Technical Memorandum 2.2
Net Economic Benefits of Irrigation in Montana

Revised August 2008

ECONorthwest
ECONOMICS • FINANCE • PLANNING

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

© ECONorthwest 2008

CONTACT INFORMATION

This report was prepared by Ernie Niemi, Cleo Neculae, and Sarah Reich, of ECONorthwest, which is solely responsible for its content.

ECONorthwest specializes in the economic and financial analysis of public policy. ECO 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

In Technical Memorandum 2.1 we present an analytical framework for describing the economic importance of irrigation and irrigated agriculture in Montana. One central concept of the framework is that water has economic importance because it, together with the ecosystem of which it is a part, provides goods and services for human use and enjoyment. Some water-related goods and services have a positive value and increase the economic well-being of Montanans, as when the irrigation services of water used by farmers increase the value of their crops. Others have a negative value and reduce economic well-being, as when flooding damages infrastructure and disrupts economic activities. Another central concept is that Montanans typically derive many goods and services from a given body of water and, hence, there often is competition for the state's water resources. In a competitive situation, using water to irrigate crops generates economic benefits for the irrigators, but it also imposes spillover effects, or externalities on others who have demands for water-related goods and services. When irrigation diminishes the supply of water-related goods and services available to others, the externality is negative, i.e., irrigation imposes an external cost on those who experience the loss of the forgone goods and services. Conversely, when it increase the supply, the externality is positive.

In this Technical Memorandum we present information that provides insights into the net economic benefits of water used for irrigation in Montana. To derive the net economic benefits of irrigation, one must subtract the gross economic costs of irrigation from the gross economic benefits of irrigation.[1] Our discussion of the net economic benefits of irrigation follows this basic equation. First, we describe the different types of goods and services Montanans derive from the state's water resources. Second, we discuss the gross economic benefits of irrigation—the full value of the goods and services produced when water is used for irrigation, considering both the benefits that arise as water irrigates crops as well as the positive externalities of irrigation. Third, we discuss the gross economic costs of irrigation—all of the costs of investing in irrigation as well as the negative externalities, i.e., the loss of goods and services that would have been produced if the water used for irrigation were put to another use. We conclude with a discussion of trends and changing conditions that might affect, positively or negatively, the way irrigation's benefits and costs manifest themselves in the future.

In all cases, we attempt to describe the costs and benefits as completely as possible. We provide as much information as possible regarding the likely magnitude of the different gross benefits and costs. Some of the studies and data we employ in this memo directly describe the value of goods and services in Montana. Others describe economic research that has focused elsewhere, but we include it in the discussion because there are reasons to believe that similar findings would be obtained if the studies were repeated in Montana. We also describe some studies with findings are not specifically applicable to Montana,

---

[1] In each case, "gross" means *without deductions*, or the full value of costs or benefits, not accounting for offsets or deductions.

but that offer useful insights into the general nature and magnitude of the value of various irrigation-related goods and services.

Following standard economic convention, we distinguish among three measures of economic value. The broadest and most fundamental measure is the public's total willingness to pay for a good or service (or for a set of goods and services).[2] This measure can have two components. One is the amount people actually pay for the good or service, i.e., their expenditures. The other exists if the amount they pay is less than what they would be willing to pay. In such an instance, the difference between the two is a net economic benefit consumers enjoy from acquiring the good or service. This net economic benefit is called consumer's surplus.

We encourage readers to use the information in this technical memorandum cautiously. The numbers we report represent not precise measurements but general indicators of the economic costs and benefits related to irrigation in Montana. We already identified one source of ambiguity: many of the numbers come from studies conducted outside Montana, and, as a general rule, the greater the ecological or economic distance between Montana and a study's focus, the more careful one must be when applying its results to Montana. In addition, some of the estimates come from studies that are several years old, and even those that are more recent may not fully reflect current ecological or economic conditions. Moreover, even those studies that were conducted recently inside Montana generally do not tell the full story, insofar as they fail to account for factors, such as externalities, that can drive a wedge between the apparent and the true values of a particular good or service.[3] The information in this memorandum provides a good representation of the general benefits and costs associated with irrigation in Montana; it would be inappropriate, however, to assume, without further investigation, that the estimates herein represent the benefits and costs of irrigation in a specific location within the state.

---

[2] In some settings, it is appropriate to measure not the amount people are *willing to pay to obtain* a good or service, but the amount they would *require as compensation to relinquish* it. In many settings, the two approaches yield equal, or closely similar, results. But, in some settings—when relinquishing control of a resource would lead to an outcome seen as morally repugnant, for example—the amount people require as compensation to relinquish a good or service can exceed, and perhaps far exceed, the willingness-to-pay measure of value. *See,* for example, the discussion in this important series of papers: Hanemann, M. 1991. "Willingness to Pay and Willingness to Accept: How Much Can They Differ?" *American Economic Review* 81 (3): 635-647; Amiran, E.Y. and D.A. Hagen. 2003. "Willingness to Pay and Willingness to Accept: How Much Can They Differ? Comment." *The American Economic Review* 93 (1): 458-463; and Hanemann, M. 2003. "Willingness to Pay and Willingness to Accept: How Much Can They Differ? Reply." *The American Economic Review* 93 (1): 464.

[3] Externality is the term economists use to describe a situation where costs or benefits resulting from an economic decision accrue to individuals, households, firms, or governments that are not a party to the decision.

I. Goods and Services Provided by Montana's Water-Related Ecosystems

From an economic perspective, water is important, not in and of itself, but because it produces goods and services that benefit people, imposes costs on them, or both. Montana's ecosystems are an integral part of the process that produces water-related goods and services, insofar as they capture snow or rain; store water in aquifers, lakes, and wetlands; and regulate the flow of water in streams. Describing the economically important goods and services derived from water is not a straightforward task, but one that requires an understanding of the numerous interactions between the state's ecosystems and its local economies. Some water-related goods and services have economic value when water is extracted from non-human elements of the ecosystem, as when water is diverted from a stream to irrigate crops. Others have value when they remain in their natural course, as when boaters use sections of a stream for recreation.

To examine the benefits and costs associated with irrigation, one must first identify the broad set of goods and services provided by Montana's water-related ecosystems, as using water for irrigation affects—both positively and negatively—the ecosystem's ability to produce goods and services.

The list of goods and services provided by Montana's water-related ecosystems is long and growing, as ecological scientists learn more about the inner workings of ecosystems and people find new ways to derive benefits from them. Table 1 illustrates the current list. Some of the goods and services will be unfamiliar to those who see water as having economic value only in terms of irrigation and other direct uses. Natural-resource and economic-development economists, however, now widely recognize the economic importance of the full slate of goods and services.

II. Gross Economic Benefits of Irrigation in Montana

The gross economic benefits of irrigation have two components. One is the value of the additional agricultural production from irrigated lands relative to what the lands otherwise would produce. The other is the value of the positive externalities that materialize when water is used for irrigation. These positive externalities arise as irrigation results in an increase in the supply of good and services other than irrigated crops. Complementary goods and services resulting from a given irrigation activity might include recreational opportunities, habitat for fish and wildlife, hydroelectric power generation, municipal and industrial water supply, and maintenance of some aspects of the quality of life valued by Montanans and visitors to the state.

Table 1. Summary of All Functions, Goods, and Services of Montana's Water-Related Ecosystems

Functions	Examples of Goods and Services Produced
Production and regulation of water	Natural and human-built features of an ecosystem capture precipitation; filter, retain, and store water; regulate levels and timing of runoff and stream flows; and influence drainage.
Formation & retention of soil	Wetlands and biota accumulate organic matter, and prevent erosion to help maintain productivity of soils.
Regulation of atmosphere & climate	Biota produce oxygen, and help maintain good air quality and a favorable climate for human habitation, health, and cultivation.
Regulation of disturbances	Wetlands and reservoirs reduce economic flood damage by storing flood waters, reducing flood height, and slowing a flood's velocity.
Regulation of nutrients and pollution	Wetlands and riparian vegetation improve water quality by trapping pollutants before they reach streams and aquifers; natural processes improve water quality by removing pollutants from streams.
Provision of habitat	Wetlands, riparian vegetation, streams, and reservoirs provide habitat for fish and wildlife.
Production of food	Biota convert solar energy into plants and animals edible by humans.
Production of raw materials	Streams and biota generate materials for construction, fuel, and fodder; streams possess energy convertible to electricity.
Pollination	Insects facilitate pollination of wild plants and agricultural crops.
Biological control	Water-related birds and microorganisms control pests and diseases.
Production of genetic & medicinal resources	Genetic material in wild plants and animals provide potential basis for drugs and pharmaceuticals.
Production of ornamental resources	Products from water-related plants and animals provide materials for handicraft, jewelry, worship, decoration, and souvenirs.
Production of aesthetic resources	Wetlands, riparian vegetation, streams, and reservoirs provide basis for enjoyment of scenery from roads, housing, parks, trails, etc.
Production of recreational resources	Streams, reservoirs, riparian vegetation, fish, waterfowl, and other wildlife provide basis for outdoor sports, eco-tourism, etc.
Production of spiritual, historic, cultural, and artistic resources	Wetlands, riparian vegetation, streams, and reservoirs serve as basis for spiritual renewal, focus of folklore, symbols of group identity, motif for advertising, etc.
Production of scientific and educational resources	Wetlands, riparian vegetation, streams, and reservoirs provide inputs for research and focus for on-site education.

Source: Adapted by ECONorthwest from De Groot, R., M. Wilson, and R. Boumans. 2002. "A Typology for the Classification, Description and Valuation of Ecosystem Functions, Goods and Services." *Ecological Economics* 41: 393-408; Kusler, J. 2003. *Assessing Functions and Values.* Institute for Wetland Science and Public Policy and the Association of Wetland Managers, Inc.; and Postel, S. and S. Carpenter. 1997. "Freshwater Ecosystem Services." in *Nature's Services: Societal Dependence on Natural Ecosystems*. Edited by G.C. Daily. Washington, D.C.: Island Press, pgs. 195-214.

A. The Benefits of Agricultural Production

Irrigated agriculture accounts for the greatest withdrawal and consumptive use of water in Montana.[4] Withdrawal represents the total amount of water diverted from surface or ground water supplies for a particular use, while "consumptive use" represents the amount of water that is evaporated, transpired, incorporated into crops, consumed by livestock, or otherwise not immediately available in the environment. In 2000, there were over 2 million acres of irrigated land in Montana. To irrigate this land, farmers withdrew about 11.6 million acre-feet of water from surface and groundwater resources, about 96.5 percent of all withdrawals in Montana. Irrigated crops consumed about 2.5 million acre-feet of the water withdrawn, much of it used in flood irrigation of forage crops. Irrigation accounted for about 93.6 percent of total consumption of water in the state.[5]

A relatively small percent of all agricultural land in Montana is irrigated: in 2002, only 3 percent of the total land in farms was irrigated, 10 percent of the total land in farms classified as cropland was irrigated, and 36 percent of all farms irrigated some or all of their crops. However, irrigated crops tend to be higher-valued than non-irrigated crops: in 2002, the market value of crops from irrigated land represented over 20 percent of the total market value of crops grown on all of Montana's farms, and over 25 percent of the market value of all agricultural products sold, including livestock, poultry, and their products.[6]

The application of irrigation water to crops produces economic benefits in two ways: by increasing the yield of a crop that was previously cultivated without irrigation, or by enabling a farmer to grow a higher-valued crop. In either case, farmers probably would not incur the expense of irrigation unless they expected to realize higher net farm earnings (crop revenues minus the costs of producing the crop) with irrigation than without it. Thus, many studies have attempted to measure the agricultural-production benefit of irrigation by looking for evidence of what farmers are willing to pay for water—either directly or indirectly by leasing or purchasing irrigated land—and, hence, for an opportunity to realize higher farm earnings. Other studies have attempted to measure the impact of irrigation on farmers' net farm earnings and assumed that farmers' willingness to pay would be a little less than this amount. We describe these studies' findings below, First, however, we summarize the findings of others who have sifted through the literature on the agricultural-production benefits of irrigation.

---

[4] Cannon, M.R. and D.R. Johnson. 2004. *Estimated Water Use in Montana 2000.* U.S. Department of the Interior, U.S. Geological Survey, and the Montana Department of Natural Resources and Conservation. Scientific Investigations Report No. 2004-5223. Retrieved February 7, 2008, from http://pubs.usgs.gov/sir/2004/5223/pdf/sir2004_5223.pdf

[5] Cannon, M.R. and D.R. Johnson. 2004. *See* footnote 4.

[6] U.S. Department of Agriculture, National Agricultural Statistics Service. 2004. *2002 Census of Agriculture: Montana State and County Data.* Volume 1, Geographic Area Series Part 26. Report No. AC-02-A-26. June.

1. Valuation Methods

Reviews of past research have found that researchers have used six different methods for measuring the agricultural-production benefits of irrigation, but each is imperfect. The methods are complicated but, in simple terms, they have the following characteristics. Four of the methods focus on estimating the increase in net earnings farmers realize when they irrigate their crops. The first looks directly at and compares the net earnings from irrigated and non-irrigated lands, but this method generally falls short of its goals because there are many factors, besides irrigation, that can contribute to the difference in earnings. The second method has biological roots, measuring how water affects a crop's growth and assuming that farmers optimize their application of water to maximize yields, while the third takes a financial approach and assumes farmers optimize their net earnings. These two methods have considerable conceptual merit, but actual farmers often deviate from the pathways these models consider optimal. The fourth method constructs a budget representative of a given type of farming operation and assumes that revenues are used to cover the costs of all other factors of production first, so that the remainder is the return on, or value of irrigation's contribution to net earnings. This approach seems sound in concept, but separating irrigation from other factors of production proves difficult in practice.

Two methods adopt a broader focus. One looks directly at evidence of what farmers pay to buy water or accept as compensation to relinquish water. In concept, if transactions occur under competitive conditions, the prices at which farmers buy and sell water should reflect the agricultural-production value of an incremental change in the supply of water. The other method looks at the prices at which farmers buy land, and uses statistical techniques to ascertain the incremental amount they are willing to pay for irrigated land relative to otherwise comparable non-irrigated land.

2. Summary Estimate of Irrigation Benefits

After sifting through numerous past studies, Robert Young, the author of the most recent and authoritative review of past studies concluded that, although values can differ over time and space, under the "most plausible assumptions," U.S. farmers are willing to pay about $46 to have an additional acre-foot available on the farm for irrigation, and about $31 per additional acre-foot for water at its source.[7,8] This general assessment of the agricultural-production value of irrigation seems reasonable to us. Thus, we anticipate that, absent

---

[7] Young, R.A. 2005. *Determining the Economic Value of Water*. Washington, D.C.: Resources for the Future, p. 187.

[8] Values adjusted to 2006 dollars using the U.S. Department of Agriculture's "Index of Prices Received by Farmers: All Crops." (U.S. Department of Agriculture, National Agricultural Statistics Service. 2007. *Agricultural Prices: 2006 Summary.* Report No. Pr 1-3 (07) a. Retrieved May 12, 2008, from http://usda.mannlib.cornell.edu/usda/current/AgriPricSu/AgriPricSu-07-20-2007_revision.pdf)

fundamental change in agricultural market conditions that cause a marked rise in the price of irrigated crops, the value of an incremental change in the supply of irrigation water in Montana probably will not exceed $46 on the farm and $31 at the source per acre-foot. Instead, the value is likely to be less, insofar as much of the state's water is used to irrigate low-value forage crops on lands without cheap access to large markets. For example, the average on-farm value for irrigation water in the Upper Missouri watershed has been found to be $23 per acre-foot.[9] The lowest values would materialize where the water would be used to produce forage on lands with poor growing conditions (high elevations, poor soils, etc.) or poor market conditions (isolation from markets, etc.) Under some conditions, the value of an incremental change in the supply of irrigation water would fall to zero.[10]

None of this is to say that the on-farm value of water used for irrigation in Montana can never exceed $46 per acre-foot. The irrigation value of water depends on many factors, including the amount and timing of the water available. Agricultural markets may evolve to markedly increase the price of irrigated crops. Or, the net value of the externalities generated by an incremental increase in irrigation system, plus the incremental agricultural-production value might exceed $31 per acre-foot. These and other factors must be evaluated to ascertain the value of irrigation in a specific time and place.

The following text presents the findings of specific efforts to apply the valuation methods for measuring the agricultural-production value of irrigation is easy to apply, we describe above. We selected studies for inclusion in the discussion bearing in mind that none of the methods is easy to apply, reviews of the literature have found numerous examples lacking sound theoretical or empirical footing,[11] and for the most part, these studies have tended to overestimate, rather than underestimate, the true agricultural-production value of irrigation.

3. Effects of Irrigation on Farm Net Earnings

In most settings, irrigation gives farmers higher net farm earnings than they would realize if their land were not irrigated and, in concept, this difference reflects the agricultural-production benefit of irrigation. Studies that attempt to measure irrigation's impact on net farm earnings rely on specific information about farm characteristics, cropping patterns, farming techniques, and yield and market-price data for a specific time and place, to arrive at net earnings with irrigation and without irrigation. Thus, they are informative to the extent that the

---

[9] Raucher, R.S., D. Chapman, J. Henderson, et al. 2005. *The Value of Water: Concepts, Estimates, and Applications for Water Managers.* Awwa Research Foundation: Denver, CO. Value adjusted to 2006 dollars. *See* footnote 8.

[10] Hansen, L.T. and A. Hallam. 1990. *Water Allocation Tradeoffs: Irrigation and Recreation.* U.S. Department of Agriculture. Agricultural Economic Report No. 634. June.

[11] *See*, e.g., Raucher, R.S., D. Chapman, J. Henderson, et al. 2005. *The Value of Water: Concepts, Estimates, and Applications for Water Managers.* Awwa Research Foundation: Denver, CO.

agricultural conditions in the analysis resemble current conditions; different commodity prices, crop types, and other variables could yield considerably different results.

The Bureau of Reclamation, among others, has used the farm-budget method to estimate the impact of irrigation on net farm earnings. It entails constructing a representative farm budget for a given type of farming operation and estimates how the budget would change with, versus without irrigation. If irrigation is seen to increase net revenues, this method then estimates the share of the increase attributable to machinery, labor, management and other factors of production, including irrigation.

The Bureau of Reclamation recently completed a farm-budget analysis to determine the benefits of irrigation along the Milk River in Blaine, Phillips, and Valley Counties. In this area, grain, forage, and livestock production are the predominant agricultural activities. The analysis found that the irrigation water in this area produces benefits of $42 per acre.[12] However, the net revenues for both the "with irrigation" and "without irrigation" cases were negative; the revenues with irrigation were simply less negative than the revenues without irrigation. The Bureau completed another farm-budget analysis for the Beaverhead Valley area in Beaverhead County, where the predominant crops are also grain and forage for livestock. This analysis found that the per-acre benefit of irrigation was $45.[13] Other similar analyses are underway, but are not currently available, for the Helena Irrigation Unit, Toston Dam, and East Bench areas in Montana.[14] To convert these per-acre values to values per acre-foot, we can divide by the average number of acre-feet of water applied per-acre to irrigate alfalfa in Montana, which is 1.4.[15] For the Milk River analysis, this would yield a per acre-foot benefit of $30, and for the Beaverhead Valley analysis, this would yield a per acre-foot benefit of $32.

A 1997 analysis by the Bureau of Reclamation also used the farm-budget method to estimate the benefits from irrigation water in the Black Hills region of South Dakota and Wyoming. In this region, the primary irrigated crops are alfalfa and

---

[12] Otstot, R.S. 2003. *Milk River Benefits Analysis.* U.S. Department of the Interior, Bureau of Reclamation, Great Plains Region. Billings, MT. April. Value adjusted to 2006 dollars. *See* footnote 8.

[13] U.S. Department of the Interior, Bureau of Reclamation, Great Plains Region, Montana Area Office. 2006. "Chapter 3: Affected Environment." In *Final Environmental Assessment and Finding of No Significant Impact: Conversion of Long-Term Water Service Contracts to Repayment Contracts.* November. Retrieved February 7, 2008, from http://www.usbr.gov/gp/mtao/clarkcanyon/index.cfm

[14] Personal communication with George St. George, Economist, U.S. Department of the Interior, Bureau of Reclamation, Great Plains Region, Montana Area Office (Billings).

[15] 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.

corn for livestock feed. This study found the benefits from irrigation to be about $51 per irrigated acre, or about $22 per acre-foot, based on average water delivery in the area of 2.5 acre-feet per acre.[16]

The Montana Department of Revenue uses a net-income approach to determine the productive value of different classes of land, including irrigated and non-irrigated land, for property tax assessment purposes. This approach involves capitalizing the net income of farm production to estimate what a farmer would be willing to pay to gain access to the land's revenue-generating ability. The Department determines a parcel's gross income per acre by multiplying the land's ability to produce a given type of crop times the price the Department expects the owner of the parcel would receive for the crop. It then deducts a fixed percent of gross income to arrive at net income—25 percent for both irrigated and non-irrigated land, with an additional expense allowance for water application on irrigated land. It capitalizes the expected future stream of annual net farm earnings using a 6.4 percent interest rate to arrive at the assessed value.

The Department's calculations for class III irrigated and non-irrigated lands growing alfalfa illustrate the results of the process. Alfalfa is the most significant crop grown on both irrigated and non-irrigated lands in Montana. The calculations for 2008 show the statewide, average assessed value is $367 per acre for irrigated farmland growing alfalfa and $259 per acre for non-irrigated land growing alfalfa.[17] The calculations suggest that the difference between these numbers, $108 per acre, equals the economic benefit of irrigation when used to grow alfalfa on class III lands. It similarly suggests that, since the statewide average amount of water applied for alfalfa is 1.4 acre-feet per acre,[18] the value of irrigation water used to grow alfalfa is $77 per acre-foot, or about $5 per acre-foot per year at a capitalization rate of 6.4 percent.

The reasonableness of this figure depends heavily on the reasonableness of the underlying assumption, that the irrigated and non-irrigated lands growing alfalfa in the state are closely similar in all ways except their access to water. This assumption is called into question insofar as irrigation projects typically target the most productive lands. Thus, it seems likely that a substantial, though unknown, portion of the $77 per acre-foot reflects factors other the economic benefits stemming solely from irrigation water. The adjustment for other factors is unlikely to eliminate the benefit attributable to irrigation, and, hence, the

---

[16] Piper, S. 1997. "Regional Impacts and Benefits of Water-Based Activities: An Application in the Black Hills Region of South Dakota and Wyoming." *Impact Assessment*. 15: 335-359. Values adjusted to 2006 dollars. *See* footnote 8.

[17] 2008 agricultural land assessment data, obtained from Dallas Reese, Management Analyst, Montana Department of Revenue Property Assessment Division. Received by email January 3, 2008.

[18] 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. From Table 28.

calculations confirm that irrigation can increase farmers' net farm incomes by increasing the yield of a crop, in this case alfalfa, that also can be grown on non-irrigated land. Additional benefits are possible in situations where irrigation can enable farmers to grow different, higher-value crops.

Table 2 summarizes the results of the studies we describe above. The right column of Table 2 shows the value of irrigation water in terms of the increase in annual net earnings farmers realize per irrigated acre. The top four rows show the increase, derived from studies that compared, for a typical farm in each study area, the annual net earnings with vs. without irrigation. The last row of Table 2 also indicates the value of irrigation, but with an important difference. It reflects calculations by the Montana Department of Revenue, of the average, statewide difference in the value of irrigated and non-irrigated class III land used to grow alfalfa. The calculations are important because much of the water used for irrigation in Montana irrigates alfalfa. The calculations indicate that the irrigated land has higher annual, net farm earnings of about $5 per acre-foot, or $7 per acre.

Table 3 provides a broader context for considering the value of irrigation water. The figures in the table show the estimated increase in net farm earnings from irrigation water reported in recent, significant studies conducted in Oregon, California, and Alberta, Canada. Faux and Perry (1999) conducted a hedonic analysis to estimate the value of irrigation water in four irrigation districts in Malheur County, in eastern Oregon, where the primary irrigated crops were onions, sugar beets, and potatoes. The study found that the marginal value of irrigation water ranged from $11 per acre-foot on the least productive land to $54 per acre-foot on the most productive land.[19] A more recent study, of land sales in

Table 2. Increase in Annual Net Farm Earnings Resulting from Irrigation, as Indicated by Recent Studies in or near Montana

	Increase in Annual Net Farm Earnings from Irrigation	
Study Location	**Per Acre-Foot**	**Per Irrigated Acre**
Missouri River Basin	$23	$32
Milk River Basin[a,b]	$30	$42
Beaverhead Valley[a]	$32	$45
Black Hills SD-WY[a]	$22	$51
Statewide Class III Land Growing Alfalfa[c]	$5	$7

Source: ECONorthwest, with data from sources described in *Technical Memorandum 2.2 – Net Economic Benefits of Irrigation in Montana*.

[a] Estimated difference in net earnings for a typical farm, with vs. without irrigation.

[b] Both dryland and irrigated farming yield negative net farm income, but losses are less with irrigation.

[c] Statewide difference between the average value of class III irrigated land and the average value of class III non-irrigated land; not an estimate of the difference in the value of the same property, with-versus-without irrigation. Value in 2008 dollars.

Table 3. Increase in Annual Net Farm Earnings Resulting from Irrigation, as Indicated by Recent Studies Elsewhere

Description	Value per acre-foot
Central Valley, CA	$27 – $58
Malheur County, OR	$11 – $54
Klamath Basin, OR	$5 – $58
Douglas County, OR	$16
Alberta, Canada	$8[a]

Source: ECONorthwest, with data from sources described in *Technical Memorandum 2.2 – Net Economic Benefits of Irrigation in Montana*.

[a] Value in 1997 Canadian dollars.

Douglas County, in western Oregon, found that farmers were willing, on average, to pay $16 per acre-foot for a one-year lease of irrigation water.[20] An analysis in southeastern Alberta found that a water right added approximately 35 percent to the value of non-irrigated land, and had an annual value of about $8 per acre-foot.[21] Researchers in California's Central Valley found that reducing the availability of federal and state water for irrigation by one acre-foot would reduce agricultural land values by about $429 to $911, which translates to an annual value of about $27 to $58 per acre-foot.[22] Recent research in the Klamath Basin of southern Oregon and northern California found the marginal value of water for irrigation in the region ranged from $5 per acre-foot to about $58 per acre-foot, depending on soil quality.[23]

---

[20] Butsic, V. and N.R. Netusil. 2007. "Valuing Water Rights in Douglas County, Oregon, Using the Hedonic Price Method." *Journal of the American Water Resources Association*. 43(3): 622-629.

[21] Veeman, T.S., M.M. Veeman, W. Adamowicz, et al. 1997. *Conserving Water in Irrigated Agriculture: The Economics and Valuation of Water Rights.* University of Alberta, Faculty of Agriculture, Forestry, and Home Economics, Department of Rural Economy. Rural Economy Project Report No. 97-01. Canada-Alberta Environmentally Sustainable Agriculture Research Project No. RES-116-94. Value in 1997 Canadian dollars.

[22] Dale. L., A. Fisher, M. Hanemann, et al. 2005. *Economic Impacts of Climate Change on Agricultural Water Use in California.* University of California, Berkeley, for the California Energy Commission, PIER Energy-Related Environmental Research. Report No. CEC-500-2005-054. March. Value adjusted to 2006 dollars. *See* footnote 8.

[23] Jaeger, W. K. 2002. "Water Allocation Alternatives for the Upper Klamath Basin," in W. Braunworth Jr., T. Welch, and R. Hathaway, eds. *Water Allocation in the Klamath Reclamation Project, 2001: An Assessment of Natural Resource, Economic, Social, and Institutional Issues with a Focus on the Upper Klamath Basin*. Corvallis, Oregon. Oregon State University, pp. 365-392. Retrieved February 26, 2008, from http://extension.oregonstate.edu/catalog/html/sr/sr1037/alternatives.pdf. Value adjusted to 2006 dollars. *See* footnote 8.

The figures in Table 3 indicate that the highest values occur in the Central Valley of California, with lower values on lower-quality land in Malheur County, Oregon (near Boise, Idaho), in the Klamath Basin (east of the Cascade Mountains, near California), and in Douglas County, Oregon (west of the Cascades). The values in Table 2, from studies in and near Montana, generally indicate that the value of irrigation water in Montana is less than the values in highly productive agricultural areas, such as the Central Valley and the best areas in eastern Oregon, but are comparable to or greater than the values in the less productive areas of Oregon. Some of these values were derived from what economists call hedonic studies, and should be considered with some caution, as recent research suggests that hedonic analysis, which is based on historical data, does not adequately consider pending changes in climate that may have significant impacts on agricultural practices.[24]

Absent a major structural change in agricultural markets, it seems likely that the value of an incremental change in the supply of irrigation water is and will continue to be less than the current, average values represented in Table 2. (Later in this section we discuss the factors that might bring about a major structural change.) In general, farmers irrigate the land and crops that yield the highest net earnings before they irrigate those with lower net earnings.[25] As a consequence, the irrigation-related net earnings from an incremental increase in the supply of irrigation water is likely to be less than the net earnings from on-going irrigation. Where water is being used to irrigate low-value crops far from major markets, the net benefits to farmers of an incremental increase in the supply of irrigation water would fall to zero.[26] Indeed, the Milk River study, shown in Table 2, indicates that using new water supplies to irrigate land currently not in crop production would yield negative net farm earnings.[27]

None of this is to say that the on-farm value of water used for irrigation in Montana can never exceed $46 per acre-foot, or that the at-the-source value can never exceed $31 per acre foot. The irrigation value of water depends on many factors, including the amount and timing of the water available, and the evolution of agricultural market conditions. These and other factors must be evaluated to ascertain the value of irrigation water in a specific time and place.

---

[24] Deschenes, O. and M. Greenstone. 2007. "The Economic Impacts of Climate Change: Evidence from Agricultural Profits and Random Fluctuations in Weather." *American Economic Review* 97(1): 354-385

[25] Griffin, R.C. 2006. Water Resource Economics: The Analysis of Scarcity, Policies, and Projects. Cambridge, MA: MIT Press.

[26] Hansen, L.T. and A. Hallam. 1990. Water Allocation Tradeoffs: Irrigation and Recreation. U.S. Department of Agriculture. Agricultural Economic Report No. 634. Retrieved June 5, 2008, from http://naldr.nal.usda.gov/NALWeb/Agricola_Link.asp?Accession=CAT10415693

[27] Otstot, R.S. 2003. *Milk River Benefits Analysis.* U.S. Department of the Interior, Bureau of Reclamation, Great Plains Region. Billings, MT. April.

4. Willingness to Pay for Irrigation: Water Transactions and Land Values

Some places in the West are experiencing the development of water markets, in which farmers pay to lease or purchase a water right. Where the markets operate competitively, the price a farmer pays to obtain water for irrigation equals his/her willingness to pay for water.[28] The price an irrigator is willing to pay for any particular water right is ultimately dependent on the conditions associated with the right (e.g., seniority, timing, etc.), and may differ the full value of irrigation water. Not all of the transactions in western water markets reflect competitive prices but the data on recent transactions nonetheless give some insights into farmers' willingness to pay for water.

A 2007 analysis of water transactions in the western United States between 1987 and 2005 found 23 transactions in Montana, including 2 sales, 10 short-term leases, and 11 long-term leases.[29] About 45 percent of the water involved in the Montana transactions was for use by agriculture; the remainder was for municipal, environmental, and other uses. The median price for one-year leases for agriculture in Montana was $6 per acre-foot. The validity of this figure is questionable, however, because it comes from such a small number of transactions that they suggest water markets in this state are not truly competitive. During the same period, by comparison, there were 1,707 water transactions in Colorado, which generally is considered to have some of the region's most robust water markets.

A broader review of transactions from throughout the western states suggests that farmers are willing to pay more than twice the amount indicated by the Montana transactions to lease water. It found that, between 1990 and 2003, the median price paid in the region for a 1-year lease was $16 per acre-foot.[30] This study also found that the median price western farmers paid to purchase water rights was $2,627 per acre-foot. Table 4 summarizes these estimates of farmers' willingness to pay for water, as reflected in the prices of market transactions. They should be used with caution, as there is no certainty that the underlying data reflect competitive market conditions. Many farmers are unfamiliar with and/or skeptical of water markets, and, in Montana and elsewhere the institutions necessary to make water markets work efficiently are not in place.

Economists generally anticipate that the evolution of efficient water markets will have two related, but distinct effects on the economic benefits of irrigation.

---

[28] Conversely, in a competitive market, the price at which a farmer sells water that he/she otherwise would use for irrigation reflects his/her willingness to accept compensation to relinquish the water.

[29] Brewer, J., R. Glennon, A. Ker, and G. Libecap. 2007. *Water Markets in the West: Prices, Trading, and Contractual Forms.* National Bureau of Economic Research. Working paper No. 13002. March. Retrieved February 28, 2008, from http://www.nber.org/papers/w13002

[30] Brown, T.C. 2006. "Trends in Water Market Activity and Price in the Western United States." *Water Resources Research.* 42, W09402. Values adjusted to 2006 dollars.

Table 4. Summary of Market Values for Irrigation Water

Description	Value per acre-foot[a]
Median price, 1-year lease for water for agricultural use in Montana, 1987-2005	$6
Median price, 1-year lease for water for agricultural use in the western United States, 1990-2003	$16
Median price, purchase of water right for water for agricultural use in the western United States, 1990-2003	$2,627

Source: ECONorthwest, from sources described in the text.

[a] All values adjusted to 2006 dollars.

Markets will facilitate the transfer of water from one location, where the economic value of the goods and services it produces is lower to a location where the value is higher. Thus, all else equal, the overall value of irrigation products should rise. In some circumstances, however, the value of an incremental increase in the supply of irrigation water likely would decline. This outcome would occur where farmers seeking more water could secure it more cheaply by buying from another farmer than by constructing irrigation infrastructure.

These findings in Table 4 compare to those of an analysis in Wyoming's North Platte River Basin, which found that the typical irrigator would be willing to pay $5 for a one acre-foot increase in a long-run lease of surface water. The authors also estimated that, with high runoff, the marginal value of water would drop below $5, perhaps to zero, but, with below-normal runoff, the value would rise: to $13 per acre-foot for a 40 percent drop in annual runoff, for example. They also found that marginal values may be higher at the end of an irrigation season if supplies were to fall short of expectations, or if forage prices were to experience a temporary rise. They observed, however, that, at the end of the 1990s, long-run values had been stable for some time.[31]

For the most part, however, Montana's farmers do not buy and sell water, *per se*, and, hence, it is not possible to observe the value of irrigation water in Montana directly from water-market transactions. Farmers in Montana do, however, buy and sell farm land, and the value of irrigation water manifests itself in the higher price of irrigated land relative to comparable dry land. The higher price of irrigated land reflects the extent to which farmers expect to realize higher net farm earnings from this land relative to dry land.

Information related to the values of property bought and sold in Montana is difficult to obtain, because Montana is a "non-disclosure state," which means that buyers and sellers are not required to report sale prices in real estate

[31] Houk, E., G. Taylor, and M. Frasier. 2000. *Valuing the Characteristics of Irrigation Water in the Platte River Basin.* Paper presented to the Western Agricultural Economics Association, Vancouver, B.C., June 29-July 1. Values adjusted to 2006 dollars.

transactions. Moreover, because property taxes for agricultural land in Montana are assessed based on productive value, rather than market value, the Department of Revenue does not estimate the market value of agricultural land. Thus, we must look primarily to other sources, and other states, for information, reflected in property values, about farmers' willingness to pay for irrigation.

Table 5 shows estimates of the effect of irrigation on the value of farm land, derived from the recent studies in or near Montana incorporated in Table 2. The figures in the first three rows, derived from studies in different locations, indicate that adding water to land that otherwise would be farmed as dry land increases the land's value by about $650 to $800 per acre. This is not inconsistent with the effect of irrigation on land value observed by appraisers in Montana. Appraisers in western Montana are generally reluctant to generalize the difference in value between irrigated and non-irrigated land, because the price of most parcels reflects not their agricultural production value, but the potential for development or scenic and recreational amenities; prices for these parcels far exceed any realistic rate of return from agriculture. Appraisers in eastern Montana, where these factors have less influence on the price of agricultural land, report that, in general, dry crop land runs several hundred dollars per acre, and irrigated land is anywhere from 4 to 7 times more valuable, depending on a variety of factors, including location, soil quality, and reliability of water delivery. Irrigated land in the most productive areas of eastern Montana can sell for as high as $4,000 per acre (see *Technical Memorandum 2.5 – Case Studies* for more detail).

The bottom row of Table 5 shows the 2008 calculations by the Montana Department of Revenue of the average difference in the value of irrigated vs. non-irrigated class III land used to grow alfalfa. For the state as a whole, the value of the irrigated class III land used to grow alfalfa is about $108 greater per acre than comparable non-irrigated land.

Table 5. Increase in the Value of Farm Land Due to Irrigation, as Indicated by Recent Studies in or near Montana

Study Location	Increase in Value Per Irrigated Acre
Milk River[a]	$656[c]
Beaverhead Valley[a]	$703[c]
Black Hills SD-WY[a]	$797[c]
Statewide Class III Land Growing Alfalfa[b]	$108[c]

Source: ECONorthwest, with data from sources described in *Technical Memorandum 2.2 – Net Economic Benefits of Irrigation in Montana*.

[a] Estimated difference in net earnings for a typical farm, with vs. without irrigation.

[b] Statewide difference between the average value of class III irrigated land and the average value of class III non-irrigated land; not an estimate of the difference in the value of the same property, with-versus-without irrigation. Value in 2008 dollars.

[c] Values from Table 5, capitalized at a rate of 6.4 percent.

Another useful, though, general source of data on the prices of irrigated and non-irrigated land in Montana comes from agricultural statistics, collected by the U.S. Department of Agriculture (USDA). Each June, the USDA's National Agricultural Statistics Service (NASS) conducts a survey of a sample of farm owners throughout the country, including some in Montana. This survey asks each participant, among other things, to estimate the market value of the land in each farm. In Montana, NASS reports this information as a statewide average value,[32] separated into categories for irrigated and non-irrigated land. According to these data, the average difference between irrigated and non-irrigated land in Montana in 2007 was $2,970 per acre: irrigated land value averaged $3,700 per acre while non-irrigated cropland value averaged $730 per acre.[33]

Figure 1 reports survey's findings for the values of irrigated and non-irrigated cropland over the period, 1997 to 2007. While a clear difference in value between irrigated and non-irrigated agricultural land is apparent, readers should consider these values with the same caution we voice above. The differences in the value of irrigated and non-irrigated land probably reflect not just irrigation but also other factors—such as proximity to urban areas, location, or soil quality—that can exert great influence over the value of land. Moreover, these are average values that represent a wide range of values across Montana. Thus, it would not be appropriate to conclude from the right side of Figure 1 that, if a parcel of non-irrigated land had instead been irrigated in 2007, its value would have risen from about $750 to about $3,750 per acre. The actual impact from such a hypothetical increase in irrigation cannot be determined from Figure 1.

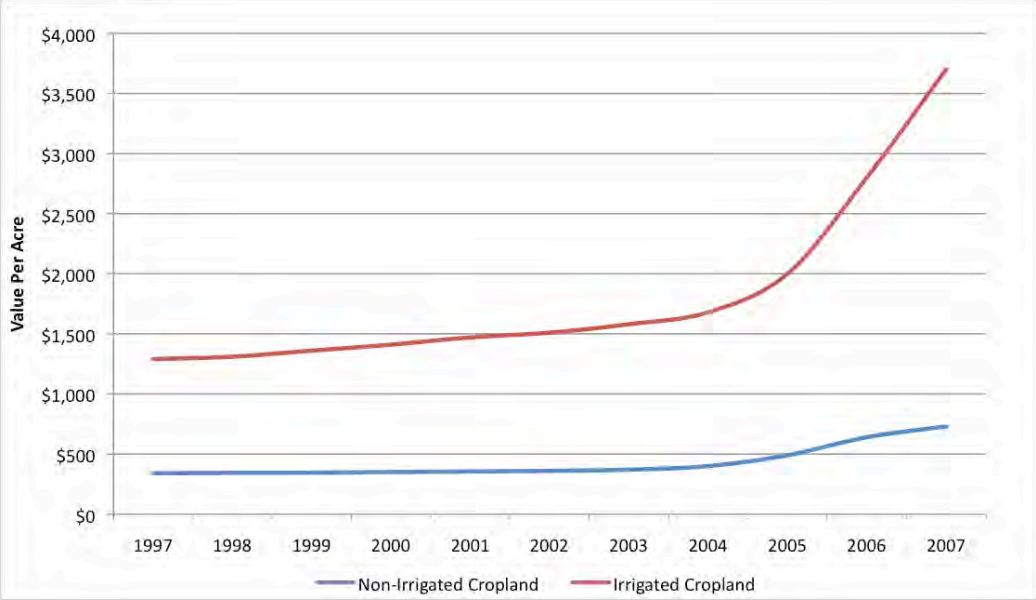
Figure 1 shows that the gap between the average value of non-irrigated and irrigated land in the state has been increasing, especially since 2004. This increase likely stems from several factors. The predominant factor is probably an increase in the demand from households seeking the lifestyle and other amenities associated with irrigated land. This demand probably reflects an on-going, growing demand for these amenities, accented by the so-called housing bubble, which stimulated real estate purchases. Another factor may be the persistence of drought over much of the period, making irrigated land more productive relative to non-irrigated land than it otherwise would be. To our knowledge there exists no analysis that estimates the relative influence of these factors.

---

[32] While the June Agricultural Survey collects data from a sample of farms across the state, the overall sample size in Montana is too small to yield a statistically meaningful estimate of property values at the sub-state (e.g. county) level. Due to confidentiality concerns, the NASS does not release the raw data from this survey (personal communication with Christel Pachl, Agricultural Statistician, U.S. Department of Agriculture, National Agricultural Statistics Service, Montana Field Office).

[33] U.S. Department of Agricultural, National Agricultural Statistics Service, Montana Field Office. 2007. *Farm Real Estate. Value of Land & Buildings, Annual Rent Per Acre & Rent to Value, Montana, USA.* August. Retrieved February 7, 2008, from http://www.nass.usda.gov/Statistics_by_State/Montana/Publications/economic/realest.htm

Figure 1. Average Per-Acre Value of Irrigated and Non-Irrigated Cropland in Montana

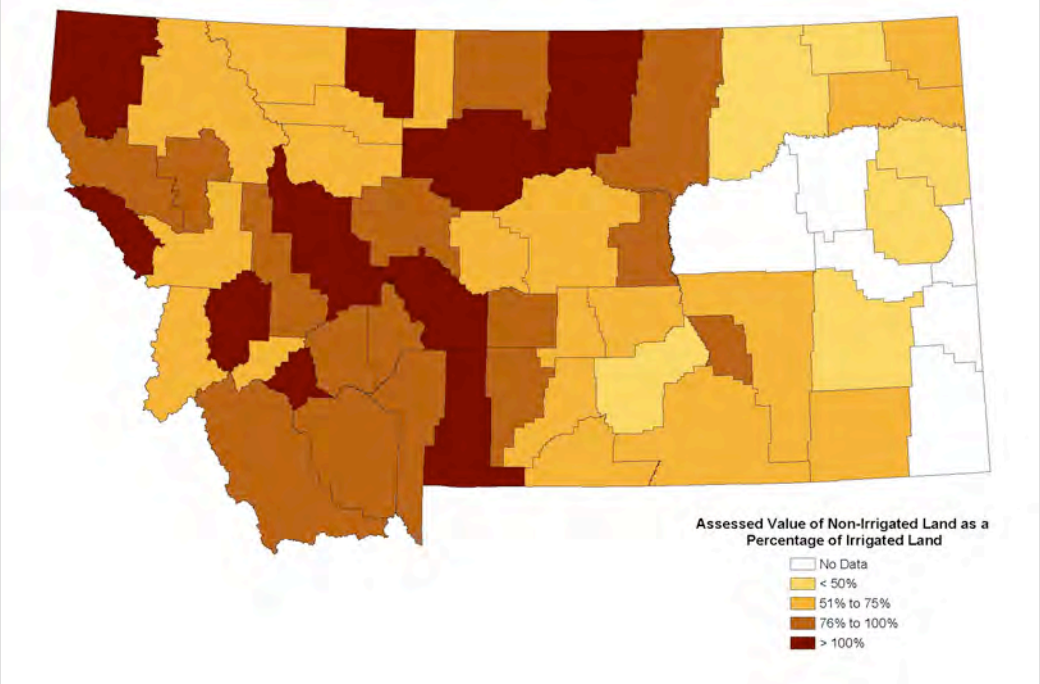


Source: ECONorthwest, with data from the U.S. Department of Agricultural, National Agricultural Statistics Service, Montana Field Office. 2007. *Farm Real Estate. Value of Land & Buildings, Annual Rent Per Acre & Rent to Value, Montana, USA.* August. Retrieved February 7, 2008, from http://www.nass.usda.gov/Statistics_by_State/Montana/Publications/economic/realest.htm

Figure 2 offers an alternative portrait of the economic benefit of irrigation water. It shows the average assessed value of class III non-irrigated land as a percentage of the average assessed value of class III irrigated land, by county. It demonstrates that the difference in the value of irrigated and non-irrigated land irrigation varies considerably across the state. In counties with the lightest shading, the average value of non-irrigated land, on a per-acre basis, is less than 50 percent of the average value of irrigated land; in counties with the darkest shading, the average value of non-irrigated land exceeds the value of irrigated land.

It is not possible to determine, from the information provided by the Department of Revenue, the extent to which the difference in assessed value for irrigated and non-irrigated land stems solely from access to water rather than from other factors. Consequently, Figure 2 does not mean that, if water became available to irrigate non-irrigated land in a county with the lightest shading, its value would more than double, or that, if water similarly became available in a county with the darkest shading, its value would decrease. Access to irrigation water is only one of the many factors that determine the value of farmland. Non-irrigated land in a given county may have a lower value than irrigated land, in part, because it is more difficult to farm, for example. It would be inappropriate to use the data in Figure 2 to conclude that giving non-irrigated land access to irrigation water would increase its value by the percentage shown or, conversely, that terminating access to water for land currently irrigated would reduce its value by the percentage shown.

Figure 2. Average Assessed Value of Class III Non-Irrigated Land as a Percentage of the Average Assessed Value of Class III Irrigated Land, by County for 2008



Source: ECONorthwest, with data from the Montana Department of Revenue.

B. Potential External Benefits of Irrigation

Irrigation systems sometimes produce multiple goods and services that otherwise would not exist. The value of these increase in supply are external benefits. We consider six types of external benefits: (1) water for municipal and domestic uses, (2) water for industrial uses, (3) increase in some recreational opportunities, (4) flood control, (5) habitat improvement and maintenance of open spaces, and (6) contributions to quality of life. Very little information exists regarding the extent or value of these external benefits. Consequently, we focus on providing background economic information about each type of externality, anticipating that it will provide a useful foundation for future evaluations of plans to rehabilitate or expand the state's irrigation systems.

1. Water for Municipal and Domestic Uses

The infrastructure to deliver water for irrigation also provides water for municipal, domestic, and industrial water users throughout Montana. If the irrigation projects did not deliver water to these customers, they would have to obtain it from other sources or go without.

According to the U.S. Geological Survey, public and domestic uses account for about 1.5 percent of all water withdrawn and about 3.1 percent of all water consumed in Montana, or 178,000 acre-feet per year and 82,000 acre-feet per year,

respectively.[34] We expect that these amounts will increase over time, reflecting expectations that Montana's population will exceed 1 million people by 2020.[35] Assuming that the levels in 2000 for public withdrawals per capita and percent of population benefiting from public supplies remain constant in the future, we estimate that by 2020 public consumption of water will increase by about 32 percent.[36] Such an estimate is probably an understatement since trends have shown a tendency for people to switch from self-supplied sources of water to public sources and, in doing so, they consume more. In Montana, for instance, water withdrawals from self-supplied sources are only a tenth of the withdrawal levels for public water.[37]

Many communities in Montana rely on water supplied by irrigation-related infrastructure, including Bureau of Reclamation projects. According to an analysis of the benefits of the St. Mary Diversion and Milk River Project, 18,600 people rely on diverted flows or associated aquifers for household water in the Milk River Project area.[38] The municipalities of Havre, Chinook, Harlem, and Hingham, and the unincorporated areas of Kremlin, Gildford, Rudyard, Inverness, and Joplin obtain their water from the project. Other municipalities throughout the state rely on Bureau of Reclamation projects for municipal and domestic water, including Chester (from the Lower Marias Project), Huntley, Pompey's Pillar, Ballantine, and Worden (from the Huntley Project), and Helena (from the Helena Valley project).[39] In Helena, about 29,000 people rely on water from Canyon Ferry Reservoir.

---

[34] Cannon, M.R. and D.R. Johnson. 2004. *See* footnote 4.

[35] NPA Data Services Inc. 2006. *Montana Population Projections: Total Population*. November. Retrieved February 7, 2008, from http://ceic.mt.gov/Demog/project/NPAallcounties_1106_web.pdf

[36] Cannon, M.R. and D.R. Johnson. 2004. *See* footnote 4, calculate a per capita rate of water withdrawals of 223 gallons per day for public supplies. Hutson, S.S., N.L. Barber, J.F. Kenny, K.S. Linsey, D.S. Lumia, M.A. Maupin. 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 estimate that 74 percent of Montana's population consumes water from public sources.

[37] Cannon, M.R. and D.R. Johnson. 2004. *See* footnote 4.

[38] 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.

[39] U.S Department of the Interior, Bureau of Reclamation, Contract Services Office, Office of Program and Policy Services. 2006. *2006 M&I Water Rate Survey Data.*

Municipal rates. Determining the economic values associated with domestic, municipal, and industrial uses of water can be extremely difficult. For the most part, users in these categories pay nothing for their water itself, but only for the costs of securing, conveying, and treating the water. The rates customers of water utilities pay for water generally are not a good indicator of the value of water to municipal-industrial users because they fail to distinguish the values associated with individual uses. Moreover, utilities generally set their rates to cover the costs of securing, treating, and conveying water rather than to reflect the values of the goods and services customers derive from the water.

Nonetheless, it is safe to say that what consumers pay for the water they use provides a lower bound for the value they place on the goods and services they derive from the water. Table 6 shows the rates charged for municipal and industrial water in areas served the Bureau of Reclamation water projects in the state.

Basic human needs. Water and human health experts generally agree that each person needs a minimum of 50 liters, or about 13 gallons, each day for drinking, food preparation, and basic sanitation.[40] Water supplies to meet these essential requirements for sustaining human life are often thought to be priceless, or nearly so. We are not aware of studies that directly test this hypothesis. Perhaps the closest is a town in an arid part of Australia, where people were willing to

Table 6. Municipal & Industrial Water Rates in Areas Served by Bureau of Reclamation Water Projects in Montana

Project	City/Town	Retail Water Rate ($ per acre-foot)	Wholesale Water Rate ($ per acre-foot)
Milk River	Chinook	$700.58	$244.01
Milk River	Harlem	$700.58	$198.81
Milk River	Kremlin	$700.58	$263.49
Milk River	Gilford	$700.58	$263.49
Milk River	Hingham	$700.58	$68.94
Milk River	Rudyard	$700.58	$263.49
Milk River	Inverness	$700.58	$263.49
Milk River	Joplin	$700.58	$263.49
Milk River	Havre	$700.58	$242.54
Lower Marias	Chester	$700.58	$195.61
Huntley	Ballantine	$474.80	$178.57
Huntley	Worden	$474.80	$134.61
Helena Valley	Helena	$322.50	$125.90

Source: U.S Department of the Interior, Bureau of Reclamation, Contract Services Office, Office of Program and Policy Services. 2006. *2006 M&I Water Rate Survey Data.* Values in 2006 dollars

pay about $33,600 per acre-foot to bring water in by truck.[41] Conditions in Montana are not nearly so extreme, however. If Montana's ecosystem did not provide sufficient water to meet basic human needs, then residents could import water from elsewhere at a far lower cost. The cost of imported water provides a useful point of reference for estimating the value of water provided by the ecosystem: in general, people would not be willing to pay more for it than they would have to pay for imported water. Using this reasoning, a study recently conducted in the Bay Area estimated the value of water to meet basic human needs.[42] It concluded that such needs extend up to 10 gallons per capita per day, with the first gallon valued at $2.50, reflecting the price of bottled water, and the price diminishing linearly to $1.00 for the tenth gallon.

Uses of water beyond meeting basic needs (e.g., for removing wastes, irrigating lawns, etc.) have lower values. The Bay Area study illustrated the range of values by assuming the value of residential consumption is $1.00 per gallon for the tenth gallon per person per day, declining to zero for the last gallon per person per day.

Price sensitivity. Rather than attempt to measure people's willingness to pay for water, economists have estimated their sensitivity to the price they pay for water. That is, they measure the extent to which water usage increases (or decreases) as prices fall (or rise). In general, the willingness to pay for water-related goods and services decreases as the amount of water increases.

Many studies have examined the value of municipal demands for water by looking at how consumers adjust their demand in response to changes in their water bills. An early effort compared historical data from three cities: Tucson, Arizona, Raleigh, North Carolina, and Toronto, Ontario.[43] It found that, for all three cities, demand was more sensitive to price in the summer, when households consumed more water for outside uses. This was especially true in Tucson, where nearly half of the summer water deliveries were for outside use. For a reduction in use of 25 cubic feet of water, the incremental value of water during the summer was about $8.40 per acre foot in Tucson, and $13.65 per acre foot in the other two cities.[44] In the winter, the incremental value was about $35 in Tucson, $65 in Raleigh, and $23 in Toronto. For larger reductions in usage, the incremental values were higher: the data showed that a summer time reduction of 200 cubic feet in Tucson would have a value of about $76 per acre-foot.

A more recent review of the literature concluded that, for overall residential

---

[41] The study's findings are reported in Young, R. A. 2005. *Determining the Economic Value of Water.* Washington, D.C. Resources for the Future, p. 106. We adjusted the values to 2007 dollars.

[42] Bay Area Economic Forum. 2002. *Hetch Hetchy Water and the Bay Area Economy*. The Bay Area Council, the Association of Bay Area Governments. October.

[43] Gibbons, D.C. 1986. *The Economic Value of Water*. Washington, D.C.: Resources for the Future, Inc.

[44] We have adjusted the study's findings to the dollars of 2007.

usage, when consumers experience a 10 percent change in price, their usage changes between 3 and 6 percent, with outdoor residential usage notably more sensitive than indoor use.[45] Changes in outdoor use can be significant in places, such as in much of Montana, where little water is used in the winter and the highest usage occurs in summer as consumers water lawns and gardens.

In general, studies indicate that the willingness of commercial and industrial users to pay for water exceeds that of residential users, but few provide reliable value estimates. In part, this is because many commercial and industrial users consider such information to be proprietary secrets.

Studies generally have found that commercial and industrial demands for water are less sensitive to price than are residential demands. In its examination of nonresidential demand for water, the City of Seattle estimated that in the short run (one year) a 10 percent change in price would lead to changes in water usage between 0.5 and 1.0 percent, depending on the sector.[46] Seattle's estimates of price tend toward the low side of the range in other studies. A broader study found that, when commercial and industrial users face a 10 percent change in the price they pay for water, their usage changes 1.4 to 3.6 percent.[47] The study also found the demand of commercial users (motels, restaurants, etc.) was much less sensitive than the demand of industrial users.

2. Water for Industrial Uses

There are no readily available data showing the extent to which industrial water users obtain water from irrigation systems. Some do, at least indirectly, as they use water from municipal systems that obtain their water from irrigation systems.

Determining the value of water used for industrial purposes is essentially impossible, as corporations protect proprietary information about their operations. Moreover, for many, if not most industries, water is not a major determinant of total production costs and, hence, firms will, within broad boundaries, pay whatever is required to obtain water. Under such circumstances, the value of water from an irrigation system would reflect not the cost of providing the water or the price an industrial user pays for water, but the cost the industrial user can avoid by meeting its demands for water from the irrigation system rather than from the best alternative source.

---

[45] Young, R.A. 2005. *Determining the Economic Value of Water*. Washington, D.C. Resources for the Future, p. 255.

[46] Ludlum, M. 2004. *Seattle Public Utilities 2004 Water Demand Forecast Update: Phase 1, Literature Review*. Seattle Public Utilities.

[47] *See,* the discussion in Young, R.A. 2005. *Determining the Economic Value of Water*. Washington, D.C. Resources for the Future. Chapter 7.

In 2000, about 1.6 percent of Montana's total water withdrawals were used for industrial processing and power generation, although this number is an underestimate, because industrial users also use water from public supplies, which do not typically report water use by category of user. According to some estimates, industrial users of public water supplies account for less than 1 percent of the total withdrawals by public water suppliers.[48] The largest industrial demand for water in western Montana comes from the wood products industry, which includes the pulp and paper industries. Other industrial demands throughout the state come from the petroleum refining and sugar processing industries. In 2000, over half (52 percent) of industrial demands for water were satisfied with self-supplied groundwater withdrawals. Surface withdrawals made up the remaining 48 percent. About 15 percent of water withdrawn was actually consumed in industrial processing.[49]

Another industrial source of demand for Montana's water is for generating electrical power. Both hydroelectric and thermoelectric generators rely on water for power production, although very little of this water is actually consumed during use. In 2000, thermoelectric power generators in three Montana Counties—Richland, Rosebud, and Yellowstone—used surface water for cooling. Only one, a power plant in Rosebud county, recirculated its cooling water and thus did not return it to the point of withdrawal. Thermoelectric generators draw their water from surface resources. The extent to which they use surface water sources also used for irrigation is unknown. Although they return most of the water they withdraw, the return flows are typically much warmer than the ambient surface water temperature.[50]

Some of the water destined for irrigation helps to produce hydroelectric power. The Bureau of Reclamation's Canyon Ferry and Yellowtail projects serve irrigation needs and produce hydropower. In 2005 these two projects produced 787,617,057 kilowatt-hours of electricity with a wholesale value of about $31.5 million.[51] The state-owned Broadwater Power Project, located at Toston Dam, which stores water for irrigation, also generates hydropower. In a year with average runoff, the facility generates 56 million kilowatt-hours of electricity.

---

[48] Cannon, M.R. and D.R. Johnson. 2004. *See* footnote 4.

[49] Cannon, M.R. and D.R. Johnson. 2004. *See* footnote 4.

[50] Cannon, M.R. and D.R. Johnson. 2004. *See* footnote 4.

[51] Production data from U.S. Department of the Interior, Bureau of Reclamation. 2008. "Canyon Ferry Powerplant." Retrieved February 8, 2008, from http://www.usbr.gov/power/data/sites/canyonfe/canyonfe.html and U.S. Department of the Interior, Bureau of Reclamation. 2008. "Yellowtail Powerplant." Retrieved February 8, 2008, from http://www.usbr.gov/power/data/sites/yellowta/yellowta.html. Calculation of wholesale value assumes average price of about 4 cents per kilowatt-hour, the price the Western Area Power Authority incurred to purchased wholesale power in 2004. Western Area Power Authority. 2005. "Power Marketing." Retrieved February 8, 2008, from http://www.wapa.gov/about/faqpm.htm.

Based on 2003 contract rates, it can generate $3.5 million in revenue.[52] The U.S. Army Corps of Engineers operates Fort Peck Dam, which provides just under 200 MW of capacity, as well as water for irrigation.[53] Other hydroelectric facilities associated with irrigation infrastructure throughout the state include a new generator at Tiber Dam, operated by Tiber Montana LLC, which has an average capacity of around 6 MW,[54] and 8 facilities operated by PPL Montana on the Missouri and Madison Rivers, which collectively provide about 292 MW of generating capacity.[55]

3. Increase in Certain Recreational Opportunities

Water used for irrigation sometimes supports recreational opportunities that otherwise would not be available or as widely available. Irrigation reservoirs provide opportunities for boating, fishing, and other water-based recreational opportunities, as well as camping and picnicking in shoreline the areas. Irrigated fields that attract wild birds and game provide opportunities for hunting and wildlife watching. Some farmers and ranchers who irrigate their land also operate private hunting operations, where hunters can, sometimes for a fee, use farmland to hunt for wild birds and game.[56]

State parks, the Bureau of Reclamation's recreation sites, Bureau of Land Management recreation sites, and National Wildlife Refuges offer public access to boating, fishing, wildlife-watching, camping, swimming, and picnicking opportunities in and around reservoirs in Montana that provide water for irrigation. Eleven major recreation sites surround reservoirs that are part of Bureau of Reclamation water projects.[57] Many of these sites provide boat ramps, restroom facilities, and campgrounds, which enhance visitors' recreation experiences. Other sites are less developed, and offer opportunities for hunting and wildlife watching.[58] According to the Bureau of Reclamation, Canyon Ferry

---

[52] Montana Department of Natural Resources and Conservation, Water Resources Division, Water Projects Bureau. 2008. *Hydropower.* Retrieved February 22, 2008, from http://dnrc.mt.gov/wrd/water_proj/hydro/hydropower.asp

[53] Montana Department of Environmental Quality. 2007. "Table E1. Electric Power Generating Capacity by Company and Plant." *Electricity Tables Workbook – 2007 Update.* Retrieved February 28, 2008, from http://www.deq.state.mt.us/Energy/HistoricalEnergy/

[54] Montana Department of Environmental Quality. 2007. *See* footnote 49.

[55] PPL Montana. 2008. *PPL Montana – Hydroelectric Plants.* Retrieved February 28, 2008, from http://www.pplmontana.com/producing+power/power+plants/PPL+Montana+Hydro.htm

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

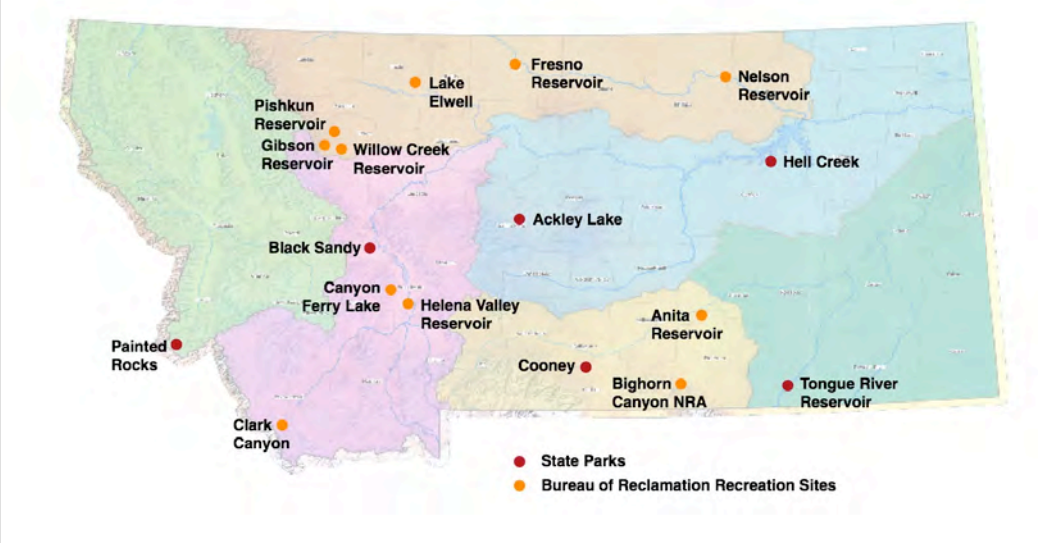
[57] These sites include Anita Reservoir, Bighorn Canyon National Recreation Area, Canyon Ferry Lake, Clark Canyon Reservoir, Fresno Reservoir, Gibson Reservoir, Helena Valley Reservoir, Lake Elwell ("Tiber Reservoir"), Nelson Reservoir, Pishkun Reservoir, and Willow Creek Reservoir.

[58] U.S. Department of the Interior, Bureau of Reclamation. 2008. *Major Recreation Sites in Montana.* Retrieved February 11, 2008, from http://www.usbr.gov/gp/recreation/montana_recreation.cfm

Reservoir is a haven for bird watchers: visitors come to view Bald Eagles, resident colonies of terns and pelicans, and other bird species that use the reservoir as a wintering ground.[59] Tailwater below the Bureau of Reclamation's Yellowtail Dam produce blue-ribbon fisheries on the Big Horn River, and within the Big Horn National Recreation Area.[60] Anglers flock to similar world-class blue-ribbon tailwater fisheries on the Missouri River, below a series of dams, including the state-owned Toston Dam, and the Bureau's Canyon Ferry Dam.[61]

State parks also provide public access to reservoirs, and Cooney Reservoir State Park is one of the most-visited state parks in Montana. In 2004, there were 162,856 visits to boat, fish, and play in the water provided by this irrigation reservoir. Other state parks associated with irrigation reservoirs in Montana include Ackley Lake, Painted Rocks, Hell Creek, Black Sandy, and Tongue River Reservoir.[62] Figure 3 shows the locations of these state parks, as well as the

Figure 3. Map of State Parks and Bureau of Reclamation Recreation Sites in Montana, by Basin



Source: ECONorthwest. Base map by PBS&J, depicting the six river basins that serve as the focus of this study.

[59] U.S. Department of the Interior, Bureau of Reclamation. 2008. *Pick-Sloan Missouri Basin Program, Canyon Ferry Unit – Montana.* Retrieved February 11, 2008, from http://www.usbr.gov/dataweb/html/canyonferry.html

[60] Montana Fish, Wildlife, and Parks. 2000. *MFWP Stream Fishery Classification, 1999 Final Sport Fisheries Value, Class I and II Streams.* Retrieved May 8, 2008, from http://fwp.mt.gov/FwpPaperApps/fishing/class1and2.pdf

[61] Montana River Guides. 1998. *The Missouri River, a Montana Tailwater Trout Fishery.* Retrieved May 8, 2008, from http://www.montana-river-guides.com/Missouririverfishing.htm

relevant Bureau of Reclamation recreation sites related to irrigated agriculture. Other state lands throughout Montana are managed to provide recreational opportunities in conjunction with irrigation. For example, Montana FWP's Freezout Lake Wildlife Management Area, located in Teton County, is augmented by canal drainage from the Greenfields Irrigation District. The Lake is a primary staging area for snow geese and tundra swans as the migrate between Canada and the Gulf Coast. People flock to the area during the migration to watch the birds, and canoe the lake throughout the spring, summer, and fall.[63]

These kinds of recreational opportunities typically are not traded in markets and, hence, it is not possible to use market prices and common, price-based techniques to estimate their value. Accordingly, economists have developed other data and techniques to estimate the value of recreational services. Sometimes they look at the trip-related costs people incur to enjoy a specific recreational amenity, and reason that recreationists would not incur these costs unless the benefits they derive from the amenity are at least this large. The U.S. Fish and Wildlife Service, for example, periodically conducts complex national surveys to determine how much people spend to fish, hunt, or watch wildlife in each state. Other times, economists use more targeted surveys to ask people engaged in fishing, boating, or other recreational activities at specific locations how much they would be willing to pay for these experiences.

By measuring the total amount people are willing to spend and subtracting the amount they actually spend, economists can estimate the net economic benefit associated with the goods and services that support a particular recreational activity. Economists frequently apply the label "consumer's surplus," to this net benefit. Consumer's surplus is important because it registers improvements in economic well-being: if someone can pay just a little to enjoy fishing, boating, or some other activity that is worth a lot, then he or she is economically better off.[64]

These techniques for determining value may not be as familiar to the general public as those that rely on market prices. A recent review of water-value studies conducted during the past several decades concluded, however, that these techniques generally have received more scrutiny and testing than those economists use to estimate values for other water-related goods and services,

---

[62] Montana Fish, Wildlife, and Parks, Parks Division. 2005. *Visitation Report 2004: Montana State Parks and Fishing Access Sites.* February. Retrieved February 22, 2008, from http://fwp.mt.gov/content/getItem.aspx?id=9299

[63] Russell Country. 2005. *Freezout Lake.* Retrieved May 9, 2008, from http://russell.visitmt.com/listings/11088.HTM

[64] In contrast, if there is no consumer's surplus, then economic well-being does not improve. For example, if one is willing to pay $25 to go fishing and incurs costs of $25 to do so, then one's economic well-being remains unchanged. Instead, one has exchanged one thing (money) worth $25 for another thing (fishing) with the same value.

such as those associated with the irrigation of crops, the generation of hydropower, and industrial processing.[65]

In the following paragraphs and tables we provide more information regarding water-related recreation in Montana, anticipating that it will provide background for describing the potential economic benefits of future investments in irrigation that would have a positive impact on the supply of some recreational opportunities. Caution must be taken in ascribing the values and other information described below to a specific irrigation system, project, or investment. One also should recognize that irrigation can cut both ways with recreation, generating benefits, as well as costs. In some cases, irrigation and recreational opportunities are complementary, as when irrigation water stored in a reservoir is also used for fishing and boating. Irrigation can also compete with recreation, diminishing certain kinds of activities, such as fly-fishing or kayaking, when water is diverted from streams to irrigate fields. The potential costs of irrigation, associated with diminished recreational opportunities, are discussed below, in Section III.

Levels of Recreational Activities in Montana. Many of Montana's residents and non-resident visitors enjoy the state's water-related recreational activities. Outdoor recreation is among the top reasons Montana residents identified for pleasure-related travel within the state. The top five activities in which Montana residents engage during overnight trips include watching wildlife (40 percent), day hiking (31 percent), fishing (23 percent) and nature photography (18 percent). The same holds true for day trips, where watching wildlife, rural sightseeing, day hiking, and fishing are among the most popular activities for Montanans. Non-resident visitors to Montana also report outdoor recreation as a primary reason for visiting the state: the top ten activities for non-residents to Montana in 2005 include wildlife watching, with 32 percent of all visitors participating, day hiking (23 percent), picnicking (20 percent), fishing (11 percent), and nature study (11 percent).[66]

The Montana Fish, Wildlife, and Parks has reported that visitation to Montana's state parks in 2004 reached its highest point since 1995: 1,650,000. Montana's water-based state parks are among the most heavily visited units in the State Park system[67] Several of these surround reservoirs primarily used to store irrigation water, including the Tongue River Reservoir and Cooney Reservoir. Cooney Reservoir received the highest number of visits of any water-based park, and was the second-most heavily visited park in Montana in 2004.

---

[65] Young, R.A. 2005. *Determining the Economic Value of Water.* Washington, D.C. Resources for the Future, p. 16.

[66] Institute for Tourism and Recreation Research. 2006. *The Economic Review of the Travel Industry in Montana.* University of Montana, Missoula. December.

[67] Montana Fish, Wildlife & Parks, Parks Division. 2005. *Visitation Report 2004: Montana State Parks and Fishing Access Sites.* February. Retrieved February 10, 2008, from http://fwp.mt.gov/content/getItem.aspx?id=9299

Table 7. Expenditures on Goods and Services Related to Fishing, Watching Wildlife, and Hunting in Montana, 2006

Activity	Participants	Days	Total Expenditure ($ per year)	Total Expenditure ($ per day)
Fishing	299,000	2.99 million	$230 million	$76
Wildlife-Watching	753,000	3.06 million[a]	$365 million	$119
Hunting	195,000	2.15 million	$315 million	$147
Total	- -	- -	$910 million	- -

Source: U.S. Fish and Wildlife Service. 2007. *2006 National Survey of Fishing, Hunting, Wildlife-Associated Recreation: State Overview. Preliminary Findings.* July. Retrieved February 7, 2008, from http://library.fws.gov/nat_survey2006_state.pdf

[a] Includes only wildlife watching away from home.

In 2006, the U.S. Fish and Wildlife Service conducted a national survey to estimate the levels of activity and expenditures, by state, associated with three primary recreational activities: fishing, wildlife watching, and hunting.[68] The survey found that more than 753,000 people participated in wildlife watching in Montana in 2006. It also found that about 195,000 people hunted in Montana in 2006, and 299,000 people fished. Table 7 reports these numbers, and the expenditures associated with each activity. Montanans have the highest participation rate in the country for hunting (19 percent) and second highest in the nation for fishing (24 percent) and wildlife watching (55 percent).[69] Many people, both residents of Montana and visitors, participate in boating, swimming, and other water-related recreational activities besides fishing, wildlife-watching, and hunting. We have been unsuccessful in our efforts to secure reliable state-wide data regarding the levels of these activities, however.

Expenditures on Fishing, Wildlife Watching, and Hunting. The 2006 survey of recreational expenditures by the U.S. Fish and Wildlife Service shows that resident and non-resident anglers in Montana fished 2.9 million days during the year and, on average, incurred trip-related expenditures of $76 per day, total expenditures of $230 million, and per capita expenditures of $768. About 753,000 participants engaged in 3.06 million days of away-from-home wildlife watching in the state, spent $485 per person, and $365 million, total. Hunters in Montana

[68] U.S. Fish and Wildlife Service. 2007. *2006 National Survey of Fishing, Hunting, Wildlife-Associated Recreation: State Overview. Preliminary Findings.* July. Retrieved February 7, 2008, from http://library.fws.gov/nat_survey2006_state.pdf

[69] U.S. Fish and Wildlife Service. 2007. *See* footnote 68.

spent $1,617 per person, hunted 2.15 million days during the year and, on average, incurred trip-related expenditures of $147 per day.[70]

We have not found studies that yield informative estimates of expenditures for water-related recreational activities other than fishing, wildlife-watching, and hunting. This does not mean the expenditures are zero, only that reliable data on the expenditures are not readily available.

Consumer's Surplus of Goods and Services Associated with Water-Related Recreational Activities. What recreationists pay to enjoy Montana's water-related, recreational goods and services usually is less than what they are willing to pay to do so. The difference between the two is a component of value called the consumer's surplus.

Little research has been conducted in Montana to estimate consumer's surplus associated with the recreational goods and services associated with irrigation. Quite a few studies have been conducted in the larger region, however. Table 8 summarizes the findings of such studies conducted in the Intermountain Region, which includes Montana, between 1967 and 1998. The data in the table show, for example, that the several studies that have estimated the average consumer's surplus associated with camping in this region is $37 per day, measured in the dollars of 2007.[71]

Some studies indicate that the consumer's surplus associated with fishing and nonmotorized boating in Montana may be significantly higher than the studies summarized in Table 8 indicate. One of these found that the consumer's surplus per day of fishing in the vicinity of Yellowstone National Park was $172 to $977. Other studies found the statewide average consumer's surplus for trout fishing was between $49 and $104 per trip. A 1988 study found the net economic value per trip for trout fishing was between $38 and $217, depending on the stream.[72] A 1991 study found the consumer's surplus associated with waterfowl hunting in Montana was $126 per trip for residents and $329 per trip for nonresidents.[73]

---

[70] U.S. Fish and Wildlife Service. 2007. *See* footnote 68.

[71] Many of the studies underlying these data measure recreational consumer's surplus using the travel-cost method (TCM). TCM tends to underestimate the full value of recreational activities, because people with the highest willingness to pay to take advantage of a recreational opportunity tend to move to be closet to the opportunity, reducing their travel costs and increasing their consumer's surplus. TCM studies that miss these people underestimate the consumer's surplus.

[72] For a summary of the studies we discuss in this paragraph, *see* Duffield, J. 2003. *Economic Valuation Studies of Fish and Wildlife Resources in Montana*. Montana Department of Fish, Wildlife, and Parks. Retrieved February 26, 2008, from http://fwp.state.mt.us/tmc/reports/ecovalues.html

[73] Neher, C. and J. Duffield. 1991. *Montana Waterfowl Hunting: A Contingent Valuation Assessment of Economic Benefits and Hunter Attitudes. A Report for the Montana Department of Fish, Wildlife, and Parks.* Helena; cited in Duffield, J. 2003. *Economic Valuation Studies of Fish and Wildlife Resources in Montana.* Montana Department of Fish, Wildlife, and Parks. Retrieved February 26, 2008, from http://fwp.state.mt.us/tmc/reports/ecovalues.html.

Table 8. Estimates of Average Consumer's Surplus per Person per Day, by Activity, for Recreational Activities on Public Lands in the Intermountain Region:[a] Summary of Studies from 1967 to 2003

Recreational Activity	Mean of Estimates[b]	Recreational Activity	Mean of Estimates[b]
Camping	$37	Motorboating	$58
Fishing	$54	Picnicking	$31
Floating/rafting/canoeing	$73	Sightseeing	$25
General recreation	$52	Swimming	$32
Hiking	$42	Waterskiing	$62
Hunting	$52	Wildlife viewing	$40

Source: Loomis, J. 2005. *Updated Outdoor Recreation Use Values on National Forests and Other Public Lands*. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Gen. Tech. Rep. PNW-GTR 658. Retrieved February 8, 2008, from http://www.fs.fed.us/pnw/pubs/pnw_gtr658.pdf.

[a] The Intermountain Region includes Arizona, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, South Dakota, Utah, and Wyoming.

[b] Values expressed in 2007 dollars, rounded to the nearest dollar.

Total Value of Goods and Services Supporting Fishing, Wildlife-Watching, and Hunting Activities. The data in Tables 7 and 8 show that the estimated expenditures and consumer's surplus for fishing are about $76 and $54, respectively, per angler-day. The latter amount, the consumer surplus, reflects the net benefit an angler derives from a day of fishing and roughly corresponds to the net earnings irrigators derive from using one acre-foot of water for irrigation. Adding these numbers indicates the total willingness to pay is ($76 + $54 =) $130 per angler-day. This total value per angler-day, multiplied by the number of angler-days of fishing effort in Montana yields the total value of Montana's ecosystem goods and services that support this activity. Table 9 shows these calculations for fishing, wildlife-watching and hunting.

Considerable evidence indicates the numbers in Table 9 may understate the actual value of the goods and services supporting fishing, wildlife-watching, hunting in Montana. Depending on the kind of fishing opportunities provided, for example, consumer's surplus might be higher than those values reported above. A recent study conducted in adjacent areas to the north and west of Montana, for example, found the consumer's surplus associated with stream fishing is as high as $100 per angler-day. Even if the estimates in Table 9 are accurate, they represent the values in 2006, and recreation values are growing rapidly. A recent summary of economic studies of recreation found that viewing scenery, fish, and wildlife is one of the fastest outdoor recreational activities in the U.S., more than doubling since 1982.[74] The author concluded that these

[74] Swanson, C. 2004. *Montana Tourism and the Role of Fish and Wildlife*. Montana Department of Fish, Wildlife, and Parks. Retrieved February 26, 2008, from http://fwp.state.mt.us/tmc/reports/tourism.html

Table 9. Estimated Total Value of Water-Related Goods and Services that Support Recreational Fishing, Wildlife-Watching, and Hunting in Montana, 2006

Activity	Level of Activity (activity-days per year)	Components of Value ($ per activity-day)			Total Value ($ million per year)
		Expenditure	Consumer's Surplus	Total	
Fishing	2.99 million	$76	$54	$130	$388.7
Wildlife-Watching	3.06 million	$119	$40	$159	$486.5
Hunting	2.15 million	$147	$52	$199	$427.8

Source: ECONorthwest

Table 10. Percentage of Adults in the Rocky Mountain Region Indicating Positive Values for Water-Related Resources

Statement	Percentage with Positive Responses[a]
If asked, I would contribute time, money, or both to an organization that works to improve the quality of wetlands, streams, and lakes, even if the results of this activity may not be observed for five to ten years.	75
Outdoor recreation areas must be maintained to better serve the public.	96
The opportunity to view wildlife and/or fish in a natural setting is important in my selection of outdoor recreation sites.	85
Wilderness is valuable for protecting water quality.[b]	97

Source: ECONorthwest, adapted from Cordell, H., J. Teasley, and G. Super. 1997. *Outdoor Recreation in the United States: Results from the National Survey on Recreation and the Environment.* U.S. Department of Agriculture, Forest Service. August.

[a] Except as indicated, positive responses to statement are "strongly agree" and "agree."

[b] Positive responses to statement are "extremely important," very important," and "slightly important."

activities are especially important in the mountain states. The authors of another study concluded that the economic values associated with outdoor recreation in the U.S., as a whole, are growing faster than inflation, with the value of an outdoor recreational activity-day growing by about $1.00 per year.[75]

[75] Rosenberger, R. and J. Loomis. 2001. *Benefit Transfer of Outdoor Recreation Use Values (2000 Revision)*. Gen. Tech. Rep. RMRS-GTR-72. Fort Collins, Colorado, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, pp. 19-20.

Results from a 1994-95 survey of Americans provide qualitative information regarding how strongly people care about the values they place on water-related resources and recreation. Table 10 summarizes some of the study's findings from its survey of people living in the Rocky Mountain states. About 75 percent of the respondents to the survey in these states agreed or strongly agreed with a statement that they would be willing to contribute money, time, or both to improving the quality of wetlands, streams, and lakes. Higher percentages agreed or strongly agreed with statements about the importance of outdoor recreation areas and opportunities to fish and/or view wildlife. Nearly 100 percent said wilderness is important for protecting water quality. These numbers indicate that the demand for high-quality, water-related, recreational resources is robust, and not likely to diminish absent unforeseen events.

4. Flood Control

Dams that impound water for irrigation may mitigate flooding, providing benefits to downstream property owners and communities. We did not find any comprehensive estimate of these benefits. The Bureau of Reclamation, however, has estimated that its dams and reservoirs in Montana have prevented millions of dollars of flood damage since the mid-twentieth century. Table 11 presents the data for the dams that also provide irrigation services. The Department of Natural Resources and Conservation also manages 21 dams that provide flood control services, in addition to irrigation water, for the state, although we did not find any estimates of the dollar value of these services.[76]

Table 11. Flood Control Benefits of Bureau of Reclamation Projects in Montana.

Project	Flood Control Benefits	Period Over Which Benefits Have Accrued
Canyon Ferry Reservoir	$126,000,000	1973 – 1998
Clark Canyon Reservoir	$11,500,000	As of 1998
Lake Elwell	$54,700,000	1956 – 1998
Fresno Reservoir	$10,900,000	1950 – 1999
Gibson Reservoir	$3,040,000	1950 – 1999
Bighorn Reservoir	$90,000,000	1966 – 1998

Source: ECONorthwest, with data from U.S Department of the Interior, Bureau of Reclamation. Various project summaries. Retrieved February 11, 2008, from http://www.usbr.gov/dataweb

[76] Montana Department of Natural Resources and Conservation, Water Resources Division, Water Projects Bureau. 2008. *State Water Projects.* Retrieved February 22, 2008, from http://dnrc.mt.gov/wrd/water_proj/

5. Habitat Improvement and Maintenance of Open Spaces

Irrigation of dry land can produce new and different types of habitat. In some cases, irrigation may provide sufficient economic stability for a farmer to maintain his or her land in agricultural production, preserving open spaces from development. These open spaces may form contiguous large areas of land with little human intrusion during parts of the year important to some species. Agricultural open space can provide benefits to humans living nearby. Water withdrawn and applied to irrigate fields produces habitat that often attracts and provides habitat for birds and wildlife species. Return flows of irrigation water may produce wetland habitats that persist during the dry summer months.

Wetlands can provide especially important goods and services. Some agricultural policies provide incentives for farmers to restore wetlands that have been lost to agricultural production over the last century. Although some wetlands are lost each year by conversion to agriculture (which represents a cost, not a benefit to society), over the last few decades, there has been a net gain of wetlands in Montana.[77] To the extent that irrigation facilitates the restoration of wetlands, it represents a benefit to society.

Table 12 illustrates goods and services from wetlands. Montana's wetlands can generate numerous, valuable goods and services. Some of these have global significance, as when the ecological processes of a wetland contribute to the regulation of global climate. Others are important primarily to local residents and visitors. Of these, some benefit people indirectly, as when wetlands help recharge aquifers or improve the quality of surface water. Others provide people with benefits directly, as when a wetland improves the view from the front window of a nearby home.

To our knowledge, no studies have estimated the economic value of the goods and services produced by wetlands in Montana, or the effect of irrigated agriculture on them. Studies elsewhere, however, have documented the values of some goods and services. A review of 39 studies found that, on average, these studies showed the services they produce increased the value of wetlands by about $1,534 per acre.[78] The studies also found that, for wetlands providing bird-watching opportunities, the value of these services was about $2,124 per acre.

Another effort summarized studies that related to the interaction between wetlands and agriculture.[79] Table 13 shows some of its findings. The authors of

---

[77] Heimlich, R.E., K.D. Wiebe, R. Claassen, D. Gadsby, and R.M. House. 1998. *Wetlands and Agriculture: Private Interests and Public Benefits.* Agricultural Economic Report 765. Washington, D.C. Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Retrieved February 12, 2008, from http://www.ers.usda.gov/publications/aer765/aer765.pdf

[78] Woodward, R.T. and Y.S. Wui. 2001. "The Economic Value of Wetland Services: A Meta-Analysis." *Ecological Economics* 37 (2): 257-270. These values are in the dollars of 2007.

[79] Heimlich, R.E., K.D. Wiebe, R. Claassen, D. Gadsby, and R.M. House. 1998. *Wetlands and Agriculture: Private Interests and Public Benefits.* Agricultural Economic Report 765. Washington,

Table 12. Functions, Goods, and Services Associated with Wetland Ecosystems
Planetary ecosystem functions
Cycle elements (carbon, nitrogen, phosphorous, sulfur, methane)
Stabilize atmospheric conditions
Capture the sun's energy (convert energy to plants and other life)
Sustain biodiversity
Hydrologic functions
Convey surface water
Store surface water
Alter flood flows
Recharge aquifer
Discharge ground water back to streams
Water quality functions
Stabilize and entrap sediment
Retain sediments/toxicants
Remove nutrients and toxic substances
Provide habitat (plants and animals)
Functions related to direct human utilization
Produce goods (wood, forage, fish, game, fur)
Provide recreational opportunities
Provide attractive vistas
Provide educational and research opportunities
Sustain landscapes associated with cultural heritage
Stabilize stream banks

Source: ECONorthwest, derived from Mahan, B. L. 1997. *Valuing Urban Wetlands: A Property Pricing Approach*. U.S. Army Corps of Engineers.

the summary noted that much of the economic research on wetlands has been conducted in urban and coastal areas and, hence, we recommend that readers use the values reported in the table (and in the preceding paragraph) with caution, as they may not accurately reflect values specific to wetlands in Montana. Nonetheless, the data in Table 13 are important, for they indicate that people place substantial economic value on the goods and services produced by wetlands elsewhere in the U.S. This value can be especially large when people

D.C. Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Retrieved February 12, 2008, from http://www.ers.usda.gov/publications/aer765/aer765a.pdf.

Table 13. Average Estimates of Economic Values of Goods and Services Produced by Wetlands, Summary of Studies, 1970 to 1996

Goods and Services	Mean Value Reported by Studies ($ per acre)[a]
Marketed goods	
Fish and shellfish	$7,993
Fur-bearing animals	$179
Nonmarketed goods and services	
General value to nonusers	$108,395
General value to users	$3,274
Fishing: value to users	$8,565
Hunting: value to users	$1,327
Recreation: value to users	$1,485
Amenity and cultural: value to users and nonusers	$3,548

Source: ECONorthwest, with data from Heimlich, R.E., K.D. Wiebe, R. Claassen, D. Gadsby, and R.M. House. 1998. *Wetlands and Agriculture: Private Interests and Public Benefits.* Agricultural Economic Report 765. Washington, D.C. Resource Economics Division, Economic Research Service, U.S. Department of Agriculture, p. 15.

[a] We converted values in the original study to their equivalent in the dollars of 2007.

place a value on wetland goods and services without using them, i.e., they place a non-use value on the wetlands. Non-use values come into play, for example, when people want to protect an endangered species or a healthy stream, even though they never intend to interact with the species or use the stream. Absent contrary information, it seems reasonable to conclude that people also place value on the goods and services produced by Montana's wetlands as well. The actual value of goods and services produced by Montana's wetlands may be larger or smaller than those shown in Table 13.

Finally, several studies have estimated the savings communities have realized by being able to rely on wetlands and riparian ecosystems to provide some services rather than having to invest in alternatives, such as water-treatment facilities. Table 14 summarizes the findings of some of these studies, as reported by the U.S. Environmental Protection Agency. These findings indicate that, in some settings at least, communities can reap substantial savings from having a healthy ecosystem capable of providing services, even though the value of these services generally goes unnoticed. We presume that these findings apply generally to the state, but going beyond this general observation would require additional study.

6. Quality of Life

Many of the goods and services produced by irrigation in Montana contribute to the quality of life enjoyed by residents and visitors. Economists often refer to

Table 14. Economic Benefits from Wetlands and Riparian Areas

Economic Benefit Derived from Wetlands and Riparian Areas	Estimated Amount
Loss of wetlands increased dredging costs downstream. (California)	$2.8 million
Loss of swamp lands and their ability to cleanse surface water increased water-treatment costs. (South Carolina)	$5 million
Loss of wetlands and their ability to cleanse surface water caused a community to incur additional sewer-system costs. (Pennsylvania)	$1.5 million
Loss of wetlands and their ability to store water causes communities to build additional storage facilities. (Minnesota)	$1.5 million per year for 5,000 acres of wetlands lost each year.
Preserving wetlands, and their ability to absorb floodwater, allowed communities to avoid building dams. (Massachusetts)	$10 million purchase of wetlands offset $100 million cost of dams.
Restoration of vegetation on streamside lands, and their ability to absorb floodwater, allowed communities to avoid costs of stormwater-control facilities. (Kansas)	$600,000 cost of restoration precluded $120 million cost of stormwater facilities.
Protection and restoration of riparian vegetation enabled a community to avoid costs of dredging and wastewater treatment. (Oregon)	$660,000 annual restoration cost precluded $1.6 million annual cost.
Establishment of vegetation along waterways to filter pollution from runoff from nearby lands reduced water treatment costs. (Iowa)	$2.7 million per year.
Improvement of riparian vegetation reduced stream sediment and water-treatment costs, and improved agricultural production. (Ohio)	$2.7 million.

Source: ECONorthwest, adapted from U.S. Environmental Protection Agency. 2005. *National Management Measures to Protect and Restore Wetlands and Riparian Areas for the Abatement of Nonpoint Source Pollution*. Office of Water. EPA 841-B-05-003. July. Retrieved February 12, 2008, from http://www.epa.gov/owow/wetmeasures/.

these as consumption amenities because they directly improve the well-being of people who consume them as they live, work, and visit nearby. Thus, residents are able to enjoy some of Montana's water-related scenery and recreational opportunities without having to pay for them. Or, if they do incur some cost—to drive to a nearby fishing spot, for example—they incur costs less than what they would if they lived outside Montana. To the extent that residents derive a net economic benefit, or consumer's surplus, from their proximity to these amenities, this net benefit increases their overall economic well-being.

It is useful to think of the net benefit residents enjoy from living in Montana as a second paycheck. Then, the sum of the second paycheck a family derives from living in Montana plus the first paycheck it earns from employment serves as a good indicator of the family's overall economic well-being. Irrigation-related amenities are important components of Montana's quality of life, but not the only ones. Also important are the character of Montana's communities, the strength of its schools, the feelings of neighborliness, and so forth.

Consider, for example, two recreationists who are otherwise identical, except one lives in Montana and the other does not. Imagine they engage in the same

fishing, hunting, and watching wildlife activities in Montana, but the one living elsewhere must incur $1,000 in travel-related costs to reach Montana, while the resident can engage in the same activities but avoid these costs just by living here. In this example, the resident enjoys a second paycheck of $1,000.

The second paycheck has special economic significance whenever it is large enough to influence the location decisions of households. The contributions water-related amenities make to the second paycheck seem especially important in Montana, insofar as many residents openly say that these aspects of the quality of life in Montana are the primary reason why they live here. Moreover, many say that preserving these aspects of the quality of life for enjoyment by future generations is a particularly important goal.

We are aware of no studies that have directly measured the value of Montana's irrigation-related amenities and their contributions to the quality of life residents enjoy here. Several efforts give some useful insights, however.

The U.S. Fish and Wildlife Service, in its 2006 survey we describe above, found that residents represented 51 percent of all the individuals who participated in wildlife-watching activities in Montana. The U.S. Fish and Wildlife Service also found that, on average, each participant in wildlife-watching activities in Montana spent $53 for lodging. Residents of Montana, however, probably incurred little, if any lodging costs. Thus, by living in Montana, each of them was able to enjoy watching wildlife without paying the $53 in lodging costs that nonresidents paid. In other words, by living in Montana, up to 1,583,000 residents were able to enjoy the benefits of watching wildlife without incurring $53 in lodging costs. Their savings represent one element of the second paycheck they enjoy from living here. The maximum total for just this one element of the second paycheck is (1,583,000 x $53 =) $ 83,899,000 per year.

Montana's residents enjoy similar benefits from living near fishing, hunting, boating, and other recreational opportunities. They also enjoy benefits from living near and enjoying the state's water-related scenery. Other quality-of-life benefits materialize, insofar as the ecosystem provides safe water for domestic and municipal-industrial uses, so that residents do not have to incur extraordinary treatment costs.

A landmark 1991 study provides the basis for estimating the overall second paycheck enjoyed by the residents of each state.[80] The authors estimated the overall value of all the consumption amenities that affected household location decisions, by looking at the extent to which households were willing to accept a lower income (first paycheck) to live in states with above-average levels of amenities or, alternatively, require a higher-than-average income (first paycheck) to live in states with lower-than-average amenities. They found that the overall

---

[80] Greenwood, M.J., G.L. Hunt, D.S. Rickman, and G.I. Treyz. 1991. "Migration, Regional Equilibrium, and the Estimation of Compensating Differentials." *The American Economic Review* 81 (5): 1382-1390.

amenities of living in Montana equaled about 14 percent of residents' earnings, i.e., about 14 percent of their first paychecks.

Many of the water-related amenities are associated with the landscapes created through agricultural use of water. Table 15 lists these amenities, and shows that, although most of them have a positive value, some are negative (and constitute an external cost).[81]

To a considerable extent, the quality of life in Montana is influenced by its landscapes. No state-specific studies quantify this influence, but studies elsewhere provide some insight. One 1993 study surveyed households in Routt County, Colorado, to determine their willingness to pay to implement a program that would protect different amounts of ranchland in the county from

Table 15. Amenities the Public Can Derive from Agricultural Lands

Positive Amenities	
Environmental	Open Space Biodiversity Recreational Opportunities Isolation from Congestion Flood Control Soil Conservation Wildlife Habitat Scenic Vistas Watershed Protection Groundwater Recharge
Rural Development	Rural income and employment Viable rural communities A diversified local economy
Social	Traditional country life Small farm structure Cultural heritage
Negative Amenities	
Environmental	Odor Soil erosion Nutrient/pesticide runoff Ecosystem fragmentation

Source: Hellerstein, D., C. Nickerson, J. Cooper, et al. 2002. *Farmland Production: The Role of Public Preferences for Rural Amenities.* U.S. Department of Agriculture, Economic Research Service. Agricultural Economic Report No. 815. October.

[81] Hellerstein, D., C. Nickerson, J. Cooper, P. Feather, D. Gadsby, D. Mullarkey, A. Tegene, and C. Barnard. 2002. *Farmland Protection: The Role of Public Preferences for Rural Amenities*. U.S. Department of Agriculture, Economic Research Service. Agricultural Economic Report No. 815. October.

development.[82] The researchers hypothesized that residents would be willing to pay to protect ranchland they do not own because the ranchland provides them with open-space, environmental, and cultural-heritage services. Respondents indicated they were willing, on average, to pay $142, $243, $307, and $340 per household, respectively, to protect 25, 50, 75, or 100 percent of the existing ranchland.[83] The researchers observed that these values are similar to those found in previous studies. They also concluded that, given these values, the number of households in the county was insufficient for a ranchland-protection program to outweigh the values associated with land development. They raised the possibility, however, that protection might be more valuable than development, if one also considered visitors' willingness to pay for protection.

A study of the influence of urban parks and other open spaces on the sale prices of homes in Portland, Oregon, found open spaces have a statistically significant impact on a home's sale price.[84] The authors concluded that the effect varies by type of open space and declines with distance, and that parks having natural characteristics have the greatest effect on the sale prices of homes.

A recent national study surveyed Americans to determine their preferences regarding the protection of open space. More than 60 percent of respondents indicated that contributions to quality of life, protection of farmland, and provision of environmental benefits were important or somewhat important reasons for protecting open space.[85] Respondents also agreed with statements that open space can make important economic contributions by attracting visitors to their communities and promoting economic development. Many residents of Montana have even stronger preferences for being surrounded by open space. Between 1995 and 2006, voters in Montana approved over $50,000,000 in funding for acquisition of open space and farmland.[86] In 2004, for example, 63 percent of voters in Gallatin County elected to spend $10,000,000 to protect the county's open spaces. Again in 2006, voters in Ravalli County approved a $10,000,000 bond to purchase farmland and open space.

---

[82] Rosenberger, R.S. and R.G. Walsh. 1997. "Nonmarket Value of Western Valley Ranchland Using Contingent Valuation." *Journal of Agricultural and Resource Economics.* 22(2): 296–309.

[83] We have converted the values reported in the study to their equivalents in the dollars of 2007.

[84] Lutzenhiser, M. and N.R. Netusil. 2001. "The Effect of Open Spaces on a Home's Sale Price." *Contemporary Economic Policy* 19 (3): 291-298.

[85] Mumford, K. and M Myszewski. 2004. *County Open-Space Protection Efforts: A Survey of the Current State of Open-Space Protection Efforts by America's Counties.* The University of Georgia, Carl Vinson Institute of Government. July.

[86] Trust for Public Land. 2008. *Conservation Alamanac: Montana LandVote Data.* Retrieved May 20, 2008, from http://www.conservationalmanac.org/

III. Gross Economic Costs of Irrigation in Montana

Irrigation provides benefits to farmers and society, but it also imposes costs. These costs range from the direct costs of investment necessary to construct, operate, and maintain the infrastructure necessary for the continued delivery of irrigation water, to the costs associated with negative externalities imposed on society by irrigation practices. We describe the different types of costs in the following paragraphs. As in the discussion of irrigation's benefits, we report that the available information is too limited to support quantification of the externalities. We therefore focus on providing background, which we anticipate can form the foundation of future efforts to describe the costs of specific irrigation projects, systems, and investments.

A. Costs of Investing in Irrigation

The costs of irrigation include capital costs of large- and small-scale delivery infrastructure (from dams and canals to on-farm pumps and sprinkler systems), operations and maintenance costs of the infrastructure, and the time and financial resources required to plan, design, and administer irrigation projects. Funding for these costs comes from public and private sources. The federal government also provides subsidies for crops grown with irrigation, and to support other agricultural activities, and these subsidies indirectly underwrite the costs of irrigation infrastructure, operations, and maintenance.

An irrigation system incurs costs when it uses a resource—money, labor, land, equipment, etc.—so that others do not have an opportunity to use it. The magnitude of the cost is the value of the forgone benefits associated with the best alternative use of the resource. Economists apply the term, opportunity cost, to these forgone benefits. The opportunity cost of a resource used in an irrigation system need not equal the price the system's owner paid for the resource. The developer of an irrigation-related dam on public land, for example, might pay little or nothing for the use of the land, but the economy as a whole might incur significant opportunity costs because the land no longer can provide habitat for a valuable species.

The concept of opportunity cost also can come into play with resources other than natural resources. If several irrigation systems compete for a limited pool of federal funding, for example, the success of one in securing funding will come at the expense of another. In this case, the opportunity cost would be the forgone benefits associated with the unsuccessful system. If only one irrigation system is seeking funds from a federal program, however, its success in securing the funds would not impose opportunity costs on another system. Federal and state dollars invested in irrigation may impose opportunity costs on federal and state taxpayers as those investments are made at the expense of other potential uses for those tax dollars. An analysis of the St. Mary Diversion and Milk River Project also highlighted the importance of opportunity cost as it applies to

labor.[87] The communities in the immediate vicinity experience chronic high levels of unemployment. Hence, the authors concluded that, if investment in irrigation resulted in new job opportunities, the workers that fill the jobs likely would not be drawn away from existing jobs. The opportunity cost of the labor would be less than the wages paid to workers.

1. Federal Costs

The federal government has shouldered much of the cost of making irrigation possible in Montana, by subsiding the construction of large irrigation projects in the state, and by subsidizing agricultural production through payments for commodities, conservation activities, and disaster assistance programs.

Cost of Federal Irrigation Projects. The U.S. Bureau of Reclamation (BoR), has spent $21.8 billion constructing 133 water reclamation projects that provide water for irrigation in the western United States. Irrigators benefit from several BoR projects constructed in Montana.[88]

In concept, irrigators benefiting from a BoR project should bear a share of the construction costs of proportional to their share of the project's total gross benefits. In practice, however, the federal government subsidizes irrigators' share of the construction costs of the BoR's projects in several ways. First, federal law exempts irrigators from having to pay interest on their share of construction costs (other beneficiaries of federal water projects, such as power producers, do not receive this exemption). Second, of the construction costs allocated to irrigators, they are required to pay back only what they are able to pay, based on the expected net income they would generate from irrigating their crops. The portion of the construction costs that exceed irrigators' ability to pay are shifted to other beneficiaries of the projects, such as power producers and municipal water users. Finally, in some cases, irrigators' repayment responsibilities are further diminished or cancelled by specific legislation, due to hardship or other special concerns. These subsidies are known as "charge-offs."[89] These subsidies together represent a considerable cost of irrigation infrastructure that is borne by those other than irrigators: federal taxpayers, electricity consumers, and municipal water customers, among others. Table 16 shows the portion of construction costs that irrigators have repaid, the amount remaining to be repaid,

---

[87] 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.

[88] The Bureau of Reclamation Projects that benefit irrigation in Montana are Buffalo Rapids, Huntley, Intake, Lower Yellowstone, Milk River, Pick-Sloan Missouri Basin Program (Canyon Ferry, Cow Creek Pump, East Bench, Helena Valley, Lower Marias, Savage, and Yellowtail Units), Shoshone, Sun River in the Great Plains Region and the Bitter Root, Frenchtown, and Missoula Valley projects in the Pacific Northwest Region.

[89] United States General Accounting Office. 1996. *Bureau of Reclamation Information on Allocation and Repayment of Costs of Constructing Water Projects.* Report to the Ranking Minority Member, Committee on Resources, House of Representatives. GAO Report No. GAO/RCED-96-109. July. Retrieved February 19, 2008, from http://www.gao.gov/archive/1996/rc96109.pdf

Table 16. Status of Repayment of Costs Allocated to Irrigation for Bureau of Reclamation Projects in Montana[a], as of September 1994[b]

Project	Repayment to Date	Future Repayment	Charge-offs and Discounted Loans
Bitter Root	$2,426,120	$10,102,720	$2,620
Buffalo Rapids	$1,260,220	$573,780	$5,063,150
Frenchtown	$389,070	$0	$1,310
Huntley	$2,181,150	$310,470	$537,100
Intake	$61,570	$0	$61,570
Lower Yellowstone	$5,205,940	$0	$856,740
Milk River	$8,862,150	$3,584,160	$4,421,250
Missoula Valley	$49,780	$0	$314,400
Sun River	$17,014,280	$0	$8,115,450

Source: ECONorthwest, with data from United States General Accounting Office. 1996. *Bureau of Reclamation Information on Allocation and Repayment of Costs of Constructing Water Projects.* Report to the Ranking Minority Member, Committee on Resources, House of Representatives. GAO Report No. GAO/RCED-96-109. July. Retrieved February 19, 2008, from http://www.gao.gov/archive/1996/rc96109.pdf

[a] Not included below are seven projects in Montana that are individual units of the larger Pick-Sloan Missouri Basin Program. They include the Canyon Ferry, Cow Creek Pump, East Bench, Helena Valley, Lower Marias, Savage, and Yellowtail Units. Of the 6 million acres of irrigation envisioned through the development of the Pick Sloan Program, only 500,000 acres nation-wide were actually developed. Determining irrigators' repayment obligations and federal subsidies of irrigation development for these projects is complicated by hydropower subsidies and other provisions unique to the Flood Control Act of 1944 and the Pick Sloan Missouri Basin Program.

[b] Values are converted to 2007 dollars.

and the amount forgiven due to charge-offs and discounted loans for Bureau of Reclamation projects in Montana as of September 30, 1994.

Even when irrigators have repaid the initial construction costs of irrigation infrastructure, operations and maintenance costs associated with these projects accumulate on an on-going basis. As the decades-old infrastructure ages, costs for massive rehabilitation projects loom on the horizon. Current estimates to rehabilitate the St. Mary Diversion in the Milk River project range between $75 and $125 million, and in 2007, Congress authorized funds of $153 million for the project.[90] The state and local irrigation districts have recently invested around $600,000 into the project, just to keep it operational.[91]

---

[90] Azevedo, P. 2007. "St. Mary Rehabilitation Project Advances on Several Fronts." *Milk River Watershed News.* Fall. Retrieved February 20, 2008, from http://dnrc.mt.gov/st_mary/news/2007/fall.pdf

[91] Azevedo, P. No Date. *The Need to Rehabilitate the St. Mary Facilities.* Montana Department of Natural Resources and Conservation. Retrieved February 20, 2008, from http://dnrc.mt.gov/st_mary/pdfs/stmarybackground.pdf

Costs of Farm Subsidies. Montana's irrigated farms and ranches receive federal subsidies through programs established in the federal Farm Bill. Some subsidies support the production of farm commodities, while others offset losses from drought, storms, and other disasters. Conservation subsidies provide incentives to preserve wetlands and grasslands, protect water and air quality, and produce other environmental goods and services. Montana's farmers receive commodity payments for eight irrigated crops: barley, corn, sorghum, oats, flaxseed, sunflower seed, soybeans, and wheat.

The amount of subsidies received for irrigated agriculture alone are not reported separately. Thus, it is difficult to determine with certainty how much subsidy the federal government paid to irrigators, versus payments to farmers who practice dry land farming. Table 17 shows the top six subsidy programs, by total funds distributed in Montana: the Conservation Reserve Program, wheat subsidies, disaster payments, barley subsidies, and livestock subsidies.[92] The Environmental Quality Incentive Program (EQIP), which provides assistance aimed at protecting the environment while maintaining agricultural production, ranked sixth. Among other things, EQIP funds irrigation infrastructure improvements that promote irrigation efficiency and water conservation.

The top two subsidy programs in Montana, for the Conservation Reserve Program (CRP) and for wheat, probably are not contributing much to support irrigated agriculture, insofar as wheat is primarily a dry land crop in Montana, and CRP provides support for farmers to convert sensitive agricultural land to native vegetative cover that would require little to no irrigation. In fact, environment-based subsidies, such as those provided under the CRP, have lowered the demand for irrigation in some areas by providing farmers with income as they preserve, or even restore the landscape. The other top subsidy

Table 17. Top Federal Subsidy Programs in Montana, 2003 to 2005[a]

Program	Subsidy Total
Conservation Reserve Program	$366,652,080
Wheat Subsidies	$308,008,564
Disaster Payments	$244,405,362
Barley Subsidies	$97,779,931
Livestock Subsidies	$48,964,651
Environmental Quality Incentive Program	$16,409,856

Source: Environmental Working Group. 2004. "Farm Subsidy Database." Retrieved February 11, 2008, from http://www.ewg.org/farm/

[a] All values adjusted to 2007 dollars.

[92] Environmental Working Group. 2006. "Montana: Top Programs in Montana." *Farm Subsidy Database.* Retrieved February 12, 2008, from http://farm.ewg.org/farm/region.php?fips=30000

programs in Montana—barley, livestock, disaster payments, and EQIP—probably do benefit irrigators:

- In 2002, 23 percent of Montana's barley crop was irrigated; in comparison, just over 2 percent of the wheat crop was irrigated.[93] Assuming irrigators received barley subsidies at the same rate as dryland farmers, and assuming the proportion of the barley crop that was irrigated remained constant between 2002 and 2005, subsidies for irrigated barley totaled around $22.4 million.
- The EQIP program helps farmers conserve ground and surface water resources. EQIP funds, for example, allow farmers to convert flood irrigation systems to more efficient irrigation technologies. Between 2004 and 2008, irrigators received $18.6 million in EQIP funds.[94]
- Livestock producers rely heavily on irrigation to produce alfalfa and feed grains, which they feed to their animals throughout the winter months.
- Irrigators may apply for disaster payments when their crops fail, due to drought, flooding, or other natural disasters. It is likely that irrigators face damage from natural disasters just as dryland farmers do, and may disproportionately experience the effects of drought if they plant crops that require more water and sufficient irrigation water does not materialize. On the other hand, irrigation can act as an insurance policy against drought, allowing farmers to produce some crops during droughts when dryland farmers experience near-total crop failure. Data on the extent to which irrigators receive disaster payments are unavailable.

2. State and Local Costs

The State of Montana offers a variety of loans and grants to support irrigation development and irrigated agricultural production. The Department of Natural Resources and Conservation, the Department of Agriculture, and Montana Fish, Wildlife, and Parks manage funds that irrigators can use to plan, design, and construct new infrastructure, rehabilitate existing infrastructure, improve water use efficiency, and retrofit irrigation infrastructure to improve fish passage and habitat. Table 18 summarizes these programs, and the most recent funding levels. Technical Memorandum 1.1 summarizes each of these programs in more detail.

---

[93] U.S. Department of Agriculture, National Agricultural Statistics Service. 2004. "Table 56. Summary by Market Value of Agricultural Products Sold: 2002." *2002 Census of Agriculture: Montana.* Volume 1, Geographic Area Series, Part 26. Report No. AC-02-A-26. June.

[94] Personal Communication with Carrie Mosley, United States Department of Agriculture, Natural Resource Conservation Service, Montana Field Office, on April 21, 2008.

Table 18. State and Local Funding Available to Irrigators in Montana

Program	Funding Level
Irrigation Development Grant Program	$149,720 in 2007-2008
Renewable Resource Grant and Loan Program (irrigation-related projects)	$1,499,355 in 2007-2008
Private Water Development Loans	$15,800,000 in 2006
Renewable Resources Project Planning Grants	$60,000 in 2007
Reclamation and Development Grants Program	Funding Level Not Specified
Fisheries Restoration and Irrigation Mitigation Program	$42,059 in 2007
Growth Through Agriculture	Funding level for irrigators unknown
Conservation District "HB 233" Grants	$17,014 in 2006
Conservation District Technical Assistance Grants	Funding level for irrigators unknown

Source: See sources described in *Technical Memorandum 1.1 – Financial and Technical Assistance Programs for Irrigated Agriculture in Montana.*

B. The Costs of Negative Externalities

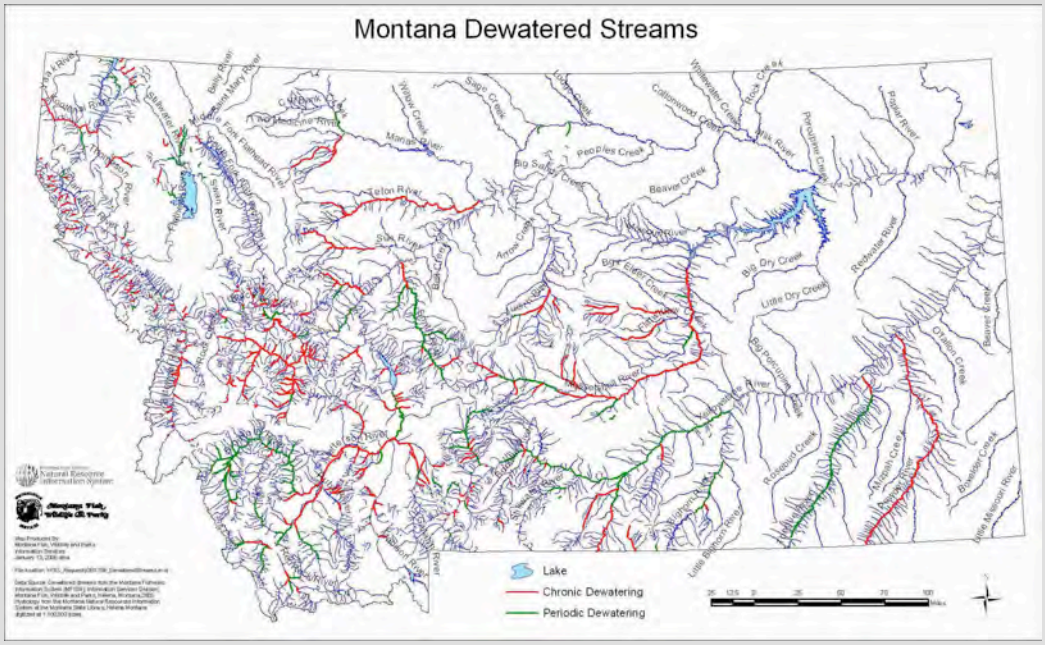
1. Reduction in Instream Flows

When irrigation water is diverted from a stream into a canal or other structure, instream flows are diminished and, perhaps, eliminated. Depending on the extent of the reduction in flows, these irrigation diversions can impose a cost on society by reducing the goods and services that would have been produced if the water had been left in the stream. These goods and services include instream and riparian habitat for fish and wildlife, recreation opportunities, pollution assimilation capacity, and a range of other important ecosystem functions, illustrated in Table 1.

Montana Fish, Wildlife, and Parks (MFWP) estimates that there are over 2,000 miles of chronically dewatered streams in the state. Of these, MFWP has created a list of dewatered streams that support important fisheries by providing spawning and rearing habitat. This list includes 278 streams, which are significantly dewatered, and 103 streams, which are periodically dewatered.[95]

[95] Montana Fish, Wildlife & Parks. 2003. *FWP Dewatering Concern Areas.* Retrieved February 12, 2008, from ftp://ftp-fc.sc.egov.usda.gov/MT/www/programs/eqip/DewateredStreams.pdf and Gosnell, H., J.J. Jaggerty, and P.A. Byorth. 2007. "Ranch Ownership Change and New Approaches to Water Resource Management in Southwestern Montana: Implications for Fisheries." *Journal of the American Water Resources Association.* 43(4): 990-1003.

Figure 5. Montana Dewatered Streams



Source: Montana Fish, Wildlife & Parks

According to MFWP, most stream dewatering is a result of irrigation withdrawals, although dam regulation for power production also contributes to the problem. Most man-made dewatering occurs during the irrigation season (July through September). Figure 5 shows a map of the MFWP's list of dewatered streams.

In response to drought conditions that exacerbated the effects of dewatered streams across the state, the Montana legislature authorized FWP to lease consumptive water rights for up to 10 years to augment instream flows.[96] Since it was grated the authority to do so, it has signed 17 leases, spending more than $260,000 to restore almost 200,000 acre-feet of instream flows. Two private parties are authorized to acquire water rights for instream flows in Montana. Montana Trout Unlimited and the Montana Water Trust have combined acquired more than 57,000 acre-feet of water, spending about $1.3 million over five years. [97] They have acquired individual leases at prices ranging from less than 75 cents to more than $99 per acre-foot.[98]

---

[96] 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

[97] 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

[98] Columbia Basin Water Transactions Program. 2008. *Water Transaction Query [Montana]*. Retrieved May 12, 2008, from http://www.cbwtp.org/jsp/cbwtp/projects/index.jsp

The data in Table 19 show that, in Idaho, the prices at which these transactions have recently occurred range from $2.70 to $100 per acre-foot, with most activity exhibiting prices between $75 and $100 per acre-foot. Similar transactions have begun to the south. In May 2005, the Colorado Water Trust paid $130,000 to a ranch in Summit County for 800 acre-feet of water ($162.50 per acre-foot) to ensure that it flowed through tributaries of the Colorado River, generating benefits for fish and kayakers.[99]

Several researchers have attempted to estimate the value of instream flows in situations where there have been no transactions. One of these looked basin-by-basin throughout the U.S. to discern the values of fishing that would be generated by increasing instream flow by one acre-foot.[100] The study found that, in the four basins that cover eastern Montana, the range of values was $8.00 to $12.60 per acre foot, measured in the dollars of 2007. In contrast, the authors concluded that the marginal value of increasing the supply of water for irrigation in each basin was zero.

Researchers in Colorado recently surveyed households to determine their willingness to pay for activities that would restore a 45-mile section of the South Platte River, near Denver.[101] The activities would take land and water out of agricultural production and, in exchange, improve the supply of five types of ecosystem services: dilution of wastewater, natural water purification, erosion control, habitat for fish and wildlife, and recreational opportunities. Respondents to the survey indicated a willingness to pay of $21 per household per month ($252 per year) for these services.

Table 19. Prices of Water Leases for Instream Flows, Indicated by Recent Water Transactions in Idaho

Length of Term	Water Source	Price ($ per acre-foot)	Activity (acre-feet per year)
Part year to annual	Surface	$75 - $100	300
Annual	Surface	$2.70	2

Source: ECONorthwest, with data from Slaughter, R. A. 2004. *Water Allocation Under Stress: Institutional Comparison of the Snake and Klamath Rivers*, University of Washington, Climate Impacts Group. February 2. Retrieved February 8, 2008, from http://www.cses.washington.edu/review0510/slaughterklamathdraft020204.pdf

[99] Berwyn, B. 2005. "Water Trust Finalizes First Sale." *Summit Daily News*. June 3. Retrieved February 29, 2008, from http://www.summitdaily.com/article/20050603/NEWS/50603032

[100] Hansen, L. T. and A. Hallam. 1990. *Water Allocation Tradeoffs: Irrigation and Recreation*. Economic Report 632. Washington, D.C. U.S. Department of Agriculture, Economic Research Service.

[101] Loomis, J., P. Kent, L. Strange, K. Fausch, and A. Covich. 2000. "Measuring the Total Economic Value of Restoring Ecosystem Services in an Impaired River Basin: Results from a Contingent Valuation Survey." *Ecological Economics* 33: 103-117.

2. Alteration of Natural Flow Regimes

Irrigation-induced alteration of natural flow regimes can have negative impacts on some goods and services. If a fish or other aquatic species is most vulnerable to environmental conditions at the end of the summer, when natural flows are lowest, for example, then agricultural diversions at this time may significantly increase the species' risk of mortality. The effects may occur even during high spring flows. The seeds of cottonwood trees, for example, germinate only during a brief period, when spring floodwaters recede and riparian areas have suitable moisture. By reducing stream flows downstream, dams and diversions may have negative effects on this species, as well as on others that are similarly adapted, and on the goods and services they provide.

Alteration of natural flow regimes may have especially significant, negative effects on the goods and services provided by riparian areas. These paragraphs explain the types of goods and services provided by riparian areas:

> Concerning the aquatic environment, riparia stabilize river banks, protecting soils against surface erosion and strengthen their resistance to destabilization. As a consequence, they improve water clarity by reducing the amount of sediment eroding from river banks, and prevent the silting of sensitive aquatic habitats (for example, the spawning grounds of salmon). Moreover, riparia trap diffuse nutrients in surface or subsurface runoff, thus counteracting the over-enrichment of rivers by phosphorus or nitrogen. In addition, as they reduce light penetration by shading, riparia limit increases in water temperature during the summer and reduce algal and macrophyte growth; they also maintain existing fish stocks through their effects on temperatures, on the diversity of aquatic habitats, and in supporting both aquatic and terrestrial prey species.
>
> Concerning the semiterrestrial environment, riparia form corridors that facilitate the movements of certain species … [and] complement grasslands and agriculture by providing forage, firewood, and other specialized products, they provide habitat for various species of mammals, birds, and invertebrates that may control pests in the adjoining agricultural land, and they form natural screens, protecting crops from direct winds and livestock from extreme heat and cold.[102]

The authors who wrote this summary also addressed the impacts that alterations in the natural patterns of stream flows can have on a riparian area's ability to provide these goods and services. They noted that such alterations affect the ecological integrity of riparian areas—by altering the transport of sediment, reducing peak flows during spring runoff, reducing the frequency of high stream flows, and limiting a stream's ability to establish and maintain new channels, for example. They also observed that, in general, the diversity of plants and animals in riparian areas is highest in areas unaffected by human alteration of the water-regulation processes, and lowest along reservoir shorelines and in other areas where the alterations are greatest. Overall, they conclude: "The alteration of flow

---

[102] Naiman, R.J., P.A. Bisson, R.G. Lee, and M.G. Turner. 1997. "Approaches to Management at the Watershed Scale." In *Creating a Forestry for the 21st Century: The Science of Ecosystem Management*. Edited by K.A. Kohm and J.F. Franklin. Washington, D.C.: Island Press, p. 274.

regimes is the most serious contemporary threat to the ecological sustainability of rivers and their associated floodplains."

To our knowledge, nobody has quantified the extent to which alterations of natural flows in Montana have had these negative effects on the riparian and aquatic goods and services produced by its water-related ecosystem. Moreover, we found no quantification of the economic values associated with these effects. Hence, at this point in time, we offer only this qualitative assessment: ecological scientists generally have concluded that such alterations can unravel the ecosystem's ability to provide such goods and services on a sustained basis.

3. Loss of Riparian and Wetland Habitats

When natural landscapes are converted to agricultural production, wetlands and riparian habitats are often lost in the process. Historically, conversion to agriculture was the primary reason for loss of wetlands in the United States. Today, development accounts for more of the nation's loss of wetlands than agriculture.[103] To the extent that irrigation promotes the conversion of wetlands and riparian areas to agricultural uses, it represents a cost to society. We have previously described the benefits of wetlands, in Section II. If wetlands are lost due to irrigation activities, these benefits would be lost to society, constituting a cost of irrigation.

4. Degradation of Water Quality

Irrigated agriculture can contribute to water quality degradation in two ways: irrigation withdrawals reduce the amount of water available in-stream to assimilate pollutants, and irrigation infiltration and return flows deliver agricultural fertilizers, pesticides and other chemicals to groundwater aquifers and surface water supplies. These effects often impose costs on society and other water users.

The Montana Department of Agriculture has determined that, when irrigation is applied to crops on which farmers have applied pesticides, it can leach pesticide residues into shallow groundwater resources.[104] These resources are often pumped out of the ground for drinking water or to be used as irrigation water. Pesticide leaching into groundwater is highest when irrigation is applied by flooding fields, but it also occurs to a lesser degree with sprinkler irrigation. Because over 60 percent of the irrigation in Montana is flood irrigation, the

---

[103] Heimlich, R.E., K.D. Wiebe, R. Claassen, D. Gadsby, and R.M. House. 1998. *Wetlands and Agriculture: Private Interests and Public Benefits.* Agricultural Economic Report 765. Washington, D.C. Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Retrieved February 12, 2008, from http://www.ers.usda.gov/publications/aer765/aer765.pdf

[104] Montana Department of Agriculture, Agricultural Sciences Division, Technical Services Bureau. 2005. *Irrigation Practices and How They Affect Pesticide Leaching to Ground Water.* July 1. Retrieved February 11, 2008, from http://agr.mt.gov/pestfert/groundwater/GWfactsIrrigate.pdf

potential for shallow groundwater contamination is considerable.[105]

Irrigators can, to a certain extent, reduce impacts to water quality by changing to more efficient irrigation techniques and timing irrigation with a delay after pesticide application, to give pesticides time to assimilate into less harmful compounds in the environment. Irrigators can also install riparian vegetation and wetlands to protect surface water from agricultural runoff.

Several studies illustrate with more detail the ways in which riparian (streamside) buffers can provide pollution-reduction services. One of these built on prior studies, which had found that streamside buffer strips of 50 feet can reduce sediment runoff by 70 to 90 percent, with somewhat lesser reductions for nitrogen and atrazine.[106] It then examined buffer strips of different widths on each side of every stream in a watershed in central Missouri. The authors found that optimal buffer strips would reduce sediment yield from 8.33 tons/hectare/year to 1.25 tons/hectare/year, with nitrogen concentrations dropping 70 percent, and atrazine concentrations dropping 80 percent. The authors also estimated the costs of the buffer strips by estimating the value of agricultural production forgone in the strips, and they estimated the benefits by estimating the value of the increased intrinsic and recreational services associated with the improvements in water quality. They concluded that the benefits were double the costs.

The details of these studies' findings should not be applied in Montana without further investigation, insofar as Montana's agricultural lands and practices are not the same as those that were the focus of these studies. The general findings, however, probably do apply. Riparian buffers in Montana probably do reduce the amount of sediment, nutrients, and other substances reaching and polluting Montana's streams and rivers.

5. Harm to Sensitive Species and Loss of Biodiversity

Irrigation activities have the potential to negatively impact threatened, endangered, and other sensitive species by changing the habitats on which they depend on for survival. For example, water withdrawn from streams can change the flow and temperature, potentially rendering them unsuitable as habitat for trout that need cool, swift flows to thrive. Diversion canals and intake structures can strand fish that find their way into these man-made channels. Studies that count fish that have become entrapped in irrigation canals indicate the scale of the problem in Montana: between 1988 and 1991, the Flathead Agency Irrigation

---

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

[106] Qiu, Z. and T. Prato. 1998. "Economic Evaluation of Riparian Buffers in an Agricultural Watershed." *Journal of the American Water Resources Association* 34 (4): 877-890.

Table 20. Aquatic Threatened and Endangered Species and Montana Species of Special Concern

Species	Status
Arctic grayling	Species of Special Concern
Blue sucker	Species of Special Concern
Bull trout	Threatened
Columbia River redband trout	Species of Special Concern
Lake trout (Native)	Species of Special Concern
Northern redbelly finescale dace	Species of Special Concern
Paddlefish	Species of Special Concern
Pallid sturgeon	Endangered
Pearl dace	Species of Special Concern
Sauger	Species of Special Concern
Shortnose gar	Species of Special Concern
Sicklefin chub	Species of Special Concern
Spoonhead sculpin	Species of Special Concern
Sturgeon chub	Species of Special Concern
Torrent sculpin	Species of Special Concern
Trout-perch	Species of Special Concern
Westslope cutthroat trout	Species of Special Concern
White Sturgeon	Endangered
Yellowstone cutthroat trout	Species of Special Concern

Source: ECONorthwest, with data from Montana Fish, Wildlife & Parks. 2008. *Montana's Threatened and Endangered Species.* Retrieved February 11, 2008, from http://fwp.mt.gov/wildthings/tande/default.html#Endangered, Montana Fish, Wildlife & Parks. 2008. *2006 Species of Concern: Fish.* Retrieved February 11, 2008, from http://fwp.mt.gov/wildthings/concern/fish.html

Division recovered 8,679 trout at 16 irrigation canals; in 1986, an estimated 2,787 salmonids were lost in a canal on the Bitterroot River.[107]

Table 20 lists the threatened species, endangered species, and species of special concern in Montana's rivers, lakes, and streams. Species of special concern are those that Montana Department of Fish, Wildlife, and Parks identifies as "at risk" due to declining population trends, restricted distribution, and threats to their

[107] Gale, S.B. and A.V. Zale. 2005. *Evaluation of Entrainment Losses of Westslope Cutthroat Trout at Private Irrigation Diversions and the Efficiency of Fish Screens on Skalkaho Creek, Montana.* Montana State University, Bozeman, Department of Ecology and United States Geological Survey, Montana Cooperative Fishery Research Unit. January.

habitats.[108] Irrigation most directly affects aquatic species, such as native trout, but it may also affect birds and mammals that depend on healthy fish populations, and healthy aquatic and riparian habitat.

Irrigation's impacts on endangered, threatened, and other sensitive species create costs for society if they reduce populations and adequate habitat, increasing the risk of extinction. The higher risk increases the costs of species protection efforts for the state and federal governments, firms, and households. Economic research has shown that people place a considerable value on the continued survival on endangered and threatened species. The data in the Table 21 show households' willingness to pay to protect some selected species. Updated to the dollars of 2007, these studies found Americans are willing to pay $58 per year per household to protect grizzly bears, and a one-time, lump-sum payment $415 per household to protect gray wolves. If these findings apply today, then these amounts, multiplied times the number of households in the country (111,617,402 in 2006) indicate the total preservation value of the nation's grizzly bears is about $6.5 billion per year, and the value of preserving gray wolves is about $44 billion. Arctic grayling and Cutthroat trout are listed as species of special concern in Montana. These fish can be adversely affected by irrigation practices in Montana. One study showed that westslope cutthroat trout become trapped in irrigation canals during migration, resulting in population loss.[109] The data in Table 21 indicate that each U.S. household would be willing to pay $19 to ensure the continued survival of cutthroat trout, totaling to more than $2 billion.[110]

When environmental resources have been degraded to the point where they jeopardize significant environmental values held by large numbers of people, actions against further degradation and/or incremental restoration to correct past degradation often will yield economic benefits greater than the costs. Many studies have documented this conclusion.[111] For example, an analysis of restrictions on logging to protect habitat for northern spotted owls in the Pacific Northwest found that the benefits outweighed the costs.[112] A study in the Klamath River State found that the potential benefits from managing water to increase salmon production would outweigh costs nine-to-one, even though

---

[108] Montana Department of Fish, Wildlife & Parks. 2008. *Montana's Species of Concern.* Retrieved February 11, 2008, from http://fwp.mt.gov/wildthings/concern/default.html

[109] Gale, S.B. and A.V. Zale. 2005. *Evaluation of Entrainment Losses of Westslope Cutthroat Trout at Private Irrigation Diversions and the Efficiency of Fish Screens on Skalkaho Creek, Montana.* Montana State University, Bozeman, Department of Ecology and United States Geological Survey, Montana Cooperative Fishery Research Unit. January.

[110] U.S. Department of Commerce, Census Bureau. 2006. *2006 American Community Survey: S1101. Households and Families.*

[111] For an overview, *see* Loomis, J.B. and D.S. White. 1996. "Economic Benefits of Rare and Endangered Species: Summary and Meta-Analysis." *Ecological Economics* 18: 197-206

[112] Hagen, D.A., J.W. Vincent, and P.G. Welle. 1992. "Benefits of Preserving Old-Growth Forests and the Spotted Owl." *Contemporary Policy Issues* 10 (April): 13-26.

Table 21. Economic Benefits of Protecting Wildlife Species

Species	Willingness to Pay per U.S. Household
Grizzly bears (annual payment)	$58
Bighorn sheep (annual payment)	$25
Arctic grayling/Cutthroat trout (annual payment)	$19
Bald eagle (one-time payment)	$3,560
Gray wolf (one-time payment)	$415

Source: Loomis, J.B. and D.S. White. 1996. "Economic Benefits of Rare and Endangered Species: Summary and Meta-Analysis." Ecological Economics 18: 197-206. We updated the reported values to 2007 dollars.

these costs would entail reductions in irrigated agricultural production.[113] And another study predicted that the recreational and intrinsic benefits that would be produced by leaving water in a portion of Colorado's South Platte River would be 25 to 60 times the value of the water if it instead were diverted for irrigation.[114]

6. Degradation of Soil Quality

When farmers apply irrigation water to agricultural land, especially in arid or semi-arid areas, the salinity of soil can increase, leading to lower crop productivity and long-term soil degradation. The degree to which this occurs depends on irrigation water quality, evapotranspiration rates, and leaching rates. Researchers have studied the potential for soil quality degradation due to irrigation in parts of Montana, such as the Powder River Basin. One study from 1991 found that it wasn't a problem for irrigators yet, but future declines in water quality would present problems for irrigators.[115] As coal bed methane extraction increases the salinity of surface flows, particularly in the Powder River Basin, the risk of irrigation activities damaging the productivity and health of the Basin's soils will increase.

7. Reduction in Certain Types of Recreation

Several studies have examined values associated with instream flows in Montana's rivers and recreation. Using data from the early 1980s, one study

---

[113] Douglas, A.J. and A. Sleeper. 2002. *Estimating Recreation Trip Related Benefits for the Klamath River State with TCM and Contingent Use Data*. Midcontinent Ecological Science Center, U.S. Geological Survey.

[114] Loomis, J., P. Kent, L. Strange, K. Fausch, and A. Covich. 2000. "Measuring the Total Economic Value of Restoring Ecosystem Services in an Impaired River State: Results from a Contingent Valuation Method Survey." *Ecological Economics* 33: 103-117.

[115] Thompson, K.S. 1991. *Irrigation Water Quality Effects on Soil Salinity and Crop Production in the Powder River Basin, Montana*. M.S. Thesis, Land Resources and Environmental Sciences. Montana State University, Bozeman.

found that decreasing instream flows by 25 percent would diminish recreational fishing values.[116] The incremental lost values per acre-foot of water would be $0.39 on the Flathead River, $1.07 on the Clark Fork, $8.96 on the Yellowstone River, and $11.51 on the Bitterroot River.[117] Another study looked at the recreational and nonuse values associated with instream flows in the upper Missouri Basin, above Ft. Peck Dam, in July and August of 1989.[118] It found that, in the upper portion of this basin, the average value of instream flows ranged from $54 to $103 per acre-foot. In the lower portion of Montana, the average value of instream flows ranged from $8.80 to $16.10 per acre-foot. Another study examined the recreational (trout fishing) values in 1988 associated with instream flows on the Big Hole and Bitterroot Rivers.[119] It found that, at low flows (100 cfs), the incremental value of increasing flows were $16.34 per acre-foot on the Bitterroot and $40.38 per acre-foot on the Big Hole. At higher flows (2,000 cfs), the incremental values were $0.77 per acre foot and $1.74 per acre-foot, respectively.

A study commissioned by the Montana Department of Fish, Wildlife, and Parks reveals estimated non-market values associated with seventeen stream trout fisheries in the state.[120] The economists used two methods to evaluate these socioeconomic values, including one that accounted for the expenses recreationists pay to travel to their respective fishing spots, and found that they ranged between $373 per fishing trip taken to Madison River and $89 per trip taken to the Kootenai, in 2007 dollars. Table 22 shows the values for each stream by method of valuation.

---

[116] Neher, C. 1989. "The Economic Value of Instream Flows in Montana: A Travel Cost Approach." Masters Thesis, University of Montana, cited in Platt, J. 2001. *Economic Nonmarket Valuation of Instream Flows,* U.S. Department of Interior, Bureau of Reclamation. Retrieved February 26, 2008, from http://www.usbr.gov/pmts/economics/reports /Flowpaper1.pdf

[117] We have converted all the estimates reported in this section to their equivalent values in the dollars of 2007.

[118] Duffield, J., C. Neher, D. Patterson, and S. Allen. 1990. *Instream Flows in the Missouri River Basin: A Recreation Survey and Economic Study*. Montana Department of Natural Resources and Conservation.

[119] Duffield, J., C. Neher, and T. Brown. 1992. "Recreation Benefits of Instream Flow: Application to Montana's Big Hole and Bitterroot Rivers." *Water Resource Research* 28(9): 2169-2181.

[120] Duffield, J. and S. Allen. 1988. *Angler Preference Study Final Economics Report: Contingent Valuation of Montana Trout Fishing by River and Angler Subgroup*. Montana Department of Fish, Wildlife, and Parks.

Table 22. Estimated Values per Trip for Stream Trout Fisheries in Montana

River	Value per Trip ($) Travel-Cost Method	Value per Trip ($) Contingent Valuation Method
Madison	373	364
Upper Yellowstone	367	239
Boulder	287	238
Rock Creek	276	147
Big Hole	261	348
Gallatin	257	287
Blackfoot	226	212
Bighorn	193	253
Beaverhead	179	317
Smith	150	244
Stillwater	131	136
Bitterroot	116	94
Md. Clark Fork	108	137
Md. Yellowstone	100	118
Missouri	96	100
Up. Flathead	89	158
Kootenai	89	61

Source: Duffield, J. and S. Allen. 1988. *Angler Preference Study Final Economics Report: Contingent Valuation of Montana Trout Fishing by River and Angler Subgroup*. Montana Department of Fish, Wildlife, and Parks. We have converted the values to 2007 dollars.

Note: These values are presented for illustrative purposes, to show the range of potential values from Montana's fisheries. Not all of these fisheries are necessarily negatively impacted by irrigation activities.

A recent analysis, which looked at the potential impacts on populations of brown trout, a popular fish species among anglers, if water, typically removed from streams in the Salt River Valley of Western Wyoming to irrigate fields, were, instead, left in the streams.[121] Part of the analysis focused on the potential impacts of tripling stream flows, from about 9 cubic feet per second (cfs) to about 27 cfs during summer months. The authors concluded that such an increase would cause populations of adult fish (more than one-year old) to triple. The increased flows would total about 3,200 acre-feet of water over 90 days.

[121] Covington, J. and W. Hubert. 2003. "Trout Population Responses to Restoration of Stream Flows." *Environmental Management* 31 (1): 135-146.

If the findings from this study also apply to areas within Montana, then they indicate some of the economic tradeoffs associated with diverting water for irrigating fields vs. leaving the water in streams. Our review of relevant studies indicates this amount of water, if consumed by irrigation, would have a net value of about $50 per acre-foot of water diverted at the source, or about $160,000 total. Based on consumption averages for agriculture in Montana, about one-third of the amount diverted would be consumed, so the cost, in forgone forage production, would be one-third this amount, or about $53,000. If the higher trout populations were to attract additional fishing activity, valued at $130 per angler-day, as indicated in Table 9, then the cost would be offset if the additional fishing activity exceeded about 408 angler-days.

IV. Net Economic Value of Irrigation in Montana

The information we describe above demonstrates that Montana's water resources produce many valuable goods and services, and using water for irrigation increases the supply of some and decreases the supply of others. That is, it produces both benefits and costs. The gross benefits of irrigation equal the sum of the increase in earnings that irrigation generates for irrigators, relative to what they would earn if their land were not irrigated, and the external benefits realized by others: households, firms, and governmental agencies. The gross costs similarly include a component that is borne by irrigators and one that is borne by others. The net benefit of irrigation equals the gross benefit minus the gross costs.

All of the benefits and costs of irrigation are difficult to quantify, but the externalities typically are more so, relative to the costs and benefits directly associated with irrigators and irrigation systems. Hence, to estimate the net benefit of irrigation in Montana we begin by looking at direct benefits and costs.

In his recent review of past studies, Robert Young focused on the benefits and costs farmers derive from water and observed that, in this context, "The standard measure of the value of irrigation water is the [farmers'] willingness to pay for water at the farm receiving point." He then observed that many factors—including the quantity of water, interest rates, crop-price expectations, and the costs associated with the non-water components of irrigated farming—influence farmers' willingness to pay for water and concluded that "one cannot point to any single measure as *the* value of irrigation water." Against this backdrop he nonetheless estimated farmers' willingness to pay for irrigation water under a set of assumptions he considered "most plausible"—among them, that irrigation would increase the market value of land by about $1,800 per acre, and that farmers would apply about 2.5 acre-feet of water per acre. He concluded that, under these conditions, farmers would be willing to pay about $46 per acre foot for water on the farm, conveying water to the farm from its source would cost

about $15 per acre-foot, and, hence, farmers would be willing to pay about $31 for water at its source.[122]

We see no strong evidence indicating that these numbers do not apply in Montana, at least as a general starting point for understanding the net benefits of irrigation in the state. The net economic benefits of irrigation will vary from place to place and over time. As Montanans evaluate specific irrigation systems or proposals to invest in irrigation, we recommend that they bear in mind these three principles:

- *Prices tell only a small part of the story.* For some of the benefits and some of the costs there is enough information to develop a quantitative estimate of their value, for others there is not. One should not, however, conclude that the former are necessarily more or less valuable than the latter. The presence or absence of quantitative information reflects not the value of a particular good or service but the status of analytical systems for measuring things from which people derive economic value in very different ways. The prices irrigators pay for irrigation water probably do not closely reflect their underlying willingness to pay for the water, and they certainly do not represent the external benefits and costs of irrigation.
- *Prices matter.* In most instances, what people and businesses pay for a good or service influences how much of it they consume. For many uses of the state's water-related goods and services, what people and businesses pay to consume an additional unit is less than the opportunity cost, i.e., less than the cost the economy as a whole incurs to provide the additional unit. This means that, from the perspective of the economy as a whole, people and businesses consume too much. This conclusion particularly applies to irrigation, which is the largest water use in the state. The price irrigators would pay for an incremental increase in water almost certainly is less than the opportunity cost that would be borne by the rest of the economy. The same is probably true for other water uses, such as commercial recreation.
- *Scarcity matters.* The value of a good or service reflects its scarcity. All else equal, the greater the scarcity the greater the value, and vice versa. In other words, as the supply of a good or service decreases, the value of the next incremental decrease rises; as the supply increases, the values of the next incremental increase declines.

  Our discussion above strongly suggests that the supply of water available for irrigation probably is abundant in most places and times, relative to the supply that would be available if irrigators were to pay prices for water that reflect the opportunity cost. The agricultural-production benefit and, hence, farmers' willingness to pay for an incremental increase in supply probably are less than what they were for the previous

[122] Young, R.A. 2005. *See* footnote 8, pp. 186-187. All values in 2006 dollars.

incremental increase. The same is true for the external benefits of irrigation, such as reservoir recreational opportunities. The converse is true for the external costs. These costs arise because irrigation reduces the supply of a good or service. An incremental increase in irrigation would reduce the supply further. The value of this reduction in supply would be more valuable than the value of the previous reduction.

In some instances, extreme scarcity leads to extreme values. This is the case, for example, with threatened or endangered species. Society has determined that it wants to avoid pushing species into extinction. The economic interpretation of this determination is that as the population of a species declines, the economic value associated with losing an additional member of the population rises and, as the population nears extinction, the incremental value can approach infinity. This relationship means that, as they evaluate the net economic benefit of irrigation systems or of investments in them, Montanans should pay particular attention to determining the effect on scarce goods or services where an incremental change would have large economic value.

V. Trends and Future Conditions

Looking forward, the net economic value of irrigation in Montana today is not likely to be the same 10, 50, or 100 years in the future, just as its value 50 years ago was different than it is today. The value of using water for irrigation changes as local, national, and global economic conditions change. This is especially true looking into the future, as the physical conditions that shape the society in which we live, such as weather, seasonal duration, and water availability, are shifting as the effects of climate change set in. Other political, economic, and social trends are also exerting their influence on the economy in Montana, such as the evolution of global free trade and global commodity markets, the progression of amenity-drive growth in the west, and the specter of interstate, intergovernmental, and international conflicts over Montana's water. All of these forces will affect the value associated with irrigated agriculture in Montana.

1. Agricultural Trends and Globalization

Montana's agricultural producers compete in a global market for agricultural commodities; trends and developments worldwide affect farmers, for better or worse, in Montana. Global supply and demand for agricultural products, as well as inputs to agricultural production, such as crude oil, influences the price Montana farmers receive for their goods. This is especially true with commodities, such as wheat and beef.[123] For example, recent high oil prices and policies to address climate change in the U.S. and Europe have led to an

[123] U.S. Department of Agriculture, Economic Research Service. 2008b. "2008 Net Farm Income Is Forecast To Be At Record Level." Farm Income and Costs: 2008 Farm Sector Income Forecast. Retrieved July 18, 2008, from http://www.ers.usda.gov/Briefing/FarmIncome/nationalestimates.htm

increased demand for corn-based ethanol and oilseed for biodiesel production, affecting the production, use, and prices of all kinds of farm commodities.[124] As demand for corn from ethanol producers has increase, it has driven up the demand for and price of substitute crops used for animal feed. This, in turn, has increased the price of beef. As participants in the global marketplace, Montana's agricultural producers will face increasing competition from producers in other countries, which will create a constant pressure to adopt more efficient methods of production. Increasing demand from developing countries, such as China, for beef, will likely increase the price farmers receive for their livestock,[125] increasing their ability to pay for irrigation improvements.

2. Climate Change

It is difficult to predict exactly how climate change will impact irrigated agricultural production in Montana. It is likely that increasing temperatures and changing precipitation patterns will increase demand for water, while at the same time, reduce available supplies during the dry summer months when they are needed for irrigation. Figure 6 shows the results of climate change modeling on expected changes in precipitation and temperature in North America between 1990 and 2030. Warmer temperatures in Montana, which are predicted in the map on the right, will increase demand for water in agriculture by increasing plant evapotranspiration rates, requiring farmers to apply more water per acre of crop. Higher temperatures will also increase demand for water for municipal uses, further exacerbating competition between agricultural and other water users. At the same time, water availability during the summer months, when it is needed most for irrigation, is likely to decline for several reasons. First, as the map on the left in Figure 6 indicates, climate change may cause absolute precipitation to decline slightly in some locations in Montana and moderately to dramatically throughout most of western United States. More importantly, however, as temperatures warm, winter precipitation is expected to fall increasingly in the form of rain rather than snow. Summer irrigation is dependent on the snow pack that builds in the winter and melts slowly during the spring and early summer; in fact, 75 percent of Montana's water supply falls as snow during winter months.[126] This snowpack has already declined by 15 to

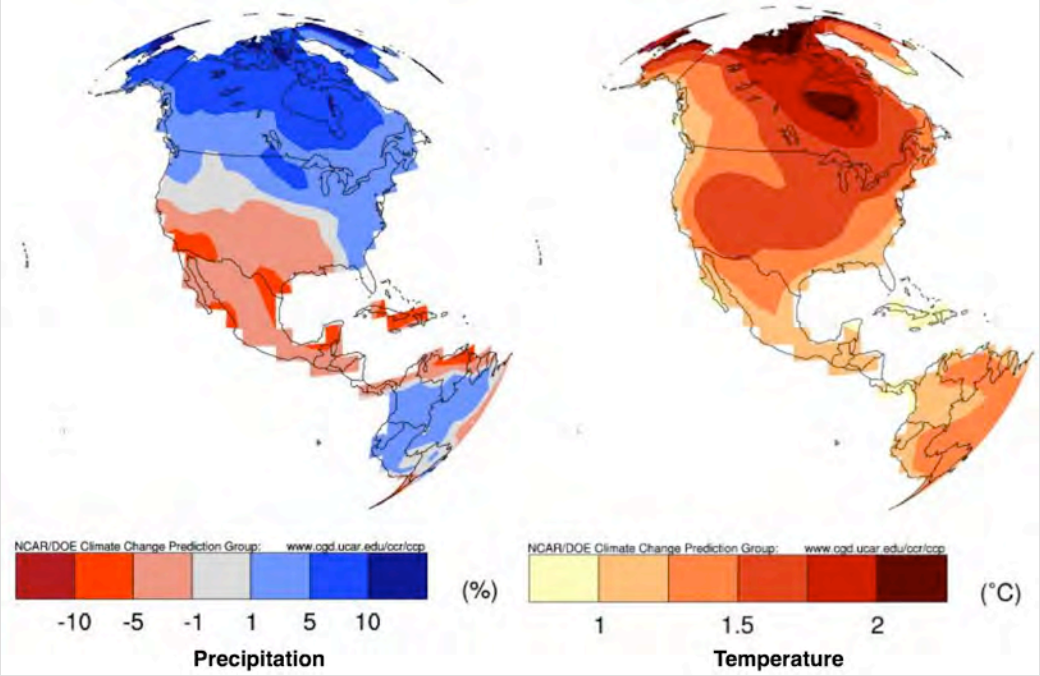
---

[124] U.S. Department of Agriculture, Office of the Chief Economist, World Agricultural Outlook Board. 2008. *USDA Agricultural Projections to 2017.* Interagency Projections Committee. Long Term Projections Report No. OCE-2008-1. February. Retrieved February 22, 2008, from http://www.ers.usda.gov/Publications/OCE081/OCE20081.pdf

[125] American Cowman. 2008. *Strong Meat Demand Supports Higher Prices.* February 11. Retrieved February 22, 2008, from http://americancowman.com/Industry_News/0211-meat-demand-prices/

[126] Karl, T.R., G.A. Meehl, C.D. Miller, et al. 2008. Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands. Synthesis and Assessment Product 3.3. U.S. Climate Change Science Program, Subcommittee on Global Change Research. June. Retrieved July 18, 2008, from http://downloads.climatescience.gov/sap/sap3-3/sap3-3-final-all.pdf

Figure 6. Expected Changes in Precipitation and Temperature, 1990-2030



Source: Tebaldi et al. 2006. "Going to the extremes; An intercomparison of model-simulated historical and future changes in extreme events." *Climatic Change* 79(3-4): 185-211.

30 percent over the last 50 years, and reductions are expected to accelerate with climate change.[127]

It remains unclear how increases in temperature, atmospheric carbon dioxide concentrations will influence agricultural productivity in Montana. Some analyses indicate that crop yields will increase, and the kinds of crops that will grow in Montana will diversify. Other analyses suggest that other changes associated with climate change, such as reduced water availability, may offset these gains in productivity. The only certainty is that agriculture will experience changes directly resulting from the changing climate.

Montana's agriculture is not only a recipient of the benefits or costs associated with climate change, but also a contributor. For this reason, regional, national, and global efforts to mitigate climate change will likely impact Montana's agricultural sector. Agriculture is the second largest source of greenhouse gas emissions in Montana, producing 26 percent of Montana's gross emissions. According to the *Montana Climate Change Action Plan*, agriculture in Montana contributed about 9.5 million metric tons of carbon dioxide equivalent in 2000, accounting for a quarter of the total greenhouse-gas emissions. Enteric

---

[127] Saunders, S., C. Montgomery, T. Easley, and T. Spencer. 2008. *Hotter and Drier: The West's Changed Climate.* The Rocky Mountain Climate Organization and Natural Resources Defense Council. March. Retrieved May 12, 2008, from http://www.nrdc.org/globalWarming/west/west.pdf

fermentation, manure management, agricultural soils, and residue burning were responsible for the most emissions in the agricultural sector. The Governor's Action Plan identified several opportunities to decrease the greenhouse gases: production of renewable fuels, protection of agricultural land from conversion to developed use, and increase the organic carbon in soil by using no-till techniques.[128]

3. Water Conflicts

In recent years, Montana has become involved in conflicts over water quality and quantity with its neighbors. Within the state, long-standing conflicts over tribal rights to water and basin-wide water allocations continue to generate tension among water users. These conflicts, whether involving allocation issues or issues of the quality of water crossing Montana's borders, will provide ongoing sources of uncertainty for irrigators.

Currently Montana is involved in water-related disputes with Wyoming that, depending on the outcomes, may affect both its water quantity and quality in the future. In one instance, Montana filed a complaint with the U.S. Supreme Court against Wyoming, claiming that the neighboring state has violated the 57-year old Yellowstone River Compact by withholding water from the Tongue and Powder rivers for its junior water-right holders at the expense of Montana's senior water users. The principal use of the water in the two rivers in Montana is irrigation.[129] Should the Supreme Court decide in favor of Wyoming, such a decision will have a huge impact on the jobs and incomes in the two basins decreasing the amount of irrigation water that Montanan farmers can claim.

Another dispute that awaits legal settlement has at its core the impacts of coal-bed methane extraction on the water quality. In 2006, four oil and gas companies filed a lawsuit against the State of Montana, claiming that its water standards that regulate salinity levels, are excessively restrictive and harm business. Settlement talks in late 2007 failed to bring all parties to an agreement.[130] The outcome of this suit will undoubtedly impact the ability of some Montana's farmers to withdraw water from streams to irrigate their crops and could increase their irrigation costs.

Water appropriation among competing water users, including irrigators, tribes, and hydroelectric dam operators, has been, and remains a source of considerable

---

[128] Montana Climate Change Advisory Committee. 2007. *Montana Climate Change Action Plan*. November. Retrieved February 12, 2008, from http://www.mtclimatechange.us/ewebeditpro/items/O127F14041.pdf

[129] "State of Montana v. State of Wyoming and State of North Dakota." U.S. Supreme Court No. 137.

[130] Brown, M. 2007. "Settlement Would Protect Tongue, Exclude Other Waterways." *The Missoulan*. November 5. Retrieved February 12, 2008, from http://www.missoulian.com/articles/2007/11/05/bnews/ br87.txt

uncertainty for many irrigators in Montana. Conflicts ensuing from federal and Tribal claims to water, which can be the most senior rights in a basin, are settled by means of negotiating a Water Rights Compact between the state of Montana and the Tribe or federal agency holding the water right.[131]The resulting agreements typically mitigate impacts to other existing water users that would be affected by compact conditions. Tribal and federal reserved water compacts, however, often close basins and constrain the availability of water for future use.

4. Property Values and Amenity-Driven Growth

According to an analysis of property sales in the western part of Montana, real estate values are increasingly reflecting the value of the land for its recreational and amenity value, rather than its value to agricultural production. Increasingly, buyers interested in using the land for hobby ranches, conservation, or recreation are willing to pay more than what the land would be worth if it was used to grow crops. The analysis, produced by an real estate appraiser based in Bozeman states:

> In the past, many buyers look at the underlying productivity of large ranch properties relative to irrigated cropland and native rangeland and considered those to have varying contributory values. It appears that within the context of the current market, buyers are more interested in the overall per acre values associated with these properties, until you get to the very upper side relative to size.[132]

The analysis indicates that property values in eastern Montana are beginning to show a pattern similar to western Montana. Although the analysis did not focus on eastern Montana, appraisers who work in eastern Montana interviewed for the analysis said that values in that market are also increasing, and more properties are being sold for recreational purposes. For example, buyers are purchasing properties along the Milk River and Yellowstone River primarily for bird hunting and recreational uses.

An analysis of ranchland ownership patterns in three counties in the Rocky Mountain West provides more evidence that buyers are increasingly purchasing ranches in Montana for amenity, rather than agricultural, purposes. The analysis looked at property transactions in Carbon County, Montana between 1990 and 2001. During this time, about half of the sales went to investors and amenity buyers. Just twenty-one percent of the purchases were by traditional ranchers.[133]

---

[131] Reserved Water Rights Compact Commission. 2008. "Reserved Water Rights Compact Commission." Retrieved August 28, 2008, from http://dnrc.mt.gov/rwrcc/

[132] Norman C. Wheeler & Associates. 2006. *For Lands Sake: Annual Montana Land Study.* Retrieved February 12, 2008, from http://www.ncwheeler.com/newsletters/2006_for_lands_sakes.pdf

[133] Gosnell, H. and W.R. Travis. 2005. "Ranchland Ownership Dynamics in the Rocky Mountain West." *Rangeland Ecology and Management.* 58(2): 191-198.

This trend could have important implications for irrigated agriculture. As more farms and ranches are purchased for purposes other than agriculture and property values increase to reflect these demands, new farmers entering the market will have a difficult time finding property at a price agricultural production could support. Moreover, fewer irrigators using irrigation delivery systems could translate to higher operations and maintenance costs for remaining irrigators.

Amenity-driven growth and rising property values have already eroded the agricultural base in many places in western Montana, causing irrigation districts to divest their irrigation infrastructure and sell their land to encroaching development or other uses more compatible with urban and suburban landscapes. While it is unlikely that agriculture in eastern Montana will experience pressures from growth to the degree seen in western Montana, the trend towards amenity-driven growth, hobby ranches, and recreational use of private property will increasingly make irrigated agriculture more expensive. These trends are not unique to Montana, and represent a larger landscape of changing preferences underlying competing demands for water across the United States. Demands for water for urban and environmental purposes continue to increase, directly affecting the shape of irrigated agriculture in many locations. The most recent report on the Nation's agricultural resources from the Economic Research Service of the USDA predicts that water withdrawals for agricultural production will likely continue to shift to satisfy these competing demands.[134]

---

[134] Gollehon, N. and W. Quinby. 2006. "Chapter 2.1: Irrigation Resources and Water Costs." *Agricultural Resources and Environmental Indicators, 2006 Edition.* K. Wiebe and N. Gollehon, eds. Economic Research Service. Economic Information Bulletin No. EIB-16. July. Retrieved February 19, 2008, from http://www.ers.usda.gov/publications/arei/eib16/