

Value of Natural Resources: Deschutes River Corridor and Its Water

M UNIVERSITY OF MICHIGAN
SCHOOL OF NATURAL RESOURCES AND ENVIRONMENT

TROUT UNLIMITED

Conserving, protecting and restoring North America's coldwater fisheries and their watersheds.

A University of Michigan Study for Trout Unlimited



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In partnership with:



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The authors submit the findings to contribute to the ongoing discussion about Central Oregon's future and effective decision making regarding the use of its limited natural resources.

Cover Photos (clockwise from top left):

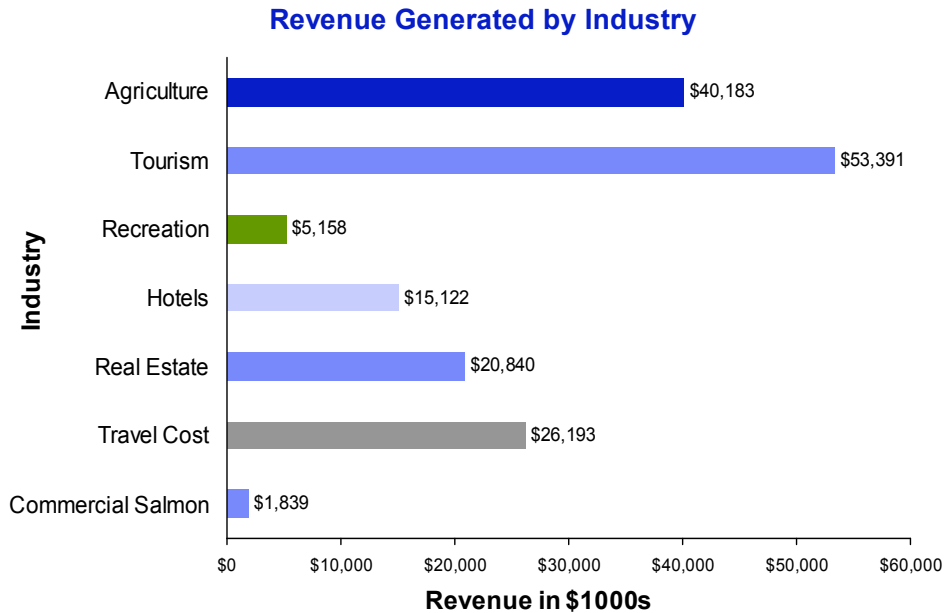
1. Central Oregon Agriculture. Courtesy Deschutes River Conservancy.
2. North Dam Spillover, Middle Deschutes. Courtesy Deschutes River Conservancy.
3. Waterfalls, Middle Deschutes. Courtesy Deschutes River Conservancy.
4. Kayaking the Deschutes. Courtesy Visit Bend.
5. Hot Air Balloons over Bend. Courtesy Visit Bend.

Abstract

The Deschutes River in Central Oregon provides numerous ecosystem services benefits to the region. This study analyzed the market and expressed values to six industries in the region: agriculture, tourism, recreation, hotels, real estate, and commercial salmon fishing. Using revealed preference methodologies to assess ecosystem services benefits to these industries, the study found the river provides a total economic value to the industries of \$185.2 million annually, of which \$134.7 is direct revenue to the region, \$28.0 is revenue outside the region, and \$22.5 million is the expressed value of products and services that residents receive for free in their market value equivalent. The benefits of the river to these industries create 3,433 in full time equivalent jobs for Central Oregon with an estimated value in wages of \$73.0 million. The study built a model to analyze the economic impact to the four industries of different water management regimes including one to maximize agricultural revenues, another to maximize recreational revenues, a third that increases productivity in all industries without adverse impact to any one industry, and a fourth which examines the current distribution under drought conditions. The four scenarios result in gains in total economic value from 19.1 to 66.2%, changes in market value from -10.5 to 47.6% and changes in expressed value that varies from -34.2 to 204.5%. The results demonstrate the potential economic tradeoffs and gains within and among industries that will be made under different water management decisions.

Executive Summary

Figure 1: Revenue Generated by the Deschutes River in 2010 from Key Industries



The Deschutes River provides tremendous value to the economy, quality of life, and residents of Central Oregon. This study was performed by a team of graduate students from the University of Michigan to estimate the economic contribution and several non-market benefits of the Deschutes River to six industries. The river generates \$185.2 million in

total economic value to six industries annually. Agriculture, tourism, recreation, hotels, and real estate provide real and direct contributions to the Central Oregon economy, \$134.7 million of which is directly attributable to the river. The river is part of the charm that draws more than 2 million visitors to the region each year, an average of 16% of which participate in river-related activities, and provides recreational opportunities for 319,062 sport anglers, rafters, canoers, and kayakers. The river also provides an additional \$28.0 million in market benefits outside of Central Oregon to Oregon's travel and

commercial salmon industries and \$22.5 million in expressed value for the services and products people receive from the river for free. Finally, the benefits of the river to these industries generate 3,433 in full time equivalent jobs for Central Oregon with an estimated value in wages of \$73.0 million.

The report takes an ecosystem services approach to analyzing economic value generated by the Deschutes River. Ecosystem services combine concepts from ecology and economics based on the significant benefits provided by ecosystems such as water supply, safe drinking water, spawning grounds for fish, recreation and cultural value of ecosystems. Using economic methods, the study examined ways that the Deschutes River ecosystem impacts the economy. Agriculture, river-based recreation, and commercial salmon rely directly on the supply of water, while industries such as real estate, hotels, and tourism benefit from the views and enjoyment of the river. These services bring benefits to the market by increasing total agricultural output, premiums for river views, and revenue for tourism and hotels.

The report assessed three types of benefits: direct revenue to the Central Oregon economy from agriculture, tourism, recreation, hotels, and real estate; indirect revenue to economies outside of Central Oregon from commercial salmon fishing and travel expenditures to get to Central Oregon; and additional benefits including job creation to Central Oregon and expressed value of the goods and services people receive from the river for free.

The study finds that \$40.2 million in agricultural revenue, \$53.4 million tourism revenue, \$5.2 million in recreational revenue, \$15.1 million in hotel revenue, and \$20.8 million in economic value to real estate sales are directly attributable to the river. Outside of Central Oregon, tourists spend \$26.2 million to travel to the region and commercial salmon fishing benefits with \$1.8 million in revenues from the Lower Deschutes salmon hatcheries. Total economic value created by the river to the six industries annually, the sum of market and expressed values, is \$185.2 million.

The second component of the report includes a Scenario Analysis of four possible future outcomes. Scenario Analysis is used by agencies and corporations to assess the effects of decisions within the control of decision-makers and the impacts of macro-changes that are outside direct control. The four scenarios include one that maximizes agricultural output (Farm Economy), another that maximizes recreation (River Recreation and Tourism Economy), a third that increases the revenue in all industries without adverse impact to any single industry (Farm and Fish Economy), and a fourth that assess the impact of reduction in total available water (Drought). Each scenario examines the economic impact on agriculture, tourism, recreation, and hotels of the decision or impact assessed. Scenarios shed light on the tradeoffs with specific courses of action for decision makers.

The Farm Economy scenario brings a net market increase in total economic value of \$47.3 million, an incremental revenue increase in agriculture of 171.0%, a loss in recreation of 66.9%, a loss in hotels of 4.0%, and a loss in tourism of 3.7% and a total economic value of \$224.8 million. The River Recreation and Tourism Economy scenario projects a total incremental benefit of \$117.5 million, an incremental benefit to recreation of 374.1%, a gain to hotels of 31.4%, a 43.8% increase in tourism revenue, and a loss to agriculture of 52.5% and a total economic value of \$294.8 million. The Fish and Farm Economy scenario assumes the region wants to maintain all the industries included in the study and prefers to improve economic output without adversely impacting any single industry. It projects a total net increase of \$44.8 million to the regional economy with gains to agriculture of 63.2%, increases in recreation of 222.0%, increases in tourism of 12.4%, and gains to hotels of 13.3% with a total economic value of \$273.8 million. The Drought scenario assumes a 15% reduction in total available river water, consistent with potential impacts of aquifer draw-downs or climate change, and project a total

incremental loss to agriculture of 61.2%, a recreational gain of 223.0%, an increase in hotel revenues of 7.4%, a tourism loss of 3.0%, and a revenue loss of \$13.9 million across the industries with a total economic value of \$211.2 million. All scenarios project a total gain to the region above the current annual economic benefits from the river, but the greatest gains to total value derived from the Deschutes River by Central Oregon are achieved in the River Recreation and Tourism Economy and Farm and Fish Economy scenarios.

Table 1: Summary of Results from All Scenarios (all numbers in \$1000s)

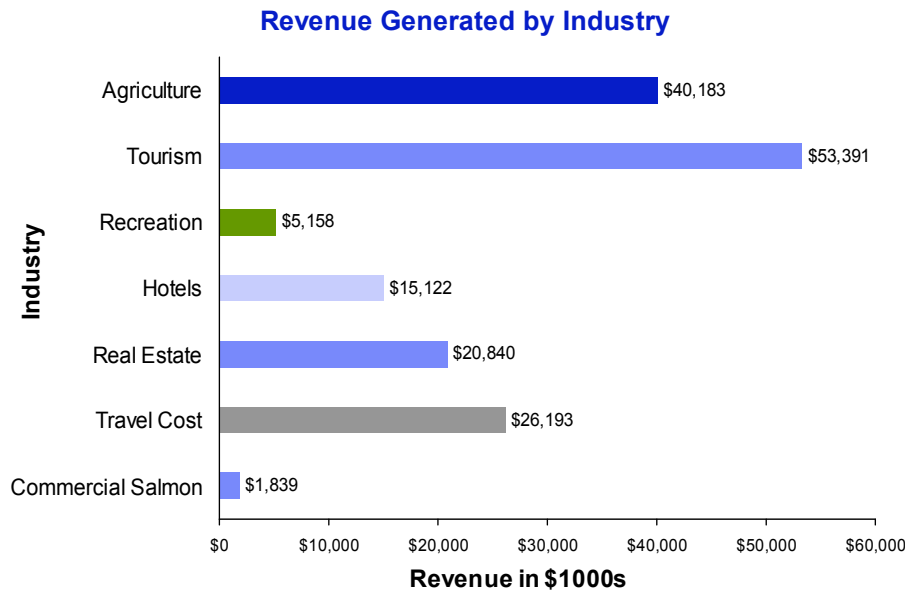
	Status Quo	Farming Economy	Recreation Economy	Fish and Farm Economy	Drought Conditions
<i>Direct Revenue for the Region and Percent Change by Scenario</i>					
Hotels	\$15,122	(4.0%)	31.4%	13.3%	7.4%
Real Estate	\$20,841	0.0%	0.0%	0.0%	0.0%
Agriculture	\$40,183	171.0%	(52.5%)	63.2%	(61.2%)
Recreation	\$5,158	(66.9%)	374.1%	222.0%	223.0%
Tourism	\$53,391	(3.7%)	43.8%	12.4%	(3.0%)
Net Change in Market Value	\$0	\$62,873	\$24,631	\$44,811	(\$13,889)
Net Change in Expressed Value	\$0	(\$15,541)	\$92,853	\$51,546	\$47,737
Market Value	\$132,041	\$194,915	\$156,673	\$176,853	\$118,151
Expressed Value	\$45,396	\$29,853	\$138,248	\$96,942	\$93,133
Total Value	\$177,437	\$224,768	\$294,922	\$273,795	\$211,285

The findings suggest that decisions about how to allocate water from the Deschutes River are likely to require tradeoffs among economic sectors as well as among different types and categories of economic value to people in the region. However there are opportunities today for economic gains in one or more industries without negative impacts to other industries that would result in net gains for the regional economy. This study is not designed to promote or examine any particular plan, but instead to provide insights into the economic benefits, synergies, and tradeoffs that are likely to result in this region from both external impacts and regional decisions.

Introduction

Findings

Figure 1: Revenue Generated by the Deschutes River in 2010 from Key Industries



Central Oregon is undergoing rapid transformation. Historically a rural economy built on agriculture, and forestry, the region has seen three decades of rapid growth associated with its increasing recognition as a tourism destination (Oregon History Project, 2004a). From 1990 – 2010, the population of Bend, the region’s largest city, grew almost fourfold from 20,469 to more than 76,639, nearly

doubling each decade (U.S. Census, 1990; U.S. Census, 2010). With only 11.94 inches of rain per year on average, these changes place increasing pressure to provide water on a finite resource: the Deschutes River.

Rivers provide numerous ecosystem services: benefits to society such as water supply, recreation, and aesthetics. The purpose of this report is to quantify some of the most important annual benefits of the Deschutes River to the regional economy and estimate the economic impacts of four potential scenarios for the region’s future. The report is intended to provide economic and policy decision-makers with information on the river’s current contributions to the economy and expected economic tradeoffs of decisions that affect use of the river’s water. Finally, the report offers educational value to students and residents on the unseen benefits of the river and its value to the regional economy.

The study concludes that the Deschutes River provides annual market value of \$134.7 million as revenue to six focal industries: agriculture, tourism, recreation, hotels, real estate, and commercial salmon. Agriculture in Central Oregon irrigated by the Deschutes River generates \$40.2 million in annual revenues. Tourism brings in an additional \$53.4 million in revenue for the region and \$26.2 million in travel expenses from visitors who travel to the region to see the river, camp, hike, bird watch, and participate in other river-related activities. Hotels located on the river generate an estimated \$15.1 million in revenue from the combination of premiums charged for river views and for location near the river. Paid recreational activities, consisting largely of guided tours or rentals for fishing, rafting, kayaking, and canoeing, generate \$5.2 million annually. Real estate realizes an annual benefit of \$20.8 million from higher value sales for homes with river views. The river indirectly supports Oregon’s commercial salmon industry with \$1.8 million due to wild and hatchery salmon leaving the Deschutes River and entering the Columbia and ocean fisheries. Additionally, recreational activities generate an additional \$19.9 million in expressed value, value that consumers enjoy for services they otherwise

would have purchased, for the 253,276 outdoor enthusiasts that do not use paid guides. The Tribes benefit from a market equivalent of \$2.7 million for salmon catch that contributes to subsistence and cultural values. Many jobs in agriculture, hotels, tourism and recreation would not be available without the river and these four industries provide an estimated 3,433 jobs with total wages of \$73.0 million to Central Oregon for residents of the region each year.

The report sponsor, Trout Unlimited (TU) is a national non-profit organization dedicated to conserve, protect and restore North America's coldwater fisheries and their watersheds. TU works to promote the restoration of watersheds and the diverse services provided by a healthy river.

The report was completed by three University of Michigan graduate students during the 2010-2011 academic year, in partial fulfillment of the requirements for the degree of Master of Science in Natural Resources and Environment. Nathan Springer, Michael Kasameyer, and Brian Hartmann are dual degree MBA and MS students at the University of Michigan studying business and sustainability with the Erb Institute for Global Sustainable Enterprise. The program provides graduates with the tools to address the challenges of sustainability facing society.

Context

The Deschutes River Basin is one of Oregon's largest river systems and runs south to north draining 26,860km² of Central Oregon before emptying into the Columbia River (O'Connor, Grant, & Haluska, 2003). It is primarily fed by Cascade snow packs with its origin at Little Lava Lake and is divided into three sections: Upper (origin to Bend), Middle (Bend to Lake Billy Chinook), and Lower (Pelton-Round Butte Dam to Moody) (O'Connor, Grant, & Haluska, 2003). Pre-irrigation summer flows averaged 1,404 cubic feet/second (cfs) at Bentham Falls in the Upper, 1,350 in the Middle near Bend, and 4,533 cfs in the Lower at Madras (Golden & Aylward, 2006). The unique volcanic geology of Central Oregon has created highly porous surface and subsurface flows that buffer variation in seasonal flow such that flow during extreme meteorological events rarely exceeds five times the average flow (O'Connor, Grant, & Haluska, 2003). The Upper and Middle Deschutes lie atop thousands of feet of volcanic geology formed by millions of years of successive volcanic periods, which has created a vast underground aquifer above impervious basalt. Much of this groundwater discharges into springs at the headwaters of the Metolius River, along the lower part of the Crooked River, and between river mile 100 and 120 of the Deschutes (O'Connor, Grant, & Haluska, 2003).

The flora and fauna of the region are characteristic of a High Desert biome. Average annual rainfall is 11.94 inches, and the region typically experiences summer highs of 82.8 degrees with winter lows of 21.6 degrees Fahrenheit (WRCC, 2010). The Lower and parts of the Middle Deschutes were historically home to steelhead and other anadromous fish populations that migrated to the Pacific Ocean by way of the Columbia River for part of their life histories (Lichatowich, 1998). Today, the Lower Deschutes is still home to spring Chinook salmon, fall Chinook salmon, summer steelhead trout, and Bull trout (Paretchan, 2003).

The regional economy and development historically revolved around use of natural resources including forests for the timber industry and water for agriculture (Oregon History Project, 2004a; Oregon History Project, 2004b). Between the early 1900's and into the 1970's, the region's use of its water resources followed the same trajectory of water development throughout the West: construction of vast dam complexes to retain water and creation of extensive irrigation channels to deliver water to fields

(Reisner, 1993). During this period of development, the population of Bend, the region’s largest city, reached 13,710 in 1970 (U.S. Census, 1990).

The flow of the river today is reduced by over 95% from its pre-irrigation flows throughout part of its length in the Upper and Middle Deschutes, primarily in support of farming activities (Paretchan, 2003; Golden & Aylward, 2006). Current managed summer flows are 1,300-2,000 cfs in the Upper, 30-75 cfs in the Middle, and 3,750-4,500 in the Lower while winter flows are 20-500 cfs in the Upper, 450-1,200 in the Middle, 3,750 – 4,500 in the Lower (Golden & Aylward, 2006). Three dams called the Pelton-Round Butte complex located 180-160km upstream from the Columbia River confluence generate 427 MW of hydroelectric power operated by Portland General Electric and the Confederated Tribes of Warm Springs (O’Connor, Grant, & Haluska, 2003).

Table 2: Pre-Irrigation and present Managed flows in cubic foot per second (cfs) of the Deschutes River by season and section of the river (all numbers in CFS)

	Pre-Irrigation	Managed	
Summer	820	1,340	Upper
	1,315	35	Middle
	4,432	4,040	Lower
Winter	730	30	Upper
	1,310	670	Middle
	4,660	4,520	Lower

As the timber industry approached its apex, some of the profits from timber fueled development of recreational resorts, such as the launch of Sunriver Resort in the 1950’s by two lumber leaders and construction of Black Butte resort in the 1960’s (Oregon History Project, 2004a). During this period, the Confederated Tribes of the Warm Springs Reservation acquired and developed a resort around Kah-Ne-Ta hot springs and Mt. Bachelor Ski resort grew throughout the 1960’s and 1970’s (Oregon History Project, 2004a). The region’s tourism industry continued to grow even as forestry and then milling declined in prominence in the region. The city of Bend has grown nearly sevenfold from 1970 to 2010, and the region now attracts 2 million tourists annually who spend \$354.9 million while visiting the region (RRC Associates, 2009; U.S. Census, 2010).

Central Oregon now faces numerous tensions during a period of social and economic transition. Second homes accounted for 10% of the region’s total housing stock in 2002, yet 1 in 9 residents live at or below the poverty level and unemployment was at 13.1% in February 2011 (Deschutes County, 2002; Bend Bulletin, 2010; Vaagen, 2011). The water management infrastructure of the 1950’s and 1960’s was built largely to support agriculture and hydropower, but infrastructure and geology cause loss rates in irrigation ditches and canals that average 43-50% (Marshall, Lite, Morgan, & Collins, 2001; Paretchan, 2003). Although Bend’s development has slowed due to the recent recession, its anticipated growth places a voracious demand on the region’s water resources, which today are almost entirely owned by farmers. Some of the tactics and strategies highlighted in this report, such as taking steps to prevent seepage in irrigation channels, are beneficial to all sectors of the central Oregon economy. Others serve to illustrate possible paths forward which favor development in different directions. As with any form of economic decision-making related to a limited resource, however, it is clear that some difficult decisions are ahead and tradeoffs will be made.

The purpose of this study is to provide information which brings to light some of the key economic factors and tradeoffs underlying Deschutes River water management decisions, describe a full range of benefits the river provides, identify opportunities for mutual gain, and support sound decisions about a finite resource. The report joins a growing number of studies, analyses, policy prescriptions, and new institutions aimed at understanding and addressing Oregon's water management challenges. New markets for water and wetland credits are emerging at the same time as private and public interests form alliances that seek innovative solutions to constrained water supplies. It is not the intention of this study to provide recommendations or judgments on the current or future situation, but to identify important information for the region to prioritize and direct its own future. This is an analysis of value, linking uses of the Deschutes River's flow to its effects on the regional economy. While the study brings to light multiple sources of direct and indirect revenue for key industries benefitting from the river, it is ultimately up to the region to decide how it values its own future.

Study Components

Organization

The study is organized into two parts: the Annual Economic Benefits of the River and Scenarios Analysis. The Annual Economic Benefits section provides detailed results of the analysis of annual river benefits for each of the six focal economic sectors by industry. For several industries, results are broken out by sections of the river. Detailed graphs and visual displays of information for each section provide at-a-glance snapshots of the benefits, by type, for each industry.

The second section uses a technique increasingly used by agencies and companies to understand the possible outcomes of their decisions and effects of potential situations outside their control. Scenario Analysis assumes a certain future situation, either through intentional actions of decision makers or from influences outside of manager control, and plays out the results over a period of time to project what the future might look like under these conditions. Four scenarios are presented here to highlight what could happen if the region invested entirely in agriculture, if the region invested entirely in recreation, if the region attempted to improve productivity in each industry without adverse impact to any other industry, or if drought conditions reduced total water availability by 15%. Although it is expected that none of these scenarios will play out perfectly, the use of this type of analysis allows decision-makers to see and understand the tradeoffs associated with different courses of action. Several of the scenarios are fairly extreme by design (indeed, the implementation of some may even be constrained by law or feasibility) to strip away the ambiguities associated with trying to accomplish everything at once and identify the economic costs and benefits of any single action.

Scope and Definitions

The study focuses on the economic contributions of six industries because of their importance to the Central Oregon economy and job creation. The industries studied are agriculture, tourism, recreation, hotels, real estate, and commercial salmon. The complex hydrology of the region made the task of isolating benefits from water especially difficult, therefore the study focuses entirely on benefits associated with the main stem of the Deschutes River. Major tributaries such as the Crooked River and Whychus Creek are not included, nor are groundwater withdrawals. However, the study examines aspects of regional economic value related to river flows along the entire length of the Deschutes River Corridor including the Upper, Middle, and Lower sections of the Deschutes River, the Little Deschutes River, and Little Lava Lake.

The study takes an ecosystem services approach to valuing the benefits of the river. Ecosystem services are services provided by nature that produce human wellbeing such as food, fuel, nutrient cycling, pollination, flood control, and many more (Fisher, Turner, & Morling, 2008; MA, 2005). Ecosystem services are divided into four categories: provisioning, those services that provide direct benefit such as food; regulating, services that control natural processes for a suitable living environment like air and water quality; supporting services that maintain other services such as nutrient cycling; and cultural services like aesthetic values and recreation (MA, 2005). Ecosystem service valuation is a relatively recent science given that the complexity of ecosystems and their incompatibility with the assumptions behind efficient markets make quantification of ecosystem benefits especially elusive (Heal, 2000; Mäler, Aniyar, & Jansson, 2008; Van Dis & Aylward, 2010; National Research Council, 2005). In addition to their impact on the local economy, the six industries were chosen in part because they all derive a

significant portion of their revenue from services provided by the river. This proportional economic benefit provided by the river is the primary focus of the ecosystem service valuation in this report.

The report quantifies three types of ecosystem service benefits: direct, indirect, and additional benefits. Direct benefits are those that accrue to the Central Oregon economy, while indirect benefits largely accrue to economies outside of Central Oregon. Additional benefits include jobs, services, and products from the river that benefit Central Oregon residents. The report assumes that the significant majority of revenue generated by agriculture, hotels, recreation, and real estate sales goes to Central Oregon. Tourism revenues benefit Central Oregon small businesses, but the report breaks out travel expenditures and assigns them to the indirect category with the assumption that other parts of Oregon and the Pacific Northwest receive the majority of automobile rental, airplane ticket, and gas expenditures by tourists traveling to the region. The other major component of indirect benefits is revenue that accrues to Oregon's commercial salmon industry as a proportion of the Deschutes River's contribution to the supply of salmon each year.

This study does not examine the hydropower impacts of the river because extensive information is already available on the economic benefit of hydropower and much of the electricity is transmitted outside of the region. However, the annual hydropower benefit of the river should be fairly easy to estimate given the availability of energy generation capacity and energy market information. Furthermore, several of the future scenarios described in this report would presumably create economic gains or losses to hydropower, which could easily be added in future assessments.

Overview of Methods

The Overview of Methods provides a summary of the approaches used to derive economic benefits of the river to specific industries. Details on the exact data and approach used for valuation of specific industries can be found in the Data Sources and Methods section of the Appendix.

All methods rely on an approach known in economics as revealed preference, in which observations of consumer behavior reveal buyer preference for specific attributes of a product that is traded in the marketplace (Heal, 2000; National Research Council, 2005; Hitzhusen, 2007). The six industries are excellent examples of the benefits of ecosystem services in that some proportion of the total economic value generated by the industries can be directly attributed to the river. In the case of agriculture, recreation, and commercial salmon, Deschutes River water directly provides a service by way of fresh water used in these industries. Consumers reveal their preference for benefits provided by the river to tourism, hotels, and real estate through premiums and higher payments for location near the river.

The study uses revenue for each of the industries as the starting point for quantification. In all cases, the report estimates the portion of revenue for an industry that can be attributed to benefits provided by the river. In other words, the analysis considers the proportion of Central Oregon agricultural revenue attributable to the Deschutes River to be equal to the proportion of Central Oregon's cultivated land irrigated by Deschutes River water. Likewise, the portion of Central Oregon's recreational revenue attributable to the Deschutes River is considered equal to the proportion of Central Oregon's recreational activities which take place on the river. Revenue numbers from this analysis are used to determine expressed value, the value river users enjoy without paying for access, river products such as fish, or a service like guided trips.

To understand the exact proportion of revenue due to the river for each industry, the analysis further relies on the economic concept called rival and non-rival goods (Fisher, Turner, & Morling, 2008). Rival goods are those goods and services in which the consumption of a good by one person reduces or eliminates availability for another person to consume, such as a specific unit of water that can be drunk by one person in its entirety leaving none for the next person. Non-rival goods are those that can be consumed by a person without diminishing the ability of another to enjoy an equal amount, such as a river view.

This report treats the industries of tourism, hotels, and real estate as non-rival, because their primary river benefits are derived from views and experiences and so are not considered dependent on specific river or flow quantities. The methods used for real estate and hotels involve hedonic pricing analysis in which two properties with equivalent attributes, with the exception that one property benefits from the view while the other does not, are compared in order to determine the relative benefit of the river view attributable to total revenue. Tourism presented a particularly challenging situation because it would require comparing Central Oregon to a region with exactly the same attributes except the presence of the Deschutes River in order to use hedonic pricing. However, Visit Bend has collected exceptional data on visitors the past three years including the percent of visitors who participate in river-related activities, and this proportion is used to estimate the proportion of total tourism revenue attributable to the river. Double counting is carefully controlled by subtracting hotel and guided recreation revenues from tourism revenues as part of the analysis.

On the other hand, the industry of agriculture is treated as rival with respect to recreation and commercial salmon, given that consumption in one industry diminishes the availability to generate revenue in the others. Water diverted for use in irrigation is no longer available for use further downstream, and likewise water left in-stream is not available for use in irrigation further up stream. Further, although several of these industries may depend on the level of water left in-stream, the optimal values for each may be different. Many of the recreational activities have upper and lower bounds on stream flow, beyond which that activity cannot reasonably occur, and these thresholds have been factored into the analysis.

To complete the Scenarios Analysis, each industry's response to changes in water flow and economic value generated per unit of water were determined based on the data collected for the industry. The team built a model of the regional economy and used it to project the effects of four possible scenarios. The model determines how the annual economic benefits of the river would look today if the Scenario described were to occur instantaneously, though in reality these courses of action would reach maximum effectiveness over time.

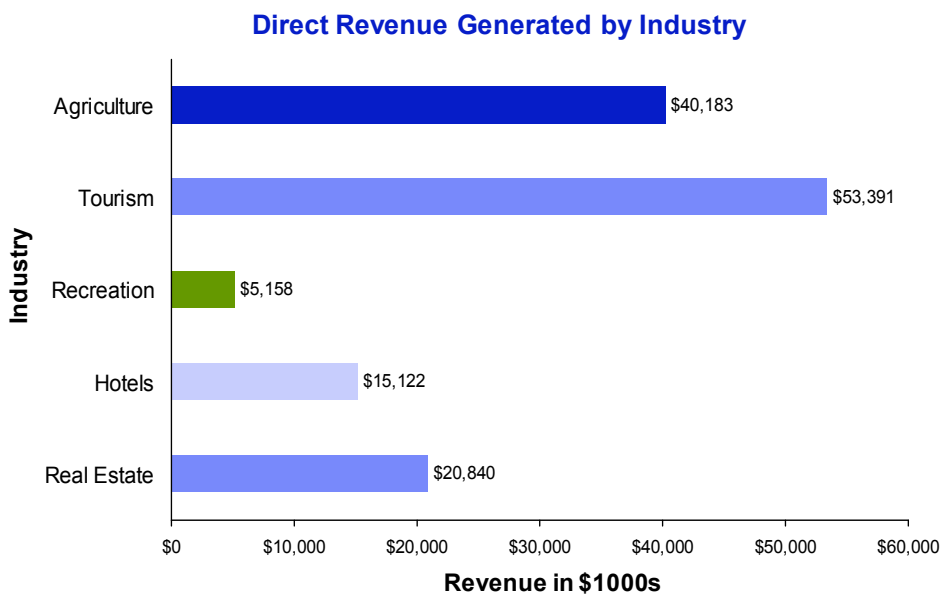
Data is primarily publicly available secondary information, collected from agencies such as the U.S. Forest Service, the Bureau of Land Management, the U.S. Agricultural Census, Economic Development for Central Oregon, the Deschutes County Assessor's Office, the Oregon Department of Fish and Wildlife, and Visit Bend. The only primary data collected for the study consisted of interviews of hotel managers. Where possible, an average of three years of data was used to estimate annual totals. Consistent with this approach, the oldest data used for all industries except commercial salmon is from 2007 to provide the most up-to-date values. Commercial salmon includes recent Chinook runs from as far back as 1996 to determine long-term trends. The Appendix contains additional detail on data sources and methods of analysis.

Annual Economic Benefits of the River

The Deschutes River already provides significant annual benefit that benefits the regional economy. It includes direct benefits to Central Oregon in the five industries of agriculture, tourism, recreation, hotels, and real estate as well as indirect benefits outside of the region to commercial fishing and traveling expenses. Additional benefits provided by the river include jobs and free opportunities for river services and products by residents and visitors. The total annual economic value to the six industries from the river is \$185.2 million with \$134.7 million direct, \$28.0 million indirect, and expressed value of \$22.5 million. The benefits provided by the river create 3,433 in full time equivalent jobs in Central Oregon that generate \$73.0 million in wages.

Direct

Figure 2: Direct Revenue to Central Oregon Generated by Industry in 2010



Agriculture

Agriculture is the historic backbone of the region's economy. The construction of retention dams and extensive irrigation canals from the early 1900's through the 1960's brought water to the High Desert and enabled explosive the industry to expand and diversify. Today it provides more than

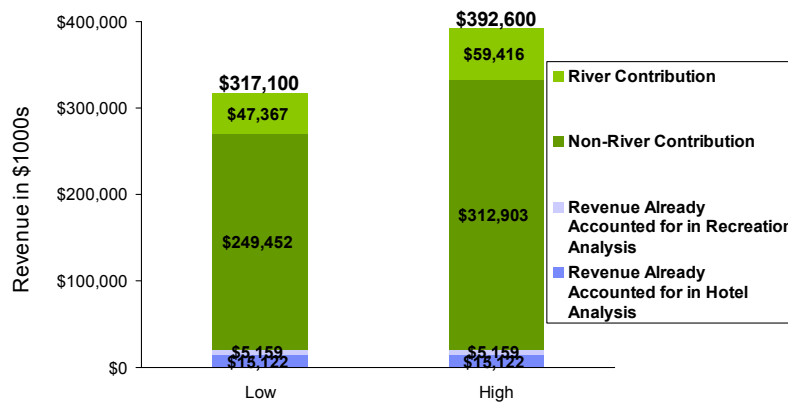
\$200 million in revenue to the region. There are 2.5 million acres in farm land in Deschutes, Jefferson, Crook, and Wasco counties, of which 187,147 is irrigated (US Department of Agriculture, 2007). The vast majority of agricultural benefit (99.2%) from the river comes from the Middle Deschutes, where numerous diversion channels extract water from the channel near Bend in the summer (Oregon Water Resources Department, 2011). Today, the Deschutes River generates \$40.2 million in revenue for farmers.

Data for the agriculture analysis were downloaded from the Oregon Water Resources Department and compared with results from the 2007 USDA Agricultural Census. The water rights data provide information on water extraction and use by township and the Census was taken by county, so water rights were mapped to each of the four counties and their extraction points were mapped to sections of the river. Additionally, only active rights used for irrigation and only actual water usage (not maximum allowed diversion amounts) were included in the analysis. Other categories, such as Supplemental Irrigation rights, were not counted. The irrigated acres specified by the water rights were used to

estimate total amount of irrigated land when comparing to the irrigated land reported in the Census. Finally, only direct withdrawals from the river and reservoirs within the Deschutes River were included; consistent with the rest of the analysis, tributaries were excluded. Given the percentage of irrigated land by county and total land irrigated with Deschutes River water, an estimate of the percent of total land irrigated by the Deschutes River was derived and subsequently used to determine the River's contribution to revenue and other metrics.

Tourism

Figure 3: Tourism Revenue by Category



Tourism is one of Central Oregon's largest and fastest growing industries, generating more than \$354.9 million for the regional economy each year (RRC Associates, 2009). It currently employs an estimated 10,510 people (Crook, Deschutes, and Jefferson Counties) and employment in the industry is projected to grow by 36% annually (EDCO, 2011). Tourism in the region includes skiing, golf, fishing, hiking, rafting, biking, camping, sightseeing,

conventions, museums, and numerous restaurants and hotels.

The estimate of river benefits to the tourism industry, after deducting guided recreation and hotels, is a \$47.4 million low estimate and a \$59.4 million high estimate, with an average of \$53.4 million. The primary sources of data for the tourism assessment are two surveys conducted by Visit Bend of visitors in 2008 and 2009. The estimate of tourism revenue generated by the river should be taken as a lower bound, or highly conservative estimate, because the source of the data only includes visitors intercepted in the City of Bend. Sun River, Redmond, Maupin and other towns offer additional lodging and tourist attractions but they are left out of the study since reliable data could not be located on these destinations.

The results were calculated by deriving the total expenditures of visitors in Central Oregon based on number of visitor-days and average daily expenditure. Results from the hotels and guided recreation analyses were deducted to avoid double counting. A proportion of total remaining tourism expenditure equivalent to the average percent of visitors who participate in river activities was applied to determine revenues to tourism due to the river.

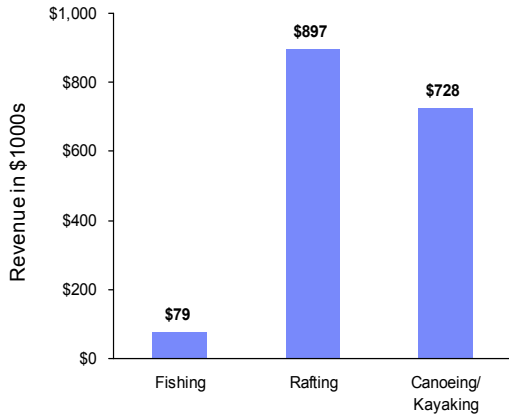
Recreation

The region's popularity as a premier outdoor recreation destination has been rapidly growing for decades and today 319,062 people enjoy river-related recreational activities each year. Recreation can be broken up both by type of recreation, and where on the river the recreation takes place. The three main types of recreation in Central Oregon include fishing, rafting, and canoeing and kayaking. Because

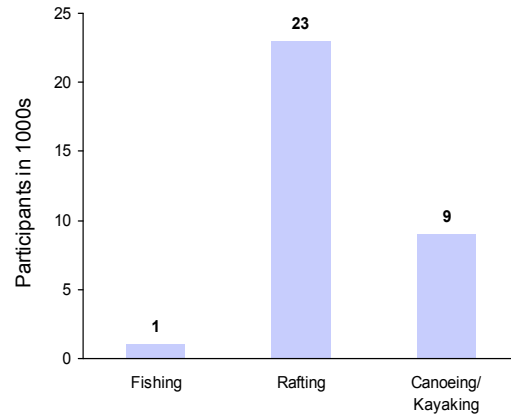
virtually all recreation currently takes place on the Upper and Lower Deschutes, the Middle Deschutes is not included in this part of the analysis of the annual economic benefits to the region.

Figure 4: Upper Deschutes Guided Recreation Revenue

Revenue by Activity



Participants by Activity



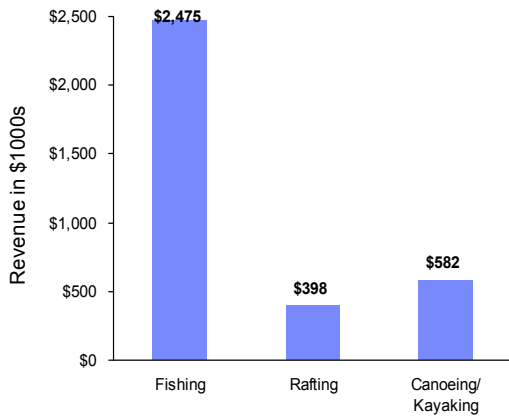
Direct value from recreation is measured using the actual revenue generated from guided activities. On the Upper Deschutes, the largest generator of recreational revenue is rafting, which accounted for \$897,000 in 2010 from 23,000 participants. Rafting was followed closely by canoeing and kayaking with a combined \$728,000 from 9,000 participants in 2010, while fishing only accounted for another \$79,000 from 540 participants. Note again that only activities on the main stem Deschutes River were included in this analysis; activities on tributary rivers were excluded.

On the Lower Deschutes, fishing accounts for the vast majority of recreational revenues at of \$2.5 million with from 17,000 participants. Canoeing and kayaking is the second biggest contributor with revenues of \$582,000 from 7,000 participants, and rafting generates \$398,000 from 10,000 participants.

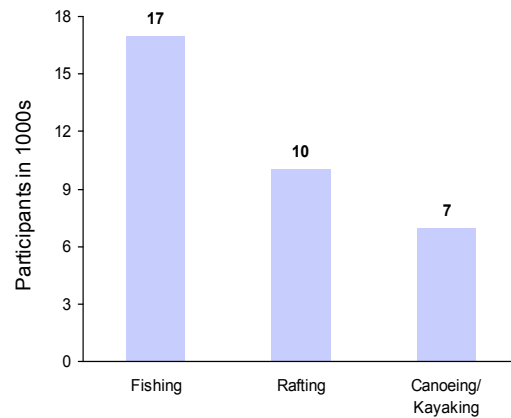
When measured both per participant and in aggregate, fishing generates the most revenue with \$2.6 million from 18,000 participants, followed by canoeing and kayaking with \$1.3 million in revenue from 16,000 participants, and Rafting with \$1.29 million from 33,000 participants in 2010. This totals \$5.2 million in recreation revenue from a total of 66,000 participants in 2010.

Figure 5: Lower Deschutes Guided Recreation Revenue

Revenue by Activity

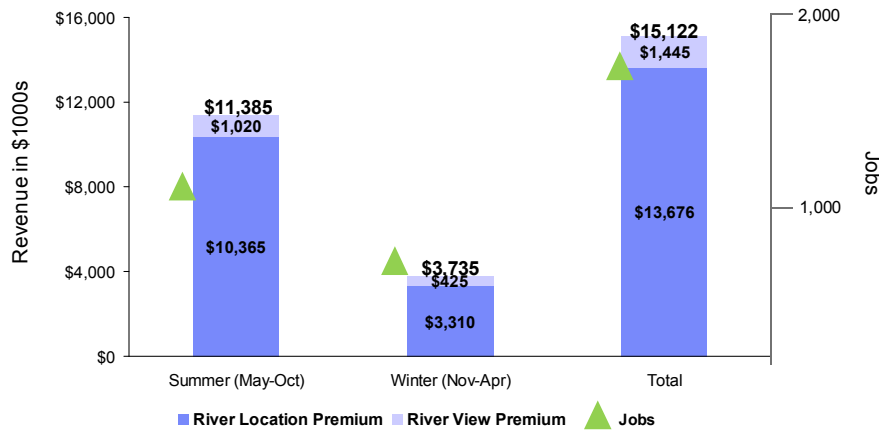


Participants by Activity



Hotels

Figure 6: Hotel Revenue and Jobs from River



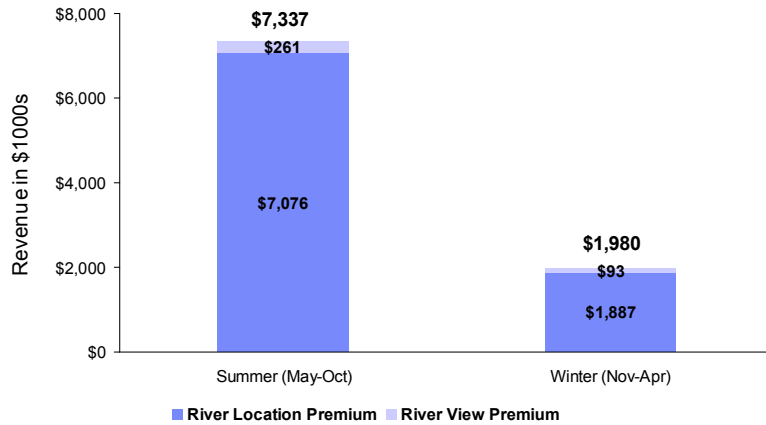
Hotels are a direct beneficiary of the Deschutes River by way of direct premiums for river views, as well as the ability to derive higher revenues from locations next to the river. Eleven hotels with a total of 1,286 rooms are located next to the Deschutes River, with a minimum of three hotels in each section of the river. River hotels derive \$15.1 million in

revenue directly attributed to the river, and these hotels employ 1,737 people in full time, part time, and seasonal positions.

Hotels derive benefit from the river in two ways: premiums charged for river views and higher revenues when compared to other hotels with otherwise equivalent attributes that are located away from the river. The data for hotels was collected through interviews with hotel managers who provided information on number of rooms (single, double, suite), room rates during peak and off seasons, occupancy during peak and off seasons, premiums charged for river views, and employment by season. All river hotels reported that they charged a premium for rooms facing the river and most reported that those rooms enjoyed higher occupancy, though only one was able to provide a specific estimate of this increase in occupancy. Where specific estimates of occupancy were not available, room premiums were determined through the sum of total number of rooms combined with the incremental premium and

average occupancy by room type and section of the river. Additional data on increased occupancy of rooms with river views would yield a higher result than this analysis currently reflects.

Figure 7: Upper Deschutes River-Related Hotel Revenue by Season



To determine the additional benefit to a hotel provided by a river location, a weighted average rate by season was used for each room type in each section of the river and combined with peak and off-peak occupancy to estimate revenue by room type and section of the river. Total revenue for all

river hotels could then be estimated. Using the American Automobile Association Diamond Rating system to control for other hotel attributes, six hotels with a total of 467 rooms were compared on a revenue-per-room basis by room type. Hotel rooms in hotels located next to the river accrue 33.1% higher revenue on average. The majority of the benefit comes from the ability of river hotels to maintain higher room rates during the off-peak season with some benefit also derived from higher occupancy. The benefit accounts for approximately 24.9% of total revenue, the proportion applied to derive the incremental revenue to hotels from a river location.

Real Estate

Real estate is a major contribution to any economy, but more so to Central Oregon and especially Bend given its explosive growth in the past three decades. Anybody who has bought or sold a house knows that location can provide advantages and command premium prices. As with hotels, the real estate industry is a direct beneficiary of the Deschutes River, primarily through premiums derived from river views. The study examines river views as one such location-dependent attribute that increases the value of homes. In early discussions with real estate agents, who are adept at highlighting the highest value attributes of the properties they sell, it became clear that proximity to the river was less relevant to home prices than was river view.

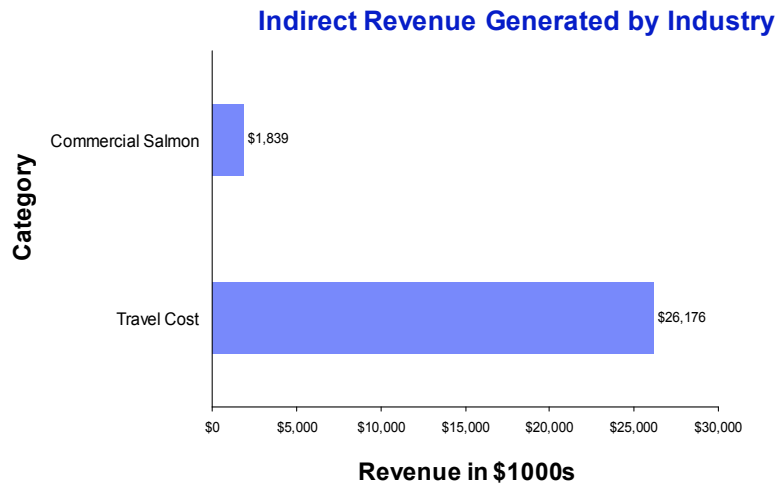
The total incremental value of properties sold with a river view in 2010 was \$20.8 million (Central Oregon Association of Realtors, 2011), and this represents the premium that home buyers paid above the price of comparable non-river view homes. In 2010, 66 of the 3,334 residential properties sold in Central Oregon had views of the river, and these properties sold for 6 - 60% more than houses of comparable size. These general results were verified through a detailed analysis of home sale data from the tax assessment records of a subset of the properties sold in 2010 to confirm that other attributes such as lot size, home size, number of bedrooms did not significantly affect the river premiums calculated using the real estate data.

This premium is taken to be the contribution of the river to the value of real estate in the region. Homes were selected with similar number of bedrooms, square footage, and location to control for other

valuable attributes. The analysis revealed that approximately 1.98% of all homes sold have river views and that such a view adds, on average, approximately 42% to the value of the property.

Indirect

Figure 8: Indirect Revenue Generated by Industry

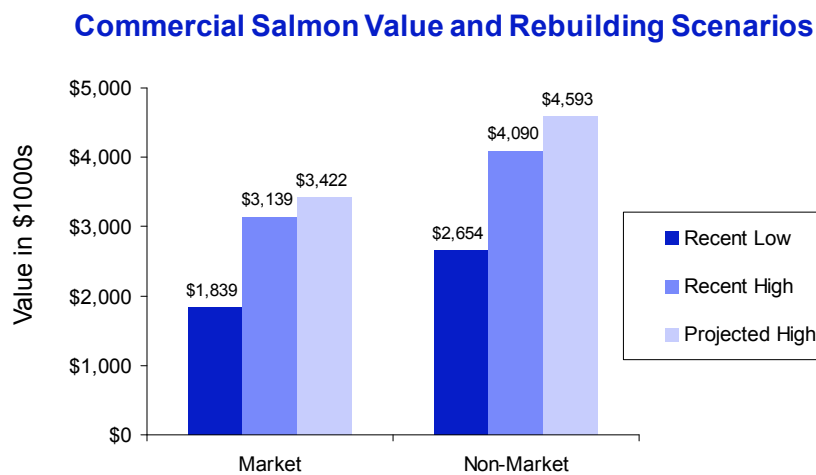


Indirect value generated by the river is revenue that largely benefits people and industries outside of Central Oregon. Two specific values are included here: the revenue from the Lower Deschutes' Chinook salmon runs to the Pacific Northwest's commercial salmon industry and the revenue to airlines, vehicle rental companies, and gas stations by tourists travelling to the region.

Commercial Salmon

Oregon's commercial fishing is a \$105 million industry (Knoder, 2010). The Deschutes Basin provides an estimated 3-5% of the Columbia Basin's fish populations (PSC, 2009). In 2007 and 2008, 114,065 and 197,295 fish ran the Columbia River, respectively, destined for areas above Bonneville Dam and the Deschutes River (PSC, 2009). Many of the salmon complete their journey to historic spawning grounds, but some of the returning fish that reach the Columbia River are caught. The tribes harvest approximately 73% of the catch for sales and subsistence under treaty, commercial fishing takes approximately 5%, and sport anglers claim the remaining 22% of the catch (PSC, 2009).

Figure 9: Commercial Salmon Values



The recent low estimate of the contribution of the Deschutes River to Oregon's commercial fishing industry is \$1.8 million annually. These numbers were based on a relatively steady annual run between 1996 and 2000, but runs spiked between 2001 and 2006. Therefore, analysis was performed

based on recent population trends for the fall Chinook runs to simulate population changes and impacts to the economy. If habitat is improved and populations reach higher levels as projected, market value of the Deschutes Chinook catch could be \$3.4 million and non-market sustenance and enjoyment would be \$4.6 million. If the populations continue with good years without significant improvements as we have seen recently, market value is \$3.1 million and non-market is \$4.1 million.

The data on the contribution of Deschutes River salmon to the total catch is limited, so this accounts only for catch of fall Chinook runs based on annual tracking since the 1970's (PSC, 2009). Combined with historic wholesale price and average markup, and assuming tribes sell and consume their catch in a 50/50 ratio, the market value was estimated. The non-market value to tribes and sport fishing uses the same retail price to estimate savings for personal consumption and value for recreational enjoyment.

Travel Cost

Tourism brings an additional economic benefit to the greater Pacific Northwest from expenditures to travel to Central Oregon, largely generated through airline tickets, vehicle rentals, and gas expenses. The travel cost method is also a widely used ecosystem service valuation tool to approximate how much a resource is valued by examining how much people are willing to expend in terms of both time and money to enjoy it (National Research Council, 2005; Hitzhusen, 2007; Sommer, 2005).

Figure 10: Travel Expense of Visitors to Central Oregon

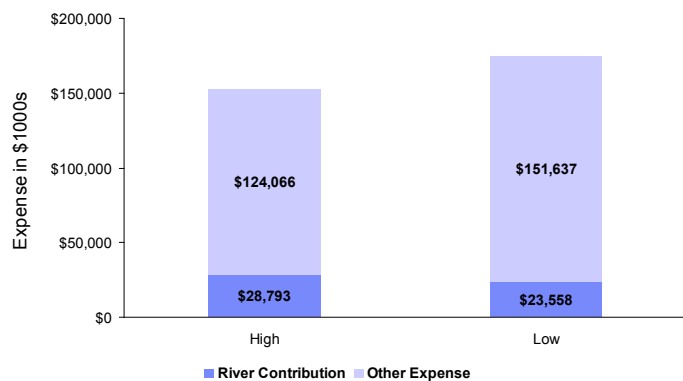
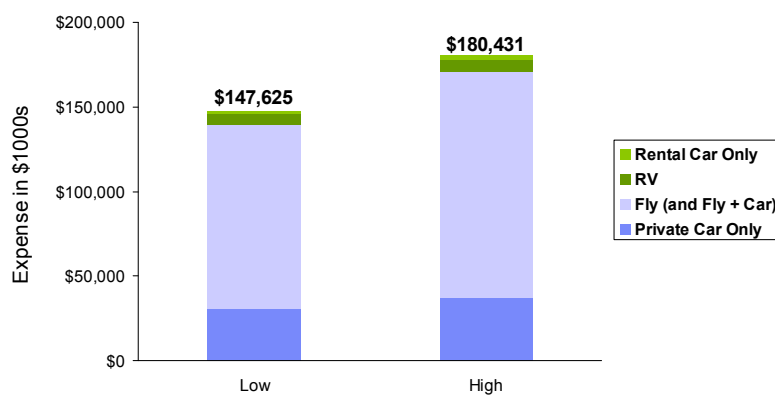


Figure 11: Deschutes River Related Travel Expenditures by Mode

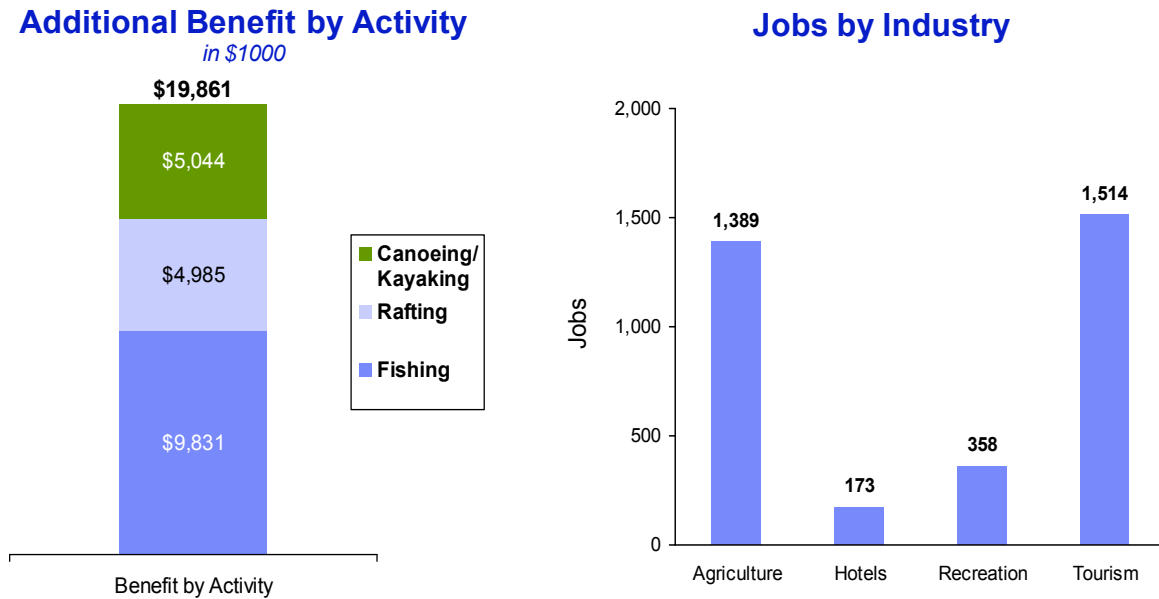


The travel costs directly attributable to river-related activities are \$26.2 million annually. The model uses survey data conducted by Visit Bend of visitors in 2008 and 2009 that provides detailed information on party size, mode of transportation, and point of origin. With this information, cost of travel for each party can be estimated using an average of the cost of airline tickets from the point of origin, gas prices and distance between Bend and points of origin,

and vehicle rental costs at the point of origin. The analysis breaks down the cost by mode of transportation. Combining all of this data into a single function, the weighted average travel cost of a visiting party (approx. 3.6 people) at the time of writing is \$291.15, indicating that visitors are willing to pay \$80.86 per person to get to and from Central Oregon specifically for the purpose of enjoying the Deschutes River.

Additional Benefits

Figure 12: Additional Benefits from Unguided Recreation and Job Creation



The Deschutes River also benefits the residents of Central Oregon in the forms of job creation and outdoor enjoyment. Although these two categories fall outside of both the direct and revealed preference valuation methods, their benefit can be quantified in other ways. Full time equivalent jobs total 3,433 from sectors of the economy that benefit from the river, with an estimated value of \$73.0 million in wages, unpaid outdoor activities are enjoyed by 253,276 people annually with a value of \$19.9 million, and the tribes receive \$2.7 million in subsistence and cultural values from their catch of Fall Chinook salmon.

Jobs

The number of full time equivalent jobs generated by the river for industries that benefit from the river is 3,433 with an estimated value of \$73.0 million in wages. Each industry was treated with the same proportional river benefit as used to estimate direct and indirect benefits. Thus, all employment in agriculture, recreation, and commercial salmon activities which use Deschutes River water is included, while a fraction of total employment in tourism, hotels, and real estate proportional to their benefit of the river is used. Jobs created by industries enabling travel to Central Oregon, such as airline or fuel station employees, were excluded. Data were gathered from primary sources such as managers of hotels located on the river and secondary sources such as the U.S. Agricultural Census and Economic Development for Central Oregon (EDCO). Wage information comes primarily from EDCO, which performs an annual survey of wages across all industries in Central Oregon.

Expressed Value

In addition to the direct revenue generated from guided recreation on the Deschutes River, there is additional value generated from products and services the river provides for free. One type of expressed value is the enjoyment that people derive from participation in outdoor activities without paying for any type of guided recreation guides. The majority, a full 77% of recreation participants, falls into this

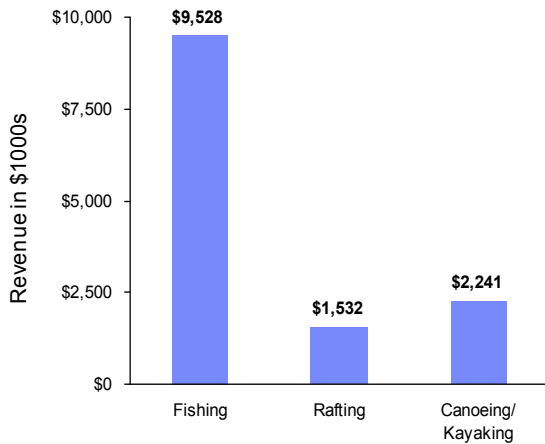
category, and are made up of from residents or people who travel to the area to enjoy their favorite outdoor activity. A second type of expressed value is products provided by the river such as fish. The Deschutes also generates an additional \$2.7 million in cultural and economic benefit by tribes who use the salmon for sustenance and sport fishing. Total expressed value of the river to these two types of river users is \$22.5 million.

On the Upper Deschutes, the largest generator of additional benefits from recreation is rafting with the equivalent of \$3.5 million in guided activity from 87,000 participants. Canoeing and kayaking account for the second largest group with \$2.8 million in equivalent activity by 34,000 participants and 2,000 anglers enjoy the equivalent of \$303,000 in guided services.

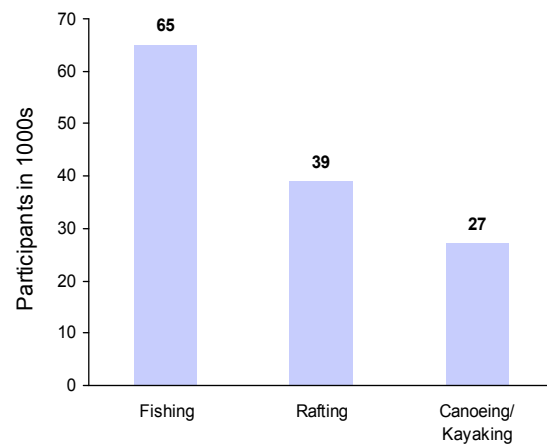
On the Lower Deschutes the majority of these additional benefits come from 65,000 anglers who enjoy the equivalent of \$9.5 million in guided activity. This is followed by canoeing and kayaking with the equivalent of \$2.2 million from 27,000 participants, and rafting with the equivalent of \$1.5 million from 39,000 participants.

Figure 14: Lower Deschutes Additional Benefits form Non-Guided Recreation

Revenue by Activity



Participants by Activity



In aggregate, fishing accounts for the most additional benefit with an equivalent \$9.8 million enjoyment from 67,000 participants, followed by canoeing/ kayaking with the equivalent of \$5.0 million from 60,000 participants, and rafting with the equivalent of \$4.9 million from 126,000 participants. This totals the equivalent of \$19.9 million in additional benefits for 253,000 participants.

Enthusiasts enjoy the same three categories of recreation analyzed above – fishing, rafting, canoeing and kayaking– and participate in activities on their own on the Upper and Lower Deschutes. Extensive data from the BLM and Forest Service, which tracks river-use permits, allows a close approximation of the total number of non-guided and self-guided participants. The value estimate is based on the price of equivalent guided services for the activity in which people participate.

Scenarios

Scenarios Overview

Figure 15: Revenue by Scenario by Category

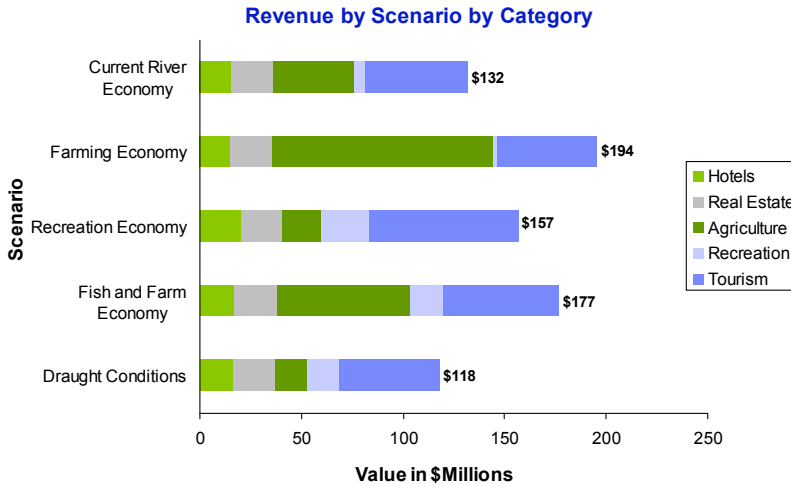
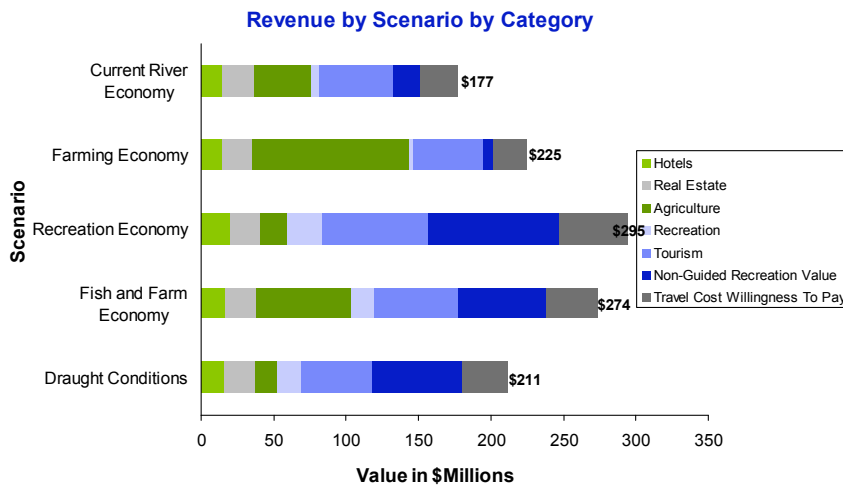


Figure 16: Total Economic Value by Scenario by Category



Scenario Analysis provides a way to view possible futures and the outcomes of specific decisions in order to evaluate several different courses of action. The Scenario Analysis in this report examines how the economy might look if decisions could be made that transformed today's economy immediately to assess tradeoffs, win-win opportunities, and opportunity costs. Each scenario examines the impact of water use on market value, expressed value, and total economic value.

The team built a model of the regional economy and used it to project the effects of four possible scenarios. Each industry's response to changes in water flow and generated per unit of water were determined based on the data collected for the industry. The model

determines how the annual economic benefits of the river would look today if the Scenario described were to occur instantaneously, though in reality these courses of action would reach maximum effectiveness over time. While examining the current annual economic benefits and the Scenarios, it should become clear that the region already manages the river for the benefit of certain industries by section. The Upper and Middle are managed primarily for the benefit of agriculture, while the Lower largely benefits recreation and commercial salmon. Real estate is shown but excluded from the per-flow revenue because the model assumes no dependency on river flows. Only industries with direct economic impacts to Central Oregon were included so that commercial salmon and travel expenditures were excluded from the analysis.

Four scenarios are explored: Farm Economy, River Recreation and Tourism Economy, Farm and Fish Economy, and Drought Conditions. The Farm Economy scenario assumes that the region decides to divert almost the entire annual flow of the Deschutes River to increase agricultural output in the region.

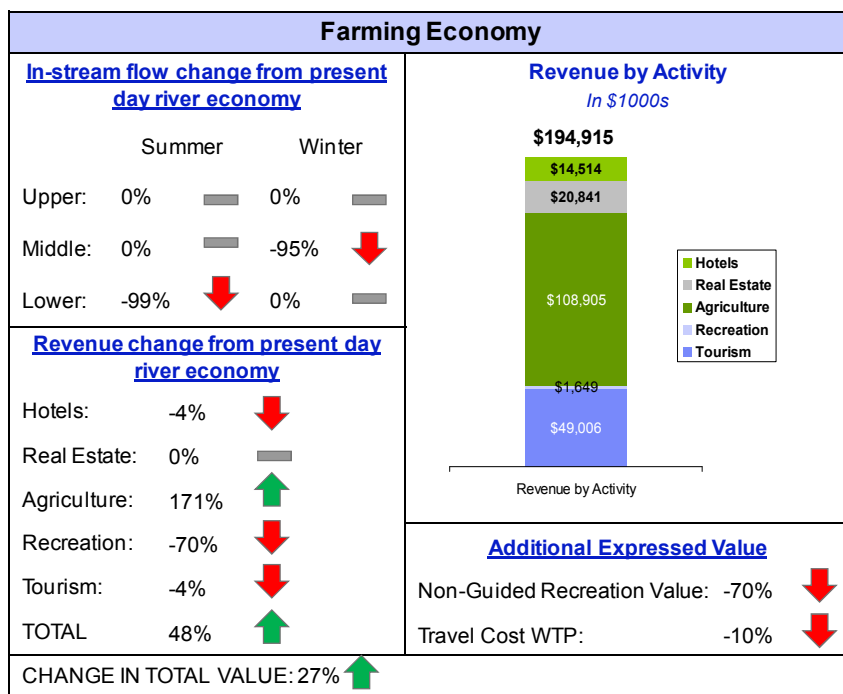
The River Recreation and Tourism Economy scenario assumes the region decides to maximize tourism and recreation. The Farm and Fish Economy Scenario uses productivity measures of each unit of water by industry to imagine a future in which the river is allocated to generate its greatest economic value for each industry without adversely affecting other industries, a concept known as Pareto-Efficiency. Finally, the Drought Conditions scenario imagines how the region’s economy would respond to a significant reduction in available water.

As with all models and projections, these scenarios are only as good as the data and assumptions upon which they are built. The team feels confident that these assumptions are reasonable, the data is good, and the model provides valuable information on the benefits and costs of specific decisions. However, additional data and assumptions will provide further refinements to the anticipated outcomes. The purpose of the model and resulting scenarios is to provide decision-makers with information on the specific economic tradeoffs of certain courses of action across all industries in Central Oregon that benefit significantly from the Deschutes River.

The scenarios ignore marginal cost of implementing each decision and only approximate marginal benefit by using a linear relationship given the existing situation. In reality, the marginal benefits may be much lower than expected for industries that are already at minimum efficient scale or higher for industries with significant room for cost-effective capacity expansion.

Numbers for the Status Quo scenario represent annual benefits to the six industries discussed above. They are slightly different from the actual numbers as described in the previous section because they are generated by the underlying equations of the Scenario model. The degree of accuracy in projecting today’s economic benefits should be taken as a sign of confidence in the underlying assumptions of the model.

Farming Economy

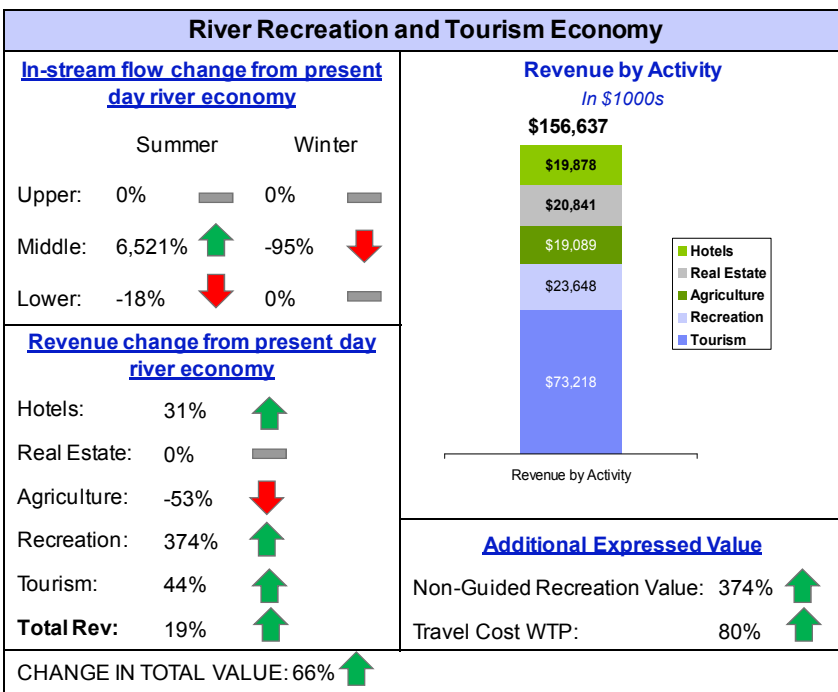


Imagine a future in which Central Oregon decides to use almost all its river water for agriculture. This represents the current situation in the Middle Deschutes, and even the Upper Deschutes maintains extremely low winter flows to build up summer water supplies for the Middle Deschutes. However, ample supplies still exist in the Lower Deschutes from additional flows brought into Lake Billy Chinook by the Crooked and Metolius Rivers, Whychus Creek and significant aquifer discharge to the Lower Deschutes. The

scenario offers insight into the benefits of additional allocation of Deschutes River water and contrasts it with the costs to other industries.

The scenario is built on several factors. First, it assumes the current summer flow of 30 cfs in the Middle Deschutes is sufficient to maintain most property and hotel values in other parts of the river. It maintains the current flow of the Upper portion of the river since that provides the supply currently diverted at Bend for much of Central Oregon’s agriculture. Therefore, although slightly more water is retained in the Upper Deschutes in the winter for use in the summer, the supply of water to Central Oregon agriculture is primarily diverted from the Lower River in the summer months. It assumes that a major irrigation project on the Lower Deschutes allows diversion of almost the entire flow of that section of the river. It does not take into account the cost of building diversion structures or canals, nor does it consider the limits on access to arable land and the increasing costs to reach distances further afield from the river. It assumes a similar rate of canal loss due to leaky channels and evaporation as in other sections of the river. The most significant negative impact of such a decision would be to nearly eliminate fishing, rafting, kayaking, canoeing, and commercial salmon industries from the Lower Deschutes with a net loss to recreation of 66.9%. However, the scenario brings with it a total incremental farming benefit of 171%, a 47.6% increase in total revenue to the region, a loss of 34.2% in expressed value, and an increase in total economic value of 26.7%,

River Recreation and Tourism Economy



Alternately, Central Oregon could focus on being a premiere recreation destination by managing the river’s flow to maximize recreational opportunities. Today, recreation is almost optimized in the Lower Deschutes due to recent management agreements with PGE and the Warm Springs Confederated Tribes, but low winter flows in the Upper Deschutes lead to winter kills of fish and diversion of nearly the entire flow of the Middle Deschutes in summer, which limits opportunities for commercial fishing or

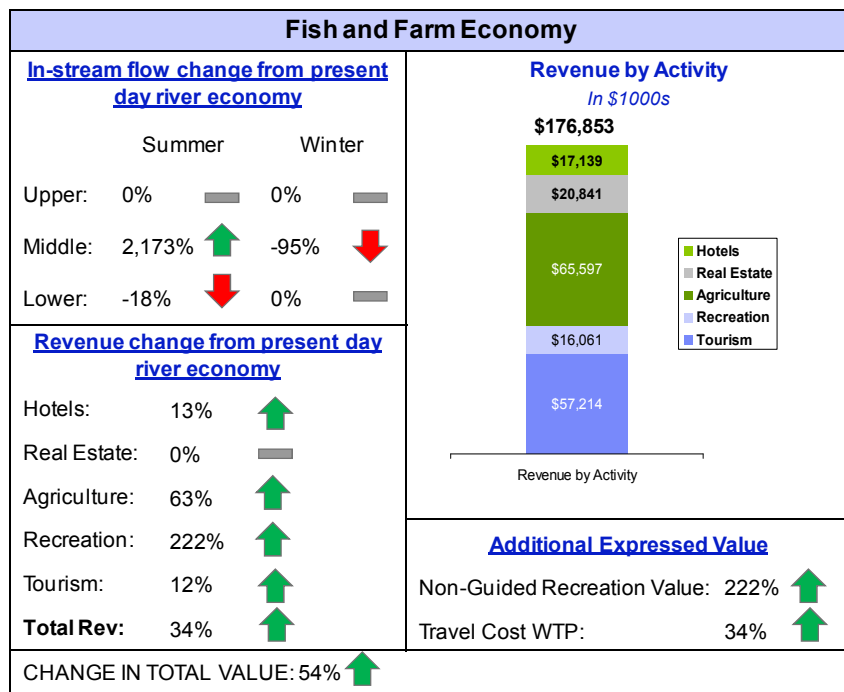
boating industry in that section.

This scenario uses the relationship between benefits to recreation and in-stream flow rate to identify the flow in each section that provides recreation with peak revenues. In the Upper and Middle Deschutes, rafting has the highest marginal benefit per unit of river flow, while in the Lower Deschutes it is fishing that is most affected by flow rates. However, this model seeks to balance the relative contributions from all activities within this industry to find the optimal flow rates in each section for

maximum recreational revenue. Thus, although the revenue potential from some sections of the river is lowered, the effect is more than offset by anticipated revenues from the activation of recreational activities in the Middle Deschutes and other effects. Further, the scenario calls for releasing less water into the Lower Deschutes in the summer, which presents opportunities for irrigation further downstream that could further enhance the total revenue. In the current model, recreational revenues are higher with higher water flows in the summer. In reality, higher summer flows penalize fishing with lower flows in winter and winter kills.

It assumes that each additional unit of water left in-stream to support recreation is one less unit of water that would be available for extraction in support of agriculture. The long-term beneficial impact to fish population growth is excluded from the analysis, though it is anticipated that improvements in habitat would lead to an increase in population size and a corresponding increase in fishing quality and quantity. The scenario does not take into account the costs of purchasing water rights or managing the river system to achieve these optimal flow rates. The major negative impact would be a significant reduction of agricultural output in the Middle Deschutes. The scenario increases recreational revenues by 374.1%, decreases agriculture by 52.5%, shows gains to hotels of 31.4%, and gains to tourism of 43.8%. The increase in total economic value is 66.2% with an 18.7% gain in regional revenue and 204.5% increase to expressed value.

Farm and Fish Economy



Central Oregon may take a third route and decide to promote productivity in each industry without negative impacts across industries. It assumes that the region values each of the six industries and would like to maintain at least the same level of output in the future. The Farm and Fish Economy scenario diverts water from any economic activity operating at a loss to more profitable (i.e. productive) operations within that industry. The results are river and water management schemes that look different from today because they

bring additional revenue to the region by pushing the use of river resources towards the efficiency frontier.

Pareto Optimality is an economic concept whereby resources are distributed to improve the situation of one person, firm, or industry without negatively impacting the situation of another. In effect, it challenges economists to look for gains without losses. In the case of this study, it compares industries and analyzes how economic gains can be achieved in one industry without diminishing the capacity of

other industries to maintain or improve their economic output. In the scenario, productivity is improved within the industry-specific constraints of the model up to the point where it adversely impacts another industry.

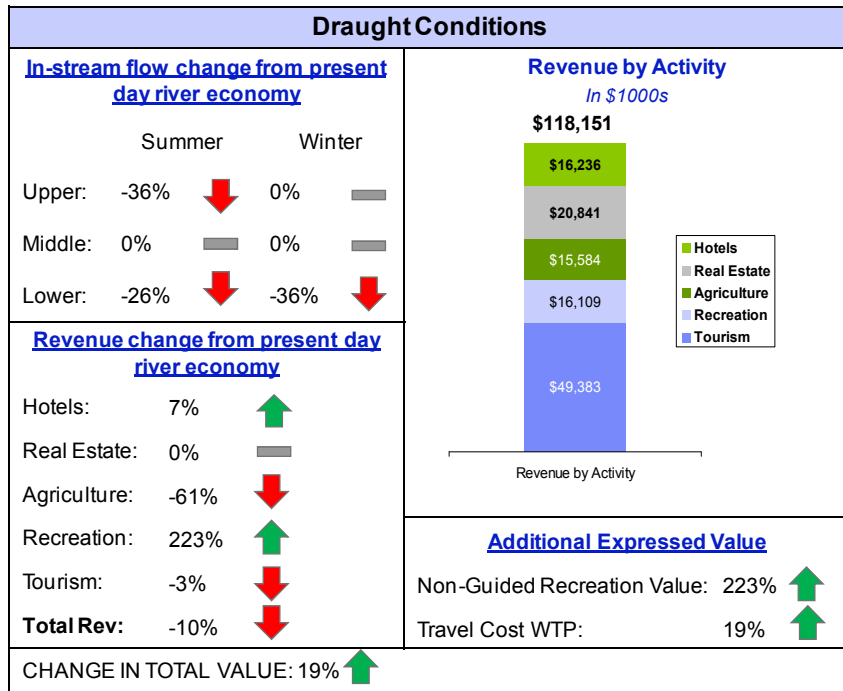
Farm and Fish Economy analyzes a scenario in which the overall regional economic output can be increased by allocating water resources to more productive use within each industry. The model distributes water from any unprofitable operations within an industry to the more profitable operations within that same industry while creating gains in other industries. In the case of agriculture, Jefferson, Crook, and Wasco counties all operate with profits, but Deschutes County agriculture loses an average \$7.3 million, with \$4.0 million associated with the use of Deschutes River water, which result in a loss of \$5,865 per cfs. Profitability aside, distributing water to Jefferson and Wasco Counties using the same ratio as today yields a higher per-cfs revenue than distributing the same water to Deschutes County, and leaves that water in-stream in the Middle Deschutes for use in recreational activities. Therefore, the model reallocates water from Deschutes County to higher productivity agriculture in Jefferson and Wasco Counties. For recreation, economic output and productivity is highest in the Lower Deschutes, but it already operates within its lower and upper thresholds such that more water increases productivity only up to a point. Due to this constraint and the industry-wide losses that would occur by diverting water from the Upper and Middle to the Lower, the model maintains minimum water levels for recreational activity in all sections of the river to maximize output in this industry.

Availability of data on profitability in recreation is harder to come by, though it is safe to assume that the industry is subject to market forces that would eliminate firms operating with losses over the long run. Since each section of the river and individual industry (fishing, rafting, canoeing/kayaking) has seen relatively steady growth the past two decades, it is safe to assume that most activity is operating at break-even or profitability. The model maximizes output in the Lower Deschutes where highest revenues are generated, but doing so does not require reallocation from the Upper or Middle.

Finally, in order to increase productivity in agriculture, benefit from the lowest cost conveyance system, and also achieve gains in recreation, the model assumes the best way to reallocate water is via the Deschutes River. Therefore, the Farm and Fish Economy scenario diverts water for the benefit of agriculture from less productive operations near the Middle Deschutes to more productive operations close to the Lower Deschutes by way of the river, thereby increasing revenue to both industries. The results are total economic value of \$273.8 million, increased revenue to agriculture of 63.2%, additional revenues to recreation of 222.0%, increases in hotels of 13.3%, gains in tourism of 12.4% and total increases in revenue and expressed value of 33.9% and 113.5%, respectively.

Drought Conditions

Several plausible futures for Central Oregon involve some constraint on total availability of water. The previous three scenarios imagined situations largely under control of the region. This last explores possible futures that depend partially on decisions made by the region, but some outcomes may be driven by decisions and impacts external to the region. The effect of pumping groundwater basin-wide is hard to estimate due to high fluctuations in groundwater levels and limited historical data, but high rates of development and water use in the region make aquifer drawdowns that exceed recharge rates a future possibility (Marshall, Lite, Morgan, & Collins, 2001). Furthermore, some expert climate change studies suggest that the Cascade Mountain snowpack, source of the Deschutes' water, may shrink with the 1-3° Celsius rise in annual global temperatures that is very likely to occur (Mote, 2006; IPCC, 2007).



Either one is possible and would have dramatic impacts on the river and its contributions to the regional economy such that exploring the potential outcomes with a scenario can be useful for decision makers.

The Drought scenario will help decision-makers understand the impacts of inaction or reaction to either one of these possible outcomes. The scenario assumes a 15% reduction in the annual flow of the Deschutes River by reducing the total volumetric inflow of tributaries by stage, and allocates impact based on

today's water rights. However, because the Upper and Middle Deschutes are already withdrawing water at a rate close to the maximum possible in order to support agriculture, it is inevitable that the largest impact will be to this sector. In fact, efforts to manage river flow to maintain water availability for farmers and others with senior water rights will also maintain flow rates at levels sufficient to continue support for recreation at close to current levels. It assumes the region's social and physical infrastructure are the same as today to help decision-makers identify the sectors of the economy that could be hit the hardest and areas with greatest opportunities for investment to maximize most efficient use of the region's scarce water resources. The scenario indicates a total gain of 19.1%, a 61.2% loss in agriculture, a 223.0% increase in recreation, a 7.4% increase in hotels, and a loss in tourism of 3.0%. Total revenue decreases 10.5% while expressed value increases 105.2%. The gains in recreation and expressed value are largely due to lower flow levels in the Lower Deschutes, which optimize conditions for fishing, the highest value recreational activity in that section.

Scenarios Analysis Summary

Table 3: Summary of Results from All Scenarios (all numbers in \$1000s)

	Status Quo	Farming Economy	Recreation Economy	Fish and Farm Economy	Drought Conditions
<i>Direct Revenue for the Region and Percent Change by Scenario</i>					
Hotels	\$15,122	(4.0%)	31.4%	13.3%	7.4%
Real Estate	\$20,841	0.0%	0.0%	0.0%	0.0%
Agriculture	\$40,183	171.0%	(52.5%)	63.2%	(61.2%)
Recreation	\$5,158	(66.9%)	374.1%	222.0%	223.0%
Tourism	\$53,391	(3.7%)	43.8%	12.4%	(3.0%)
Net Change in Market Value	\$0	\$62,873	\$24,631	\$44,811	(\$13,889)
Net Change in Expressed Value	\$0	(\$15,541)	\$92,853	\$51,546	\$47,737
Market Value	\$132,041	\$194,915	\$156,673	\$176,853	\$118,151
Expressed Value	\$45,396	\$29,853	\$138,248	\$96,942	\$93,133
Total Value	\$177,437	\$224,768	\$294,922	\$273,795	\$211,285

Conclusion

The goal of this project is to fill gaps of information on the economic contributions of the Deschutes River to Central Oregon and other locations to enhance decision-making. The analysis yields interesting and even surprising results. Today, the Deschutes River provides \$185.2 million in total economic value through six industries, of which \$134.7 million is revenue to Central Oregon, \$28.0 is revenue outside of Central Oregon, and \$22.5 million is expressed value of goods and services enjoyed for free. The river also supports 3,433 in full time equivalent jobs with wages totaling \$73.0 million.

The study sheds light on industries whose contributions to the local economy have been recognized for decades but whose benefits from the river are just now being understood. River recreation provides millions of dollars of direct benefit to the local economy and hundreds of thousands more are enjoying the river on their own. Data generated by this study reveals that hotels bring in two types of benefit: a premium for river views and higher revenues from location next to the river. Real estate agents recognize they command higher sale prices for properties with river views, but for the first time this benefit can be translated into significant value to the economy. Additionally, the river is part of the appeal that draws over 2 million tourists to the region each year.

The data on agriculture is extensive and has been studied in depth, yet analysis on the benefits this industry derives from the river, efficiencies and productivities across counties, and tradeoffs with respect to other industries performed by this study produces new insights. Agriculture in Crook and Jefferson Counties provides the highest economic return per unit of water consumed of any of the six industries studied, while Deschutes County agriculture operates at a loss. Water that supplies agriculture in Deschutes County comes with a double cost in the form of water diverted for agriculture that operates at a loss before it can reach more productive farming and unrealized potential for additional recreation, tourism, and hotel revenue in this section of the river.

Scenario Analysis indicates the cost of tradeoffs while identifying some opportunities for win-win gains. By considering different management decisions within industries, across industries, and along sections of the river, the region can understand the full costs and potential opportunities for the entire region. Further, recreational revenue could be increased by reducing flow in the lower Deschutes, while at the same time revenue could be increased by diverting that same “excess” flow into irrigation in Jefferson and Wasco Counties, a clear win-win for the region. The losses would be largely outside the region to commercial fishermen and users of Columbia River water farther downstream.

Despite the potential for these mutual benefits, there remain unavoidable conflicts over the use of water. The Cascade snowpack, annual precipitation, and aquifer can only provide so much water. If the river is pushed to the economic efficiency frontier, the region will need to make hard choices about how to manage it so that it does not deplete available resources, robbing the future of its resources. Should it reach that economic and natural frontier, gains without losses will be unavoidable in the distribution of water and decisions with specific tradeoffs will be made based on the values of the people in the region.

An underlying goal of this project was to identify value. This study quantifies one form of value from the Deschutes River to Central Oregon: economic benefits. In one sense, the economy reveals what Central Oregon values in its agriculture and when it uncovered its tourist appeal and launched the area’s explosive growth as a destination. However, economics alone cannot provide a complete picture of what is important to the people of a region. A way of life, pastoral landscapes, pristine natural spaces, even outdoor enjoyment are all values that cannot be adequately captured by the economy.

Appendices

Appendix I: Literature Review

The project takes an ecosystem services approach to determining economic value provided to the region due to the consistency of ecosystem services concepts with economic frameworks. “Ecosystem services” first entered the scientific lexicon in 1981, though its history can be traced through the writings of George Perkins Marsh and Aldo Leopold (Mooney & Ehrlich, 1997). Publications that reference ecosystem services are increasing exponentially, with more than 100 per year in the past six years (Fisher, Turner, & and Morling, 2008). Although several definitions of ecosystem services are commonly accepted (Costanza, 1997; Daily G. C., 2000 ; Fisher, Turner, & and Morling, 2008) the definition used by the Millennium Ecosystem Assessment- benefits people obtain from ecosystems- is the one most commonly used (MA, 2005). The ecosystem services concept is congruent with the services flow concept of economics, whereby goods produce value by the stream of benefits they provide (Tietenberg, 2009).

The MA classifies ecosystem services into provisioning, regulating, supporting, and cultural services (MA, 2005). Provisioning services are goods or services obtained from ecosystems, regulating services are benefits received from an ecosystem’s control of natural processes, supporting services are the natural processes that maintain the other ecosystem services, and cultural services are nonmaterial benefits received from ecosystems (MA, 2005; Layke, 2009). Despite a growing body of research on ecosystem services, the science on ecosystem services remains incomplete (Daily G. C., 2000 ; MA, 2005; National Research Council, 2005; Layke, 2009)

The social sciences are still ill-equipped to provide immediate guidance on incorporating ecosystem services into economic and policy decisions (Costanza, 1997; Fisher, Turner, & and Morling, 2008; Daily, et al., 2009) and there is a systematic failure of processes and experts that integrate natural and social sciences (National Research Council, 2005). Characteristics that make ecosystem services especially difficult to incorporate into decision-making include: spatial and temporal nonlinearity, complexity, and joint production (Fisher, Turner, & and Morling, 2008). Yet, there is an urgent need to develop the tools necessary to integrate ecosystem services into decision-making (Heal, 2000; MA, 2005; Daily, et al., 2009)

The first wave of research to integrate ecosystem services into decision making focused on economic valuation. Valuation is tool under constant development to better incorporate ecosystem services into policy and business. The purpose of developing indicators and valuation is to inform decision-making through contextualizing the value that ecosystems provide within decision-making frameworks well understood by policy makers and business leaders (Daily, et al., 2009). Although valuation of ecosystem services is a nascent science, it is rooted in foundations with a long history. Intrinsic value ascribes value to an object for its own sake and utilitarian value is value as a means to an end (National Research Council, 2005). Economic valuation falls within the realm of utilitarian value: a means towards human ends. Historically, environmentalists opposed economic valuation of ecosystems in favor of recognizing the intrinsic value of ecosystems, but proponents of economic valuation of ecosystem services argue that the intrinsic approach effectively assigns an economic value to ecosystems of zero (Costanza, 1997; Daily G. C., 2000). They argue that we make value statements about ecosystem services in the choices and decisions we make about ecological systems, and our world would look much differently if we were to incorporate the full cost of benefits humans derive from ecosystem services into the economic system (Costanza, 1997).

Unfortunately, many ecosystem services do not lend themselves well to economic valuation (Costanza, 1997; Heal, 2000; Fisher, Turner, & Morling, 2008). Several “market failures” lend themselves particularly well to describing the problem of ecosystem service valuation. The circumstance of functioning markets most often violated by ecosystems include many buyers and sellers, well-defined property rights, a homogenous product, and inclusion of all costs (no externalities). Well defined property rights, which lend themselves to a tradable market good, are typically characterized by rivalry and excludability, but many ecosystem services are non-rival and non-excludable (Costanza, 1997; Fisher, Turner, & Morling, 2008). As a result, the contribution of ecosystems to the economy and human wellbeing are grossly underrepresented in traditional methods to calculate economic value. In his seminal meta-study of the yearly value humans derive from ecosystem services, Robert Costanza estimated that ecosystem services to humanity can be valued at an average \$33 trillion dollars, or nearly twice global GDP in the year the study was performed (Costanza, 1997). Not surprisingly, he estimated that a majority of this value came from ecosystem services outside the market system, such as global gas regulation and nutrient cycling (Costanza, 1997).

Given this difficulty, valuation of ecosystem services typically falls into two categories: services that are more easily quantifiable and those that require proxies to estimate a value. Van Dis and Aylward identify four types of economic value provided by ecosystems: consumptive use values, non-consumptive use values, non-consumptive and indirect use values, or non-use values like existence, species preservation and biodiversity (Van Dis & Aylward, 2010). Direct methods to value ecosystem services include the cost of goods and services derived from ecosystems that are traded on the marketplace (Fisher et al., 2008). These goods include many of the provisioning services: food, fiber and timber, and biomass fuel. Ecosystem benefits for which methods of indirect valuation must be applied include pollination, water filtration, flood mitigation, and other services (Daily G. C., 2000 ; MA, 2005). Several tools derived from “revealed preferences” provide proxy measures of these benefits: travel costs estimate value based on how far people are willing to travel to enjoy the benefits, averting behavior infer prices from payments people make to avoid certain negative consequences of ecosystem impacts, and hedonics that infers value from price differences in marketable assets for which an ecosystem services is a critical component. Finally, people can indicate their preferences through via willingness to pay (WTP) or willingness to accept (WTA) values based on stated preferences to accept or pay for something (Daily G. C., 2000 ; Heal, 2000; National Research Council, 2005). However, even with these tools, there are still many services that cannot be quantified based on revealed preferences (National Research Council, 2005).

Good models should make explicit the costs and benefits of ecosystem services, link research with decision making, and integrate social science into decision making (Daily, et al., 2009). The National Academies advise model developers to quantify- to the extent possible- changes in the quality and quantity of an ecosystem service with respect to changes in welfare, define a clear scope that includes and excludes certain functions, services, and value, identify a spatial and temporal scale, and incorporate a relevant population (National Research Council, 2005). The Total Economic Value framework uses a checklist of potential impacts and effects on ecosystems that need to be considered when incorporating ecosystem services into decision making (National Research Council, 2005). It is within this umbrella of research to pioneer and test models to integrate ecosystem services into decision-making that our team focuses its energies.

Appendix II: Data Sources and Methods

Agriculture

Agricultural data is largely drawn from two sources: the Oregon Water Resources Department database of water rights (Oregon Water Resources Department, 2011), and the 2007 Census conducted by the US Department of Agriculture (US Department of Agriculture, 2007). Essentially, the water rights permitting withdrawal from the main stem Deschutes River are identified, sorted by the county in which the water is used, and then combined with Census data to derive the portion of agricultural activity (revenue, profit, employment and so on) attributable to the Deschutes River.

The water rights themselves are separated by the Water Resources Department into separate databases containing withdrawal rights on the one hand, and usage rights on the other. These databases were combined using the water right identifier, and some care was taken to ensure that the water was distributed to each usage location associated with the right in the same proportion to the distribution of acreage being irrigated. These were filtered to only include “NC – Non Cancelled” rights with irrigation-related codes such as “AG – Agriculture” or “IC – Primary & Supplemental Irrigation” to identify only those rights intended for primary irrigation which were active.

The resulting list of rights was filtered down to only those rights which extracted water from the main stem Deschutes River through the “source” attribute, and the county of use and section of the river from which the water is extracted was identified for each water right based on the coordinates of the township for each activity. Tributaries, including the Little Deschutes, the Crooked, and the Metolius Rivers as well as assorted wells and springs, were excluded from this analysis in order to make this section of the report consistent with the other industries studied.

This set of water rights withdrawing water directly from the Deschutes River was then summarized by county per cfs by source section of the river, and per acreage by point of use, in accordance with the information contained in the water rights themselves. The flow rates used were the “PODUseRate” (the attribute tracking actual usage, as opposed to the attribute tracking maximum withdrawal permitted, or “PODUseMaxRate”) from the point of diversion data, and the acreages used were the “Acres” attribute from the point of use data. The water flow rates arrived at through this analysis were verified using data from other sources which contained average annual and seasonal flow rates for the three sections of the river, and found to be quite accurate.

It was thus possible to determine that, for example, Jefferson County irrigates 50,425 acres of land with Deschutes River water through the withdrawal of 1,108.18 cfs from the Middle and 1.8 cfs from the Lower sections of the river.

The next step in the analysis was to determine the agriculture-based economic activity generated by the Deschutes River on a per-section of the river and per-county basis. This was accomplished through determining the proportion of total cropland per county that was irrigated by water from the Deschutes River, then applying this same proportion to the market value of crops (total and non-fruit) and other revenues from farming activities, employment information by county, and other metrics drawn from, and verified against, the USDA Census information. The only “special case” for this analysis was to exclude both the land and the revenue from a 10,279 acre area in Wasco County that is irrigated by Colombia water and is used to grow Cherry trees. These trees can only be grown in a specific area,

cannot feasibly be irrigated with Deschutes water, and are very high-value crops relative to the other crop varieties in the region so they skew the results for Wasco County if left in the analysis.

Finally, revenue was calculated on a per-cfs basis by dividing the total revenue attributable to the Deschutes River in a given county by the amount of water diverted to that county.

Continuing the earlier Jefferson County example, there are 97,191 acres of cropland of which 50,425 acres (51.9%) are irrigated by Deschutes River water. Therefore, 51.9% of the total revenue from farming (roughly \$30.8M out of \$59.4M) can be attributable to the river. Further, since there is a total of 1,109.98 cfs of water diverted to Jefferson County, farmers there are able to generate approximately \$27,778 (\$30.8M/1.1k) in revenue per cfs of Deschutes River water diverted to the county for irrigation.

Other statistics, such as jobs attributable to the Deschutes River, can similarly be determined in an absolute or per-cfs basis through applying the percent of land irrigated by the Deschutes River to the cross-county total, then divided by the amount of water diverted to the county.

Tourism and Travel Cost

Tourism data largely comes from three sources: the “Estimation of Bend, OR Visitor-Trips and Visitor-Days” (RRC Associates, 2009), the “Bend Area Visitor Intercept Survey Summer 2009 Final Results” (RRC Associates, Bend Area Visitor Intercept Survey Summer 2009 Final Results, 2010), and the “National Visitor Use Monitoring Results for the Deschutes National Forest” (USDA Forest Service, 2009). The most salient information drawn from the Visitor Intercept Survey included number of visitor-trips and visitor-days, daily mean and median per capita expenditures, activities in which tourists participated, origin of the trip, and mode of transportation. This analysis includes both the revenue directly contributed to the regional economy, and the “value” visitors place on the region as expressed through their willingness to pay to get to the Deschutes River basin.

A total direct tourism revenue estimate was made by combining visitor-days, which included low and high estimates, with daily per capita expenditures. The activities in which tourists participated involved camping, rafting/canoeing/kayaking, bird watching, fishing, the Deschutes River Trail, and Sunriver. An average of total visitors who participated in these activities was applied to the total tourism revenue to estimate the percent of river-related tourism dollars spent.

Before calculating the tourism revenue attributable to the river, the portions of this total already accounted for through river hotel revenues and recreation revenues must be deducted. The double counting of hotel revenue was estimated by determining the total number of rooms in river-hotels as a percent of total rooms in the survey, combined with the daily hotel expense reported by survey takers. Guided recreation was subtracted in its entirety from the recreation analysis results under the assumption that the vast majority of guided trips are taken by people from out of town. After the deductions, the river activity percent was applied to the remaining total to determine the tourism revenue attributable to the river.

A total travel cost estimate was derived through combining information on points of origin, modes of transportation, and prices for plane tickets, car rentals, and gas. The survey provides detailed data on the point of origin by city so that exact distances, prices for tickets to Bend, prices for rental cars, and gas prices can be used to determine the real cost of travel to Bend for 70% of visitors. The survey provides sufficient information to determine the actual number of tourists from each point of origin,

which was then applied to distance and price of gas using March 2010 averages for Oregon. More than 40% of visitors are from Oregon, and Bend's location in Central Oregon makes driving in Oregon the majority of the distance for most. Plane tickets were averaged across three different airlines for a four day trip in June 2011 for seven different points of origin. Vehicle rentals were averaged across three car rental agencies for four Oregon-based vehicles under the assumption that the majority of drivers come from within Oregon. Finally, given the proportion of tourists who used each mode of transportation (including plane + borrow car and plane + rent) and average party size, a total cost for each mode and point of origin could be estimated and summed. Applying the same river-related activity percentage to the total yields total river-related travel expenditure.

Recreation

Information on the number of people participating in each activity by month was not available for the Lower Deschutes so boater passes sold by month were used as a proxy. The number of boater passes per month for 2010 was obtained from the Bureau of Land Management. The number of boater passes was broken down into specific activities based on the Lower Deschutes Limited Entry Monitoring Project (Lindberg, 2009). Average stream flows by month found in "Instream Flow in the Deschutes Basin: Monitoring, Status and Restoration Needs" (Golden & Aylward, 2006).

For the Upper Deschutes information the number of people participating in guided activities by activity was obtained from the US Forest Service. In order to find the total number of participants it was necessary to estimate the number of non-guided people who participated in each activity. The Lower Deschutes Limited Entry Monitoring Project Final (Lindberg, 2009) provided a proxy based on the amount of guided versus non-guided recreation on the Lower Deschutes. This number was used to create a multiplier which was applied to the number of people who participated in guided recreation to find the total number of people who participated in each type of recreation activity on the Upper Deschutes by activity type.

A regression analysis was performed to identify the relationship between stream flow and participants in each recreation activity on each stretch of the river. To complete this regression, data was gathered on the number of people participating in each activity on each stretch of the river. Only the months from May through September were considered for the regression because these are the months when the vast majority of recreation takes place. This information was used as the dependent variable and a regression was completed against average stream flows by month found in Instream Flow in the Deschutes Basin: Monitoring, Status and Restoration Needs (Golden & Aylward, 2006).

The model itself uses stream flow in cfs as the only input. Stream flow must be entered separately for the upper middle and lower stretches of the river. This stream flow is multiplied by the equation given by the regression output from above. The model is constrained by the stream flow thresholds identified for each activity and for both stretches of river through interviews with OSU Cascades. This gives an output of the total expected number of participants over the course of a month if the stream flows were constantly held at that rate and the weather was appropriate for the activities (primarily the months of May through September).

Once the number of participants has been identified this number is then multiplied by a value factor which is dependent on the activity being completed. These activity values were identified by looking at the average revenue generated for each activity on the Upper Deschutes for guided activities. This

number is used as a proxy for the value of each activity on the upper, middle and lower stretches of the river and for both guided and non-guided activities.

This multiplication gives the value for each activity for both stretches. These values are aggregated to give the total monthly river recreation value based on stream flows.

Hotels

The effects of both proximity to and views of the river on Hotel revenue were determined through analysis of the results of primary research conducted between December 2010 and February 2011. The managers of 18 hotels in the area, including 11 that are adjacent to the river and 7 that are several miles from the water, were asked a series of questions including the following:

1. Peak Times: Seasons, Peak Season Events, Off-Peak Events, % of Total Revenue
2. Purpose of Visit (percent): Vacation, Business, Other
3. Party Composition (percent): Families w/ Children, Couples, Singles, Other
4. Rooms (total number of each): Single, Double, Suite, Total
5. Room Rate (price): Single (peak), Single (off-peak), Double (peak), Double (off-peak), Suite (peak), Suite (off-peak)
6. Occupancy (yearly average, percent): Winter, Spring, Summer, Fall
7. Rooms w/ River View? (yes/no)
8. Price Difference (yes/no)
9. Total Rooms (total number)
10. Higher Occupancy? (yes/no)
11. Percent (percent higher occupancy)
12. Rooms w/ Mountain View? (yes/no)
13. Price Difference (percent or dollar value)
14. Total Occupied Room Nights (percent): 2010, 2009, 2008, 2007
15. Jobs (full time/part time): Winter, Spring, Summer, Fall

Several managers declined to answer specific questions such as peak season as a percent of total revenue and yearly average occupancy for the previous four years. Single rooms were defined as rooms with a single bed, and double rooms were defined as rooms with more than one bed but without a kitchen or additional room. Suites were all rooms (single or double) with a kitchen or additional rooms. Total rooms of each type, room rates in peak and off peak season, occupancy by season, rooms with a river view and price premium, and jobs were used in the analysis. Reported peak revenues as a percent of total revenues were used to validate the accuracy of the model; the model predicted that 78% of revenue was generated during the peak season, while the average respondents reported that 75% of their annual revenue was brought in during the peak season. Due to agreements with hotel managers to encourage their participation, the data will only be shared in aggregate.

The data was used to build a model of river hotel revenues by section of the river and room type, river view room premiums, and the percent of total revenue that hotels located along the river enjoy from their river location. The model began with total number of rooms in hotels along the river (1,286) by Upper (612), Middle (632), and Lower (42) and a weighted average price charged for each type of room by season. All hotel managers agreed that June, July, and August constituted the peak season, so 92 out of 365 nights a year are peak nights. The average occupancy for each hotel was determined per section

of the river for peak and non-peak times, and the weighted average annual revenue per room was calculated by combining rate and occupancy level for peak and non-peak periods.

Once total revenue was found, three hotels adjacent to the river and three hotels several miles from it, were compared to determine the revenue differences between river and non-river hotels. The American Automobile Association Diamond Rating system was used to control for general quality and other amenities in order to isolate proximity to and views of the river, and all hotels were located in Bend and were equidistant from the city center to control for other locational benefits. The results were normalized based on revenue per-room to control for the fact that these hotels are different sizes and so have different total revenue potentials for the same occupancy and room rates. The results showed that single and double rooms within hotel type (river versus non-river) generated statistically insignificant differences in revenue, but non-river hotels had to drop prices significantly to maintain occupancy during off-peak season. Suites in three star hotels generated more revenue per room next to the river, though there are only two suites in non-river hotels. A weighted average of the total yearly revenue per room type was derived and averaged for two star and three star hotels to find that river hotels enjoy a 33.1% premium over similar non-river hotels. This proportion was converted to a percent of total revenue for river hotels to derive the total revenue generated by location along the river for hotels.

Hotel managers provided information on total rooms with river views that charged a premium (372) and the price for the premium. All hotels reported charging some premium for rooms with river view, and the average premium across all hotels with a view was \$21.90 per night. This premium was slightly higher in the region of the Upper section of the river, and lowest in the region of the Middle section of the river. They also all reported an increased occupancy for these rooms, though because only one hotel measured the actual increase the analysis only includes the increased occupancy for this one hotel so the results of the analysis on occupancy are conservative. . The same occupancy by season and section of the river which was used to estimate total revenue was combined with the sum total of the premiums and number of rooms by section to derive total revenue from premiums.

Real Estate

Real estate data is drawn from two main sources: average home sale data provide by the Central Oregon Association of Realtors (COAR) (Central Oregon Association of Realtors, 2011), and tax assessment data from Deschutes County (Deschutes County Assessor's Office, 2011). The averaged data for Central Oregon were used to calculate an approximate river premium across all properties sold in 2010, and this premium was verified by comparing the results with a more detailed analysis of 10% of the properties sold within the same period.

The COAR data includes information about number of properties sold and average sale prices, categorized by number of bedrooms. One report was for the entire market, and a second report was for homes with river views only. From these, the number of homes and average sale price for homes without a river view was calculated. Of the 3340 homes sold in Central Oregon in 2010, 66 reportedly had a view of the river. The premium paid for these river view properties was determined by calculating the percent markup for the average home sale price per property size for homes with and without a river view, and multiplying by the number of river view homes sold.

This result was verified using data from the Deschutes County Assessor's Office. The tax assessment data includes "physical attribute" information about the property, including number of bedrooms,

bathrooms, and other rooms, lot size, home size, address, most recent sale and sale price and so on. However, the tax assessor data does not contain any “aesthetic attribute” information such as proximity to downtown Bend, mountain views, or river views. Therefore, the addresses from the assessor data were used in a search of publically available real estate websites such as zillow.com, in conjunction with map and GIS data, to determine which of these properties was likely to have a full or partial river view. Approximately 10% of the properties sold in Deschutes County were analyzed to this level of depth, and the river view premium for these homes was found to be a similar but slightly smaller percentage than was found using the COAR data for all of Central Oregon.

It is presumed that the effect of a river view in more remote areas is more pronounced than the effect of a river view in more populous areas such as the city of Bend, and it is therefore expected that the average premium for all of Central Oregon would be somewhat higher than the average premium for the Bend area alone. Therefore, the results received using the COAR data seem reasonable given the verification performed using assessor data.

Commercial Salmon

Commercial Salmon data provide absolute numbers for salmon using the “Annual Report of the Exploitation of Rate Analysis and Model Calibration” of the Pacific Salmon Commission Joint Chinook Technical Committee (PSC, 2009). The data track fall Chinook runs up the Columbia River since 1971 to provide a very accurate estimate of fall Chinook salmon, but as the only resource it leaves gaps in other fish species and runs. The data track salmon run size, Bonneville Dam Chinook counts, and catch by tribes, commercial fishing, and sport fishing. Data were selected from 1996-2008, the last year of complete tracking, to provide the most up-to-date recent historical trends. Since the data begin with six years of steady runs followed by significant increases that peaked in 2004 and dropped to below historic levels in 2007, three estimates of fish population were included. The first uses the 1996-2008 average as a historical benchmark and is the value reported in the study. The second takes a midpoint average between the historic and peak to approximate populations under a moderate rebuilding scenario. The third assumes a long-term population rebuilding in which peaks become more frequent. By way of reference, the 2010 fall run was especially large.

Chinook salmon is one of the most valuable species for fresh and frozen consumption and nearly 99% of consumption occurs in one of these two forms, the study assumed average retail sale values to estimate prices (Knapp, Roheim, & Anderson, 2007). Chinook historic wholesale prices average \$2.41 and retail markups are estimated at 60% for an average retail price of \$6.02. An additional 1.7% of catch by volume is also sold as higher-value roe at \$32.21 per pound. Tribes are assumed to sell 50% of their catch at a price of \$5 per pound and consume the rest.

Jobs

The first step in finding job and wage numbers was finding sources for each industries job numbers. For agriculture the source was the US department of agriculture. The hotels job numbers are from the Economic Development for Central Oregon (EDCO) group’s report on 2009 Business and workforce. This number was multiplied by a river factor of 23%. Recreation job numbers were found by taking the number of jobs and establishments in the EDCO report for entertainment and recreation. Based on interviews with the US Forest Service and independent research it was found that there were approximately 42 recreation establishments in this region. This meant that recreation establishments made up 22% of the establishments in the entertainment and recreation category. This 22% was

multiplied by the total jobs in the category to find the number of recreation jobs in the region. Tourism jobs were taken from 2008 EDCO report, then both hotels and recreation were subtracted to avoid double counting. After this the number was multiplied by a river factor of 16%. Wage numbers were found in the ECDD regional analyst report. The number for recreation was multiplied by 5/12 because recreation jobs generally last for 5 months per year.

Scenarios Modeling

Each of the individual industry analyses produced a set of relationships between industry activities and the value provided to the Central Oregon economy as a result of those activities. The analysis also revealed drivers of value (number of visitors, access to the river, etc) for each of these industries.

Through additional research and analysis, those drivers were all linked back to in-stream and diverted flow rates for the Upper, Middle, and Lower sections of the Deschutes river. This enabled an overarching economic model to be developed which predicted a “river contribution” to the Central Oregon economy as a function of the flow rates of the Deschutes River. River flow rates were then adjusted within the model to reflect anticipated flow rates for the various scenarios explored.

While this model is ultimately an approximation based on the relationships that exist today, and while it does have some limitations (for example, it does not account for long term additive effects such as the potential for an increase in rafting revenue from increased visitors due to word-of-mouth marketing effects if the river is managed to improve the experience of rafting participants), it does offer a perspective on the overall effect of the Deschutes River on the Central Oregon economy.

Appendix III: Models and Results

Models are available upon request and included as Excel documents in the material submitted to the School of Natural Resources and Environment on April 19, 2010.

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