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Valuing Florida Water Resources: Households' Willingness to Pay for Water [1]

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Introduction: Diving into the Economics of Water Resource Valuation

This paper is a part of the series "Economic Value of Florida Water Resources." The series is intended for UF/IFAS Extension agents, water resource managers, and the public interested in water-resource management decisions. Overall, the goal of this series is to inform decisions related to water-resource protection and restoration or alternative water supply development. Often water-resource protection and restoration require significant investments. What do these resources bring to the community? Can the outcomes of water resource projects be measured in monetary terms? Papers in this series focus on Florida-based studies about the economic values that clean and plentiful water resources can provide to human society. For some topics though, only a limited number of the Florida-based studies is available, and then we rely on existing literature from other regions.

Figure 1. Florida home and pool.
Credits: Tyler Jones, UF/IFAS

The series discusses the idea that water resources provide us with a variety of goods and services that are examples of "ecosystem services." "Ecosystem services," sometimes also called "environmental services," are the benefits people derive from nature (see *Valuing Florida's Water Resources: Ecosystem Services Approach*). This paper focuses on a specific ecosystem service that water resources provide to Floridians: water supply for household needs. The paper considers the value of water for household needs. The value of protecting water quality for household water supply is discussed in *Economic Value of Florida Water Resources: Valuing the Quality of Water for Household Needs*.

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Economists develop strategies for measuring the economic value of ecosystem services. However, the answer to the question "What is the true value of water for household needs?" is always "It depends." The benefits that households derive from water depend on the tasks that the water is used for. For example, water for drinking is generally more valuable than water for yard irrigation. Compare the dissatisfaction you would experience from feeling thirst yourself or from hearing your children complain of thirst versus the dissatisfaction you would experience from watching your grass suffer from lack of water. Moreover, the value of additional water generally diminishes with increase in the water volume. For example, the first sip of water after walking or exercising can be very pleasant. However, finishing the second glass of water may be difficult, indicating the reduction in the satisfaction from every additional sip of water. The same rule applies to the other uses of water, as well as any other good or service. Economists refer to this phenomenon as "the law of diminishing marginal utility."

To provide meaningful insights, economists limit their focus to specific uses of water and to small changes in water use. For instance, a study might examine a 1 percent reduction in water use as compared to the current level. In this article, we present several examples of valuing water availability found in literature and focused on Florida and other regions.

The value of water is measured by economists as the *willingness to pay*, that is, the maximum amount that people would be willing to pay to avoid unfavorable changes. In this article, the focus is on the willingness to pay for water for household needs. The sum of the willingness to pay across individuals or households indicates the total value for a community or region.

This maximum willingness to pay is generally higher than the water price. In fact, many studies focus on the difference between the maximum people are willing to pay and the price they actually pay, aggregated across all the individuals studied. This aggregated value is referred to as "consumer surplus" or just "willingness to pay above the current price."

To further clarify the willingness to pay and consumer surplus concepts, we use an informal illustrative example from one of the presentations by Drs. Bill Huth and Ash Morgan, economists from the University of West Florida and Appalachian State University. They asked audience members to think about their last house purchase. The maximum price an audience member had in mind was equal to the maximum willingness to pay, or the total value of the house to the audience member. This maximum price was likely higher than the final price the seller agreed on, and the difference between the maximum willingness to pay and the final price was the consumer surplus.

Two methods are most commonly used to collect information from the households and estimate the willingness to pay:

- surveying people. Economists refer to this approach as "stated preference approach." For example, researchers may survey utility customers about their willingness to pay higher utility bills to avoid drought water-use restrictions; and
- observing actual choices that people make, such as reduction in water use in response to increases in water prices. Economists refer to this approach as "a revealed preference approach."

Results of estimations depend on income and price levels in the economy, as well as people's preferences, and therefore may change over time.

Using Surveys to Examine Households'

Benjamin Franklin famously said: "When the well is dry, we know the worth of water." Floridians, as well as residents of other US states and other developed countries, are very used to getting water every time they turn on the tap. As a result, we seem to be forgetting about "the worth of water."

Yet, there are instances when water becomes less available, for example, during droughts. In Florida, regional government agencies called Water Management Districts can declare a water shortage when water is not sufficient for all water users or when a temporary reduction in total water use is needed to protect water resources from serious harm. When a water shortage is declared, restrictions on residents may be required (§373.175, Fla. Stat.). For example, during extreme shortages, water users may be required to limit outdoor water use. Since such situations of reduced water availability are familiar to households, it is possible to measure households' willingness to pay to avoid such situations.

Since 2000, three studies in Australia, one study in Canada, and two in the United States have been published examining households' willingness to pay (above the current price) to avoid drought water-use restrictions (Table 1). Most of the studies examined restrictions on outdoor water use, and all of them show that households are willing to pay to increase water availability for that use. Studies from Australia and Canada showed that the willingness to pay is between 20% and 35% of households' annual water bills.

The only Florida-based study surveyed 448 households from the Orlando Utilities Commission service area (WateReuse 2013). Most of the respondents owned a house and a yard and had lived in Orlando for more than 10 years. The respondents were given a description of the next 20 years as expected to yield 7 years with no restrictions required, 10 years with Level 1 restrictions (involving one day per week irrigation restriction, along with other measures to reduce outdoor water use), and 3 years with Level 2 restrictions (when no outdoor irrigation is allowed, and other measures to reduce outdoor irrigation are taken). The households surveyed were willing to pay $23.12 per year per household (above the current water bills, in mid-2018 US$) to avoid Level 2 water use restrictions in one year over the 20 year planning horizon. Since the scenario involved up to three summers of Level 2 restrictions, the study concluded that the willingness to pay to avoid all Level 2 restrictions was $23.12 x 3 = $69.36 per household per year (in mid-2018 US$).

To estimate this willingness to pay as a percent of annual water bill, take average water use of approximately 85 gallon per person per day (Marella 2014). The average number of people per household is 2.64 (US Census 2018), and an "average" month has 30.4 days. Then, household water use is, on average, approximately 7,000 gallons per month. The monthly water bill of Orlando Utilities Commission customers for this water-use level is $14.43 (Environmental Finance Center 2018), and hence the annual bill is $14.43×12 = $173.16. Therefore, the willingness to pay to avoid 3 years of "Level 2" irrigation restrictions over the 20-year planning horizon is approximately 40% of households' annual water bill, which is comparable with the results from the other studies cited above.

The estimated service population of the Orlando Utilities Commission is 428,761 people (Environmental Finance Center 2018), or approximately 162,400 households (assuming 2.64 persons per household, US Census 2018). The willingness to pay to avoid one year of "Level 2" restrictions,then, is $23.12 x 162,400 = $3.75 million per year. The willingness to pay to avoid all three "Level 2" restrictions that are expected in the next 20 years is $11.26 million. This estimate provides a basis for significant utility investments in alternative water-supply projects to avoid the need to impose the restrictions.

Water Demand Function and Water Value

Willingness to pay can be estimated from the relationship between the price of water and the level of water use. Economists refer to this relationship as "water demand function." Most of the studies published in various countries found that, given the current level of water prices and water use, changes in prices generally resulted in small changes in water use. In other words, the percentage change in water use is generally smaller than the percentage change in price. Economists refer to such demand function as "demand with low price elasticity" or just "inelastic demand."

From Whitcomb (2005), the price elasticity or residential water demand in Florida ranged from –0.39 to –0.84 depending on household wealth. This implies that a 10% increase in price is expected to result in 3.9 to 8.4 % reduction in water use.

For example, in 2017 in Florida, the median bill for 4,000 gallons per month was $21.64 (Environmental Finance Center 2018), or $5.41 per thousand gallons, on average, including fixed water fees. Assuming the price elasticity of (-0.39), and use of 4 thousand gallons per month, the last thousand gallons per month has a value of $7.86, which is $2.45 higher than the current average water price.

Note that a water demand function approach helps assess the lower limit on willingness to pay, since it assumes that a water-use reduction affects low-valued uses (Dixon et al. 1996). This method also provides accurate results when it is applied to small changes in water availability— only a few percent as compared with the current use.

Can bottled water price be used as an indicator of the "true value" of water?

In public discussions, bottled water prices are sometimes mentioned as an indicator of the value of water.

The average *wholesale* price of domestic non-sparkling bottled water was $1.11 per gallon in 2016 (IBWA 2018). This translates into $1,110 per thousand gallons, with retail prices being even higher. This is much higher than tap water prices (e.g., Florida's median of $4/thousand gallons, when consumption exceeds 10 thousand gallons, Environmental Finance Center 2018).

Yet, the price of bottled water differs so widely among brands and bottle sizes that one may ask what customers are paying for when they buy a bottle of water.

Water sold in smaller bottles is often bought for convenience of access. That is, people pay for drinking water in

convenient containers and of a pleasant temperature when they are away from home. Customers also pay more for water labeled as artesian or natural, as well as for water produced by specific brands, especially when compared with store brands (He, Jordan, and Paudel 2008).

Purchases of bottled water, as well as of filters, are also correlated with concerns with tap water quality, and customers' concerns for the taste, odor, and/or appearance of tap water. Economists refer to such purchases as "averting behavior" and "averting expenditures." In other words, payments for water filters or bottles may indicate the value of improving tap water quality (Abrahams et al. 2000).

As these examples show, bottled water and tap water are not always direct substitutes. However, comparing the prices of tap and bottled water can be an effective tool to draw attention to the value of water resources that we use and often undervalue.

Note that important points to raise in a presentation about bottled water can be the unwanted environmental side effects of bottled water choices. A recent article in Forbes states that globally customers buy a million plastic bottles per minute, and 91 percent of them are not recycled. Plastic bottles that are commonly made of polyethylene terephthalate take approximately 400 years to naturally decompose, with the amount of plastic growing at a staggering pace in landfills and in the oceans (Nace 2017).

Conclusion

This article reviewed various methods of examining the value of water availability for household needs. The value is measured as the households' willingness to pay above the currently paid prices.

The value of water depends on the use of water by households (e.g., indoor use or outdoor irrigation), the current level of water use, household characteristics (such as income and preferences), and other factors.

Most of the studies reviewed here examined households' willingness to pay for outdoor irrigation. Specifically, the studies focused on the willingness to pay to avoid outdoor watering restrictions, a widely used strategy to manage water demand during droughts. Depending on location and the level of restrictions, households are willing to pay an additional 20–40 % of their annual water bills to avoid the restrictions. For example, Orlando residents were willing to pay, on average, $23.12 per household per year to avoid drought water-use restrictions in just one year out of 20 future years, with the restrictions involving prohibiting lawn and landscape irrigation. To avoid the restrictions in three out of 20 future years, the households were willing to pay $69.36 per household per year, on average (WateReuse Foundation 2013). The highest willingness to pay, $222.15 per household per year, was reported in the study of households in Canberra, Australia, for avoiding drought restrictions when no sprinkler irrigation was allowed year-round for the foreseeable future (Hensher et al. 2006).

Another strategy to measure willingness to pay is to estimate the responsiveness of household water use to prices. Studies from Florida and other regions show that price increases result in small changes in use, and this implies that the value of use is high.

Yet another approach sometimes used to gage the value of drinking water is to look at the prices people pay for bottled water. The average *wholesale* price of domestic non-sparkling bottled water was $1.11 per gallon in 2016 (IBWA 2018), or $1,110 per thousand gallons, which is significantly higher than the price of municipal water. This estimate should, however, be used with caution, because bottled water is not a direct substitute for municipal water (in terms of water taste, temperature, accessibility away from home, and other characteristics).

Overall, though the results of valuation studies differ, all studies show significant value of water for households. These estimates can be considered by water resource managers in their planning of investments in water infrastructure to prepare for droughts. These values can also be considered when analyzing spending on protecting source water availability, for example, by protection of aquifers or increasing the recharge of aquifers, the primary water source in Florida.

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Table 1. Summary of willingness to pay studies (only studies published in 2000 or later are included).

Source	Location	What is Valued	Additional Description	Willingness to pay above current water bill, converted to mid-2018 US$*	Willingness to pay, % of respondents' average annual bill
Australia					
Hensher et al. (20l6)	Canberra, Australia	Avoiding stage 3 drought restrictions (i.e., no sprinkler irrigation allowed) that last all year-long, for the foreseeable future.	In Canberra, stage 3 drought restrictions specifically prohibit sprinkler irrigation (handheld hoses and buckets can be used in the morning and evening on alternative days only); car washing is allowed at commercial operations only. Estimated willingness to pay is 239 AU$.	$222.15 per household per year	31%
Tapsuwan et al. (2007)	Perth, Australia	Moving from 1 day to 3 days a week of allowable sprinkler use, for a 10-year planning horizon.	Estimated willingness to pay is 22% extra on annual water usage bills (or around AU$57 based on average water usage bill of respondents surveyed = AU$260, in 2006 AU$).	$52.98 per household per year	22%
Copper and Crase (2018)	Wodonga, Bendigo, and Albury*, Australia	Avoiding water use restrictions completely. Survey conducted during drought period (in 2008)	The respondents were drawn from the cities that implemented a variety of restrictions over the years preceding the surveys; therefore, respondents are paying for avoiding all the various specifications of restrictions. Estimated willingness to pay ranged among cities from $110 to $165 per household per year*	$117.52–$176.29 per household per year	Not available
		Avoiding water use restrictions completely. Survey conducted post-drought period (in 2012)	The respondents were drawn from the cities that implemented a variety of restrictions over the years preceding the surveys. Estimated willingness to pay ranged among cities from $43–$125 per year**	$45.94–$133.55 per household per year	Not available

Source	Location	What is Valued	Additional Description	Willingness to pay above current water bill, converted to mid-2018 US$*	Willingness to pay, % of respondents' average annual bill
Canada					
Dupont (2013)	Canada	10% reduction in water use***	Willingness to pay for reclaimed water infrastructure to avoid summer water-use restrictions, with the restrictions leading to 10% reduction in water use. Estimated willingness to pay is $142 (assumed CA$, 2009). Since the average annual water bill is approximately $450, this represents a 30% increase.***	$187.38 per household per year	32%
		30% reduction in water use***	Willingness to pay for reclaimed water infrastructure to avoid summer water-use restrictions, with restrictions leading to 30% reduction in water use. Estimated willingness to pay is $149 (assumed CA$, 2009). Since the average annual water bill is approximately $450, this represents a 30% increase. ***	$196.62 per household per year	33%
United States					
Griffin and Mjelde (2000)	7 cities in Texas	Avoiding immediate restrictions in outdoor water use that are expected to last for 14 days.	Avoiding immediate restrictions in outdoor water use. The restrictions are caused by a 10% shortfall (when water supply in the community is 10% smaller than water demand), that is expected to last for 14 days. Estimated willingness to pay is $25.34 (in 1997 US$)	$39.79 per household (one-time payment)	Not available
		Avoiding immediate restrictions in outdoor water use. The restrictions are caused by a 30% shortfall (when water supply in the community is 10% less than water demand) that is expected to last for 28 days.	Avoiding immediate restrictions in outdoor water use. The restrictions are caused by a 30% shortfall (when water supply in the community is 30% less than water demand) that is expected to last for 28 days. Estimated willingness to pay is $34.39 (in 1997 US$)	$54.00 per household (one-time payment)	Not available

Source	Location	What is Valued	Additional Description	Willingness to pay above current water bill, converted to mid-2018 US$*	Willingness to pay, % of respondents' average annual bill
WateReuse Foundation (2013)	Austin, TX, Long Beach and San Francisco, CA, Orlando, FL, and an anonymous North America utility	Avoiding one year of relatively severe ("Stage 2") drought water-use restrictions in one of the years over the next 20 years.	Description of "Stage 2" restrictions varied somewhat among the cities examined. For example, in Orlando, the restrictions involved prohibition of lawn and landscape irrigation. In San Francisco, customers were subject to increased level of water rationing, with prohibition of most outdoor watering. Estimated willingness to pay is $20.20–$37.16 (assumed 2011 US$)	Range from $23.12 (Orlando) to $42.52 (San Francisco) per household per year	Not available
		Avoiding three years of relatively severe ("Stage 2") drought water-use restrictions in one of the years over the next 20 years.	The results are based on multiplying the results above by 3 (years). Estimated willingness to pay ranged from $60.60 (Orlando) to $111.48 (San Francisco) (assumed 2011 US$)	Range from $69.35 (Orlando) to $127.57 (San Francisco) per household per year	40%****

* study results are assumed to be reported in local currencies assessed for the year of publication or the year when the study was conducted
** Assuming that the study report results in 2012 AU$. The study examined 6 cities; this table reports median WTP values for the three cities for which drought and post-drought willingness to pay are different
*** Respondents were given a description of a future of more frequent water shortages for communities that could be handled either through (a) status quo approach (usual water reduction program of outdoor summer water-use restrictions) or through (b) increased reclaimed water use. The status quo program (option a) described restrictions limiting private lawns and public spaces watering and outdoor car washing). Business and firms found in noncompliance would be subject to financial penalties. Option B was described as a water supply augmentation program, when sewer infrastructure and upgrading allows the piping of treated and disinfected reclaimed wastewater back to homes through a separate system to be used only for toilet flushing. Respondents were told that the reclaimed water would not look or smell different from regular tap water. Half of the respondents were told that the summer water restrictions would require a 10% reduction in water use and the other half were told that it would require a 30% reduction.
**** estimated by the authors of this publication. See the discussion in the section above entitled "Households' Willingness to Pay as a Measure of the Economic Value of Water."