TECHNICAL MEMORANDUM 2.4

Emerging Opportunities for Sustaining or Expanding Irrigated Agriculture in Montana

Revised July 2008

ECONorthwest
ECONOMICS • FINANCE • PLANNING

99 W. 10th Avenue, Suite 400
Eugene, OR 97401
Phone: 541-687-0051
www.econw.com

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CONTACT INFORMATION

This report was prepared by Ernie Niemi, Mark Buckley, Cleo Neculae, and Sarah Reich, of ECONorthwest, with input from PBS&J on current proposals for investment in irrigation infrastructure. ECONorthwest is solely responsible for the content of this report.

ECONorthwest specializes in the economic and financial analysis of public policy. ECONorthwest has analyzed the economics of resource-management, land-use development, and growth-management issues for municipalities, state and federal agencies, and private clients for more than 30 years.

For more information, please contact:

Ernie Niemi
ECONorthwest
99 W Tenth St., Suite 400
Eugene, Oregon 97401
541-687-0051
www.econw.com

I. INTRODUCTION

In this Technical Memorandum we describe opportunities for sustaining or expanding irrigated agriculture in Montana. We first briefly summarize some of the significant proposals that have been developed over the past several years to reinforce or expand irrigated agriculture through investment in irrigation infrastructure. We then discuss the potential for irrigated agriculture to become more productive, looking at three general strategies. The first entails improving the physical efficiency of irrigation systems by reducing leakage and over-watering, for example. The second involves the development of water markets to facilitate increasing the value of the goods and services derived from a limited supply of water. This result can materialize, for example, through voluntary, market-based transactions that transfer water from irrigating one farmer's low-value crops to irrigating another's high-value crops. The third involves creating new opportunities for irrigators to generate revenue through their efforts to provide ecosystem goods and services other than irrigated crops. A growing body of evidence indicates some irrigators may receive payments for protecting fish habitat, offering recreational opportunities, sequestering carbon, and other activities.

II. PROPOSALS FOR INVESTMENT IN IRRIGATION INFRASTRUCTURE

Investments in irrigation infrastructure potentially could strengthen irrigated agriculture in Montana both by rehabilitating existing infrastructure and by developing new infrastructure. In their Technical Memorandum 1.2-1.4, PBS&J describe the location of land and water resources that may be available for future irrigation use. In this section we describe a number of investment proposals that have been under discussion over the past 10 years regarding the rehabilitation and/or expansion of irrigation infrastructure. These projects vary in size and are widely distributed. Some have taken initial steps towards realization, while others have not expanded beyond the discussion and/or study stage. The following list is not exhaustive, but provides a sampling of the projects in which varying levels of interest remain. They are organized by the six main water basins in Montana. Each of the projects described below would require the appropriation of additional water and the development of additional infrastructure.

A. Marias-Milk Basins

Rehabilitation and Improvements of the Milk River Project Infrastructure: The Bureau of Reclamation and the State have analyzed proposals for rehabilitation and improvement of irrigation infrastructure in the Milk River Basin in North Central Montana. Restoring the St. Mary diversion is among the most pressing of the proposed projects. Other proposals, including installing pumping plants,

improving canal capacity and efficiency, and adding storage facilities, have been investigated to improve the water supply in the Milk River project area.[1]

Expansion of Four Horns Reservoir: This proposal involves increasing the storage capacity of Four Horns Reservoir, an existing off-stream reservoir located on the Blackfeet Reservation. Four Horns reservoir currently serves the Blackfeet Tribe's Badger-Fisher Irrigation Project. The proposal would also involve canal rehabilitation and other infrastructure improvements to enable the increased storage to also serve the tribe's Birch Creek irrigation project and the privately owned and operated Pondera County Canal and Reservoir Company. Overall these projects serve over 100,000 acres of existing irrigated land. However, current water supplies for many of those lands are not considered adequate for full service irrigation. This proposal has been discussed in the context of the proposed compact between Montana and the Blackfeet Tribe.

The Chester Project: This project entails pumping water from the Bureau of Reclamation Project reservoir created by Tiber Dam on the Marias River (Lake Elwell) to as many as 40,000 currently un-irrigated acres generally located south and west of Chester. Power costs of pumping are considered an obstacle for this project, but prospective water users are in the process of forming an irrigation district and exploring non-traditional power sources, such as wind turbines.

B. Lower Missouri Basin

North Sprole Project: This proposed project is located on the lower Missouri River between Poplar and Brockton on the Fort Peck Reservation. Tribal and allotted lands will comprise the 22,000 acres of newly irrigated land envisioned for this project, once a series of land exchanges are completed. Water for the project would be provided under the Fort Peck Indian Tribe's reserved water right. Interest in growing seed potatoes, oil seeds, and sugarbeets is driving demand for additional irrigated lands in this area. One of the obstacles facing this project is overcoming the 300 feet of lift between the Missouri River and portions of the proposed irrigated acreage.

Fort Kipp Project: This proposed project is similar to the North Sprole project described above. It is located along the lower Missouri River between Brockton and Culbertson. However, less lift (30 feet) is required to serve the 2,000 acres proposed for irrigation. Like North Sprole, Fort Kipp would entail land exchanges to consolidate tribal and allotted lands, and would rely on tribal reserved rights for its water supply. A number of similar sites, totaling over 20,000 acres, exist on the Missouri River as it flows along the south boundary of the Fort Peck Reservation. Fort Kipp may serve as a prototype for future irrigation development on those sites.

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[1] U.S. Bureau of Reclamation, Montana Area Office. 2003. *North Central Montana Alternatives Scoping Document.* March.

Other private initiatives: Although there are no known formal proposals, additional private irrigation development is possible in the Lower Missouri Basin. The lower Missouri River from below Fort Peck Dam to where the Missouri River leaves Montana at the North Dakota border has seen a relatively high rate of utilization of the reserved water rights obtained by the Roosevelt County and Richland County Conservation Districts. Facilities that process oil seed in Culbertson and malt barley in Sidney, as well as the sugar refinery in Sidney have increased the demand for irrigated land to grow these crops along the lower Missouri River.

C. Lower Yellowstone Basin

West Crane Project: This proposed project would be located west of Sidney and north of Savage, and would rely on water pumped from the Yellowstone River near Crane. Sufficient water rights have been obtained through the Richland County Conservation District's water reservation to irrigate as much as 10,000 to 15,000 acres of land. Although the project has not yet been initiated on the ground, an irrigation district has been formed, and additional water sources, such as groundwater, are being studied and developed.

Northern Cheyenne Reservation: The water rights compact with the Northern Cheyenne provides sufficient water for the irrigation of 5,000 to 6,000 acres of currently unirrigated land in the Tongue River portion of the reservation. These lands could be irrigated with the tribe's allotment of water from Tongue River Reservoir.

Other private initiatives: Although there are no known formal proposals, additional private irrigation development is possible in the Lower Yellowstone Basin. All county conservation districts along the lower Yellowstone River (Richland, Dawson, Prairie, Custer, Rosebud, and Treasure counties) have experienced a relatively high utilization rate of their water reservations (*see* Table 1 in Technical Memorandum 1.2-1.4). In addition, irrigators have utilized Bighorn County's reservations on the Bighorn River. As in the Lower Missouri Basin, increased demand for seed potatoes, sugar beets, beans, corn, malt barley, and oil seeds fuel the demand for irrigation development.

D. Upper Yellowstone Basin

Crow Reservation: Montana's compact with the Crow Tribe allots 150,000 acre-feet of Bighorn River water to the tribe. Furthermore, about 60,000 acres of irrigable lands have been identified on the reservation, a mixture of tribal and private lands, as well-suited for irrigation. Most of these lands lie west of the Bighorn River, and at elevations that would require pumping. Pumping costs and the potential problems created by mixed land ownership are possible obstacles for significant increases in irrigated lands on the Crow Reservation.

E. Upper Missouri Basin

There are no known new irrigation projects under discussion in the upper Missouri River Basin. This is likely the result of a number of factors, including the transition from an agriculture-based economy to an amenity-based economy, a lack of additional land suitable for new irrigation development, and the closure of most of the upper Missouri to new surface and groundwater rights.

F. West Slope

Flathead Irrigation Project: The Flathead Irrigation Project on the Flathead Indian Reservation is one location in western Montana that would likely benefit from rehabilitation of its infrastructure. The Salish and Kootenai Confederated Tribes are working to consolidate ownership of land on the reservation, which has resulted in Tribal ownership of a larger percentage of land irrigated under the project.

Other than the Flathead Irrigation Project, there are no known new irrigation projects under discussion in the west slope basins. This is likely the result of a number of factors, including the transition from an economy based on agriculture, timber, and mining to an amenity-based economy, a lack of additional land suitable for irrigation development, and, in the Clark Fork Basin, the inability to secure new groundwater or surface-water rights, either as a result of formal basin closures or the existence of senior downstream hydropower rights.

G. Other Rehabilitation Efforts

In addition to these proposals, there are countless smaller proposed projects to rehabilitate individual canals, pumps, siphons, gates, and other elements of the state's irrigation infrastructure. Much of the irrigation infrastructure in Montana dates to the early part of the twentieth century, and has suffered from inadequate and deferred maintenance over the years. Much of it is in various levels of disrepair and would benefit from rehabilitation. For example, Montana Department of Natural Resources and Conservation's (Montana DNRC) Water Projects Bureau has a list of proposed rehabilitation projects that are scattered throughout the state and range in scope from repairing a section of disintegrating canal to replacing siphons, with expected individual project costs ranging from $100,000 to several million dollars.[2] Individual irrigation districts and conservation districts across the state maintain similar "wish lists" for irrigation infrastructure rehabilitation.

Each of the preceding proposals faces barriers to completion, and some projects are closer to realization than others. Major barriers include irrigators' ability (or

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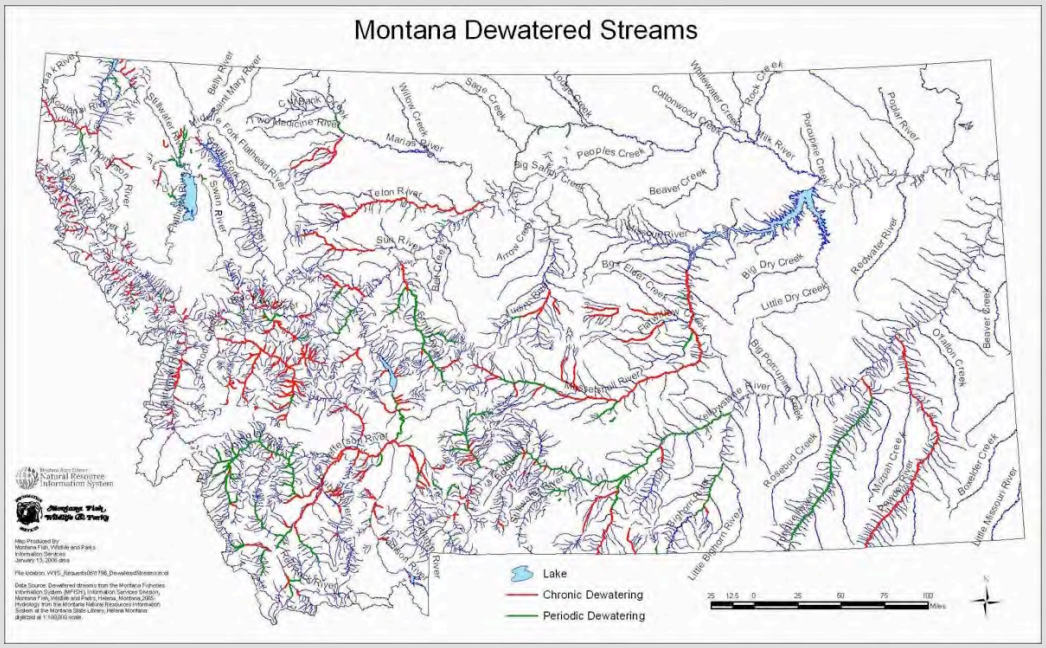
[2] Personal communication with Kevin Smith, Chief, Montana Department of Natural Resources and Conservation, Water Projects Bureau. March 26, 2008.

inability) to secure funding or financing to cover the costs of developing and maintaining new infrastructure and rehabilitation existing infrastructure, rising energy costs (particularly for those projects that would rely on extensive pumping), uncertain demand and price fluctuations for crops requiring irrigation, institutional constraints, such as land ownership patterns, and insufficient or uncertain water rights to supply new irrigation infrastructure.

III. Opportunities for Improving the Productivity of Water

Above we discuss the current proposals to sustain and expand irrigation in Montana, either by developing new irrigation systems or rehabilitating existing systems. Looking beyond specific proposals for irrigation development, there are other opportunities that have the potential to help sustain irrigated agriculture in Montana. These opportunities emphasize making water more productive, so that irrigators can derive greater net revenue per unit of water. The figures below illustrate why a focus on improving productivity is important now, as an influence on the economic outlook for irrigated agriculture, and likely to become more important in the future. Figure 1 shows that in many parts of Montana, demands for water already exceed the available supply. Montana Fish, Wildlife and Parks (Montana FWP) estimates that there are over 2,000 miles of chronically dewatered streams in the state, and concludes that the dewatering impedes the streams' ability to support important fisheries by providing spawning and rearing habitat. Of these, 278 are chronically dewatered, shown as red lines in the map. An additional 103 streams, shown in green, are periodically dewatered.

Figure 1. Dewatered Streams in Montana

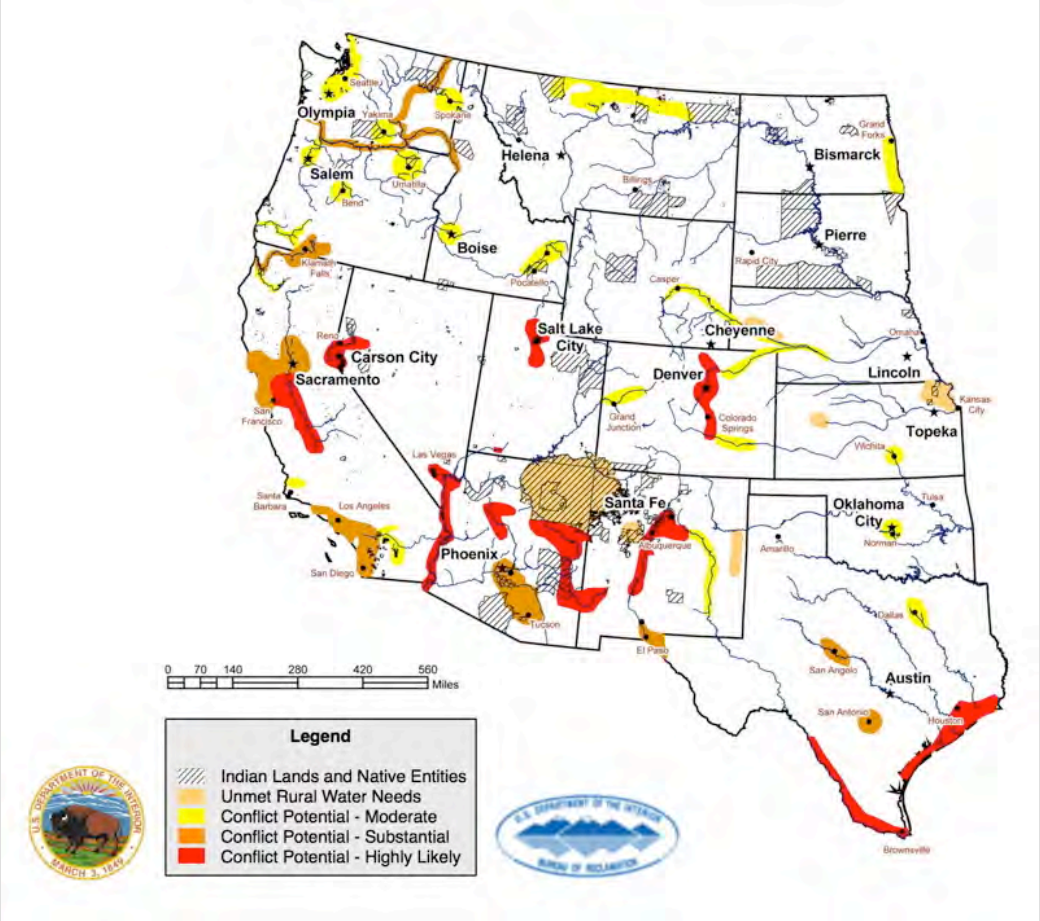


Source: Montana Fish, Wildlife & Parks, Information Services. 2006. *Montana Dewatered Streams*. Retrieved March 28, 2008, from http://www.montanariveraction.org/water-instream-map.html

Montana FWP has found that most stream dewatering results from irrigation withdrawals, and most man-made dewatering occurs during the irrigation season (July through September). In these streams, improvements in irrigation efficiency may allow farmers to continue to produce their crops, without impinging on the critical needs of the endangered, threatened, and sensitive species that inhabit these streams.

Figure 2 shows another dimension of the competing demands for Montana's water. The map points to areas in the West where the Bureau of Reclamation expects water-supply crises to arise. The likelihood that these crises will materialize by 2025 ranges from *highly likely*, in areas where severe water supply problems already exist, due to demand from high population growth and reallocation of water resources for endangered species (indicated in red on the map in Figure 2), to *moderate*, in areas where there is a risk that water supply will not meet the demand for water for threatened and endangered species, existing extractive uses, and potential population growth (indicated in yellow on the map

Figure 2. Potential Water Supply Crises in the West



Source: Adapted from U.S. Department of the Interior, Bureau of Reclamation. *Water 2025: Preventing Crises and Conflict in the West.* Retrieved March 10, 2008, from http://www.usbr.gov/water2025/supply.html

in Figure 2). The map identifies an area in northern Montana, along the Milk River, that may experience moderate conflicts by 2025.[3] The likelihood that crises will materialize also will be affected by anticipated changes in climate.[4]

Below we discuss three categories of emerging opportunities for increasing the productivity of Montana's water resources: improving irrigation-system efficiency, establishing water markets, and implementing payments for ecosystem services. Improving irrigation-system efficiency would reduce irrigation-water losses through leaky infrastructure and over-application of water, potentially making more water available for irrigation and other uses. Establishing water markets, while perhaps imposing institutional challenges, would discourage wasteful use of scarce water resources and encourage an economically-efficient allocation of water among different uses. Implementing payments for ecosystem services would provide incentives for farmers to employ conservation practices as a way to produce environmental goods and services in addition to agricultural products.

A. Irrigation-System Efficiency

Resource managers often look to improving irrigation-system efficiency as an important water-conservation strategy for the agricultural sector. The U.S. Bureau of Reclamation identifies irrigation-efficiency improvements as critical to sustaining agriculture alongside other demands for water in the western United States: "Unless highly efficient water usage practices can be developed and maintained in the west, it will not be possible to provide the water needed to sustain western ecosystems as well as economic and population growth."[5] The Bureau also has identified the following benefits of improvements in water-system efficiency, which also are widely referred to as improvements in water conservation:[6]

- Improved reliability of existing water supplies;
- Reduced overall operating costs for water users;
- Higher crop yields;

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[3] Personal communication with Miguel Rocha, Program Manager, U.S. Bureau of Reclamation on March 19; 2008; U.S. Department of the Interior, Bureau of Reclamation. *Water 2025: Preventing Crises and Conflict in the West.* Retrieved March 10, 2008, from http://www.usbr.gov/water2025/supply.html

[4] Saunders, S., C. Montgomery, T. Easley, and T. Spencer. 2008. *Hotter and Drier: The West's Changed Climate.* The Rocky Mountain Climate Organization and the Natural Resources Defense Council. March. Retrieved March 28, 2008, from http://www.nrdc.org/globalWarming/west/west.pdf

[5] U.S. Department of the Interior, Bureau of Reclamation, Water Conservation Field Services Program. 2006. *About the Program.* Retrieved March 19, 2008, from http://www.usbr.gov/waterconservation/about.html

[6] U.S. Department of the Interior, Bureau of Reclamation, Water Conservation Field Services Program. *See* footnote 5.

- Reduced soil erosion and drainage problems;
- Reduced impacts of drought;
- Increased water available for additional agricultural urban or environmental need; and
- Reduced contamination of groundwater.

These statements emphasize the reality that increasing demand for water from new agricultural developments, urban development, new environmental requirements, and new industrial development, such as oil and gas exploration, are putting pressure on the existing agricultural sector to increase the efficiency of its water use.

There are several different ways water-use efficiency is defined in an agricultural context.[7] Here we discuss irrigation-system efficiency in terms of the ratio of water consumed by crops (or other beneficial uses) to the total amount of water withdrawn. When more water is applied than is actually needed for beneficial uses, the water-use-efficiency ratio declines. In concept, achieving a high efficiency-rate of water use allows farmers to produce more goods and services with the same amount of water. In practice, the positive and negative consequences of gains in water-use efficiency are less straight-forward. We address these issues in more detail below, but first, we examine the present status of water-use efficiency in Montana.

The available evidence indicates that there are opportunities to improve the efficiency of irrigation in Montana, although it does not support a detailed assessment of the opportunities. The most recent U.S. Geological Survey (USGS) data on water use in the United States, from 2000, show that Montana had one of the highest rates of agricultural withdrawals in the United States at 5.18 acre-feet of water withdrawn per acre of irrigated land.[8] This rate of withdrawal was second only to Arizona's rate of 6.21 acre-feet per acre, and twice as high as the national average.[9] Additionally, the USGS reports that the average efficiency for all irrigation systems in Montana, which is calculated as the ratio of total consumption to total withdrawals, was 21 percent in 2000.[10] In 1995, the last year

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[7] Other definitions of irrigation water-use efficiency include productive efficiency (the crop yield produced per unit of water consumed) and economic efficiency (the value of the crop produced per unit of water consumed).

[8] As we discuss in later paragraphs, the quantity of water withdrawn is often less than the quantity of water consumed or actually used by irrigated agriculture. However, water withdrawn is diverted from a source, and so both numbers can provide insights into the way irrigators utilize water in agricultural production.

[9] Hutson, S.S., N.L. Barber, J.F. Kenny, et al. 2004. *Estimated Use of Water in the United States in 2000.* U.S. Geological Survey. Retrieved February 7, 2008, from http://pubs.usgs.gov/circ/2004/circ1268

[10] USGS calculates this efficiency rate based on about 2.5 million acre-feet of irrigation water consumed and 11.6 million acre-feet of irrigation water withdrawn. It notes that, based on evidence from other studies, the actual water-use efficiency rate could be higher, but it does not say by how much.

for which state-level consumption rates were available for the entire United States, Montana had the lowest rate of water-use efficiency for irrigation.[11]

These numbers paint Montana irrigation systems as some of the least-efficient in the nation. The upside to this story is that there are probably considerable opportunities for improvement. Assuming that current agricultural consumption remains constant, if every irrigator in Montana adopted more efficient irrigation techniques, such as sprinkler systems, which can operate at up to 85 percent efficiency (see Table 1 below), in concept, irrigators could reduce their irrigation withdrawals by 8.7 million acre-feet per year. For comparison, in 2000, the total amount of water withdrawn in the state for all purposes was just over 12 million acre-feet per year. This figure, which is based on USGS estimates of water use and current irrigation-system efficiency rates in 2000, is not intended to say that

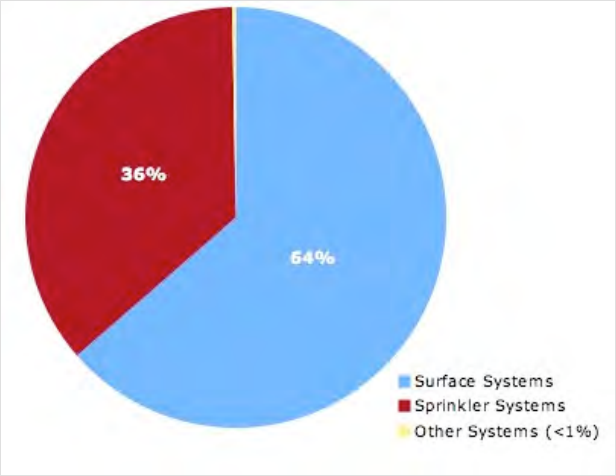
Table 1. Application Efficiencies for Various Irrigation Methods

Irrigation Method	Application Efficiency (%)	Water Required to Put One Inch of Water in Crop-Root Zone (inches)
Surface		
Furrow	35 – 65	1.5 – 2.8
Border, level	60 – 75	1.3 – 1.7
Border, graded	55 – 75	1.3 – 1.8
Flood, wild	15 – 35	2.8 – 6.7
Surge	50 – 55	1.8 – 2.0
Sprinkler		
Stationary lateral (wheel or hand move)	60 – 75	1.3 – 1.7
Solid set lateral	60 – 85	1.2 – 1.7
Traveling big gun	55 – 67	1.5 – 1.8
Stationary big gun	50 – 60	1.7 – 2.0
High pressure center pivot	65 – 80	1.3 – 1.5
Low pressure center pivot	75 – 85	1.2 – 1.3
Moving lateral (linear)	80 – 87	1.1 – 1.2

Source: Ashley, R.O., W.H. Neibling, and B.A. King. No Date. *Irrigation Scheduling: Using Water-Use Tables.* University of Idaho, College of Agriculture, Cooperative Extension System, Agricultural Experiment Station. Report No. CI-1039. Retrieved March 12, 2008, from http://info.ag.uidaho.edu/resources/PDFs/CIS1039.pdf

[11] Solley, W.B., R.R. Pierce, and H.A. Perlman. 1998. *Estimated Use of Water in the United States in 1995.* U.S. Department of the Interior, U.S. Geological Survey. Retrieved March 24, 2008, from http://water.usgs. gov/watuse/pdf1995/html/

Figure 3. Type of Irrigation System, by Percent of Acres Irrigated in Montana, 2003



Source: ECONorthwest, with data from the U.S. Department of Agriculture, National Agricultural Statistics Service. 2004. *2002 Census of Agriculture: Farm and Ranch Irrigation Survey (2003).* Volume 3, Special Studies Part 1. Report No. AC-02-SS-1. November. (Table 4)

such conversions are feasible for every irrigator, and probably represents the upper bound of conservation potential through improvements in irrigation-system efficiency. However, it illustrates the general order of magnitude of potential water savings and demonstrates that switching to more efficient irrigation technologies could have a considerable impact on how Montana's water resources are used.

1. Sources of Irrigation-System Inefficiency

Three characteristics of Montana's irrigation systems are responsible for its low rate of water-use efficiency compared to other states. One, in Montana, farmers rely more heavily on less-efficient surface irrigation techniques than farmers in other western states. Two, the methods Montana's farmers use to determine when to apply water tend to be less precise than other available methods. Three, Montana's irrigation water delivery systems tend to lose considerable amounts of water.[12] We discuss each of these sources of irrigation-system inefficiency in more detail below.

Irrigation Technology. Montana's irrigators employ surface irrigation methods to irrigate nearly two-thirds of all acres irrigated in the state. Surface irrigation systems (also known as flood-irrigation or gravity systems) distribute water in a field by allowing it to flow over the surface of the soil. In general, surface irrigation systems range from 30 to 60 percent efficiency, although some

[12] Cannon, M.R. and D.R. Johnson. 2004. *Estimated Water Use in Montana in 2000.* U.S. Department of the Interior, U.S. Geological Survey. Retrieved March 20, 2008, from http://pubs.usgs.gov/sir/2004/5223/pdf/ sir2004_5223.pdf

methods, such as uncontrolled, wild flooding, can be even less efficient. The remaining one-third of irrigated acres in Montana are irrigated using sprinkler systems. Like surface systems, there are a variety of different kinds of sprinkler irrigation methods, which vary in efficiency. On the whole, sprinkler systems are more efficient than surface systems, ranging in efficiency from about 60 to 85 percent. Table 1 outlines the different kinds of surface and sprinkler system irrigation methods and their levels of water-use efficiency.[13] The most efficient application methods, including drip systems where water is applied directly to the root system of the plant, were rarely used—in 2003, just 180 farms employed these techniques on 4,262 acres.[14] Figure 3 shows the method of water distribution, by percent of irrigated acres in Montana.

Montana's farmers rely to a greater extent on surface irrigation methods than farmers in other western states and the nation as a whole. In the United States, only 44 percent of all irrigated acres in 2003, the last year for which data were available, were irrigated using surface methods. In the Missouri River Basin, 36 percent of all irrigated acres were irrigated using surface methods.[15] The proportion of Montana's irrigated acres irrigated by surface methods is almost double that in the Missouri Basin, and 20 percentage points higher than the national rate.

Certain crops are more commonly irrigated using surface methods, while other crops are irrigated almost entirely using sprinkler systems. The feasibility of converting from surface systems to more efficient sprinkler systems may depend on the crop. Figure 4 shows the type of irrigation used on different crops in Montana. The top graph presents these data by the total number of acres irrigated by each type of system, while the bottom graph shows the same data by percentage of acres irrigated by each type of system. Some crops, such as potatoes, are entirely irrigated using sprinklers; others, such as corn, hay, sugarbeets, and pasture, are primarily irrigated using surface methods. Irrigation of alfalfa and wheat is more closely divided between sprinkler and surface methods. In terms of the total number of acres irrigated, most of the crops still irrigated with surface methods are alfalfa, hay, and pasture. On a percentage basis, corn, beans, and sugarbeets are also still primarily irrigated using surface methods, however, individually, they don't represent a large amount of total irrigated acres in Montana. Many of Montana's largest crops, in terms of overall numbers of irrigated acres, are lower-value crops, such as irrigated pasture. The revenue generated from these acres may not be sufficient to support the wide-spread adoption of sprinkler irrigation. Nevertheless, it is technically possible to

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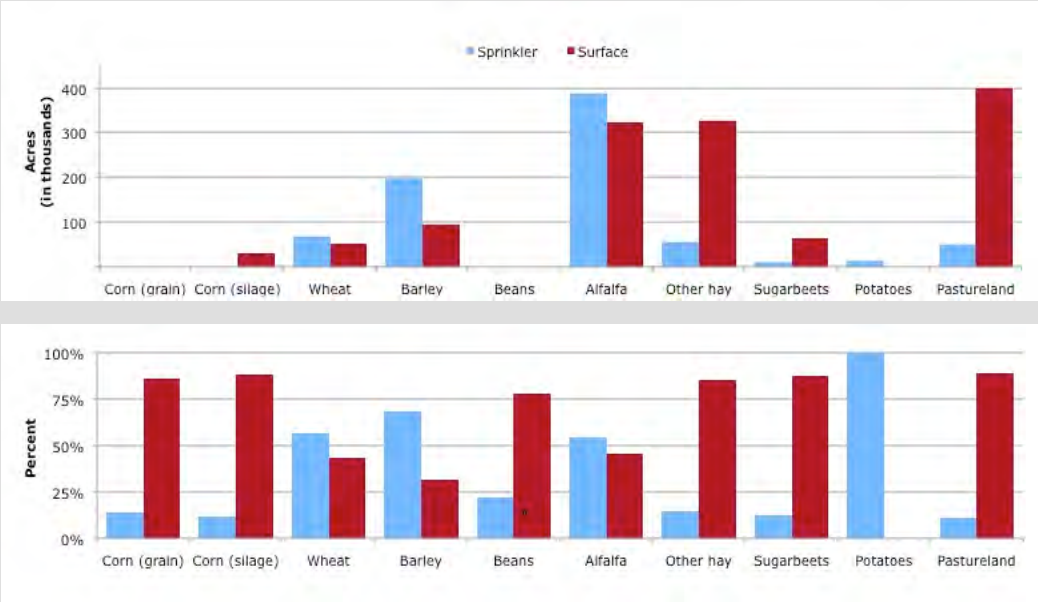
[13] For a more detailed definition of each type of method, *see* U.S. Department of Agriculture, Economic Research Service. 2004. *Irrigation and Water Use: Glossary.* Retrieved March 28, 2008, from http://www.ers.usda.gov/Briefing/WaterUse/glossary.htm

[14] U.S. Department of Agriculture, National Agricultural Statistics Service. 2004. *2002 Census of Agriculture: Farm and Ranch Irrigation Survey (2003).* Volume 3, Special Studies Part 1. Report No. AC-02-SS-1. November.

[15] U.S. Department of Agriculture, National Agricultural Statistics Service. 2004. *See* footnote 14.

Figure 4. Irrigation System by Number and Percent of Irrigated Acres of Selected Crops in Montana, 2003



Source: ECONorthwest, with data from the U.S. Department of Agriculture, National Agricultural Statistics Service. 2004. *2002 Census of Agriculture: Farm and Ranch Irrigation Survey (2003).* Volume 3, Special Studies Part 1. Report No. AC-02-SS-1. November. (Table 28)

irrigate these crops with sprinkler irrigation. Figure 4 shows that some farmers have already made the switch.[16]

Surface irrigation methods are less efficient in part because they do not offer farmers efficient and effective mechanisms for fine-tuning the flow of water across an entire field. Thus, surface irrigation methods tend to lead to more water being applied to crops than they require. It is difficult to know how much over-watering occurs with surface irrigation techniques, but the data in Table 2 suggest that it probably is more than trivial. The second column in Table 2 shows the average amount of water required for growing certain crops in Montana. The actual amount varies throughout the state, depending on climate conditions. The amount of irrigation water that should be applied to a crop is equal to the amount of water required, less the amount of precipitation that occurs during the growing season. Therefore, assuming that some precipitation occurs, the amount of irrigation water applied should be less than the amount of water required by the crop. The third column in Table 2, which shows the average amount of water that farmers applied to different crops in Montana in 2003, indicates that, for some crops, farmers are applying less irrigation water than the total crop requirement. Without knowing the exact precipitation in any given location and

[16] Holzworth, L. and J. Lacey. 1991. *Species Selection, Seeding Techniques, and Management of Irrigated Pastures in Montana and Wyoming*. Reprinted 1994. Montana State University, Extension Service Report No. EB 99. Retrieved March 18, 2008, from http://www.montana.edu/wwwpb/pubs/mteb99.pdf

Table 2. Average Consumptive Water Requirement and Amount of Water Applied for Selected Crops in Montana

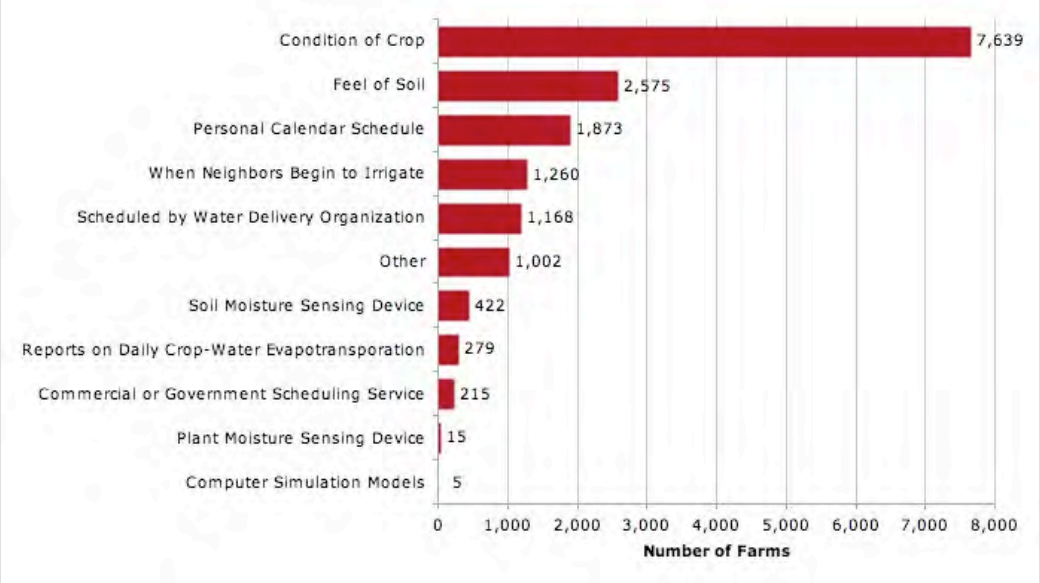
Crop	Average Seasonal Consumptive Water Requirement (inches)	Average Amount of Water Applied in 2003 (inches)
Barley	17	14
Wheat	17	13
Corn	18.5	29
Silage Corn	19	18
Beans	13.5	19
Sugarbeets	23	29
Potatoes	39	19
Alfalfa	17-26	17
Other hay	28	16

Source: Kirkpatrick, A., L. Browning, J.W. Bauder, et al. 2006. *Irrigating With Limited Water Supplies: A Practical Guide to Choosing Crops Well-Suited to Limited Irrigation.* Montana State University, Extension Service, Colorado State University, Water Center, Utah State University, Extension Irrigation Program, and Northern Plains & Mountain Regional Water Program. Retrieved March 18, 2008, from http://waterquality.montana.edu/docs/Publications/irrigatingsmallerfile.pdf

time, it is impossible to know if these crops are receiving more irrigation water than they need. For other crops, the data show that farmers are likely applying more irrigation than they need. For example, sugarbeets need an average of 23 inches during the growing season, but in 2003, farmers applied an average of 29 inches of irrigation water. Because sugarbeets are primarily irrigated using surface methods, these data suggest that surface-water irrigation leads to over-watering.

Irrigation Scheduling. The technique that farmers use to decide when to irrigate can affect how efficiently they use irrigation water. Methods that rely on imprecise observations, such as visually inspecting the crop for signs of stress, or feeling the soil to see how moist it is, often leads farmers to apply more water than their crops need. Methods that rely on direct measurement of physical variables, such as soil moisture or actual evapotranspiration, may provide a better picture to farmers of their crop's actual water needs. Figure 5 shows that most farmers in Montana rely on observing the condition of the crop or feeling the soil as the primary indicator of whether or not to irrigate. More precise measurement techniques, such as soil moisture sensing devices and plant moisture sensing devices, are less frequently used. Research from the University of California suggests that, for alfalfa and pasture irrigation, techniques that measure soil moisture provide the most accurate measure for deciding when to irrigate. Although the researchers point out that simply feeling the moisture content of the soil (the second-most common method used in Montana) is "better

Figure 5. Method Montana Irrigators Use to Decide When to Irrigate, 2003



Source: ECONorthwest, with data from the U.S. Department of Agriculture, National Agricultural Statistics Service. 2004. *2002 Census of Agriculture: Farm and Ranch Irrigation Survey (2003).* Volume 3, Special Studies Part 1. Report No. AC-02-SS-1. November. (Table 36)

than nothing," they stress that inexpensive technologies that monitor soil moisture are more precise indicators of when to irrigate.[17]

Research in Nebraska found that, although some irrigation managers irrigate their crops on a schedule that reflects careful estimates of current soil-moisture conditions and crop requirements, about three-quarters of irrigation managers do not, relying instead on less-precise methods of determining their crops' water requirements, such as feeling the soil in a couple of locations to obtain a general sense of soil moisture.[18] This less precise approach typically results in applying more water than the crops require. In some cases, irrigators who apply excess water incur higher costs and, hence, realize lower net earnings than they would if they measured and monitored soil moisture more carefully. This is especially the case where there are substantial opportunity costs for the excess water applied to a crop. High opportunity costs might materialize, for example, when over-watering depletes an aquifer so there is less water available for irrigating future crops.

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[17] Orloff, S., B. Hanson, and D. Putnam. No Date. *Soil-Moisture Monitoring: A Simple Method to Improve Alfalfa and Pasture Irrigation Management.* University of California Cooperative Extension, Siskiyou County. Retrieved March 19, 2008, from http://alfalfa.ucdavis.edu/SUBPAGES/Irrigation/IrrigationBrochure.pdf

[18] Supalla, R.J., D.L. Martin, R.M. Adams, and R.F. Weiher. 2005. *Potential Economic Value of Soil Moisture Data for Irrigation Management in the Central Great Plains.* U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Hydrology. Retrieved March 21, 2008, from http://www.economics.noaa.gov/library/documents/benefits_of_weather_and_climate_forecast/soil-moisture.doc

The degree to which irrigators apply more water than crops require is unknown, insofar as those who apply excess water typically do not conduct careful measurements to compare crop requirements against actual water applications. Anecdotal evidence from corn farmers in the Great Plains suggests, however, that irrigators who do not carefully measure and schedule irrigations in response to soil moisture probably apply 15 to 40 percent more water—about 2 to 4 inches per acre—than those who do.[19]

Irrigation Water Conveyance. The pipes, canals, and ditches that transport water from reservoirs to farmers' fields are a major source of inefficiency in many, if not most, of Montana's irrigation systems. This is particularly true of older irrigation systems, which convey water over long distances through unlined, uncovered ditches, which allow for considerable amounts of seepage and evaporation.[20] Nation-wide, the USGS estimates that the conveyance loss for agricultural water use is around 20 percent. Estimates for Montana's irrigation conveyance systems are higher. In the *1987 National Water Summary*, the USGS reported conveyance losses of 51.4 percent of total irrigation withdrawals in Montana.[21] An earlier report by the U.S. Soil Conservation Service also documented large conveyance losses in Montana's irrigation systems.[22] More recent reports indicate that conveyance losses are still a significant source of irrigation water-use inefficiency in Montana. Researchers measuring the efficiency of individual ditches throughout the state have found water losses ranging from 38 to 72 percent.[23] A study of irrigation in Wyoming, where water delivery systems are similar to those in Montana, found that unlined conveyance canals and ditches lose up to 40 percent of the water channeled through them, depending on the soil type.[24]

Irrigation districts elsewhere in the west are grappling with similar challenges and some find that investments in improvements can produce substantial benefits associated with increased stream flows. For example, an irrigation district in Oregon estimated that, when it converted its unlined canal system to pipeline infrastructure, it diverted about 25 percent less water from the

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[19] Supalla, R.J., D.L. Martin, R.M. Adams, and R.F. Weiher. 2005. *See* footnote 18.

[20] Cannon, M.R. and D.R. Johnson. 2004. *See* footnote 12.

[21] Carr, J.E., E.B. Chase, R.W. Paulson, and D.W. Moody. 1990. *National Water Summary 1987: Hydrologic Events and Water Supply and Use.* U.S. Geological Survey. Water-Supply Paper No. 2350.

[22] Cannon, M.R. and D.R. Johnson. 2004. *See* footnote 12.

[23] *See,* for example, Montana Department of Environmental Quality. 2000. *Big Creek Flow Restoration Plan (TMDL).* December. Retrieved March 21, 2008, from http://deq.mt.gov/wqinfo/TMDL/pdf/TMDL_Big_Creek.pdf; Roberts, M. No Date. *Morrison Ditch Seepage Analysis Monitoring Report.* Montana Department of Natural Resources and Conservation. Retrieved March 21, 2008, from http://dnrc.mt.gov/wrd/water_mgmt/surfacewaterstudies/pdfs/morrison_ditch_report.pdf

[24] Wyoming State Engineer's Office, States West Water Resources. 2000. *Technical Memorandum: Green Water River Basin Plan, Water Conservation.* December 7. Retrieved March 18, 2008, from http://waterplan. state.wy.us/plan/green/techmemos/conserv_hires.pdf

Deschutes River to meet the same demand. Moreover, the Deschutes River Conservancy estimated that if only 20 percent of the canals in the region were replaced with pipelines, the resulting water savings would be enough to restore ecosystems to support healthy populations of fish and other wildlife.[25]

2. Potential Economic Consequences of Improving Irrigation-System Efficiency

The discussion above suggests three approaches that potentially could improve the efficiency of irrigation systems in Montana:

- Convert less-efficient surface-irrigation methods to more-efficient surface methods and sprinkler-irrigation methods.
- Use irrigation scheduling techniques that measure soil moisture or other indicators, rather than rely on past experience and other less-precise techniques.
- Reduce conveyance losses by lining ditches and canals that deliver irrigation water.

These actions likely would reduce the overall amount of water applied to Montana's crops, leaving more water available to produce additional crops and/or other goods and services. In doing so, improving the efficiency of irrigation infrastructure could have positive consequences for Montana's economy. There also may be some potentially negative consequences. We discuss these possibilities below.

Potential Positive Economic Consequences. In theory, improving the efficiency of irrigation systems would provide opportunities to produce more goods and services with the same amount of water. Water saved in agricultural production could be used to produce more crops, or it could be used to provide goods and services in other sectors of the economy, including leaving water instream for environmental purposes. Using less water to produce the same amount of agricultural produce could also lead to increased crop yields per acre and reduced labor and energy costs, increasing agricultural producers' profits. Improving the efficiency of water use in agriculture has also been shown to reduce groundwater and surface water contamination from pesticides and salts.

An analysis of water-policy options for water conservation in the Pacific Northwest demonstrated that significant on-farm water conservation can, depending on the policy approach, occur at minimal economic cost and result in economic benefits for irrigated agriculture. The researchers found that a water policy program that encouraged the adoption of more efficient irrigation technologies would result in significant water conservation with economic benefits to agriculture. Improvements in irrigation efficiency alone, without

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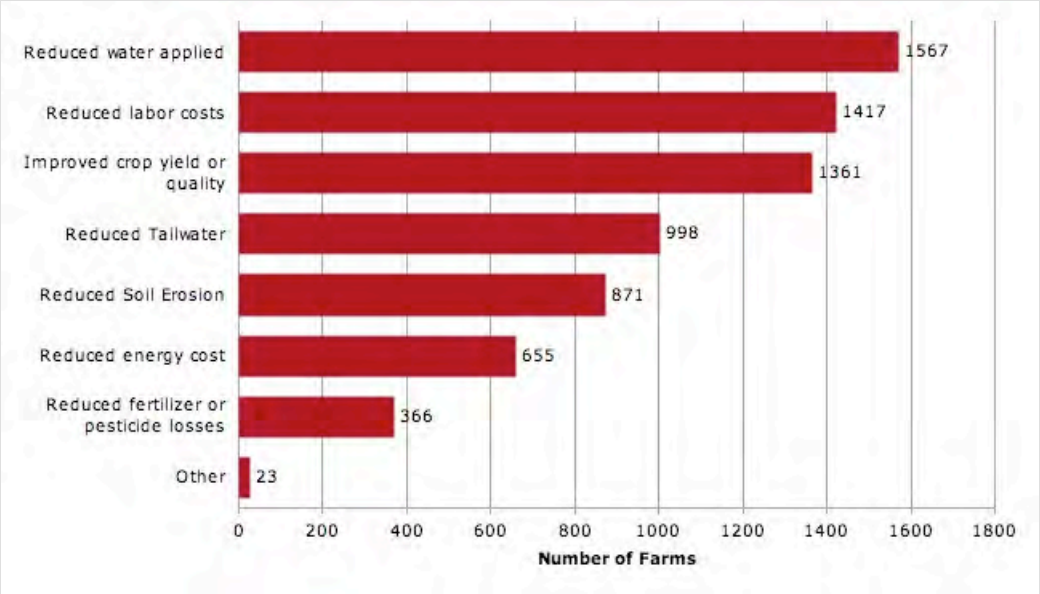
[25] Ramsayer, K. 2008. "Swalley Canal Going Underground." *The Bend Bulletin.* March 25. Retrieved March 26, 2008, from http://www.bendbulletin.com/apps/pbcs.dll/article?AID=/20080325/NEWS0107/803250424/ 1001&nav_category

resulting in increases in crop productivity, resulted in benefits to agriculture of $9.5 to $27 million (in 2000 dollars). When irrigation efficiency improvements from technical change improved crop productivity, net economic returns to agriculture increased by $56 to $167 million (in 2000 dollars).[26] The overall significance of these amounts remains unclear. They indicate that some farmers could experience increases in net farm earnings by investing in improvements in water-use efficiency, but the impacts likely would not revolutionize the overall agricultural sector in the Pacific Northwest, which, according to the author produced outputs with a total annual value of more than $8 billion (in 2000 dollars).

Some farmers in Montana are already investing in water conservation and realizing economic and other benefits. Figure 6 shows the improvements Montana farmers reported in 2003 after adopting water conservation practices. Among the top improvements are reduced labor costs and improved crop yield and quality.

Many farmers experience improvements in crop yield after switching to more efficient methods of irrigation and irrigation scheduling. Over-application of water, which commonly occurs with surface irrigation systems and can be exacerbated by imprecise methods of irrigation scheduling, can inhibit plant

Figure 6. Improvements Reported by Montana Irrigators as a Result of Water Conservation Activities



Source: ECONorthwest, with data from the U.S. Department of Agriculture, National Agricultural Statistics Service. 2004. *2002 Census of Agriculture: Farm and Ranch Irrigation Survey (2003).* Volume 3, Special Studies Part 1. Report No. AC-02-SS-1. November. (Table 39)

[26] Schaible, G.D. 2000. "Economic and Conservation Tradeoffs of Regulatory vs. Incentive-Based Water Policy in the Pacific Northwest." *Water Resources Development* 16(2): 221-238.

growth and lead to smaller yields than if crops received the optimal amount of water at the optimal time. Anecdotal evidence, for example, indicates a rancher raising cattle and irrigating hay to feed them can experience a doubling of hay production, with no interference on cattle operations, by installing a sprinkler irrigation system.[27]

Increasing the efficiency of irrigation can have positive consequences for water quality. Surface irrigation often contributes to groundwater and surface water quality problems. Switching to sprinkler irrigation can reduce impacts, such as the contamination of drinking water from the leaching of pesticides, fertilizers, and other nutrients applied to crops into shallow groundwater aquifers. Excess water that runs off fields into local water bodies or into wastewater ditches can also contribute to the pollution of groundwater.[28] A study of sugar-beet production under flood and sprinkler irrigation showed higher nitrate concentrations in groundwater and irrigation runoff under flood irrigation.[29] Because sprinkler systems typically apply less water at any given time, less water is lost to deep percolation and groundwater contamination tends to occur less frequently. Similarly, less water is lost to return flows, reducing the potential for surface water contamination. A study in the Colorado River Basin found that excess soil moisture and movements of percolated water associated with flood irrigation also contribute to salinity increases in streams. Mechanisms that result in reduced application of water on irrigated land help decrease the deep percolation of irrigated water and diminish the amount of salts in streams. The replacement of the traditional infrastructure of flood irrigation with more efficient systems, such as center-pivot sprinklers, replacement of open-conveyance ditches with gated pipe, or the construction of border-irrigation features and drip systems, can alleviate the impacts associated to increased salinity.[30] Another study in the Colorado River Basin, conducted by Natural Resource Conservation Service in Utah and Wyoming, found that 75 to 85 percent of the total annual salt load came from irrigated land.[31]

Potential Negative Economic Consequences. Investments in water-use efficiency involve costs as well as benefits, and the net outcome is not necessarily positive. Some of the costs are direct and straightforward. Conversion from

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[27] Eilperin, J. 2006. "Tide of Sentiment Shifts in Water War: Traditional Favoritism to Agricultural Interests Is Challenged as Demand Increases." *The Washington Post.* January 15.

[28] Montana Department of Agriculture, Agricultural Services Division, Technical Services Bureau. 2005. *Irrigation Practices and How They Affect Pesticide Leaching to Ground Water.* Retrieved March 19, 2008, from http://agr.mt.gov/pestfert/groundwater/GWfactsIrrigate.pdf

[29] Eckhoff, J.L.A., J.W. Bergman, and C.R. Flynn. 2005. "Sprinkler and Flood Irrigation Effects on Sugarbeet Yield and Quality." *Journal of Sugarbeet Research* (January-July).

[30] Tyrell, P. 2001. *Technical Memorandum: Green River Basin, Colorado River Basin Salinity Control Program.* States West Water Resources Corporation. April 21. Retrieved March 18, 2008, from http://waterplan.state.wy.us/plan/green/techmemos/salinity_hires.pdf

[31] NRCS study cited in Tyrell, P. 2001. *See* footnote 30.

surface irrigation to sprinklers may increase farmers' energy costs, or predicted increases in the value of crop due to irrigation changes may not materialize, for example. Others are more indirect and entail unintended or unforeseen consequences that arise from investments in water-use efficiency.

Farmers' choice of irrigation technology generally depends on multiple factors. Some stem from economic variables: investment costs, expected crop prices, expected energy costs for pumping, for example. Some are defined by the legal, contractual, and cultural framework that defines a farmer's rights and obligations for obtaining, using, and releasing water back to the environment. Others are determined by the growing conditions of a specific parcel of land and the opportunities to expand irrigation operations onto additional land. In general, farmers tend not to adopt technologies that improve water-use efficiency when crop prices are low; the investment, energy, and labor costs of the new technologies are high; the growing conditions are such that high-value crops can be grown with little or no irrigation; and opportunities for expanding irrigation operations are limited.

As farmers improve their irrigation water-use efficiency, some negative economic consequences may arise through unintended or unforeseen impacts on streamflow. Although surface-irrigation methods and leaky conveyance systems have low water-use efficiency ratios, not all of the water that is diverted is lost to the ecosystem. Water that seeps from unlined canals and excess water applied to fields often finds its way back to streams and rivers. Thus, investments in irrigation efficiency intended to improve stream conditions may not ultimately have that effect. Reducing leakage from a canal, for example, may terminate the leaks as a source of water reaching a nearby stream, reducing instream flows.

Moreover, improvements to irrigation systems may induce farmers to increase their consumptive use of irrigation water, so there is even less water in streams. If farmers have incurred costs to tighten a leaky irrigation system, for example, they may feel financial pressures to expand their operations onto newly irrigated land and/or to plant crops that have higher water-consumption requirements.[32] When these actions result in less water available for instream flows, efforts to improve irrigation efficiency to alleviate the problems and crises represented in Figures 1 and 2 can, instead, exacerbate them.

Even if agricultural producers do not use improvements in irrigation-system efficiency to increase their consumptive use of water, the improvements might have negative economic consequences by altering the timing of instream flows. When excess water applied to crops seeps into the ground and is released slowly back into a stream, irrigation can boost streamflows in the late summer. Depending on the demand for the instream flows at different times of the year, these time-shifting effects may be important. An analysis of policies to promote conservation in irrigation systems in the Snake River basin, for example, showed

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[32] Huffaker, R. and N. Whittlesey. 2003. "A Theoretical Analysis of Economic Incentive Policies Encouraging Agricultural Water Conservation." *Water Resources Development* 19 (1):37-53.

that conservation increased instream flows in April, May, and June, but reduced flows in other parts of the year.[33] A study in Montana's Gallatin River also found that irrigation-system efficiency improvements led to an increase in spring flows, but a decrease in fall and winter flows. The authors of this study argue, however, that this pattern represents a return to more natural streamflow conditions, rather than the artificially high fall and winter flows augmented by irrigation return flows.[34]

On balance, the potential positive and negative economic consequences suggest that, unless public subsidies to increase water-use efficiency are carefully researched, designed, and monitored, there is a substantial likelihood that they will not be a cost-effective mechanism for alleviating environmental pressures, urbanization, and other factors that may diminish the sustainability of irrigated agriculture.

3. Barriers to Achieving Increased Efficiency of Irrigation Infrastructure

Montana's farmers face many barriers to making improvements that increase the efficiency of irrigation systems. Figure 7 shows the range of barriers farmers face in making efficiency improvements, as reported in a 2003 survey by the U.S. Department of Agriculture. The most common challenges relate to economics. In fact, the top two reasons Montana farmers reported for not making improvements to conserve water were that they couldn't finance the improvements, and that the cost savings from water conservation would not cover the cost of the necessary improvements.

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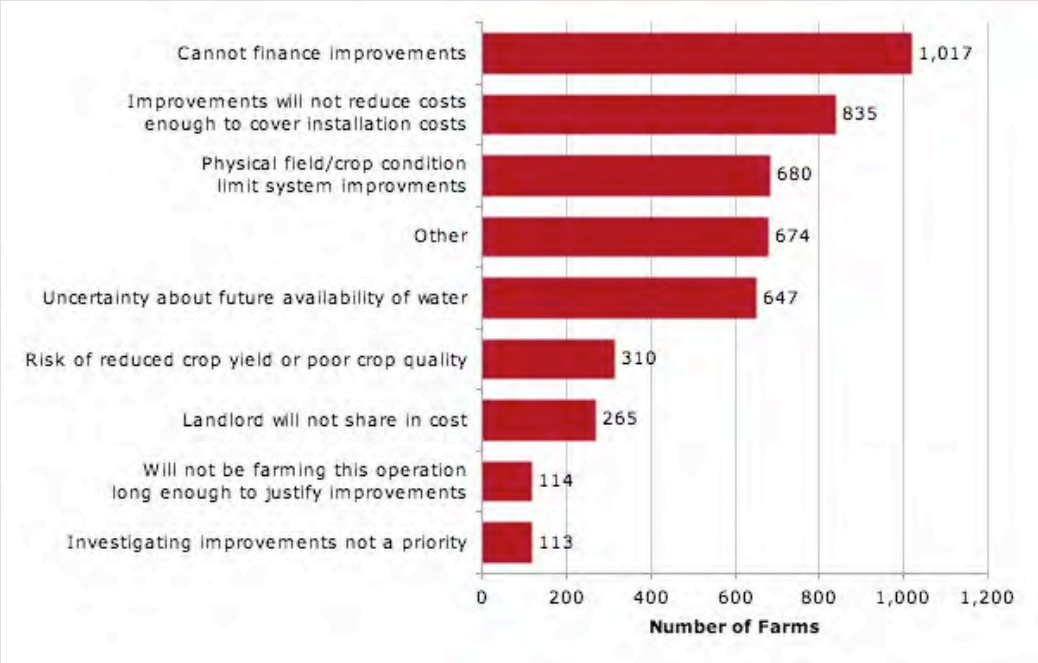
[33] Fraiser, W.M., N.K. Whittlesey, and J.R. Hamilton. 1992. *Streamflow Effects of Improving Irrigation Efficiency.* Draft Report. Washington State University, Department of Agricultural Economics and University of Idaho, Department of agricultural Economics. October.

[34] Kendy, E. and J.D. Bredehoeft. 2006. "Transient Effects of Groundwater Pumping and Surface-Water-Irrigation Returns on Streamflow." *Water Resources* Research 42(8): W08415.

Figure 7. Barriers Montana Irrigators Face in Making Improvements to Reduce Energy Use or Conserve Water, 2003



Source: ECONorthwest, with data from the U.S. Department of Agriculture, National Agricultural Statistics Service. 2004. *2002 Census of Agriculture: Farm and Ranch Irrigation Survey (2003).* Volume 3, Special Studies Part 1. Report No. AC-02-SS-1. November. (Table 40)

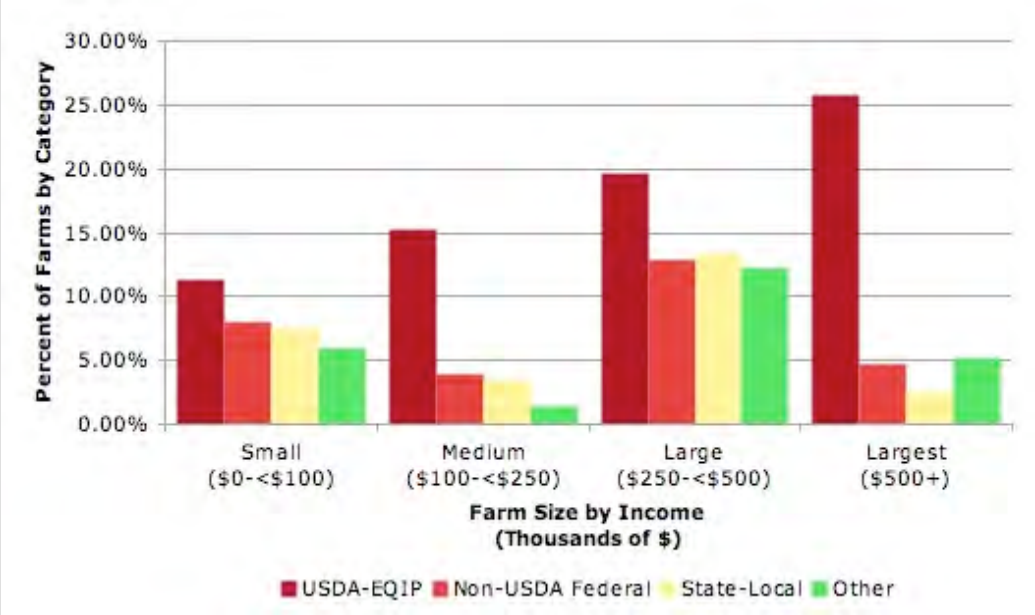
The Bureau of Reclamation also identifies a lack of capital as a primary barrier for some irrigators to install more efficient irrigation equipment. As a result, the Bureau suggests that cost-share programs may be an important strategy to increase the adoption of more efficient water management practices.[35]

Many of Montana's irrigators already utilize cost-share programs to finance improvements in irrigation-efficiency. Figure 8 shows Montana farms' participation in various cost-share programs by farm size. It is hard to know whether these cost-share programs supported irrigation improvements that led to gains in water conservation that would not have been realized otherwise. However, these participation rates at least demonstrate that, given the right incentives, Montana's farmers are willing to make such improvements.

A survey of irrigators in Colorado found that land ownership was a significant factor in whether irrigators adopted more efficient irrigation systems in drought conditions, with land owners being more likely to invest in such systems than those that leased the farm land. The level of education and scale of operation

[35] U.S. Department of the Interior, Bureau of Reclamation, Water Conservation Field Services Program. 2006. *Education – Water Management.* October. Retrieved March 19, 2008, from http://www.usbr.gov/waterconservation/watmgmnt.html

Figure 8. Participation Rates in Cost-Share Programs for Irrigation and Drainage Improvements, by Farm Size, 1994-1998



Source: ECONorthwest, with data from the Schaible, G. 2004. *Western Irrigated Agriculture: Tables*. U.S. Department of Agriculture, Economic Research Service. (Tables 16-1, 16-2, 16-3, and 16-4). Retrieved March 19, 2008, from http://www.ers.usda.gov/data/westernirrigation/ShowTables.asp?tabList=16

were also significantly correlated to the adoption of sprinkler systems.[36] Thus, lack of land ownership and lack of education may also represent barriers to making water conservation improvements.

Another barrier to adopting more efficient irrigation methods is directly related to the way water rights work in Montana. Irrigators are only guaranteed the right to use their water if they continually put it to beneficial use. If they improve the efficiency of their water use, applying less water to irrigate the same amount of crop and leaving the rest of the water instream, they risk loosing the right to use that water in the future. There is considerable uncertainty in Montana about an irrigator's right to use conserved water, and this creates a disincentive for irrigators to do anything that would reduce the amount of water they apply to their crops.

B. Water Markets

Water markets entail voluntary transactions that transfer the right to control water, on a temporary or permanent basis, from one person or entity to another. A transaction can alter the use of water (from irrigation to municipal use, for

[36] Schuck, E.C., W. M. Frasier, R.S. Webb, et al. 2005. "Adoption of More Technically Efficient Irrigation Systems as a Drought Response." *Water Resources Development* 21 (4):651-662.

example), or the timing and location of an on-going use (from irrigating one field and crop to another, for example). A water market, *per se*, comprises sellers and buyers who engage in transactions as well as the institutions and process that facilitate, approve, and validate the transactions. In most cases, a market-based transaction results in immediate change in the goods and services derived from water, as the seller relinquishes control and the buyer assumes control. Sometimes, however, a transaction results in the control of a unit of water in a water bank, where it resides and remains idle, until it expires or is withdrawn.

A temporary transfer occurs when a water-right holder retains the water right but leases the related water for use by another; a permanent transfer occurs when the water-right holder sells the water right to another. Leases can have different lengths. Some exist for only part of a season while others last an entire season, an entire year, or multiple years. A split-season lease, for example, might materialize when a farmer that typically produces two hay cuttings per year agrees to cut only once and then leases water for instream use to support fish populations during the late summer. A lease may last several years but come to life only when pre-specified conditions exist. A farmer growing an annual crop, for example, might enter into a multiple-year lease with a farmer growing perennial crops, but effect the transfer only during years when water supplies are forecasted to be low. During such a year, the seller would not plant the annual crop, transfer the water to the buyer to sustain the perennial crops, and use the compensation received from the buyer to offset the forgone revenues from the annual crops.

Water markets are most robust when they exhibit characteristics typical of other well-functioning markets. Potential sellers must have solid, verifiable property rights in the water to be leased or sold, which usually requires full adjudication of all rights in a basin. Buyers and sellers must be able to find one another easily, develop a reliable assessment of the value of the water available for lease or purchase, and execute transactions quickly. Third parties must have an opportunity to evaluate, in a timely manner, how each proposed transfer might affect them. The costs parties incur to execute a transaction must be reasonable. Once a transaction is completed, parties must have confidence that others will comply with all of its terms.

Montana took significant steps in 1985 to establish a legal framework allowing water leasing. The Legislature charged Montana DNRC with responsibility for administering the program. Currently, Montana DNRC administers almost 2,000 water marketing contracts for nearly 300,000 acre-feet of water annually and uses the revenue from such contracts to supplement the funding of water projects and project rehabilitation.[37]

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[37] Kolman, J. 2008. *An Analysis of Water Marketing and Reallocation Options in Montana for the Water Policy Interim Committee.* March 12. Retrieved March 12, 2008, from http://leg.mt.gov/content/lepo/2007_ 2008/water_policy/staffmemos/watermarketingjk.pdf

Statutes passed in 1989 and subsequent years allowed entities, such as Montana FWP, to lease consumptive water rights for instream flows and fisheries. This legislation originally capped the amount of water that could be leased at 50,000 acre-feet.[38] Recently, the Legislature amended the statute and increased the ceiling to 1 million acre-feet of water that could be leased from Montana's reservoirs. Of this water, 50,000 acre-feet could be used for beneficial uses outside the state.[39] Three major parties have played a significant role in signing leases that reserve water rights for instream uses: Montana Water Trust, Trout Unlimited, and Montana FWP.

The law allows Montana FWP to lease consumptive water rights for instream flows, without any time constraints, on up to 12 stream reaches, where Montana FWS owns the water rights. Montana FWP is currently in the process of identifying the 12 streams that would provide the greatest returns to investments in the water leases. On the remaining streams, the changes in appropriation rights cannot exceed a term of 10 years, though they may renew the 10-year lease an indefinite number of times. Montana DNRC must approve all leases. The Legislature established June 30, 2019 as the sunset for the current law. After this date, the department is not allowed to renew any old leases or enter into new contracts.[40] Since the legislature granted Montana FWP the authority to lease water rights for instream flow, it has signed 17 leases. At the end of December 2006, 12 of these remained active, and FWP signed no new agreements in 2007. Since 1999, Montana FWP has spent more than $260,000 to restore almost 200,000 acre-feet of instream water flows.[41]

Private parties, including Montana Trout Unlimited (Montana TU) and Montana Water Trust (MWT), have acquired more than 57,000 acre-feet of water through leases and donations, spending about $1.3 million over 5 years.[42] Montana TU holds 6 leases, all in the Blackfoot River Valley. The agreements reveal that many ranchers are willing to reduce irrigation for prices between 75 cents and more than $25 per acre-foot. MWT has signed 15 leases since 2001 for 2,600 acre-feet of water annually. In 2007, MWT paid out $63,000 to landowners for leased water flows.

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[38] "85-2-141. Water Leasing Program." *Montana Code Annotated – 2007.* Retrieved March 19, 2008, from http://data.opi.state.mt.us/bills/mca/85/ 2/85-2-141.htm

[39] *Senate Bill 376*. Retrieved March 19, 2008, from http://data.opi.state.mt.us/bills/2007/billhtml/ SB0376.htm

[40] Kolman, J. 2008. *See* footnote 37.; MCA 85-2-436.

[41] Scarborough, B. and H.L. Lund. 2007. *Saving Our Streams, Harnessing Water Markets: A Practical Guide.* Property and Environmental Research Center. Retrieved March 14, 2008, from http://www.perc.org/ pdf/sos_2007.pdf

[42] Scarborough, B. and H.L. Lund. 2007. *See* footnote 41.

1. Potential Economic Consequences of Water Markets

The participants in water markets are likely to experience positive economic consequences, but others—so-called third parties—may experience positive or negative consequences.

Potential Positive Economic Consequences. Economists favor water markets because they can offer robust opportunities for increasing the value of the goods and services derived from a given supply of water. Market-based, voluntary transfers of water should increase the economic well-being of both the sellers and the buyers because a transaction would occur only if both parties expected it to be beneficial. An irrigator would sell water only if the payment received from the buyer is expected to be greater than the net value of the irrigated crops that otherwise would be produced. Conversely, an irrigator would buy water only when the expected net value of additional irrigated crops to be grown with the water would exceed the payment for the water.

Potential Negative Economic Consequences. Much of the concern over water transfers arise from third parties who fear the transfers will cause them economic harm. A downstream farmer, for example, may fear that a transfer would increase the upstream consumption of water, leaving less water in the stream to meet downstream demands. Farm-supply businesses may fear that water transfers away from one type of agriculture to another will reduce the demands for their products. Nearby communities may fear that, once transfers are allowed from one farmer to another, they eventually will be allowed to shift water away from agricultural use altogether, with the water perhaps leaving the state entirely.

The regional economic effects of water transfers probably would be discernible only if the transactions altered a large enough portion of a given activity at a specific place and time to alter the overall structure of related economic activities. An incremental transfer of water from one farmer to another growing similar crops might have little effect on the overall surrounding economy. The economy might experience a discernible shake-up, however, from a transfer that significantly increased the supply of high-value, scarce goods and services while having a minor impact on the supply of abundant goods and services.

The establishment and expansion of water markets has the potential to alter patterns of both water quantity and quality. The water-quantity impacts may entail no more than a shift in water from one time, location, or use to another. Sometimes, however, market-based transfers can trigger a change in the overall amount of water being used. Some researchers have found that policies favoring the development of a short-run water-market—during a drought year, for example—can yield reductions in both the amount of water applied to irrigate crops and in the irrigated farm acreage.[43] Others have found that the response to markets can have a more complicated effect, especially when they interact with

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[43] Huffaker, R. and N. Whittlesey. 2003. *See* footnote 32.

increasing costs of using surface water.[44] As surface-water prices rise or as farmers have opportunities to sell water for higher prices, irrigators may find it cheaper to relinquish surface-water supplies and rely on on-farm wells. In general, the intensity of irrigation is not sensitive to water prices, but farmers seem more inclined to alter the acreage irrigated, or to shift cropping patterns, as water prices increase or decrease. Changes in water prices can exert a strong influence on growers' choice of irrigation technology, with increasing prices inducing irrigators to adopt technologies that use water more efficiently. Sometimes the saved water is returned to the stream, but often farmers use it to expand the acreage being irrigated and/or shift to a more water-intensive crop.

The water-quality effects of market-based transfers depend on the volume of water transferred, and on the resulting changes in timing, location, and uses. In general terms:

- Increases in agricultural uses likely would increase the potential for nutrient loadings to associated groundwater and surface water, moderate stream temperatures, and reduce stream dissolved oxygen concentrations.

- Increases in municipal uses could indirectly increase the potential for water quality degradation by supporting increased urban development. The extent and location of any degradation would be dependent on the type and location of treatment facilities used.

- Increases in instream flows likely would tend to reduce nutrient concentrations, and increase dissolved oxygen concentrations. Effects on the thermal regime would be dependent on the location of increased instream flows. In the upper basin, increased instream flows would tend to reduce stream temperatures. However, increased instream flows in the lower basin may somewhat increase stream temperature.

In the long run, water transfers may result in changes in land use, both in the areas where the water rights originated and in the recipient areas. These transfers may influence development in the surrounding local and regional economies, and contribute to the conversion of farm uses to urban or domestic uses. Transfers of water from agricultural lands may increase fallow lands that otherwise would have supported irrigated crops. Conversely, transfers that improve the reliability of an irrigation water supply may reinforce farmers' efforts to keep some properties in agricultural use that otherwise would be converted to urban uses.

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[44] Schuck, E. and G.P. Green. 2003. "Conserving One Water Source at the Expense of Another: The Role of Surface Water Price in Adoption of Wells in a Conjunctive Use System." *Water Resources Development* 19(1): 55-66.

2. Barriers to Establishing Water Markets

Several factors impede growth in the number and extent of market-based water transfers. One major factor is lack of experience. Transfers have not occurred in enough volume or for a long enough time for there to be widespread awareness, among both potential sellers and potential buyers, of the mechanics and economic opportunities associated with transfers. This lack of awareness is made more acute because there exists no permanent set of institutions to facilitate transfers and, thereby, build familiarity and trust. Instead, ad hoc efforts to promote transfers have had intermittent and limited success.

Additional barriers to water markets stem from the nature of water rights. Typically, the validity of one's claim to have a right to water is not confirmed until the state has fully adjudicated all water rights in a basin. The adjudication process has proceeded slowly in Montana, as in other states, creating uncertainty about the validity of any market-based transaction transferring a water right. This uncertainty diminishes the willingness of potential buyers to pay for a right that might later prove to be invalid. In addition, each water right carries an obligation not to diminish the rights of others. As a consequence, a proposal to lease, purchase, or donate a water right triggers a complicated process that allows all interested parties to review the proposal, gives anyone that feels it would cause harm to present evidence, and calls for a review of all evidence before the transfer is approved. Some states have taken steps to reduce the time required to complete this process. In Washington's Yakima River Basin, for example, state and federal agencies, irrigation districts, and key tribal and private entities acted in 2001, a drought year, to form an ad-hoc process to facilitate voluntary, expedited review of proposed transfers by the agencies, irrigation districts, and others. The group can recommend that the state court with jurisdiction over water rights approve proposals that satisfy the six criteria that indicate the transfer would not have substantial, adverse impacts on the environment or on third parties:

- The proposed transfer would have a neutral effect on the total water supply available in the basin;
- The proposed transfer would not increase consumptive use;
- The water would have been used, but for the transfer;
- The transfer would incorporate a specific delivery schedule;
- The transfer would not adversely affect instream flow; and
- The transfer would satisfy operational considerations for the Bureau of Reclamation.

The physical facilities and operational requirements of a water-management system also might produce some barriers to water transfers. These might arise, for example, in irrigation systems linked to projects operated by the Bureau of Reclamation, insofar as the agency has obligations to manage reservoirs according to established protocols and federal reclamation laws, and to ensure that instream flows meet established targets. Moreover, irrigation districts

typically seek to keep water levels high in their systems during the irrigation season to avoid damage that can occur when canals dry out, and to maintain sufficient pressure to move water efficiently. These operational constraints may restrict the transfer of water that increases risk to the infrastructure.

Montana Fish, Wildlife, and Parks has identified these factors as the main challenges to developing markets for leasing water in the state:[45]

> *Adjudication of water rights.* The "slow pace of Montana's general water adjudication is resulting in the loss of potential leases. Inflated, unperfected and abandoned claims impede the process."
>
> *Limitations on lease renewals*. Montana FWP argues that some landowners refuse to enter in water-lease agreements because the term of the lease, 10 years maximum with review of the renewal every 10 years, is too restrictive and short. The department contends that allowing landowners the flexibility of extending the term of the leases past 20 years may increase the number of parties interested in instream-flow agreements.
>
> *Authorization of a permanent leasing program*. Montana FWP argues that the statutory provisions guiding the water leases in Montana should be made permanent instead of having to undergo a legislative review every 10 years and should be combined into one program with statewide objectives.
>
> *Increased transaction costs for water leasing.* Costs of water leases have increased because water resources have been over-allocated and the number of parties looking to purchase new water rights is constantly increasing. The problem of allocation is made worse by new users of groundwater, who have to purchase existing water rights to mitigate for adverse effects that may result from additional use of groundwater.

C. Payments for Ecosystem Services

Irrigation systems and agricultural lands can provide a variety of goods and services extraneous to their intended objective, irrigating crops. Some systems, for example, provide water for municipal-industrial users, habitat for fish and waterfowl, recreational opportunities, maintenance of dry season instream flows, and more. Sometimes, the irrigation system or landowner receives payment for a good or service: from a municipality or industrial user for water, from a hunter for opportunities to hunt waterfowl, etc. In most instances, however, irrigation systems and landowners do not receive payment for providing goods and services that benefit others. This disconnect underlies the widely-held view, that

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[45] Montana Fish, Wildlife and Parks, Fisheries Division. 2006. *2006 FWP Annual Progress Report: Water Leasing Study.* Montana Environmental Quality Council, Montana Department of Natural Resources and Conservation, and Montana Fish, Wildlife, and Parks Commission. December. Retrieved March 13, 2008, from http://leg.mt.gov/content/lepo/2007_2008/water_policy/staffmemos/2006waterleasing.pdf

there are significant and unavoidable tradeoffs between farmers' production goals and society's goals for environmental quality and protection.[46] To avoid zero-sum outcomes and offset this perception, many farmers and ranchers have begun investigating opportunities for earning revenues from their production of goods and services that benefit the environment. Economists often call this process payments for ecosystem services.[47]

Payments for ecosystem services (PES) can take many forms. One of the most common examples is the Conservation Reserve Program (CRP) of the U.S. Department of Agriculture, in which the federal government pays farmers to take land out of production and plant vegetation providing soil, water, and habitat benefits. This and similar programs are most effective when they provide incentives that influence behavior, which usually means they must provide a farmer with sufficient revenue and/or reduce the farmer's risk sufficiently to offset the farmer's loss of expected agricultural earnings from the land as well as the costs of effecting the transaction.

Motivations for PES include:[48]

- Increased threats (real or perceived) to ecosystem services;
- Increased awareness of or belief in benefits of ecosystem services;
- Desire by landowners to increase or ensure conservation practices upstream;
- Inadequacy of regulations alone to insure ecosystem-service delivery;
- Achieving regulatory standards by more cost-effective means;
- Addressing inequities in the distribution of costs and benefits of ecosystem-service provision; and
- Stabilizing funding flow for management of protected areas.

Not all potential buyers of ecosystem services from irrigation systems in Montana are alike. The particular needs of the buyer dictate the capacity of a PES to be a worthwhile expenditure. State, federal, and local government agencies might see an opportunity to increase the production of an ecosystem service via a

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[46] Claassen, R., M. Aillery and C. Nickerson. 2007. *Integrating Commodity and Conservation Programs: Design Options and Outcomes*. U.S. Department of Agriculture, Economics Research Service. Economic Research Report No. ERR-44. October 2007. Retrieved March 28, 2008, from http://www.ers.usda.gov/publications/err44/

[47] Murtough, G., B. Aretino, and A. Matysek. 2002. *Creating Markets for Ecosystem Services*. Government of the Commonwealth of Australia, Productivity Commission. Productivity Commission Staff Research Paper No. 1709. June 17. Retrieved March 28, 2008, from http://ssrn.com/abstract=322380

[48] Tognetti, S., G. Mendoza, B. Aylward, D. Southgate, and L. Garcia. 2004. *A Knowledge and Assessment Guide to Support the Development of Payment Arrangements for Watershed Ecosystem Services (PWES)*. World Bank Environment Department. Retrieved March 28, 2008, from http://www.flowsonline.net/data/pes_assmt_guide_en.pdf

modification in an irrigation system, and provide project funding and/or direct payments toward that end. Individuals and private organizations might act similarly, by paying irrigators to improve fish habitat, for example, with the expectation that the benefits would be available to society as a whole. Alternatively, an individual or organization might pay to secure benefits solely for itself. This type of transaction occurs when hunters pay a farmer to create habitat for pheasants and grant them exclusive hunting rights, for example.

Under certain legal obligations, public or private entities might see an opportunity to employ PES to facilitate compliance with regulatory constraints. For example, a firm or community might be obligated to ensure there is a certain quantity and quality of water in a stream, and paying another party to provide that stream flow might be the lowest-cost option. Likewise, regulatory agencies might identify this potential and develop and facilitate payment schemes to allow cost savings, or increase benefits for a particular overall cost.

1. Potential Economic Consequences of Payments for Ecosystem Services

Potential Positive Economic Consequences. Buyers in PES schemes have increased opportunities to purchase services providing direct benefits or regulatory compliance. These opportunities, if taken, indicate increased benefits for existing levels of expenditures, and/or decreased costs for ecosystem-service demands or responsibilities. In some cases, these benefits are facilitated by relaxed technology-regulatory constraints. For example, National Pollutant Discharge Elimination System (NPDES) permits under the Clean Water Act have historically required onsite compliance for a particular point source of pollution, but revisions or a new permit might allow a regulated entity to pay others for offsite compliance. Clean Water Services, a wastewater utility in northwest Oregon, is taking advantage of such an opportunity by paying landowners to establish trees in streamside zones that will provide shade and equivalent cooling of streamflows rather than incurring a much larger cost by installing a chiller to cool the effluent from its treatment plants.[49]

As PES mechanisms become more established, they create opportunities for producing multiple benefits and, hence, elicit greater interest from a wider set of potential buyers. Research in Portland, Oregon, found that investments aimed at increasing salmon habitat by improving streamside vegetation and reconnecting a stream to its natural floodplain could create benefits not just for salmon advocates but also for nearby landowners, advocates of cleaner air, recreationists, and birders. They also could lower the costs nearby businesses incur to manage stormwater.[50] This research demonstrates the potential for an

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[49] Clean Water Services. 2005. *Revised Temperature Management Plan, Appendix B: Thermal Budget Explained*. February 28. Retrieved March 28, 2008, from http://www.deq.state.or.us/wq/wqpermit/docs/individual/npdes/cws/tmp/appxb.pdf

[50] ECONorthwest. 2004. *Technical Memo on the Economic Analysis of Ecosystem Services in the Lents Area*. David Evans and Associates and the City of Portland. February 18, Revised March 22.

appropriately-designed PES program to engage multiple buyers, so that each would bear only part of the overall cost. This approach indicates that PES may in the future induce firms and communities to provide irrigators with expanded incentives for managing Montana's water resources. Such arrangements may alter current regulatory approaches for accomplishing environmental objectives. As mentioned above, for instance, Oregon's Department of Environmental Quality exempted Clean Water Services from its obligation to install chilling equipment that treats wastewater-treatment-plant discharge in exchange for a commitment to pay landowners to establish riparian vegetation that will provide not just shade and cooling benefits but also other ecosystem services, such as streambank stabilization and opportunities for streamside walking and biking trails.[51] With this arrangement, the regulatory agency, utility, and landowners share the responsibilities, risks, and costs associated with satisfying regulatory requirements. Similar arrangements might help irrigators satisfy their regulatory requirements with less cost and risk. The extent to which a PES program produces benefits for farmers will depend on the program and each farmer's circumstances.

Potential Negative Economic Consequences. Payments for ecosystem services are voluntary transactions for both buyers and sellers. Consequently, buyer and seller participation demonstrates that PES can provide improved benefits and/or reduced compliance costs over the next-best opportunity. Still, new types of costs can arise for buyers, sellers, and the wider community, and particular types of costs might increase.

Both buyers and sellers might expect to incur increased information and transaction costs as they learn about and experiment with new methods, interactions, and compliance schemes. An irrigation system or a landowner might realize additional costs if a PES scheme aimed at fallowing riparian zones resulted in higher incidence of weeds or other pests. A scheme to alter stream channels and wetlands might also alter risks of flooding Farmers and ranchers are likely to anticipate these risks, and, therefore, attempts to establish PES schemes must anticipate them as well. Education or pilot-test programs can help to identify actual costs and reduce expected risk.

2. Types of Payments for Ecosystem Services

Public and private entities have found several techniques for making payments for ecosystem services. Payments can occur within constructed, administered, and regulated market mechanisms, or as direct transactions between entities. While variations across this spectrum are possible, the appropriate structure will likely be based on the existing regulatory framework, the share of administrative burden government agencies are willing to bear, the distribution of risk among interested parties, and the distribution of benefits among different groups. Payments for ecosystem services can be categorized as 1) credit trading markets,

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[51] Clean Water Services. 2005. *See* footnote 49.

2) private transactions, and 3) government payments. Table 3 provides an overview of these categories of PES, and examples of each.

Credit Trading. The largest overall number of PES transactions probably occur as credit trades, such as those established for wetland mitigation banking. Wetland mitigation banks provide offsite compliance opportunities for projects that impact wetlands under a national program administered by the Army Corps of Engineers and the U.S. Environmental Protection Agency. There were 450 functioning wetland mitigation banks in the U.S. in 2005,[52] hundreds more in development, and hundreds of million of dollars in transactions annually. The administrative process and regulatory framework is substantial, and creating centralized banks that can service mitigation needs for an entire region reduces the overall transaction costs for buyers, sellers, and regulators.

An emerging example of credit trading is carbon trading, in which carbon emitters pay farmers and ranchers for sequestering carbon on their land. Since May, 2007, ranchers have been able to generate carbon credits to sell on the Chicago Climate Exchange (CCX) by implementing on their rangeland certain land management practices that have been shown to increase the rate at which carbon is sequestered in the soil.[53] On March 27, 2008, the CCX markets closed at $5.75 per ton of CO_2. Currently, the CCX carbon price is low compared to carbon prices on markets that operate where mandatory carbon limits are already in place. For instance, on the same day, March 27, 2008, a ton of CO_2 traded for around $35.00 on the European market.[54] This suggests that as mandatory limits

Table 3. Overview of Types of Payments for Ecosystem Services

Payment Process	Typical Purchaser	Examples
Credit Trading	Regulated entities (public or private) with compliance obligations.	Wetland mitigation banking; water quality credits; carbon credits; water markets.
Private Transactions	Regulated entities and direct beneficiaries of ecosystem services.	User fees; conservation easements; instream flow leases.
Government Payments	Government agencies.	Conservation Reserve Program; Montana Enhancement Program.

Source: ECONorthwest

[52] U.S. Environmental Protection Agency. 2007. *Mitigation Banking Fact Sheet*. June 22. Retrieved March 28, 2008, from http://www.epa.gov/owow/wetlands/facts/fact16.html

[53] National Carbon Offset Coalition. No date. "CCX Rangeland Soil Carbon Management Offsets." Retrieved March 27, 2008, from http://www.ncoc.us/images/Downloads/rangelandeligibilityandcounties.pdf

[54] Chicago Climate Exchange. 2008. *Market Overview for March 27, 2008*. Retrieved March 27, 2008, from http://www.chicagoclimatex.com/

on carbon dioxide emissions are implemented in the United States, the potential revenue that farmers and ranchers can earn by implementing carbon sequestration practices on their land will likely increase.

Private Transactions. Private transactions for ecosystem services are likely the most intuitive and often have low administrative costs. User fees are usually effective when a seller can limit the enjoyment of benefits to only those who pay. For example, an irrigator can limit access to his/her private property, and charge a fee to those who wish to use the land for hunting, fishing, or other recreation. This allows irrigators to augment their traditional sources of revenue (i.e. crop production) in exchange for providing wildlife habitat and recreational opportunities. Many farmers and ranchers in Montana already charge user fees for hunters to access their land: in 1994, 12 percent of ranches surveyed in Montana charged a user fee or leased the right to hunt to outfitters.[55]

Conservation easements, an example of a private transaction, have become common in agriculture. In this type of PES, private landowners are compensated for agreeing not to develop their land, either for a limited period or in perpetuity, through a legally-enforceable contract that becomes part of the property title. Land trusts and other non-governmental organizations, such as the Nature Conservancy, rely on this technique to encourage landowners to maintain natural conditions on their property while also earning income. Just as conservation easements are often funded by private donations, private landowners might be able to establish private reserves that are eligible for tax-deductible charitable donations. These examples show that, by using land and water previously or simultaneously employed for irrigation, private landowners have many options to generate revenue and sustain their agricultural livelihood through payments for ecosystem services.

Instream-flow leases are similar in concept to conservation easements. As we discuss in Section III, B, above, owners of water rights are paid to leave a portion of their water right instream, or to put water back into the stream channel. For example, Trout Unlimited leases a water right on Wasson Creek in the Blackfoot River watershed from the Mannix Brothers Ranch. It compensates the Ranch for forgone revenues it otherwise would receive from pasture production, in exchange for leaving 0.5 cubic feet per second of flow in Wasson Creek.[56] The terms of Trout Unlimited's transactions in the Blackfoot River drainage identify payments from $0.75 to $25 per acre-foot.[57]

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[55] Swensson, E.J. and J.E. Knight. 2001. "Hunter Management Strategies Used by Montana Ranchers." *Wildlife Society Bulletin* 29(1): 306-310.

[56] Bradshaw, S. and L. Ziemer. 2007. *Water Leasing in Montana through Trout Unlimited's Eyes.* Property and Environment Research Center. June. Retrieved March 28, 2008, from http://www.perc.org/perc.php?id=886

[57] Kolman, J. 2008. *An Analysis of Water Marketing and Reallocation Options in Montana for the Water Policy Interim Committee.* March 12. Retrieved March 12, 2008, from http://leg.mt.gov/content/lepo/2007_ 2008/water_policy/staffmemos/watermarketingjk.pdf

Direct Payments. Direct payments from government agencies to private businesses and landowners can also be a cost-effective way to compensate farmers for providing ecosystem services. In Montana, there are several examples of the state and federal government paying landowners directly to provide ecosystem services. The Montana FWP and the Montana DNRC are allowed to obtain leases for instream flows. The U.S. Department of Agriculture (USDA) Natural Resources Conservation Services (NRCS) pays farmers through the Conservation Reserve Program (CRP) to limit agricultural activities and provide ecosystem services instead. In February 2008, Montana had more than 3.3 million acres enrolled in the CRP. Montana farmers were expected to receive over $109 million or $32.87 per acre enrolled in the program by the end of the year. This average is 35 percent less than the national average.[58] Figure 9 shows the distribution of the enrolled land as a ratio of CRP acres to total land, by county. The map indicates that the counties in the northern part of the state have the highest concentration of land enrolled in the conservation program, while counties in the western and southern parts have the lowest concentration. Once enrolled, CRP is not likely to be irrigated. Data on how much irrigated land farmers have converted to CRP is unavailable, but such examples likely do exist.[59]

Farmers who enroll in the CRP must weigh the revenues they might earn through fallowing their land against the revenues they otherwise might earn through producing crops on their land. The CRP may be a more favorable option when crop prices are low, but the opportunity cost of participating in the program may become too high if crop prices increase. Currently agricultural commodity prices are high, and there is evidence to indicate that farmers are choosing not to re-enroll their land in the CRP. The total acres state-wide eligible for re-enrollment ranges from 73,600 in 2008 to 383,000 in 2010. After 2010, an additional 2.7 million acres will be up for renewal. We have found no data available showing how many of the 266,000 acres eligible for renewal in 2007 actually stayed in the program. Evidence from neighboring North Dakota, however, shows that the number is probably lower than expected.[60] This signals that recently it has become more profitable for farmers to plant crops than to practice conservation.

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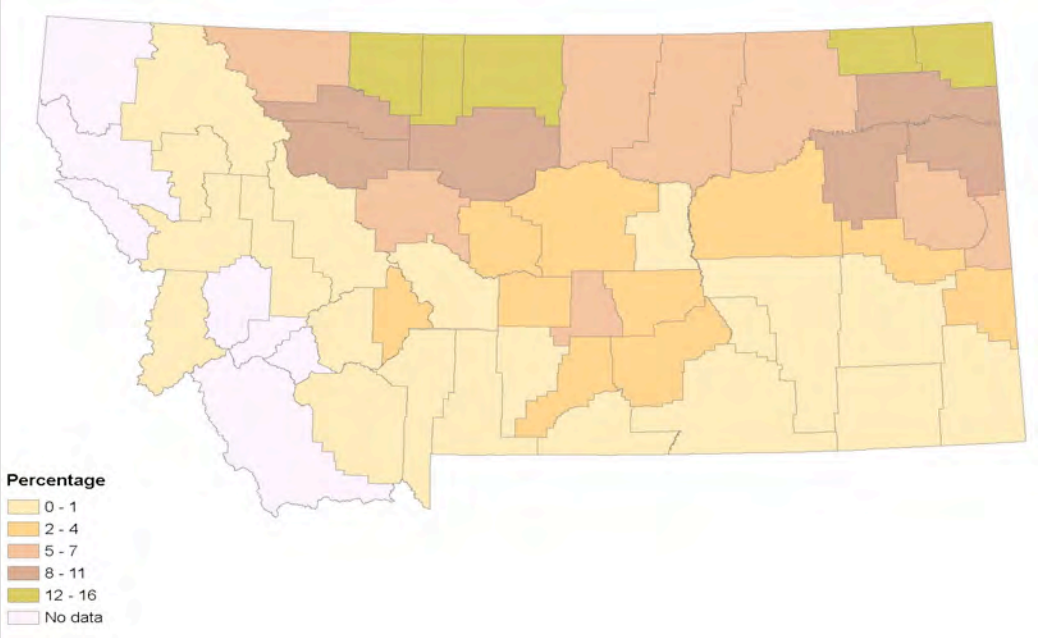
[58] U.S. Department of Agriculture, Farm Service Agency. 2008. *Conservation Reserve Program: Monthly Summary – February 2008.*. Retrieved March 31, 2008, from http://www.fsa.usda.gov/ Internet/FSA_File/ feb2008.pdf

[59] We include this discussion of CRP, not because the program is commonly utilized by irrigators, but because it is one existing example of payments for ecosystem services that irrigators can take advantage of.

[60] Ducks Unlimited. 2008. *DU Says CRP Losses Astounding: National Trend for Habitat Loss Concerning.* January 4. Retrieved March 31, 2008, from http://www.ducks.org/news/1456/ DUsaysCRPlossesastou.html

Figure 9. Acres Enrolled in CRP as a Percentage of County Area, 2004



Source: ECONorthwest, with data from U.S. Department of Agriculture, Farm Service Agency. No date. *Cumulative CRP Enrollment by County, FY 2004.* Retrieved March 27, 2008, from http://www.fsa.usda.gov/Internet/FSA_File/fy2004public.xls and National Association of Counties. *About Counties: Montana.* Retrieved March 28, 2008, from http://www.naco.org/Template.cfm?Section=Find_a_County&Template=/cffiles/counties/ state.cfm&statecode=mt

Similar to the CRP, the Montana Enhancement Program, a joint venture of the Montana Farm Service Agency and the USDA, pays farmers to plant vegetation and restore wetlands to reduce sediment in on 26,000 acres across nine counties. Program participants receive $100 to $150 per acre for riparian buffer enrollment, cost sharing for plantings, and annual maintenance payments.[61]

The Block Management Program, in which the Montana FWP pays farmers and ranchers to allow hunters to access their land during the hunting season, is another example of a direct payment by a government agency for ecosystem services. The Montana FWP selects land for the program based on habitat type and quality, providing an incentive for farmers and ranchers to maintain good-quality habitat on their land. In exchange for allowing access, landowners receive up to $12,000 in direct compensation, limited liability protection, and a complimentary sportsman's license.[62] During the 2007 hunting season, 1,250

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[61] U.S. Department of Agriculture, Farm Service Agency. 2002. "Conservation Reserve Program - Montana Enhancement Program." *Program Fact Sheets.* September. Retrieved March 28, 2008, from http://www.fsa.usda.gov/FSA/newsReleases?area=newsroom&subject=landing&topic=pfs&newstype=prfactsheet&type=detail&item=pf_20020901_consv_en_crepmt02.html

[62] Montana Fish, Wildlife, and Parks. 2008. *Block Management FAQ.* Retrieved March 27, 2008, from http://fwp.mt.gov/hunting/hunteraccess/blockman/faq.html

landowners enrolled about 8 million acres of land in the Block Management Program.[63]

3. Payments for Ancillary Ecosystem Services

While sustaining or enhancing ecosystem services might not be the primary purpose for a program or expenditure, the provision of ecosystem services is often used as supporting justification for price premiums on certain agricultural products. For example, farmers and ranchers who offer organic produce and animal products or naturally raised livestock command higher prices than conventionally-raised products. This premium is a payment by consumers for expected quality and health benefits, and for reduced environmental impacts as well. In effect, a share of the additional cost is a payment by consumers for ecosystem services protected or provided by farmers and ranchers. Protecting streams and aquatic habitat might be a valuable marketing strategy for farmers and ranchers.

Ecosystem-service benefits are part of the justification for rehabilitating the St. Mary Diversion in northern Montana. The project diverts water from the St. Mary River to the Milk River for irrigation and water supply. The Milk River would run dry in some years without the diversion. An economic analysis of efforts to rehabilitate the diversion project estimated annual recreation benefits provided by the Milk River at $8.6 to $9.7 million.[64] This analysis estimated wetland benefits on the Milk River that rely on diversion water as ranging from $4.7 to $6.9 million annually based on replacement costs.

4. Barriers to Payments for Ecosystem Services

Although specific payments for ecosystem services often appear to produce net benefits for individuals and communities, these benefits do not always materialize. Some of the barriers to implementing payments for ecosystem services include:

> *High administrative costs*. Valuing, verifying, monitoring and tracking activities that generate ecosystem services can require management systems and personnel. Existing programs, such as the water quality credit trading program on the Great Miami River in Ohio include fees on transactions to support these activities, but the Miami Conservancy District has a large role in implementation.[65]

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[63] Montana Fish, Wildlife, and Parks. 2008. *Block Management: Block Management Opportunities Abound.* Retrieved March 27, 2008, from http://fwp.mt.gov/hunting/hunteraccess/blockman/default.html

[64] Bioeconomics. 2006. *St. Mary Diversion & Milk River Project: Preliminary Economic Analysis*. Impacts and Benefit-Cost Analysis, Phase II Task 4 – Economic Analysis. Final Report. August 30.

[65] Hall, D. 2006. *Making Trading Work*. Presented at the Second National Water Quality Trading Conference, May 23-25 2006, Pittsburgh, PA. Retrieved March 31, 2008, from

No demonstration transactions or pilot projects. New types of transactions can have increased uncertainty regarding costs and benefits. Examples of transactions or service-generating activities might be necessary for others to feel confident with the investments needed.

Regulations that do not allow PES. Regulated entities under legislation, such as the Clean Water Act or the Endangered Species Act, might have obligations that could be more effectively met with PES. Permits or state-level rules might need to be modified to allow use of PES.

Funding constraints. Even though certain ecosystem services, such as instream habitat provision, might be valuable to communities, funding or mechanisms for coordinating funding might not exist.

Thin markets. While PES might offer benefits for buyers and sellers, they might not be aware of opportunities to buy or sell ecosystem services. They also might not have ways to find each other.

Increased uncertainty and risk. Buyers and sellers might perceive greater uncertainty and associated risk with PES than existing regulatory compliance or service opportunities.

Future liability. Farmers and ranchers might worry that by providing ecosystem services, particularly to satisfy regulatory obligations of others, they demonstrate a capacity to be effective targets for regulation. Program managers for water quality trading programs in Ohio and Minnesota report that some farmers stated initial unwillingness to participate because of concern that they would then receive pollutant load reduction obligations themselves on subsequent permits.[66]

If a particular payment for ecosystem services appears to be worthwhile, government assistance and program design can potentially overcome these barriers. Governmental or private organizations can take responsibility for establishing a PES framework and initial pilot transactions. Funding and thin market constraints might be due to inadequate demand. Existing permits or regulatory obligations might need to be modified with participation of additional government agencies to allow compliance through PES to increase demand. Public funding in support of natural resources might need more flexibility in order to achieve potentially increased net environmental gains from PES as opposed to existing efforts.

PES can also appear to have greater uncertainty and risk for all parties involved. Regulatory agencies and environmental organizations are often wary of permitting point sources to be offset by nonpoint sources because it is difficult to monitor the effectiveness of nonpoint-source-pollution control measures.

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http://www.envtn.org/WQT_EPA/Microsoft%20PowerPoint%20-%20Dusty%20NWQT%20II%20May%202006.pdf

[66] Personal Communication with Dusty Hall, Manager of Program Development, Miami Conservancy District, Dayton, OH. August 24, 2007.

Consequently, regulated entities might worry that the costs they incur to implement a PES scheme will be fruitless because regulators will deem it inadequate. Similarly, farmers and ranchers may be reluctant to participate due to uncertainty as to whether PES will be as reliable as their traditional sources of revenue. Government agencies, with the help of private organizations, have overcome these obstacles by acting as brokers or insurers, taking on liability (potentially for a fee) in order to facilitate PES. Examples of these liability-bearing parties include wetland mitigation bankers and conservation districts for water-quality-trading programs.

Concern for future liability might be legitimate for some farmers and ranchers. In addition, regulated parties that are buyers might see their obligations as unfair, particularly as transactions demonstrate lower provision costs for unregulated farmers and ranchers. These concerns might be insurmountable in some cases, but meetings and collaborations, as well as legally binding contracts and statues, have alleviated similar concerns in other situations.[67]

5. Additional Implementation Considerations for Payments for Ecosystem Services

In addition to the techniques offered above to overcome potential barriers to PES processes, assessment and design should also consider the following lessons from existing programs:

Avoid unintended consequences. If opportunity costs, production goals, and perceived risks are not adequately accounted for in program design, farmers and ranchers might respond in ways that are counterproductive to program goals. For example, if a program offers payments for improvements to streams, there might be an incentive to degrade a stream before baseline assessment in order to later achieve payments for improvements.

Establish baselines carefully. The points from which benefits, costs, and obligations are measured will determine allocations of costs and benefits and influence incentives for participation. Are PES offered for increases to current ecosystem services provided, or for all existing services as well?

Consider opportunity costs. Even though a PES might appear to offer adequate compensation to elicit the desired services, if it precludes other revenue opportunities or benefits, compensation might need to be greater than expected. Conversely, if other opportunities are not impacted, PES necessary to elicit service provision might be minimal. For example, if ecosystem services from irrigation activities reduce agricultural production, these lost revenues will need to be compensated. But if

[67] Personal Communication with Dusty Hall. *See* footnote 66.

adjustments to current irrigation techniques necessary to provide ecosystem services are minimal, payments can likely be less.

Identify sources of uncertainty and risk. Buyers and sellers will likely perceive different sources of risk and different possible consequences of undesirable outcomes when considering new sources of services. Regulatory agencies likely have differing concerns and unknowns as well. In order for PES processes to be successful, uncertainties and risks must be accounted for all parties, either through agreements, insurance mechanisms, or shared risk.