Understanding the Relationship between Water Price, Value, and Cost

WASHINGTON STATE UNIVERSITY EXTENSION FACT SHEET • FS110E

"Nothing is more useful than water: but it will purchase scarce anything; scarce anything can be had in exchange for it. A diamond, on the contrary, has scarce any use-value; but a very great quantity of other goods may frequently be had in exchange for it."

—Adam Smith, Chapter 4, Book I, Wealth of Nations (1776).

Introduction

The management of fresh water resources in arid regions like central Washington can be contentious. Water is a scarce resource that is critical for municipal, industrial, and agricultural development and production. Surface water in streams and rivers provide a large amount of the region's electricity and a number of ecosystem services, including the support of the regions highly valuable fisheries. As a result, society is faced with the difficult decision of how to best allocate scarce water resources across many potential uses. Reallocating water from one use to another inevitably has costs and benefits, precisely because it is a scarce and valuable resource.

Economics provides a framework for comparing the costs and benefits of water management alternatives, and for informing water use and water policy decisions. However, a number of terms used to describe economic aspects of water use can be difficult to understand, are often misunderstood, and misused. This article will provide an explanation of the terms price, value, and cost in the context of water. Our goal is to help non-economists better understand reports, analyses, and discussions on the economics of water use. The politics and law of water in the west are turbulent enough. Even if, as Mark Twain purportedly said, "whiskey's for drinkin' and water's for fightin'," at least we can try to avoid misunderstandings over economic jargon.

While the price of a good is an indication of its value, the "diamond-water paradox" alluded to in the quote above by Adam Smith, highlights how the market price of a good can be relatively unrelated to the full economic value of a good and its contributions to welfare, and in the case of water, its contribution to life itself. How could the price of something that is as essential as water be so low; and the price of something of less existential consequence be as expensive as a diamond? This "paradox" is just one example that demonstrates why economic value can be a difficult concept to grasp. The best way to develop a clear understanding of economic value is to analyze the exchange of a good in the simplest possible market.

A Textbook Model of a Market

In the simple model of a market presented in introductory economics textbooks, the observed market price is determined simultaneously by the cost to produce the good and how much consumers value it.

Producers decide to supply a good because they expect to be able to sell it for at least what it costs to produce. The term *marginal cost* is economic shorthand for "the cost of producing an additional unit." When deciding how much to supply, producers will expand production as long as the price they receive per unit is greater than the marginal cost. At some point along the production expansion path, diminishing returns to production implies increasing costs per unit of production, and eventually the cost of producing an additional unit becomes greater than the price, and expansion of production ceases.

The *value* of a productive enterprise to producers is the difference between the market price of the goods they sell and the total cost of producing the goods at the chosen scale of production; (loosely) known as profits. Another closely related concept is *opportunity cost*, which means the cost of the use of a good in terms of its value in the next-best alternative use. In many cases the opportunity cost of a good can be thought of as its market price, but not always. We will return to this later.

Now that the supply side of the market has been described, consider the consumer demand side. The benefit that a consumer receives from obtaining a unit of a good is called the *marginal benefit*. The marginal benefit is assumed to decrease the more the consumer buys and consumes. The first cheeseburger that someone eats is usually more satisfying than the second, and the third is, more often than not for most of us, a mistake to eat.

Consumers will increase their purchase of a good as long as the price is less than the benefit they receive from it.

The fact that people limit their consumption of a good when they face a fixed price for it is evidence of diminishing marginal benefits for that good. The total *value* to the consumer of consuming several units of a good is the sum of the difference between marginal benefit and price over all of the good(s) consumed. Similarly, a farmer will apply (consume) water or fertilizer for producing a crop as long as the additional benefit the farmer gets from increased yields is greater than the additional cost. If the first acre-foot of water has a bigger impact on crop yield than the second acre-foot, and the second more than the third, etc, this translates to a diminishing marginal benefit of water to the consumer (the crop producer). The value to the farmer of consuming these inputs for production is the sum of the difference between the unit price paid (marginal cost) and its marginal contribution to revenue received from the sale of the output it produces. If only two acre-feet of water are applied then one can infer that the increased revenue achieved from applying a third acre-foot is less than the cost (assuming that a third acre-foot is legally and physically available to the producer).

Figure 1 illustrates the relationship between these concepts. In our examples, marginal cost is assumed constant (though it need not be). Marginal benefit is decreasing with every additional unit of consumption. W* is the last unit of water worth using because its marginal benefit is just equal to marginal cost. The value to the farmer of the W* units of water consumed is the blue area of the graph, which is the sum of the difference between marginal cost and benefits over each of the W* units consumed.

Producers consider the marginal cost while consumers consider the marginal benefit against the price when deciding how much to produce or consume. Who determines price? The easiest case to understand is a market with many producers and consumers, which is applicable for agriculture. For the first acre-feet of water, pounds of fertilizer, bales of hay, or boxes of apples exchanged, marginal costs are low and marginal benefits are high. As more is exchanged the marginal benefit decreases and the marginal cost increases so that they start to converge to the same value. The last amount exchanged is where the marginal cost exactly equals marginal benefit. The amount that the producer and consumer exchange the good for at this point is called the market price. The total *value* of these transactions is the sum of the difference between the marginal benefit and marginal cost for each good produced and consumed. This is a simplified model of how exchange occurs in the real world but it has proven to be an incredibly valuable model for understanding and predicting market behavior.

A well-functioning market is one where producers and consumers both reap all benefits and bear all costs of

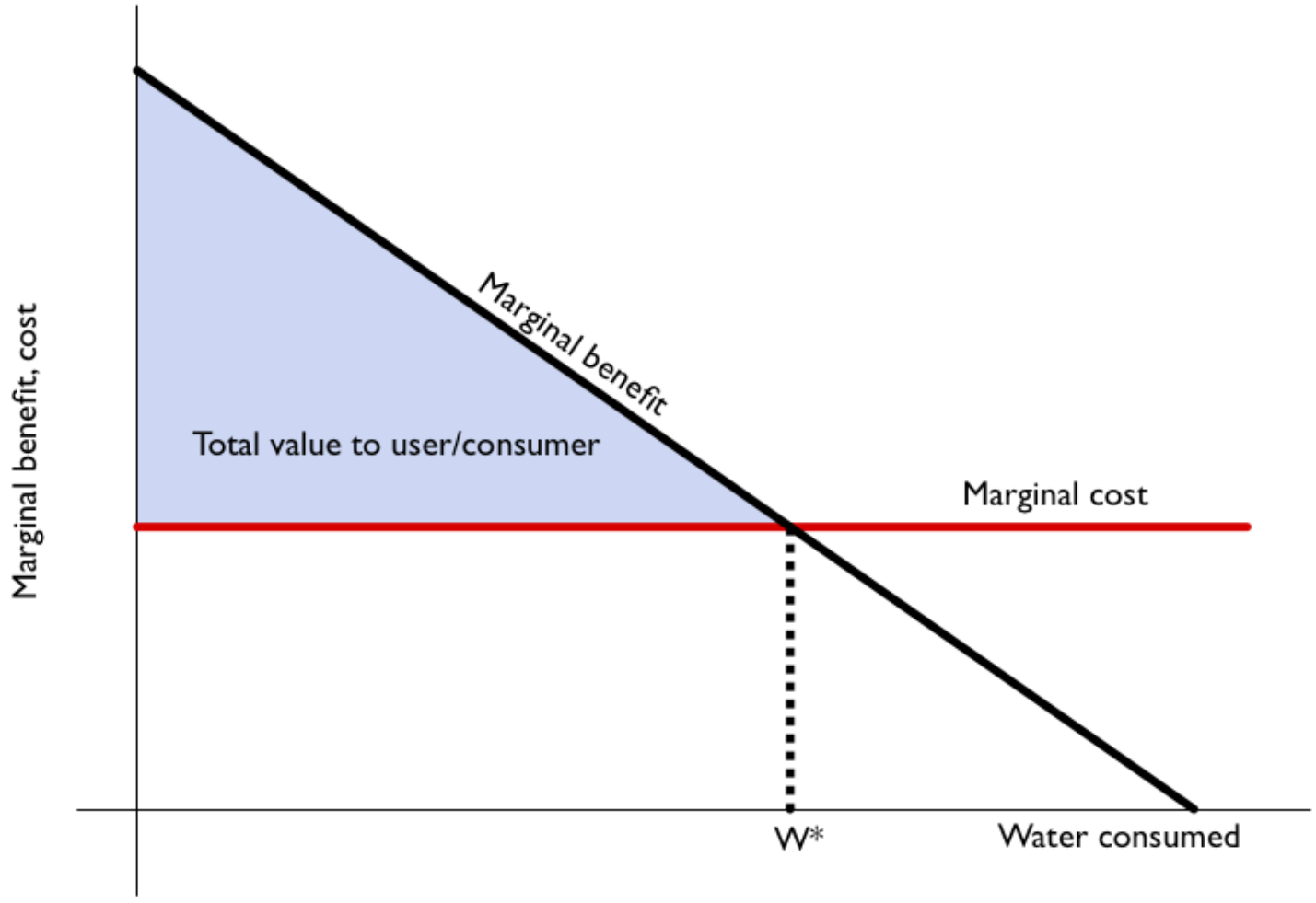

Figure 1. Benefits, costs, price, and value.

their respective activities. It is well-functioning in terms of achieving the greatest possible benefit to society. For example, farmers are constantly changing what they grow in order to respond to what consumers decide to purchase. If consumers realize that they prefer Honeycrisp apples to other varieties, they will be willing to pay more for them, which motivates growers to allocate more land and water towards growing Honeycrisp apples.

Markets are not well-functioning when producers do not bear all the costs of their production, which frequently occurs with markets for water. In fact, water markets are among the more complicated, troublesome, and cumbersome of markets. It is precisely the problems with water markets that provide a useful focus for a better understanding of the distinctions between cost, value, and price in the context of water resources.

Water Markets

The simple model of a competitive market does not apply very well to water and water resource allocation. This is due to the fluidity of water, which physically connects one individual's water use with another's, and because of water's role in ecosystems. First, water rights (historically and today) tend to define the right to use water, but do not assign ownership of the entire stock of water. When water is scarce, one person withdrawing water from a river or aquifer does not bear the full cost of withdrawal. The person downstream, who goes without water (now or in the future) due to the withdrawal, will bear the costs of upstream water consumption; or in the case of groundwater, will have to bear increased pumping costs due to aquifer decline. This means that the water user is not bearing the full cost of their use of the resource. The result is that they use more than they should; and in general, water tends to be over-used.

A major barrier to developing water markets for surface water is the issue of third-party effects. Imagine one person selling their right to someone else upstream. There will now be less water in the river for someone located in between them (intermediate user) who is not part of the transaction. If this reduction in water affects the ability of the intermediate user to use their water right, this water transfer has imposed a cost on someone not accounted for in the transaction itself. Water rights holders often oppose the development of water markets because they are concerned that the third-party will not be adequately accounted for.

The above discussion suggests that the social costs and benefits from water use extend beyond the private costs and benefits borne and acquired by individual decision makers in use and in transactions. As a result, markets involving private entities will ignore the social costs and benefits; this leads to an allocation of water that is suboptimal from a societal standpoint. This is the basis for the development of the *Prior Appropriations* (PA) Doctrine as the system of water rights in the Western U.S., which limits and prioritizes the rights to extract or divert surface water or groundwater. In Washington State, water rights and regulations are managed largely through the Washington State Department of Ecology, and this agency is often an active participant in facilitating water transactions.

The Demand and Supply of Water and Their Relationship to Benefits and Costs

The discussion above defines the consumer demand side of water (including farmers and other producers as consumers of water as an input), but who comprises the supply side for water? This is a complicated question. For our water resources in general, the public sector, specifically the State, maintains "ownership" of all water in the State, in trust for use by its citizens. From this perspective, the State is the sole "supplier" of water. However, based on the Prior Appropriations Doctrine and a myriad of state and federal regulations, the State grants usufructuary rights (the right to use property owned by someone else). These water rights are based on a seniority system which gives the holder of older water rights seniority over newer water rights. In a dry year, when there is not enough water in the rivers to satisfy everyone's right to divert water for use, a junior water right holder, whose water right was granted in 1920, may be disallowed by the State to use their water; while a senior water rights holder, having a right granted in 1890, may be able to use the water allotment.

From the perspective of water use, if a water rights holder chooses to sell or lease their water right to someone else (subject to State sanctioning authority), then the seller of the water lease or right can be thought of as a supplier of the water being traded. If the source is a waterway that provides electricity, fishing, or some other benefit to society, then the State (or Federal government in some cases) represents these interests, and can be considered the supplier of the water.

To help clarify these concepts consider an example. Suppose someone is seeking to acquire the right to divert water from a river for immediate use, and that there are two downstream water rights holders: a senior rights holder (who might use the water for irrigation, for example), and a junior water rights holder still further downstream, as in Figure 2.

The prospective user could go to the senior rights holder and say "I want to pay $X to divert Y amount of water." We know that this offered price of $X is less than, or equal to, how much the prospective user values the water. If the potential buyer is a municipality this would reflect the amount new residents are willing to pay to water their lawns. A farmer's value would be based on the additional profit gained by irrigating, relative to not irrigating, a crop.

If the senior rights holder accepts the offer and sells (subject to the approval of the State), then we know that the water is worth less *to the seller* (the senior rights holder) than the amount offered. That is, the price is somewhere in between the buyer's and seller's valuation: no higher (and probably lower) than the value of the water to the prospective user; and no lower than the seller's valuation of the water. Otherwise the sale would not occur. When a sale

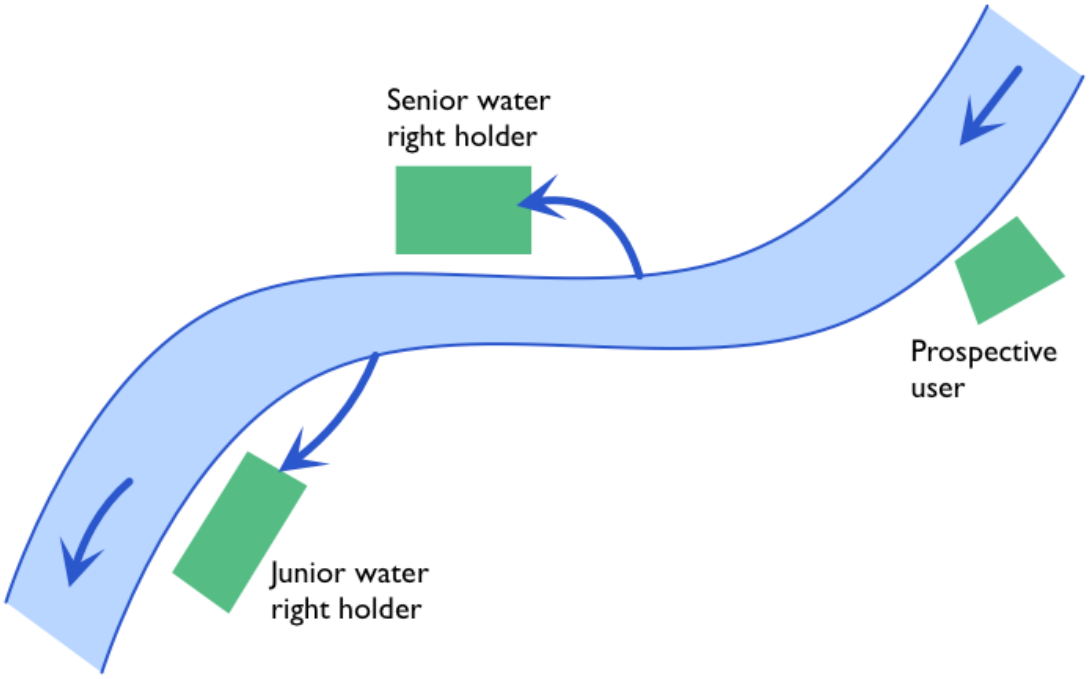

Figure 2. Water users on a stream.

occurs, it means that both the buyer and seller are better off (or at least no worse off) than before.

How do *cost*, *price*, and *value* relate to each other in this case? The cost of water to the buyer is the price, and the value of the water is at least as high as the price (cost) for each unit purchased. The total benefit of the purchase is shown in the blue area in Figure 3. From the seller's perspective, the price received for the water is its value, which is at least as high as the opportunity cost of selling the water, that is, the value to the seller of its continued use were it not sold. The total value of the sale to the seller is shown in the green area in Figure 3. So, value, price, and cost are closely related, but they are not identical concepts, and the relationship among them differs a bit depending on perspective.

Suppose instead, that the senior water right holder would not sell because the water was worth more in its current use than the bidder was willing to pay, but the downstream junior water right holder sold the water to the upstream user. This is just like the previous scenario except for one wrinkle: When the upstream purchaser starts to use the purchased water, there will be less water in the river between the downstream seller and the upstream buyer. In dry years, the upstream purchaser/user may impinge on the physical amount of water available to the senior water rights holder residing between the downstream seller and the upstream buyer—a problem that could not have occurred when the original downstream water right holder (the seller) was using the water.

Further, if the in-stream flow has value for the support of fish populations or for energy production, the transfer imposes costs in terms of these uses as well, by reducing in-stream flows. These "third party effects" of a sale impose costs (to the senior water right holder and/or in-stream flow uses) that are not accounted for in the water transfer and the price. Not only will these third parties care that they are being negatively affected, but these third party costs can actually be high enough to outweigh the value of the water transfer themselves. With all costs considered, the transfer should not occur even if the two original parties to the transfer would like to transfer the water right.

The moral of this twist to the story is that sometimes market prices do not fully capture the economic value of a good (in this case, the value lost to the intermediate user, or the senior right holder in our example). This is a problem that often arises when considering environmental amenities (and water!), and also for things like police and military defense services.

Consider a final example related to water storage. The value of water changes a great deal over the course of a year. Water has the highest value in late summer when the quantity available is low (not much water in rivers) and demand is high for irrigating crops, watering lawns, and generating electricity for air conditioning. Springtime in the West brings a lot of water to the rivers due to snowmelt, but there is little demand for it. The weather is typically cool and rainy, so crops don't require irrigation, and the demand for hydroelectricity is low.

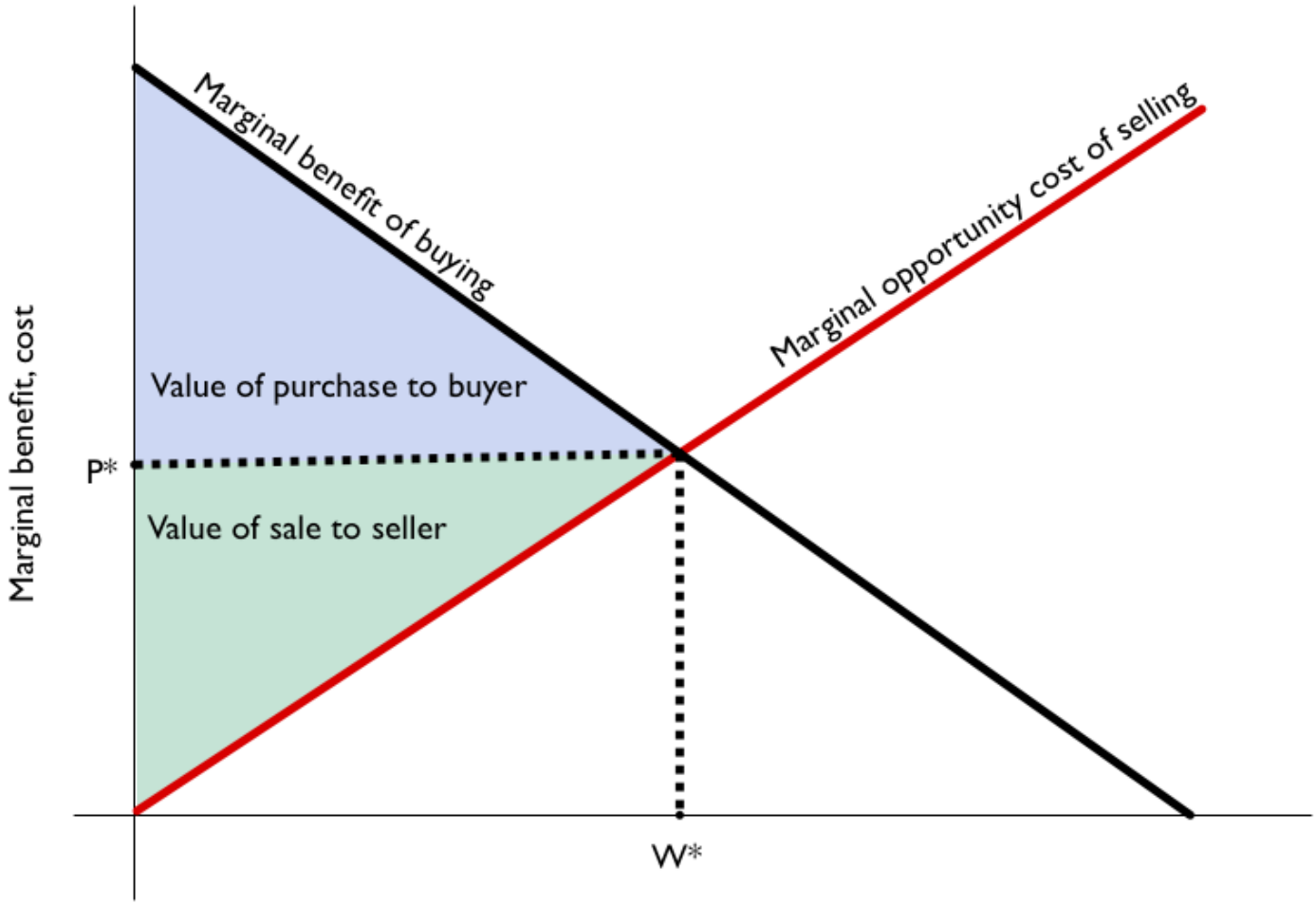

Figure 3. Opportunity cost, benefit, value, and price.

Now, suppose a person or firm builds a water storage facility (like a dam and reservoir). This storage facility changes the water's value from low (as early spring runoff) to high (from late summer releases). The annual value of the storage facility is the net gain in water value due to storage (over the life of the facility); which in turn comes from the difference between late-summer water use and early spring water use. But this annual increase in water value comes at a cost which is the annualized cost of constructing and operating the storage facility. If the net benefits of moving water from spring to summer use outweigh the cost, then a storage facility is worth the investment.

The Importance of Water Rights for Aligning Cost, Value, and Price

When rights are clear and transactions are relatively straightforward, market prices accurately reflect the full opportunity costs and values of the goods or resources being traded. Markets are extremely effective at directing those goods or resources to their highest value use. However, acquisition and enforcement of secure water rights do not happen automatically; it requires a great deal of effort.

Referring back to the quote attributed to Mark Twain, "Water's for fighting" when property rights are unclear, and people do not know who owns what, or if enforcement of ownership is uncertain. The type of interactions discussed above can really only occur if some authority is available to facilitate, allocate, and enforce rights over water use. If no such authority exists then the benefit that water provides to society is likely to be far below what could be achieved. One user could divert water without having to compensate for the costs imposed on downstream users. These allocations not only include what might be called "traditional" diversionary uses such as agricultural irrigation and municipal water use, but also benefits realized from in-stream flows that support fisheries and ecosystem services. In fact, these latter values generally represent public benefits for which any individual beneficiary may not have to pay directly. For these types of economic value, public entities often play a role in representing or reflecting the public benefits of these uses by imposing minimum in-stream flow requirements, and/or by outright purchasing water diversion rights to maintain flows for the maintenance of fisheries and other in-stream flow services.

The key to making the most out of our water resources is to continue to create and refine water management institutions that require water users, both private and public alike, to balance a full accounting of the value of water for a given use against its value in competing uses. Institutions, such as carefully designed water markets, can facilitate the movement of water to its highest valued use, but only to the extent that market prices reflect these values.

By **Michael Brady** and **Jonathan Yoder,** School of Economic Sciences, Washington State University, Pullman, WA.

Issued by Washington State University Extension and the U.S. Department of Agriculture in furtherance of the Acts of May 8 and June 30, 1914. Extension programs and policies are consistent with federal and state laws and regulations on nondiscrimination regarding race, sex, religion, age, color, creed, and national or ethnic origin; physical, mental, or sensory disability; marital status or sexual orientation; and status as a Vietnam-era or disabled veteran. Evidence of noncompliance may be reported through your local WSU Extension office. Trade names have been used to simplify information; no endorsement is intended. Published February 2013.

FS110E