising water supply contracts and some reordering of priorities, along with establishing a new shortage sharing system that goes beyond strict priority and contracts. At minimum, all rights, including the pre-1914 unregulated rights, would need to be quantified [83]. Opposition to quantification and regulation dates back to Miller & Lux's fights against it in the courts in the 1800s and would likely continue to be opposed by the holders of the most senior rights such as the Exchange Contractors. To the extent that an overhaul (whether equitable apportionment by the courts or some other way) would result in the reordering of priorities, reform can be expected to be opposed primarily by those who benefit most from the status quo: senior rights holders who suffer the least from drought and strongly support strict adherence by SWRCB to strict enforcement of the priority system [84]. Northern growers more generally can be expected to resist any rules that provide more exports from the north to the Friant Division and the junior SOD water service contractors, especially if perceived as a bailout of southern growers who rely heavily on mined groundwater.

Any overhaul of water rights involving modifications to, and reordering of, priorities can be expected to generate conflict. This is not inherently a bad thing. However, it is also true that the current priority system and its implementation by SWRCB is already plagued with conflict, which proliferated during 2012–2016. I noted above just one instance, which pertained specifically to the CVP. However, it is worth stating that a water governance system stymied by conflict cannot be an effective one, nor can it be considered a well-adapted one. Without a larger political solution that resolves problems of fairness, there is little reason to expect that future droughts will be markedly less conflict-laden than the most recent one.

5.5. Equitable (Re)Apportionment Implementation Scenarios

This raises an important question: what kind of process might be used to apply equitable apportionment to generate fairer drought outcomes? From an equity perspective, who applies equity principles and how is very important. In one hypothetical scenario, a legal dispute could lead to a court-supervised adjudication using equitable apportionment, as has been done in a number of California groundwater basins. There is some indication from past decisions that the state courts would not likely reject an equitable (re)apportionment of surface water rights as long as priority is not completely ignored [38,85].

Some potential drawbacks associated with a judicial reapportionment are: the risk that the courts could construe equity too narrowly; the transaction costs to stakeholders of time and legal fees could be very great, especially if the legal proceedings last many years; significant costs may greatly disadvantage the less powerful and/or well-heeled third-party interests most affected by past and existing inequities.

A second, more preferable scenario might be a legislative one involving a statutory reapportionment administered by the SWRCB according to its authority to alter and condition water rights and permits on behalf of the public trust [86]. Brian Gray [87] (p. 237) has argued that Section 2 of Article X of the California Constitution [88] " ... confers broad authority on the state to modify existing water rights to ensure that the current apportionment of California's water resources serves contemporary economic, social, and environmental goals in a reasonably efficient manner." SWRCB has at times exercised its authority under Section 2 and the Water Code to condition the exercise of water rights and permits in response to environmental problems without following priority [38].

Procedurally, an equitable reapportionment initiated and administered by SWRCB could take any number of different forms. Unilateral action by SWRCB would likely result in a maximum of political and legal conflict and be unlikely to generate a new arrangement that is accepted by the affected communities of users if the process deprives them of collective agency. The equity principles of value pluralism and the accommodation of multiple value claims in resource allocation decision processes suggest a need for some amount of collective, participatory action so that the values of water rights holders and third parties can be meaningfully included. A messier but more equitable process than unilateral action could entail some type of sustained, mediated negotiations overseen by SWRCB involving a broadly inclusive community of rights holders and third parties to articulate what an equitable basic apportionment and a set of drought curtailment provisions would look like. These could then be implemented in the form of revised permits and contracts by SWRCB and USBR. Besides satisfying procedural equity criteria, another benefit is the possibility of identifying nontraditional ways of responding to drought that increase both equity and adaptability such as voluntary conservation arrangements [89].

However, if Hanemann and Dyckman [90] are correct in their analysis of CALFED's failures, purely voluntary negotiations would be likely to fail without strong oversight and direction from the state, given that many of the same interest groups involved in CALFED would be involved in an equitable apportionment for the CVP. In such a scenario, it would be important for legislators and regulators to build from the positive procedural aspects of past stakeholder-driven efforts while avoiding their critical flaws such as the marginalization of environmental justice interests [91] and the lack of regulatory power and a hard statutory requirement to achieve a final resolution that hampered CALFED [90,92–94]. California could perhaps look to more successful Endangered Species Act-driven stakeholder negotiation processes in other states for ideas. For example, the Edwards Aquifer Recovery Implementation Program in Texas demonstrated the importance of designing authorizing legislation with clear deadlines and meaningful consequences for missing them for keeping all parties at the table even when they are far apart on a particularly thorny issue [95].

6. Conclusions

As Stroshane [47] (p. 168) has stated, "drought reveals the tensions in governing a capitalist, hydraulic society such as California, where competition over scarce water supplies drives conflict." A central vexing question for the state is how to deal with those tensions, knowing that there will be winners and losers with each new round of drought. Like the Colorado River Compact, the CVP is at bottom a set of promises in the form of its Settlement, Exchange, and water service contracts. The promises were always unequal; some were promised greater security in the event of shortages than others. However, also like the Colorado River and numerous other surface water bodies in the West, the resource was over-promised from the beginning. USBR delivers on average far less water than is contracted for.

In this analysis I have explored how these promises in the form of the priority system of water rights underlying the CVP water supply contracts becomes highly important during drought in determining the relative winners and losers of water distribution. I have demonstrated how this system generates uneven socioeconomic outcomes for different communities of water users. I have argued that the outcomes of CVP's contracts and shortage provisions during the drought lend support to critiques of the fairness of the priority system, and that equitable apportionment is an example of how a complex water allocation and management system like the CVP could be overhauled to incorporate and advance equity principles that currently are out of balance. Last, I have emphasized the importance of intergenerational fairness (or lack thereof) of the Central Valley overdraft problem, which, via its connection to CVP allocations, is worsened during drought.

As California and other Western states do the difficult work of increasing capacity to adapt to major climatic disruptions such as drought, it is important to do so in ways that increase equity among humans and non-humans and avoid exacerbating existing environmental and socioeconomic

inequities. This will likely require a complex balancing process that may involve state management and regulatory agencies, federal agencies, and state and federal courts, as well as communities of users and third-party interests. Therefore, strong political leadership will be critical.

Acknowledgments: I wish to thank the editors and two anonymous reviewers for helping me improve this manuscript. I also thank the Martin Daniel Gould Center for Conflict Resolution at Stanford Law School for the generous assistance with publication costs.

Conflicts of Interest: The authors declare no conflict of interest.

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