ARTICLES

Inefficient Efficiency: Crying Over Spilled Water

by Vanessa Casado Pérez

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- Summary -

As the drought in western states worsens, the agricultural sector is being criticized for failing to adopt technical responses, such as shifting to less waterdemanding crops and state-of-the-art irrigation systems. However, these responses alone are insufficient to reduce water consumption if unaccompanied by changes in how the law defines and allocates water rights. This Article proposes a redefinition of water rights to ensure that changes in crops or irrigation techniques are socially efficient. It proposes 'prior consumption" as an additional measure of water rights in prior appropriation regimes, one that more accurately reflects the true social cost of agricultural water use. This would prevent farmers from taking advantage of technical responses to increase their water use and would protect downstream users and the environment. In addition, water markets would benefit, since water rights would be better defined and the review process of water market transactions would be streamlined. The proposal is consistent with the underlying principles of prior appropriation, and would survive a potential takings challenge.

s of 2016, California is facing the fifth year of a serious drought. Other western states already suffer or are likely to suffer from similar scarcity in the near future due to climate change. As the largest water user, the agricultural sector¹ is widely criticized for misusing irrigation water by employing inefficient irrigation methods and growing water-intensive crops. The critique even made a *New York Times* Sunday editorial.²

As a response to the scarcity crisis, it is often argued that the agricultural sector should be more efficient, for instance, by adopting so-called efficient irrigation systems. Sprinklers and drip irrigation, which have little to no return flows, are thus expected to solve our water woes by ensuring that the agricultural sector conserves water for other users.³ However, this is not the case. Experts have proven that technically efficient irrigation systems may end up consuming more water than traditional irrigation methods.⁴ This is because flood or furrow irrigation meth-

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- . In California, agricultural use amounts to 80% of the water consumed, while its contribution to the state's gross domestic product is 2%.
- 2. Watering California's Farms, N.Y. TIMES, Apr. 4, 2015.
- 3. Conservation is not a univocal concept. In this Article, it is used to mean making more water available to others. However, A. Dan Tarlock notes that "in this century [the 20th century] 'conservation' has been defined either as maximizing the use of water by augmenting the supply or as an efficient engineering method of using less water to achieve the objective." A. Dan Tarlock, *The Changing Meaning of Water Conservation in the West*, 66 NEB. L. REV. 145, 147 (1987).
- 4. Frank Ward & Manuel Pulido-Velázquez, Water Conservation in Irrigation Can Increase Water Use, 105 PNAS 18215 (2008); Ray Huffaker & Norman Whittlesey, The Allocative Efficiency and Conservation Potential of Water Laws Encouraging Investments in On-Farm Irrigation Technology, 24 AGRC. ECON. 47 (2000); Brian Venn et al., Hydrologic Impacts Due to Changes in Conveyance and Conversion From Flood to Sprinkler Irrigation Practices, 130 J. IRRIGATION & DRAINAGE ENGINEERING 192 (2004); Aurélien Dumont et al., Is the Rebound Effect or Jevons Paradox a Useful Concept for Better

ods do not consume all water diverted: a large part of it goes back to the river via return flow. With drip irrigation, this is not the case: plants consume almost all of the water and there is no return flow. Thus, once some farmers adopt technically efficient irrigation methods, other users, including the environment, who were relying on the return flow can no longer use that water and streamflow downstream is reduced.⁵

Adopting efficient irrigation systems does not achieve the goal pursued by conservation policies of saving water for other users. Policies advocating for technological solutions without taking into account this "rebound effect" are misleading. Given how overallocated streams are, the extra water consumed using drip irrigation is water that some other user had been relying on for decades. The adoption of drip irrigation or sprinklers may translate into water being in fewer hands. The U.S. Supreme Court case *Montana v. Wyoming*⁶ illustrates this point: the Yellowstone River that these two states share had less water than it did in 1950 when they signed the compact. In the 2000s, there was not enough water flowing to Montana because Wyoming farmers adopted sprinkler irrigation systems and consumed more than before.

Drip irrigation and sprinkler systems are labeled efficient because they increase the yield at the plot installed or lose less water to evaporation or return flow. However, the desirability of their adoption should be analyzed on the basis of their positive effect on the overall water use value. If some farmers adopt drip or sprinklers and increase their yields, but other farmers are no longer able to produce because they are deprived of the return flow, the change in the overall allocation is not a Pareto-efficient improvement. Not only may the adoption of technically efficient irrigation systems be unfair to users who have been relying on return flows, it may also be inefficient.

The burden should be on proponents of new technologies to prove that the aggregate outcome constitutes an improvement (or, in other words, is Kaldor-Hicksefficient even if not Pareto-efficient); that is, that their increased profits could hypothetically offset the losses imposed on users who can no longer irrigate. But this is not what prior appropriation, the regime that allocates water in the West, establishes: as the Supreme Court stated in the aforementioned interstate compact dispute, farmers are allowed to change irrigation methods even if their consumption goes up.

The notion that conservation strategies may backfire is not new. However, the scholarship on water law has rarely considered this possibility. The discussion in the energyefficiency world has been heated for a long time. Fuelefficient cars may induce driving more miles because of cheaper fuel, increasing overall emissions compared with less-efficient cars. Efficient appliances may save less energy than we expect because the amount a consumer saves in her energy bill is spent on other goods in her basket that consume energy. This is known as the rebound effect. The increase in consumption when changing irrigation methods can be considered an extreme example of the rebound effect. Users will increase how much they drive, but rarely will drive twice as much. But with water-efficiency measures farmers, particularly in water-short basins, are likely to consume as much as possible if this allows them to increase production.

An Intergovernmental Panel on Climate Change (IPCC) report calls for taking into consideration the potential rebound effect when calculating energy savings. Likewise, water regulation should not accept at face value that technologically efficient measures produce real water savings and bring our water allocation closer to efficiency. Prior appropriation needs to account for this rebound effect. Prior appropriation defines water rights according to the volume diverted and, thus, it allows farmers to consume as much as they have the right to divert. Accordingly, when adopting technically efficient irrigation systems, they can consume more water than they were consuming previously.

Hence, prior appropriation does not ensure that when changes in consumption happen, the new allocation is equal or more efficient than the status quo. Even more, as shall be seen, it encourages farmers to consume as much as possible because those farmers may fear losing their rights due to non-use. This is why I propose including an additional variable-historical consumption-in the definition of prior appropriation water rights; users will be able to consume only what they have been consuming historically, thus preventing the rebound effect. Introducing consumption as a limit allows farmers to change the irrigation method if it is Pareto-efficient to do so; the farmer adopting drip irrigation increases her profits and the rest of the users are not harmed. But as I explain, this proposal would also facilitate the purchase of water from those less efficient by those who need to increase the amount consumed once they install a different irrigation system.

Management of Water Resources? Insights From the Irrigation Modernisation Process in Spain, 1 AQUATIC PROCEDIA 64 (2013); Julio Berbel et al., Literature Review on Rebound Effect of Water Saving Measures and Analysis of a Spanish Case Study, 29 WATER RES. MGMT. 663 (2014).

^{5.} TECHNICAL WORK GROUP FOR THE INTERAGENCY TASK FORCE ON IRRIGATION EFFICIENCIES, IRRIGATION WATER USE, AND MANAGEMENT, AT Glossary 1-5 (June 1978 review draft), *cited in* George W. Pring & Karen A. Tomb, *License to Waste: Legal Barriers to Conservation and Efficient Use of Water in the West*, 25 ROCKY MTN. MIN. L. INST. 4 (1979) ("It is estimated that return flow amounts to 92 million acre feet annually as compared to the 79 million acre feet consumed by crops each year. Return flow is commonly utilized downstream but it carries the problems of erosion and water quality degradation.").

^{6. 131} S. Ct. 1765, 179 L. Ed. 2d 799, 41 ELR 20168 (2011).

The above proposal addresses not only irrigation efficiency, but also other choices that farmers make that may affect water consumption. This is particularly the case for crop choice. Farmers are free to choose which crop they may grow. Their choices are often highly influenced by federal and state subsidies. Alfalfa production in California's Central Valley has been the focus of critiques for many years because it is a low-value crop that consumes a lot of subsidized water.⁷

Today, many critics focus on the high levels of water required to grow almonds, a crop increasingly adopted by California growers even in the midst of the current water crisis. Almonds are profitable because their market price is high, but almond trees require more water than the crops previously grown in the same area. In addition, they introduce inflexibility in the water management system; almond trees cannot be fallowed in the event of a crisis. If farmers were restricted to consume the same amount they have been consuming historically, their choice of crops would be limited. They could change and grow almond trees, but if the nuts require more water than a previous crop, farmers would plant fewer acres or buy extra water.

This Article proceeds as follows: Section I describes the choices that farmers have and the potential impacts on water distribution and efficiency. Section II analyzes how those changes are treated under prior appropriation law. Section III describes different regulatory options to deal with the effects of farmers' choices in water use, proposes using consumptive use as a measure of water rights, and analyzes the strengths and challenges of such a proposal, mainly the measurement difficulty and the potential takings challenges. Section IV concludes.

I. Irrigation Efficiency: Effects

A. Farmers' Choices

Farmers have many choices when trying to make the most of their water, which, individually, means obtaining the maximum amount of profit per drop. First, they may improve current systems, both of irrigation and of water conveyance. They can level their fields when using flood irrigation, allowing a more even distribution of water, or adopt optimal irrigation schedules catering to the plants' needs. Farmers may also reduce transfer losses; they may improve the conveyance system from the river or stream from where they take their water to their field. But as the water savings achieved by lining the All-American Canal show, those changes are not necessarily a Pareto improvement. As a result of the canal lining, farmers in Mexico did not have enough groundwater to irrigate. It inhibited water seeping, which recharged the aquifers on the other side of the frontier. Conveyance infrastructure improveSecond, farmers may change the type of crop they are growing. Water consumption varies depending on the crop. Farmers maximize their revenues. The amount of water they are legally entitled to and that is available to them may be a constraint if the volume is lower than some crops require. Provided they have enough water, farmers will grow the crop that brings them more profits, once other variable costs are taken into account. Depending on the state where the farmer resides, these choices are sometimes distorted because farmers not only get the market price for their harvest, but also some federal or state subsidies.

Third, farmers can shift to more technically efficient irrigation methods. Changing to sprinklers or drip irrigation entails high upfront fixed costs.8 Such an investment will not always be profitable. It will depend on the type of soil, the water available to farmers, and the crop farmers want to grow. Federal and state governments have given incentives to farmers to shift irrigation systems based on the idea that they will conserve water. These incentives take two forms: direct funding of those mechanisms, or grant farmers title to the amount of water they save. Granting title to the amount of water conserved implies that farmers can sell that water.⁹ The statutes that grant the farmer rights to the water conserved by changing the irrigation method or taking other measures have, to a great extent, acknowledged the rebound effect described in the introduction. These statutes only grant title to the amount of water really conserved; the shift in irrigation systems cannot cause an increase in consumption.

However, there are programs at the state and federal levels that fund technically efficient irrigation methods but do not consider the potential effects of changing those methods. Also, farmers may decide to change the methods just because it is economically sensible for them to do so even if systemically it has deleterious effects. The management of drip irrigation implies less labor costs while producing a higher yield. For the water system, drip irrigation ensures that pesticides and fertilizers are not carried back to the river via return flows. Hence, nonpoint source pollution is reduced.

The type of crop also influences the choice of irrigation method. In general, field crops like alfalfa are usually less amenable to drip irrigation than garden crops such as vegetables. Drip irrigation is also not advisable in areas where water contains high levels of salinity because salt can build up on the field. Similarly, if surface water supply is not continuous, drip irrigation may not work as well as it does when the source is groundwater because with

ments pursued by irrigation districts could result in similar outcomes.

It is estimated that drip irrigation requires an investment between \$800 and \$1,200 per acre. Ari Michelsen et al., Evaluation of Irrigation Efficiency Strategies for Far West Texas: Feasibility, Water Savings, and Cost Considerations 52 (2009).

Justin Fox, Why California Needs Thirsty Alfalfa, BLOOMBERG, May 26, 2015, http://www.bloombergview.com/articles/2015-05-26/why-they-growthirsty-alfalfa-in-parched-california.

^{9.} Such provisions need to ensure that farmers do not fear the forfeiture of their rights. In prior appropriation, unused rights can be forfeited by the water agency. For a discussion of forfeiture and the incentives arising from that institution, see *infra* note 45 and accompanying text.

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the latter, the farmer can dictate when her demand will be satisfied. In sum, it is a factual inquiry whether adopting technically efficient irrigation methods is more beneficial than costly, but the assumption that it is always an improvement is a mistake.

B. Example

The following example and figures describe how a shift in irrigation methods changes the flow, yield, and water available for other users and the environment.¹⁰ For simplicity purposes, I assume that rights are only defined by volume, not by flow per unit of time as they normally are in prior appropriation states. I illustrate the change from flood irrigation to drip irrigation. The results could be similar if instead of drip, a farmer adopts microspray, which is a type of sprinkler. Traditional sprinklers are also an improvement over flood or furrow irrigation, and may consume more water. Not all methods are suited to all environments. For example, center pivot sprinklers may not be suited to windy environments because the water may be carried away before it reaches the soil. Similarly, drip irrigation may be problematic for areas where water is saline, requiring extra management.

The effects may be similar whenever there is a change in irrigation management that increases the amount of water consumed. Lining the canals should not increase consumption per se but it may change where water returns to the basin; before lining the canals, water used to percolate, but after, it may reenter as return flow. Changing the crop grown may also translate to increased water consumption.

The situation portrayed here illustrates what happens in areas like the Lower Rio Grande or Colorado's Big Thompson project, where irrigators rely on others' return flows. In water-short scenarios, drip irrigation tends to consume more than flood irrigation if the user is not receiving the full amount of water that she needs. This is a likely situation in many western states where scarcity has dictated that very few farmers receive their full allotments every year. In a water-scarce scenario, it is likely that fewer users will be able to use water once efficient irrigation systems have been installed.¹¹ As mentioned, pollution will be reduced if drip is installed, but pollution is also more concentrated the less water there is.

However, in other situations, return flows are not being reused. For example, in the Imperial and Coachella Valleys, runoff from agricultural producers flows to the Salton Sea, a saline lake created by that runoff. In this case, reducing runoff to the Salton Sea would not necessarily generate a negative outcome; however, the surrounding ecosystem has grown dependent on the existence of this salty lake, and excessive reductions in runoff could threaten the fish and wildlife now reliant on agricultural runoff.¹² Still, in water-abundant areas, return flows may not have been appropriated yet. Thus, the increase in consumption may not affect other consumptive uses because there is enough water to satisfy them. Environmental flows will be nonetheless reduced but perhaps not to levels that threaten the survival of species. Those water-abundant areas are less and less common in the West. Overappropriation is the norm.¹³

I. Flood Irrigation

The first scenario (Scenario 1) is the situation before any improvement in the irrigation system has been made. Two farmers are using flood irrigation, a low-tech method where the farmer, using gravity or pumps, diverts water out of the stream and covers the whole field with water. From that water, the amount of water lost to the river is the amount evaporated and the amount consumed by the plants. Plants receive part of the water. However, because the water does not target the plants, part of it evaporates and/or is irretrievably lost from the basin as it seeps and becomes unrecoverable groundwater.¹⁴ The rest of the water goes back to the river or recharges the aquifers.

Flood irrigation is a cheaper method in terms of capital investment but, depending on the scale of the agricultural production, may incur more variable costs, such as fertilizers and labor, than other irrigation methods. A system similar to flood irrigation is furrow. Furrow irrigation also uses gravity to move water around the field, but instead of flooding the whole acreage, water gets channeled by dirt furrows. Flood and furrow have lower yields than other irrigation methods because water does not reach plants in the optimal places or at the optimal times.

Farmer A grows alfalfa, a crop that is often blamed for consuming a lot of water, and is common, for example, in California's Imperial Valley,¹⁵ a former desert.¹⁶ The river, as it reaches farmer A's plot, has available 8.5 acre-feet (acft). Farmer A has a right to use 5 ac-ft, and in Scenario 1 she diverts that amount to irrigate her crop. Her production of

^{10.} Most of the data (crop yield, evapotranspiration, and crop price) is taken from Frank Ward & Manuel Pulido-Velázquez's study in the Lower Rio Grande Basin, one of the studies that looks holistically at the effects of shifting to technically efficient irrigation methods. Ward & Pulido-Velázquez, *supra* note 4.

^{11.} Scholars exploring the shift from flood irrigation to center pivot sprinklers have shown that the more water-short the scenario, the more consumption goes up when changing irrigation methods (from flood to sprinklers in their case) even though the acreage is lower when applying center pivot. Daniel M. O'Brien et al., *Economics of Surface to Sprinkler Irrigation System Conversion for Lower Capacity Systems*, KAN. ST. U., http://www.k-state.edu/ irrigate/reports/irrext2k.pdf.

Sue McClurg, The Salton Sea: The Environmental and Economic Values of This Vast Inland Lake Prompt Local Officials to Launch a New Restoration Effort, WATER EDUC. FOUND. (Mar./Apr. 1994), available at http://www.sci.sdsu. edu/salton/EnvirnEconValueSaltonSea.html.

Gregory J. Hobbs Jr., Beneficial Use & Anti-Speculation, Can These Water Law Principles Meet the Challenges of Climate Change?, 137 WATER REP. 1 (2015).

^{14.} The extracted water ends up as: (1) beneficial evapotranspiration, which is the part that the plant consumes; (2) non-beneficial evapotranspiration, that is, evaporation; and (3) nonrecoverable runoff or percolation. Charles M. Burt et al., *Irrigation Performance Measures: Efficiency and Uniformity*, 123 J. IRRIGATION & DRAINAGE ENGINEERING 423 (1997).

IMPERIAL IRRIGATION DISTRICT, ANNUAL INVENTORY OF AREAS RECEIVING WATER: YEARS 2013, 2012, 2011, *available at http://www.iid.com/home/showdocument?id=9071.*

HARRY T. CORY & WILLIAM P. BLAKE, THE IMPERIAL VALLEY AND THE SALTON SINK 24 (1915).

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alfalfa amounts to 8 tons that she sells at a price of \$130 per ton. She has a return flow of 2.8 ac-ft, which means that the stream between plot A and plot B has 6.3 ac-ft available. The return flow can be used by other farmers and feed instream flows. For the purposes of the example, there are no groundwater effects. The evapotranspiration (ET) or the amount consumed (that is, depleted from the river) is 2.2 ac-ft. Not all of the 2.2 ac-ft of water is consumed by the plants.

Water that is not lost or wasted reenters the stream as return flow, available to downstream users and the overall ecosystem. In Scenario 1, farmer B produces pecans using flood irrigation. He relies on farmer A's return flow because he needs to divert 6 ac-ft from the 6.3 ac-ft available. His return flow is 3.1 ac-ft and the stream carries downstream 3.4 ac-ft.

2. Adopting Drip Irrigation

In Scenario 2, farmer A decides to change her irrigation method and she shifts from flood to drip irrigation. Once she has installed drip irrigation, she diverts 2.7 ac-ft (less diversion than Scenario 1), but she consumes all of it. There is no return flow. In the example, her yield has increased 25%, so her revenues have also gone up: from \$1,040 in Scenario 1 to \$1,300 in Scenario 2. Farmer A's diversion is lower, but her consumption has increased, so there is less water available in the stream after her plot.

In Scenario 2, the stream does not carry enough water for farmer B if he keeps using the same irrigation method and depends on farmer A's return flow to fulfill his needs. If farmer B cannot produce, the increase in revenues by farmer A is not enough to offset farmer B's losses. He, of course, could use all of the water available (or all the water available minus the water needed in the stream to protect the ecosystem if there was a minimum streamflow imposed) and still produce. But his production will decrease assuming no change in irrigation methods. The river flow will also decrease.

Drip irrigation is normally considered a more "efficient" irrigation method. It produces more crop per drop; that is, drip irrigation maximizes water productivity for that particular crop in a particular field. This efficiency, akin to technical efficiency,¹⁷ only refers to the particular farmer; it says nothing about the impact on allocative efficiency, that is, on whether it is efficient at a systemic level. If the farmer decides to change the irrigation system, then drip irrigation must also be economically efficient for the individual farmer because it may bring her more profit, which will allow her to recover the investment. But it may not be efficient in terms of the overall value obtained with water if other users cannot irrigate as a result of the increase in consumption.

Scenario 3 presents exactly the same situation as Scenario 2, except farmer B also installs drip irrigation. It may be thought that farmer A's change of irrigation method will give farmer B the proper incentive to do so. However, as the example shows, drip also increases farmer B's consumption, and thus there may be less water available for instream flows and other users downstream of farmer B. There is no way to know ex ante whether those users that now cannot irrigate would have produced more or less than the increase in farmers A and B's production resulting from the irrigation system change.

In Scenario 2, it is clear that the shift in irrigation systems by farmer A is not a Pareto improvement.¹⁸ Whether it could be Kaldor-Hicks-efficient will depend on whether the increase in farmer A's benefits due to increased yield, minus the capital investment in drip irrigation, is enough to offset not only farmer B's losses, but also those of further downstream users and the environment. Drip also has social benefits in the form of reduced nonpoint source pollution. However, there are regulations addressing nonpoint source pollution and, assuming those are enforced, if drip is the most efficient method to comply with them, farmers will change the irrigation method accordingly. Hence, if anything, pollution abatement may provide further incentives for farmers to adopt drip irrigation no matter how the volume of the right is calculated.

Proponents lauding the technical efficiency of drip irrigation do not fully consider whether water is being used in the most socially efficient way, which is what our policies prescribing or encouraging the shift to drip or sprinklers aim to achieve. In fact, it may well be that water, like many other assets, has decreasing marginal returns. This means that the extra water consumed by farmer A in Scenario 2 may produce less return than the same water being used by farmer B who could not irrigate otherwise. In other words, the increased revenue of the farmer whose consumption grows is not enough to offset the decrease in revenue of the farmer who now cannot irrigate at all.¹⁹

In sum, individually efficient irrigation systems are not equivalent to systemic efficiency. Also, if the measure of success were food production, the shift in irrigation methods only tells us that farmer A will produce more, but it does not tell much about the effects on overall agricultural production. The status quo may not be efficient, but a shift toward technically efficient irrigation methods does not unequivocally bring about a better situation systemically, even if some farmers produce more and pollute less,

^{17.} For a discussion of the positions of welfarists and environmentalists advocating economic efficiency as a reaction to the technological efficiency embraced in the 20th century, see Tarlock, *supra* note 3, at 147.

For a review of the concepts of technical and allocative efficiency and how legal scholarship has used them, see Lewis A. Kornhauser, A Guide to the Perplexed Claims of Efficiency in the Law, 8 HOFSTRA L. REV. 591 (1980).

^{19.} Deficit irrigation exposes the crop to a certain level of water stress. Sam Geerts & Rick Gaes, *Deficit Irrigation as an On-Farm Strategy to Maximize Crop Water Productivity in Dry Areas*, 96 AGRIC. WATER MGMT. 1275 (2009). Their analysis confirms that deficit irrigation can stabilize crop yields, not maximize them, provided there is some moisture. Some crops are better-suited to this than others, for example sugar beets and sunflowers. See Cevat Kirda, *Deficit Irrigation Scheduling Based on Plant Growth Stages Shoring Water Stress Tolerance, in DEFICIT LRIGATION PRACTICES* (Food and Agriculture Organization of the United Nations 2002).

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could sell the extra amount of water she is now consuming

to farmer B if he valued it more because he could profit

more from it than farmer A. Or farmer A could sell it to

those who want to protect the environment. But such a

because other farmers and the environment are likely to suffer from reduced water availability.

Scenarios 2 and 3 should not be problematic from an efficiency viewpoint if there were a perfectly functioning market for irrigation water. If that were the case, farmer A

SCENARIO I



market does not exist.20

SCENARIO 2



SCENARIO 3



^{20.} See infra notes 75-83 and accompanying text. As Section III.C. will describe, the proposal this Article puts forward may make water markets more efficient by reducing transaction costs.

Beyond this hypothetical example, there are several basinwide studies testing how technically efficient irrigation methods affect water distribution and welfare.²¹ For example, Frank Ward and Manuel Pulido-Velázquez analyze the effects of subsidized efficient irrigation techniques in the Upper Rio Grande Basin in the United States, specifically the 89,000 acres served by the Elephant Butte Irrigation District.²² Their findings confirm that return flows are an important source of supply for downstream users.²³ Their study considers the benefits and costs to farmers from increased yield, surplus of urban consumers, and net ecological benefits of reduced pollution and reduced flow, taking into account the enjoyment of nature as well as the costs of preserving it. Their results show that the adoption of those technologies does not reduce water usage even if the farmers are diverting less. The environment suffers. In their study, even though the change is beneficial for farmers as a group in the basin, it is not beneficial for the overall population.

Ward and Pulido-Velázquez provide their analysis on an aggregated basis, so it is not possible to analyze the harm imposed to some agricultural users. It is also not possible to identify whether farmers could increase yields to a profitable volume when shifting irrigation systems without increasing consumption. Government subsidies, at both the federal and state levels, play an important role in shaping the choices of the agricultural sector. As Section II.F. explains, existing public policy assumes that by encouraging the agricultural sector to adopt innovative irrigation technologies, more water will be available for other users and the environment. This logic is flawed and oversimplifies the reality of how more technically efficient irrigation systems function.

As Section II describes, the response that prior appropriation gives to certain individual technically efficient measures is unsatisfactory. To avoid the potentially undesirable effects that could arise from an increase in consumption, this Article puts forward a proposal in Section III: adding consumption as a variable to the definition of water rights under prior appropriation. This proposal is not the only way to address some of the effects that arise from changing irrigation methods, as Section III.F. shows.

II. Current Regulation and Its Problems

A. Current Definition of Prior Appropriation Rights

Settlers of the states west of the 100th meridian understood early on that sensible allocation of water was key for their societies to thrive. It did not take them long to learn that legal solutions developed on the East Coast would not provide much help. Riparianism, which confers upon those owning a land adjacent to a river a right to a reasonable use of water, proved particularly ill-suited for the West, where the most profitable uses, like mining or irrigated agriculture, occurred further from the streams. The shortcomings of riparianism paved the way for a shift to prior appropriation, under which rights to use water are acquired by diverting water and putting it to beneficial use. Prior appropriation's original goal was producing as much as possible.

Charles Meyers summarizes the elements of prior appropriation in his 1971 report to the National Water Commission:

A property right in the use of water is created by diversion of the water from a stream (or lake) and its application to a beneficial use. Water can be used at any location . . . In the event of a shortage of supply, water will be supplied up to a limit of the right in order of temporal priority: the last man to divert and make use of the stream is the first to have his supply cut off.²⁴

Prior appropriation has remained the cornerstone of water law in the American West. Modern statutory systems have adopted the tenets of prior appropriation. The main difference between common-law prior appropriation and statutory prior appropriation is that under the latter, the user needs to apply for a right before a water agency and, thus, agencies have a tighter control over those rights.

The question of whether a farmer can increase her consumption if she does not divert more water when shifting irrigation methods was addressed for the first time before a court in the interstate compact dispute between Montana and Wyoming. The 1951 Yellowstone River Compact grandfathered pre-1950 water use rights in both Montana and Wyoming, giving those rights the highest priority. Wyoming appropriators, the upstream users, consumed more water as a result of adopting sprinklers as an irrigation method, and there was not enough water for Montana's pre-1950 appropriators. Montana argued that such an increase in consumption violated the compact. The Supreme Court was asked to decide whether the technological change, and the concomitant reduction in water flows, conformed to the Yellowstone River Compact, which provided that pre-1950 rights "shall continue to be enjoyed in accordance with the laws governing the acquisition and use of water under the doctrine of appropriation."25

The Supreme Court, following the special master's report from 2011, concluded that the Compact did not prohibit pre-1950 Wyoming appropriators from increasing their consumption on existing acreage to the detriment of pre-1950 Montana appropriators. Even though the decision of the Supreme Court is not binding for prior appropriation states when it comes to defining their water rights, it serves as an analysis of how prior appropriation treats the change in irrigation methods with the subsequent increase in consumption. The position of Wyoming upstream made it akin to the position of a senior right holder in the river.

^{21.} See supra note 4.

^{22.} Ward & Pulido-Velázquez, supra note 4.

^{23.} Id. at 18219.

^{24.} Charles J. Meyers, A Historical and Functional Analysis of the Appropriation System 4 (1971).

^{25.} Yellowstone River Compact, Pub. L. No. 82-231, 65 Stat. 663, art. V.A.

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As the Court concludes, prior appropriation permits such a change in irrigation methods, even if those changes may increase the amount of water used. In fact, prior appropriation may incentivize water rights holders to consume more. Some tenets of prior appropriation illustrate this point.²⁶

First, beneficial use is the "basis, the measure, and the limit" of an appropriation.²⁷ It is a necessary element to establish a right. As a limit and a measure, beneficial use affects two dimensions: the type of use and the amount used. The type of use is of less consequence for present purposes, but it is important to note that this is one element that has evolved through time. Initially, consistent with the idea of unfettered consumption to maximize production, only consumptive uses such as agricultural or domestic were considered beneficial. Increasingly, though, non-consumptive ones have been recognized. Non-consumptive uses not only include hydropower, but also the protection of ecosystems.

In relation to the entitlement given by a water right, prior appropriation grants a right to the amount of water put to beneficial use. The amount put to beneficial use is normally measured according to the amount diverted. Initially, it was so because diversion was a way to give notice to other users that an appropriation was happening.²⁸ In fact, the ditch capacity was the limit; a farmer could not obtain a right larger than the amount she could divert. It was assumed that someone would not build infrastructure capable of conveying more water than they needed because that would have been an irrational investment. In fact, even today, some states use diversion facilities to measure the volume of the right that is used.²⁹ Often, however,

- 27. United States v. Alpine Land & Reservoir Co., 697 F.2d 851 (9th Cir. 1983) The issue we review is whether the district court reached a correct determination of beneficial use as of 1980. It is settled that beneficial use expresses a dynamic concept, which is a "variable according to conditions," . . . the use cannot include any element of "waste" which, among other things, precludes unreasonable transmission loss and use of cost-ineffective methods.
 - Cost-effective methods is a very open-ended concept.
- 28. Barton H. Thompson Jr. et al., Legal Control of Water Resources 216 (5th ed. 2013).

"Under prior appropriation, a diversion traditionally served dual purposes—providing notice of a user's intent to appropriate water, and defining the extent of the use." In re Adjudication of Existing Rights to the Use of All Water, 2002 MT 216, P22 (Mont. 2002).

 The definition of conserved water in Oregon takes existing diversion as the measure to calculate the baseline against which to measure conservation. Or. ADMIN. R. 690-018-0020(4):

"Conserved Water" means that amount of water that results from conservation measures, measured as the difference between: (a) The smaller of the amount stated on the water right or the maximum amount of water that can be diverted using the existing facilities; and (b) The amount of water needed after implementation of conservation measures to meet the beneficial use under the water right certificate. the amount in the paper right, which was normally based just on the declaration of the appropriator, was larger than the amount really put to use because the facilities were not used to their full capacity.

Today, overstating rights is less common because the agencies or the state engineers approve the applications. However, agencies work under the premise that users are not employing all the water they have been granted.³⁰ For example, in California, where the recording system is still incomplete,³¹ rights have been granted for five times the amount of water available.³² Such a situation exacerbates the effects of allowing right holders to consume all the water they were granted because other users have been relying for decades on those users' return flows.

Even though many have labeled irrigation practices like flood or furrow wasteful because some water evaporates and other goes back to the river, these practices have not been outlawed by a thorough enforcement of beneficial use.³³ A beneficial use is a reasonable one³⁴ and there is no vested right to waste water.³⁵ Rarely enforced, the prohibition against waste has focus on the means of conveyance³⁶ or certain outrageous practices such as drowning gophers. But irrigation practices have not been tackled. Waste provisions have been interpreted in a way that is very deferential to the irrigator's choice of irrigation method.³⁷ Beneficial use has thus not worked as a technology-forcing doctrine.³⁸ This current understanding of beneficial use that accepts historical irrigation practices is often criticized for not encouraging conser-

- 33. For a critical view of this interpretation as one that undermines prior appropriation itself, see Reed D. Benson, *Maintaining the Status Quo: Protecting Established Water Uses in the Pacific Northwest, Despite the Rules of Prior Appropriation*, 28 ENVTL. L. 881 (1998).
- 34. State Dep't of Ecology v. Grimes, 121 Wash. 2d 459, 852 P.2d 1044 (Wash. 1993).

The current Washington definition is: "Beneficial use involves the application of a reasonable quantity of water to a non-wasteful use, such as irrigation, domestic water supply, or power generation, to name a few." State of Washington, Department of Ecology, *Water Rights*, http://www.ecy. wa.gov/programs/wr/rights/water-right-home.html (last visited Oct. 12, 2016).

- 35. DAVID H. GETCHES, WATER LAW IN A NUTSHELL 129 (2009).
- 36. Tonkin v. Winzell, 27 Nev. 88 (Nev. 1903). State ex rel. Crowley v. District Court, 88 P.2d 23 (Mont. 1939). When some conveyance means have been considered wasteful, the parties claiming the waste may be required to pay part of the cost of the works to decrease waste and improve the efficiency of the conveyance means.
- 37. "[A]n appropriator cannot be compelled to divert according to the most scientific method known. He is entitled to make a reasonable use of the water according to the general custom of the locality." Janet C. Neuman, *Beneficial Use, Waste, and Forfeiture; The Inefficient Search for Efficient Western Water Use*, 28 ENVTL. L. 919, 933 (1998).
- 38. Richard B. Stewart & Bruce A. Ackerman, *Reforming Environmental Law*, 37 STAN. L. REV. 1333 (1985). This is no different though than other technology-forcing provisions adopted in antipollution statutes. When an industry is subject to a best available technology provision, its permit includes neither a vague reference imposing the most innovative technology available nor a specific technology; instead, it quantifies how much pollutant the permittee may discharge.

^{26.} Montana v. Wyoming, 131 S. Ct. 1765, 179 L. Ed. 2d 799, 41 ELR 20168 (2011).

In *Montana v. Wyoming*, the special master considered that depletion could not be the measure of the right. Instead he, and the majority of the Supreme Court, believed that the compact adopted diversion as the measure as it was conventional at the time, while depletion was unfamiliar. Supplemental Opinion of the Special Master on Wyoming's Motion to Dismiss Bill of Complaint 9 (Sept. 4, 2009) [hereinafter Supplemental Opinion] on *Montana v. Wyoming and North Dakota*, No.137.

Adell Amos, Freshwater Conservation in the Context of Energy and Climate Policy: Assessing Progress and Identifying Challenges in Oregon and the Western United States, 12 U. DENV. WATER L. REV. 1, 42 (2011).

Theodore E. Grantham & Joshua H. Viers, 100 Years of California's Water Rights System: Patterns, Trends, and Uncertainty, 9 ENVTL. Res. LETTERS 1, 3 (2014).

^{32.} Id.

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vation.³⁹ The current interpretation may change, but that is yet to be seen.⁴⁰

Given that the volume a water right entitled has been roughly measured as the amount diverted, return flow was included in the right. The doctrine of recapture confirms it. With few exceptions, a farmer or other water right holder can recapture water before it leaves her property and returns to the stream from which it came.⁴¹ The common example to understand this doctrine is a user who employs flood irrigation and thus returns a lot of water to the river, and who builds a little paved ditch at the end of her property to collect water that would otherwise be lost to her use because it was returning to the stream. Even though junior users acquire rights to the stream as it exists⁴² and depend on return flow, junior appropriators relying on others' "waste" often have no legal claim to it.⁴³

Another way to present the claim made by this Article is to argue that return flow is insufficiently protected; those who are relying on return flow should not be at the mercy of other senior or upstream irrigators who decide to change their crops or their irrigation systems. There are very few

- Montana v. Wyoming, 131 S. Ct. 1765, 1775, 179 L. Ed. 2d 799, 41 ELR 20168 (2011).
- 42. As stated in Vogel v. Minnesota Canal & Reservoir Co.:

This court has often said, in substance, that a junior appropriator of water to a beneficial use has a vested right, as against his senior, in a continuation of the conditions on the stream as they existed at the time he made his appropriation. If this means anything, it is that when the junior appropriator makes his appropriation he acquires a vested right in the conditions then prevailing upon the stream, and surrounding the general method of use of water therefrom. He has a right to assume that these are fixed conditions and will so remain, at least without substantial change, unless it appears that a proposed change will not work harm to his vested rights.

Vogel v. Minnesota Canal & Reservoir Co., 107 P. 1108, 1111 (Colo. 1910). The change planned by a senior in this case was changing the point of diversion, but the principle it states should encompass the change of irrigation methods.

43. Recapture must happen on one's property before water has returned to the stream. In the interstate water dispute mentioned above, Montana argued that this rule does not apply when the water returns to the same stream from which it was originally drawn, citing the Utah case *Estate of Steed v. New Escalante Irrigation Corp.*, 846 P.2d 1223 (Utah 1992). In this case, an estate was unable to collect damages from an irrigation corporation that changed its flood irrigation to a pipe-based sprinkler system, because the runoff from irrigation would not have reached the same stream from which the water was taken. Lawrence MacDonnell, analyzing Montana's arguments in *Montana v. Wyoming* in relation to this issue, claims that:

the doctrine [of recapture] should be limited to those appropriations that contemplated the necessity for such recapture to achieve their intended beneficial purpose. Otherwise, water properly diverted and applied to beneficial use that remains unconsumed after use should be regarded as returned to the hydrologic system and available for use according to state laws once it leaves the appropriator's lands. cases where those relying on return flow have been protected, and none refers to changes in irrigation methods or change of crops.⁴⁴ According to Tarlock, in protecting return flow, these decisions show a preference for equity over efficiency under prior appropriation.⁴⁵ This Article argues that in terms of both equity and efficiency, return flow should no longer be part of the water right of the user returning it to the river.

A farmer entitled to consume as much as she diverted will do so if it is beneficial for her to consume as much. She may have incentives to consume all the water she has a right to divert, not only because that amount may allow her to produce more, but because of regulatory incentives. Under prior appropriation, water rights can be forfeited if they go unused for a specified period of time, no matter what the intent of the user is. The "use-it-or-lose-it" doctrine implies the loss of all or a portion of the right. Those forfeiture provisions may motivate the farmer to divert as much as possible⁴⁶ and, where using technically efficient irrigation techniques, the majority or all of the water diverted will be consumed. Given that an increase in consumption is likely to harm other users, forfeiture provisions alone cannot achieve their original aim of protecting the investments made by juniors who were relying on the unused rights of others.⁴⁷

Junior users have another source of protection: senior water right holders may have priority in times of shortage but they cannot do all they please. Some changes in their water rights are subject to the "no-injury" rule, which holds that a senior appropriator cannot make certain changes in the way it uses its water if they would harm the junior user. Montana and Wyoming, for example, require prior appropriators to apply for a change in their right when they plan to alter the type of use, the place of use, or the point of diversion. This rule reflects the reality that such changes may harm other users in the stream since they alter the quantity and quality of the flow. The no-injury rule does not apply to changes in consumptive use caused by a change in irrigation methods or crops.⁴⁸

^{39.} There seems to be a contradiction between two values that waste provisions may embody: economic efficiency and stability. While the anti-waste tenet in beneficial use seems to be based on utilitarian values, the interpretation seems to be based on stability and preservation of the status quo. Michael Pappas, *Anti-Waste*, 56 ARIZ. L. REV. 741 (2014).

^{40.} Neuman, supra note 37.

Lawrence J. MacDonnell, Montana v. Wyoming: *Sprinklers, Irrigation Water Use Efficiency, and the Doctrine of Recapture*, 5 GOLDEN GATE U. ENVTL. L.J. 265 (2012). MacDonnell would require an intention for recapture to be allowed. He proposes the application of his reinstatement of the doctrine to apply across the board, no matter the technicalities of the different states' water laws that differentiate between seepage, wastage, drainage, or return flow.

^{44.} For a comment on these cases, see GEORGE RADOSEVICH, WESTERN WATER LAWS AND IRRIGATION RETURN FLOW 75, 100 (1978). Two illustrative cases are *Kovacovich* and *Shelton Farms*. In *Kovacovich* [Salt River Valley Water Users' Ass'n v. Kovacovich, 3 Ariz. App. 28, 411 P.2d 201 (Ariz. Ct. App. 1966)], the court found against a farmer who lined her ditches and used the recovered water to irrigate land beyond that for which the water right was granted. In *Shelton Farms* [Southeastern Colo. Water Conservancy Dist. v. Shelton Farms, Inc., 529 P.2d 1321 (Colo. 1974)], the person who eliminated phreatophytes was found not to be entitled to the water those plants used to consume and, instead, the downstream users were.

^{45.} Tarlock, supra note 3, at 156.

^{46.} Krista Koehl, Partial Forfeiture of Water Rights: Oregon Compromises Traditional Principles to Achieve Flexibility, 38 ENVTL. L. 1137, 1139 (1998). In re Willow Creek, 144 P. 505 (Or. 1914), is a decision that states that the water saved by more efficient irrigation systems is forfeited to the state.

Charles B. Roe & William J. Brooks, *Loss of Water Rights: Old Ways and New*, 35 ROCKY MTN. MIN. L. INST 1, 3 (1989).

^{48.} Bower v. Big Horn Canal Ass'n, 77 Wyo. 80 (Wyo. 1957) ("If the senior appropriator by a different method of irrigation can so utilize his water that it is all consumed in transpiration and consumptive use and no waste water returns by seepage or percolation to the river, no other appropriator can complain."). However, in that case, water was not returning to the same stream.

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For example, a farmer in Arizona has the right to change from maize production to sugarcane, which consumes twice as much water,⁴⁹ and to disregard the effects this will have on junior appropriators. The same farmer cannot move her production to a different farmland further upstream if the flow of the river would be affected and her former junior downstream neighbor would be harmed. That farmer who was originally growing maize will not be able to grow sugarcane upstream because it consumes more and it will harm other users. The differential treatment of those different changes, even though their effects on juniors are similar, seems incoherent and lacks a justification in terms of allocation efficiency or fairness.

Another source of inconsistency arises in relation to water transactions. A user can transfer her water right but the transfer is subject to the no-injury rule. In practice, this rule has meant that only the amount historically consumed can be transferred.⁵⁰ It can be said that water rights have different definitions when used by the original right holder than when transferred. If the farmer growing maize sells the water to another farmer who has a field of similar acreage growing sugarcane, the latter will most likely be permitted to consume only as much water as the former was consuming when growing maize.

B. Statutes Encouraging Agricultural Water Conservation

Even though the general definition of rights under prior appropriation does not protect junior users or the environment from changes in irrigation methods or crops, some state statutes encouraging conservation have acknowledged the paradox exposed in this Article-that technologically efficient irrigation methods may increase consumption. Those statutes do not understand conservation as a synonym of development of supplies through dams as it was understood in the past, but as a way to save water by some users to ensure other users can satisfy their demands. These statutes give incentives to shift irrigation methods granting rights over the conserved water to the right holder implementing the conservation practices, protecting her also from forfeiture. Some statutes also give financial incentives to farmers to help them fund the initial capital investment needed to implement technically efficient irrigation practices. The statutes either define conservation plainly as a reduction in the amount consumed historically or subject the right to conserved water to a no-injury rule.

In 1992, California enacted the Agricultural Water Conservation and Management Act. The Act defined conservation as "the reduction of the amount of water consumed or irretrievably lost in the process of satisfying beneficial uses which can be achieved either by improving the technology or the method for diverting, transporting, applying, reusing, salvaging, or recovering water, or by implementing other conservation methods."51 This is a satisfactory definition of conservation, understood as an increase in overall efficiency in water allocation, such that no one will be made worse off. Washington's Trust Water Rights Program, enacted in 1991, refers to "net water savings," which are defined as:

the amount of water that is determined to be conserved and usable within a specified stream reach or reaches for other purposes without impairment or detriment to water rights existing at the time that a water conservation project is undertaken, reducing the ability to deliver water, or reducing the supply of water that would otherwise have been available to existing uses.

Washington and California have regulated conservation as the reduction in consumption, not giving farmers the possibility of double-dipping by profiting from their own purportedly wasteful practices and receiving subsidies for not conserving water. Thus, in those states, the farmer installing drip irrigation has the choice of keeping her right as it is, perhaps facing a reduction in the amount she is entitled to as a result of her reduced diversion under drip irrigation, consuming more water, or reducing consumption and being able to take title to the amount of water she no longer consumes.

The definition of conservation as the reduction in consumption has not been adopted everywhere. Oregon used to define conservation as "the amount of water, previously unavailable to subsequent appropriators, that results from conservation measures." But this policy did not succeed, and very few applications were received. In 2003, a new statute defined conservation as "the reduction of the amount of water diverted to satisfy an existing beneficial use achieved either by improving the technology or method for diverting, transporting, applying or recovering the water or by implementing other approved conservation measures."⁵²

Apparently, the explanation behind the adoption of such a definition is one of public choice. Agricultural interests convinced the Oregon Legislature that this more open-ended definition would still generate incentives for conservation. It may indeed generate incentives to install sprinklers or drip irrigation pipes conserving water that would otherwise be lost to evaporation, but it may not contribute to overall water efficiency if the consumptive use is increased despite the reduction in diversion. Strangely

^{49.} Food and Agriculture Organization of the United Nations, Irrigation Water Management: Irrigation Water Needs ch. 3 (1986), *available at* http://www.fao.org/docrep/S2022E/s2022e07.htm.

^{51.} CAL. WATER CODE \$10521(a), the Agricultural Water Conservation and Management Act.

^{52.} OR. REV. STAT. §537.455: Definitions for ORS 537.455 to 537.500 and 540.510.

Colorado has never successfully passed a conservation statute, but the Colorado Water Conservation Board uses a definition based on decrease in use: "Water conservation is any beneficial reduction in water loss, waste, or use. It is the reduction in water use accomplished by implementation of water conservation or water efficiency measures. It is improved water management practices that reduce or enhance the beneficial use of water."

enough, environmental groups supported the statute, equating reduced diversion with reduced consumption.⁵³

In addition, Oregon's conservation statute allows the farmer to keep 75% of the water conserved, while the other 25% is allocated to the state. The 25% might be reduced if the farmer has received public funds to pay for the change in irrigation systems. This division of the water conserved-that is, the amount by which the diversion has been reduced-suggests that the fear of forfeiture for not diverting all of it may have been a concern. However, in order to determine the amount conserved, the reduction of diversion is reduced to ensure that other water rights are not harmed. This means that a farmer can increase her consumption by implementing conservation policies, but will only acquire a right over the amount conserved if her change does not impose negative externalities on other users. There is no mention of negative effects on the environment, but the allocation of 25% of the conserved water may mitigate those concerns. The fact that the statute limits the amount of water conserved that the user implementing conservation practices is entitled to when other users are harmed implies that conservation practices will be treated more favorably in streams where water is abundant.

Even though the definitions of conservation in the three statutes analyzed take into account the paradox exposed in the scientific literature, the farmer may still prefer to do without the incentives and shift irrigation methods. If the general definition of prior appropriation is not changed, a farmer may still find it more profitable to shift irrigation methods, increasing consumption. It may be more profitable because of the higher yield she produces when consuming more and because if she increases the amount consumed today, she will be able to sell a higher amount of water in the future. Profits from increased consumption may be higher than the profits from a lower yield and lower water application under drip irrigation today and the expected profits from using or selling, subject to a more streamlined procedure, the amount of water she no longer consumes immediately.

It is important to note that the conservation statutes analyzed in this Article assume that the farmer was not wasting water before,⁵⁴ which means that although many consider flood or furrow irrigation practices wasteful and inefficient, the statutes allow farmers to profit from their previous inefficiency.

Unfortunately, not all initiatives to promote conservation have protected other users from the potential increase in consumption. This is the case of federal agricultural programs. The federal Agricultural Water Enhancement Program, part of the Farm Bill's Environmental Quality Incentives Program (EQIP), was proven not to achieve real water conservation. Bills were introduced to correct it,⁵⁵ but they were ultimately not approved. These programs gave subsidies to farmers to implement technically efficient irrigation methods, sometimes in cooperation with the states.⁵⁶ Given the potential increase in consumption and the effects on other users and the environment, those subsidies may not render social benefits.⁵⁷

III. Better Incentives Through a New Measure of Rights: Consumptive Volume

A. Definition

Montana v. Wyoming showed the effects at an interstate level of shifts of irrigation methods, but similar situations must be arising internally as well. Recently, state policymakers have started to acknowledge the problems that accompany shifts to efficient irrigation systems. As more efficient methods are adopted, some farmers may produce more, but less water may be available for other users. The conservation statutes of Oregon, Washington, and California illustrate that states are starting to realize the effects. Those statutes only count as savings the reductions in consumption, not only the adoption of efficient irrigation systems that divert less. None of the states have addressed it in the general regulation of water rights. The New Mexico Interstate Stream Commission commissioned a report to study precisely the increase in consumption that a shift from flood to drip irrigation can bring about.⁵⁸ But New Mexico has yet to take measures to address it. It is time that prior appropriation evolves, like it has done in the past to adapt to changes in social values.

Today, consumptive use, as the Idaho Code puts it, is not part of the definition of the right. The amount of water put to use when a right holder appropriates the right

57. Ward & Pulido-Velázquez, supra note 4, at 18219.

Ray Huffaker & Normal Whittlesey, The Allocative Efficiency and Conservation Potential of Water Laws Encouraging Investments in On-Farm Irrigation Technology, 24 AGRIC. ECON. 47, 58 (2000).

^{54.} Neuman, supra note 37, at 957.

^{55.} As part of the EQIP, the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Agricultural Water Enhancement

Program (repealed by the 2014 Farm Bill; *see* http://www.nrcs.usda.gov/ wps/portal/nrcs/main/national/programs/financial/awep/) funded several of these projects. NRCS would pay up to \$400 per acre, which means it would cover from 25% to 50% of the capital cost of drip irrigation per acre.

In 2013, Sen. Tom Udall (D-N.M.) introduced a bill to make sure that taxpayer-funded irrigation improvements result in real savings (S. 923, 113th Cong. (2013/2014)—Balancing Food, Farm, and the Environment Act of 2013) after several studies showed that federal subsidies aiming at conservation translated into more water consumption. Ron Nixon, *Farm Subsidies Leading to More Water Use*, N.Y. TIMES, June 6, 2013, http://www. nytimes.com/2013/06/07/us/irrigation-subsidies-leading-to-more-water-use.html?_r=0.

^{56.} In Montana, EQIP aids farmers in switching to more efficient irrigation systems, generally from flood irrigation to center-pivot sprinkler irrigation. To receive the funding, farmers must complete the Farm Irrigation Rating Index (FIRI), which predicts the increase in efficiency that would result from switching irrigation systems given specific data provided by the individual. FIRI must report at least a 10% hypothetical increase in efficiency to ensure eligibility. The FIRI measure of efficiency is neither a measure of consumption nor diversion. It is a calculation that takes into account conveyance efficiency and application efficiency. Thus, the goal of EQIP in Montana is not conservation in the sense of reducing consumptive use. Rather, the focus is to increase water productivity or yield.

^{58.} New MEXICO INTERSTATE STREAM COMMISSION, REMOTE-SENSING-BASED COMPARISON OF WATER CONSUMPTION BY DRIP-IRRIGATED VERSUS FLOOD-IRRIGATED FIELDS (2013), *available at* http://nmawsa.org/ ongoing-work/agricultural-water-use/comparison-of-water-consumptionby-drip-irrigated-versus-flood-irrigated-fields/view.

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defines the volume of the said right.⁵⁹ It is normally measured according to the volume diverted. But this needs to change. I propose to define water rights both in terms of diversion and in terms of consumption or depletion. Adopting consumption as part of the right's definition will prevent the detrimental incentives to right holders when adopting modern irrigation technologies, sometimes aided by public subsidies funding part of the cost of that investment. But it will also address the effects of other farming decisions such as a change in crops.

In short, this Article proposes that the farmer should lose the right to her return flow. Or in other words, a right holder will be entitled to keep diverting the same amount but could only consume the amount she had been consuming on average over the past five years, whether or not she changes the method of irrigation or the crops. The number of years across which to average consumption may be debatable, but five years is a common measure in water law. For example, in Washington State, the amount of water that a consumptive user can donate, sell, or lease to the state to become a trust water right, that is, a right on behalf of the environment, is calculated according to the extent the right was exercised in the past five years.⁶⁰ This historical account should mitigate the potential moral hazard of increasing the consumption in the very last period before the measure was implemented.

Under this proposal, a farmer could decide to keep irrigating using flood or furrow irrigation, diverting the same amount and consuming the same amount. She could also choose to install sprinklers and divert less, but she will not be able to consume more than she did in the status quo. Even without increasing her consumption when shifting to sprinklers or drip, her plants may be consuming more than in the status quo where she used flood irrigation because part of the ET was lost due to evaporation, but with drip there may not be any evaporation.

Under my proposal, in the example used in Section I, farmer A, who has a prior appropriation right of 5 ac-ft, could only consume 2.2 ac-ft. This is the amount she consumed when she was flooding her field to grow alfalfa. If she decides to change the irrigation method, as she does in Scenario 2, she will not be able to consume 2.7 ac-ft as she did in that example. She would have to keep consuming 2.2 ac-ft at most even though her right would have entitled her to divert 5 ac-ft. Where using drip, the 2.2 ac-ft may be consumed by the plants, while with flooding, part of the amount consumed is lost to evaporation.

In my proposal, current total forfeiture rules will apply to both dimensions: diversion and consumption. That is, completely unused rights will be forfeited. Partial forfeiture rules should not apply when the change in the amount diverted comes from better irrigation practices or changes to less water-intensive crops. Once the consumptive volume a right entitles has been defined, reductions in consumption could be sold or leased to other users. Those reductions shall be protected from forfeiture in order to give incentives to adopt better irrigation practices, as California's conservation statute does. Users would be protected to keep diverting as much as they were diverting.

Conversely, if partial forfeiture rules applied to diversion, they could be mostly innocuous to the farmer. If a farmer installs a more advanced irrigation system and only allows it to consume the amount that under the prior system was depleted, she will be diverting less than before. However, for her, losing the difference between the volume she diverts today and the volume she diverted in the past has no effect. She has no incentive to divert more in the future, because to do that will imply uninstalling the new equipment and losing the investment, only to divert more but consume the same.⁶¹ Having said that, since there might be new innovations in irrigation that could perhaps require more diversion for the same consumption, diversion needs to remain as one, but not the only, measure of a water right. Consequently, it would be better to derogate partial forfeiture provisions for these cases. Additionally, she may be able to sell a non-consumptive right to the total amount diverted.

For new permits, including the amount consumed in the definition of rights could be an opportunity to adopt a technology-forcing provision.⁶² Agencies granting water permits could define the consumptive and diversion volumes of a right according to the best available irrigation technology instead of their current practice of granting the amount requested by private parties within the limit of the water duties,⁶³ which tend to be too generous. For new permits, drip or microspray may be the technology chosen because they reduce evaporation and fewer pollutants end up in the river. Agencies could tailor the volume to each permit depending on the soil and the crop because the agencies will already have the relevant information in order to regulate existing permits. Alternatively, they could create a duty of water, which averages water needs accord-

^{59.} Idaho Code §42-202В.

^{60.} Wash. Rev. Code §90.42.080(4).

^{61.} This would mean that in some cases the river flow may be reduced—not the amount available for others to use—between the point of intake and the return of the farmer who is diverting more than before, but not more than she was diverting in the first place. Thus, some small externalities may occur that may need to be disregarded.

Arizona's groundwater management regulations include a technologyforcing provision for non-irrigation uses at ARIZ. REV. STAT. ANN. §45-566.

^{63.} Another application of the reasonable-use requirement centers on the water duty required to satisfy the appropriator's end use. "Water duty" is generally equated with the amount of water that, through efficient and prudent management without unnecessary waste, is reasonably required for land to produce a maximum amount of crops as are ordinarily grown. "The extent of the duty to conserve must take into account what conservation measures are financially and physically feasible." Water duty requirements take into consideration the amount of water that may adequately serve the water requirements of various end uses. The appropriator is not entitled to apply water to an end use in a wasteful manner.

CAL. WATER CODE \$1004 provides that 2.5 ac-ft of water per acre is the maximum amount of water that can be applied to uncultivated land. Other water duty factors have been established by the State Water Resources Control Board and are contained in CAL. CODE REGS. tit. 23, \$697. In the absence of a statutory guideline, the applicable water duty is a question of fact that is dependent on the particular circumstances of any given case. SCOTT S. SLATER, 1-2 CALIFORNIA WATER LAW AND POLICY \$2.27 (LexisNexis 2015).

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ing to the most common crops in the area when using the irrigation technology of their choice.

B. Effects of the Proposal

I. Reliance of Junior Appropriators

The priority system in prior appropriation is a mechanism for sharing the effects of a drought. When there is not enough water to satisfy the rights of everyone, those who appropriated the right first will be served first. Senior users are normally farmers and, thus, they are not necessarily the ones that value the water most. Similarly, it is implausible to assume that upstream farmers are more productive than downstream ones. At equal priority, upstream users have an advantage over downstream users under the current system: if rights are just measured according to diversion, and upstream consumption increases, the users downstream will have less water available to them.

The above is what happened in *Montana v. Wyoming*, where pre-1950 appropriators from both states have the same priority. However, because Wyoming appropriators decided to change their crops or irrigation methods, there was not enough water downstream. Similarly, groundwater users, where groundwater and surface water are regulated as if they were two separate bodies of water, may see their aquifers depleted not by their pumping, but because some surface water right holders have consumed more than they used to and, thus, the recharge of the aquifer has been reduced.⁶⁴

Those junior or downstream appropriators have been relying on that return-flow water for decades. Diversion was a sound measure in the past because it was administrable, but so was relying on the river as junior appropriators or downstream users found it. Those users knew that if it was a dry year, they may not get enough water. They could not expect that upstream or senior appropriators would start using their paper rights in full, despite the doctrines of recapture. Any of those users relying on the river as it flows to them "frequently cannot ascertain what portion of the flow of a stream is natural and what portion represents return flow from upstream users."65 Recapture of runoff is more the exception than the rule.66 Those other users, who relied on the return flow that some farmers have now reduced, are the ones whose investment-backed expectations may be defeated under the current system if the adoption of new irrigation technologies keeps growing.

2. Streamflow Unaltered

The example in Section II focuses on the interaction between two farmers. However, there are other users in the river that may be affected by the increase in consumption that prior appropriation embraces and that some conservation statutes sanction. In particular, fish and wildlife are likely to be affected by an increase in consumption, because there will be less water flowing. The decrease in flow does not necessarily happen when there is a change in one of the characteristics of a right or when it is transferred, and these changes are subject to a review to prevent uncompensated effects on third parties and the environment.⁶⁷

Environmental concerns have increased in recent decades and in particular in the area of water management, where they are expressed in legal regimes like the Endangered Species Act (ESA),⁶⁸ the public trust doctrine, and the protection of instream flows. Instream flows have been protected via, among other things, minimum flow requirements or non-consumptive rights. The decision of the Supreme Court in *Montana v. Wyoming*⁶⁹ pays lip service to this developing central theme in the way society views water. Its analysis focuses only on the theme that existed at the birth of prior appropriation: water as a commodity. Water was an input to make our economies thrive through unfettered consumption.⁷⁰

Today, both beneficial use and the regulation of water transfers reflect that regard for the environment. Related to beneficial use and its evolution, the inclusion of instream non-consumptive uses as beneficial uses stands out. Nowadays, private organizations and/or administrative agencies can hold rights to protect fish and wildlife. Our concern for fish species and river ecosystems is also reflected in the approval procedure in water markets. Transfers of conserved water for less than one year, which imply a decrease in diversion, are subject to a less demanding procedure in California, because fewer effects are expected when less water is used. However, those transactions are still subject to a binding standard that they produce "no unreasonable effects on fish and wildlife."71 This supplemental provision is necessary because the transactions may alter the geography of where water flows, as in any change to a water right. Even in the absence of a regulation imposing limits on the amount consumed or not imposing compensation of harm to other users, minimum streamflows should be protected from these changes. In this regard, it may be advisable for states to at least adopt a provision similar to Oregon's conservation statute, which allocates 25% of the water conserved to the state.

^{64.} This could happen, for example, in Pixley Irrigation District (California); see Brett Walton, Spending to Conserve Water on California Farms Will Not Increase Supply, CIRCLE OF BLUE, Feb. 28, 2014, http://www.circleofblue. org/waternews/2014/world/conserve-water-california-not-increase-supply/.

^{65.} George A. Gould, Water Use and the Prior Appropriation Doctrine, in WESTERN WATER; EXPANDING USES/FINITE SUPPLIES (Natural Resources Law Center, University of Colorado School of Law 1986), http://scholar.law. colorado.edu/cgi/viewcontent.cgi?article=1008&context=western-waterexpanding-uses-finite-supplies.

^{67.} See id.

^{68. 16} U.S.C. §§1531-1544, ELR Stat. ESA §§2-18.

Montana v. Wyoming, 131 S. Ct. 1765, 179 L. Ed. 2d 799, 41 ELR 20168 (2011).

Barton H. Thompson, Water as a Public Commodity, 95 MARQ. L. REV. 17, 23-24 (2011); Steven J. Shupe, Waste in Western Water Law: A Blueprint for Change, 61 OR. L. REV. 483 (1982) ("Antiquated legal interpretations unsuited to a conservation ethic restrict the ability to manage wisely the limited waters of the arid west.").

^{71.} Cal. Water Code §1011(b).

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3. Fewer Incentives to Grow Water-Intensive Crops

If rights are defined according to consumptive use, not only will changes in irrigation methods not increase the amount of water depleted from the basin, but neither will changes in crops. Today, a farmer can change from soybeans to alfalfa without applying for a change in the irrigation permit.⁷² The expansion of almond farming in California has received many critiques in the midst of the current drought because almonds are a permanent crop that cannot be fallowed and consumes more water than tomatoes or grapes.⁷³

It is not feasible for a state water agency to police which crop each farmer is growing, and such policing seems to interfere too much with business decisions by the farmer. Agricultural models could be used to analyze those changes and how they affect other users, but if the proposal of this Article were to be adopted, there would be no need to require a farmer to apply for a change in a water right when deciding to plant a different crop. However, if a farmer decided to stop growing her current crop, she would need to choose a crop that consumes the same or less water, or plant it only in part of her acreage to ensure that her consumption does not increase.

4. Incentives to Shift Irrigation Methods Still Exist

Adoption of irrigation technologies such as drip irrigation could be beneficial if consumption would not increase. They could be socially beneficial because, among other effects, there would not be pollutants sent to the river via the return flow or runoff, thus creating savings in water purification, and fewer negative impacts on the environment, except for the potential increase in soil salinity in some areas. It may be argued that the proposal set forth in this Article decreases the incentives to adopt drip irrigation or sprinklers, even though those are beneficial for water quality, by not allowing users to consume more than they were consuming before. A farmer when deciding whether to install drip or sprinklers may decide not to if he cannot increase the amount he is consuming with a more traditional irrigation method.

My proposal tackles the potential negative externality less water available—that shifting to technically efficient irrigation methods imposes on other users who are relying on the return flow that a user has been returning to the river for decades. Drip or sprinklers may have a positive externality—reduced pollution—too. However, these two effects on third parties are not in the same currency (water quantity versus water quality), and the trade off cannot be made by assuming the positive externality is overall more socially beneficial. This Article addresses the negative externality in terms of increased consumption and leaves the management of nonpoint source pollution problems to clean water regulations. Given that nonpoint sources of water pollution mainly agricultural runoff draining into the rivers—can be regulated, as is the case in some states, compliance with those regulations may give further incentives to farmers to change irrigation methods if it were the less costly way to do so. For example, if a tradable water quality program were in place, farmers may decide to reduce the amount they pollute by installing drip or sprinklers and sell the credit to pollute to an industrial polluter.

The shift to drip and sprinklers may also be beneficial for individual farmers because they will also save in variable costs. They will save because drip and sprinkler technologies are less labor-intensive, and they increase yield; they produce more crop per drop. And there may be more drops because by shifting irrigation methods, the farmer can capture the amount of water that was evaporating when she used furrow or flood. Jurisdictions could design the measure of consumption to include more than the water previously consumed by plants and irretrievably lost. It could include the amount evaporated, increasing the incentives farmers would have to change irrigation methods.

Drip or sprinklers require some capital investment upfront. Modern irrigation technologies are costly, and perhaps unaffordable for many farmers, because in the short term the increase in yield will not be enough to recover the initial capital investment.⁷⁴ Multiple jurisdictions have adopted subsidies in order to decrease the costs that farmers face in adopting those technologies. Those subsidies could still work under the proposal set forth here. Perhaps, subsidies are even more necessary, because the increase in yield would be less if consumption after the installation cannot be higher than consumption under flood irrigation. If rights were defined according to consumptive use, those subsidies will be achieving their real goal.

It may be asked why we should have the taxpayer pay for those irrigation methods. To decrease the need for public subsidies, it could be said that perhaps it would be better to keep current policy where the farmer can increase the amount consumed so that she can recover the investment more quickly. In fact, one argument made in passing in the special master's report for *Montana v. Wyoming* is that we want farmers to be more efficient, even though the result of adopting those policies is reduced instream flow for other users.⁷⁵ Another way to give incentives without relying on subsidies would be to grant rights to the amount of water saved, as California does. But granting that right requires real water savings; consumption must be lower than in the status quo and, thus, yield may be also lower.

^{72.} Section II.B. above explains which changes require a change in the permit.

California Almond Growers to Expand Orchards, Despite Drought, SACRAMENTO BEE, Apr. 16, 2014.

^{74.} The cost of installing sprinklers is around \$550 per acre and installing drip irrigation can average \$1,200 per acre. Howard Neibling, Irrigation Systems for Idaho Agriculture (University of Idaho, College of Agriculture 1997); Steve Amosson et al., Economics of Irrigation Systems (2011).

^{75.} Supplemental Opinion, supra note 28, at 29.

A savings-sharing arrangement like the Oregon legislation established, where the farmer could keep part of the water she saved but another part is allocated to the state in proportion to the funds provided, would also be advisable. Hence, establishing the volume historically consumed as a definitional variable will allow those systems that grant rights to the amount of water conserved to work more efficiently. Farmers should therefore have more incentives to introduce innovations that actually save water. Those regulations, modeled after the California one, could be a companion to the proposal set up here.

In many situations, though, it makes economic sense to adopt drip irrigation even without increasing consumption and without receiving subsidies.76 The Lower Arkansas Water Management Association proposed a plan for 2015/2016 to be approved by the division engineer in which the improvements in irrigation do not imply an increase in consumption. The owner of three farms changed the irrigation method from flood to center pivot sprinklers. Center pivot sprinklers reduce the surface irrigated because the corners of the farm cannot be reached by the water. Even reducing the acreage and keeping consumption constant, the farmer installed sprinklers and he benefited from it. In this case, no other users or the environment are going to be seriously affected by the change because return flows and effects of deep percolation are accounted for. Thus, this is a Pareto-efficient improvement.

There are also other techniques that can conserve water without affecting historic return flows. These techniques include rotational fallowing, deficit irrigation, or crop switching. These techniques entail a lower up-front cost so they will be more attractive to farmers. Some of the techniques may reduce productivity, but lower profits may be compensated by the lease or sale of the water conserved.⁷⁷ Calculating the amount actually conserved would be easier if consumption is adopted as one of the measures of the water right.

C. Unintended Benefits: Market Booster

I. The Indirect Definition of Rights by the No-Injury Rule

Prior appropriation rights are transferable. But there is a limit: the no-injury rule. This rule also applies when there are changes in water rights even if the right holder remains the same.⁷⁸ Water transactions cannot be carried out if they injure third parties, be they other users or the environment.⁷⁹ Transactions change the status quo. If A—a downstream user—transfers water to B—an upstream one—at

a minimum, there will be less water flowing between A and B, and other users who were using part of that water or needed more power to divert water out of the stream may be harmed. If B ends up consuming more than A used to, users downstream of A may also be harmed. The transfer may not make economic sense. It is clear that B values the water more than A, but if A used to return a certain amount of water to the river that was used over and over again, and now B does not return the same amount, we cannot be sure that the transfer is beneficial. This is so because the value of that water to A is lower than the total value of that water to A and the other users jointly.

A system to handle those externalities could rely on private bargaining between the parties A and B and the other users affected, but transaction costs will be too high and government or private nongovernmental organizations, if there are instream flow rights defined, would have to represent the environment. Instead, the system in place requires users to seek approval before the water agencies when entering into water transactions. Those agencies enforce the noinjury rule. The approval procedure generates transaction costs that may deter water transfers.

To a great extent, the no-injury rule⁸⁰ results in limiting transfers to the amount consumed; a farmer will not be able to transfer the amount she returned to the river. The amount returned to the river may have been used by other farmers, given that agencies have overallocated streams assuming that farmers do not use all their paper rights.⁸¹ Those other users may be harmed if the transaction takes place. Further, streamflows will be altered, which may, in many circumstances, translate into harm for the ecosystem. Oregon, for example, allows farmers to only transfer the consumptive use, but the Department of Water Resources interprets this limit generously and normally grants the consumptive use of the most water-consuming crop in the area where the seller or lessor of the water right is.

It seems inconsistent that a farmer is allowed to use her water right fully by changing her crop or her irrigation method, even if other users are harmed, but she cannot sell the whole amount of water she is entitled to,⁸² reinforcing the idea that usufructuary⁸³ water rights do not fit a concept of property shaped for land.⁸⁴ In sum, the no-injury

Telephone Interview with Karl Nyquist, Vice President, C&A Companies (July 13, 2015).

^{77.} For a discussion of those techniques and the necessary steps to ensure that conserved water is easily tradable, see Mark Squillace & Anthony McLeod, *Marketing Conserved Water* (working paper, on file with the author).

^{78.} See supra Section II.D.

The no-injury rule is followed by all states in the western United States. THOMPSON ET AL., *supra* note 28, at 307.

^{80.} Meyers & Richard Posner propose to minimize the costs arising from the cumbersome administrative review procedure related to de minimis externalities. It consists in adopting "substantial injury" or "no unreasonable effect" as a standard for review, instead of "no injury." CHARLES J. MEYERS & RICHARD A. POSNER, TOWARD AN IMPROVED MARKET IN WATER RESOURCES 27 (National Water Commission 1971). A standard similar to "substantial injury" is applied regarding the effects on the environment: transfers unreasonably affecting fish, wildlife, or other beneficial instream uses are not authorized in California. CAL. WATER CODE \$\$1725 and 1735.

^{81.} GETCHES, *supra* note 35, at 155. See also Oregon Hearing on S. 869, *cited in* Koehl, *supra* note 46, at 1160. An additional reason for the overappropriation is that some junior users may know that they can only exercise a right in particularly wet years.

Mark Squillace, *The Water Marketing Solution*, 42 ELR 10800, 10805 (Sept. 2012).

Conversation with Teri Hranac from Oregon Water Resources Department (July 11, 2015).

Sandra B. Zellmer & Jessica Harder, Unbundling Property in Water, 59 ALA. L. REV. 679 (2008).

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rule indirectly defines the volume that water rights entitle their holder to by allowing only the amount consumed to be sold or leased.⁸⁵ In addition, some states, like Wyoming, specifically limit the amount to be transferred to the amount effectively consumed.⁸⁶ In practice, there might be situations where the amount that can be transferred is even lower than the amount historically consumed by the farmer, where there is a change in the place of use and users located between the seller and the buyer would have the water available to them reduced. The proposal of defining rights according to the consumptive use will give coherence to the dichotomy as to how the volume of the right is defined depending on which stick in the bundle a right holder is trying to exercise: use or transfer.

2. Fewer Potential Externalities: Streamlined Authorization Procedure

Defining rights according to consumptive use for the purposes of water markets only is not a new idea. This Article has proposed to adopt consumption as the measure of the right for all purposes, but consumption has already been adopted by some conservation regulations, as the previous section shows, or advanced by some scholars as a variable defining water rights when it comes to water transactions.⁸⁷

California's regulation of water transactions differentiates between short-term transfers (one-year maximum) of consumed water and other transfers. Short-term transfers of post-1914 prior appropriation rights of consumed water are subject to a more streamlined review procedure.⁸⁸ "Consumptively used" water includes "water which has been consumed through use by evapotranspiration, has percolated underground, or has been otherwise removed from use in the downstream water supply as a result of direct diversion.⁷⁸⁹

This definition gives security to downstream users of the stream because the return flow is not included. Conversely, in the regulation of long-term transfers, there is no limit as to the origin of the water that can be transferred. The difference is reflected in the thoroughness of the review pro-

WYO. STAT. §41-3-104 (LexisNexis 2014).

cess, which is more expedited for short-term transfers. The time frame to carry out the review of short-term transfers is tight. The investigation has to start within 10 days of the receipt of the petition, and the Board has, on a normal basis, 35 days after that to render the decision.⁹⁰ The reason behind this less-demanding review procedure is that externalities in short-term transfers are not only short-lived, but also minimized.⁹¹ The procedure can be streamlined because the transactions taking place under this framework are likely to produce fewer externalities, as no more water is taken from the river than before.

Mark Squillace proposes to define rights both in terms of the amounts diverted and consumed for purposes of water transactions—but for *all* water transactions, not just for short-term ones. But such a definition by itself cannot make transfers simpler, as California's short-term transfers show, unless the no-injury rule is relaxed. He acknowledges that the high transaction costs imposed today by the no-injury rule to which water transfers are subject make it extremely difficult, if not impossible, for water markets to fulfill the role in allocating water flexibly as increasing scarcity challenges require.92 If only the amount consumed will be transferable, further streamlining of the review procedure would be in order for all types of transactions because the no-injury rule will have a lesser role to play. Squillace proposes to relax the no-injury rule and considers that a minimal or nonexistent review of transfers of the

The review procedure imposes large transaction costs, which may discourage some transactions. Transaction costs arising from these review procedures are always negatively regarded as a waste of money. But, as Bonnie Colby suggests, perhaps they should not be considered so negative, since in the absence of a perfect definition of property rights with the resulting complete internalization of third-party effects, transaction costs could be a useful tool to ensure that transactions that provide net benefits go forward. According to Colby, often there are no perfect mechanisms to compensate for these environmental externalities in western U.S. states because standing might be controversial and only transactions causing outrageous effects are barred. Thus, transaction costs arising from the review procedure might be a good substitute for the lack of perfect compensation. If a transferee's ideal benefit function should be benefits from the new water bought minus price and costs imposed on third parties and the environment, in the absence of a compensation mechanism but with a lengthy review procedure, the formula would substitute the external costs compensation by a mix of compensation to other right holders and the "policy-induced transactions costs." The author argues that these costs are not dollars burned, but a redistribution of dollars from the applicants to the agents intervening in the transaction review process (agencies, lawyers, or consultants). Bonnie G. Colby, Transaction Costs and Efficiency in Western Water Allocation, 72 Am. J. Agric. Econ. 1184 (1990).

^{85.} Squillace, supra note 82, at 10804.

^{86.} Wyoming law states:

The change in use, or change in place of use, may be allowed, provided that the quantity of water transferred by the granting of the petition shall not exceed the amount of water historically diverted under the existing use, nor exceed the historic rate of diversion under the existing use, nor increase the historic amount consumptively used under the existing use, nor decrease the historic amount of return flow, nor in any manner injure other existing lawful appropriators.

^{87.} See Squillace, supra note 82. See also Ronald N. Johnson et al., The Definition of a Surface Water Right and Transferability, 24 J.L. & ECON. 273 (1981). For an analysis of the market inefficiencies arising from the current definition of prior appropriation rights according to the amount diverted, see H. Stuart Burness & James P. Quirk, Water Law, Water Transfers, and Economic Efficiency: The Colorado River, 23 J.L. & ECON. 111 (1980).

^{88.} CAL. WATER CODE §1725 (temporary change in the right).

CAL. WATER CODE \$\$1745.10, 1745.11. The review procedure for longterm transfers is much less spelled out in the regulation. Transactions cannot substantially injure other users or unreasonably affect fish, wildlife, or other instream beneficial uses. CAL. WATER CODE \$1736.

^{90.} Barton Thompson Jr., Institutional Perspectives on Water Policy and Markets, 81 CAL. L. REV. 671, 705 (1993) (Thompson gives some comparative data on the duration of approval procedures in many states: "any transfer applications take only a month or two to resolve, but the average processing time appears to range from six months to one and one-half years (with controversial transfers occasionally taking up to several years)." His data relies on a 1990 study by ROBERT S. ROBINSON & LAWRENCE J. MACDONNELL, 2 THE WATER TRANSFER PROCESS AS A MANAGEMENT OPTION FOR MEETING CHANGING WATER DEMANDS 47 (Natural Resource Law Center, University of Colorado School of Law 1990)). This can be conceptualized as an embellished no-injury rule. Jedidiah Brewer et al., Law and the New Institutional Economics: Water Markets and Legal Change in California, 1987-2005, 26 WASH. U. J.L. & POL'Y 183, 195 (2008).

^{91.} Another important reduction of transaction costs in these short-term transfers in California occurs because they are not subject to the California Environmental Quality Act.

^{92.} Squillace, supra note 82.

consumptive amount would accept certain negative effects on third parties. In fact, he argues that prior appropriation law already tolerates some negative effects on other users when farmers change crops or irrigation systems.⁹³

The proposal set forth in this Article will define the consumptive amount a user is entitled to for all purposes: use in her own land or transfer. For transactions, a lessened review procedure in line with Squillace needs to accompany the change. The fact that the volume consumed is already defined should make transactions even easier because parties will not need to bring evidence of the amount historically consumed during the review of transactions.

Australia implemented a regulatory regime that proves that making rights more fungible increases water market activity. Some Australian states—Queensland, New South Wales, Victoria, and South Australia-unbundled their water rights. Previously, all the sticks were amalgamated in a single water license. After the reform, which was aimed at improving water management and enhancing water transfers, the licenses were divided into as many as four different rights. A water right holder had four sticks: the access entitlement, the water allocation, the water resource work approval, and the site use, which allows water to be used in a particular location.⁹⁴ Water allocations embody the right to withdraw a certain amount of water in a particular season, and are transferable. They are recorded in water accounts, a system similar to a bank account, which makes them even easier to transfer. This sharper definition of water rights increased the activity in the water market because the rights were more fungible,95 allowing for a more streamlined transaction approval procedure, and this contributed to better water management.⁹⁶

By changing the definition of water rights, adopting consumption as one of the variables defining the volume, and making transactions of consumed water easier, this Article's proposal is more likely to achieve an efficient allocation of water than the current definition can. If transactions are easier, a farmer who wants to shift to drip irrigation but who needs to consume more water to do so profitably may resort to the market to buy the extra water she needs. It may be argued that the same could happen today if the increase in consumption harms a junior whose use is more valuable: the said junior could buy out the senior. The only difference would be distributional consequences, which may not matter in terms of efficiency.⁹⁷ Thus, the current system may not need to be amended.

Beyond fairness arguments, which favor the proposal put forward here, current regulation of water transactions imposes higher transaction costs than the proposal in this Article. Accordingly, fewer transactions will happen even in situations where the junior user values the water more than the senior consuming more as a result of a change in the irrigation method. Further, under current regulation, if instream flows are not defined, government or private parties may need to buy out the senior willing to increase her consumption. This will not be necessary under the proposal set forth because changes in irrigation methods or other technically efficient measures adopted by the farmer will not translate into diminished streamflows.

The Lower Arkansas River Basin, particularly the 2015 Lower Arkansas Valley Water Conservancy District (LAVWCD) Plan Request, shows that this proposal may also enhance markets. It does so by reducing transaction costs because it matches the current definition of the amount transferable in practice. But it also enhances markets by motivating farmers to resort to the market when they want to increase their consumption, making sure that water is put to the most valuable use. In the LAVWCD, several farmers installed center pivot systems. Those systems consume more than traditional irrigation methods. The regulations in the Lower Arkansas River Basin in Colorado require the right holders to make up for the increase in consumption in order to approve the change in irrigation method. The district in this example used several sources to make up for the change in return flows, including water leases from Pueblo. The LAVWCD has a long-term contract with Pueblo Board of Water Works to provide up to 500 ac-ft per year of fully consumable supplies to meet the obligations imposed by the regulations implementing the Arkansas River Compact.

D. Implementation

I. Mechanisms of Change

Western states have migrated to statutory prior appropriation systems. The agencies granting and enforcing those permits could review the existing permits and incorporate consumption volume as an additional variable in their definition. Doing so would be similar to a state agency-initiated general adjudication where the burden of proof is arguably on the agency. General adjudications of streams for which rights need to be quantified are a

^{93.} Id. at 10805.

^{94.} These first two components of the right are personal property, not appurtenant to land. Such a definition increases the fungibility of water rights in a similar way as using consumptive use as the measure of the transferable right. The access entitlement "provides an ongoing right to a specified share of water available for allocation from a prescribed water resource." The water allocation is "the right to take a specific volume of water for a given period of time, not exceeding 12 months, based on the volume of water available for allocation in that period." Each share translates into a certain water allocation.

^{95.} Lack of fungibility is a problem in water rights. Squillace, *supra* note 82, at 10804. Another example of fungibility resulting in increased water market activity is the Colorado-Big Thompson Project. *See* JEDIDIAH BREWER ET AL., WATER MARKETS IN THE WEST: PRICES, TRADING, AND CONTRACTUAL FORMS 11, 33 (Nat'l Bureau of Econ. Research, Working Paper No. 130002, 2007), http://www.icer.it/docs/wp2007/ICERwp30-07.pdf.

^{96.} MIKE YOUNG, THE ROLE OF THE UNBUNDLING WATER RIGHTS IN AUSTRALIA'S SOUTHERN CONNECTED MURRAY DARLING BASIN (2011), available at http://www.feem-project.net/epiwater/docs/d32-d6-1/CS23_ Australia.pdf.

Ronald H. Coase, The Problem of Social Cost, 3 J.L. & ECON. 1, 44 (1960);
C. Carter Ruml, The Coase Theorem and Western U.S. Appropriative Water Rights, 45 Nar. Res. J. 169 (2005).

situation where consumptive use as a variable defining the right could be incorporated.⁹⁸

Alternatively, the regulation for changes in water rights could include a provision establishing that a change in the amount consumed would require approval. Such a provision would imply that the consumptive value would only kick in whenever the farmer wants to change her current practices. This provision would be broader than a provision establishing that changes in the irrigation method and crop need to be approved by the water agency. If only these two types of potential changes are included, there might be some increases in consumption that may escape the need for approval, such as planting more intensively than before. These individual adjudications may generate many costs to the individual farmers, and if they do not comply with the regulations, enforcement may be very difficult because, for example, there might be no records available to the agency of which crop the farmer was growing before. If this route is chosen, further reporting obligations should be imposed on farmers. Whether using this procedure or a more general regulation applying to all rights, state water agencies, probably collaborating with their agricultural agencies, should establish an agricultural register that contains detailed information about which crop is grown on each acre of agricultural land.99

In fact, imposing the variable of consumption, while maintaining the diversion amount, has exactly the same effect as requiring farmers to apply for changes in their rights when consumption changes, because it allows farmers to continue with their current practices. So, the choice of one over another will depend on who should bear the costs: individuals or the agency. The agency has experts at its beck and call; hence, it has an advantage. Either the general procedure or an individual adjudication of changes in water rights where the burden of proof is placed primarily on the agency builds on this expertise of the agency. The general procedure will obviously be more lengthy. If that is the strategy chosen, while it is being implemented, the cutoff date must be set to avoid opportunistic changes in crops or irrigation methods, or the time frame established to calculate average consumption must aim at reducing moral hazard.

For new rights, the agency may decide to grant permits fixing diversion and consumption according to the most efficient irrigation technology. The most efficient irrigation technology socially, not only individually, may be drip because pollution is reduced, yield increases, and current rights are not affected. Farmers may or may not adopt the technology used to calculate irrigation needs. Perhaps changing the crop, leveling the fields, and optimizing irrigation scheduling can spare them the investment while still complying with the limit set forth in the new permit.

Other systems, like riparian states, could adopt consumption as a potential measure of the right. Permits granted in regulated riparianism systems¹⁰⁰ are very similar in nature to statutory prior appropriation permit systems regarding the control over the water right by the agencies granting them. In fact, the Regulated Riparian Model Water Code opens the door to adopting consumption as the measure; it states among the elements of the permit "the amount of return flow, if any, required and any required place of discharge."¹⁰¹ However, among regulated riparianism states, diversion or withdrawal is still the norm even if, for example, Wisconsin requires the application to include: "The estimated average annual and monthly volumes and rates of water loss."¹⁰²

Colorado is implementing a system similar to the one proposed in the Arkansas River Basin. The Rules Governing Improvements to Surface Irrigation Systems in the Arkansas River Basin in Colorado were proposed by the state engineer and approved by the water court in 2009.¹⁰³ Those rules aim to comply with the Arkansas River Compact, which is a "depletion" compact; Colorado cannot consume more water than it used to because the Compact grants Kansas undiminished flows.¹⁰⁴

According to the Supreme Court decision in *Kansas v. Colorado*, Colorado's groundwater regulation violated the Compact because the increasing number of wells impacted the amount of water flowing down to Kansas. The state engineer considered that improvement in irrigation methods could have the same effects, and the aforementioned rules require users to apply before the state engineer whenever they are changing their irrigation system. There is no control when farmers change the type of crops. Farmers challenged the rules before a water court, but they were

- 103. In the Matter of the Proposed Compact Rules Governing Improvements to Surface Water Irrigation Systems in the Arkansas River Basin in Colorado, Case No. 09CW110, Water Division 2, col.
- 104. Article IV-D of the Compact reads as follows:

^{98.} Neuman, *supra* note 37, at 979 (emphasizing the role that general stream adjudications may have in redefining beneficial use).

^{99.} The USDA Census of Agriculture and its publicly available maps are a step in this direction and may be helpful to state agencies (*see* http://www.agcensus. usda.gov/Publications/2012/Online_Resources/Ag_Atlas_Maps/), but they neither amount to a Register nor contain individualized information per plot of land.

^{100. &}quot;Regulated riparianism" is a term coined by and encapsulated in the water right permit systems adopted by eastern U.S. states to deal with the shortcomings of the common law of riparianism: among others, the preference for use on riparian lands, arising from reasonable use requirements, and the difficulty for cities in supplying their citizens. Joseph W. Dellapenna, *The Evolution of Riparianism in the United States*, 95 MARQ, L. REV. 53 (2011). See ROBERT W. ADLER ET AL., MODERN WATER LAW 231 (2013). Shortages prompted states to also include conservation goals in their statutes. See THOMPSON ET AL., supra note 28, at 136.

^{101.} AMERICAN SOCIETY OF CIVIL ENGINEERS, THE REGULATED RIPARIAN MODEL WATER CODE: FINAL REPORT OF THE WATER LAWS COMMITTEE §7R-1-01(g) (Joseph W. Dellapenna ed., 2003). *See also id.* §6R-2-01, when listing the requirements of an application: "e. the place of the proposed return flow of withdrawn water; f. an estimate of the projected overall consumptive use of water."

^{102.} WIS. STAT. §§30.18(6)(a), 281.35(4), 281.35(5)(a)(7).

D. This Compact is not intended to impede or prevent future beneficial development of the Arkansas river basin in Colorado and Kansas by federal or state agencies, by private enterprise, or by combinations thereof, which may involve construction of dams, reservoirs and other works for the purposes of water utilization and control, as well as the improved or prolonged functioning of existing works: Provided, That the waters of the Arkansas river, as defined in Article III, shall not be materially depleted in usable quantity or availability for use to the water users in Colorado.

not frontally opposed to the regulations because they understood that Colorado was trying to avoid a new, costly interstate conflict with Kansas, and the Supreme Court in *Kansas v. Colorado* agreed with the special master that the Arkansas River Compact was a depletion compact.¹⁰⁵ Thus, Colorado cannot increase consumption.

The office of the state engineer made an effort to reach out to stakeholders during the drafting process. One of the arguments employed by the officials was that the Irrigation Improvement Rules also protect users in Colorado from the increase in consumption by other users. Everyone is a junior and a senior to another water user. The proposal of adopting consumption as one of the definitional variables of the water right will face a similar political economy as Colorado faced. Farmers are likely to be the losers in any water law reform in the future. Urban water savings are not enough to mitigate the scarcity crisis. Agriculture must be the source of potential mitigation. The proposal put forward in this Article is more palatable for the agricultural sector because it does not force farmers to incur any new investments, it allows farmers to keep their business as usual, and it does protect them from increases in consumption by other farmers.

2. Measuring Is Possible

Diversion was administratively sound as a measure of the right in the absence of meters, but today we can rely on meters and models to measure consumption. It will take time to decouple different elements of water rights by including in the definition not only the flow withdrawn (cubic feet per second) as the measure, but also the volume consumed (acre-feet). First, not all water rights are wellrecorded. But this problem is not particular to the amendment to prior appropriation rights proposed here. Second, water right holders do not have meters measuring the diversion, much less their consumption.¹⁰⁶ But they could have their consumption estimated by agricultural models that can approximate the amount depleted given the type of soil, the crop selected, and the irrigation method. These models, like those used in technical studies cited in this Article, could only provide estimates, yet they will be cheaper than relying on expert testimony in an adversarial process, where determinations of historical use for the purposes of water transfers have proven to be very costly.

It must be acknowledged, however, that courts in the past have been reluctant to accept evidence from models or experiments, instead of actual practices.¹⁰⁷ But since there is extensive experience in the use of sprinklers and drip irrigation, the agencies could base their estimates on actual data, not mere assumptions. In addition, models such as the Penman-Monteith, recommended by the Food and Agriculture Organization of the United Nations, have been

used to calculate ET for a long time by water agencies, 108 even in the context of water markets. 109

The Compact Rules Governing Improvements to Surface Water Irrigation Systems in the Arkansas River Basin in Colorado use the Irrigation System Analysis Model (ISAM) to evaluate the changes brought about by the change in irrigation methods.¹¹⁰ It helps reduce costs because each user will not need to hire an engineer to do a study. There are two parts to the model. One establishes the baseline and makes a threshold determination of whether changes in irrigation method will increase consumption by comparing the water balance with and without the improvement during the period 1997-2006. This is a representative period of diverse water supply conditions.

The second part is a model that helps the farmer to implement the changes in the upcoming year by calculating her historical consumption in a year similar to what the upcoming one is expected to be. This model requires very little information from the farmers. They need to provide only "the number of acres irrigated by each type of system; any change in acreage due to the improvement . . .; the surface water right or rights on that acreage (or the number of ditch shares, if applicable); and whether there is supplemental irrigation from a well."

Models, though technically complex, have been a tool welcomed by the farm sector in Colorado. Farmers have welcomed the ISAM model given the office of the state engineer's willingness to work on updates if new information suggests that the model is too stringent. Even if the route taken is a case-by-case adjudication when a farmer wants to introduce a change in her water right, a model to be applied across the board should be approved beforehand, with an appropriate notice-and-comment period.

E. Takings Challenges

Limiting the amount that a holder of a prior appropriation right can consume to the amount consumed on average over the past five years might raise takings challenges when those limitations are imposed on existing rights. General stream adjudications do not amount to a taking even when resulting in adverse effects on the rights. However, water agencies' regulations restricting existing rights, be they common-law or permit-based prior appropriation rights, are likely to be challenged on takings grounds. Given that such regulations will be state regulations, the private right holder may assert her claim based on the state and federal constitution. The analysis here focuses on the latter.

The first step in analyzing whether there has been a taking is to ask whether water rights are property protected by the Fifth Amendment. Landmark judicial decisions on

^{105. 514} U.S. 673, 675, 115 S. Ct. 1733, 1736, 131 L. Ed. 2d 759, 767 (1995). 106. Neuman, *supra* note 37, at 985.

^{107.} United States v. Alpine Land & Reservoir Co., 697 F.2d 851 (9th Cir. 1983). See also In re SBA Case No. 39576 (Idaho 1997) (commenting in special master report on the engineering model used by Idaho).

California Department of Water Resources, Agricultural Water Use Models, http://www.water.ca.gov/landwateruse/models.cfm (last visited Oct. 12, 2016).

^{109.} Lana Jones & Bonnie G. Colby, Measuring, Monitoring, and Enforcing Temporary Water Transfers: Considerations, Case Examples, Innovations, and Costs (2012).

^{110.} Rule 9.B.i.

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water rights takings have not spent much time discussing the nature of the water rights; they have assumed they were protected. Some commentators argue that water rights are not property with respect to takings, only with respect to protection under the Due Process Clause given their public property nature and how subject to the control of government they are.¹¹¹ But those commentators are in the minority.¹¹²

Assuming that water rights are protected, the second step of the analysis is to assess whether we are facing a categorical or per se taking, or one that requires a balancing test. There are two types of categorical takings: physical and those without physical invasion but where the regulation wipes out any economic value the right might have.

Regarding water, the doctrine is muddy. In *Tulare Lake Basin Water Storage District v. United States*,¹¹³ the court stated that a reduction in the amount of water available for pumping as a result of complying with the ESA constituted a physical taking, even though the National Marine Fisheries Service and the U.S. Fish and Wildlife Service did not take possession of the water but mandated the reduction.¹¹⁴ *Tulare* is still an exception, being often rejected by subsequent decisions.¹¹⁵ If a court were to follow the *Tulare* reasoning, then the redefinition of rights proposed here may amount to a physical taking,¹¹⁶ and thus require compensation because there will not be a difference between the government actually taking the water and not allowing the farmer to consume it.

The second type of categorical takings—elimination of all economic value—arising from the decision in *Lucas v. South Carolina Coastal Council*,¹¹⁷ does not fit the situation at hand, where the amount of water the farmer can consume is limited to the amount consumed on average for the period chosen. In the proposal put forward by this Article, the farmer could keep her business as usual; she may keep diverting the same amount if she returns the same amount to the river in the form of return flow. She may also divert only the amount to be consumed if she has installed some

irrigation method, such as trickle irrigation, which does not produce return flow. This means that the farmer will not see her potential economic benefits reduced with respect to the status quo. *Lucas*' categorical regulatory taking requires the deprivation of all economic use of the right, in that case the land, which is not what limiting the amount of water consumed to the historical average entails.

Once the possibility of categorical taking is excluded, the third step is to determine whether there has been a taking under the balancing doctrine resulting from *Penn Central*. If the court undertakes the regulatory takings analysis following *Penn Central*, the proposal advanced in this Article will most likely survive the challenge. This type of analysis is the most common in water rights takings cases.¹¹⁸ The factors to be considered when analyzing whether the regulation has gone too far are:

- (1) "the economic impact of the regulation on the claimant";
- (2) "particularly, the extent to which the regulation has interfered with distinct investment-backed expectations . . ."; and
- (3) "the character of the governmental action. A 'taking' may more readily be found when the interference with property can be characterized as a physical invasion by government . . ., than when interference arises from some public program adjusting the benefits and burdens of economic life to promote the common good."¹¹⁹

Here, the economic impact is nonexistent. First, it is important to note that water rights have been given for free.¹²⁰ Second, they are already heavily regulated; for example, they are subject to forfeiture if not used¹²¹ and there are no defeated expectations. Much as in *Penn Central*, where the station could continue to be used as it had been used in the past, in this case, if the farmer wants to keep using the water the way she has been using it for decades, she can. If instead she decides to install sprinklers or drip irrigation, she may incur investment expenses, but it can be a profitable investment even if she keeps consumption constant.

Alternatively, if a farmer has incurred the investment expenses for a more advanced irrigation system before the proposed definition is adopted and, thus, started consuming more than she used to, the consumption measure would take her most current consumption into account. So, if the farmer incurred those expenses calculating that she can consume as much as she diverted and invested more than she would have if she knew she would only be allowed to consume the amount she had been consuming, she would still be able to use the amount of water she was planning to because the investment is prior to the redefinition. Much along the lines of *Penn Central*, where the

^{111.} Zellmer & Harder, supra note 84.

^{112.} Dave Owen, Taking Groundwater, 91 WASH. L. REV. 253, 275 (2013).

^{113. 49} Fed. Cl. 313, 31 ELR 20648 (2001). See Melinda Harm Benson, The Tulare Case: Water Rights, the Endangered Species Act, and the Fifth Amendment, 32 ENVTL. L. 551 (2002).

^{114. 32} ENVTL. L. at 555. In the *Tulare* case, the plaintiffs were contractors receiving water from the State Water Project. As Benson points out, the court did not discuss at length whether those rights were interests protected under the Fifth Amendment. Regulations in other fields have also been considered physical takings. *Nollan v. California Coastal Commin*, 483 U.S. 825, 17 ELR 20918 (1987), where a landowner was required to provide an easement to receive a building permit, required an essential nexus between the burden imposed by the regulated activity and the restriction. In this case, increasing consumption imposes externalities on other users and the public. *Dolan v. City of Tigard*, 512 U.S. 374, 24 ELR 21083 (1994), further refined the nexus requiring the connection to be proportionate. If historical consumption is adopted as a new limit defining water rights, there is no burden imposed on the holder of a water right because she can keep irrigating, and the fact that she cannot increase her consumptions is not disproportionate.

^{115.} Owen, supra note 112, at 273.

Robin Kundis Craig, Defining Riparian Rights as "Property" Through Takings Litigation: Is There a Property Right to Environmental Quality?, 42 ENVTL. L. 115, 122 (2012).

^{117. 505} U.S. 1003, 22 ELR 21104 (1992).

^{118.} Owen, *supra* note 112, at 287.

^{119.} Penn Cent. Transp. Co. v. New York City, 438 U.S. 104, 124, 8 ELR 20528 (1978).

^{120.} Squillace, *supra* note 82, at 10803.

^{121.} *Id*.

railroad company was not able to build a 50-story building, but still could build a less-tall building or sell its air rights,¹²² farmers who still choose to shift irrigation methods may be able not only to use the water consumed by the plants when using flood irrigation, but also the amount that evaporated.

Finally, consideration of the character of the government action may allow the public trust doctrine to play a role. As the Mono Lake decision stated in 1983, water is protected under the public trust doctrine.¹²³ Accordingly, if the government is acting as the trustee for the public in order to make sure water is managed in the most beneficial way possible for society by regulating existing water rights, such a regulation should not be considered a taking.¹²⁴ In this case, the government wants to protect not only other users who are relying on the water returned by the farmers, but also instream flow, which would be diminished if the definition of prior appropriation rights remains unchanged and the adoption of innovative irrigation systems is encouraged. Beyond the fairness of water allocation, without the redefinition proposed in this Article, a change in irrigation methods is not likely to bring about the socially efficient solution.

Further, arguments have been made that the takings doctrine should not be an obstacle to changes in water law if the changes reduce waste. It could be said that to some extent the proposal of defining rights according to the volume consumed, instead of just the volume diverted, is a way to prevent users from profiting from their waste. Some farmers use antiquated irrigation methods and do not try to adopt simple measures to save water like watching carefully the times when they irrigate. Today, flood irrigation, still the main type of irrigation used in the United States, could be considered archaic. Technology has advanced, and farmers have not always caught up.

The fact that farmers' practices have lagged behind provides one further reason this proposal should survive the takings challenge. Stephen Shupe, in his blueprint for change in western water law, reads the Oregon Supreme Court decision *Hough v. Porter*¹²⁵ as saying that the volume of the water right may change as technology advances.¹²⁶ The definition of property rights evolves as technology changes,¹²⁷ and water rights should be no different. While Shupe asks for a more current interpretation of waste

126. Shupe, supra note 70, at 496:

127. Gary D. Libecap, Contracting for Property Rights 16 (1989).

doctrines and better enforcement,¹²⁸ this Article proposes introducing another dimension to the definition of property rights.

F. Alternatives to the Adoption of Consumption

Instead of reforming prior appropriation to include an additional variable to the definition, as this Article proposes, there are other amendments that could partially address the same issues. The first variation would be to require approval of any change in irrigation methods. The provisions regulating the approval of changes in the place of use or type of use are already in place. If a change in the method of irrigation were to be included, then it would be subject to the no-injury rule. In this case, consumption will only enter into the picture once a change in irrigation method triggers it. Administrative costs would be lower, but the risk of moral hazard is greater because unless the consumption amount is fixed for everyone at the same time, farmers would have an incentive to increase consumption using other methods not to be constrained when in the future they change irrigation methods.

This proposal is similar to the requirements established in the Lower Arkansas Valley, where a farmer cannot increase the amount she has been consuming. If, instead, only a no-injury rule were in place, a farmer could increase the amount consumed if there were no negative effects for the environment or for other users. The Lower Arkansas framework also mitigates moral hazard because the amount consumed is not allowed to change from historical consumption levels. The main problem of subjecting the change of irrigation method to the regulation of change in water rights, or adopting the approach of the Lower Arkansas Basin, is that not all production changes aimed at efficiency and resulting in changes in consumption are shifts in irrigation methods. The list of triggers of changes in water rights provisions could be endless.

A second option would be to enforce the prohibition against waste, reducing the amount available for each farmer. If current flooding practices are not considered socially acceptable, the permits could be reduced. However, it is unclear how the amount of water awarded to a right holder once waste is discounted would be calculated or whether a particular technology would be imposed. In any case, if provisions against waste are strengthened and rely on innovative technologies, they must take into consideration the impact on consumption given the reliance of other users and the dependence of the environment on return flows. The effects would be very similar to the ones proposed in this Article. But there are two main differences. First, using anti-waste provisions implies that the agricultural sector would be blamed and that sector may be less willing to accept such an enforcement policy. Second, it would also be less welcome by private parties because they would not be allowed to continue with their current

^{122.} Calvert G. Chipchase, From Grand Central to the Sierras: What Do We Do With Investment-Backed Expectations in Partial Regulatory Takings?, 23 VA. ENVTL. L.J. 43, 51 (2004).

^{123.} National Audubon Society v. Superior Court, 33 Cal. 3d 419, 13 ELR 10272 (Cal. 1983) (commonly known as the "*Mono Lake*" case).

^{124.} Owen, *supra* note 112, at 296 (analyzing natural rights property theories and their implications for takings).

^{125. 51} Or. 318, 95 P. 732, modified, 51 Or. 318, 420, 98 P. 1083, 1102 (1908), affd on rehearing, 51 Or. 318, 102 P. 728 (1909).

This holding recognizes that while appropriators have a vested right to irrigate their land, the volume of water associated with this right may change as technology develops. With the advent of more efficient techniques, the excess water demands of the old systems are "declared to be wasteful and have been only a privilege and not a right."

^{128.} Shupe, supra note 70.

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practices. They will be required to improve the conveyance system or the irrigation method.

The third alternative implies a more acute departure from the current system: bill farmers for the amount of water they consume, not the amount they divert. Harm to other users may still exist, but a pricing mechanism could be envisioned that would achieve an efficient solution. Such a scheme may prove unfeasible because water pricing is a thorny issue. A pricing scheme may be more difficult to implement than the proposal presented in this section for reasons of political economy. In addition, this proposal would require calculating current consumption and, thus, it would be more costly to administer than adopting consumption as one of the variables defining prior appropriation rights.

The fourth alternative is aimed at achieving the best allocation possible, not at amending the current system per se. There could be a system where instream flows are defined as reserved water and all the water over that amount is allocated using rights defined according to diversion with or without a no-injury rule. In such a hypothetical ideal world, parties could negotiate over the externalities imposed and water should end up in the fields of those who value it the most. Under a no-injury rule, the farmer who wants to increase his consumption would pay to compensate those harmed. Or, without a no-injury rule, those harmed would pay the farmer not to increase consumption if they value water more than he did. However, a river is not the world of blackboard economics. A change in a water right will affect a large number of users who may not find it beneficial to bargain with the right holder who, thus, will not internalize the social cost of his action.

The proposal advanced in this Article assumes that consumption will fill the meaning of beneficial use when it comes to the volume, and the establishment and administration of those limits will be in the hands of the water agencies as it is today. Instead of relying on bargaining between private parties, a liability system could also be enforced by a water agency. The agency would make a farmer pay if she exceeds her consumption limit. It may be difficult to identify who is consuming more, but it would be possible to measure the reduction in stream flow accounting for natural variances. If that is the case, a system where every user is liable for the difference between the actual amount and the amount that should be flowing in the stream should provide the correct incentives to ensure that the user does not increase her consumption.¹²⁹ However, this framework is a departure from the traditional enforcement mechanisms in water law that have been reactive; enforcement actions are undertaken if another user or someone representing the environment files a complaint because she or the ecosystem is being affected.

This Article's proposal to add consumptive volume to the definition of water rights is an incremental improvement of the current system of prior appropriation. It would not require farmers to undergo any change in their production methods. Thus, there should not be a farming-sector upheaval against it. Adopting consumption as part of the definition tackles not only a change in irrigation methods, but also any change in agricultural production that results in increased consumption. Such an amendment may harm some farmers, but would also protect junior right holders and prevent socially undesirable behavior. In addition, once a model to calculate consumption is adopted, administering the system would be less daunting. In Colorado, the model used in the Lower Arkansas Basin has been widely accepted. By settling the amount of water a user is entitled to as the average of water consumed during the past five years, the race to consumption will be prevented.

IV. Conclusion

Water is getting scarcer in the western United States and elsewhere. The doctrine of prior appropriation, which regulates water allocation in that region, does not live up to current challenges. Water is primarily allocated to the agricultural sector, which still uses archaic irrigation methods and incentivizes the planting of water-intensive crops. Time and time again, farmers are blamed for the water crisis or targeted as the source of the remedy. Prior appropriation is a doctrine "designed to allow as many people to use as much water as possible."¹³⁰ But the provisions against waste have not had teeth. Those farmers who are using purportedly wasteful practices are not considered to be in violation of the law.

Policymakers, media, and scholars claim that the agricultural sector should install efficient irrigation systems, such as sprinklers or drip irrigation, either as part of a more thorough enforcement of anti-waste provisions or with a soft-law approach. These irrigation systems produce more crop per drop. However, most proposals to modernize irrigation fail to understand that those technically efficient irrigation systems may reduce the amount withdrawn from the field, but not the overall amount consumed. Those systems may be more efficient and less wasteful than flood or furrow irrigation at the individual level, but not in the aggregate. Drip irrigation or sprinklers may increase consumption in water-short scenarios. Given how overallocated rivers are, the increase in consumption by one user translates into others not being able to access that water. The situation after the change is not only unfair because users may have been relying on that water for decades, but may also be inefficient because we cannot be sure that the new allocation maximizes the value of water.

The translation between technological efficiency at the field level and efficiency of the overall water allocation is not automatic, and illustrates another instance where regulation borrowing technical terms has had unintended con-

^{129.} This idea was put forward by Robert D. Cooter & Ariel Porat, *Total Liability for Excessive Harm, in* GETTING INCENTIVES RIGHT 74-91 (2014). The authors discuss the pollution of a river, which is a case analogous to the one presented here. *Id.* at 86.

^{130.} Tarlock, *supra* note 3, at 152.

sequences. Just as energy regulations are now taking into account the rebound effect, it is time for water regulations to do so too.

Even though some conservation statutes only consider savings arising from changes in irrigation when they effectively reduce the amount consumed, prior appropriation has lagged behind. Under prior appropriation, there are no barriers to a farmer increasing the total amount she consumes when she changes the irrigation method or the crop even if other users or the environment are harmed. To achieve the conservation goal of making water available to other users, the volume of water rights needs to be defined not only according to the amount diverted, but also according to the amount consumed or depleted.

Incorporating this measure of consumption will not only ensure that changes in irrigation bring real water savings, but will also discourage the adoption of water-intensive crops when, to do so profitably, water use would have to increase. This proposal also has ancillary benefits, thus, if adopted, water transactions would be subject to less scrutiny because fewer transaction costs are likely to arise. In fact, some authors have already proposed the adoption of consumption as the measure of water rights only regarding water transactions.

Prior appropriation is a doctrine that has evolved over time.¹³¹ The time has come for it to evolve again. The doctrine served us well in the past, but it is time to abandon the unfettered consumption paradigm for one that centers on efficient use, real conservation, and environmental concerns. The proposal of defining rights according to the volume historically consumed protects the status quo, but does not ossify it: it allows changes if these certainly bring social benefits.

Scrubbers were the solution to sulfur dioxide (SO₂) pollution adopted in the late 1970s Clean Air Act regulations. The reduction in emissions did not happen: midwestern power plants used high-sulfur coal.¹³² Scrubbers cleaning emissions from high-sulfur coal or drip irrigation in water-scarce overallocated aquifers are not solutions to acid rain or water scarcity. As the SO₂ example and this Article show, technology can be a solution for our environmental problems, but only when accompanied by a proper regulatory framework.

^{131.} See A. Dan Tarlock, The Future of Prior Appropriation in the New West, 41 NAT. RESOURCES J. 769, 770 (2001) ("The distinguishing feature of prior appropriation is its continual evolution in response to a changing West. Because prior appropriation is grounded in both abstract principles of justice and hard experience, it has constantly had to adapt to changed conditions.").

^{132.} BRUCE A. ACKERMAN & WILLIAM T. HASSLER, CLEAN COAL/DIRTY AIR: OR How the Clean Air Act Became a Multibillion-Dollar Bail-Out for High-Sulfur Coal Producers (1981).