Ecosystem Service Valuation of the Colorado River Basin:
A Literature Review and Assessment of the Total Economic Value of the Colorado River Basin

A Report
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Executive Summary

The Colorado River Watershed, or Colorado River Basin (CRB), is the primary water source for approximately 30 million people in the US and Mexico. People depend on water from the watershed for drinking, agriculture, watering lawns, and a variety of other industrial and municipal uses. However, these CRB uses are not the only aspects of importance. The ecosystem services within the CRB provide us with food, erosion control, natural disturbance regulation, and a variety of recreation activities. When considering all ecosystem service values, instead of solely focusing on the economic value of the conservation use of water, a more complete perspective is obtained. This literature review focused on obtaining a baseline for the knowledge available specific to the value of ecosystem services in the CRB, as well as determining where there is a lack in ecosystem service information. This baseline value can be applied in the determination of how ecosystem values would change if there was a decrease, or increase, in water flow, to obtain a more complete understanding of the ecosystem service value of the CRB.

This study's focus was on locating recreation, food production, water purification, erosion control and natural disturbance[1] regulation ecosystem service valuation related publications. In total, 516 valuation observations from 119 studies were recorded in a database. While values for all ecosystem services of interest were located, not all studies were CRB specific. Instead, many of the studies collected information in reference to entire states located in the watershed.[2] As such, these valuation observations are relevant to the watershed, but not watershed specific.

Ecosystem services were divided into four categories: information, production, regulation, and habitat. Information services include functions that contribute to human health, such as recreation, education and aesthetic experiences. Production functions are those functions that result in an output of living biomass, such as raw materials and food. Regulating services provide people with benefits, such as flood regulation and detoxification, from the regulation of ecosystem processes. Habitat refers to those functions that provide reproduction habitat and refuge to wild animals and plants (Bateman et al., 2010; de Groot et al., 2002; Kaval, 2010; Millennium Ecosystem Assessment, 2005). One additional category containing studies valuing all functions was created.[3]

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[1] Natural disturbances are disturbances that occur naturally, such as a lightning strike or a flash flood. Natural disturbance regulation refers to how the ecosystem regulates the disturbance. For example, if a flash flood occurs and there is a large wetland in its path, the wetland will absorb the floodwaters before the waters reach the nearest town. However, if there is no wetland, the flood may reach the town and flood the basements of the homes in its path. In this way, the wetland "regulates" the natural disturbance (the flash flood).

[2] The Colorado River Basin consists of land in nine states: seven US states (Colorado, Wyoming, Utah, New Mexico, Arizona, Nevada and California) and two Mexican states (Baja California and Sonora).

[3] Note that observations collected were valuation based, therefore, a study on reproductive habitat would not be included if it did not discuss the monetary value of the reproductive habitat.

The percentage of observations located for each category include information functions (91.60% of the observations), production functions (3.44%), regulation functions (4.39%), habitat functions (0%), and studies that valued all functions (0.57%). Recreation and preservation studies were located within the information function category. Within the production function category, observations were located for food production and raw material studies. Within the regulation function, observations included erosion control, natural disturbance regulation, and the purification and regulation of water. No observations were located for the habitat function category.

Table ES1 below illustrates a summary of the ecosystem service valuation *information function* studies located in relation to the CRB. This category was composed of recreation and preservation studies. The economic recreation values listed in the table should not be added together, as there may be some overlap, however, the results clearly illustrate that the value of recreation activities, specifically in the CRB, are worth over $10 billion annually to the US economy. The majority of the recreation observations focused on fishing, river rafting, hunting and wildlife watching. While over 87% of the observations in the database were composed of recreation values, no data was located for the values of some other popular CRB activities, including motor boating, house boating, and canyoneering, while very little was found on beach recreation and birdwatching.

Preservation value is the value a person perceives to preserve something, such as an endangered species in a river. People in Colorado households were asked whether they were willing to pay a particular amount of money to preserve forests, wilderness and ranchland views. Their responses were overwhelmingly positive. However, many of these studies collected their data in the 1980's and 1990's, and therefore, values may have changed since these studies were conducted.

Another study attempted to determine the value of preservation in relation to Natural Resource Conservation Service Program (NRCS) conservation programs. It was determined that for every $1 spent on NRCS conservation programs, $1.60 is spent in the economy as direct expenditures and $2.49 is the total output or flow-on impact. In summary, the ecosystem service information functions of the CRB are significantly large and a significant amount of work has been conducted in this area (92% of the observations in the database).

Ecosystem Service Category		Economic Values (2009 USD)	Value Description
Information Functions			
	Recreation		
		$4.1 billion annually	Colorado River Basin Direct Expenditures for Fishing, Hunting and Wildlife Watching in the U.S.
		$10.5 billion annually	Colorado River Basin Flow-On[1] Impact for Fishing, Hunting and Wildlife Watching in the U.S.
		$3.4 billion annually	Colorado River Basin Recreation Consumer Surplus Values for the entire basin (including Mexico)
		$55 million annually	Direct Expenditures for Whitewater Rafting in the Colorado River Basin in the state of Colorado
		$141 million annually	Flow-On Impact for Whitewater Rafting in the Colorado River Basin in the state of Colorado
		$960 million annually	Direct Expenditures for National Park Lands in the Colorado River Basin
		$1.3 billion annually	Flow-On Impact for National Park Lands in the Colorado River Basin
	Preservation		
		$73-$83/Colorado household/year	Colorado Household Value to Preserve Wilderness and Forest Quality
		$155-$371/Routt County Colorado household/year	Routt County Colorado Household Value to Preserve the Scenic Landscape View of Ranchlands
		$1.60 on total value added and $2.49 on total output	For every $1.00 the NRCS spends on programs, $1.60 is spend in the economy as direct expenditures and $2.49 is the total output or flow on impact
	[1]Flow-on impacts include the "indirect" and "induced" business impacts of an activity.		

Table ES1. Information Function Ecosystem Service Values.

In relation to the ecosystem service *production functions*, the 2007 value of crops requiring supplemental water in the seven states in the CRB in the US, including nursery and greenhouse crops, was approximately $27 billion (2009 USD). These are state values and not basin specific, although data has been located that could result in a more basin specific calculation. The value of crops in the Mexicali Valley of Mexico is worth $2.7 billion annually. This is a basin specific value, but does not include values for all CRB locations in Mexico (Table ES2).

Ecosystem Service Category		Economic Values (2009 USD)	Value Description
Production Functions			
	Food production	$2.7 billion annually	The total value of crops requiring watering in the Mexicali Valley of Mexico
		$26.8 billion annually	Total value of crops requiring watering in the seven Colorado River Basin states (not basin specific).

Table ES2. Production Function Ecosystem Service Values.

Many studies attempted to determine the value of instream flow and riparian habitat. These water related services are part of the ecosystem service *regulation function*. Several studies focused on asking people what they were willing to pay to maintain water values at current levels, to increase current levels, or, in many cases, to prevent a decrease in water flows. These values ranged from a $5 increase in an entrance fee to Rocky Mountain National Park to $166/Colorado household/year to maintain river flow through wild and scenic designation. One study focused on what would happen if there was a decrease in the water level and found that expenditures for fishing and whitewater rafting in Colorado would decrease. Another study determined that a newly created wetland in Colorado would take 13 years to reach optimum functioning. If this wetland were 100 acres in size, its ecosystem service value would be at least $2.5 million[4] over the 13 year period. Another way to think about this is that if we destroy a 100 acre wetland, we are losing millions of dollars in ecosystem service functions (Table ES3).

[4] The number has not been discounted for inflation for the 13 year period.

Ecosystem Service Category		Economic Values (2009 USD)	Value Description
Regulation Functions			
	Purification and regulation of water		
		$166/Colorado household/year	Annual Colorado Household Value to Place and Keep Rivers in a Wild and Scenic Designation
		$5.30 increase in park entrance fee	Increase in the park entrance fee to contribute to protecting water levels in Rocky Mountain National Park, Colorado
		$19.09 in taxes annually to $40.64 in electricity bill annually by local residents	Glen Canyon Dam moderation in water flow to potentially increase native fish populations, increase non-native fish populations, increase vegetative area for a 10% increase in wildlife and bird habitat, decrease in erosion that Native American sacred and archeological sites would experience and size of beaches remains the same
		$73.38 to $89.68/ New Mexico household/year for five years	Maintain or increase instream flow to protect native fish
		$59,000 to $131,000 annually	Instream flow (Aravaipa Canyon Wilderness Section of the San Pedro River in Arizona) - Total Amount Visitors are Willing to Contribute to protect water flow in the park
		$35/ one acre foot (thousand cubic meters)	Value of an increase in instream flow in the Mexicali Mexico area
		$19 million decrease in annual expenditures	Decrease in Expenditures as a result of a 25% drop in water level in relation to white water rafting in Colorado (Note: Not Colorado River Basin Specific)
		$49 million decrease in annual expenditures	Decrease in Expenditures as a result of a 25% drop in water level in relation to fishing in Colorado (Note: Not Colorado River Basin Specific)
		$2.5 million**	Value of a 100 acre wetland for 13 years (obtained from the creation of new wetlands). Note that it takes 13 years to establish a fully functional wetland in Colorado.
		$5,321/acre foot to $10,642/acre foot	Cost savings as a result of Colorado Water Conservation Board and the collaborative Upper Colorado River Endangered Fish Recovery Program instream flow programs
		$5,000 to $14,000 per home in Arizona	Riparian Habitat Preservation in Arizona: Homes were found to sell for higher prices when located close to riparian habitat
		$3.3 million annually	The total amount visitors were willing to contribute to maintain water flow at San Pedro Riparian National Conservation Area in southeastern Arizona
	**Number has not been discounted for inflation for the 13 year period		

Table ES3. Regulation Function Ecosystem Service Values.

One study attempted to determine the value of ecosystem services for water in the Colorado River Delta, as well as for croplands, desert land, floodplains and estuaries. Illustrating these values demonstrates how converting a floodplain into cropland results in a significant decrease in the value of ecosystem services overall. However, it should be noted that these values were estimated from the Costanza et al. (1997) article. Therefore, while estimates were made for the Colorado River Delta, they are not as accurate as they could be if original Colorado River Delta data were applied[5] (Table ES4).

All Ecosystem Service Functions		**Economic Values (2009 USD)**	**Value Description**
	Ecosystem Services		
		$236.23/acre foot	Colorado River Delta Water total ecosystem service value
		$203-$249/hectare/year[1]	Cropland total ecosystem service value
		$139/hectare/year	Desert total ecosystem service value
		$14,015/hectare/year	Floodplain total ecosystem service value
		$1,967/hectare/year	Estuary total ecosystem service value
	[1]One hectare is equal to 2.47105381 acres.		

Table ES4. Ecosystem Service Values for Studies of All Functions

In summary, this study has presented the information currently available for use in determining the value of ecosystem services for the CRB. Results illustrate that the ecosystem service value of the CRB is significant and is in the tens of billions of dollars. However, the data is not complete by any means. Of the four ecosystem service valuation categories, data was only found for three, with a majority of that data focused on the information function category (92%). Only 4% of the observations were regulation function related, 3% were production function related and no observations were located for the habitat function category. In addition, data for many of the studies was collected during the last century; therefore, values may have changed.

There are many techniques available that can be applied to further this effort. One technique is to collect available data on CRB specific ecosystem services and then use the available data to determine economic values. Another is to conduct a field study on a specific area of the basin, such as a one quarter mile stretch of the river, particular river segment or community, and conduct a variety of experiments to determine the value of several of the ecosystem services in that particular area. Once a comprehensive study is conducted on one area, the same techniques can be used to value another section of the river. Another option is to focus on a specific service, such as the scenic value of the river, and conduct an appropriate study to determine the value of that service, such as a hedonic study, by obtaining values for homes with a view of the river and

[5] That being said, there is currently no Colorado River Specific original data available.

comparing that to the value of similar homes near the river, but without a river view. Several counties currently have hedonic information available on their websites, which would make this data collection process easier. A future study could also follow the work of Costanza et al. (2006) on valuing the ecosystem services of New Jersey to value the CRB. This involves value transfer, hedonic analysis, and spatial modeling. However, instead of value transfer just from CRB specific studies, values can be transferred from river basin areas in other locations to the CRB.

When a more complete ecosystem service valuation is calculated for the CRB, it can be used to improve the cost-effectiveness of fish and wildlife recovery policies. This improvement would be expected to lead to an improvement in the ecosystem service functions (and sustainability) of the watershed, not to mention an increase in the economic returns to the community.

Table of Contents

Introduction

The Colorado River Watershed, or Colorado River Basin (CRB)[6], not only includes the 2,333 kilometer (1,450 mile) long Colorado River, but also all of its tributaries and the lands drained by these waters. The four largest Colorado River tributaries include the Gila River, San Juan River, Green River, and Gunnison River. However, the total number of tributaries is much greater (Table 1).

Colorado River Tributaries:			
Agua Fria River	East River	Little Colorado River	San Miguel River
Animas River	Elk River	Little Snake River	San Pedro River
Big Sandy River	Escalante River	Meadow Valley Wash	San Rafael River
Black River	Florida River	Muddy Creek	Santa Cruz River
Blacks Fork	Fraser River	Muddy River	Santa Maria River
Blue River	Fremont River	North Fort Gunnison River	Snake River
Bouse Wash	Fryingpan River	Oak Creek	Tapeats Creek
Bright Angel Creek	Gila River	Paria River	Taylor River
Centennial Wash	Gore Creek	Piedra River	Tenmile Creek
Chemeheuvi Wash	Grand Gulch	Piute Wash	Thunder River
Conejos River	Green River	Plateau Creek	Tonto Creek
Crystal River	Gulf of California (Sea of Cortez)	Price River	Tyson Wash
Dark Canyon	Gunnison River	Puerco River	Uncompahgre River
Deer Creek	Hardy River	Range Creek	Verde River
Diamond Creek	Hassayampa River	Roaring Fork River	Virgin River
Dirty Devil River	Havasu Creek	Sacramento Wash	White River
Dolores River	Jones Hole Creek	Salt River	Williams Fork River
Duchesne River	Kanab Creek	San Francisco River	Willow Creek
Eagle River	Las Vegas Wash	San Juan River	Willow River
			Yampa River

Table 1. Partial List of Colorado River Tributaries.

The CRB consists of land in nine states: seven US states (Colorado, Wyoming, Utah, New Mexico, Arizona, Nevada and California) and two Mexican states (Baja California and Sonora). Not all land within the states is part of the CRB; however, for some, it is a large proportion. Of the seven US states, almost 40% of the lands in Colorado and 50% of the lands in Utah are located within the CRB, while primarily all land in Arizona is in the CRB (95%) (Table 2). The states with the least amount of land in the CRB include California (2%), Nevada (11%), Wyoming (17.4%), and New Mexico (19.0%). Interestingly, California has the smallest amount of land in the basin (2%), yet receives the largest share of CRB Water (36.1%)[7] (Colorado River Board, 1997; U.S. Bureau of Reclamation, 2005).

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[6] The terms Colorado River Watershed, Colorado River Basin, and the CRB will be used interchangeably throughout the document.

[7] In 1997, California was consuming 5.2 million acre-feet (MAF) per year of Colorado River water, even though its mainstream apportionment is 4.4 MAF Colorado River Board. 1997. Colorado River Board 4.4 Plan: Californians Use of Its Colorado River Allocation [Online] http://www.sci.sdsu.edu/salton/CoRiverBoard4.4plan.html (verified 11 January 2011), U.S. Bureau of Reclamation. 2005. Quality of Water, Colorado River Basin Progress Report No. 22..

	Area (sq. km.) of the Colorado River Basin Within Each State	Area (sq. km.) of Total State Land	Percentage of the State That Contains the Colorado River Basin	Amount of Water Removed from the Colorado River Basin in 1000 Acre Feet/Year in 2010	Percentage of Water Removed from the Basin
Arizona	281,437	295,260	95.3%	2850	23.4%
California	9,543	411,048	2.3%	4400	36.1%
Colorado	100,024	269,596	37.1%	2580	21.1%
New Mexico	59,754	314,926	19.0%	548	4.5%
Nevada	32,106	286,352	11.2%	300	2.5%
Utah	105,337	219,899	47.9%	1009	8.3%
Wyoming	44,120	253,325	17.4%	517	4.2%

Table 2. Colorado River Basin and US State Land Area Data (Koenig, 2010; U.S. Bureau of Reclamation, 2005; www.city-data.com, 2010)

In total, the CRB drains 635,000 square kilometers (245,000 square miles) of land, with 627,000 square kilometers (242,000 square miles) in the US and 8,000 square kilometers (3,000 square miles) in Mexico. Seventy-five percent of CRB lands in the US fall within federal land jurisdiction and include national parks, national forests, and Native American Indian reservations (Anderson, 2002; Christensen and Lettenmaier, 2006; Kammerer, 1990; Pontius and SWCA Inc., 1997; U.S. Department of the Interior, 2000).

Approximately 30 million people depend on the river for watering lawns, drinking water, irrigated agriculture, and a variety of other industrial and municipal uses; however, not all of these 30 million people live in the basin, as Colorado River water is diverted to areas outside of the CRB through trans-basin diversions. Non-CRB residents receiving water from the CRB include residents of Los Angeles (CA), San Diego (CA), Denver (CO), Albuquerque (NM) and Salt Lake City (UT). Consequently, more water is exported from the CRB than any other river in the US (Anderson, 2002; Youngs, 2008).

To assist with water demand and gain more control of water use, there are over 40 dams in the CRB. These dams are used to store water and/or produce electricity (Anderson, 2002; Christensen and Lettenmaier, 2006; Kammerer, 1990; Pontius and SWCA Inc., 1997; U.S. Department of the Interior, 2000).

The demand for Colorado River water has caused several problems, one of which is an increase in CRB water salinity. Salt concentrations are so high in some areas that the river water would require treatment if it is to be used for human consumption. Salt concentrations will continue to rise as the human population and human water demand continues to increase (Anderson, 2002; Christensen and Lettenmaier, 2006; Kammerer, 1990; Pontius and SWCA Inc., 1997; U.S. Department of the Interior, 2000).

Another issue in the CRB is the decline in native fish species and habitat. Prior to extensive human use, the waters in the CRB were habitat to 42 native fish species, 30 of which were endemic (Benke and Cushing, 2005; Mac et al., 1998; Sanderson, 2011). Since then, people have introduced a minimum of 72 non-native fish species to the CRB, some of which are predators of native fish (Benke and Cushing, 2005; Sanderson, 2011). The non-native fish introduction, as well as the modification in the flow regime, temperature and salinity of the water, has led to the eradication of four native fish species (Pahranaghat spinedace, Las Vegas dace, Monkey Springs chub, and Monkey Springs pupfish), while 16 of the 26 (62%) remaining native endemic fish species have become threatened and/or endangered (Benke and Cushing, 2005; Carlson and Muth, 1989; Mac et al., 1998; Maddux et al., 1993; Sanderson, 2011; Upper Colorado River Endangered Fish Recovery Program, 2006).

Human activity has had an effect on water level and water quality in the CRB. Therefore, it is recommended that future CRB decision-making policies that will impact the water in the CRB be based on the results of detailed research studies, including valuation studies, to provide managers with a more balanced perspective of the situation. The purpose of this study is to assist in increasing the knowledge base about the value of the CRB, more specifically, the ecosystem service value of the CRB, by summarizing the literature. To accomplish this goal, the value transfer method, a methodology that uses currently existing valuation information and applies it to a study site, in this case, the CRB, will be conducted. Focus will be placed on locating CRB valuation studies, rather than a new study or analysis.

The rest of this report will be organized as follows. As the reader should have a basic understanding of ecosystem services and ecosystem service valuation, the next two sections elaborate on these two areas, specifically in relation to the CRB. A description of the methodology and brief details about the studies entered into the database follows. Results are then discussed in detail for the ecosystem service categories of interest. The report finishes with some discussion and conclusions that can be used to assist people involved with CRB management.

Ecosystem Services

Ecosystem services are the functions and services provided by ecosystems that enable life on earth to exist. In this context, life not only refers to people, but all flora and fauna. While there are many ecosystem services, some are more vital to sustain life on earth than others. According to Daily (1997), a minimum of 13 ecosystem service functions and services are necessary:

- *Purification of air and water*
- *Pollination of crops and natural vegetation*
- *Control of the vast majority of potential agricultural pests*
- *Mitigation of floods and droughts*
- *Detoxification and decomposition of wastes*
- *Protection from the sun's harmful ultraviolet rays*
- *Partial stabilization of climate*
- *Generation and renewal of soil and soil fertility*
- *Dispersal of seeds and translocation of nutrients*
- *Maintenance of biodiversity (from which humanity has derived key elements of its agricultural, medicinal and industrial enterprise)*
- *Moderation of temperature extremes and the force of winds and waves*
- *Support of diverse human culture*
- *Providing of aesthetic beauty and intellectual stimulation that lift the human spirit (Daily, 1997)*

Costanza et al. (1997), provides a similar list that consists of 17 basic functions and services perceived to be the bare minimum needed to sustain life on earth:

Nutrient cycling	*Soil formation*	*Gas regulation*
Raw materials	*Food production*	*Habitat refugia*
Cultural	*Recreational*	*Genetic resources*
Water supply	*Water regulation*	*Disturbance regulation*
Biological control	*Pollination*	*Waste treatment*
Climate regulation	*Erosion control and sediment retention*	
(Costanza et al., 1997)		

Compiling the Daily (1997), Costanza et al. (1997) and de Groot et al. (2002)[8] list of functions, Kaval (2010) updated the list to include 22 ecosystem service functions and services that are not only necessary to sustain life on earth, but are also important in ecosystem service valuation. As the focus of this study is ecosystem service valuation, this list will be used in this paper:

[8] The de Groot et al. (2002) ecosystem service function list includes *gas regulation, climate regulation, disturbance prevention, water regulation, water supply, soil retention, soil formation, nutrient regulation, water treatment, pollination, biological control, refugium function, nursery function, food, raw materials, genetic resources, medicinal resources, ornamental resources, aesthetic information, recreation, cultural and artistic information, spiritual and historic information and science and education.*

aesthetic beauty	*biodiversity maintenance*
erosion control	*food production*
genetic and medicinal resources	*human culture*
natural disturbance regulation	*natural pest and biological control*
nursery function	*nutrient cycling*
partial climate stabilization	*plant and animal refugia*
plant pollination	*raw materials*
recreation	*science and education*
seed dispersal	*soil formation*

preservation (including existence, bequest, and option value)
protection from the sun's ultraviolet rays
detoxification and decomposition of wastes
purification and regulation of air and water (Kaval, 2010)

The ecosystem service function list may be more easily understood if it is categorized into groups. The Millennium Ecosystem Assessment (2005) divided ecosystem services into four groups: supporting, provisioning, regulation and cultural services. By their definition, supporting services are necessary for the production of ecosystem services and include nutrient cycling and soil formation. Provisioning services are the goods that ecosystems provide to people and include food, genetic resources, water, and biochemicals. Regulating services provide people with benefits such as flood regulation and detoxification from the regulation of ecosystem processes. Cultural services include all non-material benefits obtained from ecosystems and can include recreational, spiritual and educational benefits (Millennium Ecosystem Assessment, 2005).

In a similar fashion to the Millennium Ecosystem Assessment, de Groot et al. (2002) divided ecosystem services into four categories: regulation, habitat, production and information. Their regulation definition follows that of the Millennium Ecosystem Assessment. Habitat refers to those functions that provide reproduction habitat and refuge to wild animals and plants, such as the natural tree hollows that the Eastern Bluebird (Sialia sialis) of North America requires for nesting. Consequently, people have been constructing nest boxes for these birds due to a loss in the number of natural tree hollows. Production functions are those functions, such as nutrient uptake by autotrophs and photosynthesis by plants, that results in an output of living biomass, such as raw materials and food. The information category is similar to the Millennium Ecosystem Assessment cultural services category and includes those functions that contribute to human health, such as recreation and aesthetic experiences (de Groot et al., 2002). The list of ecosystem functions important for ecosystem service valuation created by Kaval (2010) were categorized according to de Groot et al. (2002) (Table 3). This table also provides examples of each function to better understand their meaning.

Ecosystem Service Category		Ecosystem Service Functions	Examples
Regulation Functions			
	1	Biodiversity maintenance	Kelp forests are an intricate ecosystem in that they depend on sea otters and sea urchins. If the sea otter population is exterminated, perhaps by overhunting, the sea urchins will eat all the sea kelp and the forest will disappear.
	2	Detoxification and decomposition of wastes	How a plant can convert a toxic chemical in the soil into a non-toxic chemical by the process of phytoremediation.
	3	Erosion control	How the roots of vegetation assist in the prevention of erosion.
	4	Natural disturbance regulation	How coral reefs provide the lands near them with protection from storms.
	5	Natural pest and biological control	How ladybugs feed on insects, such as aphids, that are a considered an agricultural pest.
	6	Nutrient cycling	How a grizzly bear obtains some of its nutrients by eating salmon from a river.
	7	Partial climate stabilization	How dimethylsulfide (DMS) production by plankton communities assists in cloud production that helps control climate.
	8	Plant pollination	How bees pollinate flowers.
	9	Protection from the sun's ultraviolet rays	How the ozone layer provides all creatures on the planet with protection from the sun's ultraviolet rays.
	10	Purification and regulation of air and water	How trees convert carbon dioxide into oxygen, a gas that people and other animals need to survive.
	11	Seed dispersal	When a coconut that falls into a river or ocean is carried away to another location to eventually reach land and become a tree.
	12	Soil formation	How the wind weathers a rock, turning it into soil.
Habitat Functions			
	13	Nursery function	How an estuary provides suitable reproductive habitat for fish, birds and invertebrates.
	14	Plant and animal refugia	How holes in the ground provide a place for prairie dogs to sleep in and be protected from predators.
Production Functions			
	15	Food production	How apple trees provide apples for people and other animals to eat.
	16	Genetic and medicinal resources	How chewing on a piece of willow bark will relieve a headache.
	17	Raw materials	How some trees are cut down and used as lumber in the construction of homes.
Information Functions			
	18	Aesthetic beauty	How the view of a snowcapped mountain or a colorful flower garden is perceived by an observer as beautiful and/or pleasing to the eye.
	19	Human culture	The presence of an ancient and sacred Native American Indian burial ground.
	20	Preservation (including existence, bequest and option value)	How values exist in relation to knowing that the Old Faithful Geyser in Yellowstone National Park 'exists,' that you have the 'option' of visiting the geyser if you wish to, and that it will be around for your great grandchildren to see ('bequest'), even though you may never choose to visit there yourself.
	21	Recreation	Activities such as fishing, hunting, swimming, or hiking on public lands.
	22	Science and education	When schoolchildren visit a pond to learn about the creatures that live in the water.

Table 3. Ecosystem Service Functions Listed by Category with Examples (Kaval, 2010)

All twenty-two ecosystem service functions within the four categories apply to the CRB. However, focus for this project will be on five ecosystem service functions: recreation, food production, the purification and regulation of water, erosion control, and natural disturbance regulation. These functions fall into the categories of regulation, production and information functions. More specifically, within the function of natural disturbance, efforts were placed on protection from flooding and sediment loading, while in the category of purification and regulation of water, focus was placed on groundwater recharge (Table 4).

Ecosystem Service Category	**Ecosystem Service Functions**	**Goods and Activities**
Regulation Functions	Natural disturbance regulation	Protection from flooding
	Natural disturbance regulation	Sediment loading
	Erosion control	Control of riverbank erosion
	Purification and regulation of water	Groundwater recharge
Production Functions	Food production	Food from agricultural crops
	Food production	Fish
Information Functions	Recreation	Focus placed on fishing, motorized boating, and non-motorized boating, but other Colorado River Basin recreation activities will also be considered

Table 4. Ecosystem Services of Importance to this Study

Ecosystem Service Valuation

As stated previously, there are 22 ecosystem functions important for ecosystem service valuation that humans depend upon. A simple example is how plants produce oxygen, a gas we need to breathe, and how the ozone layer protects our skin from the sun's rays. Without oxygen and the ozone layer, we would die. However, it is difficult to understand the comparison between how much oxygen a person needs, how much oxygen one tree produces, and how well the ozone layer prevents us from getting skin cancer or burning. Consequently, it would be easier to compare human oxygen requirements, tree oxygen production, and ozone layer protection, if they are all expressed in the same type of unit.

Economists have recommended the use of a dollar value as the common unit of comparison, as most people use currency as a medium of exchange. In this way, it is a concept understood by a large proportion of the population and is therefore a logical comparison medium (Costanza et al., 1997; Daily, 1997; Daily et al., 1997; de Groot et al., 2002).

Placing a dollar value on ecosystem services requires consideration of the interconnectedness of the ecosystem. In this way, the total economic value, or the aggregation of all use and non-use values provided by a particular ecosystem, in this case the CRB, can be calculated. This is easier said than done, however, as ecosystem services consist of many different values, from the cost of purchasing gold to the value of the ability of the Colorado pikeminnow[9] to have a clear migration path to travel on to spawn (Merlo and Croitoru, 2005; Pearce and Turner, 1990).

Therefore, in relation to economic valuation, it may be easier to think of these services according to the type of value they provide (Figure 1). The first step in accomplishing this task is determining whether the good or service should be classified as a market value or non-market value. Market values are simply the out-of-pocket expenses traded in formal markets, such as the sale of fish caught by a commercial angler or the cost of a monthly water bill. Ecosystem services that cannot be measured in terms of market values have a non-market value,[10] where no 'direct' exchange of money takes place (Anderson, 2006; Bateman et al., 2010; Freeman, 2003; Hartwick and Olewiler, 1998; National-Research-Council, 2005; Pearce and Turner, 1990; Tietenberg, 2006).

Both market and non-market values can be categorized into use values or non-use values. Use values focus on a person using a resource in some way. They can be further subdivided into direct and indirect use values. Direct use values are those values where the user directly participates in an activity, such as swimming or birdwatching. Indirect use values are those values where the user obtains value from the activity, but does not use it directly, such as the value of erosion control preventing a home from slipping into the ocean.

Non-use values are sometimes called passive use values or preservation values. Three types of non-use values are commonly studied: 1) existence value, 2) bequest value, and 3) option value. Existence value is the value one obtains from knowing something exists, i.e., knowing that the Colorado pikeminnow exists and is important to people, even if they never see one in their lifetime. Bequest value is the value received from knowing that something will be around for future generations. For example, someone may have a granddaughter that likes to go rafting and even though they may never go rafting themselves, they know that the Grand Canyon section of the Colorado River is an area that their grandchild may wish to visit someday and is available to them. Option value refers to having the option to use a resource in some way if the opportunity arises. Perhaps a person has always heard stories about the beautiful scenery at the Grand Canyon and would someday like to go there, but, due to financial circumstances, they may not currently be able to go. As long as they have the option to go there sometime in the future, if they have the means, they consider it is worth something to them to have it protected in the meantime (Pearce and Turner, 1990; Freeman, 2003).

[9] The Colorado pikeminnow used to be called the Colorado squawfish.
[10] Non-market values can be anthropocentric (human centered) or ecocentric (nature centered).

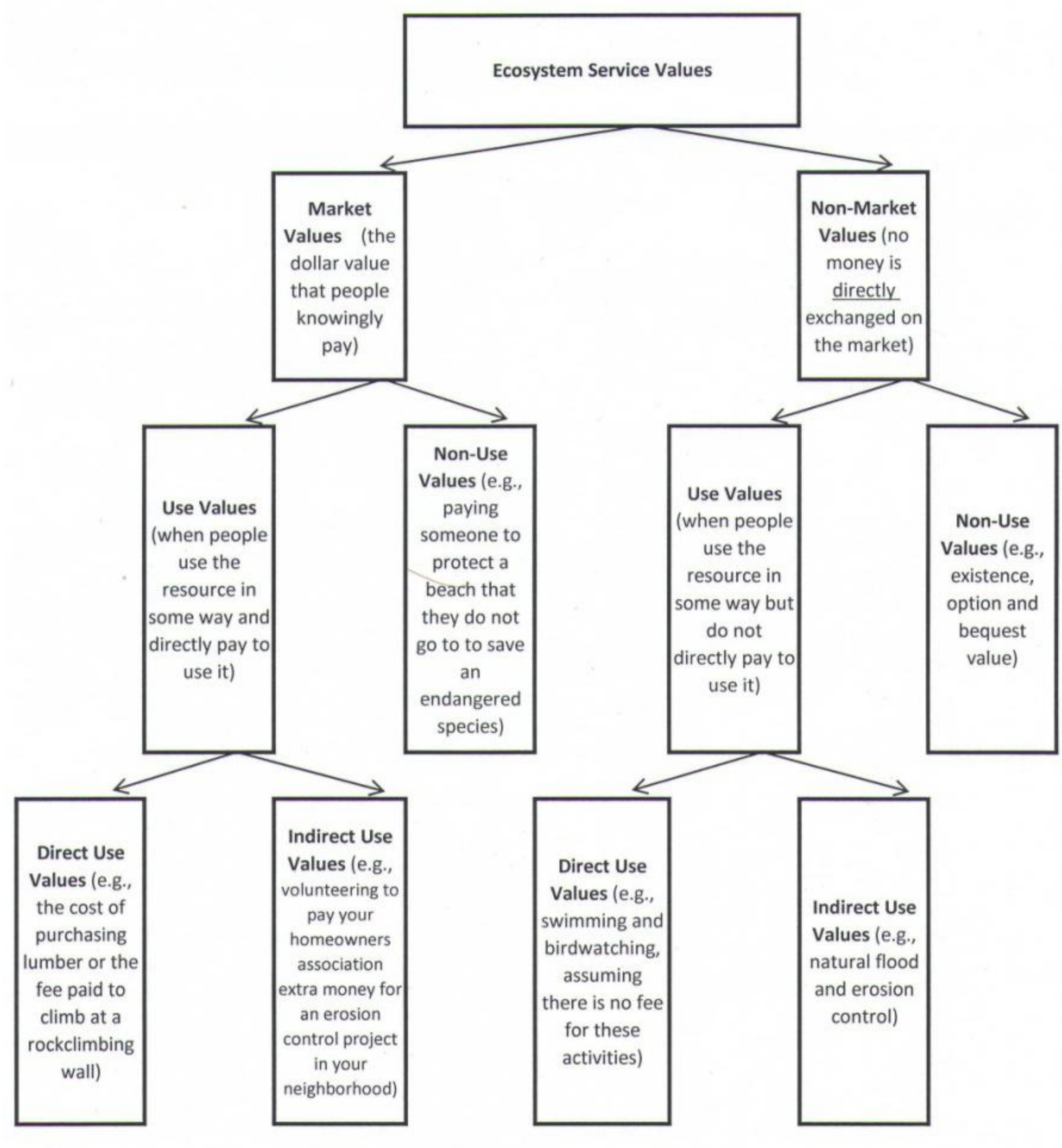


Figure 1. Ecosystem Service Valuation Types. *Note:* Market values are typically measured as direct use values, whereas indirect use and non-use values are more commonly measured as non-market values (Kaval, 2010).

Once the ecosystem service valuation type has been determined, one or more valuation methods can be applied to estimate the value. As stated previously, market values are simply the out-of-pocket expenses traded in formal markets, hence, they are typically easier to calculate than non-market values. Several tools have been devised to calculate non-market values, as they are more difficult to calculate, since no direct exchange of money takes place. These tools include the travel cost method, hedonic pricing method, contingent valuation method, choice modeling method, avoided cost, restoration cost, replacement cost, factor income and the benefit transfer method. All of these tools have been used to calculate ecosystem service values. Some studies may only use one technique, while others may use two or more. Since the focus of this study is on value transfer, or benefit transfer, a detailed explanation of each method will not be presented in the main body of the text. For more information, a brief description and example of each method is presented in Appendix A.

Primary research is a “first-best” strategy for information gathering. However, when primary research is not possible, the benefit transfer technique can be used as a good “second-best” strategy. Benefit transfer is a practical technique that can be used to evaluate management or policy impacts. It refers to the use of existing values or methodological formulas from a “policy site” transferred to new sites or areas called the “study site” (Kaval and Loomis, 2003; Rosenberger and Loomis, 2001).

Benefit transfer is an appropriate tool to conduct when data is required, but time and funding for primary data collection is low, or when expected resource impacts will be low or insignificant, but the technique is not issue free. Benefit transfers can only be as good as the data that is obtained. In other words, if the data came from a low quality study, the results will be of lower quality. In addition, there may not always be studies available with the exact data requirements of your study. As most primary research is not designed for value transfer, the data between studies may not be equally comparable. Another factor is that different statistical methods can lead to large value differences and that some of the data that does fit your qualifications may be old and values may have changed. Any or all of these issues can lead to biased results. However, not accounting for values is the worst strategy, as this implies a zero value (Kaval and Loomis, 2003; Rosenberger and Loomis, 2001).

There are two primary benefit transfer approaches: value transfer and function transfer. Value transfers focus on the transfer of benefit estimates from a study site to a policy site. Function transfers encompass the transfer of benefit or demand functions from a study site. The adapted function is then used to ‘forecast’ policy site benefit measures. For more detailed information about benefit transfer, refer to Kaval and Loomis (2003) and Rosenberger and Loomis (2001). As the CRB covers an extensive area, value transfer is more appropriate for this particular study.

Methods

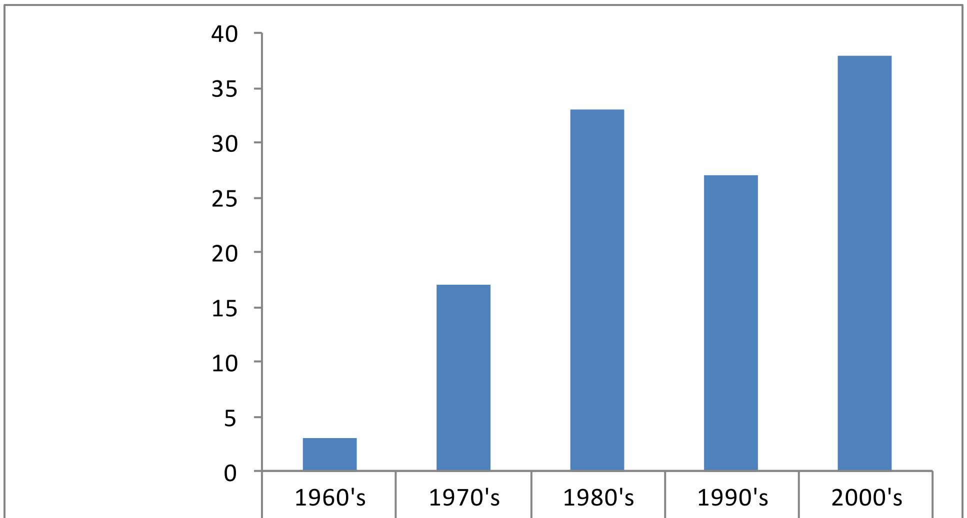
This study summarizes the literature on the ecosystem service values of the CRB by applying the value transfer method. As stated previously, the value transfer process involves the transfer of economic value estimates from previous CRB related studies to calculate values for the CRB. While it would be ideal to calculate original values, time and funding does not permit that for this particular project.

The literature search was conducted during the months of July 2010 through September 2010. In total, 431 potentially relevant studies were located. After a thorough review of all of the works, 119 were identified as including the necessary information and were entered into the database. However, while all of the 119 studies were related to the CRB, only 38 were specific to the CRB.

Each observation entered into the database contains an ecosystem service monetary value. Because some studies reported more than one value, such as the value of fishing, hunting and wildlife watching related recreation, there are more observations in the database than there are studies. Overall, the database contains 516 observations and 70 variables. Variables include year of publication, full reference, the good or service that was valued, location of the study, ecosystem service or ecosystem type, the reported value, the year the data was collected, and the valuation methodology used in the study, to name a few. The completed data table was used to calculate ecosystem service values as well as analytical diagrams and summaries for this report. Please refer to Appendix C for more detail on the search process.

Database Summary

Of the 119 studies collected, 80 (68%) used data collected prior to the year 2000. Thirty-eight studies (32%) had collected their data between the years of 2000 and 2009 (Figure 2). Several of the newer studies were summaries of the previous literature and did not report original data. These literature review studies were extremely useful in the process of locating relevant studies. As 68% of the data from the studies was collected prior to the year 2000, there is the possibility that the results they present no longer reflect current values. However, collecting new data is beyond the scope of the current study.



	1960's	1970's	1980's	1990's	2000's
Number of Studies	3	17	33	27	38

Figure 2. Database Studies Categorized by Data Collection Year. Note that several studies in the 2000's were literature review/meta analyses. Therefore, the number of studies using original data in the 2000's is fewer than 38. Most studies are relevant to, but not specific for, the Colorado River Basin (such as a study on river rafting in the entire state of Colorado).

Some of the database studies included information specifically on the CRB, while others focused on one or more of the nine states (seven in the US and two in Mexico) in the CRB (Figure 3). Overall, 20% of the studies in the database applied to Arizona and 19% applied to Colorado. Only 1% of the studies presented valuation data for Mexico. There is the possibility that other studies have been conducted for the Mexican section of the CRB, however, only studies written in English were investigated here.

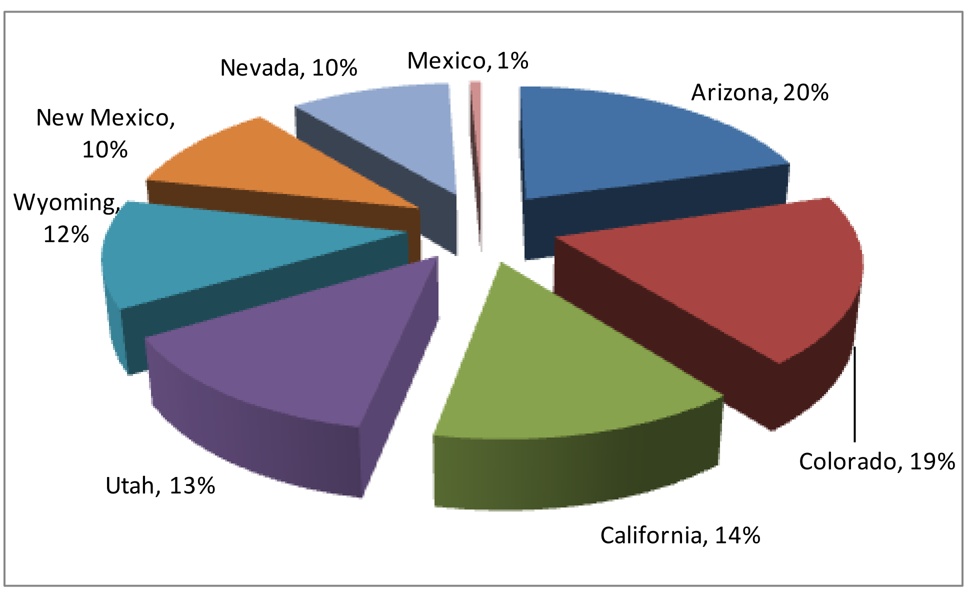


Figure 3. Percentage of Studies by Location

As stated previously, there were 516 ecosystem service valuation related observations entered into the database. Sorting the observations by ecosystem service categories yields four categories: the information function (91.60%), regulation function (4.39%), production function (3.44%), and a category for studies that investigate all ecosystem service values (0.57%). None of the located studies focused on valuing habitat functions (Figure 4).

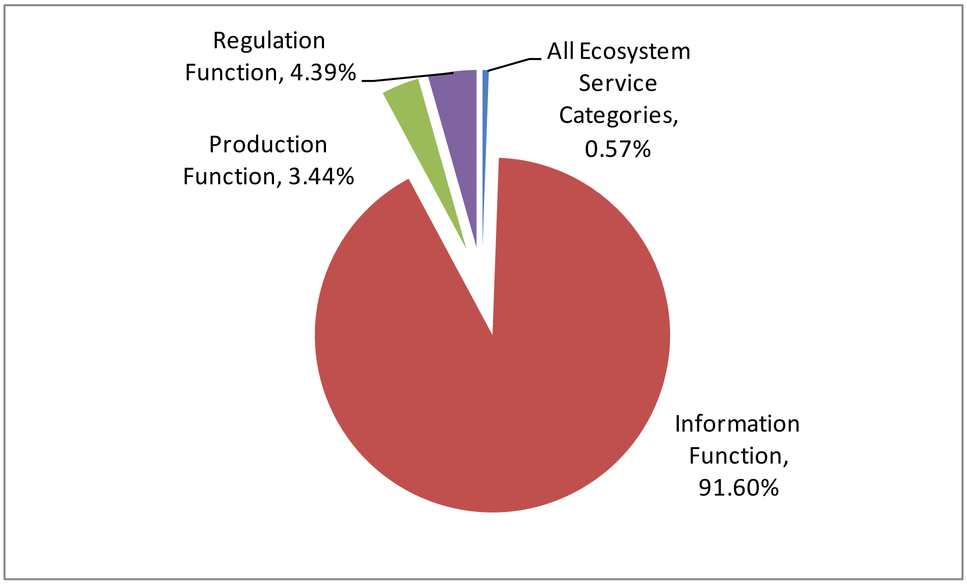


Figure 4. Study Observation Percentage by Ecosystem Service Category

Ecosystem Service Categories can be subdivided further into ecosystem service functions. The regulation function consisted of the purification and regulation of water flow, which composed 4% of the observations in the database. The production function was composed of food production (1.34%) and raw materials (2.10%). Less than 1% of the observations focused on the value of all ecosystem services. As stated previously, 91.6% of the observations fell into the information function category; this category could be further broken down into recreation (87.4%), preservation (3.82%) and human culture (0.38%)[11] (Figure 5).

[11] One study was located that values human culture, the Welsh et al. (1997) study. They investigated the value people had for an increase in water flow, which leads to an increase in vegetative area that would result in a 10% increase in wildlife and bird habitat, Native American sacred and archeological sites would experience a decrease in the risk of erosion and the size of beaches would remain the same. However, since the study focused more on instream flow valuation than Native American sites, it was placed in the Regulation Function category under Instream Flow.

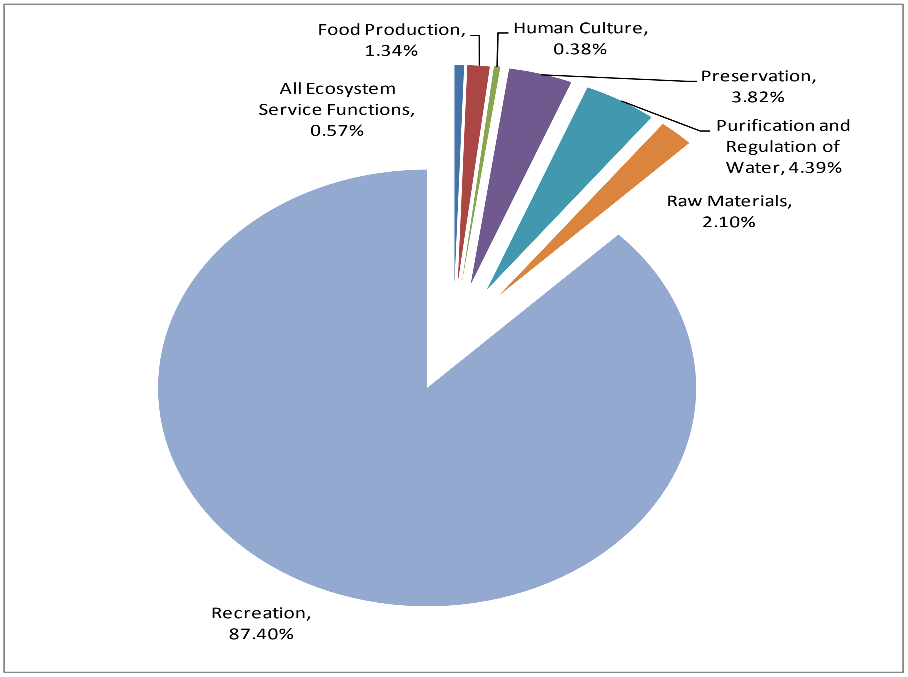


Figure 5. Study Observation Percentage by Ecosystem Service Functions

Recreation studies focused on 18 specific activities: backpacking (1% of the observations), birding (1%), camping (2%), cross country skiing (1%), downhill skiing (<1%), fishing (20%), general recreation (3%), hiking (2%), hunting (27%), motorboating (<1%), mountain biking (<1%), recreation in National Parks (<1%), non-motorized boating (primarily rafting) (6%), off road vehicle use (<1%), picnicking (1%), sightseeing (including pleasure driving) (1%), snowmobiling (2%), swimming and other beach recreation (<1%) and wildlife watching (18%). Three of these activities (fishing, hunting, and wildlife watching) made up almost 2/3 of the observations in the database (Figure 6). This is due to the availability of longitudinal data from the National Survey of Fishing, Hunting and Wildlife Associated Recreation (to be discussed in detail in the results section).

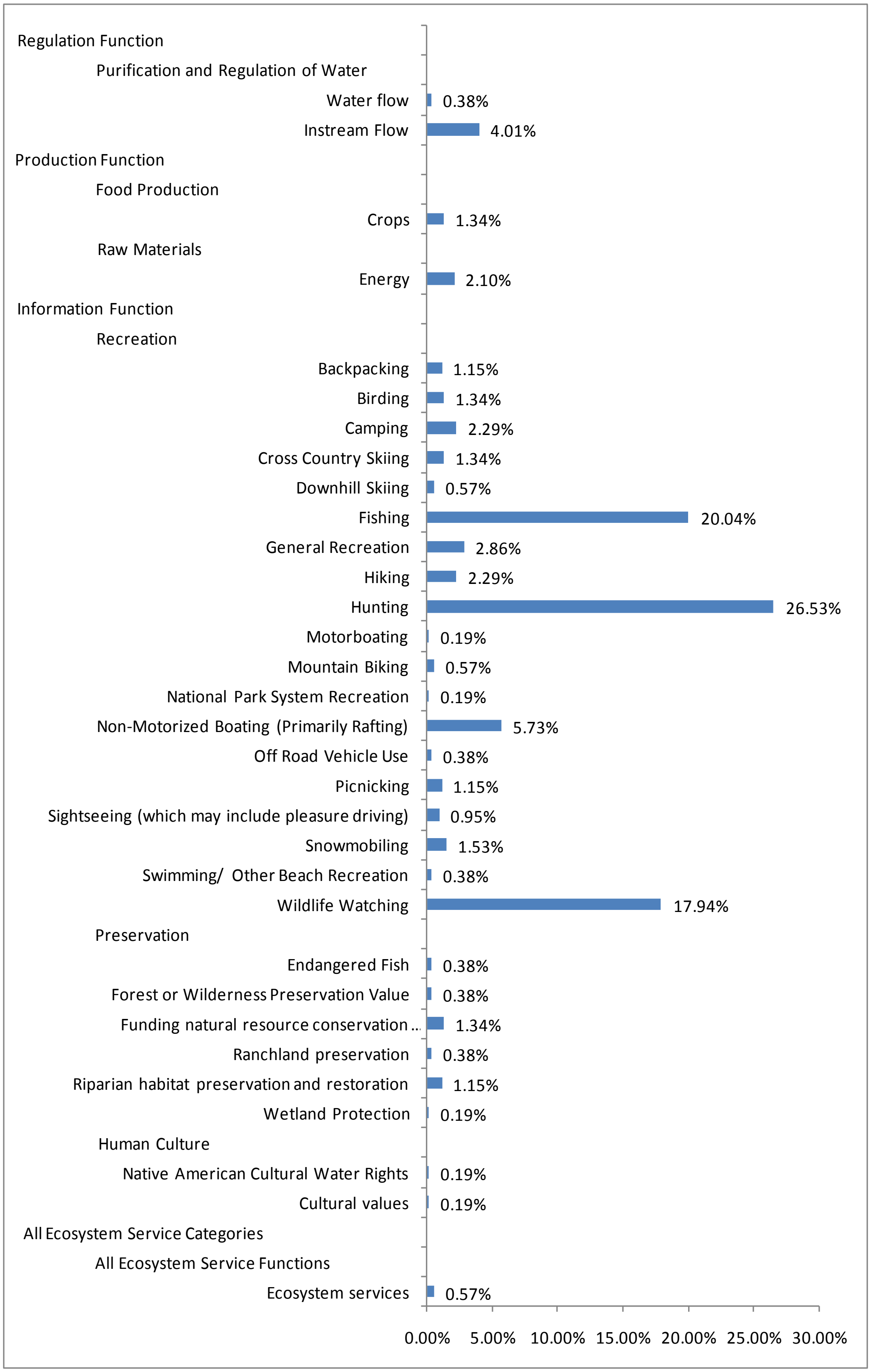


Figure 6. Percentage of Database Observations by Ecosystem Service Category, Ecosystem Service Function, and Ecosystem Service

Results

Ecosystem Service Information Function Category: Recreation Function

There were more recreation related observations (87%) in the database than all of the other ecosystem service function observations combined. Studies investigated 18 specific recreation activities, including both water and land based studies.

National Survey of Fishing, Hunting, and Wildlife-Associated Recreation

The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (National FHWAR Survey) has been conducted every five years since 1955 at the request of state fish and wildlife agencies. It is an extremely comprehensive survey and involves interviews with US residents to determine the number of participants in fishing, hunting, and wildlife watching activities in the US, as well as how often they participate and how much they spend on these activities. According to the US Department of the Interior, Fish and Wildlife Service, US Department of Commerce, and US Census Bureau (2006), the 1991, 1996, 2001, and 2006 surveys applied similar methodologies, and therefore, their data is comparable. Data in the survey are presented on a state by state basis and not specific to any water basins, such as the CRB. As such, the data presented here focused on information for the seven US states that fall within the CRB (U.S. Department of the Interior et al., 2001; U.S. Department of the Interior et al., 1991; U.S. Department of the Interior et al., 1996; U.S. Department of the Interior et al., 2006).

Data from the National FHWAR Survey were collected and summarized for the years of 1991, 1996, 2001 and 2006 for fishing, hunting and wildlife watching recreation activities in the seven CRWB US states. Details are presented in Appendix D. Table 5 presents expenditures for freshwater fishing, hunting and wildlife watching by state. Total expenditures for all activities and all states within the basin combined for 2006 were $15 billion.[12] Wildlife watching, an activity participated in by significantly more people than the activities of freshwater fishing and hunting combined (refer to Appendix D), had $8.5 billion in expenditures in 2006. Hunting had $2.4 billion expenditures and freshwater fishing had $4.1 billion.

[12] Unless otherwise noted, all values in this study have been converted to 2009 USD for comparison purposes using the Consumer Price Index. Consumer Price Index values are located in Appendix A.

	Freshwater Fishing	Hunting	Wildlife Viewing	Totals
Arizona	$853,896,634	$343,449,162	$892,101,160	$2,089,446,956
California	$1,279,080,000	$865,424,547	$4,447,786,841	$6,592,291,388
Colorado	$577,778,151	$472,556,394	$1,476,788,083	$2,527,122,628
New Mexico	$153,915,399	$174,851,644	$316,243,656	$645,010,699
Nevada	$320,423,141	$137,363,064	$385,473,235	$843,259,440
Utah	$394,900,257	$291,350,591	$600,663,307	$1,286,914,155
Wyoming	$554,943,156	$146,073,295	$420,207,744	$1,121,224,195
Totals	$4,134,936,738	$2,431,068,697	$8,539,264,026	$15,105,269,460

Table 5. Total State Expenditures for Freshwater Fishing, Hunting, and Wildlife Watching Activities in 2006 (2009 USD).

The values in Table 5 represent expenditures for the entire states located within the basin. If we make the assumption that recreation expenditures in each of the CRB states corresponds directly with the percentage of land located within the CRB in each of the states, then recreation expenditures for fishing, hunting and wildlife watching specific to the CRB can be estimated. This assumption is based on the fact that 75% of the lands within the basin are federally managed.

By extrapolating the data to be more specific to the CRB, we find that total expenditures for fishing, hunting and wildlife watching activities in the basin were $4 billion (Table 6). Wildlife watching ($1.9 billion) had the highest expenditures of the three activities ($1.4 billion for freshwater fishing and $736 million for hunting).

	Freshwater Fishing	Hunting	Wildlife Viewing	Totals
Arizona	$813,920,982	$327,370,395	$850,336,941	$1,991,628,319
California	$29,696,150	$20,092,392	$103,263,396	$153,051,938
Colorado	$214,363,430	$175,324,750	$547,908,153	$937,596,333
New Mexico	$29,203,838	$33,176,272	$60,003,929	$122,384,039
Nevada	$35,925,749	$15,401,107	$43,219,147	$94,546,003
Utah	$189,166,216	$139,563,568	$287,731,404	$616,461,188
Wyoming	$96,650,020	$25,440,420	$73,184,229	$195,274,668
Totals	$1,408,926,386	$736,368,904	$1,965,647,198	$4,110,942,488

Table 6. Estimated Colorado River Basin Expenditures for Freshwater Fishing, Hunting, and Wildlife Watching Activities by State in 2006 (2009 USD).

Flow-On Impacts

The aggregate annual expenditures in Table 6 are a net gain to the seven US states located within the CRB, a large percentage of this monetary gain would not be captured without the existence of the CRB. These expenditures account for the direct costs of participating in recreation activities, such as fishing licenses, hunting licenses, park entrance fees, gas and campground stays. However, this direct expenditure is only the first-round impact. Subsequent flow-on impacts to the region, such as spending by employees servicing visitors and employee compensation, can be estimated using an input-output model[13] or an economic multiplier.[14]

A more complete impact would account for:

- Gross revenue, sales or output in dollars
- Net household income (after tax and retirement savings) in dollars
- Employment impact in full-time equivalent employees (FTEs)
- Regional value added or GDP(gross domestic product)/GRP(gross regional product) in dollars

An input-output model, such as Implan, can be used to estimate detailed flow-on impacts. However, when detailed flow-on impact models are not available, a multiplier can be used to estimate flow-on impacts. Chang (2001) investigated recreation and tourism multipliers throughout the US. For rural locations, of which much of the basin is located, Chang found that for each dollar spent on tourism, another $0.75 (1.75 multiplier) to $1.83 (2.83 multiplier) is incurred to the economy in indirect or induced effects (Chang, 2001). However, specifically for recreation in rural areas, the multiplier was found to be 2.55.[15] According to Weisbrod and Weisbrod, when considering national impacts, the multiplier typically ranges between 2.5 and 3.5, for state impacts from 2.0 to 2.5 and for local impacts from 1.5 to 2.0 (Weisbrod and Weisbrod, 1997). The National Park Service, Greiner and Werner, and the Colorado Tourism Board reported a 2.56 multiplier for recreation in Colorado, such as rafting (Greiner and Werner, 2010; U.S. Department of the Interior, 1995). Searns conducted a study on a riverfront greenway in North Dakota and found a multiplier of 2.66 (Searns, 2007). Three New Zealand studies on the creation of new parks and rail trail projects found economic impact multipliers of 1.71, 1.73, and 1.75(Hughes et al., 2004; Kaval, 2006; Kaval, 2008). All of the US recreation studies located had multiplier ranges that fell within Chang's recommended range for tourism activities in rural areas, as such, the multiplier used in this project is 2.55, which was the recommended range for recreation activities in US rural areas (Chang, 2001).

Applying the 2.55 multiplier to the activities of freshwater fishing, hunting, and wildlife watching in the Colorado Basin Area, we find a total flow-on impact of $10.5 billion (Table 7). Wildlife watching had a total flow-on impact of $5 billion, where the greatest impact resulted from wildlife watching in Arizona ($2 billion) and the least impact from wildlife viewing in Nevada ($110 million). The total for hunting was $1.8 billion. The least impact resulted from

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[13] An example of the results of flow-on impact calculations from an input-output model are presented in Appendix E.
[14] An economic multiplier captures the effect on the overall economic activity as a result of a change in a project or event, such as tourism in an area.
[15] Chang (2001) found multipliers of 2.55, 2.84, and 3.07 for recreation in rural, small metro, and larger metro areas, respectively.

hunting in Nevada ($39 million), while the greatest impact resulted from hunting in Arizona ($834 million). For freshwater fishing, the total flow-on impact was $3.5 billion, with the least impact from fishing in New Mexico ($74 million) and the greatest impact from Arizona fishing ($2 billion).

	Freshwater Fishing	Hunting	Wildlife Viewing	Totals
Arizona	$2,075,498,504	$834,794,508	$2,168,359,200	$5,078,652,213
California	$75,725,182	$51,235,600	$263,321,660	$390,282,442
Colorado	$546,626,747	$447,078,112	$1,397,165,790	$2,390,870,649
New Mexico	$74,469,788	$84,599,494	$153,010,018	$312,079,299
Nevada	$91,610,660	$39,272,822	$110,208,824	$241,092,307
Utah	$482,373,852	$355,887,099	$733,715,080	$1,571,976,030
Wyoming	$246,457,551	$64,873,071	$186,619,783	$497,950,404
Totals	$3,592,762,284	$1,877,740,706	$5,012,400,354	$10,482,903,344

Table 7. Economic Flow-On Impacts from Fishing, Hunting and Wildlife Viewing in the Colorado River Basin.

In summary, many people participate in the activities of fishing, hunting, and wildlife watching associated recreation in the seven US states where the CRB is located. These activities account for approximately $4 billion in direct expenditures and almost $10.5 billion in flow-on impacts. An increase in the quality of these activities as a result of an increase in the quality of the watershed and its ecosystem services would likely result in an increase in expenditures and flow-on impacts. Consequently, a decrease in the quality of ecosystem services, and hence, a decrease in the amount of recreation in the CRB, would result a decrease in the value.

Recreation Consumer Surplus Values

One technique commonly applied to calculate the value of recreation is to ask people what they would be willing to pay over and above what they already pay. This value is their consumer surplus value and this particular methodology is called the contingent valuation method. An example of what consumer surplus represents is illustrated in Figure 7. In this figure, we see that the cost of the entrance to the park is $2. At this price, 100 people enter the park, providing a market value of $200 ($2 x 100). This market value is represented by the grey box labeled MV. However, many of these people were willing to pay more than the $2 entrance fee. This extra amount they are willing to pay over and above the $2 is their consumer surplus and is indicated as the triangle CS in Figure 7. Consumer surplus in this example would be $25 (($2.50-$2.00) x 100 x 1/2). Therefore, the total benefit of the park is $225 ($200 + $25). This example assumes that there is a substitutable good available for the good in question (the park in this case) and that the supply curve is represented by an upward sloping line, which may not always be the case (Bateman et al., 2002; Champ et al., 2003; Costanza et al., 1997; Pearce and Turner, 1990).

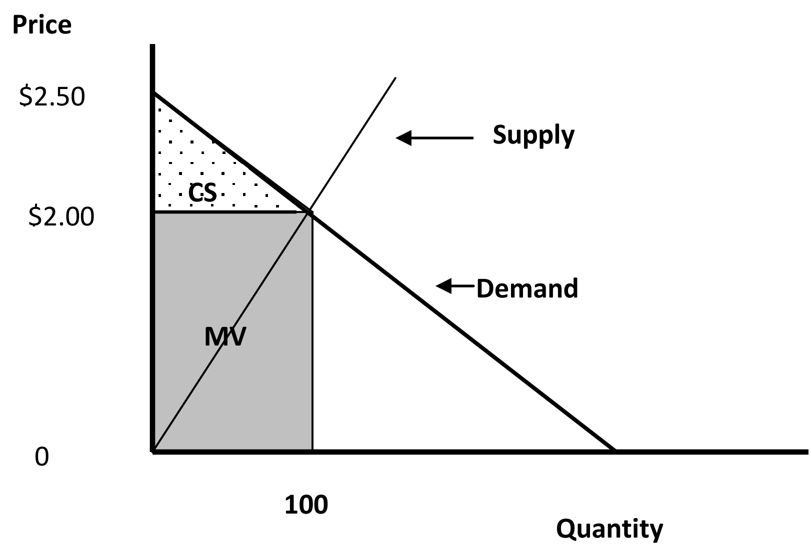


Figure 7. Consumer Surplus for Entrance to a Park that Charges a $2 Entrance Fee

When there is no substitutable good, the consumer surplus value may take a different shape (Figure 8). There is now a limited supply (only one park) and the shape of the supply curve would be a vertical line. Because of this limited supply, as the quantity decreases, the consumer surplus of the good would increase.

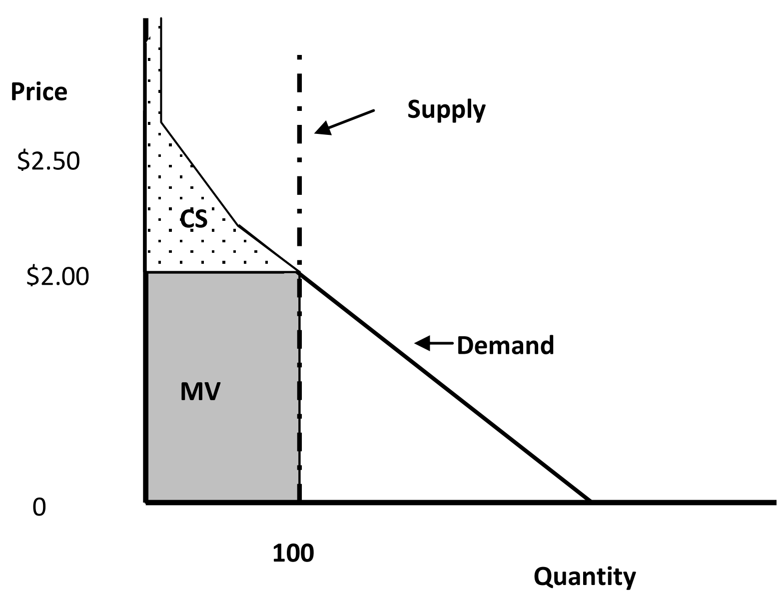


Figure 8. Consumer Surplus for the Entrance to a Park with No Park Substitute

The recreation observations in the database assume consumer surplus as in Figure 7. The studies in the database calculated consumer surplus values for seventeen recreation activities (Figure 9). Mountain biking was found to have the highest consumer surplus value/person/day ($271.73), while the lowest value was for hiking ($30.80/person/day). Non-motorized boating, primarily rafting, had a value of $201.14/person/day (2009 USD). The overall average consumer surplus value of studies in the database was $92.08/person/day.

In relation to numbers of observations, the activity with the most observations was hunting (32). There was only one observation for swimming/ other beach recreation and one observation for motorboating. This was surprising, as both of these activities are popular in the CRB.

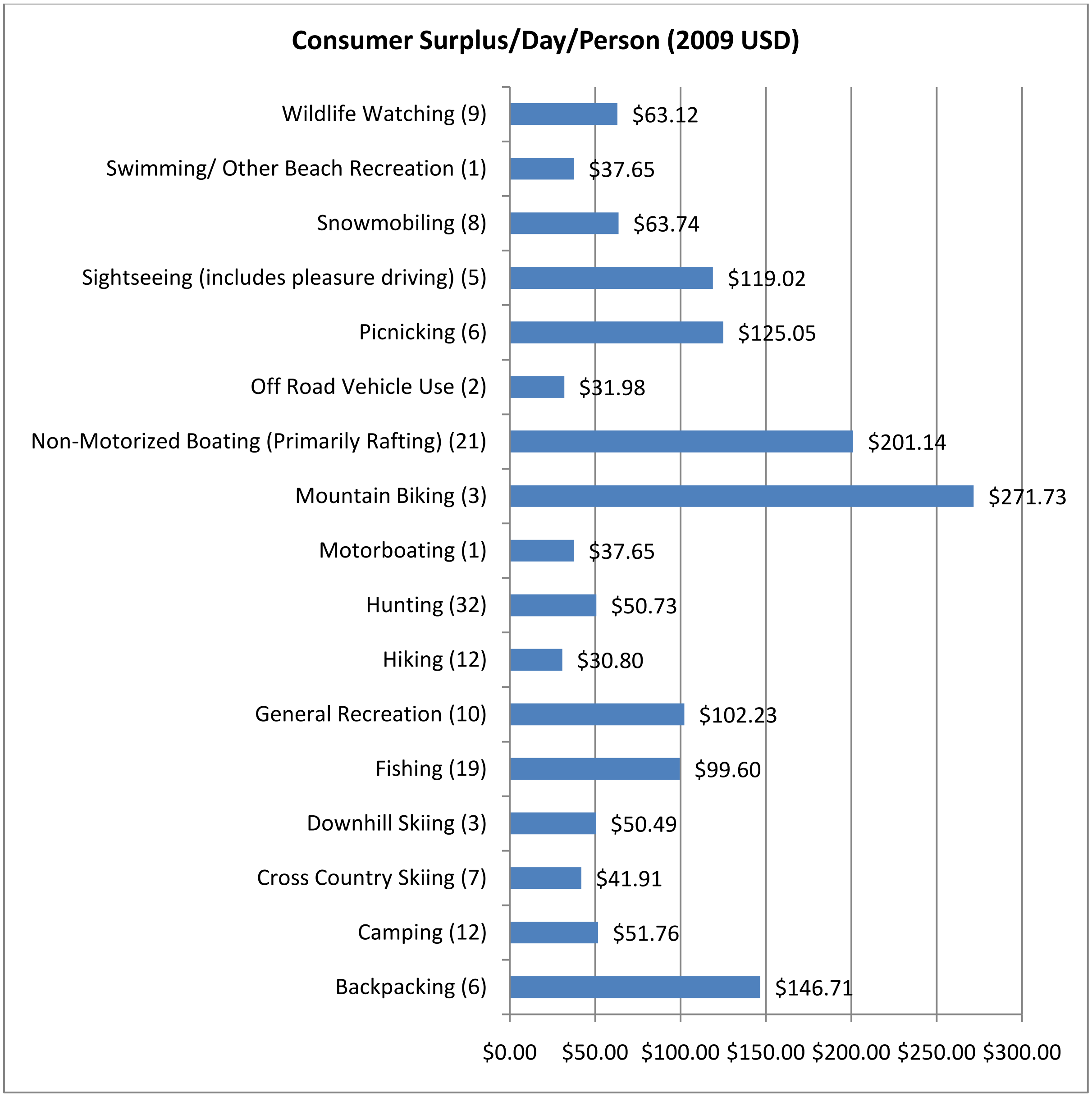


Figure 9. Consumer Surplus Values/Day/Person (2009 USD) by Activity for Activities Either Directly within the Colorado River Basin or in the States the Basin is Located in. Numbers in Parenthesis Indicate the Number of Observations.

According to the Outdoor Foundation (2010), 48.9% of Americans and 55% of people in the Mountain States (AZ, CO, NV, WY, NM, UT, ID, and MT) participate in outdoor recreation activities for an average of 54.2 outdoor recreation days a year. In this case, outdoor recreation activities include all outdoor activities from picnicking, walking the dog, and having lunch outside, to backpacking, fishing and cross country skiing. Using these numbers can assist in the calculation of the consumer surplus value of outdoor recreation participants in the nine CRB states (US and Mexican).

If we assume that the same percentage of people in the two CRB Mexican states participate in outdoor activities as people in the mountain states, then 55% of the people in the nine CRB states participating in outdoor activities yields 25 million people. This 25 million person number represents all people participating in recreation in the states, not just the number of people participating in the CRB area located within the states. Many of the located consumer surplus studies were conducted prior to the year 2000. As significant time has passed since then, it may be the case that values have changed, therefore, the average of $92.08/person/day may actually be an overestimate. However, we do know that people still participate in all these activities; therefore, people still have a value for them. Consequently, the lowest consumer surplus value in Figure 9 was $30.80/day for hiking. As such, we assume that people value all activities at least at this minimum amount and will base our calculations on this minimum. In 2008, the median US household income was $50,112, while the median Mexican household income was $10,611 (Exchange-Rates.org, 2010; Instituto Nacional De Estadistica y Geografia Mexico, 2009; U.S. Census Bureau, 2010). Adjusting for inflation and assuming consumer surplus is directly related to income, we find that the consumer surplus value for a person in Mexico is $6.52/person/day.

After all calculations were made, it was determined that the consumer surplus value for outdoor recreation for all people in the 9 CRB states is slightly over $39 billion (Table 8). This considered recreation of all people in the states in general. If we use the same calculation from the previous section to determine CRB specific calculations, we find that the consumer surplus value of the CRB for people in all 9 states in the basin is $3.4 billion.

Country	State	2009 Population	Household Number	Population Aged 18 and Over	People that Participate in Outdoor Recreation Activities (Over 18) Assuming 55% of people participate	Annual Consumer Surplus for Outdoor Recreation Assuming $30.80/person/day ($6.52/person/day for Mexico) for 54.2 days/year for the Entire State	Annual Consumer Surplus for Outdoor Recreation for the Colorado River Basin Only
United	Arizona	6,595,778	2,752,991	4,863,759	2,675,067	$4,465,650,598	$1,962,303,459
States	California	36,961,664	13,433,718	27,525,982	15,139,290	$25,272,925,321	$376,574,027
	Colorado	5,024,748	2,167,850	3,796,985	2,088,342	$3,486,194,184	$544,445,576
	Nevada	2,643,085	1,137,997	1,962,052	1,079,129	$1,801,454,120	$90,303,640
	New Mexico	2,009,671	878,043	1,499,433	824,688	$1,376,701,410	$128,441,689
	Utah	2,784,572	952,999	1,915,748	1,053,661	$1,758,940,195	$289,287,961
	Wyoming	544,270	249,388	412,245	226,735	$378,501,922	$26,073,508
Mexico	Baja California	3,165,776	1,207,427	2,349,322	1,292,127	$456,617,115	$5,811,836
	Sonora	2,510,562	957,528	1,863,088	1,024,698	$362,112,031	$4,608,972
Totals		62,240,126	23,737,941	46,188,614	25,403,738	$39,359,096,896	$3,427,850,669

Table 8. Population of People Participating in Outdoor Recreation Activities and Their Corresponding Consumer Surplus Values by State. Sources: (Consejo Nacional de Poblecion, 2010a; Consejo Nacional de Poblecion, 2010b; Exchange-Rates.org, 2010; Instituto Nacional De Estadistica y Geografia Mexico, 2009; Outdoor Foundation, 2010; U.S. Census Bureau, 2010). Data for Mexican households and persons over age 18 are estimates using 38.14% of the population as the household number and 74.21% of the population as aged over 18 from the table averages. The lowest consumer surplus value in Figure 9 was applied (and adjusted in the case of Mexico according to average income). The specifics of 55% and 54.2 days/year were from the Outdoor Foundation (2010) report.

River Rafting and Kayaking

Greiner and Werner (2010) reported user days and values for rafting on all rivers in the state of Colorado. Nine of the rivers are located in the CRB: Animas, Blue, Colorado, Dolores, Green/Yampa, Gunnison, Piedra, Roaring Fork, San Juan, San Miguel, and the Taylor. They also reported values for the Arkansas River, which is not a Colorado River Tributary, but does receive water from the Colorado River to enable it to maintain reliable summertime flows. Overall rafting commercial user days for all rivers in Colorado was 326,242 in 1991. This number increased by 61% to 539,222 in 2007 (Figure 10).

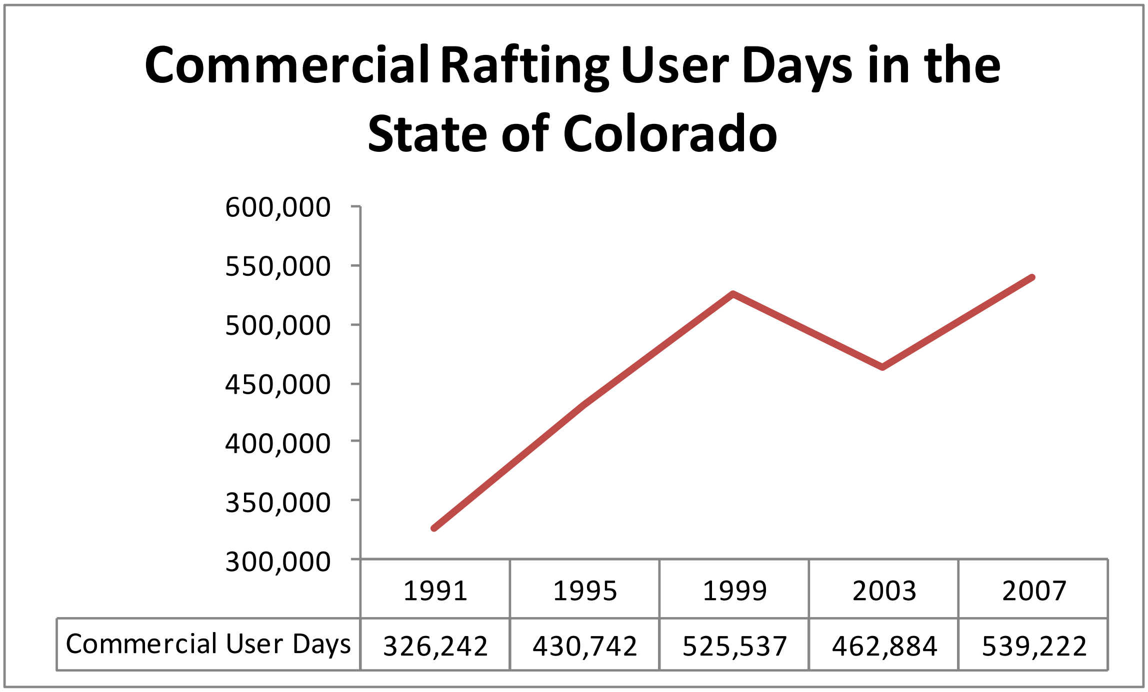


Figure 10. Commercial Rafting User Days for All Rivers in the State of Colorado (Greiner and Werner, 2010).

The most popular river for rafting was the Arkansas, with 205,876 user days in 2009. Direct expenditures for the Arkansas were $23,470,236 and flow-on impacts were $60,083,805.[16] The next most popular river, and one located in the CRB, was the mainstem of the Colorado River with 90,600 user days in 2009 (Table 9); this resulted in direct expenditures of $10.3 million. If all flow-on impacts are included, the total value of rafting on the Colorado River is $26.5 million. Overall, rafting values for all rivers in the state of Colorado yielded $55 million in direct expenditures and nearly $142 million in total flow-on impacts. It is important to note, however, that their expenditure data was based off of results from a 1991 survey focussed on the Arkansas headwaters recreation area. As illustrated in Figure 10, rafting has dramatically increased in popularity since 1991, therefore, actual expenditures have most likely increased alongside the increase in river rafting participation (Greiner and Werner, 2010).

[16] Flow-on impacts include the "indirect" and "induced" business impacts of an activity.

Section	River	User Days	Direct Expenditures	Economic Flow-On Impact
Colorado River Tributaries				
	Animas	42,421	$4,836,071	$12,380,341
	Blue	3,089	$352,152	$901,508
	Colorado	90,660	$10,335,404	$26,458,634
	Dolores	536	$61,105	$156,429
	Green/Yampa	12,194	$1,390,138	$3,558,753
	Gunnison	9,269	$1,056,682	$2,705,107
	Piedra	547	$62,359	$159,639
	Roaring Fork	5,511	$628,264	$1,608,356
	San Juan	4,107	$468,205	$1,198,606
	San Miguel	3,782	$431,155	$1,103,756
	Taylor	14,332	$1,633,874	$4,182,717
	Tributary Totals:	186,448	21,255,409	54,413,846
River that receives water from the Colorado River				
	Arkansas	205,876	$23,470,236	$60,083,805
Totals for All Rafting Rivers in the State of Colorado		**486,151**	**$55,422,094**	**$141,880,559**

Table 9. Rafting User Days by River As Well As Direct Expenditures and Total Flow-On Economic Impacts for Rivers in the State of Colorado. Source: Greiner and Werner (2010).[17] [18]

National Park Recreation

Duffield et al. (2007 and 2008) estimated the value of CRB related National Park Service locations. Visitation for three national recreation areas within the CRB (Curecanti, Glen Canyon, and Lake Mead) was found to be 100% water-based. These three national recreation areas accounted for over 10 million visitors in 2005, with more than 7.6 million visitors to Lake Mead National Recreation Area alone. Lake Mead had more visitors than the Grand Canyon National Park (4.4 million visitors) in 2005 (Table 10).

[17] Greiner and Werner's economic expenditure estimates were taken from a 1991 survey titled "The Use and User Characteristics, Management Preferences, and Satisfaction of Boaters and Anglers on the Arkansas Headwaters Recreation Area (Colorado)." To calculate the flow-on impact of rafting, they multiplied the expenditure values from the 1991 survey by user days and an economic multiplier. They used 2.56 as the economic impact multiplier, according to a Colorado Tourism Board recommendation (Greiner and Werner, 2010).

[18] The Animas included the Upper Section of the River as well as the main section. The Colorado River sections included the Glenwood, Upper, Horsethief/Ruby and Westwater. The Gunnison River sections included the Gunnison Gorge as well as the Upper, Escalante, and Lake Fork Sections. The Roaring Fork River data included the Upper and Lower Roaring Fork Sections.

Park	State	Water Type	Number of Visitors in 2005	Number of Water Related Visitors in 2005	Percent of Visitation that is Water Related
Arches National Park	Utah	River	781,670	negligible	0.00%
Black Canyon of the Gunnison National Park	Colorado	River	180,814	46	0.03%
Canyonlands National Park	Utah	River	393,381	11,508	2.93%
Curecanti National Recreation Area	Colorado	Reservoir	882,768	882,768	100.00%
Dinosaur National Monument	Colorado	River	360,584	12,802	3.55%
Glen Canyon National Recreation Area	Utah	River and Reservoir	1,908,726	1,908,726	100.00%
Grand Canyon National Park	Arizona	River	4,401,522	22,000	0.50%
Lake Mead National Recreation Area	Arizona	River and Reservoir	7,692,438	7,692,438	100.00%
Rocky Mountain National Park	Colorado	River	2,798,368	negligible	0.00%

Table 10. 2005 Park Visitation from National Parks within the Colorado River Basin. Table reproduced from Duffield et al. (2008). Note that it may appear that the Grand Canyon water recreation numbers are low, as so many people say they have rafted the Colorado River through the Grand Canyon, however, most rafting trips that are called “Grand Canyon Rafting Trips” actually begin outside of the park, in the Lake Mead National Recreation Area or Glen Canyon National Recreation Area (Lee’s Ferry). These rafters are therefore believed to be accounted for in visitation numbers for either Lake Mead or Glen Canyon National Recreation Areas.

Duffield used the visitation numbers to Colorado River related National Park Service locations to determine the flow-on impacts of these parks by applying a tool called the MGM2 NPS Money Generation Model (http://web4.msue.msu.edu/). He determined that visitor spending for 2005 was $823 million for the parks within the CRB. Indirect and induced spending (the flow-on impacts) was $319 million, while the total spending impact was $1.142 billion, which supports an estimated 25,222 jobs (Table 11) (Duffield et al., 2007; Duffield et al., 2008; Duffield et al., 2009; Greiner and Werner, 2010).

Park Unit	Estimated Annual Direct Visitor Spending	Estimated Indirect and Induced Spending	Estimated Total Spending Impact	Estimated Total Personal Income Impact	Estimated Total Jobs Impact (full & part time jobs)
Glen Canyon NRA	$100,377,665	$45,239,324	$145,605,329	$52,783,098	2,668
Lake Mead NRA	$206,165,393	$65,083,996	$271,249,390	$95,480,625	6,052
Curecanti NRA	$32,973,404	$14,667,801	$47,641,206	$17,361,174	887
Grand Canyon NP	$347,958,027	$158,081,122	$506,039,149	$197,992,000	7,812
Dinosaur NM	$8,173,393	$2,646,734	$10,820,127	$3,707,759	237
Canyonlands NP	$15,040,909	$4,932,019	$19,972,928	$6,750,920	433
Black Canyon NP	$6,902,495	$2,273,626	$9,176,121	$3,101,459	199
Arches NP	$63,090,201	$20,765,782	$83,855,984	$28,740,962	1,756
Rocky Mountain NP	$179,161,714	$58,542,950	$237,704,664	$80,707,887	5,178
Totals	$959,843,202	$372,233,355	$1,332,064,897	$486,625,882	25,222

Table 11. Expenditures Resulting from 2005 Visitation to the Various National Park Service Related Parks in the Colorado River Basin (2009 USD). Source: Duffield et al. (2007). Note: NRA=National Recreation Area, NP=National Park, and NM=National Monument.

Ecosystem Service Information Function Category: Preservation Function

Forest and Wilderness Preservation

Walsh et al. (1984)

According to Walsh et al. (1984), without information on preservation values, it may be the case that there is an insufficient amount of public land allocated to wilderness protection, specifically in states like Colorado, where development infrastructure, such as roads, mining, logging, and housing, may irreversibly degrade the natural environment. In this way, governments worldwide must determine how much public land to allocate for protection purposes, including national parks, wilderness areas and wildlife sanctuaries.

In the Walsh et al. (1984) study, they attempted to determine how much wilderness to protect in Colorado via a mail survey of Colorado households. Surveys were mailed in the summer of 1980. Respondents were shown four state maps, each depicting a different amount of wilderness area, from the current amount at the time of 2% of the state to 15% of the state. Respondents were asked "to write down the maximum amount of money they would be willing to pay annually for protection of current wilderness, and for hypothetical increases in wilderness depicted on four maps." Respondents were then asked to use their highest value for wilderness and allocate it among four areas: 1) a portion it would go to their actual use of the wilderness, 2) part of it would go to an option value, or insurance type premium, enabling them to have the option to use the wilderness in the future, 3) a portion would go to the existence value of knowing the wilderness lands continue to exist, and 4) a portion would go to their bequest value, to ensure that the wilderness will be available to future generations. The last three portions make up their non-use preservation value.

Walsh et al. (1984) found that value to Colorado residents of preserving wilderness areas in Colorado was worth approximately $83/household/year. This value could be broken down into a $29/household/year existence value, $24.03/household/year option value and a $29.84/household/year bequest value (Walsh et al., 1984).

Walsh et al. (1990)

In Walsh et al. (1990), a case study was conducted to determine whether respondents were willing to pay to protect forest health or what they termed forest quality. The case study area included 11 National Forests in Colorado: Arapaho, Grand Mesa, Gunnison, Pike, Rio Grande, Roosevelt, Routt, San Isabel, San Juan, White River and the Uncompahgre. As in the Walsh et al. (1984) study, respondents were asked to value several aspects of forest quality including their actual use value, as well as their option, existence and bequest values.

Data was collected in the form of personal interviews at Colorado resident's homes. Interviews were conducted in 1983. Respondents were told that forest quality is one of the most important problems we face today as citizens of the state of Colorado and that infestations of mountain pine beetles or spruce budworm could lead to a decrease in forest quality. They were then shown three color photographs of forested areas with varying amounts of live trees, representing three levels of forest quality and asked to read a background information statement:

> "Why we might value forest quality in the state: (1) use, a list of 16 recreation activities such as camping, picnicking, hiking, fishing, hunting, sightseeing, etc.; (2) might use, to have forest quality if you decide in the future that you want to use it; and (3) non-use, just because it's there - satisfaction from knowing that forest quality exists, that others can enjoy its recreation use, and that it is preserved for future generations."

Respondents were provided with a summary of average annual costs for several goods including newspapers, food, taxes, health insurance and housing. They were then asked to place a value on the recreation use value, as well as the option, existence and bequest value of high quality forests. They discovered that the total value of forest quality protection from these threats was $73.24/household/year. This value can be broken up into an existence value ($21.54/household/year), bequest value ($30.16/household/year) and an option value ($21.54/household/year) (Walsh et al., 1990).

Landscape View or Scenery Protection

Rosenberger and Walsh (1997)

According to Rosenberger and Walsh (1997), agricultural land in many areas of the country is being lost to development, resulting in an increased concern for land to be preserved for posterity's sake. The ecosystem services involved in preserving land include the production of food and fiber, watershed conservation, soil conservation, plant and animal habitat, biodiversity and cultural heritage values. In this study, they estimated the non-market value of preserving 50,000 acres of ranchland in the Yampa River Valley of Routt County, Colorado, with 10,000 of these acres being located near the Steamboat Springs ski area.

Data were obtained from a mail survey distributed in the winter of 1993-94. Respondents consisted of registered voters in Routt County, Colorado. Respondents were asked two hypothetical voter referendum questions focused on the potential support of a valley ranchland protection program, whether they would be willing to support it financially or not. They were then asked for the highest annual amount they would be willing to pay to preserve range open space and were provided with a range of possible dollar values from $0 to $500, as well as a blank space to fill in their own number.

They found that people in Routt County Colorado had a value to preserve ranchland open space. This value varied depending on the location of the ranch as well as its size. Results illustrated that respondents were willing to pay $155/household/year to $371/household/year to preserve ranchland throughout Routt County (Table 12). They stated that while local residents' willingness-to-pay was found to be substantial, it was not sufficiently high enough to justify protection of the existing quantity of valley ranchland at the time of the study (Rosenberger and Walsh, 1997).

Valley Ranchland near Steamboat Springs in Routt County Colorado	2,500	$72.00	$104.23
	5,000	$102.00	$147.66
	7,500	$118.00	$170.82
	10,000	$121.00	$175.16
Valley Ranchland in Routt County Colorado, not Including Steamboat Springs	10,000	$36.00	$52.11
	20,000	$68.00	$98.44
	30,000	$94.00	$136.08
	40,000	$116.00	$167.92
Total Valley Ranchland Protection for Routt County Colorado	12,500	$107.00	$154.90
	25,000	$181.00	$262.02
	37,500	$231.00	$334.40
	50,000	$256.00	$370.59

Table 12. Willingness-to-Pay by Routt County Residents to Protect Valley Ranchland for Scenic Protection. Results of the Rosenberger and Walsh (1997) Survey.

Natural Resource Conservation Service Program Value

Buland et al. (2004)

According to Buland et al. (2004), the value of many federal programs exceeds the initial costs of the programs. This study estimated the total values of eleven projects within the Natural Resource Conservation Service Program (NRCS). Financial data was collected for all US states for the years of 1997 through 2003 for the following programs: Watershed Operations, Farmland and Ranchland Protection Program, Environmental Quality Incentives Program (EQIP), Watershed Surveys and Planning, Watershed Rehabilitation, Grassland Reserve Program, Wildlife Habitat Incentives Program, Agricultural Management Assistance, Wetlands Reserve Program, Conservation Operations, and Resource Conservation and Development. Data was assessed at the national and state levels using the IMPLAN software program.

Overall, it was found that for every dollar spent on Natural Resource Conservation Service programs, $1.60 was spent in the economy and the total flow-on impact was $2.49 (Table 13).

The aggregate multipliers for the states within the CRB ranged from 1.18 total value added in New Mexico to 1.51 in Utah, while the total flow-on impact ranged from 2.16 in Nevada to 2.51 in Utah. The number of jobs created or supported by the NRCS programs was also calculated. The NRCS created or supported 50,230 jobs in the US in 2003. Of those, 716 were in Arizona, 2,081 were in California, and 1,024 were in Colorado. Data for all states within the CRB are located in Table 13. This example illustrates that the Natural Resource Conservation Service programs contribute significantly in terms of economics to the country. It also demonstrates the link between investing in conservation and economic benefits.

	Program Expenditures (2009 USD)		NRCS Program Impacts on Employment	Economic Impacts (2009 USD)		Aggregate Multipliers for All Programs (Total)	
	NRCS Program Expenditures	**NRCS Program and Matching Private or State Expenditures**	**NRCS Jobs Created or Supported**	**Total Value Added**	**Total Output**	**Total Value Added**	**Total Output**
United States	$10,252,166,731	$11,481,573,906	50,230	$18,403,019,071	$28,621,825,242	1.60	2.49
Arizona	$116,612,046	$136,927,758	716	$190,238,328	$299,230,847	1.39	2.19
California	$400,296,059	$477,274,978	2,081	$692,336,680	$1,096,981,401	1.45	2.30
Colorado	$234,099,731	$262,660,750	1,024	$381,601,016	$572,763,819	1.45	2.18
Nevada	$56,481,493	$62,633,674	549	$91,167,436	$135,115,153	1.46	2.16
New Mexico	$131,292,328	$174,844,816	722	$206,182,664	$341,159,259	1.18	1.95
Utah	$103,757,998	$116,992,512	773	$177,057,193	$293,444,367	1.51	2.51
Wyoming	$119,140,153	$141,976,021	740	$185,132,143	$321,071,827	1.30	2.26

Table 13. NRCS (Natural Resources Conservation Service) Expenditures and Economic Impacts by State and Overall (2009 USD). Source: (Buland et al., 2004).

Ecosystem Service Production Function Category: Food Production Function

Commercial Fisheries

Very little information was located in relation to commercial fishing on CRB locations. In Adler (2007), it was noted that there was a cannery near Grand Junction, Colorado, many years ago that distributed pikeminnows around the country as "white salmon." This is no longer a viable commercial fishery. In Laguna Salada (Mexicali, Baja California), an enclosed CRB section that is part of the Colorado River Delta, there is currently some commercial fishing for squid. Mullet and tilapia are also located in this area. However, no valuation or fish catch numbers were located (Adler, 2007; Jimenez).[19]

Agriculture

Medellin-Azuara (2006)

Two studies were located that discussed the value of agriculture in CRB related locations. The first is a study of the Mexicali Valley in Mexico. This region of the country grows ten types of irrigated crops: alfalfa, asparagus, barley, canola, green onion, rye grass, sorghum for forage, sorghum for grain, and wheat. Medellin-Azuara (2006) stated that these crops account for 72% of the total water use in this irrigation district (Irrigation District 014). Production, yield, price and water usage data for these crops was collected for the year 2005 (Table 14). The three most water intensive crops were found to be asparagus, requiring 257,673 cubic feet/ acre (18,030 cubic meters/ hectare) of water, alfalfa, requiring 211,083 cubic feet/ acre (14,770 cubic meters/ hectare) of water, and cotton, requiring 162,635 cubic feet/ acre (11,380 cubic meters/ hectare) of water. Canola required the least amount of water at 60,738 cubic feet/ acre (4,250 cubic meters/ hectare) of water. The total market value of all crops in the Mexicali Valley was $2.7 billion (2009 USD).

[19] As this area is located in Mexico, there may be commercial fishing numbers in studies written in Spanish, however, no details were located for any studies written in English.

Name of Crop	Production (Tons)	Yield in Tons/Ha (Tons/Acre)	Yield in Tons/ Acre	Production Value	Water Usage in Cubic Meters/ Hectare	Water Usage in Cubic Feet/ Acre	Mean Rural Price ($/Ton)
Alfalfa	1,931,036	76	31	$526,346,499	14,770	211,083	$273
Asparagus	9,583	5	2	$430,989,610	18,030	257,673	$44,974
Barley	4,638	3	1	$8,427,929	7,170	102,469	$1,817
Canola	5,116	2	1	$14,351,511	4,250	60,738	$2,805
Cotton	71,076	4	2	$302,546,886	11,380	162,635	$4,257
Green Onion	48,826	12	5	$380,515,180	5,820	83,176	$7,793
Rye Grass	244,677	42	17	$55,298,882	6,960	99,468	$226
Sorghum Forage	315,260	61	25	$59,793,706	9,320	133,195	$190
Sorghum Grain	31,257	5	2	$47,923,793	7,840	112,044	$1,533
Wheat	425,667	5	2	$873,571,108	8,340	119,190	$2,052
Totals	3,087,136	213	86	$2,699,765,103	93,880	1,341,671	$65,920
These crops account for approximately 72% of all water use in Irrigation District 014.							
Details from table reproduced from Medellin-Azuara (2006) with reference to CNA (2006) and SAGARPA (2006).							

Table 14. Primary Crops and Water Use for the Year 2004 in the Mexicali Valley (2009 USD) (CNA (Comisión Nacional del Agua), 2006; Medellín-Azuara, 2006; Medellín-Azuara et al., 2007; SAGARPA (Secretaría de Agricultura, 2006)

Franklin et al. (1983)

Franklin et al. (1983) conducted a study on the value of crops versus the value of large deposits of tar sands, oil shale, crude oil, natural gas and coal in the Green River drainage of Wyoming in the CRB. Franklin et al. (1983) stated that over 90% of water in the area was used for agriculture, higher than the 72% value reported by Medellin-Azuara (2006) for the Mexicali Valley. They also stated that increases in water prices would provide an incentive for agriculturalists and power companies to conserve water. This implies that if water prices go up, costs go up and, with other things remaining the same, their profits would decrease. However, if they were to conserve water, then their costs may remain the same and their profits would remain the same. They then illustrate that net returns for all crops, except wheat, had higher returns for a sprinkler irrigated acre than a flood irrigated acre. The downside of this article is that values reported for agriculture and energy were from 1980, therefore, they may no longer be relevant (Table 15).

	Alfalfa Full	Alfalfa Partial	Nurse Crop	Barley	Wheat	Oats	Hay	Pasture
	ton	ton	bu.	bu.	bu.	bu.	ton	AUM
Annual flood irrigated yield	2.00	1.25	55.00	55.00	32.10	60.00	1.50	2.00
Annual sprinkler irrigated yield	2.20	1.38	60.50	60.50	35.31	66.00	1.65	2.20
	acre feet	acre feet	acre feet	acre feet	acre feet	acre feet	acre feet	acre feet
Consumptive use per acre for flood irrigation	2.10	1.10	1.60	1.20	1.67	1.60	1.60	1.30
Consumptive use per acre for sprinkler irrigation	2.31	1.21	1.76	1.32	1.84	1.76	1.76	1.43
	dollars/acre	dollars/acre	dollars/acre	dollars/acre	dollars/acre	dollars/acre	dollars/acre	dollars/acre
Net returns per flood irrigated acre	$42.58	$15.06	$34.87	$34.87	$19.98	$2.88	$24.69	$9.00
Net returns per sprinkler irrigated acre	$46.84	$16.57	$68.61	$68.61	$14.63	$3.17	$27.16	$9.90
	acres		acres		acres	acres	acres	acres
Current irrigated acres	62,317.00		19,767.00		3,550.00	2,383.00	185,867.00	85.00

Table 15. Estimated Annual Crop Yields, Consumptive Use, and Net Returns Per Irrigated Acre for Flood and Sprinkler Irrigated Acres for the Year 1980. Source: (Franklin et al., 1983).

As the numbers from the Franklin et al. (1983) study were believed to be outdated, data from the 2007 Census of Agriculture State Profiles for all states within the CRB were obtained (U.S. National Agricultural Statistics Service, 2010). Data illustrates that the value of crops, including nursery and greenhouse crops, for the seven states located in the CRB, were $29 billion in 2007. The approximate value of dryland hay was $2 billion; therefore, the overall value of crops requiring supplemental water was approximately $26.8 billion. 92% of the crop value is for crops requiring supplemental water. The value of livestock in the seven CRB states was approximately $21 billion in 2007. In total, approximately 15 million acres of land were planted in 2007, of which 6.2 million was for dryland hay. Therefore, 59% of the crop acreage planted was for irrigated crops in the CRB states (Table 16).

	Value of Crops Including Nursery and Greenhouse	Value of Other Crops Including Dry Hay (Primarily Dry Hay)	Irrigated Crop Value Estimate: Value of Crops - Value of (Primarily) Dry Hay	Percentage Value of Estimated Irrigated Crops	Value of Livestock, Poultry and Their Products
Arizona	$1,979,397,732	$276,206,222	$1,703,191,510	86.05%	$1,367,396,851
California	$23,697,781,522	$1,105,600,912	$22,592,180,610	95.33%	$11,363,132,212
Colorado	$2,050,155,768	$329,329,847	$1,720,825,922	83.94%	$4,221,306,381
Nevada	$226,952,379	$146,855,130	$80,097,249	35.29%	$304,127,631
New Mexico	$572,334,579	$144,285,967	$428,048,611	74.79%	$1,678,223,138
Utah	$385,318,559	$156,672,374	$228,646,184	59.34%	$1,079,484,021
Wyoming	$221,227,377	$135,429,960	$85,797,417	38.78%	$976,476,420
Totals	$29,133,167,915	$2,294,380,413	$26,838,787,503	92.12%	$20,990,146,655

	Principal Crops Planted Acres	Principal Crops Harvested Acres	Dry Hay Acreage	Irrigated Planted Acreage Estimate: Planted Acreage - Dry Hay Acreage	Percentage of Irrigated Acreage Estimate
Arizona	741,000	734,000	310,000	431,000	58.16%
California	4,106,000	3,550,000	1,520,000	2,586,000	62.98%
Colorado	6,061,000	5,781,000	1,600,000	4,461,000	73.60%
Nevada	519,000	512,000	490,000	29,000	5.59%
New Mexico	1,045,000	714,000	320,000	725,000	69.38%
Utah	994,000	936,000	690,000	304,000	30.58%
Wyoming	1,704,000	1,611,000	1,270,000	434,000	25.47%
Totals	15,170,000	13,838,000	6,200,000	8,970,000	59.13%

Table 16. 2007 Crop Value, Crop Acreage and Livestock Values for States within the Colorado River Basin. 2007 Census of Agriculture State Profiles (2009 USD). Data: USDA National Agricultural Statistics Service (http://www.nass.usda.gov).

The US National Agricultural Statistics Service website has data-mining capabilities, allowing the user to obtain specific information. For example, data is available on a county basis and data is available for irrigated crops. There is also a watershed category; however, no specific CRB information was located. Several attempts were made to download state specific data, and results were inconsistent. In addition, data is not easily comparable or easily additive, as different crops are measured in different ways; some crops are listed as harvested numbers of bushels, some crops are listed as harvested numbers of acreage, some list value per bushel, while others list value per acre. In addition, just because the harvested acreage is listed, the value per acre may not be, and vice versa. Therefore, while data more specific to the Colorado River Basin can be obtained, this process may take some time to collect.

Ecosystem Service Production Function Category: Raw Materials Function

Energy

Bureau of Reclamation (2009)

Within the production function ecosystem service category is raw materials. The energy or electricity produced by the hydroelectric power plants within the CRB is an ecosystem service benefit. The Bureau of Reclamation has reported the total production costs of the fifteen hydropower power plants located in the CRB. Production costs are composed of operation and maintenance costs, which includes the costs of supplies, equipment, administration, payroll, travel, and benefits. The largest of the 15 plants is the Hoover Power Plant which produced 1910 MW of electricity in 2009 for a cost of $16,254,442. The second largest is Glen Canyon Power Plant, which produced 1320 MW of electricity in 2009 for a cost of $8,295,246. One of the power plants, the McPhee Power Plant, only produced 1 MW of electricity for a cost of $74,417 in 2009. In total, all of the power plants produced 4,026 MW of electricity for $39,091,971 (Table 17).

The Bureau of Reclamation stated on their website that the annual value of hydroelectricity in the US is $9 billion (Bureau of Reclamation, 2009). However, more specific information was not located. Consequently, the Bureau of Reclamation was contacted in an attempt to determine the annual hydroelectricity economic value of each of the CRB power plants, however, no response has been obtained as of yet.

Colorado Basin Section	Power Plant	Date Power Plant Went In-Service	Operating and Maintenance Costs $/MW for 2007 (2009 USD)	Number of Staff Required	Total Equivalent Work Year Staffing/MW	MW in 2007	Present Capacity (MW)	Total 2007 Operating and Maintenance Costs (2009 USD)
Lower Colorado								
	Hoover	Sep-36	$8,509	95.51	0.05	1,910	2,079	$16,254,442
	Parker	Dec-42	$25,131	11.88	0.11	108	120	$2,714,128
	Davis	Jan-51	$10,941	15.10	0.07	216	255	$2,360,115
Upper Colorado								
	Blue Mesa	Sep-67	$19,611	4.56	0.06	76	86	$1,490,412
	Crystal	Jun-78	$54,339	4.06	0.14	29	32	$1,575,817
	Deer Creek	Feb-58	$26,240	0.23	0.06	4	5	$100,587
	Elephant Butte	Nov-40	$37,750	3.18	0.13	24	28	$923,424
	Flaming Gorge	Nov-63	$14,663	13.61	0.10	136	152	$1,995,600
	Fontenelle	May-68	$55,800	1.87	0.21	9	10	$496,889
	Glen Canyon	Sep-64	$6,253	39.80	0.03	1,327	1,320	$8,295,246
	Lower Molina	Dec-62	$70,892	2.61	0.60	4	5	$308,378
	McPhee	Dec-92	$68,905	0.27	0.25	1	1	$74,417
	Morrow Point	Dec-70	$13,390	6.52	0.04	163	173	$2,182,581
	Towaoc	May-93	$5,594	0.32	0.03	11	11	$59,665
	Upper Molina	Dec-62	$32,908	1.74	0.22	8	9	$260,269
	Totals		$450,924	201.26	2.10	4,026	4,286	$39,091,971

Table 17. Colorado River Basin Hydropower Operation and Maintenance Costs. Source: Bureau of Reclamation Powerplant Performance Reports (www.usbr.gov/projects) (Bureau of Reclamation, 2009).

Ecosystem Service Regulation Function Category: Purification and Regulation of Water

Instream Flow

Instream flow is directly linked to many ecosystem services goods and activities including the improvement of habitat for riparian vegetation and wildlife, which, for the CRB, includes endangered fish species, the restoration of estuaries and floodplains, erosion control, and the improvement of water quality, to name a few. There were ten directly related studies in the database focused on instream flow values and several others that were indirectly related. As stated in the introduction of this report, there are no methodology standards for ecosystem service valuation, as such, a variety of techniques were used to place a value on instream flow.

Brown (1991)

Of the 10 studies on instream flow, the oldest paper was Brown (1991), who conducted a literature review to summarize the studies that had estimated an economic value for instream flow. He recommended that recreation values alone were not enough to justify the reservation of any flows above minimum flows, suggesting that economic justification lies in the calculation of preservation or existence values. One of the studies he listed was by Walsh et al. (1985). Walsh et al. (1985) had distributed a mail survey in 1983 to Colorado households statewide to determine their value for preserving 11 free-flowing rivers recommended for wild and scenic designation status in Colorado, including the Yampa, Dolores and Green Rivers. The respondents were told that the funds would "guarantee that these rivers are protected . . . from diversion and dams . . . Assume that if you do not pay, the process of water development will begin next year." The annual willingness-to-pay for preservation of the rivers was $77 in 1983 dollars ($166 in 2009 dollars) (Brown, 1991).

Taylor et al. (1995)

Taylor et al. (1995) looked at the value of instream flow by conducting a survey of visitors to Rocky Mountain National Park. This study focused on valuing the preservation of potential losses of water, riparian vegetation or riparian dependent wildlife in Rocky Mountain National Park. In addition to valuation questions, respondents were asked to take pictures of landscapes around the park on a disposable camera that were of significance to them in some way. Water was shown to contribute significantly to a park visitor's experience, ranking second only to mountain vistas in importance. Water resources were found to be more important to hikers and backpackers than campers or drive-through visitors. When asked how much more of an entrance fee they would be willing to pay, in addition to the park entrance fee of $5.00, to preserve these resources, the respondents averaged approximately $3.50 (1993 USD) or $5.20 in 2009 USD. At the time of the study, this willingness-to-pay was a 70% increase in the park entrance fee. Overall, visitors reported a serious negative response to potential losses of water, riparian vegetation, or riparian-dependent wildlife (Taylor et al., 1995).

Welsh et al. (1997)

The Welsh et al. (1997) study stated that dam operations that value electric power produced at the Glen Canyon Dam powerplant result in river fluctuations below the dam, decreasing the amount of sediment below the dam, which decreases the number and size of beaches and changes the habitat of terrestrial and aquatic species, including endangered native fish. Water fluctuations also have an effect on the resources located in Grand Canyon National Park. The daily water fluctuations also result in a decrease in quality in fishing and rafting below the dam.

This study attempted to measure the non-use benefits of alternative water fluctuations; a survey was used to collect the data. Survey respondents were told that instream flow would return the water to more normal flows (where the highest releases are in the spring and daily fluctuations are eliminated), native fish populations would potentially increase, and non-native fish populations would increase (and as a result of this increase, stocking of fish would no longer be required). There would be an increase in vegetative area that would result in a 10% increase in wildlife and bird habitat, Native American sacred and archeological sites would experience a decrease in the risk of erosion and the size of beaches would remain the same.

Respondents were first asked whether they would vote in favor of changing dam operations if there was no cost to them. Operation changes were directly related to water flow changes and included: moderate fluctuating flow, low fluctuating flow, seasonally adjusted steady flow with moderate fluctuating flow impacts costs to power and a seasonally adjusted steady flow. If they said yes, then they were asked for their willingness-to-pay for the program. For some respondents, passage of the program would result in an increase in taxes that they would pay for every year, for others, it resulted in an increase in their monthly electric bill that would continue indefinitely.

Results revealed that people asked to pay for the change through their taxes had a lower willingness-to-pay value than those respondents that would be paying the fee as an increase in their electricity bill (Table 18). Willingness-to-pay also varied by flow change: moderate fluctuating flow, low fluctuating flow and seasonally adjusted steady flow. The value of the change ranged from a low of $13.56 annually in their taxes ($19.09 in 2009 USD) to a high of $28.87 ($40.64 in 2009 USD) annual increase in their electric bills. These increases not only include the change in flow, but also what that change involves: the potential increase in native fish populations, the increase in non-native fish populations, an increase in vegetative area that would result in a 10% increase in wildlife and bird habitat, a decrease in the risk of erosion that Native American sacred and archeological sites would experience and the assumption that the size of the beaches would remain the same (Welsh et al., 1997).

	National Respondents	National Respondents	Regional Respondents	Regional Respondents
	Respondents asked to pay more annually in their taxes	Respondents asked to pay more annually in their taxes	Respondents asked to pay more annually in their electricity bills	Respondents asked to pay more annually in their electricity bills
Various Flow Regimes	1995 USD	2009 USD	1995 USD	2009 USD
Moderate Fluctuating Flow	$13.56	$19.09	$22.06	$31.05
Low Fluctuating Flow	$20.15	$28.37	$21.45	$30.20
Seasonally Adjusted Steady Flow	$20.55	$28.93	$28.87	$40.64

Table 18. Value of Modifying the Flow Regime of the Water Below the Glen Canyon Dam (Welsh et al., 1997)

Berrens et al. (1996, 1998 and 2000)

Berrens has been involved in several instream valuation studies in Arizona and New Mexico. In the Berrens et al. (1996) and Berrens et al. (2000) studies, they investigated the non-market benefits of protecting minimum instream flows on all major rivers in New Mexico, some of which are tributaries of the Colorado River. Protecting water flow not only meant that there would be an increase in river water, but also that the increase in water would assist in the recovery of 11 threatened and endangered fish species. To obtain their data, a contingent valuation telephone survey was conducted. The telephone survey was administered in 1995 as part of a regular New Mexico quarterly profile telephone survey.[20] Random New Mexican phone numbers were dialed. They were told that with their help, a special trust fund could be set up in New Mexico for buying or leasing water to protect minimum instream flows, specifically to protect the silvery minnow. This would be an annual value per household that would continue each year for five years.

Results revealed that respondents had significant non-market values to protect instream flows. The mean value was found to be $89.68/ household/year for five years (standard error of $5.91, N = 277) ($126.24 in 2009 USD) for the protection of minimum instream flows on all major New Mexico rivers (85% of the predicted values were positive) (Berrens et al., 1996; Berrens et al., 2000).

The Berrens et al. (1998) study was conducted in the same manner and for the same purpose as the Berrens et al. (1996) and Berrens et al. (2000) studies; however, data was collected in 1995 and in 1996. Results revealed an average willingness-to-pay of $73.38/ household/ year ($100.34 in 2009 USD) for five years to assist in paying for a special trust fund that was to be used to purchase or lease water for the purpose of maintaining instream flows (Berrens et al., 1998).

Weber and Berrens (2006)

The Weber and Berrens study (2006) focused on the consumer surplus values of visitors to the Aravaipa Canyon Wilderness River Section of the San Pedro River in Arizona. The Aravaipa Wilderness is a lush riparian canyon in the Sonoran Desert of Southern Arizona with two access points: the eastern site near Klondyke Arizona, a more remote site with a 70 mile (110 km) dirt access road, and the west site, accessible by passenger car and has more visitors, likely because of access. This study employed a travel cost model using collected visitation data for the period of 1998 through 2002. This study assumed that the permit data captured all visitation. While trips to the areas typically last from one to three recreation visitor days, only single-day trips were included in the estimation. It was determined that single-day trips account for 30% of the visitation at the east site and 40% of the visitation at the west site.

The range of consumer surplus estimates was $23.00 ($26.82 in 2009 USD) to $35.05 (40.87 in 2009 USD) per recreation visitor day for the east site (the more remote site).[21] This resulted in a total annual value of $50,600 ($58,998 in 2009 USD) to $71,100 ($82,900 in 2009 USD). For the

[20] The survey had been conducted quarterly since 1988. However, it is believed that the contingent valuation supplement to the survey was only a temporary addition to the survey.
[21] Most visitors were in the area for one to three days.

west site, the consumer surplus values ranged from $16.25 ($18.95 in 2009 USD) to 22.07 ($25.73 in 2009 USD) per recreation visitor day. This amounted to $82,700 ($96,425 in 2009 USD) to $112,300 ($130,938 in 2009 USD) annually. They then stated that remoteness and permit limits may affect consumer surplus benefits. This result was exemplified by the apparent premium paid for the more remote east site visits.

Medellin-Azuara et al. (2007)

Medellin-Azuara et al. (2007) applied an economic-engineering optimization model to examine instream flow in relation to various environmental restoration water supply options for the Colorado River Delta in Mexico. An optimization model such as this is used to maximize or minimize an output aspect, such as minimizing environmental costs, maximizing water flow and maximizing profits. The optimization model examined a range of required environmental flows for the delta to determine water scarcity volumes and costs and environmental flow costs. The methodology quantifies trade-offs between environmental flows and urban and agricultural water use, where water value is estimated from the opportunity cost to other uses. In this way, water for urban and agricultural production is implicit in the valuation. More specifically, their optimization model was based on the CALVIN model, a model developed and applied in California to strategically manage water supplies. According to Medellin-Azuara et al. (2007), this model is very insightful for water management issues, because it evaluates many water use related options including water markets, dam removal, facility expansion, users willingness-to-pay for water and the economic costs of environmental restrictions.

The analysis was based on values from Irrigation District 014 in the CRB in the Mexicali Valley section of Mexico, where the primary crops are wheat, cotton and alfalfa. According to the 1944 US–Mexico Water Treaty, part of their water flow is guaranteed, as Mexico is to receive a minimum of 1.5 million acre feet (1,850 million cubic meters) of water annually via the Colorado River.

They determined that the value of an increase in instream flow was worth $35/ thousand cubic meters (approximately 1 acre foot)[22] ($37.50 in 2009 USD) for recommended environmental flows being doubled and $24 ($25.54 in 2009 USD)/ thousand cubic meters (approximately 1 acre foot) of water with recommended restoration flows. They also concluded that economically viable water sources currently existed to aid in restoring the Colorado River Delta. They determined that potential water sources could come from local agricultural and urban water use reductions through wastewater reuse, water markets and additional Colorado River flows from the US. At current prices, transboundary water purchases from the US could not be supported. In relation to environmental aspects, they determined that it was more cost effective to develop an avian flyway in the Colorado River Delta than dedicate flows to the Salton Sea. They also recommend that decision-makers use this framework for their environmental flow quantification.

[22] 1 Cubic Meter = 35.3146667 Cubic Feet

Loomis (2007)

Loomis (2007) conducted a study to determine how the value of rafting and fishing activity, and hence rafting and fishing expenses, is dependent on river water level in the Colorado River in Colorado. This study used secondary data.[23] Rafting and fishing use was found to increase with increases in river flow, where rafting increases continue until the river is 100% bankfull, while fishing increases until the river is 70% bankfull. Consequently, 5% and 25% drops in water levels would result in decreases in river rafting and fishing participation. These decreases are expected to negatively impact the flow-on impacts of rafting and fishing activities, including a reduction in expenditures, number of jobs, and income related to rafting and fishing. As can be seen in Table 19, a 5% drop in the water level for river rafting would result in an estimated $8 million decrease in expenditures and a loss of 365 jobs. For fishing, this 5% drop would be an $8 million decrease in expenditures and a loss of 332 jobs. If the drop increased to 25%, this decrease would be almost $19 million in expenditures and 843 jobs for rafting and $49 million in expenditures and 2,030 jobs for fishing.

Activity	Percentage Bankful Drop in Water Level from Baseline	Expenditures	Jobs	Income
River Rafting	5% drop in water level	-$8,116,515	-365	-$5,795,598
(Baseline 70% Bankful)	25% drop in water level	-$18,735,091	-843	-$13,377,792
Fishing	5% drop in water level	-$8,054,820	-332	-$6,189,727
(Baseline 55% Bankful)	25% drop in water level	-$49,190,675	-2,030	-$37,800,582

Table 19. Results of a Drop in Water Level for River Rafting and Fishing (2009 USD)

Loomis and Ballweber (2010)

Loomis and Ballweber (2010) investigated the role of instream flow in relation to endangered fish populations. They examined two endangered fish species recovery programs focused on instream flows and calculated cost savings to water developers from additional instream flow appropriations and cost savings from water acquired from the Colorado Water Conservation Board and the collaborative Upper Colorado River Endangered Fish Recovery Program. To accomplish this goal, they conducted several in-person and phone interviews and reviewed the literature.

The Colorado Water Conservation Board and the collaborative Upper Colorado River Endangered Fish Recovery Program have two primary goals: endangered fish population recovery and the continuation of water development and management. The recovery program

[23] It is important to note that rafting data came from the Greiner and Werner (2007) report, which based their expenditure data on the results of a 1991 survey, while fishing data was obtained from the 2006 results of the National FHWAR Survey. Details on the National FHWAR Survey are presented in Appendix D.

was found to save municipalities, irrigation districts and water districts money in relation to water depletion replacements and study costs. The value of this amounts to several million dollars. They also provide for increases in streamflow by identifying and securing large blocks of stored water. This has also lowered costs for meeting US Fish and Wildlife Service flow recommendations. The program obtained over $200 million in funding for fish hatcheries, passages and habitat development, as well as water delivery efficiency projects. Their work results in staff time savings and savings in legal expenses by decreasing the number of ESA compliance lawsuits to zero since 1988. Acquiring water rights has also been beneficial for many other threatened fish species, as their habitat is not degraded further, therefore, avoiding placement on the endangered species list.

This increase in instream flow, as a result of the recovery program, has resulted in a minimum cost savings of $5,321/acre foot to $10,642/acre foot. They also determined that increases in instream flow as a result of these appropriations and acquisitions have resulted in savings per consultation on medium to large projects in Endangered Species Act Section 7 consultations for depletions of 4,500 acre feet of water or more. In addition, time to conduct the consultations has decreased from 4 years to 1 year. Overall, the recovery program has proven to be very economically beneficial.

Instream Flow Summary

Overall, the instream flow related studies illustrate the positive value people have for instream flows in the form of increased spending on fishing and rafting activities with increases in water flow, as well as people willing to pay more in their taxes or electricity bills to prevent decreases in instream flows. In addition, by providing instream flows, recovery programs are linked to the prevention of further habitat decline for threatened species. Keeping threatened fish species off the endangered species list results in significant savings from EPA requirements, such as consultation and legal fees (Table 20).

Reference	Data Collection Year	What Was Valued and Valuation Location	Values (2009 USD)
Brown (1991)	Data from a Walsh et al. 1985 study conducted in 1983	Instream flow (For 11 rivers in Colorado recommended for wild and scenic designation, including the Yampa, Dolores and Green Rivers)	$166/ household/ year to preserve 11 Colorado rivers and protect them from diversions and dams by designating them as wild and scenic rivers.
Taylor et al. (1995)	1993	Instream flow: Value of preserving potential losses of water, riparian vegetation or riparian-dependent wildlife. (Rocky Mountain National Park in Colorado)	$5.20 more in park entrance fees (at the time, this value was an increase of 70% over the current entrance fee) to prevent any decreases in the amount of water, riparian vegetation or riparian dependent wildlife
Welsh et al. (1997)	1994-1995	Instream flow including native fish, non-native fish, wildlife and bird habitat vegetation, cultural values and beach recreation. (Glen Canyon Dam in Arizona)	$19.09 to $28.93/ household/ annually in their taxes or $30.20 to $40.64/ household/ annually in their electricity bill
Berrens et al. (1996) and Berrens et al. (2000)	1995	Instream flow (All major rivers in New Mexico including the Gila (will assist 11 threatened and endangered fish species)	$126.24/ household/ year for 5 years to contribute to a special trust fund to be set up in New Mexico for buying or leasing water to protect minimum instream flows, specifically to protect the silvery minnow.
Berrens et al. (1998)	1995-1996	Instream flow (New Mexico)	$100.34/ household/ year for 5 years to contribute to a special trust fund to be set up in New Mexico for buying or leasing water to protect minimum instream flows.
Weber and Berrens (2006)	1998-2002	Instream flow (Aravaipa Canyon Wilderness Section of the San Pedro River in Arizona)	Consumer surplus estimates of $18.95 to $40.87 per Recreation Visitor Day (visitation averaged from 1 to 3 days). This resulted in a total annual value of $58,998 to $96,425. Sites that were more remote were valued more highly.
Medellin-Azuara et al. (2007)	2000-2006	Instream flow (Colorado River Basin, Mexicali Valley, Mexico)	They determined that the value of an increase in instream flow was worth $37.50/ thousand cubic meters for recommended environmental flows being doubled and $25.54 / thousand cubic meters of water with recommended restoration flows.
Loomis (2007)	Data from the 2006 National Survey of Fishing, Hunting and Wildlife-Associated Recreation and the 2007 Greiner and Werner Study (that used data from a 1991 survey)	Instream Flow of Fishing (Colorado). 25% Drop in Water Level. Baseline 55% Bankful.	A 25% drop in water level in the Colorado River will results in a loss in expenditures and jobs related to fishing activity (-$49,190,675 in expenditures and -2,030 jobs)
Loomis (2007)	Data from the 2006 National Survey of Fishing, Hunting and Wildlife-Associated Recreation and the 2007 Greiner and Werner Study (that used data from a 1991 survey)	Instream Flow of River Rafting (Colorado). 25% Drop in Water Level. Baseline 70% Bankful.	A 25% drop in water level in the Colorado River will results in a loss in expenditures and jobs related to rafting activity (-$18,735,091 in expenditures and -843 jobs)
Loomis and Ballweber (2010)	Data came from a 2006 study	Instream Flows and Endangered Fish (Colorado)	Water acquired by the Colorado Water Conservation Board dedicated to instream flow results in a decrease in costs associated with ESA compliance of $5321-$10642/ acre/ foot because threatened species are not listed on the endangered species list. It also results in a reduction in consultation time of 3 years (from 4 years to 1 year) for the same reasons.

Table 20. Ecosystem Service Values of Studies Focused on Instream Flow (Berrens et al., 1996; Berrens et al., 2000; Berrens et al., 1998; Brown, 1991; Loomis, 2007; Loomis and Ballweber, 2010; Medellín-Azuara et al., 2007; Taylor et al., 1995; Weber and Berrens, 2006; Welsh et al., 1997)

Creation of New Wetlands

Gutrich (2004) focused on determining the value of the creation of a new wetland. Wetlands are important, because they provide many ecosystem services functions in many of the ecosystem service categories. In the Habitat Function Category, they provide nursery function and plant and animal habitat. In the Production Function Category, they contribute to food production in the form of fish and provide genetic and medicinal resources. In the Information Function Category, they provide a place for recreation, as well as a place of aesthetic beauty. Some wetlands also have cultural significance. In the Regulation Function Category, they provide erosion control, natural disturbance regulation, such as protection from flooding, as well as groundwater storage and recharge, the purification and regulation of air and water, biodiversity and carbon sequestration, to name a few.

Gutrich (2004) determined how long it would take to create a new wetland in Colorado that has achieved floristic functional equivalency, meaning it is fully functional in relation to the key wetland processes of natural wetlands, focusing on both plants and soils. More specifically, these functional indicators included the percentage of native plant species, floristic quality[24] , plant species richness, percentage of hydrophytes and the percentage of soil samples with colors indicative of hydric soils. Natural equivalency was believed to have been achieved when the constructed sites functional indicator was greater than, or equal to, that of the average functional indicator for natural reference wetlands.

It was determined that it would take 13 years for a newly created wetland in Colorado to achieve floristic functional equivalency. The cost of such a new wetland is approximately $35,274/acre plus a lag cost of 50%/acre, or $17,637/acre, until it achieves floristic functional equivalency. Therefore, a 100 acre wetland that takes 13 years to mature would be a cost to society of almost $2.5 million, with an initial cost of approximately $350,000, but an additional cost to society of $2.1 million (not accounting for annual inflation) waiting for the wetland to be become fully functional. According to Gutrich, an important finding from the study for Colorado was that society incurs half the cost of wetland mitigation (waiting for wetland services to be restored) without compensation. Another way to think about it is that preserving a fully functional natural 100 acre wetland would be worth approximately $2.5 million over a 13 year period in terms of ecosystem service values.

Riparian Habitat

Colby and Wishart (2002)

Riparian areas in the arid western US provide public benefits in terms of water quality filtration, open space, wildlife habitat, flood control and recreation. They are also home to large stands of

[24] Determined by using a Floristic Quality Assessment Index

trees that support a diverse population of birds and other wildlife. Homeowners living near these areas can enjoy all of these benefits (Colby and Wishart, 2002). Colby and Wishart (2002) evaluated real estate and geographical information system data for private properties along a 15 mile wash proposed for protection by Pima County in Arizona, to determine if homes near riparian areas receive a premium price for their property. Data was collected for the 1996-1999 period and included sales year, home size, parcel size, home age, garage size and distance to the riparian corridor. Focus was placed on homes located within 1.5 miles of a riparian corridor. Homes averaged 2000 square feet in size with a one car garage on ¼ acre of land that were 15 years old.

Colby and Wishart determined that homes closest to riparian areas had the highest premiums. These premiums decreased as the homes were located further away from the riparian area up to 1.5 miles away. More specifically, homes located closer to riparian areas were worth approximately $5,000 to $14,000 more than homes that were not located near a riparian area (Colby and Wishart, 2002a).

Colby and Orr (2005)

Colby and Orr (2005) determined the economic tradeoffs in preserving the San Pedro Riparian National Conservation Area in southeastern Arizona, which spans 36 miles of the river corridor and includes approximately 57,000 acres of land. This area has one of the largest populations of bird biodiversity in the US, with 1 to 4 million migrating songbirds using the area annually. Birds frequent the riparian area, as it is an oasis between a desert and a grassland. Consequently, this is also one of the most threatened rivers in the US.

Data was collected in 2001 by surveying Upper San Pedro River visitors.[25] The surveys were completed on site. Respondents were asked if they would be willing to make a one-time contribution to the conservation foundation, a non-profit organization, to assist with water flow to maintain the abundance and diversity of birdlife in the area. Respondents could then choose a value between $0 and $1000. They determined that respondents were willing to make a $95.09 one time contribution to the foundation, which would result in donations of $3.3 million to riparian restoration projects by non-local visitors (Colby and Orr, 2005).

All Ecosystem Service Categories: Total Ecosystem Service Value

All Ecosystem Services

Flessa (2004)

Flessa (2004) determined the ecosystem services value of water, as well as the ecosystem service value of floodplains, estuaries, deserts, and croplands in the Colorado River Delta and estuary,

[25] Visitors were not local residents.

located in the US and Mexico. Some of the ecosystem service valuation data was obtained from a study by Costanza et al. (1997). The Costanza et al. (1997) article is a seminal piece of ecosystem service valuation literature. In this study, Costanza and his colleagues attempted to calculate the values for 17 ecosystem services within 16 biomes around the world. Their calculations were primarily based on secondary data. One issue with using this data is that is it not specific to the Colorado River Delta region, instead providing a general world average for ecosystem service values. That being said, it is an approach that has been used in many other studies, likely because extensive data on ecosystem service valuations does not exist.

Flessa calculated the total ecosystem service values of a floodplain to be $14,015/hectare/year, [26]for estuaries the value is $1967/hectare/year, for deserts it is $139/hectare/year and for croplands it is $203-$249/hectare/year (Table 21). In this way, if someone were to convert a 100 hectare floodplain into cropland in the Colorado River Delta, society would be losing almost $140,000 worth of ecosystem services annually. Flessa determined the ecosystem service value of water to be $236.23/acre foot, yet water prices were found to be $18.17 to $36.34/acre foot. This indicates that existing water prices are not based on lost ecosystem services.

Biome	Ecosystem Service Value
Colorado River Delta Water	$236.23/acre foot
Cropland	$203-$249/hectare/year
Desert	$139/hectare/year
Floodplain	$14,015/hectare/year
Estuary	$1,967/hectare/year

Table 21. Ecosystem Service Values by Biome (Flessa, 2004). Values are in 2009 USD.

Ultimately, this study suggested that restoring the Colorado River Delta floodplain habitat through the fallowing of 170,000 hectares of cropland could pay off the current ecosystem service deficit in the CRB, as water would again flow to the Gulf of California and 57,000 hectares of estuary would be restored. By applying the results from Gutrich (2004), 57,000 hectares of estuary would be worth approximately $14 billion dollars (not accounting for annual inflation) over the 13 year period that it would take for the estuary to become fully functional.

[26] One hectare is equal to 2.47105381 acres.

Discussion and Conclusions

Reviewing the literature to determine the information available on assessing the ecosystem service value of the Colorado River Basin (CRB) led to an assessment of the existing information, as well as gaps in that information. Overall, 90% of the observations in the database were categorized in the information function ecosystem service category. These observations were primarily recreation or preservation based.

In relation to recreation, the National Survey of Fishing, Hunting and Wildlife Association Recreation has been conducted every five years since 1955 and is an extremely comprehensive study. Therefore, it provides a significant amount of information on fishing, hunting and wildlife related recreation by state. This is an exceptional resource to apply to the CRB. These studies do ask respondents whether they participate in activities in their state or in another state, but do not break down their recreation numbers any further than that in their summary reports. As a result, while these numbers are relevant to the CRB, they are not specific to the CRB. However, these numbers can be extrapolated to estimate CRB details. As recreation data is not lacking, further details about this survey may not be necessary, but there is the possibility that obtaining the raw data from the survey administrators will reveal more site specific information and enable a more accurate CRB specific calculation.

The majority of studies collected on recreation attempted to determine the consumer surplus value[27] of a variety of outdoor recreation activities in various basin states. Many of these were not CRB specific, but these values can be extrapolated to represent the CRB. While there is a lot of recreation data information on a variety of recreation activities that are basin related, there is a lack of data related to several activities that are very relevant to the CRB. These include motor boating, house boating, beach recreation, birdwatching and canyoneering.

In relation to white water rafting, there is an extensive amount of data available on numbers of participants in rafting activities, specifically in Colorado. The Grenier and Werner (2010) report was a very recent study illustrating numbers of rafters and expenditures in Colorado and was river specific. However, the issue with this study, as well as with the Loomis (2007) study that attempted to determine how expenditures would change for rafting and fishing if the river level dropped, is that their expenditure data is based on a 1991 study. Therefore, it is recommended that new expenditure data be obtained to determine a more accurate value of whitewater rafting activities on the Colorado River Tributaries, especially since rafting has increased in popularity upstream of Lake Mead.

Many of the preservation related studies, specifically Walsh et al. (1984), Colby and Wishart (2002), Rosenberger and Walsh (1997) and Walsh et al. (1990), collected their data in the 1980's

[27] Their willingness-to-pay over and above what they already pay for.

and 1990's. As values may have changed since these studies were conducted, it may not be appropriate to extrapolate these numbers.

There have been several recent studies conducted on riparian habitat preservation and instream flow preservation in Arizona and New Mexico (Bark et al., 2009; Colby and Orr, 2005; Weber and Berrens, 2006; Berrens et al., 2000). The New Mexican studies have even taken advantage of "tagging on" extra questions to a survey that is conducted statewide every year to obtain values for instream flow. However, no studies were located on instream flow or riparian values in Utah, Nevada, California, or Wyoming. Therefore, it may be useful to explore studies in these states.

As there is a large Native American population in the basin and there are many cultural resources, such as the many cliff dwellings, as well as the petroglyphs and pictographs, it may be useful to determine the value of the cultural resources in the basin. As stated in the Welsh et al. (1997) study, modifications in water flow will have an effect on ancient riverside rock paintings and carvings.

There is information available on food production, which falls in the production function ecosystem service category. The National Agricultural Statistics Service has recently made data available to the public for agricultural products by county. Therefore, if the list of all the counties within the basin is formalized, agricultural data can be made more specific to the CRB. That being said, the only studies found on the valuation of crops in Mexico were the studies by Medellín-Azuara (2006 and 2007). However, to obtain more information on Mexican data for crops, as well as that of all the other ecosystem services in the CRB in Mexico, may require a contact in Mexico that reads Spanish fluently. Medellin-Azuara was contacted several times during this particular study for more information on his studies, he is currently in California and may be a good person to contact if that is a pursued direction. That being said, only 1.3% of the CRB is located in Mexico, so it may not be worth the effort to pursue this aspect. However, it may be worth expanding the Medellin-Azuara approach to states in the US.

In relation to the habitat function, no studies were located that were primarily focused on valuing the nursery function or plant and animal refugia, but there is some non-valuation data available on these particular aspects. Perhaps a next step may involve obtaining habitat function data and using other study recommendations to determine its value.

A lot of work has been done on ecosystem service regulation functions, such as erosion control and flow regimes, as well as preserving endangered species, however, very few of these studies have placed a value on these particular resources. These are areas that are important to the CRB ecosystem services and should be accounted for accordingly. Considering that the recovery program spends approximately $11 million annually, it should be relatively straightforward to determine preliminary values (Upper Colorado River Endangered Fish Recovery Program, 2011).

In summary, this study has illustrated the information currently available for use in determining the value of ecosystem services for the CRB, but the data is not complete by any means. Consequently, there are many ways to further this effort. One way is to collect available data on CRB specific ecosystem services and then use techniques to convert the available data to values. Another way is to conduct a field study on a specific area of the basin, such as a one quarter mile stretch of the river, and conduct a variety of experiments to determine the value of several of the ecosystem services in that particular area. Once a comprehensive study is conducted on one section of the river, the same techniques can be used to value another section of the river. Another way is to focus on a specific service, such as the scenic value of the river, and conduct an appropriate study to determine the value of that service, such as a hedonic study by obtaining values for homes with a view of the river and comparing that to the value of similar homes near the river, but without a river view. Several counties have hedonic information available on their websites, which would make the data collection process simpler. Another suggestion is to follow the work of Costanza et al. (2006) on valuing the ecosystem services of New Jersey to value the CRB. This involves value transfer, hedonic analysis, and spatial modeling. However, instead of value transfer just from CRB specific studies, values can also be transferred from river basin areas in other locations to the CRB.

When a more complete ecosystem service valuation is calculated for the CRB, it can be used to improve the cost-effectiveness of fish and wildlife recovery policies, specifically fish native to the CRB. This improvement in the cost-effectiveness of the fish and wildlife recovery policies will also lead to an improvement in the ecosystem service functions (and sustainability) of the watershed, not to mention an increase in the value of ecosystem services.

Acknowledgements

I would first like to thank the Nature Conservancy for funding such an important project. In addition, I would like to thank the many people that contributed their time and knowledge to the project, as this report would not have been as complete without their assistance. I would sincerely like to thank Taylor Hawes for her insight on the project, as well as her comments and extensive editing assistance. I would also like to thank Jonathan Mathieu for his comments and editing assistance. Taylor and Jonathan's comments and suggestions greatly improved the work. I would like to thank people from the ResEcon mailing list that responded to my request for information, as well as those people that were directly contacted, for sending related papers and leads to papers. More specifically, I would like to thank Karl Vigerstol, John Sanderson, Timm Kroeger, John Duffield, Matthew Weber, Rick Casey, Mark Eads, Bruce Peacock, Max Kaufman and Andy Seidl for leads to many significant papers. I would like to thank John Loomis, Tom Brown, Richard Bishop, Nick Flores, and Robert Richardson for related papers and advice. I would like to thank John Gutrich and Josue Medellin-Azuara for responding to clarification questioning. And I would like to thank Jan Koenig for Colorado River Basin data. I also appreciate the support of Thomas Wilding, Charlie Cache Wilding, and Lucy dog in this endeavor.

Appendix A: Ecosystem Service Valuation Methods with Brief Descriptions and Examples

For more information on applying any of these methods, refer to Kaval (2010) or Riera et al. (2010) (Bateman et al., 2010; Kaval, 2010; Riera et al., 2010).

Valuation Method	Brief Description	Brief Example
Market valuation	The price that buyers and sellers trade merchandise, services, or securities for in an open marketplace	The cost of a fishing license, where a monetary exchange took place
Travel cost or Clawson method	Uses surveys to collect information about observed behavior to value recreational uses of the environment	Cost of fishing in a particular stretch of river located in a particular park; this value can include all costs incurred as a result of the trip, such as fuel, meals and lodging
Hedonic pricing method	Value of an environmental amenity; this value is typically in relation to a house, building or property price.	Imagine a builder built 50 identical homes; 25 have a view of the river and 25 do not. If the equilibrium price of the homes with a view of the river is higher than those without the view, the implicit price difference represents the hedonic value of the river view.
Contingent valuation method	Uses surveys to determine the value people place on amenities, goods, and services. The respondent is typically presented with one hypothetical scenario.	Would you be willing to pay $15 annually in your taxes for the construction and maintenance of a kayak park on the river that goes through your town?
Choice modeling method	Uses surveys to determine the value people place on amenities, goods and services. The respondents are asked to simultaneously compare several hypothetical scenarios, where each scenario is composed of several attributes	Would you be willing to pay; Option 1: $15 annually in your taxes for the construction and maintenance of a 1.0 kilometer (0.6 mile) long kayak park with six drop structures on the river that goes through your town; Option 2: $20 annually in taxes for the construction and maintenance of a 0.4 kilometer (0.25 mile) long kayak park with 5 drop features on the river that goes through your town; Option 3: No cost and no kayak park (this is the current situation).
Avoided costs	Value of costs that you avoid paying for because a service is being provided by the ecosystem	There is a large wetland in your town. The wetland absorbs flood waters that would otherwise flood streets and the basements in peoples homes. Because the wetland exists, the townspeople are avoiding paying for the basement damages they would incur if the wetland were not there.
Restoration costs	Value of an ecosystem service restoring an ecosystem to its natural state after a disturbance	If you were to crash your car off the road and some oil spilled into the river, the river may be able to dilute the oil so it dissipates and does not harm the river in any significant way. If the river could not dissipate the oil so it does not have an effect on the river or surrounding area because the spill was too large, the restoration cost would be the cost society (or you, depending on the situation) would have to pay to restore the river to its natural state (prior to the spill).
Replacement costs	Value of not having to pay for a manmade product to replace a needed service that is currently supplied by the ecosystem.	Plants are removing toxins from the soil through phytoremediation. If the plants are removed, a costly artificial treatment system will be required to remove the toxins (and replace the work currently being conducted by the plants).
Factor income	Value of an ecosystem service that enhances the market value of other ecosystem services	Crops may produce more (or larger) fruit when their flowers are pollinated by bees. Factor income would be the difference between the value of the fruit if the plants were not pollinated by bees and the value of the fruit if they were.
Value transfer or Benefit transfer method	Valuing an ecosystem service by using results from one study and transferring that data to another study area. This procedure may be used when there is not enough time and/or funding to conduct an original study.	If you wanted to estimate the value of a specific lobster fishery in one cove, but did not have the time or funding to collect your own original data, you could use the results of at least one other study in a similar area with a similar situation to represent what you believe are valid data for your study.

Appendix B: Methodology Details

A concerted effort was made to locate all potentially relevant CRB valuation studies. The search process was conducted during the months of July 2010 through September 2010. The process began by directly contacting academics and practitioners believed to have been involved in, or aware of, potentially relevant studies. In addition, an email message was sent to the ResEcon (Land & Resource Economics Network) listserv. The ResEcon listserv enables environmental and resource economists to contact others in the system to receive information relevant to their work. People were asked whether they knew of, or had written any, CRB valuation reports or articles. Several respondents provided references, some provided actual articles or reports, while others provided contact details for people they believed may have relevant information. All new contacts were subsequently contacted. Some people responded immediately to the request, however, others took several weeks or months to respond. Therefore, the report and article collection process took several months. Consequently, this was a successful venture as it resulted in a collection of 63 potentially relevant studies, many of which were unpublished reports that may not have been located otherwise.

In August of 2010, a thorough academic literature search was conducted. Searched databases included:

- ProQuest – All of ProQuest including, but not limited to:
  - ABI/Inform Trade & Industry
  - CBCA Business
  - ERIC
  - ProQuest Asian Business and Reference
  - ProQuest European Business
  - ProQuest Science Journals
  - ProQuest Social Science Journals
- Wiley Interscience
- JStor
- EconLit
- ISI Web of Knowledge – All of ISI Web of Knowledge including, but not limited to:
  - Science Citation Index Expanded
  - Social Sciences Citation Index
  - Arts & Humanities Citation Index
  - Conference Proceedings Citation Index – Science
  - Conference Proceedings Citation Index – Social Science and Humanities
- Google Scholar
- Google

Once a potentially relevant reference was located, it was downloaded directly from a website, requested from a library, or acquired directly from the author. The waiting period to receive articles and reports that were not directly available online was anywhere from a few days to a few months.

All obtained reports and articles went through an initial screening process. During this process, 17 duplicate studies were deleted. Once duplicate studies were removed, the remaining studies were reviewed in detail. Several studies were found to be relevant to ecosystem service valuation in general, but not the CRB. Others were relevant to the CRB, but not the ecosystem service valuation of the CRB. These studies were not included in the database. Another area searched to locate studies was report and article reference lists, especially meta-analyses and review studies, such as Kaval and Loomis (2003) and Duffield et al. (2007).

References for all relevant studies were entered into an endnote file, while relevant data from the studies were entered into an excel database. The academic literature search resulted in 368 potentially relevant studies. Adding the number of academic and direct contact literature obtained yielded 431 studies. After a thorough review of all of the works, 119 were deemed to be relevant to the study, contained the required information, and were entered into the database (Table B1). Each observation in the database contains an ecosystem service value. Because some studies reported more than one value, such as the value of fishing, hunting and wildlife watching related recreation; there are more observations in the database than there are studies. Overall, the database contains 516 observations and 70 variables. Variables include year of publication, full references, the good or service that was valued, location of the study, ecosystem service or ecosystem type, the reported value, the year the data was collected, and the valuation methodology used in the study, to name a few. The completed data table was used to calculate ecosystem service values as well as analytical diagrams and summaries for this report.

	Potentially Relevant Studies	Studies Entered into Database (includes general statewide studies)	Studies Specific to the Colorado River Basin	Percentage of Database Studies Compared to Original Number of Potentially Relevant Studies	Percentage of Database Studies Used Specific to Colorado River Basin
Contact List Search	63	31	25	49%	81%
Academic Search	368	88	13	24%	15%
Total	431	119	38	28%	32%

Table B1. Number of Studies Located and Entered Into the Database. Database references include: (Aiken, 2003; Aiken, 2009; Baker, 1996; Bark-Hodgins et al., 2005; Bark, 2009; Bark et al., 2009; Bergstrom et al., 1996; Berrens et al., 1995; Berrens et al., 1996; Berrens et al., 2000; Berrens et al., 1998; Bishop et al., 1989a; Bishop et al., 1989b; Bowes and Loomis, 1980; Boyle et al., 1988; Brown and Hay, 1987; Brown et al., 1989; Brown, 1991; Brown, 2004; Brown, 2007; Brown et al., 1988; Buland et al., 2004; Bureau of Reclamation, 2009; Bureau of Reclamation: Upper Colorado Region, 2008a; Bureau of Reclamation: Upper Colorado Region, 2008b; Carver, 2009; Chakraborty and Keith, 2000; Chicetti et al., 1976; Colby and Wishart, 2002a; Colby and Orr, 2005; Colby and Wishart, 2002b; Connelly and Brown, 1988; Cooper and Loomis, 1993; Cory and Martin, 1985; Coupal et al., 2001; Crandall, 1991; Creel and Loomis, 1990; Daubert and Young, 1981; Douglas and Harpman, 1995; Douglas and Johnson, 2004; Duffield et al., 2007; Duffield et al., 2008; Duffield et al., 2009; Fix and Loomis, 1998; Fix et al., 2005; Flessa, 2004; Franklin et al., 1983; Garrett et al., 1970; Gilbert et al., 1988; Greiner and Werner, 2010; Gutrich and Hitzhusen, 2004; Hammer, 2001; Harpman et al., 1993; Hay, 1985; Hjerpe and Kim, 2007; Johnson and Walsh, 1987; Kaval and Loomis, 2003; Keith et al., 1982; Keith, 1980; King and Lenox, 2000; King et al., 2006; King and Hof, 1985; Knetsch et al., 1976; Loomis, 1979; Loomis, 1982; Loomis, 2007; Loomis, 2008; Loomis and Caughlan, 2003; Loomis and Ballweber, 2010; Loomis et al., 1989a; Loomis et al., 1989b; Lutz et al., 2000; Markstrom and Rosenthal, 1987; Martin et al., 1974; Martin et al., 1980; Martin et al., 1982; May, 1997; Medellín-Azuara, 2006; Medellín-Azuara et al., 2007; Miller and Hay, 1984; Morey, 1985; Peacock, 2009; Pickton and Sikorowski, 2004; Richards and Brown, 1992; Richards et al., 1985; Richardson, 2002; Roberts and Grossman, 2008; Rosenberger and Walsh, 1997; Rosenberger and Loomis, 1999; Rosenthal and Walsh, 1986; Siderelis and Moore, 1995; Silberman and Andereck, 2006; Smith and Kopp, 1980; Southwick Associates, 2003; Southwick Associates, 2007a; Southwick Associates, 2007b; Southwick Associates, 2007c; Sublette and Martin, 1975; Taylor et al., 1995; U.S. Department of the Interior et al., 2001; U.S. Department of the Interior et al., 1991; U.S. Department of the Interior et al., 1996; U.S. Department of the Interior et al., 2006; U.S. National Agricultural Statistics Service, 2010; Waddington et al., 1991; Walsh et al., 1980a; Walsh and Olienyk, 1981; Walsh and Gilliam, 1982; Walsh and Davitt, 1983; Walsh et al., 1981; Walsh et al., 1983; Walsh et al., 1984; Walsh et al., 1985; Walsh et al., 1987; Walsh et al., 1989; Walsh et al., 1980b; Walsh et al., 1990; Ward, 1982; Weber and Berrens, 2006; Welsh et al., 1997).

Appendix C: Consumer Price Index Values Used for Calculations

Source: US Department of Labor Bureau of Labor Statistics. Data sourced on 15 October 2010.

Year	CPI Percentage Change	CPI for 2009 Base Year	Year	CPI Percentage Change	CPI for 2009 Base Year
1930	16.7	1284.652695	1971	40.5	529.7209877
1931	15.2	1411.427632	1972	41.8	513.2464115
1932	13.7	1565.963504	1973	44.4	483.1914414
1933	13	1650.284615	1974	49.3	435.1663286
1934	13.4	1601.022388	1975	53.8	398.767658
1935	13.7	1565.963504	1976	56.9	377.0421793
1936	13.9	1543.431655	1977	60.6	354.0214521
1937	14.4	1489.840278	1978	65.2	329.0444785
1938	14.1	1521.539007	1979	72.6	295.5055096
1939	13.9	1543.431655	1980	82.4	260.3604369
1940	14	1532.407143	1981	90.9	236.0143014
1941	14.7	1459.435374	1982	96.5	222.3181347
1942	16.3	1316.177914	1983	99.6	215.3985944
1943	17.3	1240.098266	1984	103.9	206.4841193
1944	17.6	1218.960227	1985	107.6	199.383829
1945	18	1191.872222	1986	109.6	195.745438
1946	19.5	1100.189744	1987	113.6	188.852993
1947	22.3	962.0493274	1988	118.3	181.3499577
1948	24.1	890.1950207	1989	124	173.0137097
1949	23.8	901.4159664	1990	130.7	164.144606
1950	24.1	890.1950207	1991	136.2	157.5161527
1951	26	825.1423077	1992	140.3	152.9130435
1952	26.5	809.5735849	1993	144.5	148.4685121
1953	26.7	803.5093633	1994	148.2	144.7618084
1954	26.9	797.535316	1995	152.4	140.7723097
1955	26.8	800.511194	1996	156.9	136.734863
1956	27.2	788.7389706	1997	160.5	133.6679128
1957	28.1	763.4768683	1998	163	131.6177914
1958	28.9	742.3425606	1999	166.6	128.7737095
1959	29.1	737.2405498	2000	172.2	124.5859466
1960	29.6	724.7871622	2001	177.1	121.1389046
1961	29.9	717.5150502	2002	179.9	119.2534742
1962	30.2	710.3874172	2003	184	116.5961957
1963	30.6	701.1013072	2004	188.9	113.5717311
1964	31	692.0548387	2005	195.3	109.8499744
1965	31.5	681.0698413	2006	201.6	106.4171627
1966	32.4	662.1512346	2007	207.342	103.4701122
1967	33.4	642.3263473	2008	215.303	99.64422233
1968	34.8	616.4856322	2009	214.537	100
1969	36.7	584.5694823	2010	217.7748	98.51323477
1970	38.8	552.9304124			

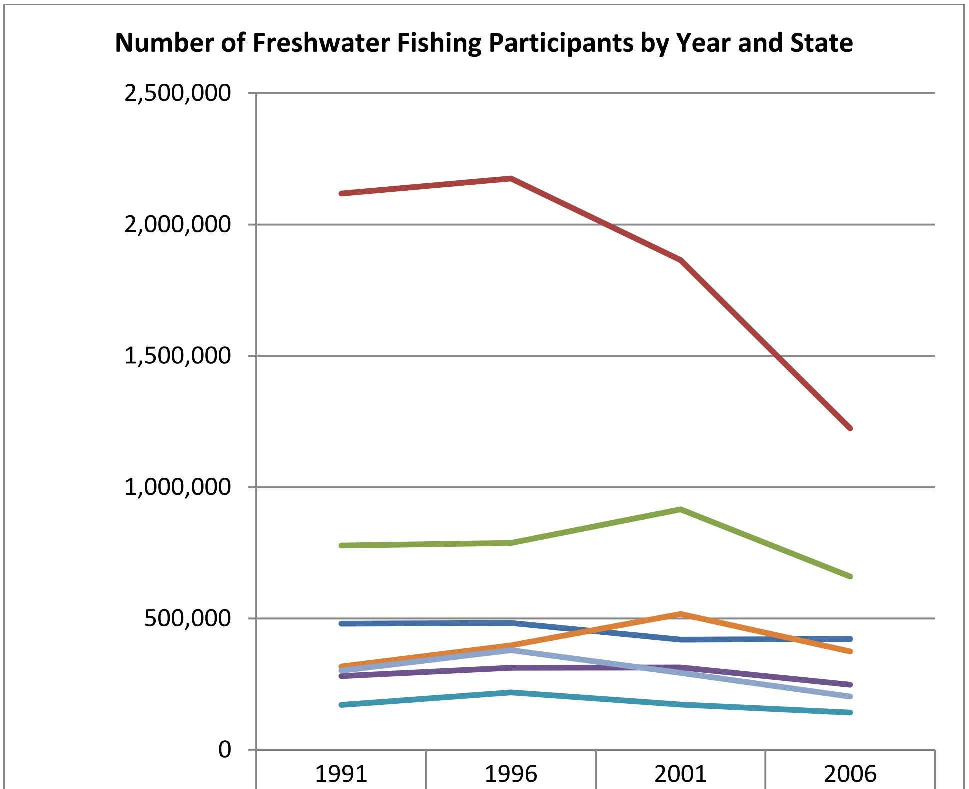
Appendix D: More Detail about the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Data Numbers

The National Survey of Fishing, Hunting and Wildlife-Associated Recreation (National FHWSR Survey) presents information on participant numbers and expenditure data for three activity categories: fishing, hunting and wildlife watching. Data specifically for the CRB was not available; however, specific state-wide data was available. As such, the data presented here focused on information for the seven US states that fall within the CRB (U.S. Department of the Interior et al., 2001; U.S. Department of the Interior et al., 1991; U.S. Department of the Interior et al., 1996; U.S. Department of the Interior et al., 2006).

National Survey of Fishing, Hunting, and Wildlife-Associated Recreation: Fishing

One recreation area of importance in the National FHWAR Survey is fishing. In the CRB, fishing is primarily focussed on introduced fish species, such as the rainbow trout. However, there are many native and non-native species of fish in the CRB waters, although many of the native fish are endangered or threatened. Results of the National FHWAR Survey reveal that in 1991, approximately 4,446,000 people participated in freshwater fishing in the seven US states (Arizona, California, Colorado, New Mexico, Nevada, Utah, and Wyoming) within the CRB. This number increased to 4,752,000 in 1996, but then began a steady decrease to 4,495,000 in 2001 and 3,274,000 in 2006. Overall, there were 1.5 million fewer people participating in freshwater fishing within these seven US states between 1991 and 2006. Of the states in the CRB, California had the largest number of participants (average of 1,845,500), with Colorado having the second largest number of participants (average of 785,000). Nevada had the fewest number of participants (average of 176,000).

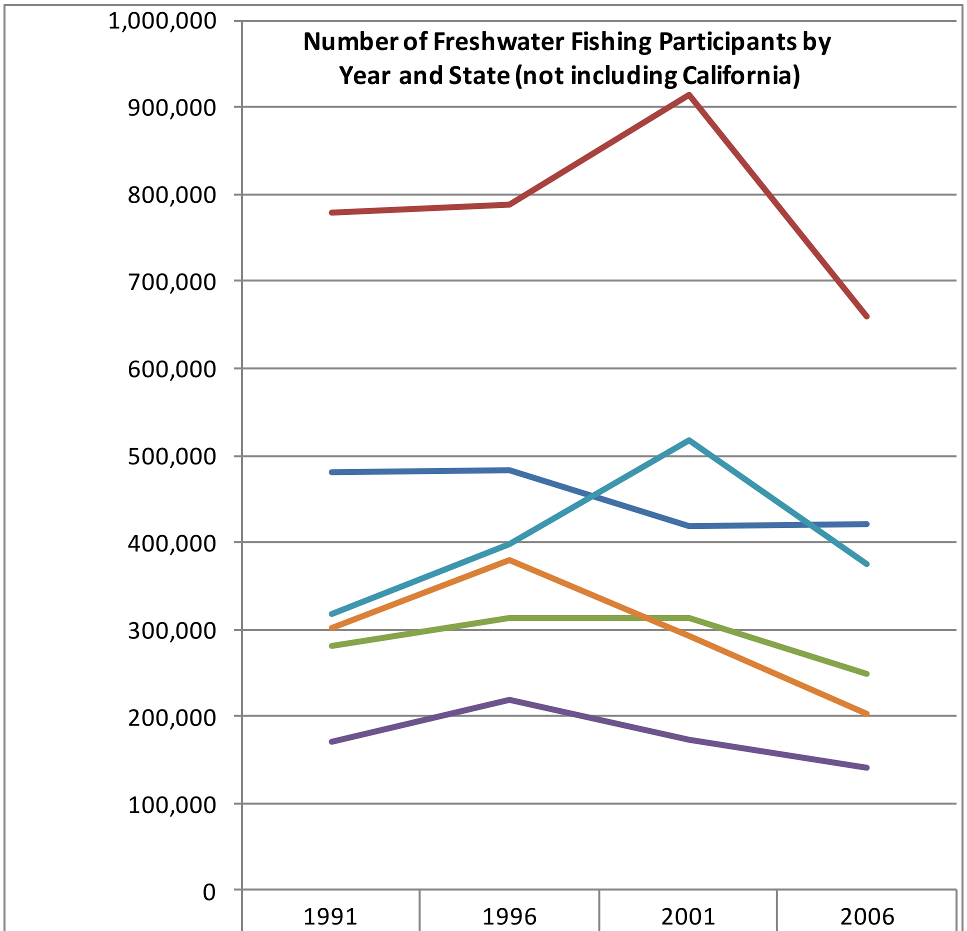
It is interesting to note that there was an increase in the participation of freshwater fishing in all states between 1991 and 1996. In 2001, the number of participants continued to increase in Colorado, New Mexico and Utah; however, Arizona, California, Nevada and Wyoming all experienced a decrease in the number of participants in freshwater fishing between 1996 and 2001 (Figure D1). Between 2001 and 2006, a decrease in the participation of freshwater fishing was experienced in all states in the CRB except Arizona, which experienced an increase of 3,000 participants, from 419,000 to 422,000.



	1991	1996	2001	2006
Arizona	480,000	483,000	419,000	422,000
California	2,118,000	2,175,000	1,865,000	1,224,000
Colorado	778,000	787,000	915,000	660,000
New Mexico	281,000	312,000	314,000	248,000
Nevada	171,000	219,000	172,000	142,000
Utah	317,000	397,000	517,000	375,000
Wyoming	301,000	379,000	293,000	203,000

Figure D1. Number of Freshwater Fishing Participants by Year and State. Note: Only States Within the Colorado River Basin are Included (U.S. Department of the Interior et al., 2001; U.S. Department of the Interior et al., 1991; U.S. Department of the Interior et al., 1996; U.S. Department of the Interior et al., 2006).

Figure D2 illustrates the number of freshwater fishing participants by year and state, but does not include California numbers, so readers can experience a potentially more interesting visual perspective.



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Wyoming	301,000	379,000	293,000	203,000

Figure D2. Number of Freshwater Fishing Participants by Year and State. Note: Only States within the Colorado River Basin are Included except California (U.S. Department of the Interior et al., 2001; U.S. Department of the Interior et al., 1991; U.S. Department of the Interior et al., 1996; U.S. Department of the Interior et al., 2006).

While the overall number of freshwater anglers decreased from 1991 to 2006, the average amount of money they spent increased (Figure D3) from $721/angler (2009 USD) in 1991 to $1045/angler (2009 USD) in 2006.

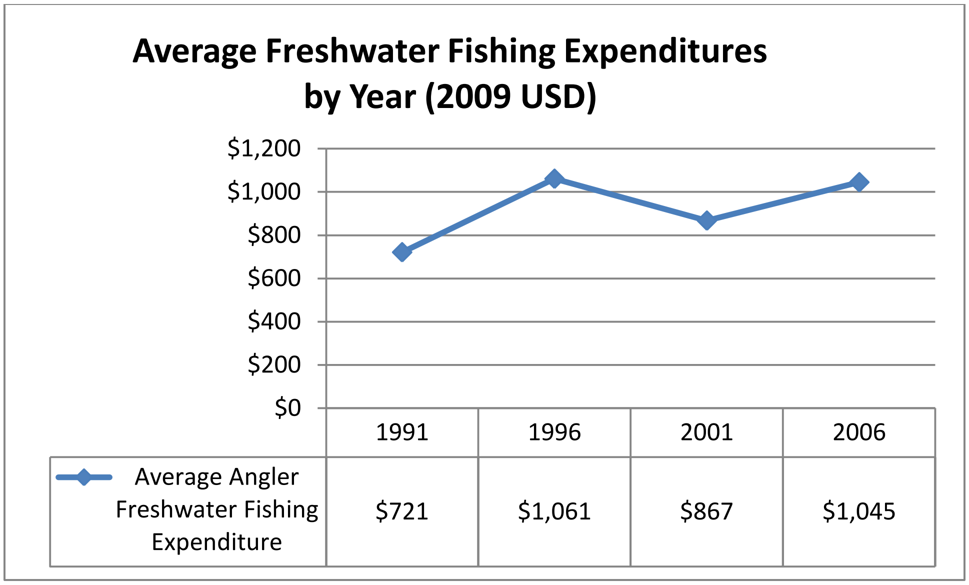
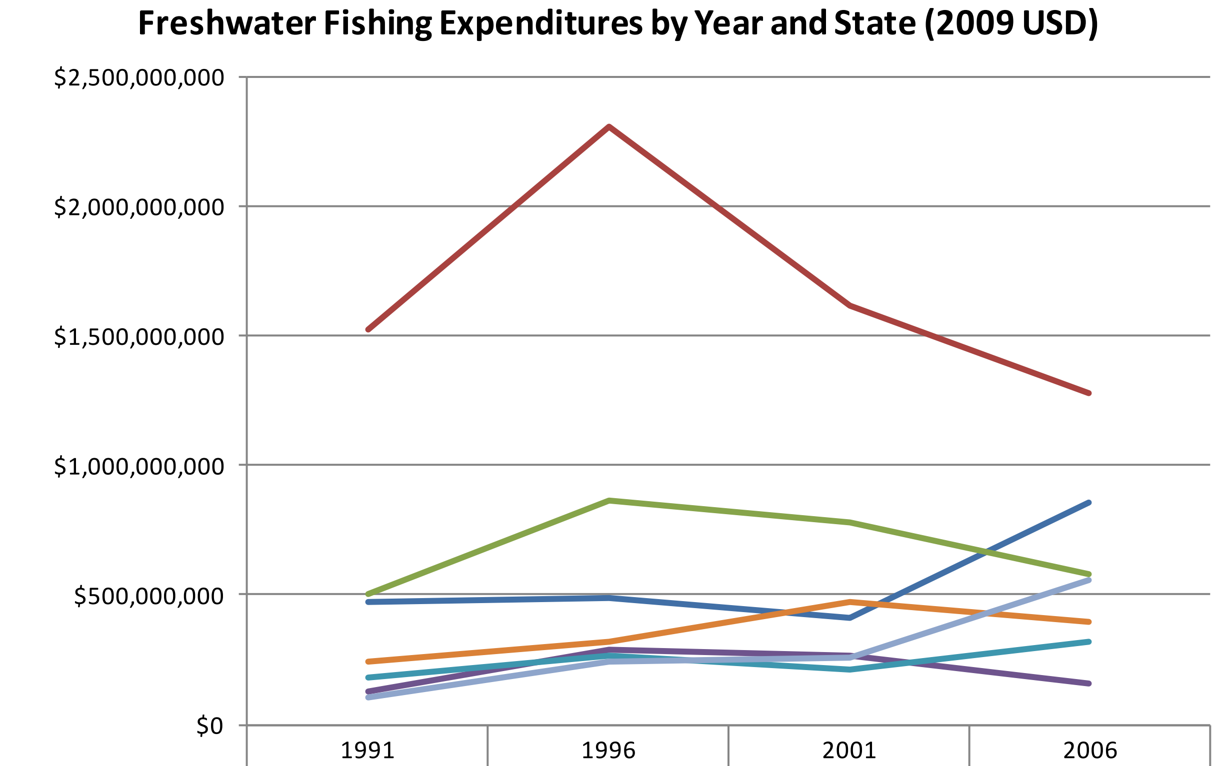


Figure D3. Average Expenditure by Freshwater Fishing Angler in 2009 USD for All Seven US States Located within the Colorado River Basin (U.S. Department of Labor, 2010; U.S. Department of the Interior et al., 2001; U.S. Department of the Interior et al., 1991; U.S. Department of the Interior et al., 1996; U.S. Department of the Interior et al., 2006).

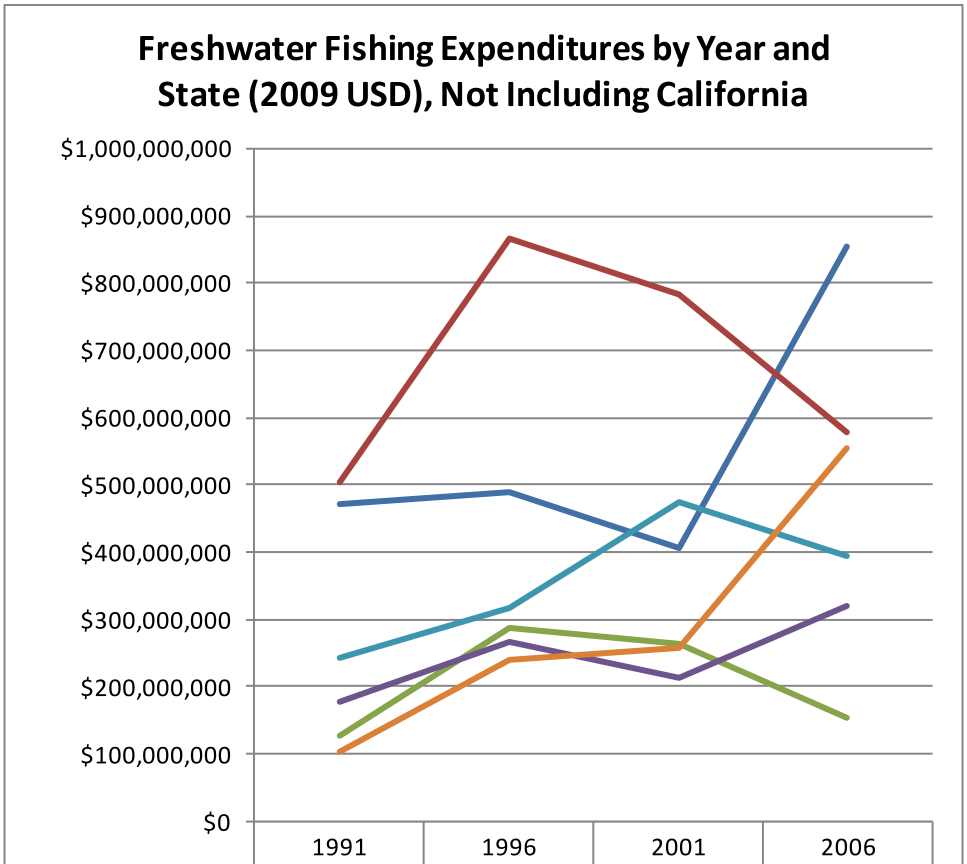
Freshwater fishing expenditures by year and state are presented in Figure D4. California was a state with freshwater and saltwater fishing activities, as such, fishing expenditures in the National FHWAR Survey illustrated the value of both activities for California. Therefore, freshwater fishing expenditures for California were estimated by multiplying the number of freshwater fishing participants by the average freshwater fishing expenditures by year from Figure D3. Total freshwater fishing expenditures were found to increase between 1991 and 1996. Between 1996 and 2001, expenditures for all states except Utah and Wyoming decreased. The value for 2006 expenditures decreased between 2001 and 2006 for California, Colorado, New Mexico and Utah but increased for Arizona, Nevada and Wyoming. It is interesting to note that expenditures increased every year for Wyoming.



	1991	1996	2001	2006
Arizona	$471,905,792	$489,707,708	$407,381,656	$853,896,634
California	$1,527,078,000	$2,307,675,000	$1,616,955,000	$1,279,080,000
Colorado	$502,922,298	$867,510,236	$782,425,282	$577,778,151
New Mexico	$126,206,667	$288,636,357	$262,533,445	$153,915,399
Nevada	$177,777,455	$266,649,391	$213,781,093	$320,423,141
Utah	$242,897,783	$316,256,799	$475,611,933	$394,900,257
Wyoming	$104,385,954	$238,704,887	$256,245,125	$554,943,156

Figure D4. Freshwater Fishing Expenditures by Year and State (2009 USD) (U.S. Department of Labor, 2010; U.S. Department of the Interior et al., 2001; U.S. Department of the Interior et al., 1991; U.S. Department of the Interior et al., 1996; U.S. Department of the Interior et al., 2006).

Figure D5 illustrates freshwater fishing expenditures by year and state, but does not include California numbers, so readers can experience a potentially more interesting visual perspective.



	1991	1996	2001	2006
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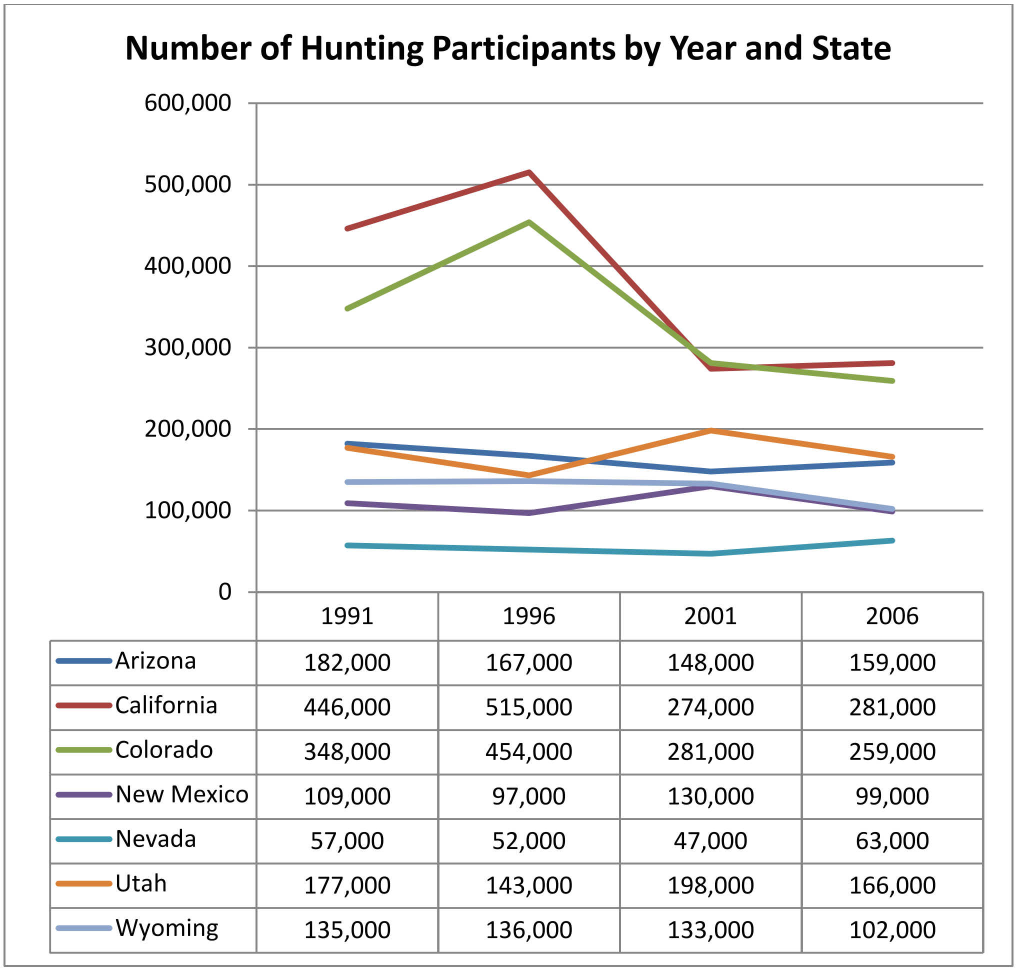
Wyoming	$104,385,954	$238,704,887	$256,245,125	$554,943,156

Figure D5. Freshwater Fishing Expenditures by Year and State (2009 USD), Not Including California (U.S. Department of Labor, 2010; U.S. Department of the Interior et al., 2001; U.S. Department of the Interior et al., 1991; U.S. Department of the Interior et al., 1996; U.S. Department of the Interior et al., 2006)

National Survey of Fishing, Hunting, and Wildlife-Associated Recreation: Hunting

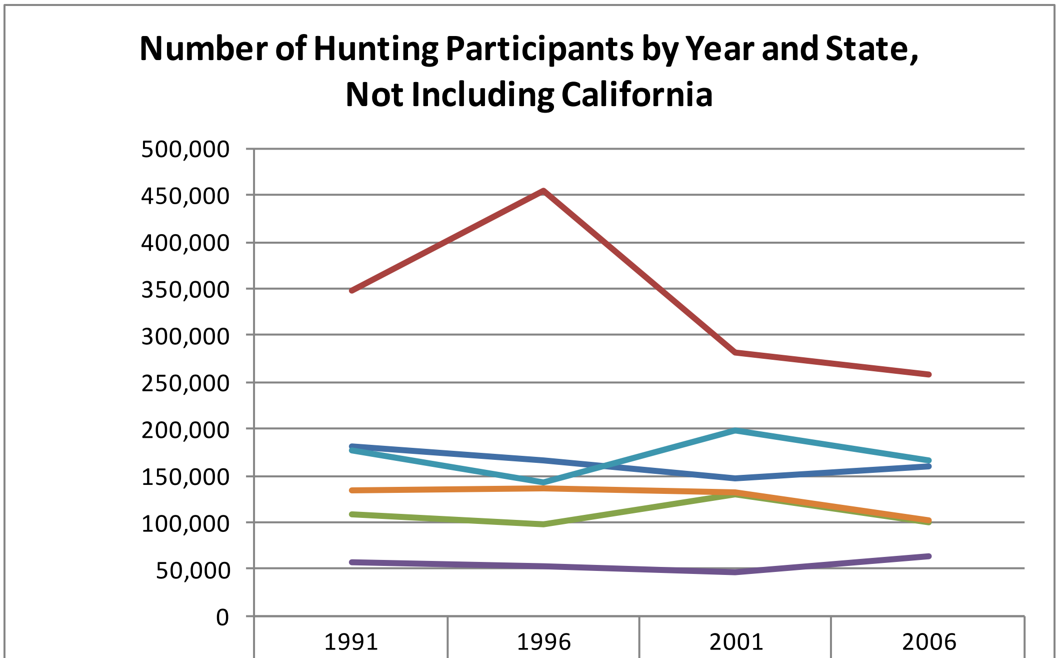
Hunting was another recreation activity of interest in the National FHWAR Survey. Hunting in the CRB includes that of waterfowl, as well as land mammals, such as rabbits and deer. Overall, the number of participants in hunting decreased between 1991 and 2006, with the most drastic decreases occurring in California (446,000 in 1991 to 281,000 in 2006) and Colorado (348,000 in 1991 to 259,000 in 2006). Hunting in Nevada increased between 1991 and 2006, but only by 6,000 participants (from 57,000 to 63,000) (Figure D6).



	1991	1996	2001	2006
Arizona	182,000	167,000	148,000	159,000
California	446,000	515,000	274,000	281,000
Colorado	348,000	454,000	281,000	259,000
New Mexico	109,000	97,000	130,000	99,000
Nevada	57,000	52,000	47,000	63,000
Utah	177,000	143,000	198,000	166,000
Wyoming	135,000	136,000	133,000	102,000

Figure D6. Number of Hunting Participants by Year and State (U.S. Department of the Interior et al., 2001; U.S. Department of the Interior et al., 1991; U.S. Department of the Interior et al., 1996; U.S. Department of the Interior et al., 2006).

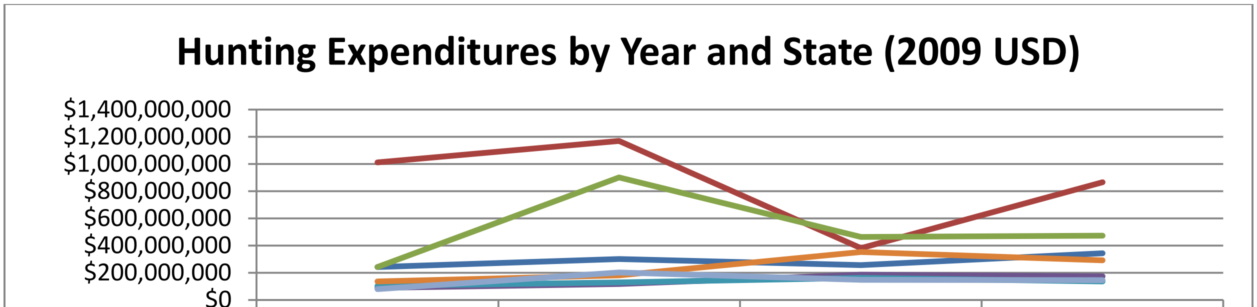
Figure D7 illustrates the number of hunting participants by year and state, but does not include California numbers, so readers can experience a potentially more interesting visual perspective.



	1991	1996	2001	2006
Arizona	182,000	167,000	148,000	159,000
Colorado	348,000	454,000	281,000	259,000
New Mexico	109,000	97,000	130,000	99,000
Nevada	57,000	52,000	47,000	63,000
Utah	177,000	143,000	198,000	166,000
Wyoming	135,000	136,000	133,000	102,000

Figure D7. Number of Hunting Participants by Year and State, Not Including California (U.S. Department of the Interior et al., 2001; U.S. Department of the Interior et al., 1991; U.S. Department of the Interior et al., 1996; U.S. Department of the Interior et al., 2006)

Even though the number of hunters decreased over the time period, expenses did not (Figure D8). Hunting expenditures were found to increase for all states within the CRB between 1991 and 1996. Between 2001 and 2006, hunting expenditures increased for Arizona, California, and Colorado, while they decreased during that same time period for New Mexico, Nevada, Utah and Wyoming. Over the entire time period of the studies, 1991 to 2006, an increase in expenditures was seen in all states except California.

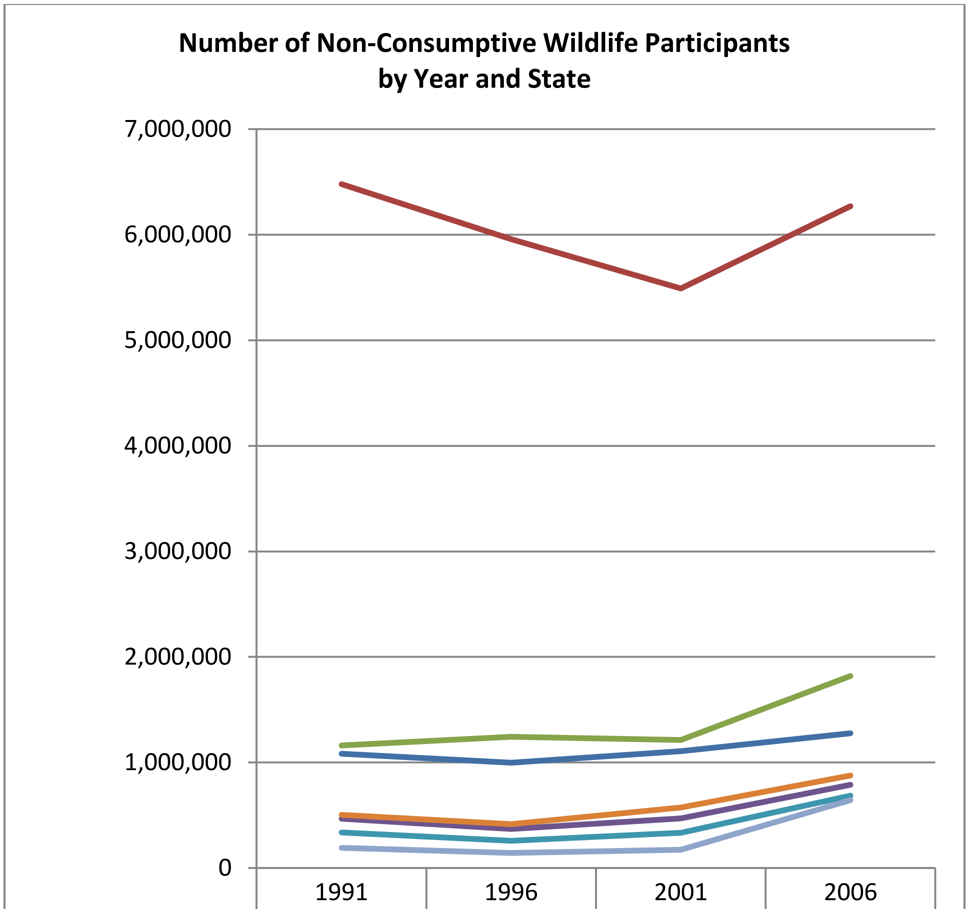


	1991	1996	2001	2006
Arizona	$241,946,151	$301,415,899	$256,216,253	$343,449,162
California	$1,013,064,154	$1,169,026,821	$381,838,608	$865,424,547
Colorado	$243,360,645	$902,055,836	$463,476,603	$472,556,394
New Mexico	$89,913,283	$117,258,467	$185,810,267	$174,851,644
Nevada	$102,928,830	$129,782,025	$162,449,822	$137,363,064
Utah	$135,800,844	$180,829,303	$353,856,710	$291,350,591
Wyoming	$79,150,215	$203,502,701	$149,359,541	$146,073,295

Figure D8. Hunting Expenditures by Year and State (2009 USD)

National Survey of Fishing, Hunting, and Wildlife-Associated Recreation: Wildlife Watching

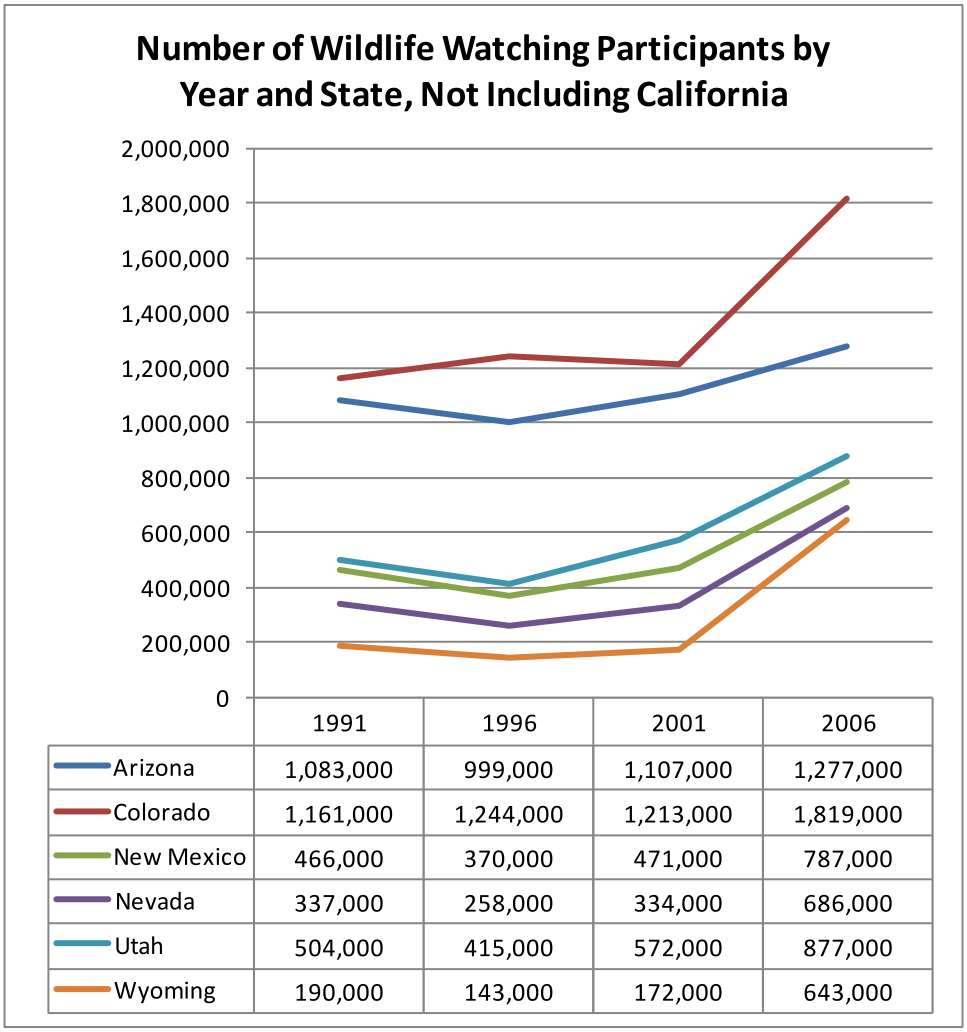
The final major activity type in the National FHWAR Survey is wildlife watching. For people participating in these activities on the lands and waters of the CRB, this could mean bird watching, photography, scenic driving, and boating with the purpose of seeing an animal on the riverbank. Unlike the number of people participating in fishing and hunting, the number of participants in wildlife watching activities increased between 1991 and 2006 in all states except California (Figure D9). However, even though the number of participants in California decreased overall, they did experience an increase between 2001 and 2006 of over ½ million people. In addition, in Nevada, participant numbers nearly doubled, while in Wyoming, participant numbers more than tripled.



	1991	1996	2001	2006
Arizona	1,083,000	999,000	1,107,000	1,277,000
California	6,480,000	5,959,000	5,491,000	6,270,000
Colorado	1,161,000	1,244,000	1,213,000	1,819,000
New Mexico	466,000	370,000	471,000	787,000
Nevada	337,000	258,000	334,000	686,000
Utah	504,000	415,000	572,000	877,000
Wyoming	190,000	143,000	172,000	643,000

Figure D9. Number of Wildlife Watching Recreation Participants by Year and State

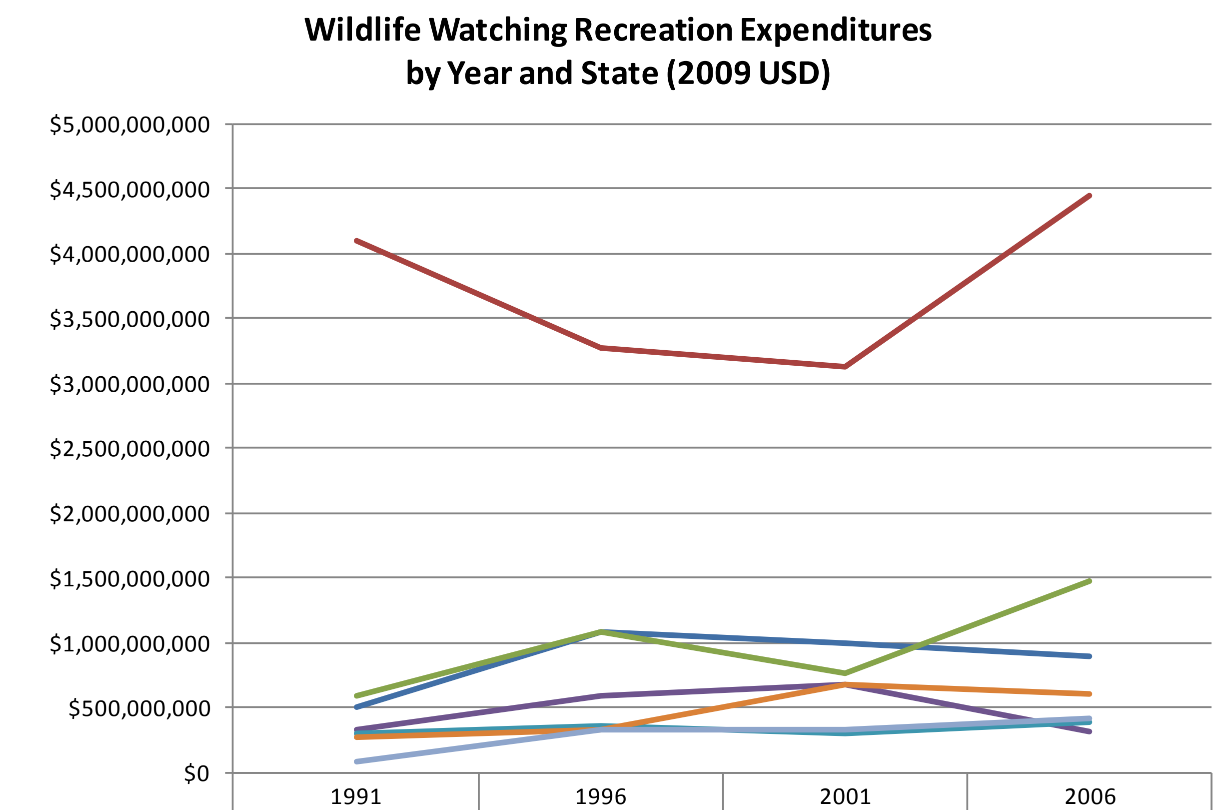
Figure D10 illustrates the number of wildlife watching participants by year and state, but does not include California numbers, so readers can experience a potentially more interesting visual perspective.



	1991	1996	2001	2006
Arizona	1,083,000	999,000	1,107,000	1,277,000
Colorado	1,161,000	1,244,000	1,213,000	1,819,000
New Mexico	466,000	370,000	471,000	787,000
Nevada	337,000	258,000	334,000	686,000
Utah	504,000	415,000	572,000	877,000
Wyoming	190,000	143,000	172,000	643,000

Figure D10. Number of Wildlife Watching Recreation Participants by Year and State, Not Including California

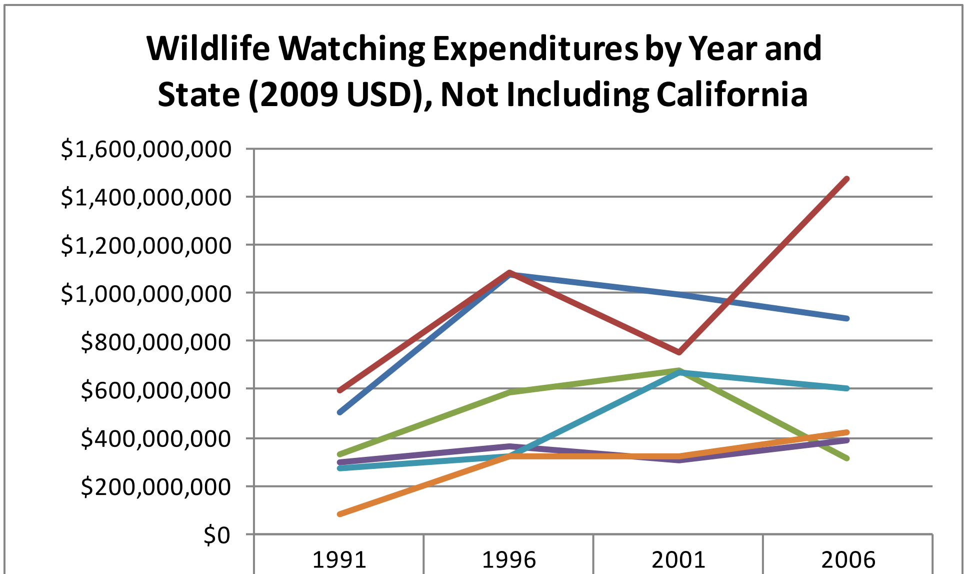
Wildlife watching associated recreation expenditures illustrate that, between 1991 and 2006, all states except New Mexico experienced an increase in expenditures. The largest increase in expenditures was for Colorado, where expenses increased from almost $600 million in 1991 to nearly $1.5 billion in 2006. Arizona, California, Utah and Wyoming each had increases of approximately $300 million, while Nevada experienced an increase of $89 million and New Mexico experienced a decrease of approximately $13 million (Figure D11).



	1991	1996	2001	2006
Arizona	$504,610,382	$1,076,766,247	$994,209,578	$892,101,160
California	$4,103,594,231	$3,277,276,786	$3,126,446,166	$4,447,786,841
Colorado	$594,712,684	$1,083,098,445	$756,394,339	$1,476,788,083
New Mexico	$329,792,824	$586,367,537	$676,306,923	$316,243,656
Nevada	$296,823,150	$359,336,845	$303,023,152	$385,473,235
Utah	$268,019,775	$323,550,561	$673,181,537	$600,663,307
Wyoming	$80,525,330	$320,802,188	$320,934,764	$420,207,744

Figure D11. Wildlife Watching Recreation Expenditures by Year and State (2009 USD)

Figure D12 illustrates wildlife watching expenditures by year and state, but does not include California numbers, so readers can experience a potentially more interesting visual perspective.



	1991	1996	2001	2006
Arizona	$504,610,382	$1,076,766,24	$994,209,578	$892,101,160
Colorado	$594,712,684	$1,083,098,44	$756,394,339	$1,476,788,08
New Mexico	$329,792,824	$586,367,537	$676,306,923	$316,243,656
Nevada	$296,823,150	$359,336,845	$303,023,152	$385,473,235
Utah	$268,019,775	$323,550,561	$673,181,537	$600,663,307
Wyoming	$80,525,330	$320,802,188	$320,934,764	$420,207,744

Figure D12. Wildlife Watching Recreation Expenditures by Year and State (2009 USD), Not Including California

National Survey of Fishing, Hunting, and Wildlife-Associated Recreation: Fishing, Hunting, and Wildlife Watching Summaries

The number of participants by activity (fishing, hunting and wildlife watching) between 1991 and 2006 for the states in the CRB reveals interesting patterns (Figure D13). We see that the number of people participating in hunting is lowest of the three activities and has decreased over the analyzed time period. The number of freshwater anglers is higher than the number of hunters, but lower than the number of wildlife watching participants. The number of freshwater fishing participants was also found to decrease between 1991 and 2006. The number of wildlife watching participants in 2006 almost tripled that of freshwater fishing and hunting participants combined. In addition, the number of wildlife watching participants has increased by over 2 million participants over the time period, unlike the number of hunting and fishing participants.

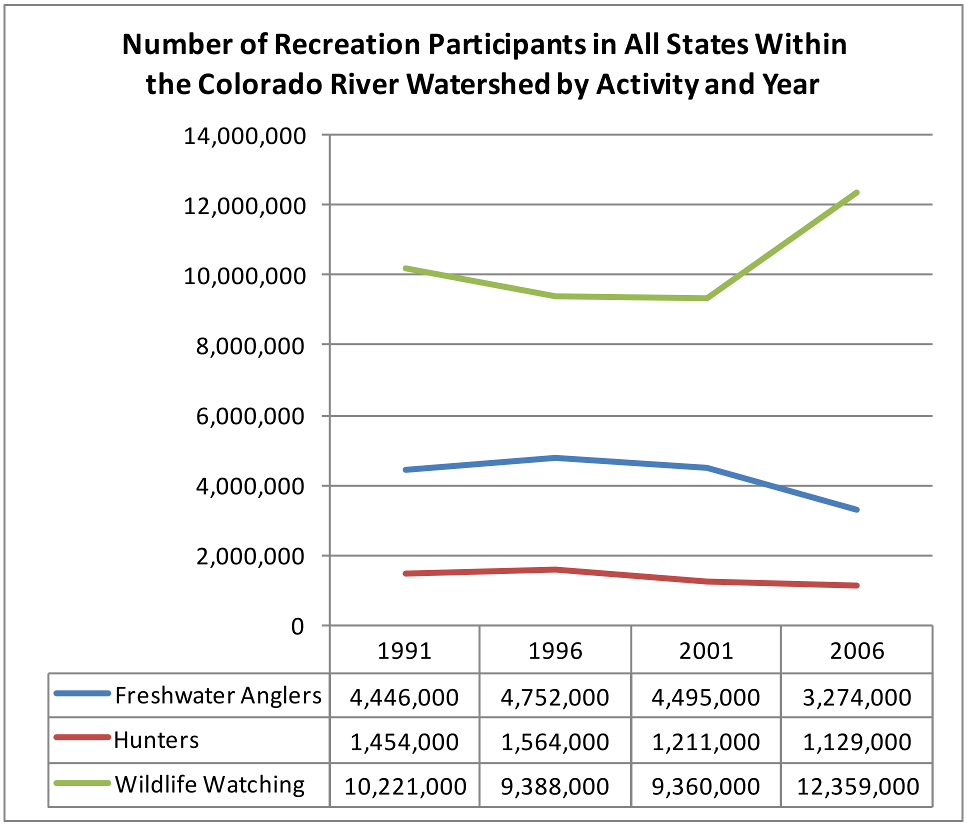
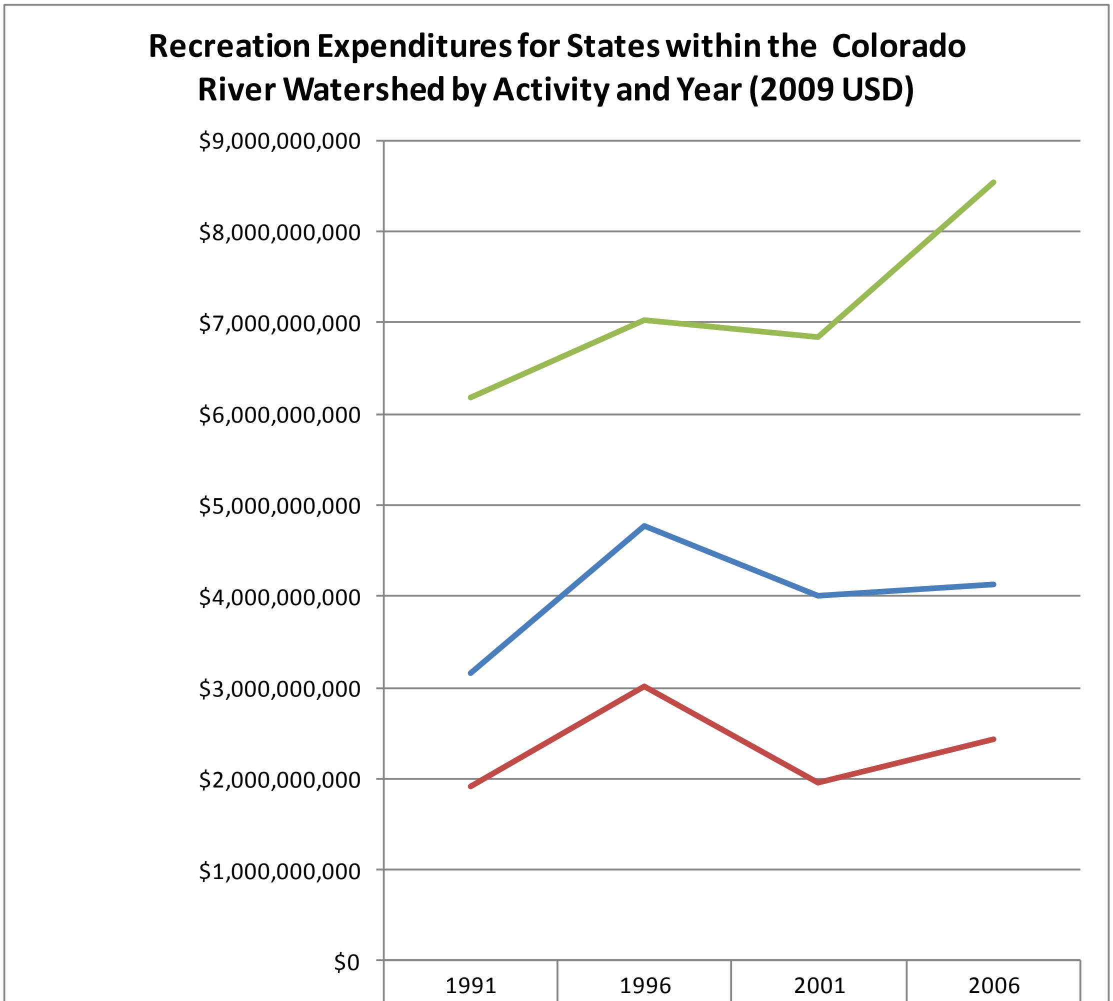


Figure D13. Number of Freshwater Fishing, Hunting, and Wildlife Watching Recreation Participants by Year in Colorado River Watershed States Combined

Expenditure data for the three activities in the National FHWAR Study were summarized by year for the seven states within the CRWB (Figure D14). Hunting was found to have the lowest amount of expenditures, but expenditures increased over the 1991 to 2006 period. People paid more for freshwater fishing activities than hunting; these values increased over the time period by approximately $200 million. Wildlife watching expenditures were higher than fishing and hunting expenditures combined. In 1991, over $6 billion was spent on wildlife watching recreation activities. In 2006, this number increased by almost $2.5 billion to $8.5 billion.



	1991	1996	2001	2006
Freshwater Fishing	$3,153,173,950	$4,775,140,378	$4,014,933,535	$4,134,936,738
Hunting	$1,906,164,122	$3,003,871,052	$1,953,007,804	$2,431,068,697
Non-Consumptive Wildlife Recreation	$6,178,078,376	$7,027,198,610	$6,850,496,459	$8,539,264,026

Figure D14. Freshwater Fishing, Hunting, and Wildlife Watching Recreation Expenditures by Year in Colorado River Watershed States Combined (2009 USD)

Appendix E. Recreation Flow-On Impacts for 2006 Calculated by Southwick Associates for the State of Utah

The economic flow-on impacts of fishing, hunting, and wildlife watching related expenditures were calculated for the state of Utah using data from the 2006 National FHWAS Survey (Southwick Associates, 2007b; U.S. Department of the Interior et al., 2006). According to Southwick Associates (2007), by applying the results of the National FHWAS Survey, estimates of the total flow-on impacts can be calculated, including the number of jobs associated with people continuing to enjoy these activities. For fishing, 7,001 jobs are needed, for hunting, 6,487 jobs are needed and for wildlife watching associated recreation, 10,569 jobs are needed. As can be seen, if only expenditures are considered ($1.2 billion), the full economic impact is not considered (Table E1).

	Total Persons Participating in the Activity	Total Recreation Days	Expenditures (Retail Sales)	Salaries, Wages and Business Earnings	Number of Jobs	Federal Tax Revenues	State and Local Tax Revenues
Fishing: Utah Residents	288,334	3,387,324	$327,943,146	$165,299,834	5,529	$34,846,534	$32,815,661
Fishing: Utah Visitors	86,977	434,220	$78,770,338	$41,491,758	1,472	$8,799,436	$8,343,726
Total Fishing	**375,311**	**3,821,544**	**$406,713,484**	**$206,791,592**	**7,001**	**$43,645,970**	**$41,159,388**
Hunting: Utah Residents	143,659	1,623,889	$279,518,885	$153,221,264	5,955	$32,078,178	$29,683,292
Hunting: Utah Visitors	22,714	91,067	$24,484,777	$15,496,785	532	$3,199,458	$2,503,806
Total Hunting	**166,373**	**1,714,956**	**$304,003,662**	**$168,718,049**	**6,487**	**$35,277,636**	**$32,187,098**
Wildlife Viewing: Utah Residents	194,237	2,409,031	$120,839,341	$63,783,257	2,361	$13,517,691	$12,686,099
Wildlife Viewing: Utah Visitors	324,200	1,517,507	$453,387,050	$235,232,398	8,208	$49,626,806	$45,029,566
Total Wildlife Viewing	**518,437**	**3,926,538**	**$574,226,392**	**$299,015,655**	**10,569**	**$63,144,497**	**$57,715,664**
Overall Totals	**1,060,121**	**9,463,038**	**$1,284,943,537**	**$674,525,296**	**24,057**	**$142,068,103**	**$131,062,150**

Table E1. Total Economic Flow-On Impacts of Hunting, Fishing, and Wildlife Watching Associated Recreation in Utah (2009 USD) (Southwick Associates, 2007b; U.S. Department of the Interior et al., 2006).

References

References

Adler, R.W. 2007. Restoring Colorado River Ecosystems: A Troubled Sense of Immensity.

Aiken, R. 2003. Net Economic Values of Wildlife-Related Recreation in 2001. U.S. Fish & Wildlife Service, Washington D.C.

Aiken, R. 2009. Net Economic Values of Wildlife-Related Recreation in 2006. U.S. Fish & Wildlife Service, Washington D.C.

Anderson, D.A. 2006. Environmental Economics and Natural Resource Management. Second ed. Pensive Press.

Anderson, D.L. 2002. Utah's Perspective: The Colorado River.

Baker, J.C. 1996. A nested Poisson approach to ecosystem valuation: An application to backcountry hiking in California, University of Nevada, Reno, Nevada (USA).

Bark-Hodgins, R.H., D.E. Osgood, B.G. Colby, G. Katz, and J. Stromberg. 2005. Do homebuyers care about the 'quality' of natural habitats? American Agricultural Economics Association, Providence, Rhode Island.

Bark, R. 2009. The Arizona Water Settlement Act and urban water supplies. Irrigation and Drainage Systems 23:79-96.

Bark, R.H., D.E. Osgood, B.G. Colby, G. Katz, and J. Stromberg. 2009. Habitat preservation and restoration: Do homebuyers have preferences for quality habitat? Ecological Economics 68:1465-1475.

Bateman, I., G. Mace, C. Fezzi, G. Atkinson, and K. Turner. 2010. Economic Analysis for Ecosystem Service Assessments. Environmental and Resource Economics:1-42.

Bateman, I., R.T. Carson, B. Day, M. Hanemann, N. Hanley, T. Hett, M. Jones-Lee, G. Loomes, S. Mourato, E. Ozdemiroglu, D.W. Pearce, R. Sugden, and J. Swanson. 2002. Economic Valuation with Stated Preference Techniques: A Manual. Edward Elgar.

Benke, A.C., and C.E. Cushing. 2005. Rivers of North America Academic Press.

Bergstrom, J.C., J.M. Bowker, H.K. Cordell, G. Bhat, D.B.K. English, R.J. Teasley, and P. Villegas. 1996. Ecoregional estimates of the net economic values of outdoor recreational activities in the United States: Individual model results. . Final Report submitted to Resource Program and Assessment Staff, USDA Forest Service, Washington, DC.

Berrens, R.P., P. Ganderton, and C. Silva. 1995. Valuing the Endangered Silvery Minnow and the Protection of Minimum Instream Flows in New Mexico.

Berrens, R.P., P. Ganderton, and C.L. Silva. 1996. Valuing the Protection of Minimum Instream Flows in New Mexico. Journal of Agricultural and Resource Economics 21:294-309.

Berrens, R.P., A.K. Bohara, C.L. Silva, D. Brookshire, and M. McKee. 2000. Contingent values for New Mexico instream flows: with tests of scope, group-size reminder and temporal reliability. Journal of Environmental Management 58:73-90.

Berrens, R.P., A.K. Bohara, H. Jenkins-Smith, C.L. Silva, P. Ganderton, and D. Brookshire. 1998. A joint investigation of public support and public values: case of instream flows in New Mexico. Ecological Economics 27:189-203.

Bishop, R.C., C.A. Brown, M.P. Welsh, and K.J. Boyle. 1989a. Grand Canyon Recreation and Glen Canyon Dam Operations: An Economic Evaluation. University of Maine, Orono, Maine.

Bishop, R.C., C.A. Brown, M.P. Welsh, and K.J. Boyle. 1989b. Grand Canyon Recreation and Glen Canyon Dam Operations: An Economic Evaluation, p. 407-435, *In* K. J. Boyle and T. Heekin, eds. Natural Resources Planning: Interim Report 2. University of Maine, Orono, Maine (USA).

Bowes, M.D., and J.B. Loomis. 1980. A note on the use of travel cost models with unequal zonal populations. Land Economics 56:465-470.

Boyle, K.J., W. M., and R.C. Bishop. 1988. Analyzing the effects of Glen Canyon Dam releases on Colorado River recreation using scenarios of unexperienced flow conditions. University of California at Davis, Davis, California (USA).

Brown, G., and M. Hay. 1987. Net economic recreation values for deer and waterfowl hunting and trout fishing. U.S. Fish and Wildlife Service, Division of Policy and Directive Management, Washington, DC (USA).

Brown, T., T. Daniel, M. Richards, and D. King. 1989. Recreation participation and the validity of photo-based preference judgements. Journal of Leisure Research 21:40-60.

Brown, T.C. 1991. Water for Wilderness Areas: Instream Flow Needs, Protection and Economic Value. Rivers 2:311-325.

Brown, T.C. 2004. The Marginal Economic Value of Streamflow from National Forests. U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado

Brown, T.C. 2007. The Marginal Economic Value of Streamflow from National Forests, pp. 458-466, *In* M. Furniss, et al., (eds.) Advancing the Fundamental Sciences: Proceedings of the Forest Service National Earth Sciences Conference, San Diego, California.

Brown, T.C., T. Daniel, M.T. Richards, and W.P. Steward. 1988. Personal Communication, *In* D. A. King, (ed.), Tucson, Arizona.

Buland, D., L. Knight, T. Kuntz, G. Schaefer, J.S. Nelson, and C. Zelek. 2004. Assessing the Economic Impact of NRCS Programs on the U.S. Economy. United States Department of Agriculture.

Bureau of Reclamation. 2009. Bureau of Reclamation: Hydroelectric Powerplants Listed by Name [Online] www.usbr.gov/power/data/faclname.html (verified November 21, 2010).

Bureau of Reclamation: Upper Colorado Region. 2008a. Final Environmental Assessment Experimental Releases from Glen Canyon Dam, Arizona, 2008 through 2012.

Bureau of Reclamation: Upper Colorado Region. 2008b. Environmental Assessment Experimental Releases from Glen Canyon Dam, Arizona, 2008 through 2012.

D. P. Dodge (ed.) 1989. Proceedings of the international large river symposium. Canadian Special Publication of Fisheries and Aquatic Sciences.

Carver, E. 2009. Birding in the United States: A Demographic and Economic Analysis. U.S. Fish & Wildlife Service, Washington D.C.

Chakraborty, K., and J.E. Keith. 2000. Estimating the Recreation Demand and Economic Value of Mountain Biking in Moab, Utah: An Application of Count Data Models. Journal of Environmental Planning and Management 43:461-469.

Champ, P.A., K.J. Boyle, and T.C. Brown. 2003. A Primer on Non-Market Valuation Klumer Academic Publishers.

Chang, W.-H. 2001. Variations in Multipliers and Related Economic Ratios for Recreation and Tourism Impact Analysis, Michigan State University.

Chicetti, C.J., A.C. Fisher, and V.K. Smith. 1976. An econometric evaluation of a generalized consumer surplus measure: the mineral king controversy. Econometrica 44:1259-1275.

Christensen, N., and D.P. Lettenmaier. 2006. A multimodel ensemble approach to assessment of climate change impacts on the hydrology and water resources of the Colorado River basin. Hydrology and Earth System Sciences Discussions 3:3727-3770.

CNA (Comisión Nacional del Agua). 2006. Informes de Distribución de Aguas 2000-2006. Anexos II. Jefatura del Distrito de Riego 014, Río Colorado, Mexicali, Baja California, México.

Colby, B., and S. Wishart. 2002a. Riparian Areas Generate Property Value Premium for Landowners. University of Arizona.

Colby, B., and P. Orr. 2005. Economic Tradeoffs in Preserving Riparian Habitat. Natural Resources Journal 45:15-32.

Colby, B.G., and S. Wishart. 2002b. Quantifying the Influence of Desert Riparian Areas on Residential Property Values. The Appraisal Journal.

Colorado River Board. 1997. Colorado River Board 4.4 Plan: Californians Use of Its Colorado River Allocation [Online] http://www.sci.sdsu.edu/salton/CoRiverBoard4.4plan.html (verified 11 January 2011).

Connelly, N., and T. Brown. 1988. Estimates of nonconsumptive wildlife use on Forest Service and BLM lands. U.S. Forest Service and Cornell University, Ithaca, New York (USA).

Consejo Nacional de Poblecion. 2010a. Baja California: Indicadores demograficos.

Consejo Nacional de Poblecion. 2010b. Sonora: Indicadores demograficos.

Cooper, J., and J. Loomis. 1993. Testing Whether Waterfowl Hunting Benefits Increase with Greater Water Deliveries to Wetlands. Environmental and Resource Economics 3:545-561.

Cory, D.C., and W. Martin. 1985. Valuing wildlife for efficient multiple use: Elk vs. cattle. Western Journal of Agricultural Economics 10:282-293.

Costanza, R., R. D'Arge, R. DeGroot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, and M. VanDenBelt. 1997. The Value of the World's Ecosystem Services and Natural Capital. Nature 387:253-260.

Coupal, R.H., C. Bastian, J. May, and D.T. Taylor. 2001. The Economic Benefits of Snowmobiling to Wyoming Residents: A Travel Cost Approach with Market Segmentation. Journal of Leisure Research 33:492-510.

Crandall, K.B. 1991. Measuring the Economic Benefits of Riparian Areas, University of Arizona, Tucson, Arizona (USA).

Creel, M.D., and J.B. Loomis. 1990. Theoretical and Empirical Advantages of Truncated Count Data Estimators for Analysis of Deer Hunting in California. American Journal of Agricultural Economics 72:434-441.

Daily, G.C. 1997. Nature's Services: Societal Dependence on Natural Ecosystems Island Press, Washington, D.C.

Daily, G.C., S. Alexander, P.R. Ehrlich, L. Goulder, J. Lubchenco, P.A. Matson, H.A. Mooney, S. Postel, S.H. Schneider, D. Tilman, and G.M. Woodwell. 1997. Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems. Issues in Ecology 2:1-16.

Daubert, J.T., and R.A. Young. 1981. Recreational demands for maintaining instream flows: A contingent valuation approach. American Journal of Agricultural Economics 63:666-676.

de Groot, R.S., M.A. Wilson, and R.M.J. Boumans. 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics 41:393-408.

Douglas, A.J., and D.A. Harpman. 1995. Estimating Recreation Employment Effects with IMPLAN for the Glen Canyon Dam Region. Journal of Environmental Management 44:233-247.

Douglas, A.J., and R.L. Johnson. 2004. Empirical evidence for large non-market values for water resources - travel cost model benefits estimated for Lake Powell. International Journal of Water 2:229-246.

Duffield, J.W., C.J. Neher, and D.A. Patterson. 2007. Final Report: Economic Values of National Park System Resources Within the Colorado River Watershed - Phase II. Prepared for the National Park Service.

(ed.) 2008. Proceedings of the Colorado River Basin Science and Resource Management Symposium, Scottsdale, Arizona (USA). November 18–20, 2008.

Duffield, J.W., C.J. Neher, and D.A. Patterson. 2009. Economic Values for National Park System Resources within the Colorado River Watershed.

Exchange-Rates.org. 2010. U.S. Dollar Exchange Rates for 2008 [Online] http://www.exchange-rates.org/HistoricalRates/A/USD/12-31-2008 (verified December 16, 2010).

Fix, P., and J. Loomis. 1998. Comparing the economic value of mountain biking estimated using revealed and stated preference. Journal of Environmental Planning and Management 41:227-236.

Fix, P.J., M.J. Manfredo, and J.B. Loomis. 2005. Assessing validity of elk and deer license sales estimated by contingent valuation. Wildlife Society Bulletin 33:633-642.

Flessa, K.W. 2004. Ecosystem services and the value of water in the Colorado River delta and estuary, USA and Mexico: Guidelines for mitigation and restoration, pp. 79-86 International Seminar on Restoration of Damaged Lagoon Environments, Matsue, Japan.

Franklin, D.R., J.J. Jacobs, and P.J. Farris. 1983. Water Resource Development Impacts in the Green River Drainage of Wyoming. University of Wyoming, Laramie, Wyoming (USA).

Freeman, A.M. 2003. The Measurement of Environmental and Resource Values Resources for the Future, Washington D.C.

Garrett, J., G. Pon, and D. Arosteguy. 1970. Economics of big game resource use in Nevada. University of Nevada, Agricultural Experiment Station, Reno, Nevada (USA).

Gilbert, A.H., D.W. McCollum, and G.L. Peterson. 1988. A comparison of valuation models using cross-country skiing data from Colorado and Vermont. Draft paper. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado (USA).

Greiner, J., and J. Werner. 2010. Commercial River Use in the State of Colorado: 1988-2009. Colorado River Outfitters Association.

Gutrich, J.J., and F.J. Hitzhusen. 2004. Assessing the substitutability of mitigation wetlands for natural sites: estimating restoration lag costs of wetland mitigation. Ecological Economics 48:409-424.

Hammer, M.Z. 2001. Applying the TCM with Secondary Data to White Water Boating in Grand Canyon National Park, Colorado State University, Fort Collins, Colorado (USA).

Harpman, D., E. Sparling, and T. Waddle. 1993. A methodology for quantifying and valuing the impacts of flow changes on a fishery. Water Resources Research 29:575-582.

Hartwick, J.M., and N.D. Olewiler. 1998. The Economics of Natural Resource Use. Second ed. Addison-Wesley.

Hay, J.M. 1985. Net Economic Values of Non-consumptive Wildlife-related Recreation. Division of Policy & Directives Management, U.S. Fish & Wildlife Service.

Hjerpe, E.E., and Y.-S. Kim. 2007. Regional economic impacts of Grand Canyon river runners. Journal of Environmental Management 85:137-149.

Hughes, W., P. Kaval, and F. Scrimgeour. 2004. Te Kouma Farm Park: An Economic Analysis. Regional Economic Bulletin. Waikato Management School. 1:1-10.

Instituto Nacional De Estadistica y Geografia Mexico. 2009. National Survey of Income and Expenses 2008 [Online] http://www.inegi.org.mx/inegi/contenidos/espanol/prensa/comunicados/enigh2008.asp (verified 16 December 2010).

Jimenez, G.C. Federal Fishery Delegation in Baja California: Preliminary Study of the Fishery in Laguna Salada, Baja California [Online] http://www.sci.sdsu.edu/salton/PrelStdFisheryLagunaSalada.html.

Johnson, D.M., and R.G. Walsh. 1987. Economic benefits and costs of the fish stocking program at Blue Mesa Reservoir, Colorado. Colorado Water Resources Research Institute.

Kammerer, J.C. 1990. Water Fact Sheet: Largest Rivers in the United States. U.S. Geological Society.

Kaval, P. 2006. The Hauraki Rail Trail Project: A Regional Economic Contribution Study. Hauraki Rail Trail Inc.

Kaval, P. 2008. The Central North Island Rail Trail Project: A Regional Economic Contribution Study. Department of Conservation.

Kaval, P. 2010. A Summary of Ecosystem Service Economic Valuation Methods and Recommendations for Future Studies. University of Waikato, Hamilton, New Zealand.

Kaval, P., and J. Loomis. 2003. Updated Outdoor Recreation Use Values with Emphasis on National Park Recreation. Report for the National Park Service, Fort Collins, Colorado (USA).

Keith, J., P. Halverson, and L. Furnworth. 1982. Valuation of a free flowing river: the Salt River, Arizona. Utah State University of Arizona, Tucson, Arizona (USA).

(ed.) 1980. Proceedings of the North American Symposium on Dispersed Winter Recreation, St. Paul, Minnesota. University of Minnesota.

King, A.A., and M.J. Lenox. 2000. Industry Self-Regulation without Sanctions: The Chemical Industry's Responsible Care Program. The Academy of Management Journal 43:698-716.

King, A.M., S.C. Burgess, W. Ijomah, and C.A. McMahon. 2006. Reducing waste: repair, recondition, remanufacture or recycle? Sustainable Development 14:257-267.

King, D., and J. Hof. 1985. Experimental commodity definition in recreation travel cost models. Forest Science 31:519-529.

Knetsch, J., R. Brown, and W. Hansen. 1976. Estimating Expected Use and Value of Recreation Sites, *In* C. Gearing, et al., eds. Planning for Tourism Development: Quantitative Approaches. Praeger Publishers, New York (USA).

Koenig, J. 2010. Colorado River Basin Area by State, pp. 1, *In* P. Kaval, (ed.), Colorado River Basin Area by State ed.

Loomis, J. 1979. Estimation of recreational benefits from Grand Gulch primitive area. Bureau of Land Management, Moab, Utah (USA).

Loomis, J. 1982. Use of travel cost models for evaluation lottery rationed recreation: application to big game hunting. Journal of Leisure Research 14:117-124.

Loomis, J. 2007. How the Economic Contribution of Angling and Rafting to the Colorado Economy Changes with Variation in Instream Flow. Colorado State University, Fort Collins, Colorado (USA).

Loomis, J. 2008. The Economic Contribution of Instream Flows in Colorado: How Angling and Rafting Use Increase with Instream Flows. Colorado State University, Fort Collins, Colorado (USA).

Loomis, J., and L. Caughlan. 2003. Economic Analysis of Alternative Bison and Elk Management Practices on the National Elk Refuge and Grand Teton National Park: A Comparison of Visitor and Household Responses, Draft Report. . U.S.G.S. Biological Resources Division, Fort Collins, Colorado (USA).

Loomis, J., and J. Ballweber. 2010. Cost Savings Associated with the Upper Colorado River Basin Endangered Fish Recovery Program, Instream Flows, and Prospects for the Future.

(ed.) 1989a. Transactions of the 50th North American Wildlife and Natural Resources Conference, Washington D.C. Wildlife Management Institute.

Loomis, J., M. Creel, and J. Cooper. 1989b. Economic benefits of deer in California: Hunting and viewing values. College of Agricultural and Environmental Sciences, University of California, Davis, California (USA).

Lutz, J., J. Englin, and J.S. Shonkwiler. 2000. On the Aggregate Value of Recreational Activities. Environmental and Resource Economics 15:217-226.

Mac, M.J., P.A. Opler, C.E.P. Haecker, and P.D. Doran. 1998. Southwest. United States Geological Survey, Reston, Virginia.

Maddux, H.R., L.A. Fitzpatrick, and W.R. Noonan. 1993. Colorado River endangered fishes critical habitat draft biological support document. U.S. Fish and Wildlife Service, Salt Lake City, Utah.

Markstrom, D., and D. Rosenthal. 1987. Demand and value of firewood permits as determined by the travel cost method. Western Journal of Applied Forestry 2:48-50.

Martin, W., R. Gum, and A. Smith. 1974. The demand for and value of hunting, fishing, and general rural outdoor recreation in Arizona. Agricultural Experiment Station, University of Arizona, Tucson, Arizona (USA).

Martin, W.C., F.H. Bollman, and R. Gum. 1980. The economic value of the Lake Mead fishery with special attention to the largemouth bass fishery. Final Report to the Arizona Game and Fish Department and the Water and Power Resources Service, Sacramento, California (USA).

Martin, W.C., F.H. Bollman, and R. Gum. 1982. Economic Value of Lake Mead Fishery. Fisheries 7:20-24.

May, J.A. 1997. Measuring Consumer Surplus of Wyoming Snowmobilers Using the Travel Cost Method, University of Wyoming, Laramie, Wyoming (USA).

Medellín-Azuara, J. 2006. Economic-Engineering Analysis of Water Management for Restoring the Colorado River Delta, University of California at Davis, Davis, California (USA).

Medellín-Azuara, J., J.R. Lund, and R.E. Howitt. 2007. Water Supply Analysis for Restoring the Colorado River Delta, Mexico. Journal of Water Resources Planning and Management 133:462-471.

Merlo, M., and L. Croitoru. 2005. Valuing Mediterranean Forests: Towards Total Economic Value Cabi Publishing.

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington D.C.

Miller, J., and M. Hay. 1984. Estimating substrate values for fishing and hunting. Transactions of the North American Wildlife and Natural Resources Conference 49:345-355.

Morey, E. 1985. Characteristics, consumer surplus, and new activities. Journal of Public Economics 26:221-236.

National-Research-Council. 2005. Valuing Ecosystem Services: Toward Better Environmental Decision-Making The National Academies Press, Washington D.C.

Outdoor Foundation. 2010. Outdoor recreation participation report: A look at trends in American participation in outdoor recreation with a focus on youth, diversity and the future of the outdoors.

Peacock, B. 2009. Economic Values of National Park System Resources Within The Lower Colorado River Basin: A Compilation of Existing Data and Proposal for Future Work. National Park Service Environmental Quality Division.

Pearce, D.W., and R.K. Turner. 1990. Economics of Natural Resources and the Environment Pearson Education Limited, Essex.

Pickton, T., and L. Sikorowski. 2004. The Economic Impacts of Hunting, Fishing and Wildlife Watching in Colorado. Prepared for the Colorado Division of Wildlife.

Pontius, D., and SWCA Inc. 1997. Colorado River Basin Study. Report to the Western Water Policy Review Advisory Commission.

Richards, M., and T. Brown. 1992. Economic value of campground visits in Arizona. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado (USA).

Richards, M., D.B. Wood, and D. Coyler. 1985. Sport fishing at Lees Ferry, Arizona: User differences and economic values. Northern Arizona University, Flagstaff, Arizona (USA).

Richardson, R.B. 2002. Estimating the economic effects of climate change on nature based tourism: a comparison of revealed and stated preference methods, Colorado State University, Fort Collins, Colorado (USA).

Riera, P., G. Signorello, M. Thiene, P.A. Mahieu, S. Navrud, P. Kaval, B. Rulleau, R. Mavsar, L. Madureira, and J. Meyerhoff. 2010. Good practice issues on non-market valuation of forest goods and services.

Roberts, M.G., and D. Grossman. 2008. Healthy Rivers, Healthy Economy: Enhancing Instream Flows Will Benefit Colorado's Environment and Economy. Environmental Defense.

Rosenberger, R., and J.B. Loomis. 2001. Benefit Transfer of Outdoor Recreation Use Values: A Technical Report Supporting the Forest Service Strategic Plan (2000 Revision). U.S. Forest Service Rocky Mountain Research Station Fort Collins, Colorado (USA).

Rosenberger, R.S., and R.G. Walsh. 1997. Nonmarket Value of Western Valley Ranchland Using Contingent Valuation. Journal of Agricultural and Resource Economics 22:296-309.

Rosenberger, R.S., and J. Loomis. 1999. The Value of Ranch Open Space to Tourists: Combining Observed and Contingent Behavior Data. Growth and Change 30:366-383.

Rosenthal, D., and R. Walsh. 1986. Hiking values and the recreation opportunity spectrum. Forest Science 32:405-415.

SAGARPA (Secretaría de Agricultura, G., Desarrollo Rural, Pesca y Alimentación),. 2006. Sistema de Información Agroalimentaria y Pesquera (SIAP), Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. .

Sanderson, J. 2011. Colorado River Basin Fish Species Discussion.

Searns, R. 2007. The Case for Trails: Well Done, Medium Rare and Works in Progress. American Trails Magazine.

Siderelis, C., and R. Moore. 1995. Outdoor Recreation Net Benefits of Rail-Trails. Journal of Leisure Research 27:344-359.

Silberman, J., and K.L. Andereck. 2006. The Economic Value of Off-Highway Vehicle Recreation. Journal of Leisure Research 38:208-223.

Smith, V.K., and R. Kopp. 1980. A regional recreation demand and benefits model. Land Economics 56:64-72.

Southwick Associates. 2003. The 2001 Economic Benefits of Watchable Wildlife Recreation in Colorado.

Southwick Associates. 2007a. Sportfishing in America: An Economic Engine and Conservation Powerhouse. Produced for the American Sportfishing Association

with funding from the Multistate Conservation Grant Program.

Southwick Associates. 2007b. The 2006 Economic Benefits of Hunting, Fishing and Wildlife Watching in Utah.

Southwick Associates. 2007c. Hunting in America: An Economic Engine and Conservation Powerhouse. Produced for the Association of Fish and Wildlife Agencies with funding from Multistate Conservation Grant Program.

.

Sublette, W., and W. Martin. 1975. Outdoor recreation in the Salt-Verde Basin of central Arizona: Demand and value. Agricultural Experiment Station, University of Arizona, Tucson, Arizona (USA).

Taylor, J.G., K.J. Czarnowski, N.R. Sexton, and S. Flick. 1995. The Importance of Water to Rocky Mountain National Park Visitors: An Adaptation of Visitor-Employed Photography to Natural Resources Management. Journal of Applied Recreation Research 20:61-85.

Tietenberg, T. 2006. Environmental and Natural Resource Economics. Seventh ed. Pearson.

U.S. Bureau of Reclamation. 2005. Quality of Water, Colorado River Basin Progress Report No. 22.

U.S. Census Bureau. 2010. Population and Income Estimates.

U.S. Department of Labor. 2010. Consumer Price Index, All Urban Consumers, All Items, 1913 to October 15, 2010.

U.S. Department of the Interior. 2000. Colorado River Interim Surplus Criteria: Final Environmental Impact Statement.

U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce. 2001. 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

U.S. Department of the Interior, Fish and Wildlife Service, U.S. Department of Commerce, and Bureau of the Census. 1991. 1991 Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

U.S. Department of the Interior, Fish and Wildlife Service, U.S. Department of Commerce, and Bureau of the Census. 1996. 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation:176.

U.S. Department of the Interior, Fish and Wildlife Service, U.S. Department of Commerce, and U.S. Census Bureau. 2006. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

U.S. Department of the Interior, N.P.S. 1995. Economic Impacts of Protecting Rivers, Trails, and Greenway Corridors: A Resource Book.

U.S. National Agricultural Statistics Service. 2010. Statistics by Subject.

Upper Colorado River Endangered Fish Recovery Program. 2006. Upper Colorado River Endangered Fish Recovery Program [Online]. Available by U.S. Fish and Wildlife Service http://www.fws.gov/coloradoriverrecovery/ (verified November 11, 2010).

Upper Colorado River Endangered Fish Recovery Program. 2011. Upper Colorado River Endangered Fish Recovery Program [Online]. Available by U.S. Fish and Wildlife Service http://www.fws.gov/coloradoriverrecovery/ (verified January 11, 2011).

Waddington, D.G., K.J. Boyle, and J. Cooper. 1991. 1991 Net Economics Values for Bass and Trout Fishing, Deer Hunting, and Wildlife Watching. Division of Federal Aid, US Fish and Wildlife Service.

Walsh, R., R. Aukerman, and R. Milton. 1980a. Measuring benefits and the economic value of water in recreation on high country reservoirs. Colorado State University, Fort Collins, Colorado (USA).

Walsh, R.G., and J.P. Olienyk. 1981. Recreation demand effects of mountain pine beetle damage to the quality of forest recreation resources in the Colorado Front Range. Colorado State University, Fort Collins, Colorado (USA).

Walsh, R.G., and L. Gilliam. 1982. Benefits of wilderness expansion with excess demand for Indian Peaks. Western Journal of Agricultural Economics 7:1-12.

Walsh, R.G., and G.J. Davitt. 1983. A demand function for length of stay on ski trips to Aspen. Journal of Travel Research 22:23-29.

Walsh, R.G., R. Gillman, and J. Loomis. 1981. Wilderness resource economics: recreation use and preservation values. Department of Economics, Colorado State University, Fort Collins, Colorado (USA).

Walsh, R.G., N. Miller, and L. Gilliam. 1983. Congestion and willingness to pay for expansion of skiing capacity. Land Economics 59:195-210.

Walsh, R.G., J.B. Loomis, and R.A. Gillman. 1984. Valuing Option, Existence, and Bequest Demands for Wilderness. Land Economics 60:14-29.

Walsh, R.G., L.D. Sanders, and J.B. Loomis. 1985. Wild and Scenic River Economics: Recreation Use and Preservation Values. Department of Agricultural and Natural Resources Economics, Colorado State University, Fort Collins, Colorado (USA).

Walsh, R.G., L.D. Sanders, and J.R. McKean. 1987. The value of travel time as a negative function of distance. Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, Colorado (USA).

Walsh, R.G., F.A. Ward, and J.P. Olienyk. 1989. Recreation Demand for Trees in National Forest. Journal of Environmental Management 28:255-268.

Walsh, R.G., R. Ericson, D. Arosteguy, and M. Hansen. 1980b. An empirical application of a model for estimating the recreation value of instream flow. Colorado State University, Fort Collins, Colorado (USA).

Walsh, R.G., R.D. Bjonback, R.A. Aiken, and D.H. Rosenthal. 1990. Estimating the Public Benefits of Protecting Forest Quality. Journal of Environmental Management 30:175-189.

Ward, F.A. 1982. The demand for and value of recreational use of water in southeastern New Mexico 1978-79. New Mexico State University, Los Cruces, New Mexico.

Weber, M.A., and R.P. Berrens. 2006. Value of Instream Recreation in the Sonoran Desert. Journal of Water Resources Planning and Management January/February:53-60.

Weisbrod, G., and B. Weisbrod. 1997. Measuring Economic Impacts of Projects and Programs. Economic Development Research Group.

Welsh, M.P., R.C. Bishop, M.L. Phillips, and R.M. Baumgartner. 1997. Glen Canyon Dam, Colorado River Storage Project, Arizona: Nonuse Values Study Report. U.S. Bureau of Reclamation, Salt Lake City, Utah (USA).

www.city-data.com. 2010. Land Area of States [Online]. Available by www.city-data.com www.city-data.com (verified 15 November 2010).

Youngs, Y. 2008. Nature, Culture and History at the Grand Canyon: Colorado River [Online] http://grandcanyonhistory.clas.asu.edu/history_coloradoriver.html (verified November 10, 2010).