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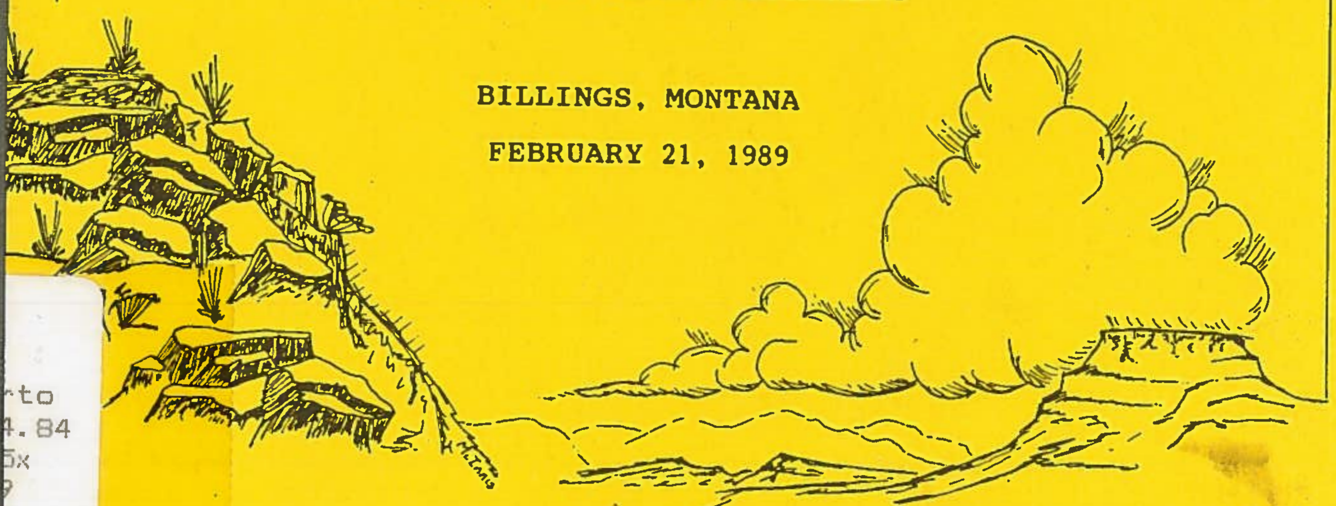
WESTERN REGIONAL COORDINATING COMMITTEE
ON RANGE ECONOMICS

WRCC-55

AT THE

42ND ANNUAL MEETING OF THE
SOCIETY FOR RANGE MANAGEMENT

BILLINGS, MONTANA
FEBRUARY 21, 1989



Economic Value of Riparian Zones in Differing Channel Conditions in Wyoming

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Riparian habitat in the western United States represents a small percentage of the land area, yet the benefits provided by this habitat type are numerous (Thomas, et al, 1979 and Meyer, 1985). Many uses are dependent upon and influenced by riparian habitat, such as: fisheries, wildlife habitat, livestock grazing, recreation, and water quality (King, et al, 1978). Public land managers are aware that these areas are important and justify more intensive management. However, it is difficult for managers to prioritize these areas when dollar values for the benefits resulting from special management practices have not been quantified.

Because economic values for riparian areas are strikingly absent from the literature, there exits a need to study riparian areas to:

1) determine and elucidate the economic benefits of riparian areas in semi-arid western rangeland.

2) determine how economic values may change with differing riparian zone conditions.

3) determine the economic viability of managing riparian areas for increased vegetation production, improved water quality, or changes in the timing of the flow regime.

4) develop a method for applying dollar values to the measurable physical, chemical, and biological parameters associated with riparian

areas.

A logical approach in addressing these needs was to conduct a review of the literature regarding dollar values reported from previous water research studies that could be applied to specific uses of riparian zones. The dollar values could then be applied to the parameters measuring the various uses of riparian areas in the western United States. The following study objectives are addressed by this paper and presentation:

1) Determine the economic benefits of riparian areas located in cold desert shrub zones characteristic of the central Rocky Mountain Region using values published in previous water research studies.

2) Determine if economic benefits vary with stream channel conditions and their associated riparian zones by applying appropriate per unit values to vegetation, water quality and ground water storage measurements.

3) Determine the cost effectiveness of using instream structures as a method to change stream channel conditions and their associated riparian zones.

PERTINENT LITERATURE

A literature search was conducted to locate published economic values that may be applied to the uses associated with riparian areas. The Selected Water Resources Abstracts from 1975 to August 1987 were reviewed using the following subject catagories: "Costs", "Cost-Benefit", "Economics", "Riparian", "Value", "Water Resources Development", and "Watershed". As appropriate journal and technical articles were located, their respective bibliographies were reviewed for additional pertinent literature. The table of contents of selected journals and several symposia proceedings were reviewed. A Bibliography Database Search of 9 database indices was also conducted.

Economic values were summarized into tables showing the pertinent dollar values that were located in the literature. There was little or no continuity in how water values are reported. They appeared as prices paid, residual values or willingness to pay. In order for the values to be as comparable as possible, all were converted to a net, annual value when adequate information was presented.

Vegetation Values for Livestock and Wildlife: The most straight forward value to estimate was the value of increased production of forage for livestock. Markets for forage for livestock do exist, commonly sold on an Animal Unit per Month (AUM) basis. A comprehensive study of livestock forage markets in the West was conducted through a joint effort of the Forest Service and Bureau of Land Management (USDA-F.S. & USDI-BLM). Table I reflects the private lease rate and the fair market value for Area 3 which included portions of Wyoming, Colorado, New Mexico, Montana, Idaho and North Dakota.

Quantifying the value of increased vegetation production for wildlife was more difficult. Values of game species can be estimated by determining expenditures made by hunters while pursuing these species or

TABLE I. LIVESTOCK PRIVATE LEASE RATE, FAIR MARKET VALUE, AND FEDERAL LEASE RATE[1]

AUTHOR	YEAR	PRIVATE LEASE RATE		FAIR MARKET VALUE		FEDERAL LEASE RATE $/AUM
		YEARLINGS $/head	MATURE CATTLE $/pair	YEARLINGS $/head	MATURE CATTLE $/pair	
USDA-FOREST SERVICE & USDI-BLM	1985	$6.25	$8.00	$5.90	$7.60	$1.35

[1] Combined effort of the two agencies to document fair market and private lease rates throughout the western U.S.

by estimating the willingness to pay (WTP) of the hunters. Hunter expenditures per day and per license were obtained for residents and non-residents from Wyoming and Colorado and are included in Table II.

The Wyoming Game and Fish Department estimated hunter expenditures per license for residents. The values varied from $83.99 for black bear to $1,188.00 for Bighorn Sheep. Antelope and moose hunter expenditures /license were $145.54 and $429.51, respectively. Non-resident expenditures/license for the same species were: Black Bear-$126.20; Bighorn Sheep-$2,933.44; Antelope-$445.89; and, Moose-$898.17 (Wyoming Game and Fish, 1985).

A similar survey of hunters in Colorado was conducted by McKean and Nobe (1983), who reported fixed and variable costs/license for resident and non-resident hunters. Resident variable costs ranged from $101 for antelope to $140 for deer. Non-resident expenditures varied from $101 to $473 for antelope and deer, respectively.

Sorg and Loomis (1984) determined expenditures/day for resident and nonresident hunters combined for deer, waterfowl and small game. Deer expenditures varied from $131.80 in Colorado to $47.05 in Arizona. Waterfowl expenditure/day was highest in Wisconsin at $84.73/day, and lowest in the Intermountain region at $32.34/day.

Loomis, et al (1985) determined net willingness to pay (WTP) for big game species in Idaho. Values ranged from $73 for antelope to $360 for Mountain Goat. Net WTP is a more accurate measure of what the wildlife is worth than are expenditure methods. The expenditures values represent the gross amount spent on the hunt. It is likely that some of

TABLE II. EXPENDITURES PER DAY AND EXPENDITURES PER LICENSE FOR RESIDENT AND NON-RESIDENT HUNTERS OF VARIOUS WILDLIFE SPECIES

AUTHORS	YEAR	RESIDENT		NON-RESIDENT		COMBINED	
		PER DAY EXPENDI-TURE $/day	EXPENDITURE PER LICENSE HOLDER $/license	PER DAY EXPENDI-TURE $/day	EXPENDITURE PER LICENSE HOLDER $/license	PER DAY EXPENDI-TURE $/day	EXPENDITURE PER LICENSE HOLDER $/license
WYOMING GAME & FISH DEPARTMENT	1985						
Antelope		$ 91.66	$145.54	$195.86	$445.89	$150.67	$288.72
Deer		48.94	195.80	126.58	502.80	74.86	298.45
Elk		68.54	329.86	220.07	1,178.83	90.34	441.25
Moose		89.17	429.51	199.69	898.17	110.07	523.16
Bighorn Sheep		103.00	1,188.10	360.73	2,933.44	152.04	1,624.44
Black Bear		5.64	63.99	22.30	126.20	8.96	100.70
Upland Bird/Waterfowl		30.06	177.72	40.85	252.37	31.24	185.62
Turkey		62.34	130.04	140.89	389.94	77.92	170.89
Small Game		88.45	359.70	69.02	288.38	87.48	356.22
SORG & LOOMIS	1984						
Deer (Colorado)						131.80	
Deer (Arizona)						47.05	
Deer (Pennsylvania)						128.59	
Waterfowl (Wisconsin)						84.73	
Waterfowl (Pacific Flyway)						61.11	
Waterfowl (Intermountain)						32.34	
Small Game (Idaho)						42.58	
Small Game (Intermountain)						22.42	

TABLE III (con't).

AUTHORS	YEAR	RESIDENT VARIABLE COSTS $/license	RESIDENT FIXED COSTS $/license	NON-RESIDENT VARIABLE COSTS $/license	NON-RESIDENT FIXED COSTS $/license	WETLANDS CONTRIBUTION $/acre/year	COMBINED RESIDENT & NON-RESIDENT PER DAY EXPENDITURES $/day	NET WTP* PER LICENSE $/license
MCKEAN & NOBE	1983							
Colorado (1981 dollars)								
Antelope		$101	$870	$101	N/A			
Bear		105	210	105	152			
Deer		140	507	473	905			
Elk		137	585	459	853			
Fishing		300	815	482	774			
Small Game		215	780	215	150			
JAWORSKI & RAPHAEL	1978							
(Michigan)								
Sport Fishing						$286.00		
Nonconsumptive Recreation						138.24		
Waterfowl						31.23		
Trapping furbearers						30.44		
LOOMIS, ET AL	1985							
(Idaho)								
Bighorn Sheep							$ 28.00	$239.00
Mountain Goat							90.00	360.00
Moose							19.00	113.00
Antelope							38.50	73.00
SORG AND NELSON	1986							
Elk							22.57	

* Net Willingness to Pay per permit using the Travel Cost Method

the money would have been spent elsewhere in the economy. Net WTP reflects the net amount directly attributable to the wildlife hunting license.

Jacobs, et al (1987) determined the average trespass fee charged by Wyoming land owners to be $17.44 per day. The average hunt for deer and antelope was four days long.

Water Quantity Values: The value of water will vary greatly with the use and location of the water. The value of water can be determined from the payments made by various users for an acre foot of water, or can be based on the cost of developing water storage. Table III shows values of water to various users in different areas. Wilson and Ayer (1982) found the value of water to irrigators to be between $2.21/acre foot in Utah to $26.75 in Oregon. Young (1983) found irrigation water values from $7/acre foot in the Imperial Valley of California to $45/acre foot for ground water from the Ogallala aquifer.

Young also surveyed industrial users and found them paying up to $600/acre foot for use in cooling towers. A proposed coal slurry operation from Colorado to Texas was willing to pay up to $1,600/acre foot. Values reflecting purchases of perpetual water rights need to be annualized to be comparable to other reported values. Annualized values range from $30.30/acre foot to $142.12/acre foot for industrial users. The value of water for municipal uses varied from $150/acre foot/year for lawn watering to $250/acre foot/year for in-house use. Water for these municipal uses would be of a higher quality since it would have been through municipal treatment. These values at-the-tap

TABLE III. VALUE OF WATER USED FOR IRRIGATION, INDUSTRIAL, MUNICIPAL, DILUTION AND HYDROPOWER PURPOSES, ANNUAL VALUES

AUTHOR	YEAR	IRRIGATION $/acre foot	INDUSTRIAL $/acre foot (as reported)	INDUSTRIAL $/acre foot (annualized at 6% for 40 years)	HOUSEHOLDS $/acre foot	DILUTION $/acre foot	HYDROPOWER $/acre foot
YOUNG	1983						
(1982 dollars)							
Upper Colorado and Snake Rivers		$10-15					
Southwest and central California		20-25					
Groundwater-Ogallala aquifer		40-45					
Platte River Basin		25					
California							
Central Valley		23-25					
Imperial Valley		7					
Cooling towers			$ 600	$ 30			
Coal Slurry (Colorado to Texas)			1,600	142			
Households							
Lawn watering					$150		
In-house use					250		
Colorado							
Irrigation							
Coal mining							
Electronics							
YOUNG & GRAY	1985						
Western States							$ 3.30-10.00
Columbia River Basin							30.00
Oregon						$ 1.30	
Lower Missouri River Basin						3.25	
Lower Colorado River Basin						15.00	

TABLE III (con't).

AUTHOR	YEAR	IRRIGATION $/acre foot	INDUSTRIAL $/acre foot
YOUNG & GRAY	1972		
Sevier Basin, Utah Short Run Rental (1959 dollars)		9.60	
South Platte, Colorado			
Early season rental		3.50	
Late season rental		4.85	
Southeast Wyoming (1970 dollars) Short run marginal value			
1st acre foot applied		17.60	
2nd acre foot applied		12.50	
Mountain meadows		2.00	
Southwest Utah (1966 dollars)			
Marginal value: 1st acre foot		22.00	
5th acre foot		8.00	
Long Run Analysis			
Salinas Valley (1970 dollars)		11.60-16.40	
South central Nebraska (1966 dollars)		7.00-12.00	
No. Dakota (1968 dollars)		18.38	
Maryland (1966 dollars)			Steel $13.03
California (1970 dollars)			Steel 4.89
Arizona (1963 dollars)			Minerals 3.26-6.52
Various (1963 dollars)			Paper 26.06
Great Plains			Sugar Beet Processing 37.15
Mexico			Chemicals 22.81

would not be comparable to the other values given due to the improved quality.

Young and Gray (1985) reported values from $1.30/acre foot in Oregon to $15/acre foot in the lower Colorado River basin for dilution of salinity and other pollutants. Water used for hydropower ranged in value from $3.30 to $10.00/acre foot/year in the western states to $30.00/acre foot/year in the Columbia River basin.

The cost of developing water for later use or for a more constant supply can be expressed two different ways. One is to divide the annualized construction cost (40 year planning horizon at 4% and 8% opportunity costs) of the facility by the number of acre feet it will hold. This calculation is shown in Table IV. As reported by the U.S. Army Corps of Engineers (1986) in their draft Environmental Impact Statement (EIS) for proposed water development along Colorado's Front Range, $/acre foot of capacity can range from $22.51/acre foot/year for the Two Forks proposal to $83.11/acre foot/year for the Estabrook dam and reservoir.

Not all the water in a facility can be used because of prior appropriations, variability in annual supply, and reservoir dead space. The amount actually available for use by the entity constructing the facility is the firm yield. The annualized construction cost divided by the firm yield is also shown in Table IV for several facilities. The cost/firm yield for projects under consideration by the Wyoming Water Development Commission (1984) range from $29.64/acre foot for the proposed Fish Creek Dam to $344.19/acre foot for the proposed Upper

TABLE IV. FIRM YIELD, STORAGE CAPACITY, CONSTRUCTION COST, ANNUALIZED COST/FIRM YIELD, & ANNUALIZED COST/CAPACITY FOR VARIOUS WATER DEVELOPMENT PROJECTS AT 4 AND 8% OPPORTUNITY COST OVER 40 YEARS.

AUTHOR	YEAR	FIRM YIELD ac. ft.	STORAGE CAPACITY ac. ft.	CONSTRUCTION COST $1,000	ANNUALIZED CONSTRUCTION COST/CAPACITY AT 4% $/acre foot	ANNUALIZED CONSTRUCTION COST/CAPACITY AT 8% $/acre foot	ANNUALIZED CONSTRUCTION COST/FIRM YIELD AT 4% $/acre foot	ANNUALIZED CONSTRUCTION COST/FIRM YIELD AT 8% $/acre foot
WYOMING WATER DEVELOPMENT COMMISSION	1984							
Upper Savery Dam		9,600	40,000	$ 65,400	$62.61	$137.11	$344.19	$571.30
Pot Hook Dam		31,200	61,600	26,300	21.57	35.38	42.59	69.85
Sandstone Dam		25,700	52,000	61,300	59.56	98.86	120.51	200.02
Three Forks Dam		73,000	100,000	73,900	37.34	61.97	51.15	84.89
Fish Creek Dam		45,000	60,000	26,400	22.23	36.90	29.64	49.20
U.S. CORPS OF ENGINEERS	1986							
Colorado								
Two Forks (1.1 mil. AF)		98,000	1,100,000	490,000	22.51	37.36	256.62	419.30
Two Forks (400,000 AF)		62,000	400,000	310,000	39.16	64.99	252.62	419.30
Estabrook (400,000 AF)		58,000	400,000	451,000	56.97	94.55	392.66	652.06
Estabrook (200,000 AF)		46,000	200,000	329,000	83.11	137.95	361.35	599.78
Cheesman		68,000	743,000	680,000	46.24	76.75	505.23	838.60

Savery Dam, at a 4% discount rate.

Population increases in cities in the West and Southwest have created a need for these cities to expand their water supplies. Saliba, et al (1987) reviewed the costs of water development to several cities. The water purchases were shares of water stock, land purchases for the accompanying surface appropriations, or groundwater rights. Values ranged from $3.50/acre foot for the West Coast Basin of California to $202.00/acre foot in the Gila Basin of New Mexico at 4% opportunity cost, as shown in Table V. If groundwater rights are developed by municipalities, there may be significant costs associated with transporting the water from the well locations to the city for treatment and use that are not reflected in the above values.

Recreation Values Associated with Riparian Habitat: Riparian zones provide numerous recreational opportunities such as fishing, kayaking, picnicing, and camping. Quantifying the value of these opportunites is similar to the approach described for game hunting. Participants are asked to estimate what the opportunity is worth to them or to estimate their willingness to pay (WTP). Their WTP can be reflected on a per day or per acre foot basis, as shown in Table VI.

Daubert (1979) interviewed fishermen at the Poudre River in Colorado to determine their WTP/day/acre foot at various flow levels. Fishermen had the highest WTP during low flows at $13.30/day/acre foot at flows of 50 cubic feet per second (cfs). At flows greater than 500 cfs, fishermen reported negative WTP's because high flows hinder the fishing experience.

TABLE V. COST OF PURCHASING ADDITIONAL WATER RIGHTS BY MUNICIPALITIES, ANNUALIZED BASED ON 40 YEAR PAYMENT PERIOD AT 4% AND 8%.

AUTHOR	YEAR	COST TO MUNICIPALITIES $/acre foot	ANNUALIZED COST AT 4% $/acre foot	ANNUALIZED COST AT 8% $/acre foot	ORIGIN OF WATER RIGHT
SALIBA, ET AL	1987				
(1986 dollars)					
Tuscon, AZ		$650-850	$ 32.84-42.94	$ 54.51-71.28	LAND PURCHASE
Mesa, AZ		1,000	50.52	83.86	" "
Phoenix, AZ		1,500	75.79	125.79	" "
Scottsdale, AZ		1,300	65.68	109.02	" "
California					
Central Basin		184	9.30	15.43	GROUNDWATER RIGHTS
West Coast Basin		70	3.54	5.87	" " "
Northern Front Range, Colorado		1,000	50.52	83.86	SHARES OF WATER STOCK
Aurora, CO		2,675	135.15	223.33	" " "
Colorado Springs, CO		1,600	80.84	134.18	" " "
Pueblo, CO		2,500	126.31	209.65	BOUGHT FROM AURORA, CO
Fallon, Nevada		300	15.16	25.16	GROUNDWATER RIGHTS
Reno-Sparks, NV		1,500	75.79	125.79	LAND PURCHASE
Reno-Sparks, NV		7,000	353.66	587.02	GROUNDWATER RIGHTS
Gila Sub-Basin, New Mexico		2,000-4,000	101.05-202.09	167.72-335.44	LAND PURCHASE
Silver City, NM		2,300	116.20	192.88	GROUNDWATER RIGHTS
Sevier River Basin, Utah		350-700	17.68-35.37	29.35-58.70	PURCHASE OF WATER STOCK

TABLE VI. RECREATION VALUES ASSOCIATED WITH RIPARIAN HABITAT

AUTHOR	YEAR	VALUE $/ACTIVITY DAY	WTP/DAY/ ACRE FOOT	WTP MARGINAL BENIFITS/ ACRE FOOT/ DAY
WALSH	1980			
(Colorado)				
WTP at 35% of maximum flow				
Fishing				$13.08
Kayaking				3.60
Rafting				2.36
DAUBERT	1979			
(Colorado)				
Fishing				
cfs				
50			$13.30	
100			11.70	
200			8.54	
300			5.37	
400			2.19	
500			- .98	
600			-4.15	
DONNELLY, ET AL	1985			
Steelhead fishing		31.45		
CLARK, ET AL	1985			
(1978 dollars)				
Cold water fishing		10.96-24.09		
Warm water fishing		9.65-21.43		
Catfish/Rough fish		7.00-16.03		

Sorg and Loomis (1984) combined several previous studies of recreation WTP per activity day. Values for cold water fishing ranged from a WTP of $8.58 per fishing day in Kentucky to $37.75/day in Washington. Warm water fishing reflected a much narrower range of values from $22.70/day in Georgia to $26.35/day inFlorida. Values per day for camping range from $6.70/day in Idaho to $26.18/day in Arizona.

Water Quality Values: The value of water is also dependent upon the quality of the water and its suitability for a particular use (Sutherland, 1982, Walsh, 1978, and Kleinman, 1974). Much of the arid West has erodible soils that contain highly alkaline or salty components (Howe and Orr, 1974). The water reaching the lower Colorado River basin contains a high percentage of salts (Miller, et al, 1981). Table VII shows that the costs associated with salinity can be very high in this region. Estimates of annual total damages were $447,700 for each mg/l increase in salinity and municipal damages were $291,000/mg/l increase/year (Evans, 1981). Costs in the upper Colorado River basin are much lower at $30-82/ton of salt removed (Howe and Orr, 1974, and Jackson, et al, 1985).

The effects of water quality on recreation has also been examined and some results are shown in Table VIII. Sutherland (1982) contacted recreation planners in the Pacific Northwest and asked them to estimate the number of recreation facilities that could be constructed if water quality were improved. The estimated value/mile of river improved varied from $2,325/mile/year for Washing ton to $3,098/mile/year for Idaho. Walsh (1978) estimated WTP of Front Range residents in Colorado

TABLE VII. COSTS ASSOCIATED WITH INCREASED SALINITY

AUTHOR	YEAR	SALINITY $/mg/l/YEAR	SALINITY $/ACRE/mg/l/YEAR	COST/ACRE/YEAR	$/TON OF SALT/YEAR
EVANS	1981				
Soil Conservation Service Lower Colorado River Municipal damages		$291,000			
Agricultural damages		124,800			
USDI-Water & Power Resources Service Imperial Dam-total damages		447,700			
FRANKLIN, ET AL	1983				
Big Sandy Project, Wyoming					
Cost in Wyoming					$ 30.00
Charge to Wyoming for increased salinity at Imperial Valley					133.94
KLEINMAN, ET AL	1974				
Direct Salinity Impacts to Agriculture		66,900	$0.0621		
Total Impact to Agriculture		108,400	0.1007		
Southern California		45,600	0.0649	$20.77	
Lower Main Stem-Colorado River		13,000	0.0556	19.04	
Gila River area		8,300	0.0533	17.09	
Per household annual cost		.0514-.1747			
Industrial impacts		1,500			
Total impacts for lower basin		83,800-285,000			
JACKSON, ET AL	1985				
Lower Wolf Creek-northwestern Colo.					82.39

TABLE VI (con't).

AUTHCR	YEAR	WTP VALUE $/activity day
SORG & LOOMIS	1984	
Cold Water Fishing		
Coloradc		$11.99
Arizona		25.75
Intermountain		15.59
Idaho		11.57
Washington		37.75
Kertucky		8.58
Missouri		19.43
New York		37.28
Warm Water Fishing		
Arizona		23.41
Louisiana		25.69
Georgia		22.70
Florida		26.35
Camping		
Cclcrado		12.41
Arizona		26.18
New Mexico		15.00
Idaho		6.70
Washington		11.40
New York		18.60
Picnicing		
Cclcrado		6.53
Arizona		28.54
New Mexico		10.26
California		7.75
Nonmotorized bcating		
Colorado		14.65
Idaho		76.85
Utah		33.22
Washington-Oregon		6.28

TABLE VII (con't).

AUTHOR	YEAR	$/mg/1/YEAR	$/TONS OF TDS/YEAR
USDI-BUREAU OF LAND MANAGEMENT	1977		
Environmental Protection Agency Average annual agricultural damage		45,900	
Kleinman Average annual agricultural damage when salinity 1300-1400mg/1		76,865	
Valentine (1974 dollars) Municipal damages		124,300	
Anderson & Kleinman Municipal damages		240,500	
EPA Industrial damages		1,148	
USDA-MEDICINE BOW NATIONAL FOREST	1981		
Cost at Imperial Dam of increasing salinity in Wyoming		469,000	
HOWE & ORR	1974		
Upper Colorado River (Colorado)			$20-40

TABLE VIII. RECREATION VALUES ASSOCIATED WITH IMPROVED WATER QUALITY

AUTHOR	YEAR	ANNUAL RECREATION VALUE (1979 DOLLARS)	GENERAL QUALITY IMPROVEMENTS		WTP/ HOUSEHOLD	WTP/ MILE OF STREAM
			MILES OF DEGRADED RIVER	VALUE IN $/MILE OF RIVER/YEAR		
SUTHERLAND	1982					
Annual Recreation Benefits						
Washington		$5,107,656	2,197	$2,325		
Oregon		6,435,952	2,614	2,462		
Idaho		7,264,805	2,345	3,098		
WALSH, ET AL	1978					
South Platte River Basin, Colorado						
Annual benefits from improved water quality						
Recreation Use Value					$45.80	$3,206
Option Value					18.22	1,275
Existence Value					24.98	1,749
Bequest Value					17.00	1,190

using a bidding game. They were asked how much they were willing to pay based on increased sales tax to remove heavy metals that remained in the river from old mining opera tions. The WTP per mile of stream for recreation use was $3,206.

The costs resulting from sedimentation can be expressed in cost/acre foot of lost storage or in $/ton of sediment (Table IX). Crowder (1987) estimated the annual cost/acre foot of storage lost in the Mountain states and Northern Plains reservoirs to be $500/acre foot. The BLM (USDI-BLM, 1977) estimated the cost/ton of sediment at $0.58/ton for loss in capacity at Lake Powell.

RIPARIAN CASE STUDY AND VALUE DETERMINATION

The following values discussed in the Pertinent Literature above were applied to measured changes at a study area in Wyoming. The USDA-FS/USDI-BLM (1985) findings of $1.35 for the Federal lease rate and $8.00 for the private lease rate were used for domestic livestock. Two values were utilized for increased wildlife production: average trespass fees charged by Wyoming land owners (Jacobs, et al, 1987) and the WTP value for antelope presented by Loomis, et al (1985).

Stored groundwater used for irrigation was valued at $12.50 per acre foot, an average of the upper Colorado River basin and Snake River area presented by Young (1982). A range of $30 to $142 per acre foot was used to value groundwater for industrial uses, also from Young. An average of the annualized values from Saliba, et al (1987) represented

TABLE IX. COSTS OF SEDIMENTATION IN RESERVOIRS

AUTHOR	YEAR	STORAGE CAPACITY LOST ANNUALLY (1,000 AC. FT)	SEDIMENTATION: COST PER YEAR OF SEDIMENTATION DUE TO LOST CAPACITY (MILLIONS OF $)	SEDIMENTATION: COST/ACRE FOOT OF SEDIMENTATION $/ACRE FOOT	DREDGING	$/TON OF SEDIMENT REDUCED
CROWDER	1967					
Northern Plains		184.6	$ 92.3	$500		
Mountain States		302.5	151.3	500		
Dredging					$2,500/acre foot	
CLARK, ET AL	1985					
Michigan					5.29/cu. yard	
USDI-BUREAU OF LAND MANAGEMENT	1977					
Lake Powell						$0.58

conditions and the associated riparian zone.

A management strategy utilizing instream, wire faced dams has been implemented within the RSR study area. These structures are constructed of woven wire, steel posts, synthetic erosion mat fabric, and used, discarded tires. They are anchored in straight sections of the stream by digging trenches into the bank and attaching the woven wire to fence posts placed in the trenches as well as in the stream itself. The dams, approximately 36 centimeters high, trap sediment which raises the channel bottom. This increase causes overbank flooding during periods of high flow. Increased vegetation production, sediment deposition on banks, and increased groundwater recharge and storage may then result.

Case Study Dollar Values: The data available from the Muddy Creek study area allows for the estimation of economic values associated with riparian areas. Actual parameter measurements from Muddy Creek were multiplied by the dollar values determined from the presented pertinent literature.

The comparison of values from the DSR and the RSR of Muddy Creek will show if there is a difference based on riparian area channel type. Comparison of data collected on the RSR prior to instream structure installation or on control areas downstream, with data collected after the structures are in place will allow for a determination of the economic desirability of the instream strucures. A planning horizon of 30 years and discount rates of 4%, the interest rate charged by the Wyoming Water Development Commission, and 8% will be used to determine the long term benefits of riparian reclamation.

Summaries of expected benefits from riparian areas in differing channel conditions and from riparian reclamation will be presented from three points of view. The first will show the direct benefits to a private land owner. The second will be from a Federal agency's point of view and will include benefits realized by socity as a whole. The third will include the possibility of use of stored groundwater by agriculture, industry or municipalitites. The total benefits for each of the 3 scenarios will be divided by the total hectares of riparian habitat in the DSR and the RSR to obtain a value/area. Total benefits will also be shown on a per kilometer of stream basis.

<u>Vegetation:</u> Benefits from increased vegetation production can be quantified by determining the additional livestock or wildlife the increased forage will sustain. For livestock, markets do exist based on Animal Unit Months (AUM). To quantify wildlife values, the increase in hunter access fees or the WTP values of additional licenses will be estimated.

Total above ground biomass at Muddy Creek was sampled annually from 1984 through 1987 on 19 cross sections on the straight sections in the RSR. Sampling was also done on 3 meanders in both the DSR and the RSR in 1986 and 1987. On each of the 19 sites in the RSR, 5 cross sections were identified on both the right and left bank. Each bank was further divided into lower bank, middle of the floodplain, and the upper floodplain. At each of the three locations per cross-section, one permanent half meter circular plot was established and vegetation inside was weight estimated. A second plot was located in the interspace the range, $85-143 per acre foot, of values to municipalities.

Values for sediment storage were derived from Crowder (1987) who reported $.27 per ton of sediment, and the BLM Salinity Status Report (USDI-BLM, 1977), at $.58/ton. A range of $30 to $82 per ton of salt was used to value salt storage. These values were published by Franklin, et al (1983) and Jackson, et al (1985), respectively.

<u>Study Area Description:</u> Muddy Creek is a perennial stream typical of those draining cold desert shrub foothills in the semi-arid western United States, and is a tributary of the Green-Colorado River system. The study area is located approximately 40 kilometers north of Baggs, Wyoming in the south central part of the state. Historic use of the Muddy Creek drainage basin includes livestock and wildlife grazing, recreation, and oil and gas production. The study area includes 12 kilometers of Muddy Creek which has been divided into 2 sections based on stream channel morphological characteristics. The first section is 5 kilometers long and is downstream from active head cutting. Floodplains are developing within the new channel. This reach provides an opportunity to study degraded channel conditions and associated riparian zones.

The second is 7 kilometers long and is the location of stream channel restoration (RSR -restoring stream reach). This reach is 31.7 kilometers downstream from the DSR (degraded stream reach). It contains a channel with mature floodplains and is located immediately below Muddy Creek's confluence with an ephemeral stream that carries large sediment loads. This reach provides an opportunity to study restoring channel between cross sections at each bank level where production was estimated and then clipped. For each instream structure site, 60 plots were measured each year.

For the 3 meanders in each study area, vegetation was sampled in June, July and August at three bank locations; stream side, middle of the floodplain and upper floodplain. A similar weight estimation and clipped sampling scheme was used for meander sampling.

To determine potential livestock benefits, total above ground biomass was determined for both study areas by multiplying the sample data by the area, which was determined from aerial photos using an electronic planimeter. Surface areas in square meters for the two Muddy Creek study areas are as follows:

	Area (m^2)	
	Meanders	Straights
DSR	11,125	2,509
RSR	27,809	10,097

Total vegetation production was converted to AUMs, at a conversion rate of 363.6 kg equalling one AUM. A utilization rate of 65% was assumed. Values per AUM of $1.35, the current Federal lease rate, and $8.00 the average private lease rate were used to estimate a range of values of forage production to domestic livestock. The 1984 vegetation production level is assumed to stay constant over the 30 year planning horizon to compare production with the structures to production without the structures being installed.

Indirect methods of valuing vegetation production for wildlife must be used since no markets exist for forage for wildlife production. A study by Severson, et al, (1980) in the Red Desert of Wyoming showed that antelope diets in that area consisted of 98% shrub species. The assumption was made that since the only shrub species located in the riparian area is willow (Salix spp.), its production would be the best estimate of critical forage required by mule deer and antelope in the area. The vegetation sampling conducted on both the straights and meanders estimated willow separately from the other species present so an estimation of willow production can be made.

To determine the number of deer or antelope that could survive on the two study areas, total willow production was determined from the vegetation sampling results and the areas from aerial photos. A 40% utilization rate and a daily intake rate of 0.82 kg/animal/day (Severson, et al, 1980) was used to find the number of animal days that could be sustained by the willow production. The Wyoming Game and Fish Department (personal communication with Walter Gasson, Planning Coordinator) estimate the number of licenses sold equals 35% of the population on average. The number of licenses was mulitiplied by the WTP value from Table II for estimating the value from the federal agency's point of view. To determine the value of wildlife to the private land owner, the average access fee per day charged by Wyoming land owners as reported by Jacobs, et al, 1987 was multiplied by the average number of days spent hunting. The 1984 production level was assumed to remain constant to compare production with the structures to production without the structures being installed.

Water Quantity: A groundwater monitoring well network exists directly above and below the DSR and RSR study areas. This network was monitored biweekly in 1986 and 1987 from April to November. One well per study area was equipped with a Stevens recorder to obtain continuous water level changes. All wells were logged using gamma and gamma-gamma radiation. These logs were utilized to obtain the bulk density of potential aquifer strata along Muddy Creek. This information was used to estimate potential groundwater storage. The quantification of groundwater-surface water interactions at Muddy Creek has just begun, with data available on all wells for 1987 only. The total acre feet of water estimated to have been stored on the two study reaches is an approximation only, and will be refined by additional years of data collection.

The estimated storage in acre feet for each study area was multiplied by the dollar values of water used for irrigation, municipal and industrial uses, shown in Table III. No baseline data were collected on groundwater-surface water interactions, making predictions of ground water responses to the installation of the structures impractical.

Recreation: Recreational benefits associated with riparian areas vary from kayaking and rafting to camping and picnicing to fishing. The value of the riparian resource for these activities can be determined by estimating the recreationalist's WTP. The Travel Cost Method or a Contingent Value Method such as bidding games are used to estimate WTP. The Travel Cost Method surveys the user to determine what expenses he incurred getting to the recreational site. Demand curves for the recreational experience can be developed using the amount spent on travel as a substitute for price. Bidding games ask the recreationalist to place a dollar value on dif fering levels of resource or opportunity. For example, photographs of a river with varying flows would be shown to a fisherman and he would place a dollar value on each condition. Determination of the recreational use at Muddy Creek was beyond the scope of this research.

Sediment: Crossections at 16 instream structure sites in the RSR on Muddy Creek have been surveyed annually from 1984 to 1987. In addition, 3 cross sections below the structures and 5 cross sections in the DSR have been surveyed. The increase or decrease in bank and channel due to deposition or scouring can be determined from the survey data. Four inch square plates of 0.64 centimeter metal flashing were buried on the meanders in both study areas in June of 1986. Four plates were placed at each June vegetation sampling location for a total of 108 in the RSR and 72 in the DSR. Sixty five of these plates were relocated in June, 1987, to estimate the depth of deposition on the meanders.

Average depth of sediment was determined from the survey data and buried plates. Total deposition was estimated using these depths mulitplied by the area from the aerial photos. Bulk densities of the bank material of 1.231 g/cm^3 for the DSR and 1.139 g/cm^3 for the RSR were known from a previous study, allowing for the calculation of weight of sediment deposited. Dollar values were reported in dollars/ton. One citation was in acre feet of sediment in reservoirs, so it was assumed that sediment weighed 85 pounds per cubic foot (USDI-BLM, 1977) to convert Crowder's (1987) value of $500/acre foot to $0.27/ton. Actual conversion using bulk densities from Muddy Creek equals 73.8 pounds/ft^3 or $0.31/ton.

This method of valuing sediment deposition makes the assumption that for every ton of sediment stored on Muddy Creek there is a corresponding decrease of one ton of sediment at a downstream reservoir. This may not be completely accurate since the water that has dropped its sediment load may be "hungry" and will regain some of its sediment load downstream.

To estimate what deposition may have been without the structures, the average deposition on the controls below the instream structures for 1984-87 was found and multiplied by the area of the RSR. The average for the area where the structures are installed for 1984-87 was also mulitiplied by the entire area. No estimation was made for the meanders since no data were collected prior to 1986 on the meanders. Using the average for the straights should be a conservative value since when data were collected in 1986-87, the amount of deposition on the meanders exceeded the amount on the straights. The values for depositon with and without the structures was discounted at 4% and 8% over a 30 year planning horizon.

Salinity: Bank soils and bed material samples were collected during June, July, and August of 1986 on the meander sites in both reaches. These samples were ana lyzed by the University of Wyoming Soils Laboratory for Magnesium, Potassium, Sodium and Calcium. The 1973 USGS Water Resources Data for Wyoming was used to estimate for Muddy Creek the anions that would accompany these cations to form salts, reported in mg salt/kg of soil.

Since the tons of sediment deposited was calculated, the total amount of salt was estimated using the tons of sediment deposited on channel banks and bottoms. The assumption was made that this salt would remain "stored" with the sediments. It is possible that the salt concentration of the streamflow will not be decreased at down stream locations. Additional salts may be dissolved as the stream continues through salty and alkaline soils, decreasing the dollar value of storing salts in the upper watershed. Dollar values for salinity were given in dollars per ton, and tons of salt associated with the sediment could be determined since mg of salt per kg of soil was known.

To compare salt storage with and without the structures, the amounts of salt included in the sediments found in the control areas below the dam sites and in the RSR were discounted at 4% and 8% over a 30 year planning horizon.

Instream Structures: The number of structures needed and the number of years for installation in a given stream section will change with the channel conditions of the area. The cost of an individual structure was determined using the new cost of construction materials. The individual cost was then multiplied by the number required on Muddy Creek each year. All costs were discounted back to 1984 which was the first year that structures were installed. There may be additional maintenance costs associated with keeping the structures anchored after the final installation year. No estimation of these costs was made.

RIPARIAN CASE STUDY VALUES

Vegetation: Data from the vegetation sampling and the number of AUM's for livestock are shown in Table X. The value of vegetation production for livestock use averaged over 1986 and 1987 was greater in the RSR with a range of $51- 302 per year compared to $ 7-40 for the DSR. When comparing the influence of the instream structures on the value of vegetation for livestock use, the area with the structures shows a net present value (NPV) of $574-3,400 when discounted at 8% over 30 years. The estimated production of the areas without the structures would be $420-2,490 over the same 30 year period. The production on the meanders in the RSR has continued to increase each year. Using the 1986-87 average over the 30 year planning period may be a conservative approach.

Salix production for the two study areas for 1986 and 1987 and for the RSR in 1984 are shown in Table XI. Conversions to animals/year and dollar/study area are also shown. Wildlife values to the private land

TABLE X. VEGETATION PRODUCTION IN ANIMAL UNIT MONTHS (AUMS) FOR EACH STREAM REACH

	DEGRADED STREAM REACH (DSR)			
AUMS	1984	1985	1986	1987
STRAIGHTS			.75	.72
MEANDERS			4.37	4.24
AVERAGE 1986-87			5.04	
	RESTORING STREAM REACH (RSR)			
	1984	1985	1986	1987
STRAIGHTS	5.6	6.77	8.26	8.00
MEANDERS	22.05	25.16	27.70	31.50
AVERAGE 1986-87			37.75	

VEGETATION PRODUCTION IN G/M^2

STRAIGHTS—(RSR)

	1984	1985	1986	1987
TOTAL BIOMASS	310.16[1]	374.89	457.66	442.92[1]
SALIX PRODUCTION	187.65[1]	235.12	265.56	278.48[1]
MEANDERS				
DSR				
TOTAL BIOMASS			219.74	213.36
SALIX PRODUCTION			123.38	123.93
RSR				
TOTAL BIOMASS			557.65	633.29
SALIX PRODUCTION			269.98	378.91

[1] Production levels in 1984 & 1987 are significantly different at the .05 level.

TABLE XI. CONVERSION OF *SALIX* PRODUCTION TO VALUE OF INCREASED ACCESS FEES OR NET WILLINGNESS TO PAY FOR ADDITIONAL LICENSES

	1986 DSR	1986 RSR	1987 DSR	1987 RSR	1984 RSR
Salix production in kg/Study Area					
Meanders	1,372.7	7,507.8	1,378.8	10,536.9	7,100.2
Straights	254.3	2,681.5	266.7	2,811.9	1,894.8
Total	1,627.0	10,189.3	1,645.5	13,348.8[1]	8,995.0[1]
40% utilization	650.8	4,075.7	658.2	5,339.5	3,597.9
Days at .82 kg/ animal/day	793.7	4,970.4	802.7	6,511.6	4,387.8
Animals/year	2.17	13.62	2.20	17.80	12.02
Licenses issued at 35% of herd size	.76	4.8	.77	6.2	4.2
Value/ license at net WTP of $73	55.48	350.40	56.21	452.60	306.60
Value of access fees at $17.44/day x 4 days x # licenses	53.02	334.85	53.72	432.51	292.99

[1] Production levels in 1984 & 1987 are significantly different at the .05 level.

owner vary from $53 on the DSR to $384 on the RSR. These values were calculated based on an average trespass fee charged by Wyoming land owners of $17.44. An average hunt of 4 days was assumed. The value to society ranges from $56 on the DSR to $402 on the RSR. Over a 30 year planning horizon at 8% discount rate, the area where structures are installed will yield $4,520 compared to $3,450 without structures.

Water Quantity: Table XII shows the acre feet of ground water storage at Muddy Creek during the 1986 and 1987 seasons. This water could have a large differential in value depending upon its availability and use. The value of the average amount of water stored in the DSR in 1986 and 1987 would vary from $2,250 if used for irrigation purposes at $12.50/acre foot, to $25,560 if used by industry. Water for municipal uses could be worth $15,300-25,740 at $85-143/acre foot.

Sediment: At Muddy Creek, the DSR accumulated 1,625 tons of sediment over the 1986-87 period. During this same time period, 8,664 tons of sediment deposited over the RSR. Storage of this deposition has a value range of $.27/ton to $.58/ton resulting in annual values of $439-943 for the DSR and $2,339-5,025 for the RSR.

The use of instream structures is estimated to increase the accumulation over the RSR from 1,356.2 tons/year to 2,856.7 tons/year. Over a 30 year period at 8% discount rate, the area with structures would yield a NPV of $8,683-18,653 compared to $4,122-8,855 without the structures.

TABLE XII. COMPUTATION OF VALUE OF STORED WATER AT MUDDY CREEK WHEN USED FOR IRRIGATION, MUNICIPAL OR INDUSTRIAL PURPOSES

REACH	AVERAGE WATER LEVEL[1] (feet)	PER CENT POROSITY (%)	AREA (Acres)	STORAGE DURING SEASON (Ac. Ft.)	VALUE TO IRRIGATION AT $12.50/AF ($)	VALUE TO INDUSTRY AT $30-142/AF ($)	VALUE TO MUNICIPALITIES AT $85-143/AF ($)
DEGRADED STREAM REACH							
1986	0.97	24.5	615	150	$1,675	$4,500-21,300	$12,750-21,450
1987	1.39	24.5	615	210	2,625	6,300-29,820	17,850-30,030
AVERAGE 1986-87				180	2,250	5,400-25,560	15,300-25-740
RESTORING STREAM REACH							
1986	1.23	20.3	1,590	400	5,000	$12,000-56,800	$34,000-57,200
1987	1.89	20.3	1,590	600	7,500	18,000-85,200	51,000-85,800
AVERAGE 1986-87				500	6,250	15,000-71,000	42,500-71,500

[1] Average change in water level from highest to lowest point during the measuring season, April-November.

Salinity: Tons of salt stored with the sediment deposited ranged from 1.847 tons on the DSR to 3.641 tons on the RSR. The annual values of storing these salts ranges from $55.41-152.17 for the DSR to $109.23-299.98 for the RSR at values of $30 to $82.38/ton. A value of $133.94/ton was reported by Franklin, et al (1983) as the value to water users in the Imperial Valley of California if the salt were retained in Wyoming.

The installation of instream structures increases the amount of salt stored on the RSR from .5696 tons/year without the structures to 1.1998 tons/year with the structures using 1984-87 averages. Over a 30 year period with an 8% discount rate, the area with structures would have a NPV of $405-1,113 in comparison to $192-528 for the area without structures.

Dollar values associated with salt storage on riparian zones could be large because of the large cost associated with increased salinity levels in the lower Colorado River system. As can be seen from Table VII, the $/mg of salt/l of water range from $76,865 for agricultural damage to $240,500 for municipal damages to $447,700 estimated annual total damage for each mg/l increase of total salts in the lower Colorado River basin.

Instream Structures: Table XIII shows the materials and their costs required for the construction of a single structure. It is estimated that 104 structures will be needed at Muddy Creek. Table XIV

TABLE XIII. CONSTRUCTION COSTS FOR A SINGLE INSTREAM STRUCTURE

4 hours labor x 4 people at $5.00/hour	$ 80.00
6 steel posts at $2.60 each	15.60
30 feet woven wire at $.25/foot	7.50
10 yards erosion mat fabric at $.69/yard	6.90
TOTAL COST	$110.00

TABLE XIV. CONSTRUCTION COSTS FOR INSTALLING INSTREAM STRUCTURES AT MUDDY CREEK

YEAR	NUMBER OF COLLECTORS	TOTAL COST ($)	NPV AT 8% ($)	NPV AT 4% ($)
1984	32	$3,520	$3,520	$3,520
1985	16	1,760	1,630	1,693
1986	16	1,760	1,506	1,628
1987	8	880	699	782
1988	8	880	647	752
1989	8	880	595	723
1990	8	880	554	695
1991	8	880	513	669
TOTAL			$9,668	$10,462

shows the timing of the installation of the structures and the discounted NPV at 4% and 8%. The NPV of the total installation is projected to be $9,668 at 8% and $10,462 at 4%.

<u>Combined Benefits:</u> The benefits that a private land owner could expect if an area similar to Muddy Creek were restored are shown in Table XV. The private land owner would receive benefits from vegetation as AUM's for domestic livestock. Increased trespass fees from additional hunters pursuing the increased wild game the vegetation could support would also be generated. If the land owner's riparian habitat could support a fishery, there may be additional income generated from fishing access fees or access fees charged for nonconsumptive uses such as photography, birdwatching, camping, or picnicing.

From the land owner's point of view, benefits from the DSR are $93. The instream structures would not pay for themselves if new materials were used in their construction. However, the materials can be found on most ranches and can be constructed by ranch labor. At an 8% discount rate, the net benefit is negative at $-1,945. A positive benefit of $5,789 would be realized without the structures being installed. Total benefits per area and per km of stream are shown since the DSR and the RSR are not of equal size. The benefits from the RSR range are $113/hectare compared to $32/hectare for the DSR.

Because a Federal agency is responsible to the society as a whole, additional benefits can be included in the economic analysis. The value of the stored sediments and accompanying salts can be included in the

TABLE XV. VALUE OF BENEFITS FROM RIPARIAN AREAS IN DIFFERENT CHANNEL CONDITIONS, AVERAGE OF 1986-87, AND NET PRESENT VALUE OF RECLAMATION USING INSTREAM STRUCTURES OVER A 30 YEAR PERIOD AT 4% AND 8% DISCOUNT RATES FROM THE PRIVATE LAND OWNER'S POINT OF VIEW.

CHANNEL CONDITION	LIVESTOCK PRODUCTION ($)	WILDLIFE PRODUCTION[1] ($)	RECREATION[2]	TOTAL ANNUAL BENEFITS ($)	TOTAL BENEFITS/ HECTARE ($)	TOTAL BENEFITS/ KILOMETER ($)
ANNUAL BENEFITS						
DEGRADED STREAM REACH (DSR)	$ 40	$ 53		$ 93	$ 32	$ 27
RESTORING STREAM REACH (RSR)	302	384		686	113	138
PRESENT VALUE OF COSTS AND BENEFITS				NPV BENEFITS		
NO STRUCTURES INSTALLED AT 4%	3,825	5,066		$ 8,891		
AT 8%	2,490	3,299		5,789		
WITH STRUCTURES INSTALLED AT 4%	5,222	6,640		11,862		
AT 8%	3,400	4,323-27,717		7,723-31,117		
COST OF STRUCTURES						
AT 4%				10,462		
AT 8%				9,668		
NET BENEFIT (COST) OF INSTALLING STRUCTURES						
AT 4%				1,400		
AT 8%				(1,945)		

[1] Derived from access fees charged by Wyoming land owners (Jacobs, et al, 1987).

[2] No recreation values documented for the study area but could include access fees for fishing, photography, camping or other non-consumptive uses of the riparian area.

total benefits (Table XVI). These benefits occur when the private land owner completes improved riparian area management as well. However, the land owner is not receiving any dollars directly from sediment or salt storage. There may be areas where the control of salts and sediment is important from society's point of view and cost share programs could be entered into by the land owner and the federal government.

The average value of benefits from 1986-87 are $557-1,191 for the DSR to $2,01-6,029 for the RSR, from the Federal agency's point of view. After including the additonal benefits of sediment and salt storage, the instream structure installation is economically viable if the upper values can be applied. At an 8% discount rate, the structures show a net benefit of $4,514-18,018 compared to $8,186-15,325 without the structures. Benefits per area vary from $193-414/hectare for the DSR to $477-992/hectare for the RSR.

If industry, a municipality or irrigators were to pump the groundwater for use off-site, the value of water at Muddy Creek could be quite high, up to $77,529 over the 30 year planning period (Table XVII). The hydrological interactions are not well enough documented to estimate what effect differing pumping levels at various times during the season will have on other parameters such as vegetation production or return flows. No baseline data were taken on groundwater levels prior to instream structure installation, so no estimation of the structures impact on groundwater storage can be made.

TABLE XVI. VALUE OF BENEFITS FROM RIPARIAN AREAS IN DIFFERENT CHANNEL CONDITIONS, AVERAGE OF 1986-87, AND NET PRESENT VALUE OF RECLAMATION USING INSTREAM STRUCTURES OVER 30 YEARS AT 4% AND 8% DISCOUNT RATES FROM A FEDERAL AGENCY'S POINT OF VIEW.

CHANNEL CONDITION	LIVESTOCK PRODUCTION ($)	WILDLIFE PRODUCTION[1] ($)	RECREATION[2]	SEDIMENT ($)	SALINITY ($)	TOTAL BENEFITS ($)	TOTAL BENEFITS/ HECTARE ($)	TOTAL BENEFITS/ KILOMETER ($)
ANNUAL BENEFITS								
DEGRADED STREAM REACH (DSR)	7-40	56		439-943	55-152	557-1,191	$193-414	$161-343
RESTORING STREAM REACH (RSR)	51-302	402		2,339-5,025	109-300	2,901-6,029	477-992	583-1,211
PRESENT VALUE OF COSTS AND BENEFITS						NPV BENEFITS		
NO STRUCTURES INSTALLED AT 4%	654-3,825	5,302		6,332-13,601	297- 812	12,585-23,540		
AT 8%	420-2,490	3,452		4,122- 8,855	152-528	8,186-15,325		
WITH STRUCTURES INSTALLED AT 4%	882-5,222	6,943		13,337-28,651	622-1,70	21,784-42,525		
AT 8%	574-3,400	4,520		8,683-18,653	405-1,113	14,182-27,686		
COST OF STRUCTURES								
AT 4%						10,462		
AT 8%						9,668		
NET BENEFIT OF INSTALLING STRUCTURES								
AT 4%						11,322-32,063		
AT 8%						4,514-18,018		

[1] Value based on Willingness to Pay value from Loomis, et al, 1985.

[2] No recreation values were documented for the study area but could include access fees for fishing, photography, camping or other non-consumptive uses of the riparian area.

TABLE XVII. VALUE OF BENEFITS FROM RIPARIAN AREAS IN DIFFERENT CHANNEL CONITIONS, AVERAGE OF 1986-87, FROM A FEDERAL AGENCY'S POINT OF VIEW WITH GROUNDWATER PURCHASES BY IRRIGATORS, MUNICIPALITIES, OR INDUSTRY.

CHANNEL CONDITION	LIVESTOCK PRODUCTION ($)	WILDLIFE PRODUCTION ($)	RECREATION	SEDIMENT ($)	SALINITY ($)	IRRIGATION ($)	MUNICIPAL ($)	INDUSTRIAL ($)
ANNUAL BENEFITS								
DEGRADED STREAM REACH (DSR)	$ 7– 40	$ 56		$ 439- 943	$ 55-152	$2,250	$15,300-25,740	$ 5,400-25,560
RESTORING STREAM REACH (RSR)	51-302	402		2,339-5,025	109-300	6,250	42,500-71,500	15,000-71,000

TOTAL BENEFITS FOR EACH GROUNDWATER USER

	IRRIGATION	MUNICIPAL	INDUSTRIAL
DSR	$2,807-3,441	$15,857-26,931	$ 5,957-26,751
TOTAL BENEFITS/ HECTARE	975-1,195	5,506-9,351	2,068-9,289
TOTAL BENEFITS/ KM OF STREAM	809- 952	4,570-7,761	1,717-7,709
RSR	9,151-12,279	45,401-77,529	17,901-77,029
TOTAL BENEFITS/ HECTARE	1,505-2,020	7,467-12,751	2,944-12,669
TOTAL BENEFITS/ KM OF STREAM	1,838-2,466	9,117-15,568	3,595-15,468

The sediment data used for this document was collected using stream cross section and buried plate techniques. Since 1987, suspended sediment in streamflow has been collected above and below the DSR and RSR using the standard U.S.G.S., USDH 48 and 49 samplers and the Equal Transect Rate method biweekly from March through October. The estimate of deposited sediment using this technique, along with data collected from the stream gaging stations, is a more accurate measurement of sediment transport and deposition along the channel of Muddy Creek. In addition, sediment transport is being measured below the DSR and above the RSR, above and below a 7 km improved riparian zone. These data from 1987 will modify the benefits presented in the following manner.

The conservative estimate of sediment for the RSR presented in this paper is 8,664 tons, whereas using the 1987 data the estimate is 450,000 tons. These estimates equate to 3.64 and 189 tons of deposited salt respectively. The difference in annual dollar values are $ 2339 and $121,500 for 1987 for sediments at the low end of the range presented in Table IX. The difference in salts is $ 109 and $ 5,673 at the low end of the range [Table VII].

The 1987 data reflected a contribution of 2.5 million tons of sediment being transported out of the DSR. These sediments being transported from the stream reach equate to losses of $675,000 for the value of the sediment and $85,245 of potential damage of the salts downstream, using values of $0.27/ton for the sediments and $30/ton for the salts. However, these sediments are deposited in the improved reach which lies between the DSR and the RSR. This improved section stored

3.2 million tons of sediemnt in 1987. This equates to $864,000/year in sediment storage and $109,115 in storage of salts, using the low range of values.

These differences based on a more accurate measurement of sediemnt transport and deposition illustrate potential value of riparian zones for control of non-point source pollution. Although private landowners will not receive direct benefit from the storage of these sediments and salts, these benefits do provide justification for the public land agencies to evaluate management strategies.

SUMMARY

The major strength of this research lies in the data that have been collected at the two study sites. The dollar values for the various benefits are based on actual physical changes recorded and the economic information gathered from other studies. This paper provides a starting point for the refinement of riparian area values as additional information is gathered. It also provides the public resource manager with justification to proceed in riparian area management and reclamation. Two main weaknesses are present in this research. The first is applying economic values that were determined under a different set of circumstances to riparian uses. The second concerns the limited data available on rip arain areas and the interactions between the differing uses. The relationships have not been quantified, making it difficult to determine whether the uses of a riparian area are complementary or competitive. For example, if groundwater were pumped for use off-site, how would the vegetation production and sediment storage be affected? Additional research is needed to document these inter realtionships.

Further riparian research is required before more definitive statements of economic worth can be made. Documentation of the physical responses that will occur is needed before management practices can be judged on their economic merit. A goal of riparian management should be to have the necessary information available such that the point of greatest net marginal benefits for alternative management strategies can be determined.

Although the results from this research have many caveats attached, it is a first attempt at quantifying the benefits associated with riparian areas in the West. The important point of this paper is not the absolute dollar values, but the process presented. As additional information is obtained, the tables presented can be refined so that the information is based on riparian research rather than associated water research. This paper provides few concrete answers, but presents a starting point for land managers that must make decisions today, and can't wait for an all inclusive understanding of riparian zones and their ecological functions, when subjected to user pressure.

Based on the information obtained through the pertinent literature and the case study, the following conclusions can be made:

1) There are values associated with the production of riparian areas in the cold desert shrub areas of the West as shown by the values

found in the literature review that may be applied to benefits from riparian areas.

2) A difference in values between a riparian area in an improving and one in a degraded condition does exist, as shown by Tables XV, XVI, and XVII.

3) The use of instream structures to slow stream flow velocity and raise the channel bottom with deposited sediments may be economically viable depending upon the user's point of view.

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