Water Prices in the U.S. are *Not* "Cheaper when Drier" (but they might be more affordable)

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Abstract

In a recent paper in *Water Resources Research*, Luby, Polasky, and Swackhamer come to a provocative conclusion, that urban water prices in the United States are "cheaper when drier." Additionally, they argue that utilities are failing to provide affordable water and that they are charging less for additional use compared to essential use. In this paper we challenge these findings. While the authors are correct in pointing out the many challenges that utilities face in supplying affordable water while meeting conservation and revenue goals, we argue that there are serious flaws in how the authors measure price, affordability, and scarcity. These measurement issues lead the authors to incorrect conclusions about water pricing in the United States. Using improved measures of price and water scarcity, we find little statistical relationship between the marginal price of water/sewer services and scarcity. Additionally, we find that water tends to be more affordable in scarce regions and that the percentage increase in price for additional use tends to be higher where water is scarcer. Our findings point to important avenues for future research.

1. Introduction

In a recent article in *Water Resources Research*, Luby, Polasky & Swackhamer analyze water and sewer utility pricing in 35 major American cities, with an aim of evaluating "the use of pricing in managing physical water scarcity."[1] Luby, et al. do an excellent job of describing many of the challenges facing utilities in setting rates; their Section 2 provides a solid overview of the multiple values that governments consider when setting rates. The authors correctly observe that, as public agencies, urban water suppliers in the United States must consider efficiency alongside other social goals like equity and affordability when setting prices. They argue that these other goals keep public utilities from setting prices equal to marginal cost. Their discussion of water pricing culminates with what amounts to three generally sensible hypotheses (p.3), that:

1) "To address scarcity, we would expect prices per unit to be higher in water-stressed areas;"
2) "To cover costs, we would expect higher rates on additional water use (increasing block rates)"; and
3) "To address equity concerns we would expect low prices on the first block of essential water use."

The first of these is the main focus of the article, as its title suggests. Their 35-city analysis of water and sewer prices finds that, contrary to both intuition and economic orthodoxy, "cities facing the most water stress have the lowest prices" (1). They also find that prices are lower for "additional water use," and high for essential water use. These results are provocative, with potentially important policy implications for water-scarce regions.

In this paper we challenge Luby, et al.'s analysis and their inferences about water pricing. Significant methodological problems give reason to doubt their principal finding that

[1] Luby, Ian H., Stephen Polasky & Deborah L. Swackhamer, "U.S. Urban Water Prices: Cheaper When Drier," *Water Resources Research* (2018) https://doi.org/10.1029/2018WR023258.

water is “cheaper when drier” in America. Both of the main variables in their analysis—water prices and water scarcity—are measured inaccurately for purposes of understanding pricing as a means of achieving resource efficiency. These problems lead Luby, et al. to the wrong conclusion about the relationship between scarcity and pricing. Indeed, our reanalysis of the same 35 cities with more appropriate metrics and methods shows essentially no statistical relationship between price and water scarcity. Moreover, reanalysis contravenes their findings about the relative prices of essential and “additional water use”. Finally, we find that, on average, the affordability of essential water use improves with scarcity across these 35 cities.

We begin by identifying key flaws with Luby, et al.’s measurement of water pricing in Section 2. Section 3 discusses problems with their measure of water scarcity. In Section 4 we reanalyze the same 35 cities using current pricing data with more appropriate metrics of water scarcity. Section 5 turns their findings on pricing for essential versus “additional” water. Section 6 takes up Luby, et al.’s claims about affordability, where our analysis shows that the affordability of essential water also correlates positively with scarcity. Section 7 concludes with a summary of our findings in contrast to Luby et al.’s and remarks about further inquiry on the topic.

2. Problems with Price Measurement

Several problems with Luby et al.’s analysis follow from the way that they measure the price of water. These problems lead to mistaken inferences.

Average vs. marginal price. The measures of price that Luby et al. use are not appropriate to the claims they make about the prices of “additional water use” and “price per unit.” Specifically, rather than measuring marginal price (the price for the last unit of water consumed), they measure of total price at eight hundred cubic feet (8 ccf), 12 ccf, and 16 ccf.

These total prices include both fixed and volumetric elements. In addition to volumetric prices, residential customers pay fixed periodic charges for water service in 30 of the 35 utilities that they analyze; 25 of these cities impose fixed charges for sewer service, too. As we will see, these fixed charges can be quite substantial.

According to basic microeconomic theory and much of the research literature that Luby, et al. cite, the crucial price for purposes of resource efficiency is *marginal* price, not total price. For prices to affect consumer behavior, the customer's costs must vary with the volume of water consumed. For Luby et al.'s first and second hypotheses, the relevant metric is the price of the last unit of water consumed, not the total price of water at a given volume. By including fixed costs in their measure of price, Luby, et al.'s analysis understates the efficiency signals that water customers receive with higher marginal use. For inferential purposes, measuring total price biases their analysis against utilities that have low fixed prices and high marginal prices at high volumes.

Elasticity. Luby, et al. rest their claims about the relationship between scarcity and price on comparative total prices at 12 ccf, a level that approximates average residential water use in the U.S. (Dieter 2017).[2] Problematically for their analysis, the first 12 ccf of water includes a significant amount of water for essential use; in fact, Luby, et al. define "essential use" as 8 ccf monthly for a family of four. The problem is that essential use—water used to drink, cook, bathe, flush toilets, clean their homes, and wash clothes and dishes—is relatively price inelastic. According to a 2016 residential end uses of water report, the average household uses about 5.6 ccf of water a month for indoor use alone (DeOreo et al. 2016). This level aligns closely with

[2] In depicting 12 ccf as "average use" across the 35 cities that they analyze, Luby, et al. ignore regional demand variation that likely relates to both climate and urban density. The systems they analyze generally serve urban areas, where average residential demand is lower than in the suburban areas that make up much of America's residential water use.

Chenoweth's (2008) claim that 35.6 gallons per capita per day (a little less than 6 ccf per month for a family of four) is the "minimum water requirement for social and economic development." Water use is unlikely to fall significantly below this level in a modern country, no matter how it is priced.

Although some behavioral changes and increased efficiency of appliances may reduce essential use, major differences in price at lower levels of consumption will likely have little effect on resource conservation. Thus about half of the consumption that Luby, et al. calculate for their main price metric is mostly inelastic to price signals. Even if Luby et al. had considered the marginal price rather than the total, marginal pricing at 12 ccf would not accurately depict the level at which pricing would matter for conservation.

Sewer rates. Luby, et al. include the price of sewer service in their measure of water pricing. That is an important merit of their study, since drinking water and sewer services are provided by the same entity in most of the cities that they analyze, and customers pay for both services with the same bill. In responding to prices, residential customers are unlikely to distinguish between the volumetric prices of water and sewer if both service are metered and billed together.

However, Luby, et al.'s depiction of sewer rates is unclear. The authors note that the "negative relationship between water price and water scarcity also persists when we exclude sewer rates for the subset of cities for which we have separate water and sewer rate information" (4), but do not identify which cities are included or excluded in these tests. Based on their reported rate calculations, it appears that they exclude the five cities in where drinking water and sewer services are provided by different organizations.

In eight of the utilities that they analyze, volumetric sewer rates are charged according to average winter water use, not total use. That is, customers will not be charged a volumetric rate for sewer consumption above their winter average use. The rationale for such rate structures is that average winter consumption reflects indoor water use, which typically results in wastewater flowing into the sewer system. Since water beyond winter average use is mostly for outdoor irrigation, these utilities do not bill that use for sewer services. Luby et al. do not explain how they deal with this complication.

Water budgets. Finally, three of the 35 drinking water utilities that Luby, et al. analyze employ *water budgets* (Denver, Los Angeles, and Riverside). Water budgets impose individualized rate structures that vary from one residential customer to another. Water budgets may present customers with very high or very low marginal costs at various consumption levels, depending on characteristics of their homes, land, and households. It is possible that not all of these utilities employed water budgets in 2015 when Luby, et al. gathered rate information, but based on the links provided in their appendix, at least one did use a water budget at the time. Luby et al. do not mention how they dealt with this.

Affordability. Luby et al. correctly point out that fixed prices and total prices have important implications for affordability.[3] The authors declare that "the first 8 CCF should be priced affordably," and then calculate total water and sewer prices at that volume to gauge affordability. This level of consumption is a reasonable standard for essential use, approximating indoor water efficiency guidelines in California (California Water Boards 2018) and Texas (Texas Water Development Board 2004), as well as Teodoro's (2018) recent analysis of affordability in major U.S. cities. The authors find that a "majority of cities (18 of 35) have bills

[3] One of the difficulties with Luby, et al.'s treatment of *affordability* is that they use the term in interchangeably with *equity*. Although the two concepts are related, they are not the same. In water rate design, *equity* is the degree to which price a that customers pay reflect the cost of serving them (AWWA 2012). *Affordability* is the ability of individual customers to pay for water/sewer services to meet their basic needs while maintaining the ability to pay for other essential costs (Teodoro 2018).

over $75 per month. Such rates for this level of water use correspond to a water bill of over $900 per year, a considerable burden for low-income households" (5). They pessimistically conclude that "water pricing policies do not bode well for meeting future water shortages in an equitable manner," implying that utilities in water-scarce regions not only price their services inefficiently, but also unaffordably.

Unfortunately, Luby, et al. simply measure prices at 8 ccf and declare that utilities should "set prices for essential use within the ability of all to pay" (6) without providing a standard by which to gauge that ability or the "burden" reflected in 8 ccf prices. The relevance of comparing affordability across utilities is also unclear. What should we infer from the fact that essential water is more expensive in Portland than in Pittsburgh? Lower prices are always more affordable than higher prices, *ceteris paribus*. However, *ceteris* is not always *paribus.* Costs of living and labor values vary widely across the 35 cities in Luby, et al.'s analysis, and so context can change the significance of a $75.00 water/sewer bill to low-income households. A meaningful assessment of affordability must include some means of capturing the opportunity cost of water for customers of limited means.

3. Problems with Scarcity Measurement

In addition to the problems with price measurement, the measure of water scarcity that Luby et al. employ does not accurately reflect scarcity conditions in the United States. Their sole measure of scarcity is the Water Supply Sustainability Index (WSSI) from the Natural Resources Defense Council (NRDC). The WSSI assigns each U.S. County a four-point scale, where 1 indicates relatively more sustainable and 4 relatively less sustainable water supply, based on projected supply and demand conditions in 2050 (NRDC 2010). There are a number of problems with the WSSI for purposes of analyzing water prices.

2050 Projections. First, the WSSI is an engineering firm's 2010 *projection* of water supply shortage risk in 2050, not a measure of *current* water scarcity. NRDC developed the WSSI with a goal of understanding the impact of climate change on future water risk. The authors do not make this distinction clear, only mentioning that it is a projection once, and suggesting that it is "based on current weather patterns."

While WSSI *projections* are based on current weather patterns, they do not necessary reflect *current* water scarcity. Repeatedly Luby, et al indicate that WSSI measures current scarcity with present tense language. They suggest "the least expensive water in the country is found in the cities with high water scarcity" (p.1). On page 4 they state that "cities with high water scarcity dominate the ranks of low-price cities even more." The only point at which the authors mention that WSSI is a projection to 2050 is in the caption to Figure 1. At best, this is an expository failure; at worst, it is misleading since the authors claim repeatedly that the WSSI measures water scarcity.

The WSSI's focus on the future makes it ill-fitting for Luby, et al.'s purposes. It seems unreasonable to expect that projected water supply risk 40 years in the future (rather than past or present supply risk) would explain current water rates. There is surely merit in evaluating the utilities' preparedness to deal with potential water risk due to climate change, but that is not Luby, et al.'s analytical aim.

Sustainability vs. scarcity. As its name suggests, WSSI is not even a measure of projected climatological water *scarcity* at all; rather, it is a measure of projected *sustainability*, understood as stress for water resources in a region (NRDC 2010). In addition to climatological projections, it includes projections for population growth. Nowhere does the NRDC's report itself refer to the WSSI as a measure of scarcity (NRDC 2010). While population growth and climate change may certainly stress water supply conditions in a region, they are not what the authors imply with their title or language: that urban water prices are "Cheaper When Drier." The WSSI is not a measure of moisture at all. Nowhere in the paper do the authors mention that the measure of water scarcity is really a measure of risk to water supplies from both climatological and demographic stressors; they mention only WSSI's climatological aspects. While it is certainly reasonable to consider both the demand side and supply side of water use when it comes to evaluating urban water rates, Luby, et al.'s title and rhetoric suggest only the supply side.

The WSSI lacks even face validity as a measure of water scarcity in terms of climatological moisture. A cursory look at the WSSI ratings for each of the utilities investigated in Luby, et al. shows the problem with this approach to measuring scarcity. Consider two of the largest cities in California, Los Angeles and San Francisco, for example: according to the NRDC measure, rainy San Francisco is a 3, while semi-arid Los Angeles is only a 2. Even more egregious is Las Vegas, which sits in the middle of the Mojave Desert: WSSI assigns it score of 3—the same rating it gives to Charlotte, Columbus, and Philadelphia. Using the correlation of water prices with such a measure to suggest that utilities in drier areas charge less for water is simply incorrect.

Categorical vs. continuous metrics. Finally, WSSI is a categorical variable that is meant to capture a continuous phenomenon. WSSI is based on whether counties throughout the United States meet a series of five criteria related to water sustainability risk (NRDC 2010). It does not give information about which criteria are being met or the variation within the categories. A more continuous measure of scarcity for evaluating water prices would more adequately capture the variation across cities.

4. Cheaper when drier?

Here we reanalyze the relationships between water/sewer pricing, water scarcity, and affordability for the same 35 cities that Luby, et al. studied, using more appropriate measures.

Data. In September 2018 we collected current water and sewer rates data for each of the cities that Luby, et al. analyzed. We collected new rates data rather than relying upon theirs for two main reasons.[4] First, it is impossible to distinguish between fixed and the variable prices in Luby, et al.'s publicly available replication dataset; they simply provide a total price at zero to 30 ccf for each city. Since the more appropriate way of understanding the conservation commitment of water utilities is through the marginal price, disentangling fixed and variables prices is crucial. Second, as mentioned previously, it is important to consider the impact of winter average volume caps for sewer on marginal price; it is difficult to tell how Luby et al. deal with these features of sewer rates.[5]

In cases where drinking water and sewer services are provided by different organizations, we gathered sewer rates from the agency that provides sewer services in the city. For example, Northeast Ohio Regional Sewer District provides sewer services in Cleveland, and so we use the district's rates to calculate sewer costs in that city. For systems that apply volumetric sewer rates to winter average volume, we capped volumetric charges at the equivalent of 8 ccf.

[4] Some inconsistencies in Luby, et al.'s replication dataset make us reluctant to use it, rather than collecting our own data. For example, they report that water prices in Tampa drop by almost $80 between 26 and 27 ccf. It also is not always clear whether their calculations include sewer rates. Finally, although most of the 35 utilities' rate schedules set prices by ccf, others use thousand gallon units. It was not clear that Luby, et al. consistently transformed charges to reflect differences in units.

[5] The statistical appendix contains various analyses using their replication dataset. These analyses do not greatly differ from those we present in the paper.

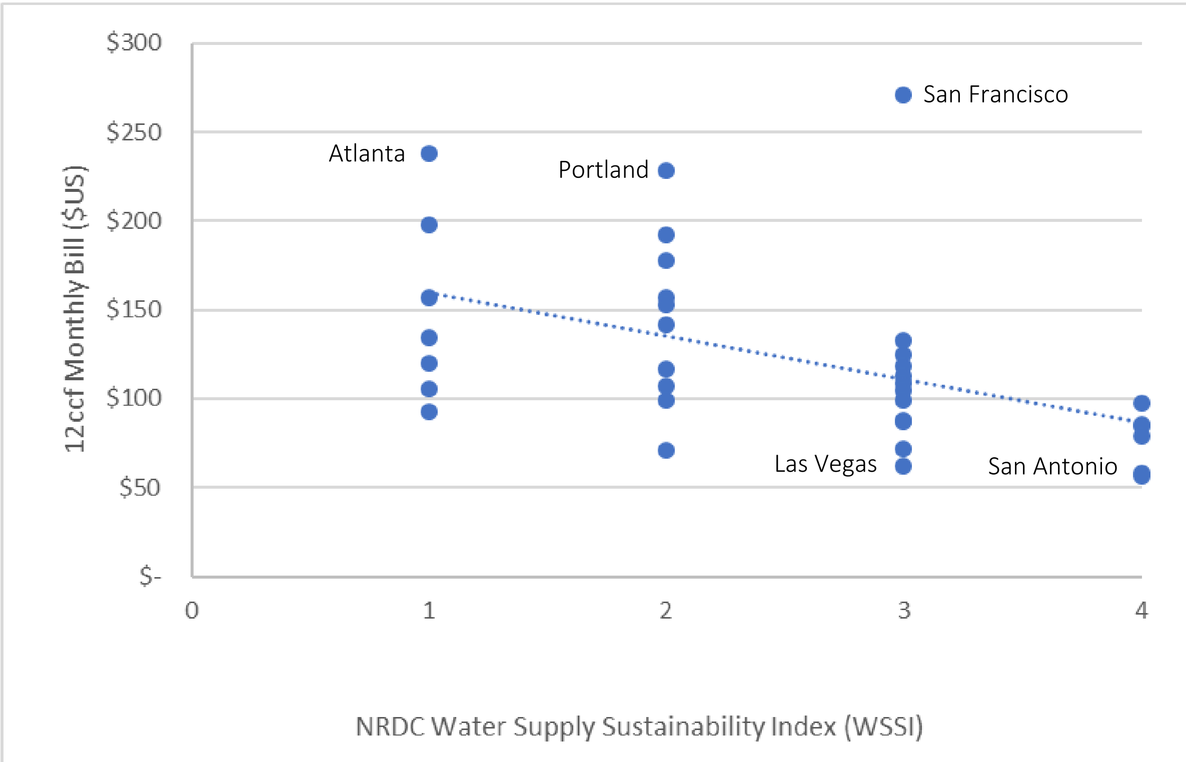

Figure 1. Monthly residential water and sewer utility bill for 12 CCF of water as a function of the Water Supply Sustainability Index. A score of 1 is low risk and a score of 4 is extremely high risk of water shortage by 2050.

We begin by showing that the use of the 2018 data does not substantially change the results of the analysis using their methodological approach. Figure 1 shows the relationship between total price for the first 12 ccf of consumption across WSSI categories. Although the ordinal ranking of the cities changes somewhat, the overall picture is remarkably similar to Luby, et al.'s Figure 1: as WSSI score increases, 12 ccf price declines. It is important to show the alignment of our respective Figures 1 because it establishes that our subsequent results we get in further analysis are not driven by underlying differences between 2015 and 2018 rates. The correlation between WSSI and the total price at 12 ccf is fairly high, at -0.471.

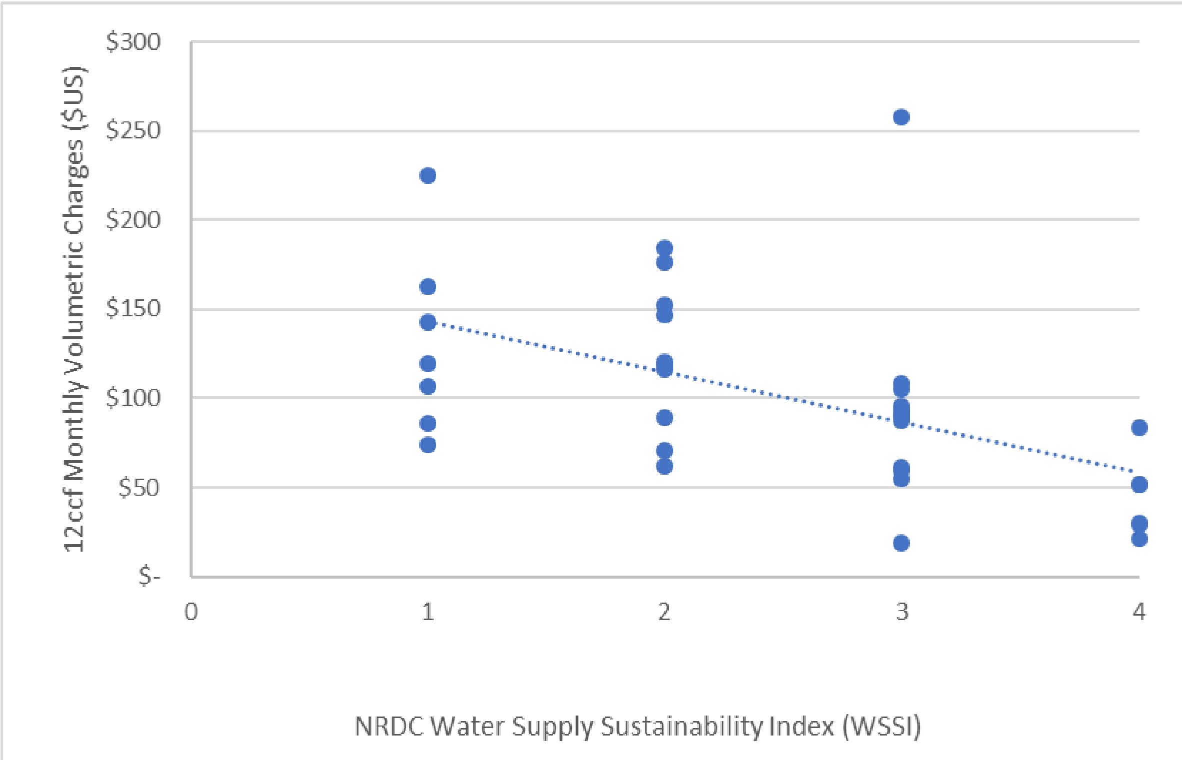

Figure 2. Monthly residential water and sewer volumetric charge for 12 CCF of water as a function of the Water Supply Sustainability Index. A score of 1 is low risk and a score of 4 is extremely high risk of water shortage by 2050.

As a first step in improving the analysis, we look at what happens when we improve the measure of price, without adjusting their measure of scarcity. Figure 2 shows the relationship between WSSI's projection of projected water stress in 2050 and the volumetric price of 12 ccf of water consumption (that is, excluding fixed charges). Interestingly, even with a more appropriate measure of price, it appears that Luby et al.'s findings about the relationship between the WSSI and price are still supported: the marginal price of water for 12 ccf of consumption declines as the WSSI index increases. In fact, the correlation is even stronger, at -0.520.

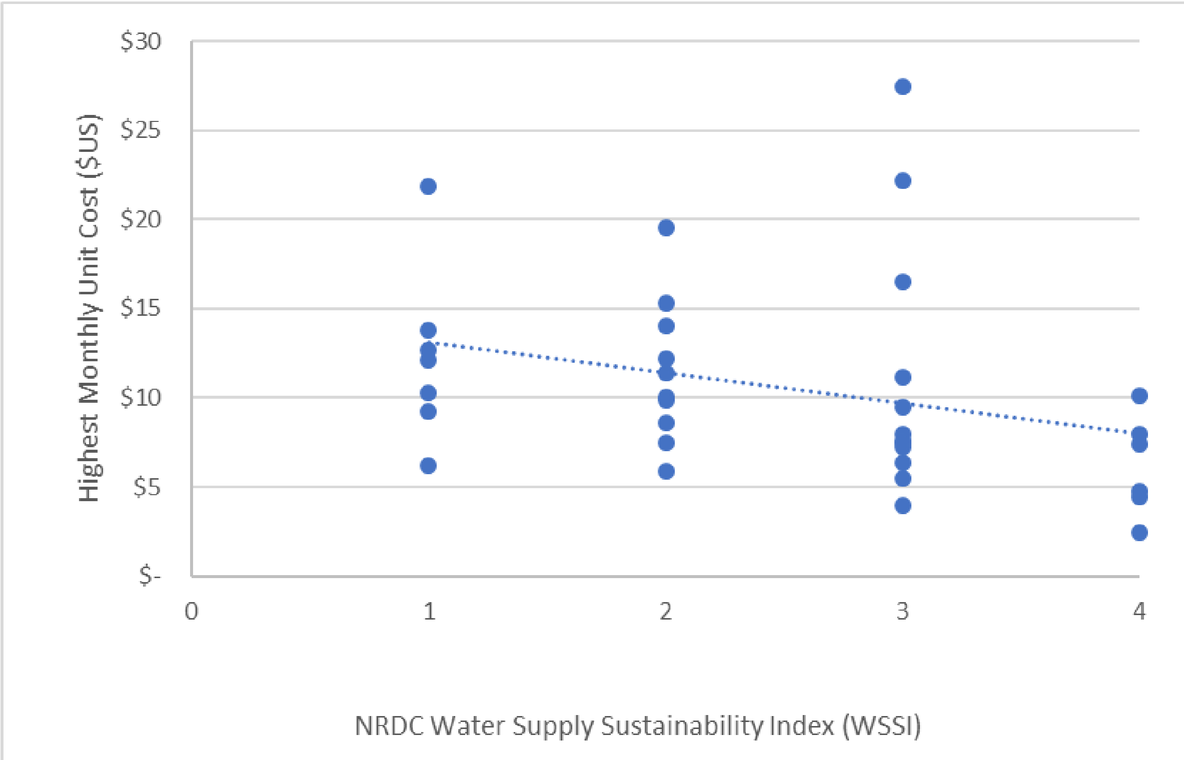

Figure 3. Highest marginal water/sewer price charged for 1 ccf of consumption as a function of the Water Supply Sustainability Index. A score of 1 is low risk and a score of 4 is extremely high risk of water shortage by 2050.

As discussed, however, even measuring volumetric prices at 12 ccf is misleading, since it includes the relatively inelastic essential use. As an alternative measure of the conservation orientation of water rates, we consider the highest marginal unit price of water for 1 ccf of consumption in the first 30 ccf charged in each metro area. Figure 3 shows the relationship between the NRDC measure and the highest marginal price. Once again, it appears that the marginal price is actually lower when the WSSI is higher, although in this case it the relationship is not as strong, at only -0.221.

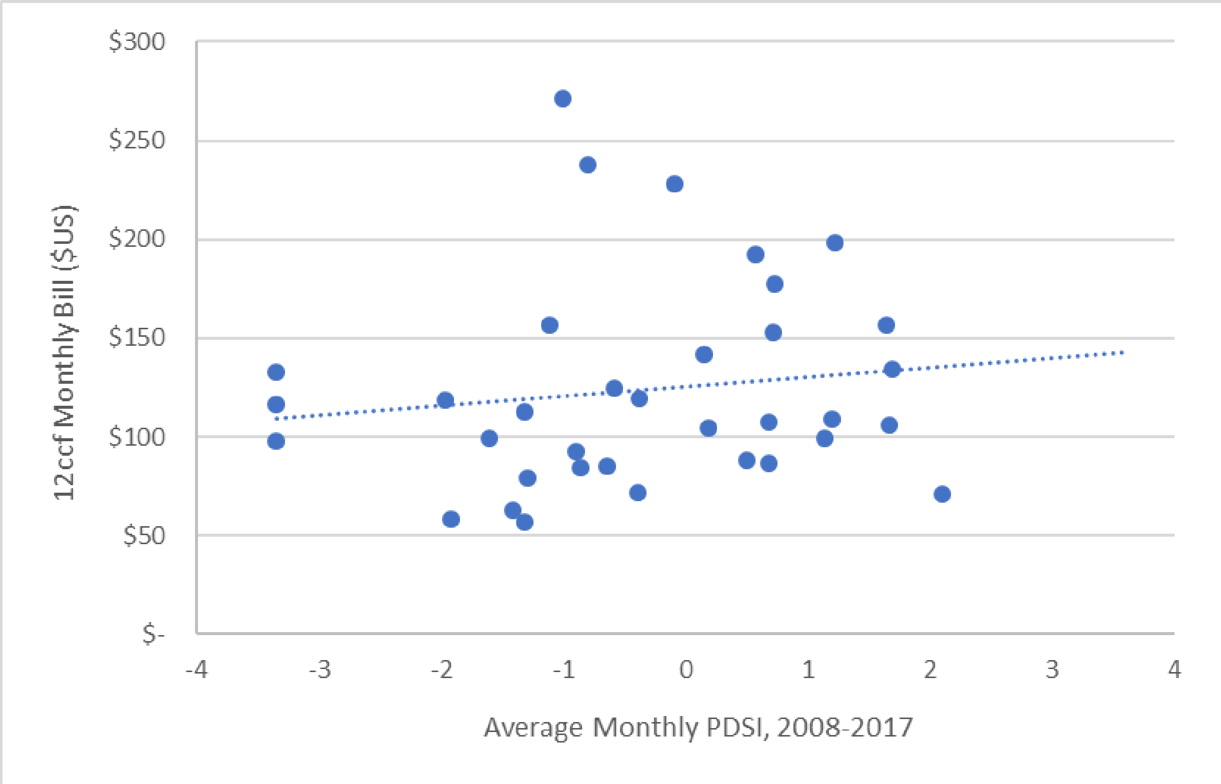

Figure 4. Monthly residential water and sewer utility bill for a household of four using 12 CCF of water as a function of monthly average PDSI from 2008-2017. Higher PDSI indicates moister regions.

The picture begins to change when we introduce a more meaningful measure of water scarcity. In order to capture water scarcity conditions that are not projections or categorical, we employ the Palmer Drought Severity Index (PDSI), the most commonly used measure of regional moisture levels. The PDSI assigns values to the level of water supply/demand in a region (Palmer 1965). The zero-centered index ranges from dry to moist, with a value of -4 or below suggesting that an area is in extreme drought, while a value of 4 or above means that an area is extremely wet. We matched each utility in the dataset to an NOAA climate division. We then calculated the average monthly PDSI for the 10-year period from 2008 to 2017 to create a measure of water moisture levels. Perhaps not surprisingly, this measure does correlate well with the WSSI measure (p=-.52), but it more fully captures the variation within and between the categories. It is not projection or population based, but based instead on climatological data from the previous 10 years.

As a first look at the relationship between our scarcity measure and price, we examine how the average total price for 12 ccf of usage, including fixed costs, is associated with scarcity measured with PDSI. Figure 4 shows that, while utilities in drier regions charge slightly less for water, the relationship is weak. The correlation between average monthly PDSI and total price for 12 ccf is 0.13. Even when using average price rather than marginal price, there is only weak support for Luby, et al.'s claim.

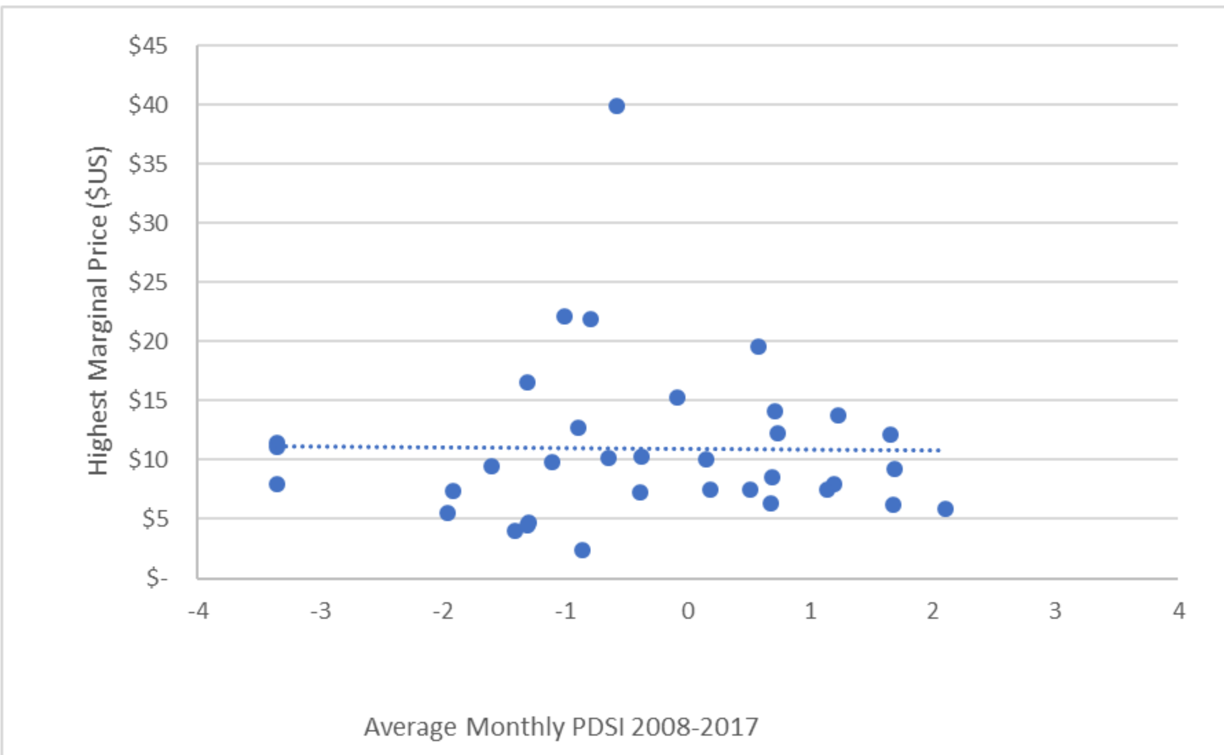

Figure 5. Highest marginal water/sewer price charged for 1 ccf of consumption as a function of monthly average PDSI from 2008-2017. Higher PDSI indicates moister regions.

Looking at the relationship between highest marginal price and average monthly PDSI, however, shows that there is essentially no meaningful relationship between price and water scarcity, at least among these 35 cities. Figure 5 shows that the correlation between highest marginal price and water scarcity approaches zero at just -0.012. This is perhaps evidence that prices do not relate to scarcity in the way that we would expect, but it is not evidence that prices are "cheaper when drier."

5. Increasing Volumetric Prices?

Luby, et al. reason that to "to address water scarcity and cover the cost of provision, prices for water beyond essential use may need to be substantially higher" (5). The authors do not mean to evaluate how well rate structures cover costs, because they do not have data on utilities' capital and operating costs. Rather, their analysis of "prices beyond essential use" or "additional use" is another way of investigating how conservation-oriented rates are. To do so, they measure the difference between total prices at 8 ccf and 16 ccf. Luby, et al. label this interval the price of "additional use," and then compare it to the price of water at 8ccf ("essential use"). Among the 35 cities they analyze, the authors find that "that only 13 cities have higher prices, 20 cities have lower prices, and 2 cities have constant prices" for additional use (p.5). This result, they argue, shows that utilities are failing to accomplish a key goal because the majority of areas have lower marginal prices for "additional use" than total prices for "essential use."

There are at least two significant problems with this analysis. First, Luby et al. once again fail to address sewer rate structures that cap charges at winter average use. Calculating the price from 8 to 16 ccf without considering that some utilities cap sewer charges based on winter use may lead to misleading findings. This is especially true since three of the utilities that Luby et al. estimate as having the largest difference between the prices charged for "essential" and "additional" use (Los Angeles, Austin, and Phoenix) employ winter average caps for sewer charges. Second, Luby, et al. suggest that they are interested in examining the differences between the prices at the different levels of consumption in part because utilities should be addressing scarcity through increasing block rate pricing. But their analysis once again includes fixed prices for the first 8 ccf of consumption, so their analysis really compares the *total* price of essential use with the *marginal* price of additional use. After correcting these issues, we found that the majority of cities had higher marginal prices from 8-16 ccf than the first 8 ccf: 21 of the areas had higher prices, 5 had the same price, and 9 had lower prices. Further, 6 of the 9 who charged lower marginal prices for the higher consumption block use winter average caps for their volumetric sewer rates.

However, the primary difficulty with Luby et al.'s argument about essential versus additional use prices is logical, not methodological. It is difficult to see what they are arguing is wrong with water pricing for "additional use." Is it that prices are not high enough for additional use compared to essential use, and so are not sufficient to cover costs? It would be difficult to suggest that these utilities are not meeting their costs without more detailed information on revenues and expenditures. Is the problem affordability? The price of water beyond essential use is not relevant to affordability.

Luby, et al. may be arguing that prices are not high enough on additional use compared to essential use, and so do not adequately reflect scarcity. The authors do not directly test this possibility, as they do not show how the difference in price between the first 8 ccf and second 8 ccf correlates with WSSI. In Figure 6 we show the relationship between PDSI and the percent difference in *volumetric* prices (excluding fixed charges) at 8ccf and 16ccf.

Figure 6. Percent difference in volumetric price between additional and essential use as a function of monthly average PDSI from 2008-2017. Higher PDSI indicates moister regions. Triangles represent cities that cap sewer charges at winter average volume. Dotted line shows average for cities that apply sewer volume charges for all water consumption; dashed line shows average for cities that cap sewer volume charges at winter average consumption. Compound line shows overall average.

The heavy compound line in the middle of the graph shows that, similar to the relationship between highest marginal cost and scarcity, there is very little statistical relationship between scarcity and the overall percent difference in the marginal price of the first 8 ccf and second 8 ccf. The average percentage difference is slightly higher in utilities in drier regions, but the correlation is weak. The correlation changes markedly, however, when accounting for structural differences in sewer billing. The dashed line in the lower part of Figure 6 depicts the correlation for the eight cities that cap volumetric sewer rates at winter average volume. Notably, volumetric prices at 16ccf are all lower than at 8 ccf in these cities, precisely because sewer charges do not apply to the second 8 ccf. The higher dotted line shows the correlation for cities that charge volumetric sewer rates for all volume. The result is striking: the difference between 8 ccf and 16 ccf volumetric prices now declines steeply with scarcity (ρ=-.64). Thus, it appears that reveals that sewer rates—not water rates—account for much of the difference between 8 ccf and 16ccf prices that Luby, et al. observe.

4. Affordability and Scarcity

Luby, et al.'s third hypothesis is about affordability, a topic of increasing scholarly and public importance. The vagueness of their claims about affordability makes them difficult to verify or falsify. As discussed earlier, the authors do not really measure affordability in a substantively meaningful way; rather, they simply calculate water/sewer prices at 8ccf and then claim that the prices they observe are burdensome in the 18 cities where prices are greater than $75.00 per month.

Our aim here is not to advance an argument about water affordability, but rather to provide more meaningful measurement across the 35 cities at hand. We follow Teodoro's (2018) suggestion to express the price of essential water and sewer service in terms of Hours at Minimum wage (HM). This approach contextualizes water/sewer prices for low-income households by capturing opportunity cost of water bills for low-wage workers. Although it HM is an imprecise measure of household-level burden, it at least provides an objective, substantively meaningful depiction of affordability and so is better than simply measuring a price. Teodoro suggests 8.0 HM threshold as an intuitive rule-of-thumb for affordability.

Essential water and sewer service prices average 9.7 HM across the 35 cities analyzed here; fourteen of them meet Teodoro's 8.0 HM rule-of-thumb. This result is roughly consistent with Luby, et al.'s general observations about affordability across these 35 cities, but the findings diverge for several cities. In three cities (Los Angeles, San Jose, and Washington, DC), essential monthly service is more than $75 but is less than 8.0 HM; in three others (Charlotte, Dallas, and Philadelphia) essential service is less than $75, but more than 8.0.

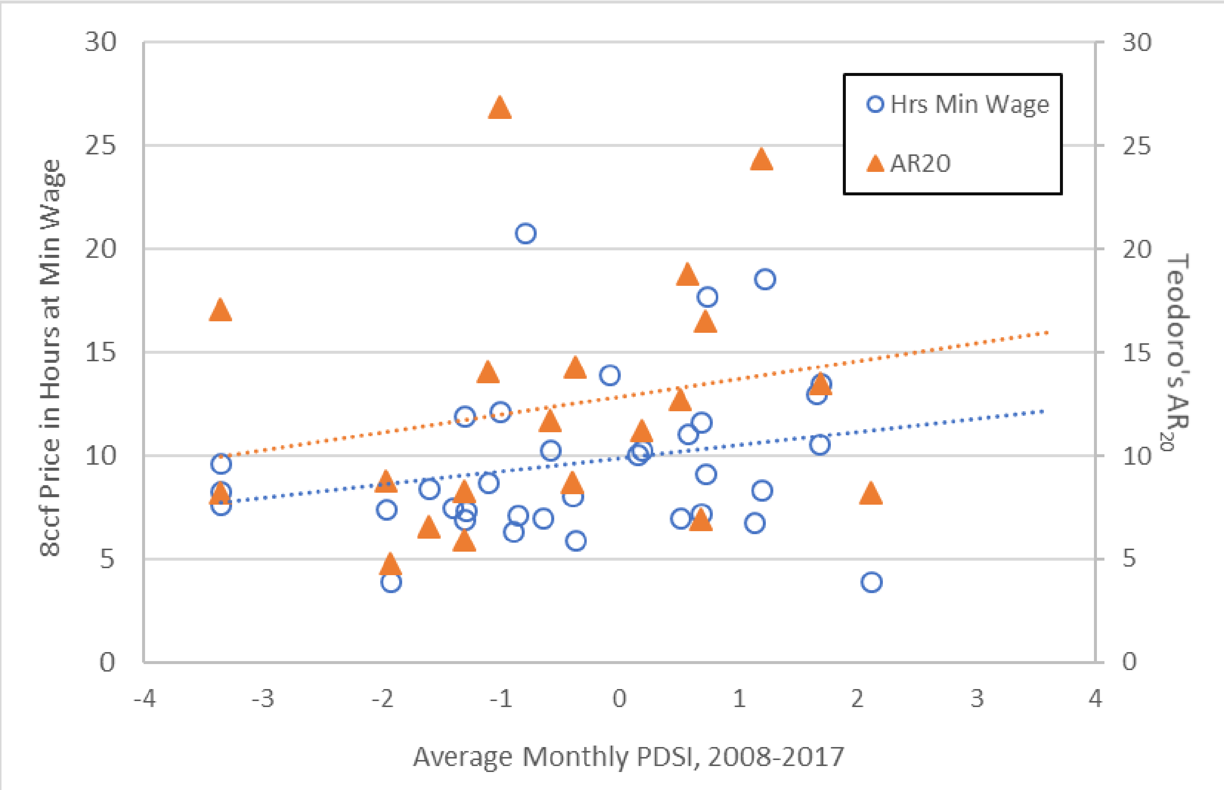

Figure 7. Circles are Hours of Minimum Wage labor (HM) required for 8 ccf of water as a function of monthly average PDSI from 2008-2017. Triangles are Teodoro' s AR_{20}. Higher PDSI indicate moister regions.

Figure 7 shows how values of HM vary across levels of average monthly PDSI. To complement HM, we also show in Figure 7 Teodoro's Affordability Ratio at the 20th income percentile (AR_{20}) for the twenty cities in the Luby, et al. sample that are also in Teodoro's (2018). Teodoro's AR_{20} estimates the price of essential water and sewer service as a percentage of disposable household income (i.e., available income after paying for taxes, housing, health care, food, and home energy) for households at the 20th income percentile. For both HM and AR_{20}, higher values indicate less affordable water/sewer service. As Figure 7 shows, the two metrics indicate the same basic relationship between scarcity and affordability: as moisture increases, so do HM (ρ=.24) and AR_{20} (ρ=.22). That is, prices for essential service are, on average, more affordable in drier regions.

7. Conclusion

A number of potentially important implications can be drawn from our reanalysis of water pricing in the 35 largest U.S. metropolitan areas. Our results do not support Luby, et al.'s main claim that U.S. water prices are "cheaper when drier." Once improved measures of prices and scarcity are applied, there appears to be no meaningful relationship between scarcity and price. We also find no evidence to support their conclusions about the relative prices of essential and "additional use" of water. Although their claims about affordability are difficult to evaluate, we find evidence that water and sewer rates may present significant affordability challenges in more than half of the 35 utilities analyzed here, though not in the same cities that Luby, et al. identify. Intriguingly, it appears that affordability generally improves as water scarcity increases. In sum, our reanalysis yields no evidence that water in America is "cheaper when drier," but it appears to be more affordable when drier.

As a final remark, we wish to emphasize that none of these findings should be seen as representative of the United States as a whole. Luby et al. (2018) claim that "As a general rule U.S. urban water prices do not satisfy either scarcity or equity pricing principles" (6). There are thousands of municipal water systems in the U.S., and these systems vary widely in demographic, economic, political, and climatological conditions; Luby, et al. analyze 35 of them. Inferring a pattern—let alone a "general rule"—based on simple bivariate correlations within such a small, non-random sample is inappropriate. Future research on water pricing should measure pricing appropriately, look beyond the largest utilities, and seek to identify the natural, institutional, and social causes of variation in utility pricing in the United States.

Data

All data used in this analysis is available in the supplemental materials.

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