RECLAMATION

Managing Water in the West

Economic Impacts of Drought on Recreation and Irrigated Agriculture

Upper Red River Basin Study

Technical Memorandum

U.S Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

May 2018

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Executive Summary

Altus Lake and Tom Steed Reservoir are two important water resources located in the Upper Red River Basin that have been affected by drought in recent years. Altus Lake supports recreational and educational activities at Quartz Mountain Arts & Conference Center and Quartz Mountain Nature Park. Releases from Altus Lake supports irrigated crop production in the Lugert-Altus Irrigation District. Tom Steed Reservoir supports recreational activities at Great Plains State Park.

The purpose of this analysis is to evaluate the effect of changes in reservoir levels and water deliveries at Altus Lake and Tom Steed Reservoir on recreational benefits, irrigation benefits associated with irrigation water deliveries to project lands within the Lugert-Altus Irrigation District, and regional economic activity in the Upper Red River Basin. Economic benefits are different than regional economic impacts in that benefits are a measure of the value of a good or service to society as a whole while regional economic impacts are a measure of impact to a specific region.

Recreation activity in these areas are influenced by conditions at the reservoirs located adjacent to the parks. This analysis provides an evaluation of the estimated impacts of changing reservoir levels and storage at Altus and Tom Steed Reservoir on recreation visitation and irrigated agricultural output as well as the associated impacts on recreational benefits, agricultural benefits, and regional economic activity. This analysis can be used to help evaluate the effects of drought on recreational activity and agricultural output, the potential benefits from mitigating drought conditions, and the regional economic effects of drought.

The impact of changes in reservoir elevation on recreation at three recreation facilities are evaluated through the estimation of visitation models for each site. Separate models are estimated for the eight month period from March through October (recreation season) and the four month period from November through February (winter season). It is expected that the types of recreation activities that take place during the winter season and the recreation season will react differently to changes in lake elevation. Six recreation participation models are estimated for three recreation sites.

The impact of changes in lake elevation on irrigation water deliveries is based on a simple model of historic irrigation releases as a function of lake elevation, precipitation, and temperature. Irrigation releases are modeled for the months June through September, when the vast majority of irrigation releases occur. There were minor May releases in 2007 and 2011 and these small releases were added to June releases for these two years.

The recreation visitation models are used to evaluate the magnitude of impacts associated with variables that influence recreation activity. The visitation models are the core of the recreation analysis. The variables included in the recreation visitation models are reservoir level, the climatic factors precipitation and temperature, dummy variables for different months of the year, household income, and a cost of travel index. The visitation models are estimated using historical July 2000 to November 2016 monthly visitation data at the three sites, end of month reservoir elevation data, average monthly climatic data, and average monthly data for income and travel cost. Recreation visitation data were only available on a monthly basis. It is acknowledged that monthly models will not account for variation in the above variables that could occur within each month. However, using data from a relatively long period of time compensates somewhat for intra-month variation.

The irrigation release model is not a hydrologic model that accounts for the effects of all variables that influence irrigation releases. However, the model can be used to translate changes in reservoir elevation to changes in irrigation releases based on historic variation. This is similar to the recreation visitation models that convert changes in reservoir elevation to changes in visitation. The change in irrigation releases are then used to estimate changes in irrigation supply benefits.

The change in recreation and irrigation supply benefits associated with changes in visitation and irrigation deliveries requires estimation of the economic value of recreation activities and crop production in the area. Data are not available to estimate site specific economic values for recreation at each site. Therefore, the benefit values associated with recreation in the study area are based on estimates from previously completed analyses that represent similar recreation activities and experiences at Great Plains State Park and Quartz Mountain Nature Park and Lodge. Irrigation benefit values were obtained from a Bureau of Reclamation 2015 Altus Dam Safety of Dams, Irrigation Benefits Technical Report (Altus Safety of Dams Report).

The regional impacts from recreation are estimated using estimated changes in recreation spending per visit as inputs into the IMPLAN (IMPact analysis for PLANning) model. Irrigation related regional impacts are based on the gross value of crop outputs per acre-foot of water delivered, which are input into the IMPLAN model.

Modeling Results

Recreation modeling results indicate reservoir elevation has a significant impact on recreation visitation during recreation season months at all of the three recreation sites evaluated. However, reservoir elevation does not have a significant impact on visitation during the winter season months. This reservoir elevation result was expected. Temperature was significant and positive, as expected, at all sites and for all seasons except for Quartz Mountain Nature Park during the recreation season. Temperature has a positive but insignificant impact for Quartz Mountain Nature Park.

The variable representing higher than normal precipitation was statistically significant for only Quartz Mountain Lodge during the winter season. The income variable was not statistically significant in the models except for the Quartz Mountain Nature Park winter season and Quartz Mountain Lodge during the recreation season. Finally, the cost index representing the relative cost of travel was significant and negative, as expected, for both Great Plains State Park models and was significant but positive for the Quartz Mountain Lodge winter season. The cost index variable was statistically insignificant for the other three models.

The calculated F-statistics from the estimated recreation models indicate the overall modelling results are statistically significant. In other words, the explanatory variables as a group explain a significant portion of the variation in recreation visitation for all six models. The independent variables in the recreation models explained 52.4% to 68.2% of the total observed visitation variation. The reservoir elevation variable is consistently significant and positive as expected. The estimated impact of a 1 foot change in reservoir elevation on visitation holding all other independent variables constant is summarized in Table ES-1. The visitation numbers and percentages shown in Table ES-1 include only those months, March through October, where the estimated recreation models indicated reservoir elevation had a statistically significant impact on visitation.

Table ES-1 - Estimated changes in visitation from a 1 foot change in elevation

Recreation Site	**Average annual March to October Visitation**	**Estimated average change in March to October visitation from a one foot change in elevation**	**Change in March to October visitation from a one foot change in elevation**
Great Plains State Park	99,184	1,482	1.49%
Quartz Mountain Park	6,664	159	2.39%
Quartz Mountain Lodge	12,383	81	0.65%

The modeling results shown in Table ES-1 above represent long term visitation relationships on a monthly basis and therefore cannot be used to precisely predict visitation for a specific month. For example, a one-foot decrease in elevation at Tom Steed Reservoir over the March to October recreation season would be expected to decrease visitation by 1,482 visits on average, or about 185 visits per month. However, the actual observed change in visitation from a one foot change in elevation during any particular month during the recreation season could be very different than 185 visits. There may be no change or a very large change during any particular month. But on average over many years a one foot change in reservoir elevation would be expected to change visitation by 185 visits per month and by 1,482 visits over the recreation season.

It should also be noted that the models do not account for all of the factors that influence visitation and the possible lagged effects of recreation site conditions over time. These factors also affect the accuracy of visitation estimates for a specific month. As a result, an evaluation of the effects of construction or management options on recreation is based on a comparison of the long term effects of different options on reservoir elevations and visitation.

The irrigation release modeling results indicate reservoir elevation has a positive influence on irrigation releases to the Lugert-Altus Irrigation District. It is estimated that on average a one foot change in reservoir elevation corresponds with an average of 396 acre-feet of releases per month during the irrigation season. Assuming a four month irrigation season, a one foot change in lake elevation translates into a total change in releases of 1,584 acre-feet for the entire irrigation season. According to the U.S. Department of Agriculture (USDA) Risk Management Agency (2017), an average of 65,390 acre-feet of irrigation water were released annually from Lake Altus over the 1995 to 2010 period and 43,363 acre-feet reached the fields in the Lugert-Altus Irrigation District. This translates into an average efficiency of 66.3 percent, so a one foot change in reservoir elevation translates into a change in irrigation deliveries of about 1,050 acre-feet during the irrigation season.

The Altus Safety of Dams Report estimated that there are 47,841 irrigated acres in the Lugert-Altus Irrigation District and an average of 76,197 acre-feet of irrigation deliveries, which is an average of 1.59 acre-feet of water per irrigated acre during the irrigation season. Therefore, a one foot change in reservoir elevation translates into an equivalent change in irrigated acreage of about 660 irrigated acres, which is approximately 1.38% of total irrigated acreage in the Lugert-Altus Irrigation District.

Economic Benefits Associated with a Change in Reservoir Elevation and Water Supply

Estimates of changes in recreation visitation and irrigation water supply deliveries associated with a one foot change in reservoir elevation are combined with the estimated economic value and expenditures associated with recreation and irrigated agricultural production to evaluate the economic benefits and regional impacts resulting from the change. The change in benefits and regional impacts are compared to historic average baseline levels of recreation at Great Plains State Park, Quartz Mountain Nature Park, and Quartz Mountain Lodge and historic baseline levels of irrigated crop production in the Lugert-Altus Irrigation District to understand the magnitude of impacts.

Total estimated annual recreation visitation over the period for which data were provided, from July 2000 to December 2016, was 112,059 visits to Great Plains State Park, 15,713 visits to Quartz Mountain Lodge, and 7,067 visits to Quartz

Mountain Park. Day use visitation at Great Plains State Park is estimated to represent about 81.5% of Great Plains State Park visitation and the remaining 18.5% are overnight trips. Visitation at Quartz Mountain Nature Park and Quartz Mountain Lodge are assumed to be overnight trips. The average value of recreation in this analysis is estimated to be $60 per trip for multiple day/overnight trips and $20 per day for day use visits. The multiple day/overnight benefits per visit for Quartz Mountain Nature Park are assumed to be the same as the estimated benefits per visit at Great Plains State Park given the similarity of activities at the two sites. Camping rates at Quartz Mountain Nature Park range from $10.00 to $24.00 per night depending on the type of camping (tent or RV), location, and amenities of the site and camping rates at Great Plains State Park range from $20.00 to $30.00 per night, with an average of about $22.00 per night. The similarity of rates suggests a similar type of experience is being purchased.

The estimated average annual benefits of recreation at Great Plains State Park based on average annual visitation and the distribution of day use and multiple day visitation described above are approximately $3.07 million annually. A total of $1.24 million in benefits are attributable to overnight stays and $1.83 million are attributable to day use visits. Using a value of $60 per visit and annual average visitation of 7,067 visits for Quartz Mountain Nature Park and 15,712 visits for Quartz Mountain Lodge, recreation benefits to Quartz Mountain Nature Park and Lodge are estimated to be $1.37 million annually. Total estimated annual recreation benefits at all three sites combined is $4.44 million.

The benefits from visiting Quartz Mountain Lodge could be different than the benefits from visiting Great Plains State Park and Quartz Mountain Nature Park because of the difference in accommodations. The average cost of staying at the Quartz Mountain Lodge, based on data from January of 2010 to December of 2016, was $82.17 per night compared to $10 to $30 per night at Great Plains State Park and Quartz Mountain Nature Park. The higher price paid by those staying at the Lodge could indicate Lodge recreation generates higher benefits per visit than at Great Plains State Park or Quartz Mountain Nature Park. However, the relevant benefit measure is net benefit, which reflects total benefit in excess of what is paid to participate in the activity. A lodging price that is 3 to 8 times higher than the price of camping does not necessarily mean the net benefit of lodging above the price paid would be 3 to 8 times higher than the net benefit of camping. Therefore it is assumed that the net benefit of staying at the Quartz Mountain Lodge and Nature Park is the same overnight value of $60 per visit used for other non-day use recreation activities at Great Plains State Park.

The estimated change in recreation visitation from a one foot change in elevation is estimated to be about 1,482 visits (1,191 day use visits and 291 overnight visits) annually for Great Plains State Park, 159 visits each year for Quartz Mount Nature Park, and 81 visits per year for Quartz Mountain Lodge. This translates into a change in net recreation benefits of $41,300 for Great Plains State Park, $9,500 annually for Quartz Mountain Nature Park, and $4,900 for Quartz

Mountain Lodge. The total change in recreation benefits for all three sites combined is $55,700 annually. This represents approximately 1.27 percent of estimated annual recreation benefits for all three recreation areas combined.

The Altus Safety of Dams Report estimated that there are 47,841 irrigated acres in the Lugert-Altus Irrigation District and the total benefits associated with a full irrigation supply were estimated to be about $5.06 million annually in 2013 dollars, or $5.21 million in 2016 dollars using the Consumer Price Index to index 2013 values to 2016. The Report also estimated an irrigation requirement equal to 1.59 acre-feet per acre. Assuming application of 1.59 acre-feet per acre of irrigation water, irrigation benefits are estimated to be approximately $68.50 per acre-foot delivered in 2016 dollars. The results of the irrigation release model indicated a one foot change in reservoir elevation would lead to a 1,053 acre-feet change in deliveries. Therefore, a one foot change in reservoir elevation would result in a change in irrigation benefits of about $72,100 annually. This is approximately 1.38 percent of total estimated annual irrigation benefits assuming average annual deliveries of 76,197 acre-feet.

Regional Economic Impacts Associated with a Change in Reservoir Elevation and Water Supply

The regional impacts associated with recreation activities are generated through recreation expenditures within the study region by visitors originating from outside the region and the regional impacts from agricultural production are the result of crop sales. It is assumed that all crop sales represent purchases by entities from outside the study region. The estimated average annual recreation expenditures within the region for transportation, food, lodging, and other miscellaneous expenditures are $4.72 million for Great Plains State Park visitation, $0.59 million for Quartz Mountain Nature Park visitation, and $2.60 million for Quartz Mountain Lodge visitation. The change in annual recreation expenditures associated with a one foot change in reservoir elevation was estimated to be about $63,400 for Great Plains State Park, $10,700 for Quartz Mountain Nature Park, and $17,000 for Quartz Mountain Nature Lodge. Total revenues from irrigated crop production in the Lugert-Altus Irrigation District are estimated to be $39.84 million annually. The estimated change in crop revenues from a one foot change in reservoir elevation are estimated to be a little over $566,000 annually.

Recreation expenditures and crop sales generate regional economic impacts through three different types of effects: direct, indirect, and induced. Direct effects represent impacts on the industry that is immediately affected. For example, if recreation visitation increases as a result of higher lake levels, then the amount of recreation services demanded would increase and more inputs would be needed to meet that demand. The direct effect would be the increase in income and employment needed to satisfy increased demand for recreation services.

Indirect effects account for transactions between different sectors. If the recreation service industry expanded in the region to satisfy increased demand, then the recreation service industry will increase demand for locally produced materials and labor to produce recreation services. The result is additional jobs and income created to meet new recreation industry demand. Induced effects measure the effects of the changes in household income resulting from direct and indirect effects on demand for goods and services such as housing, restaurants, and retail sales. Regional impacts are generally measured in terms of employment, income, and the value of output produced.

The IMPLAN (impact analysis for planning) model is used in this analysis to estimate regional economic impacts. The IMPLAN Model translates changes in final demand into impacts on regional output, income, and employment. Final demand is represented by demand for recreation related goods and services and demand for crop production. The regional economic impacts associated with recreation activity at the three recreation sites are estimated to be $7.28 million in regional output, $2.09 million in labor income, and 103 jobs. A one foot change in elevation is estimated to have an $82,400 impact on the value of output, $23,900 impact on labor income, and a labor impact of 1.3 jobs. The regional economic impacts associated with irrigated crop production in the Lugert-Altus Irrigation District are estimated to be $57.38 million in regional output, $26.61 million in labor income, and a little over 450 jobs. A one foot change in elevation is estimated to have a $0.79 million impact on the value of output, $0.35 million impact on labor income, and a labor impact of 6.3 jobs.

The economic benefits and regional economic impacts for recreation and irrigated crop production are summarized in Tables ES-2 and ES-3.

Table ES-2 – Estimated recreation benefits and regional impacts associated with a one foot change in reservoir elevation

	Visitation			**Recreation Benefits**	**Recreation Regional Impacts**	
Recreation Area	**Average Annual Visitation (2000-2016)**	**Change in visitation for a one foot change in elevation**	**Percentage change in recreation season visitation for a one foot change in elevation**	**Change in recreation value from a one foot change in elevation**	**Change in Recreation Spending from a one foot change in elevation**	**Change in the value of regional output from a one foot change in elevation**
Great Plains State Park	**112,059**	**1,482**	**1.32%**	**$41,200**	**$63,400**	**$54,000**
Quartz Mountain Nature Park and Lodge	**22,780**	**240**	**1.05%**	**$14,400**	**$27,700**	**$28,400**

Table ES-3 – Estimated irrigation benefits and regional impacts associated with a one foot change in reservoir elevation

	Irrigation Deliveries			Irrigation benefits	Irrigation Regional Impacts	
Agricultural Area	Average irrigated acreage (acres)	Change in irrigated acreage for a one foot change in elevation (acres)	Percentage change in irrigated acreage for a one foot change in elevation	Change in irrigation benefits from a one foot change in elevation	Change in gross agricultural revenues from a one foot change in elevation	Change in the value of regional output from a one foot change in elevation
Lugert – Altus Irrigation District	**47,841**	**660 acres**	**1.38%**	**$72,100**	**$566,000**	**$794,000**

In order to better understand the potential impact of drought on recreation activity, historical monthly average elevations at Altus Reservoir and Tom Steed Reservoir were compared to monthly average elevations over the 2010 to 2013 period, which was a period of drought. The difference in elevation was calculated as the difference in weighted monthly elevation, where the weight is based on the percentage of total recreation visitation that occurs each month during the March to October recreation season.

The weighted average difference in elevation during the drought years 2010 to 2013 compared to other years is 9.83 feet for Altus Reservoir and 3.02 feet for Tom Steed Reservoir. The estimated loss of recreation benefits during the 2010 to 2013 drought period are $266,300 annually and the estimated reduction in recreation related expenditures are $464,300 annually. Reduced expenditures translates into a loss of 6.6 jobs, a $126,000 loss in labor income, and a reduced value of output of $442,300 annually. These results indicate substantial recreation losses as a result of drought conditions.

A community profile for the Altus region by the Altus Southwest Area Economic Development Corporation (2018) indicates there are two major contributors to economic growth and stability in the region, Altus Air Force Base and the agricultural industry. Altus Air Force Base has a significant impact on the regional economy as a result of expenditures, employment, and income associated with the Base. Although this analysis is an evaluation of the economic impacts of water supply conditions on activities in the region and is not an evaluation of the Base in particular on the regional economy, it is important to recognize the economic impacts of Altus Air Force Base operations on the region and potential impacts of water supply shortages that would threaten the viability of Base operations.

A Fiscal Year 2016 Altus Air Force Base Economic Impact Statement (Altus Air Force Base, 2018) indicated that there was a total of 3,164 military personnel and dependents and 1,507 civilian personnel associated with the Air Base. Total construction and operations expenditures on the Air Base were a little over $60.8 million and total payroll was about $230.6 million. A 2011 report evaluating the economic impact of five Oklahoma military installations, including Altus Air Force Base (Oklahoma Department of Commerce and The State Chamber of Oklahoma, 2011), indicated an annual employment impact of about 7,500 jobs over the 2011 to 2015 time period. A more up to date 2017 report by the Oklahoma Aeronautics Commission, estimated that the Altus Air Force Base directly and indirectly accounts for nearly 8,890 jobs per year in the region. Assuming an employment-population ratio of 1.674 people per employed person, which is a national average obtained from the Federal Reserve Economic Data database, the Altus Air Force Base accounts for about 14,900 people in the region. The study area includes five counties: Caddo, Comanche, Jackson, Greer, and Kiowa Counties. In 2017 the total population of these counties was 190,560. Therefore, the population associated with Altus Air Force Base represents approximately 7.8% of the total study area population.

The analysis of recreation impacts estimated that about 4.2% of total recreation visitation at Great Plains State Park and Quartz Mountain Nature Park and Lodge are from the five county study region. Therefore, if the Altus Air Force Base related population was no longer in the region this would represent a 0.33% loss in recreation visitation. Average visitation at all three recreation sites is estimated to be 134,839 annually, so a 0.33% decrease in visitation represents an average reduction of 445 recreation visits per year. This would represent a loss in regional economic activity in addition to the loss of jobs an income described above.

Introduction and Background

Altus Lake and Tom Steed Reservoir are two important water resources located in the Upper Red River Basin that have been affected by drought in recent years. Altus Lake supports recreational and educational activities at Quartz Mountain Arts & Conference Center and Quartz Mountain Nature Park. Releases from Altus Lake provides water for irrigated crop production in the Lugert-Altus Irrigation District. Tom Steed Reservoir supports recreational activities at Great Plains State Park.

The purpose of this analysis is to evaluate the effect of changes in reservoir levels and water deliveries at Altus Lake and Tom Steed Reservoir on recreational benefits, irrigation benefits associated with irrigation water deliveries to project lands within the Lugert-Altus Irrigation District, and regional economic activity in the Upper Red River Basin. Economic benefits are different than regional economic impacts in that benefits are a measure of the value of a good or service to society as a whole while regional economic impacts are a measure of income, output, and employment impacts on a specific region. This analysis can be used to help evaluate the effects of drought as reflected by changes in reservoir levels and storage on recreational activity and agricultural output, the potential benefits from mitigating drought conditions, and regional economic effects. The important role of Altus Air Force Base in the regional economy is also described, reflecting the importance of insuring a reliable water supply for the Base.

Regional Economy

A community profile for the Altus region by the Altus Southwest Area Economic Development Corporation (2018) indicates there are two major contributors to economic growth and stability in the region, Altus Air Force Base and the agricultural industry. Wheat, cattle, and cotton are important agricultural products produced in the area. Jackson County, which includes Altus, is the highest cotton producing county in Oklahoma. For the purposes of this analysis the study area includes five counties: Caddo, Comanche, Jackson, Greer, and Kiowa Counties. More detail regarding the choice of counties used for this analysis is presented in the Regional Impact Analysis section.

According to an Altus Air Force Base Economic Impact Statement for Fiscal Year 2016 (Altus Air Base Impact Statement), as of January 2017 there were 3,164 total military and dependents and 1,507 civilian personnel associated with the Air Base (Altus Air Force Base, 2018). The Altus Air Base Impact Statement also indicated that total construction and operations expenditures on the Air Base were a little over $60.8 million and total payroll was about $230.6 million.

A 2011 report evaluating the economic impact of five Oklahoma military installations, including Altus Air Force Base (Oklahoma Department of

Commerce and The State Chamber of Oklahoma, 2011), indicated an annual employment impact of about 7,500 jobs over the 2011 to 2015 time period. A more up to date 2017 report by the Oklahoma Aeronautics Commission, estimated that the Altus Air Force Base directly and indirectly accounts for nearly 8,890 jobs per year in the region.

As indicated by the Altus Southwest Area Economic Development Corporation, Agricultural production is an important part of the regional economy. County level data for the market value of agricultural products sold in the study area were obtained from the 2012 Census of Agriculture (USDA, 2014) and are summarized below in Table 1. The 2012 Census of Agriculture is the most recent county level agricultural market value data available. The data show that agricultural related sales in 2012 were valued at nearly $340 million.

Table 1 – Study area market value of agricultural products sold

County	Total Market Value of Agricultural Products Sold (1,000's)	Market Value of Crop Products Sold (1,000's)	Market Value of Livestock Products Sold (1,000's)
Caddo	$128,882	$60,383	$68,499
Comanche	$47,373	$17,002	$30,372
Greer	$32,709	$20,105	$12,604
Jackson	$53,154	$41,847	$11,307
Kiowa	$107,805	$63,668	$44,137
Total	**$369,923**	**$203,005**	**$166,919**

Crop acreage data are available for 2016 and livestock production data are available for 2017 from the United States Department of Agriculture, National Agricultural Statistics Service (USDA, NASS, 2017). Harvested crop acreage and beef cattle numbers are shown in Table 2. Crop acreage data were not available for all of the study site counties. Wheat and cotton, respectively, represent the first and second greatest crop acreages in the region and there were nearly 300,000 head of beef cattle in the five county region.

Table 2 – Study area harvested crop acreage and number of cattle

County	Cotton acreage (2016)	Alfalfa hay acreage (2016)	Other hay acreage (2016)	Wheat acreage (2016)	Beef Cattle Head (2017)
Caddo	12,400	4,300	50,000	112,000	110,000
Comanche	-	-	42,600	43,000	67,000
Greer	12,600	1,400	14,700	51,000	27,000
Jackson	96,000	-	-	149,000	25,000
Kiowa	-	-		168,000	65,000

Additional population, labor force, and occupation data presented in Tables 3 and 4 illustrate the importance of agricultural production as well as recreation related activities to the regional economy. The importance of recreation activities to the region is described in more detail in the Regional Impact Analysis section. The

Table 3 – Study area population and labor force

County	2016 Population	2016 households	Population 16 years of age or older	Population in labor force	Civilian Labor force
Caddo	29,510	10,368	22,917	12,414	12,405
Comanche	124,583	42,929	97,520	63,100	53,950
Greer	6,081	2,107	5,079	2,367	2,367
Jackson	25,864	10,151	19,628	12,586	11,419
Kiowa	9,239	3,956	7,309	4,259	4,240
Total	**195,277**	**69,511**	**152,453**	**94,726**	**84,381**

Table 4 – Study area employment for agricultural and recreation related sectors

County	Employment in the agriculture, forestry, fishing and hunting, and mining sector	Ranking of agricultural sector employment	Employment in arts, entertainment, recreation, and accommodation and food services	Ranking of arts, entertainment, recreation, and accommodation and food services sector employment	Employment of top ranked sector
Caddo	1,508	2nd	1,285	3rd	2,228
Comanche	1,020	11th	5,085	4th	11,537
Greer	301	2nd	238	4th	497
Jackson	683	6th	954	4th	2,561
Kiowa	522	2nd	281	6th	1,015
Total	**4,034**	**-**	**7,843**	-	**17,838**

agricultural and recreation sectors are both heavily dependent on water as an input to production.

The top ranked employment sector for all five study area counties is the educational services, health care and social assistance sector. The data presented in Tables 3 and 4 does not create a complete picture of the impact agricultural production has on the local economy. Direct employment in the agriculture, forestry, fishing and hunting, and mining sector has indirect impacts on other sectors. Inputs are needed to support agricultural production and recreation activities and income from agricultural and recreation service jobs is spent in other sectors of the economy. Therefore, the 4,034 jobs shown in Table 4 for agriculture, forestry, fishing and hunting, and mining jobs and the 7,843 jobs shown for arts, entertainment, recreation, and accommodation and food services sector jobs understate the actual impact of these sectors on the regional economy.

Recreation

The recreation portion of this analysis includes Great Plains State Park, Quartz Mountain Nature Park, and Quartz Mountain Lodge. Great Plains State Park is located south of Hobart in Kiowa County, Oklahoma on the eastern shore of Tom Steed Reservoir. The park covers a little over 480 acres and includes trails for mountain biking and hiking, boulder fields for rock climbing, and is the site of an abandoned mine. Recreation resources at Tom Steed Reservoir include over 30 miles of shoreline, a beach area, boat ramps, and developed camping and picnicking areas. Recreation activities include swimming, fishing, water-skiing, camping, picnicking, hiking, and sight-seeing. The campground includes 34 tent sites and 56 RV sites, some with sewer, water and electricity hookups. Facilities at the Park also include comfort stations, a bait shop, and playgrounds.

Quartz Mountain State Park was one of the first seven designated Oklahoma state parks. The Park was operated by the Oklahoma Tourism and Recreation Department, Division of State Parks until 2002, when operations were transferred to the Oklahoma State Regents for Higher Education and the Park was renamed Quartz Mountain Nature Park and Quartz Mountain Resort, Arts & Conference Center (Quartz Mountain Lodge). The Park and Lodge includes nearly 4,300 acres of land and over 6,000 surface water acres. Facilities at the Park and Lodge include a 122 room lodge, 8 cabins, a dormitory, restaurant, 5 campgrounds with a total of 214 sites, 7 comfort stations (4 with showers), a swimming pool, a golf course, and a seasonal fun park. Additional recreational activities include boating, hiking, and a 50 acre riding area for four-wheelers.

The impact of changes in reservoir elevation on recreation at the three recreation facilities are evaluated through the estimation of visitation models for each site. Separate models are estimated for the eight month period from March through October (which is referred to as the recreation season) and the four month period from November through February (winter season). It is expected that the types of recreation activities that take place during the recreation season and the winter season will react differently to changes in lake elevation. Six recreation participation models are estimated for three recreation sites.

The recreation visitation models are used to evaluate the magnitude of impacts associated with variables that influence recreation activity. The visitation models are the core of the recreation analysis. The variables included in the visitation models are reservoir level, monthly precipitation, average monthly temperature, dummy variables for different months of the year, median household income, and a cost of travel index. The visitation models are estimated using historical July 2000 to November 2016 monthly visitation data at the three sites, end of month reservoir elevation data, average monthly temperature and precipitation data, and average monthly data for income and the cost of travel. Recreation visitation data were only available on a monthly basis. It is acknowledged that monthly models will not account for variation in the above variables that could occur within each month.

Irrigated Agriculture

The Lugert-Altus Irrigation District receives water from Altus Reservoir through about 30 miles of main canal running from the lake to just south of Altus and approximately 300 miles of smaller canals and laterals that supply the water to individual farms. Rainfall in the Lugert–Altus Irrigation District area is sufficient to grow crops with fairly good yields. However, there is a high potential for drought in the area. Supplemental irrigation supplies provide protection against drought and allows more diversified agricultural production. Cotton is the major irrigated crop in the District. Other crops include wheat, alfalfa, grain sorghum, and specialty crops such as potatoes and onions. Average crop yields presented in the 2015 Altus Dam Safety of Dams, Irrigation Benefits Technical Report were 1.23 tons per acre for wheat, 1,110 pounds per acre for cotton, and 0.8 tons per acre for cotton seed.

The impact of changes in reservoir elevation on irrigation water deliveries is based on a simple model of historic irrigation releases as a function of lake elevation, precipitation, and temperature. Irrigation releases are modeled for the months June through September, when the vast majority of irrigation releases occur. There were minor May releases in 2007 and 2011 and these small releases were added to June releases for these two years of irrigation release data. The results of the model are combined with irrigation efficiency estimates obtained from a Bureau of Reclamation 2015 Altus Dam Safety of Dams, Irrigation Benefits Technical Report (Altus Safety of Dams Report) and information from the U.S. Department of Agriculture (USDA) Risk Management Agency (2017) to estimate changes in irrigation water deliveries.

The irrigation release model is not a hydrologic model that accounts for the effects of all variables that influence irrigation releases. However, the model can be used to translate changes in reservoir elevation to changes in irrigation releases based on historic variation. This is similar to the recreation visitation models that convert changes in reservoir elevation to changes in visitation. The change in irrigation releases are then used to as the basis for estimating changes in irrigation supply benefits.

Economic Benefits and Regional Economic Impacts from Recreation and Irrigated Agriculture

The change in recreation and irrigation supply benefits associated with changes in visitation and irrigation deliveries requires estimation of the economic value of recreation activities and crop production in the area. Data are not available to estimate site specific economic values for recreation at each site. Therefore, the benefit values associated with recreation in the study area are based on estimates from previously completed analyses that represent similar recreation activities and experiences at Great Plains State Park and Quartz Mountain Nature Park and Lodge. Irrigation benefit values were obtained from the Altus Safety of Dams Report.

The regional impacts from recreation are estimated using estimated changes in recreation spending per visit as inputs into the IMPLAN (IMPact analysis for PLANning) model. Irrigation related regional impacts are based on the gross value of crop outputs per acre-foot of water delivered, which are input into the IMPLAN model.

Impacts of Lake Elevation on Recreation Visitation

It is generally assumed that a decline in lake water levels translates into a decrease in lake recreation visitation (Cordell and Bergstrom, 1993; Platt and Munger, 1999; Jakus, et al., Hanson et al. 2002). It is also generally believed that a decrease in lake elevation will have an adverse effect on the value of recreation (Platt and Munger, 1999). The extent to which changes in lake elevation influences visitation and value depends on the physical characteristics of the lake, the ability to gain access to and use facilities at different lake levels, the baseline lake elevation, the types of recreation at the site, and the availability of substitute sites.

Site-specific studies estimating the relationship between lake elevation and visitation, such as Bergstrom et al. (1996) and Allen et al. (1996), are based on visitor survey data. Using site specific survey data allows an analyst to estimate changes in recreation participation (visitation) and recreational quality (value) as water levels change. However, this level of data collection and statistical analysis is not possible for a reconnaissance level analysis such as this basin study.

Platt and Munger (1999) evaluated methods that can be used to evaluate the effect of fluctuating lake levels on recreation visitation and value. Approaches were reviewed which have a wide range of data requirements and estimation accuracy. Three methods were discussed by Platt and Munger (1999) that use existing data and information for changes in lake elevation to estimate potential recreation impacts. These methods include:

- Ratio method, which is based on the assumption that visitation will change by the same proportion as lake elevation or surface area,

- Facilities or resource access method, which is based on thresholds where a facility such as a marina or boat launch are no longer usable so visitation associated with that facility becomes zero,

- Statistical recreational use estimation models, which are annual or monthly visitation models that include lake elevation and other explanatory variables.

The most rigorous of the methods that do not require primary data acquisition is the statistical use modeling approach. Monthly visitation data are available for the three recreation areas, lake level data are available for Altus Lake and Tom

Steed Reservoir, and climate and socio-economic data are available for the study area. Therefore, the monthly visitation approach is used in this analysis to evaluate the impact of changes in lake elevation and other factors on visitation at Great Plains State Park and Quartz Mountain Lodge and Nature Park.

It is very likely that the impact of a change in lake elevation on visitation, both in absolute terms and in terms of the percentage change in visitation, will be very different during the recreation season (defined in this analysis as the months March through October) than during the winter season (November through February). This is due primarily to the different types and characteristics of recreation activities in the winter compared to the warmer recreation season months. Recreation during the winter months is less likely to be tied to lake conditions, so lake elevation is likely to be a less important component of the decision to participate in recreation activities. As a result, separate recreation models are estimated for the recreation season and the winter season.

Monthly visitation data for Great Plains State Park for the years 2000 through 2016 were obtained from the Oklahoma Tourism and Recreation Department, Division of State Parks. Visitation data from July 2000 to June 2006 included information on the number of out of state visitors, day use visitors, and camp sites rented. After June 2006 only total visitation and camp site rental data were provided. Sales data for rooms and park facility tickets at Quartz Mountain Lodge and Quartz Mountain Nature Park were provided by the Lodge General Manager and the Park Manager for the period from January 2010 to December 2016. Monthly average visitation at Great Plains State Park, Quartz Mountain Lodge, and Quartz Mountain Nature Park are shown in Table 5.

Table 5 – Estimated Great Plains State Park and Quartz Mountain visitation

Month	Great Plains State Park	Quartz Mountain Lodge	Quartz Mountain Park
January	2,228	628	74
February	2,600	861	80
March	8,015	1,339	480
April	10,916	1,217	644
May	21,849	1,296	1,130
June	20,074	2,536	1,442
July	10,848	1,872	1,256
August	10,881	1,402	680
September	9,466	1,234	529
October	7,135	1,488	503
November	5,003	1,116	219
December	3,044	724	30
Total	**112,059**	**15,713**	**7,067**

Great Plains State Park out of state visitation data from July 2000 to June 2006 indicates about 18.16% of total visitation to the State Park originated from out of state. The percentage of visitors from out-of-state changed over the 2000 to 2006 period and varied by month. There was a general decreasing trend of out-of-state visitation as a percentage of total visitation to Great Plains State Park from 2000 through 2006, as is shown in Table 6.

Table 6 – Percentage of out of state visitation for Great Plains State Park

Year	Percentage of visitation from out of state
2000	27.91%
2001	21.96%
2002	20.34%
2003	15.74%
2004	14.23%
2005	13.85%
2006	13.08%
Average	**18.16%**

Recreation Visitation Modeling

Recreation visitation models represent the relationship between the factors that influence the level of recreation participation at a site and the number of recreation visits. It is recognized that every variable which influences recreation cannot be included in a visitation model, the estimated model needs to include the most important variables that influence visitation in order to provide reliable estimates of the influence of important variables on visitation. If important variables are missing, then the explanatory power of the model will be greatly reduced and the resulting estimates of the influence of lake elevation on visitation may be biased.

Potential explanatory variables discussed in Platt and Munger (1999) include water level, water quality, climate variables such as temperature and precipitation, whether or not school is in session as an indicator of the vacation season, and socio-economic variables such as population and income. A study of the influence of water levels on recreational use at Lakes Mead and Powell (Neher, Duffield, and Patterson; 2013) included reservoir volumes during the summer, reservoir volume during the shoulder months (the months between peak and off-peak seasons), monthly regional gasoline prices, months where the U.S. economy was officially in a recession, indicators for critical lake levels that impact recreation, and dummy month variables representing the summer season and shoulder months. Climate variables were not included in the models estimated by Neher, Duffield, and Patterson (2013). The monthly dummies were included to represent different characteristics during each month, which could include climatic variation. It was noted in the lakes Mead and Powell study that most studies use lake elevation rather than volume as an explanatory variable for visitation. However, near perfect correlation between volume and elevation at Lakes Mead and Powel allow using either variable to estimate visitation and would produce nearly identical results.

The explanatory variables included in the Platt and Munger (1999) and the Neher, Duffield, and Patterson (2013) studies were used as a basis for the variables included in the Great Plains State Park and Quartz Mountain Lodge and Nature Park visitation models. It is recognized that all of the variables that could influence recreation cannot be included in the estimated model due to unavailability of some data. However, the goal is to capture the most important variables so a statistically significant model can be estimated which explains a relatively large portion of the variation in visitation. The theoretical models applied to both reservoirs and three recreation sites are shown below.

Great Plains Models:
Visitation = *f* (Lake Elevation, Temperature, Wet Month, Income, Month Dummies, Cost Index for Gasoline and Time)

Quartz Mountain Lodge and Nature Park Models:
Visitation = *f* (Lake Elevation, Temperature, Wet Month, Income, Price, Month Dummies)

The only difference between the two theoretical models is the inclusion of a specific price variable for the Quartz Mountain Lodge and Park models and a general cost of travel variable for the Great Plains State Park models. Recreation visitation price data were not available by type and date of visit for the Great Plains State Park, so a generic cost of travel variable (Cost Index for Gasoline and Time) was used as a proxy for price. However, monthly revenue data are available for Quartz Mountain Nature Park and Lodge so an individual proxy visitation price can be included in these models.

The lake elevation explanatory variable is the decision variable of interest which could potentially be varied through operational changes or facility modifications. It is expected that lake elevation will have a much larger and significant impact on visitation during the recreation season months compared to the winter season. Another important variable that influences visitation is the price of participating in recreation activities. Although price is not explicitly considered as a decision variable in this analysis, it should be noted that potential impacts could be at least partially mitigated by changes in price. The other explanatory variables included in the model are exogenous to the model, meaning that they are imposed on the system and cannot be modified or controlled within the system under consideration. For example, household income cannot be influenced by decisions made regarding reservoir and park operations. However, the exogenous variables would be expected to have an impact on visitation so they need to be included in the model.

A missing variable that could potentially have an effect on the model estimates is the population of the region from where visitors originate. A greater population would translate into greater demand and higher visitation. Annual estimates of the Oklahoma state population were considered for inclusion in the model. However, the population variable was discarded because population was increasing over the data period so it simply becomes a trend variable that is ultimately not statistically significant. The variables included in the visitation model are discussed below. The data used to estimate the models are presented in Appendix A.

Visitation

The dependent variable in the visitation models is monthly visitation. Monthly visitation data from July 2000 through November 2016 were obtained from the Oklahoma Tourism and Recreation Department, Division of State Parks. From July 2000 to June 2006 visitation data included total visitation, out of state visitation, day use visits and campsite rentals. From July 2006 on only total visitation and campsite rental data were provided. In order to use all of the available data and maintain a consistent data set for estimating the visitation models, total visitation was used as the dependent variable.

Lake Elevation

Lake elevation was the primary explanatory variable of interest because it represents a variable that can be influenced by operating policies and decisions. Estimating a statistically significant model of the influence of lake elevation on visitation would enable an analyst to be able to estimate the impact of operational changes that influence water levels on visitation. It is expected that lake elevation would have a positive impact on visitation, assuming that a higher elevation results in greater surface area and improved aesthetics (easier access, reduced mudflats, etc.). End of month forebay elevation data were obtained for Altus Reservoir and Tom Steed Reservoir from Bureau of Reclamation Hydromet monthly value data.

Temperature

The temperature variable would generally be expected to have a positive influence on visitation, except possibly when temperatures are high enough to discourage participation in lake related recreation. However, through the relevant range of temperature on an average monthly basis higher temperature would translate into greater recreation. Monthly average temperature data were obtained from the National Oceanographic and Atmospheric Administration National Centers for Environmental Information Climate Data Online Search web site. The stations used for climactic data were Altus Dam, Oklahoma for Quartz Mountain Nature Park and Lodge and Hobart, Oklahoma for Great Plains State Park.

Wet Month

Precipitation is accounted for in the model through a variable that compares observed monthly precipitation relative to the monthly average. This is a dummy variable that is equal to one if monthly precipitation is greater than the average for the month and is equal to zero otherwise. Generally, higher levels of precipitation would be expected to have a negative effect on visitation.

The relationship between precipitation and visitation is not necessarily a simple direct relationship. For example, it is possible that a month that typically has a large amount of precipitation is also a month for which other characteristics draw people to the area. Therefore, it is hypothesized that dryer than normal months would tend to attract more visitors than wetter than normal months and the variable would be expected to have a negative effect on visitation. Monthly precipitation data were obtained from the National Oceanographic and Atmospheric Administration National Centers for Environmental Information Climate Data Online Search web site for the same stations discussed in the temperature section above.

Income

For a normal good income has a positive effect of the quantity of the good or service purchased because the income constraint to purchasing a good or service is reduced as income increases. For this model it would generally be expected that an increase in income would increase visitation. However, it is possible that an increase in income could translate into a shift from staying at a lake to more luxurious accommodations or to visit more exotic locations. The income variable used in the models is based on median household income for the State of Oklahoma as reported in the United States Census American Community Survey.

Month Dummy

The month dummy variable is included to account for basic non-climatic differences in the characteristics of recreation activities and recreation participants from month to month. For example, summer months are traditional vacation months so visitation would be expected to be higher during June, July, and August compared to other months all other things being equal. Some activities are in season only during specific times of the year, which could be accounted for by the month dummy. This type of dummy variable is referred to as an intercept dummy, which means that a value of 1 leads to a parallel shift of the visitation function but does not affect the slope of the function.

Cost Index for Gasoline and Time

The purpose of this cost index is to represent a price of participating in recreation activities at Great Plains State Park. Two major categories of costs associated with recreation participation are gasoline and time spent getting to and coming back from a visit to the site. Retail regular grade gasoline prices in the Midwest region (which includes Oklahoma) over the 2000 to 2016 period was obtained from the Energy Information Administration (2017). Gasoline costs are based on monthly prices for all grades of conventional retail gasoline for the Midwest area. The conventional gasoline category does not include reformulated gasoline blendstock for oxygenate blending, such as fuel ethanol. Monthly retail prices were converted from nominal into real prices using the Consumer Price Index.

The real gasoline prices were then normalized relative to the highest gasoline cost over the data period.

The cost index for time was based on per capita personal income estimates for Oklahoma from the Department of Commerce, Bureau of Economic Analysis. The per capita income estimates were indexed to 2016 using the Consumer Price index and then divided by 2,080 hours to represent a proxy for average hourly wage. The hourly wage was then divided by 3 to represent the opportunity cost of time (the value of time that could not be spent doing something else). The 1/3 of wage value is frequently used in recreation studies to value time (Cesario, 1976). The real cost of time was then normalized for each year relative to the highest cost of time over the data period. The gasoline and time indexes were then averaged to get an index for gasoline and time. It is assumed that the two costs have the same influence on the cost of accessing recreation.

Price

A specific own price variable was included in the Quartz Mountain Nature Park and Quartz Mountain Lodge models. The influence of own price is distinct from the cost of traveling to and from the recreation site and should ideally be included in all of the recreation models. However, representative price data for all types of recreation were not available for Great Plains State Park. The price of a good or service will typically have a negative effect on the quantity purchased of a good or service. A proxy for price at Quartz Mountain Nature Park and Lodge was calculated as the revenue generated during a specific month divided by the number of tickets sold.

Recreation Visitation Modeling and Results

The models used to evaluate recreation visitation at Great Plains State Park are shown below. lnVisitsSeas is the model used for recreation season months and lnVisitsWinter is the model used for winter season months.

$$lnVisitsSeas = \beta_0 + \beta_1\, lnElev + \beta_2\, Temp + \beta_3\, Wetmonth + \beta_4\, lnInc + \beta_5\, March + \beta_6\, April + \beta_7\, May + \beta_8\, June + \beta_9\, July + \beta_{10}\, August + \beta_{11}\, Cost + \varepsilon_0$$

$$lnVisitsWinter = \beta_0 + \beta_1\, lnElev + \beta_2\, Temp + \beta_3\, Wetmonth + \beta_4\, lnInc + \beta_5\, December + \beta_6\, January + \beta_6\, Cost + \varepsilon_0$$

Where:

β_0	= Constant term
lnVisitsSeas	= Natural log of monthly visits at Great Plains State Park during the March through October months.
lnVisitsWinter	= Natural log of monthly visits at Great Plains State Park during the November through February months.
lnElev	= Natural log of monthly average lake elevation.
Temp	= Average monthly temperature.
Wetmonth	= A dummy variable equal to 1 when precipitation was greater than the monthly average and 0 when less than or equal to the monthly average.

lnInc	= Natural log of median household income for Oklahoma.
March	= Dummy variable equal to 1 for March visitation, equal to zero otherwise.
April	= Dummy variable equal to 1 for April visitation, equal to zero otherwise.
May	= Dummy variable equal to 1 for May visitation, equal to zero otherwise.
June	= Dummy variable equal to 1 for June visitation, equal to zero otherwise.
July	= Dummy variable equal to 1 for July visitation, equal to zero otherwise.
August	= Dummy variable equal to 1 for August visitation, equal to zero otherwise.
December	= Dummy variable equal to 1 for December visitation, equal to zero otherwise.
January	= Dummy variable equal to 1 for January visitation, equal to zero otherwise.
Cost	= A combined index based on real gasoline prices and real wages in Oklahoma.
ε_0	= Classic error term.

The models used to evaluate recreation visitation at Quartz Mountain Nature Park and Quartz Mountain Lodge are shown below. $\text{lnVisitsSeas}_{\text{PARK}}$ is the model used for Quartz Mountain Nature Park during the recreation season, $\text{lnVisitsSeas}_{\text{LODGE}}$ is the model used for Quartz Mountain Lodge during the recreation season, $\text{lnVisitsWinter}_{\text{PARK}}$ is the model used for Quartz Mountain Nature Park during the winter season, and $\text{lnVisitsWinter}_{\text{LODGE}}$ is the model used for Quartz Mountain Lodge during the winter season.

$$\text{lnVisitsSeas}_{\text{PARK}} = \beta_0 + \beta_1 \text{ lnElev} + \beta_2 \text{ Temp} + \beta_3 \text{ Wetmonth} + \beta_4 \text{ lnInc} + \beta_5 \text{ lnRev/Sale} + \beta_6 \text{ March} + \beta_7 \text{ April} + \beta_8 \text{ May} + \beta_9 \text{ June} + \beta_{10} \text{ July} + \beta_{11} \text{ August} + \beta_{12} \text{ Cost} + \varepsilon_0$$

$$\text{lnVisitsSeas}_{\text{LODGE}} = \beta_0 + \beta_1 \text{ lnElev} + \beta_2 \text{ Temp} + \beta_3 \text{ Wetmonth} + \beta_4 \text{ lnInc} + \beta_5 \text{ lnRev/Sale} + \beta_6 \text{ July} + \beta_7 \text{ August} + \beta_8 \text{ Cost} + \varepsilon_0$$

$$\text{lnVisitsWinter}_{\text{PARK}} = \beta_0 + \beta_1 \text{ lnElev} + \beta_2 \text{ Temp} + \beta_3 \text{ Wetmonth} + \beta_4 \text{ lnInc} + \beta_5 \text{ lnRev/Sale} + \beta_6 \text{ December} + \beta_7 \text{ January} + \beta_8 \text{ Cost} + \varepsilon_0$$

$$\text{lnVisitsWinter}_{\text{LODGE}} = \beta_0 + \beta_1 \text{ lnElev} + \beta_2 \text{ Temp} + \beta_3 \text{ Wetmonth} + \beta_4 \text{ lnInc} + \beta_5 \text{ lnRev/Sale} + \beta_6 \text{ December} + \beta_7 \text{ January} + \beta_8 \text{ Cost} + \varepsilon_0$$

Where:

β_0	= Constant term
$\text{lnVisitsSeas}_{\text{PARK}}$	= Natural log of monthly visits to Quartz Mountain Nature Park during the March through October months.
$\text{lnVisitsSeas}_{\text{LODGE}}$	= Natural log of monthly visits to Quartz Mountain Lodge during the March through October months.
lnVisitsWinter	= Natural log of monthly visits to Quartz Mountain Nature Park or Quartz Mountain Lodge during the November through February months.
lnElev	= Natural log of monthly average lake elevation.
Temp	= Average monthly temperature.
Wetmonth	= A dummy variable equal to 1 when precipitation was greater than the monthly average and 0 when less than or equal to the monthly average.
lnInc	= Natural log of median household income for the state of Oklahoma.
lnRev/Sale	= Natural log of revenues reported by the Lodge or Park manager divided by the number of park entrances or rooms sold.
July	= Dummy variable equal to 1 for July visitation, equal to zero otherwise.
August	= Dummy variable equal to 1 for August visitation, equal to zero otherwise.

December	= Dummy variable equal to 1 for December visitation, equal to zero otherwise.
January	= Dummy variable equal to 1 for January visitation, equal to zero otherwise.
Cost	= A combined index based on real gasoline prices and real wages in Oklahoma.
ε_0	= Classic error term.

The constant term can be interpreted as the number of visits that would occur if all of the explanatory variables included in the model were equal to zero, which is not likely to occur. The error term accounts for the fact that the model will not be able to explain all of the variation in visitation.
The dependent variable visits and the explanatory variables representing elevation and income are converted into natural logs. This is a common functional form used to estimate recreation visitation models and the estimated coefficient for lake elevation represents the percentage change in visitation for a one percent change in lake elevation. Therefore, using this functional form the influence of elevation on visitation is constant for all elevations. This assumption may not be accurate for extreme elevations, but is likely to be reasonable for the relevant range of elevations experienced at the recreation areas over the data period.

The models used to estimate the impact of water levels on recreational use is very similar to other recreation models, such as a study of recreational use at lakes Mead and Powell (Neher, Duffield, and Patterson; 2013). In the lakes Mead and Powell study dummy variables were included in the model to account for monthly variation in visitation independent of lake elevation and other explanatory variables. As described in Neher, Duffield, and Patterson (2013), monthly dummy variables can capture the expected variation in participation as a result of changes in elevation during different months. For example, in July the demand for recreation facilities may be very high and leading to a relatively small change in visitation even if lake elevation is low. Similarly, low lake levels in September may have a relatively large impact on visitation because other activities may be substituted for recreation during less desirable recreation months. At any rate, the response to changes in lake elevation would be expected to vary by month.

The regression models were run for the above visitation models using Stata Statistics/Data Analysis Version 14 econometric software and the data described above and presented in Appendix A. The modeling results for Great Plains State Park are shown in Table 7 and Table 8, the results for Quartz Mountain Nature Park are shown in Table 9 and Table 10, and the results for Quartz Mountain Lodge are shown in Table 11 and Table 12.

Table 7 – Great Plains State Park Recreation Season Regression Results

Explanatory Variable	Coefficient	t-statistic	Corrected t-statistic
CONSTANT	-138.4053	-	-
LN ELEVATION	22.1777	2.38**	2.40**
TEMP	0.0142	2.20**	2.38**
WET MONTH	0.0598	1.01	1.09
LN INCOME	-1.2384	-1.03	-1.15
MARCH	0.3358	2.25**	2.57**
APRIL	0.4540	4.12*	4.41*
MAY	1.0430	10.92*	14.89*
JUNE	0.8009	6.72*	7.32*
JULY	0.0739	0.55	0.57
AUGUST	-0.0701	-0.53	-0.50
COST INDEX FOR GAS AND TIME	-1.3956	-6.28*	-6.20*
Adjusted R – Squared = 0.682	F – Statistic = 58.41*		
Durbin – Watson Statistic = 1.525	Number of observations = 124		

* significant at the 1% level

** significant at the 5% level

Table 8 – Great Plains State Park Winter Regression Results

Explanatory Variable	Coefficient	t-statistic	Corrected t-statistic
CONSTANT	167.5389	-	-
LN ELEVATION	-20.3430	-1.37	-1.12
TEMP	0.3579	3.62*	3.37*
WET MONTH	-0.0807	-0.83	-0.80
LN INCOME	-1.0777	-0.55	-0.50
DECEMBER	-0.0306	-0.25	-0.33
JANUARY	-0.2460	-1.95***	-1.93***
COST INDEX FOR GAS AND TIME	-2.5275	-7.35*	-7.17*
Adjusted R – Squared = 0.597	F – Statistic = 13.68*		
Durbin – Watson Statistic = 1.640	Number of observations = 61		

* significant at the 1% level

** significant at the 5% level

*** significant at the 10% level

Table 9 – Quartz Mountain Nature Park Recreation Season Regression Results

Explanatory Variable	Coefficient	t-statistic	Corrected t-statistic
CONSTANT	-260.5806	-	-
LN ELEVATION	36.9497	4.48*	4.33*
TEMP	0.0077	0.67	0.63
WET MONTH	0.0424	0.31	0.32
LN INCOME	-0.2191	-0.10	-0.10
lnREVENUE/SALE	-0.8709	-1.83***	-1.72***
MARCH	0.0517	0.19	0.20
APRIL	0.1138	0.58	0.74
MAY	0.3394	1.93***	1.50
JUNE	0.7239	3.35*	3.44*
JULY	0.5112	2.06**	2.06**
AUGUST	0.0269	0.11	0.11
Adjusted R – Squared = 0.618	F – Statistic = 9.10*		
Durbin – Watson Statistic = 1.236	Number of observations = 56		

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level

Table 10 – Quartz Mountain Nature Park Winter Season Regression Results

Explanatory Variable	Coefficient	t-statistic	Corrected t-statistic
CONSTANT	-554.2132	-	-
LN ELEVATION	40.9313	1.11	1.03
TEMP	0.1071	2.31**	2.43**
WET MONTH	0.4796	1.12	1.66
LN INCOME	23.7661	2.82**	2.61**
lnREVENUE/SALE	-0.7119	-0.99	-1.36
DECEMBER	-0.7960	-1.46	-1.16
JANUARY	0.2830	0.49	0.40
Adjusted R – Squared = 0.565	F – Statistic = 6.00*		
Durbin – Watson Statistic = 1.992	Number of observations = 28		

* significant at the 1% level
** significant at the 5% level

Table 11 – Quartz Mountain Lodge Recreation Season Regression Results

Explanatory Variable	Coefficient	t-statistic	Corrected t-statistic
CONSTANT	-9.6322	-	-
LN ELEVATION	10.5936	2.02**	1.89***
TEMP	0.0098	2.76*	2.78*
WET MONTH	-0.0701	-0.96	-0.96
LN INCOME	-5.3323	-4.12*	-4.10*
lnREVENUE/SALE	-0.9604	-5.73*	-5.34*
JULY	0.4287	3.21*	3.35*
AUGUST	0.0539	0.43	0.40
Adjusted R – Squared = 0.586	F – Statistic = 10.46*		
Durbin – Watson Statistic = 1.193	Number of observations = 56		

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level

Table 12 – Quartz Mountain Lodge Winter Season Regression Results

Explanatory Variable	Coefficient	t-statistic	Corrected t-statistic
CONSTANT	25.0353	-	-
LN ELEVATION	2.9404	0.29	0.29
TEMP	0.0233	1.80***	2.03***
WET MONTH	0.3082	2.52**	3.03*
LN INCOME	-3.3267	-1.25	-1.62
lnREVENUE/SALE	-1.2193	-2.31**	-1.89***
DECEMBER	-0.1245	-0.84	-1.37
JANUARY	-0.2830	-1.77***	-1.72***
Adjusted R – Squared = 0.524	F – Statistic = 5.24*		
Durbin – Watson Statistic = 1.678	Number of observations = 28		

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level

The coefficient estimates in the above tables indicate the effect of each explanatory variable on the natural log of monthly visitation. The t-statistics indicate the extent to which the estimated coefficient is statistically different from zero for each explanatory variable. A lower percentage of significance indicates a greater level of significance from zero. For example, significance at the 1 percent level represents a greater level of statistical significance than significance at the 10 percent level. No asterisks for the t-statistics in the above tables indicate the estimated coefficient is not significantly different from zero. The t-statistic used to evaluate the models is the t-statistic corrected for serial correlation or for heteroskedasticity depending on the potential econometric problem detected, which is described in Appendix B.

The overall fit and statistical significance of the overall model is evaluated using the adjusted R^2 and the F-statistic. The adjusted R^2, or coefficient of determination, indicates the percentage of variation in the dependent variable (natural log of visits) that is explained by the model. For the three recreation season models estimated in this analysis the adjusted R^2 values range from 0.586 to 0.682, which means 58.6 percent to 68.2 percent of the variation in visitation is explained by the models. These are good results for this type of recreation model using aggregated monthly data. As expected, the winter models explained less of the variation in visitation, with adjusted R^2 values ranging from 0.524 to 0.597. The F-statistics indicated all of the models as a whole are statistically significant at the 1 percent level.

The winter season models were much less robust than the recreation season models. Relatively few of the winter season explanatory variables were statistically significant compared to the recreation season models. Reservoir elevation is statistically significant for all three of the recreation season equations but is not statistically significant in any of the three winter season models. This was an expected result given that the types of recreation experienced during the recreation season would be more directly influenced by reservoir levels than typical winter recreation activities.

The price (cost) of recreation visitation, measured as the travel cost index for Great Plains State Park or as the average cost of staying at Quartz Mountain Nature Park and Lodge, is a statistically significant variable and has the expected sign for five of the six estimated models. The only model where the price variable was not statistically significant is the winter Quartz Mountain Nature Park model. Given that the prices variables used in each model is a proxy for price rather than an actual traditional market price, the insignificant price variable in the winter Quartz Mountain Nature Park model may be due to a poor proxy variable for price or it may be that other variables are much more important than price in determining recreation visitation at that location in the winter.

The temperature variable was also significant and the sign of the coefficient was the expected positive value in five of the six models. Temperature was not significant for the Quartz Mountain Nature Park recreation season model. The wet month variable indicating actual precipitation is greater than historical average precipitation for a particular month was not significantly different from zero for five of the six estimated models. The only model for which the wet month variable was significant was the Quartz Mountain Lodge winter season model. However, the wet month coefficient in the Quartz Mountain Lodge winter season model was of the wrong sign. An average monthly precipitation variable was also tried for each model, but average monthly precipitation was statistically insignificant. One possible explanation is that the decision to recreate at a site is made prior to the occurrence of precipitation, so precipitation may not actually influence the original visitation decision. It is also possible that precipitation does not interfere with important recreation activities.

Income was found to be significantly different from zero in only two of the six models and had the correct positive sign in only the Quartz Mountain Nature Park winter season model (income had a negative sign for the Quartz Mountain Lodge recreation season model). It is possible that recreational activities at Quartz Mountain Nature Park in the winter represent a “normal good” where higher income results in greater participation while recreational activities at Quartz Mountain Lodge during the recreation season are an “inferior good.” An “inferior good” is a substitute for more expensive goods and when income increases households purchase more of the expensive good and less of the “inferior good.” Another possibility is that there is multicollinearity between the cost index for gas and time and income which is causing insignificant t-statistics and/or an incorrect coefficient sign. It is important to remember that multicollinearity does not cause biased estimates. Given the unexpected result for the income variable, it seems likely that the aggregated income data is not an accurate representation of income for those visiting Quartz Mountain Lodge.

The wet month variable in the Quartz Mountain Lodge winter season model was significant but had an unexpected positive sign. It could be argued that the wet month variable for the Quartz Mountain Lodge winter season model should be positive since winter precipitation would be snow and could represent a positive experience. If this is the case, then the coefficient for the wet month variable would have a positive sign.

An important result of the modeling runs is that the elevation coefficient is statistically significant and positive for all of the recreation season models indicating higher lake elevation corresponds with greater levels of recreation, but was not significantly different from zero for the winter season models. As a result, the discussion below focuses on the results of the recreation season models. It is assumed that elevation changes during the winter months will have no significant impact on visitation. Using the regression results presented in Table 7, Table 9, and Table 11 the change in recreation visitation associated with changes in reservoir elevation can be estimated. These estimates are presented in the following section.

Predicting the Impact of Changes in Reservoir Elevation on Visitation

The estimated coefficients for reservoir elevation in each of the estimated visitation models represents the impact of elevation on visitation, holding all of the other variables that influence visitation constant. The coefficient estimates for the natural log of elevation variable in the recreation season models was 22.18 for Great Plains State Park, 36.95 for Quartz Mountain Nature Park, and 10.59 for Quartz Mountain Lodge. Since the visitation and elevation variables were converted into natural logs, the coefficient estimates can be interpreted as percentage changes in recreation for a 1% change in elevation. So, for Great Plains State Park a 1% change in elevation results in a 22.18% change in visitation, a 1% change in elevation at Quartz Mountain Nature Park leads to a 36.95% change in visitation, and a 1% change in elevation for Quartz Mountain Lodge leads to a 10.59% change in visitation. Although these percentages changes appear to be very large, it should be noted that a 1% change in elevation represent a very large change in elevation, approximately 15 feet for Lake Altus and 14 feet for Tom Steed Reservoir. Based on historical variation in lake levels, a 1% change in elevation would represent a major change in reservoir level that would be expected to have a large impact on visitation.

The ability of the visitation models to predict visitation for a specific month is limited and subject to error for several reasons. First, 17 years of historical data are used to estimate each model. Therefore, the model represents the visitation relationship over a fairly long period of time during which considerable variation can occur during any one year. Second, the models are not perfect and do not account for all of the factors that influence visitation. Therefore, important influences that may have a large impact on visitation during some months may not be taken into account. Last, recreational experiences influenced by good or bad conditions during one visit may linger over time even though conditions change over time. For example, if an individual goes to a site when the reservoir level is high and conditions are good they may continue to visit the site during poor conditions with the hope or expectation that conditions will be good again.

As a result of these limitations, visitation projections based on different reservoir elevations resulting from a range of construction or management options for a specific month may not be very accurate. A better approach for evaluating construction or management options would be to compare the long term effects of different options on reservoir elevations. For example, if it is estimated that one option could increase reservoir elevation by an average of one foot in July over a 50 year planning period compared to a baseline condition, then the visitation model could be used to estimate the difference in visitation over the long term. It would be recognized that July visitation with the option during any one year could be higher or lower than predicted.

Based on the modeling results, a change in elevation of 1 foot during the March to October recreation season for Great Plains State Park will lead to an average change in visitation of 1,482 visits during the recreation season compared to baseline average elevation. For Quartz Mountain Nature Park, a 1 foot change in elevation will lead to an average change in recreation season visitation of 159 visits and for Quartz Mountain Lodge a 1 foot elevation change will results in a change of 81 visits. Estimated changes in visitation from a 1 foot change in reservoir elevation are summarized in Table 13.

Table 13 – Estimated changes in visitation from a 1 foot change in lake elevation

Recreation Site	Average annual March to October Visitation	Estimated average change in March to October visitation from a one foot change in elevation	Change in March to October visitation from a one foot change in elevation
Great Plains State Park	99,184	1,482	1.49%
Quartz Mountain Park	6,664	159	2.39%
Quartz Mountain Lodge	12,383	81	0.65%

The Value of Recreation

Site specific data such as visitor origin data are not available to evaluate the change in the value of a recreation visit at different lake elevations. Therefore, previously completed studies that provide estimates of the value of similar recreation activities are used to estimate the economic benefit of recreation at Great Plains State Park, Quartz Mountain Nature Park, and Quartz Mountain Lodge and to estimate the value of changes in visitation due to changes in reservoir elevation. The use of results from previously completed studies to estimate benefits is called benefits transfer.

The accuracy of benefits-transfer based estimates depends on the similarity of recreation at the site where the original detailed analysis was completed and the site of interest where the transferred benefits are applied. Similarity can be defined in terms of economic conditions, population characteristics, resources within an area, or other characteristics. Application of the benefit transfer method assumes that the relationship between a resource improvement and economic value in one area can be estimated and applied to another geographic area or resource.

For this analysis it is assumed that the value of a recreation visit is the same at different elevations. However, it should be recognized that a visit to a lake at a higher elevation is likely to have a greater value than a visit to a lake at a lower elevation. The use of benefits transfer represents a potential source of error in the estimation of the change in recreation benefits resulting from a change in reservoir level.

A database of recreation use values is maintained by the Oregon State University College of Forestry (2017). The database contains over 3,000 individual recreation estimates for 21 different types of recreation from over 350 economic valuation studies over the 1958 to 2016 period. The latest website version is dated November 1, 2016. The estimates are measures of net WTP or consumer surplus for recreational access to specific sites or for activities in broader geographic areas. The database includes 21 recreation value estimates for Oklahoma from 7 studies over the 1987 to 2003 time period, so they are somewhat dated studies. A total of 13 of the value estimates are for fishing, 5 are for hunting, and 3 are for wildlife viewing. The estimated values, in 2010 dollars, range from $22.16 to $127.22 per day. The highest value is based on a 1993 travel cost model for fishing. It should be noted that most of the estimated values had a fairly large confidence interval, which represents the range of values which contain the true value of a variable based on a given level of significance. Some of the estimated values have very wide confidence intervals while others are much narrower.

Two recent studies published by the Oklahoma Cooperative Extension Service and a third study published in Lake and Reservoir Management provide more up to date estimates of recreation values at various Oklahoma lakes that are applicable to Great Plains State Park and Quartz Mountain Lodge and Nature Park. Melstrom, et al. (2015) used fishing trip survey data collected by the Oklahoma Department of Wildlife Conservation from 780 randomly selected fishing license holders in Oklahoma combined with individual recreation site characteristic data to estimate a lake visitation model. The survey asked about fishing participation, location of participation, species preferences, and other visitation characteristics. Additional data were collected related to site characteristics for 148 Oklahoma lakes, including water quality data. The demand analysis was combined with a travel cost model to estimate the value of a fishing trip. Melstrom, et al. estimated a value of $59.58 per sportfishing trip to Tom Steed Reservoir and a value of $59.47 per sportfishing trip to Altus City Reservoir. The study estimated a narrow range of sportfishing values for 148 individual lakes, ranging from $59.47 to $62.36 per individual per trip. The study by Melstrom, et al. also provides estimates of recreation spending on transportation, lodging and food, and fishing costs which will be useful for estimating regional impacts associated with recreation.

Boyer, et al. (2015) provided a summary of studies estimating Oklahoma recreation values. The summarized studies included Fort Cobb Lake in Southwestern Oklahoma and several recreation sites on the Illinois River in Eastern Oklahoma. Fort Cobb Lake is most applicable to the Upper Red River study area. The estimated recreation value was $60 per trip and $18 per visitor day for Fort Cobb Lake.

Boyer, Melstrom, and Sanders (2017) estimated a model evaluating the impact of water levels and climate variation on monthly recreational visitation as well as a second model estimating the economic value of a trip to Fort Cobb State Park. The valuation model estimated an economic value of $60 per trip and $20 per day. This result combined with the narrow range of recreational benefits estimated in Melstrom, et al. (2015) supports the use of a recreation value of $60 per trip and $20 per day for recreation associated with Altus Lake and Tom Steed Reservoir. Recreational benefits are different for overnight trips than for day use trips. This is addressed by applying the $20 per day estimate to the estimated number of day use visits and applying the $60 per visit value to all remaining non day use visits.

The estimated number of day use visitors was available for each Oklahoma State Park from Oklahoma Tourism and Recreation Department data from July 2000 to June 2006. These data are used to estimate the percentage of total recreation visits that are represented by day use activities. The results are summarized below in Table 14 and Table 15.

Table 14 - Estimated average monthly day use and overnight visitation for Great Plains State Park

Month	Great Plains State Park		
	Total Use	**Overnight Use**	**Day Use**
Recreation Season			
March	8,015	465	7,550
April	10,916	5,382	5,534
May	21,849	2,753	19,096
June	20,074	2,529	17,545
July	10,848	2,864	7,984
August	10,881	2,220	8,661
September	9,466	1,140	8,326
October	7,135	2,190	4,945
Recreation Season Total	**99,184**	**19,543**	**79,641**
Winter Season	2,228	91	2,137
January	2,600	648	1,952
February	5,003	316	4,687
November	3,044	121	2,923
December	**12,875**	**1,176**	**11,699**
Winter Season Total			
Total All Months	**112,059**	**20,719**	**91,340**

Table 15 – Estimated day use and overnight use recreation visitation

Recreation Area	**Average annual visitation**	**Day use as a percentage of total use**	**Estimated average annual day use**	**Overnight use as a percentage of total use**	**Estimated annual average overnight use**
Great Plains State Park	112,059	81.5 percent	91,340	18.5 percent	20,719
Quartz Mountain Park	7,067	0 percent	0	100 percent	7,067
Quartz Mountain Lodge	15,712	0 percent	0	100 percent	15,712

Using the estimated number of visits presented in Table 10, average annual recreation benefits can estimated. Based on benefits of $60 per user per visit for overnight trips and $20 per user per visit for day trips, the average benefit from recreation at Great Plains State Park over the July 2000 to November 2016 period was about $3.07 million annually. Approximately $1.24 million is attributable to overnight stays and $1.83 million is attributable to day use visits.

The estimated recreation visitation models can be used to estimate the impact of a change in reservoir elevation on recreation visitation. The changes in visitation can then be multiplied by the recreation values to estimate the change in recreation benefits associated with a change in elevation. It is estimated that a one foot change in reservoir elevation will result in a 1.345% reduction in annual recreation benefits and a 1.49% reduction in recreation season benefits for Great Plains State Park. The recreation benefit results are summarized in Table 16.

Table 16 – Estimated impacts of a one foot elevation change at Tom Steed Reservoir on recreation visitation and visitation value at Great Plains State Park

Month	**Overnight visits**	**Day use Visits**	**Total visits**	**Value of overnight visits**	**Value of day use visits**	**Total Value**
March	7	119	126	$420	$2,380	$2,800
April	81	83	164	$4,860	$1,660	$6,520
May	43	298	341	$2,580	$5,960	$8,540
June	39	274	313	$2,340	$5,480	$7,820
July	43	119	162	$2,580	$2,380	$4,960
August	28	109	137	$1,680	$2,180	$3,860
September	16	113	129	$960	$2,260	$3,220
October	34	76	110	$2,040	$1,520	$3,560
Total	**291**	**1,191**	**1,482**	**$17,460**	**$23,820**	**$41,280**

It is assumed that Quartz Mountain Nature Park would provide the same level of benefits per visit as recreation at Great Plains State Park given they support similar activities. It should also be noted that camping rates at Quartz Mountain Nature Park range from $10.00 to $24.00 per night depending on the type of camping (tent or RV), location, and amenities of the site and camping rates at Great Plain State Park range from $20.00 to $30.00 per night, with an average of about $22.00 per night. The similarity of rates suggests a similar type of experience is being purchased. Using a value of $60 per visit (these are assumed overnight visits) and annual average visitation of 7,067 visits, the annual benefit of Quartz Mountain Nature Park visitation is $424,000.

The benefits from visiting Quartz Mountain Lodge could be different than the benefits from visiting Great Plains State Park and Quartz Mountain Nature Park because of the difference in accommodations. The average cost of staying at the Quartz Mountain Lodge, based on data from January of 2010 to December of 2016, was $82.17 per night compared to $10 to $30 per night at Great Plains State Park and Quartz Mountain Nature Park. The higher price paid by those staying at the Lodge indicates Lodge recreation generates higher benefits per visit than Great Plains State Park or Quartz Mountain Nature Park. However, the relevant benefit measure is net benefit, which reflects total benefit in excess of what is paid to participate in the activity. A lodging price that is 3 to 8 times higher than the price of camping does not mean the net benefit of lodging above the price paid is 3 to 8 times the net benefit of camping. For the purposes of this analysis it is assumed that the net benefit of staying at the lodge is the same overnight value of $60 per visit used for other non-day use recreation activities at Great Plains State Park and Quartz Mountain Nature Park, recognizing that benefits may be understated. Over the January 2010 to December 2016 period average visitation at Quartz Mount Lodge was 15,712 visits annually, resulting in an estimated average net benefit of $942,700 annually.

The estimated change in recreation visitation from a one foot change in elevation was estimated to be 159 visits each year for Quartz Mount Nature Park and 81 visits per year for Quartz Mountain Lodge. This translates into a net benefit value of $9,540 annually for Quartz Mountain Nature Park and $4,860 for Quartz Mountain Lodge. The total change in recreation benefits for all three recreation sites combined is $55,680 annually. This represents a change of approximately 1.25 percent of annual recreation benefits.

It should be noted that Lake Altus-Lugert experienced a golden algae bloom in the winter of 2012 as a result of a severe drought when the water elevation was extremely low. The outbreak killed nearly every fish in the lake and in 2013 Oklahoma Department of Wildlife Conservation biologists announced the fishery was essentially dead. The lake was stocked with shad and sunfish, but another golden algae bloom occurred in the summer of 2014 which essentially killed the fishery a second time. After several seasons of growth without a golden algae bloom the fishery has recovered considerably as of May 2017. Using monthly visitation and elevation data over several years to evaluate the impact of reservoir elevation on visitation will tend to understate the impact of extreme conditions, such as severe and extended droughts, on visitation.

Irrigation Releases, Deliveries, and Impact on Irrigated Acreage

Changes in reservoir conditions can also have an impact on irrigation water releases and deliveries, which affects agricultural output and will have economic impacts. In order to evaluate the potential impact of changes in reservoir elevation and storage volume on agricultural benefits and the regional economy, a model linking reservoir elevation to irrigation releases and deliveries is needed. This type of model can also be used to estimate the impact of drought and drought mitigation on releases and deliveries through changes in reservoir elevation and storage.

Two simple regression models of irrigation releases were estimated. Both models estimate releases as a function of reservoir elevation, precipitation, and temperature using data from July 2003 to September 2016. One model is based on total annual releases while the second is based on monthly releases. These irrigation release models are not hydrologic models that include the variables needed to represent hydrologic processes, but are models that use historic data to correlate changes in irrigation releases with changes in reservoir elevation and climatic variables. This is similar to the recreation visitation models that are used to convert changes in reservoir elevation to changes in visitation. The change in irrigation releases can then be used to estimate the change in irrigation supply benefits. The estimated irrigation release model is shown below.

$$\text{Releases} = \beta_0 + \beta_1 \text{ Elev} + \beta_2 \text{ Precip} + \beta_3 \text{ Temp} + \varepsilon_0$$

Where:
β_0 = Constant term
Releases = Releases over observation time period.
Elev = Average reservoir elevation.
Precip = Total precipitation.
Temp = Average temperature.
ε_0 = Classic error term.

The results of the irrigation release model using monthly release data are shown in Table 17 and the results of the model using annual release data are shown in Table 18.

Table 17 – Irrigation release regression results using monthly release data

Explanatory Variable	**Coefficient**	**t-statistic**	**Corrected t-statistic**
CONSTANT	-681,343	-	-
ELEVATION	396.209	2.28**	2.53**
PRECIPITATION	-916.603	-1.32	-1.83***
TEMPERATURE	1,050.961	3.24*	3.01*
Adjusted R – Squared = 0.220	F – Statistic = 9.21*		
Number of observations = 56	Durbin-Watson d-statistic = 1.3918		

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level

Table 18 – Irrigation release regression results using annual release data

Explanatory Variable	**Coefficient**	**t-statistic**	**Corrected t-statistic**
CONSTANT	-3,182,660	-	-
ELEVATION	2,272.115	2.25**	2.08***
PRECIPITATION	-688.0168	-0.36	-0.56
TEMPERATURE	-3,245.71	-0.86	-1.23
Adjusted R – Squared = 0.3138	F – Statistic = 4.45**		
Number of observations = 14	Durbin-Watson d-statistic = 1.2284		

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level

The number of statistically significant explanatory variables (t-statistics) is larger for the monthly based model than for the annual model, while the annual model with fewer observations explains a greater percentage of the variation in releases (adjusted R-Squared). The greater statistical significance of the individual monthly data model is due to the greater number of observations. The irrigation season model uses aggregated data that has less variation of the observations, which means the adjusted R-Squared will tend to be higher. Assuming a four month irrigation season, the total four month variation in irrigation releases using the monthly model would be about 1,580 acre-feet for a 1 foot change in elevation. Using the irrigation season model, the change in releases from a 1 foot change in elevation would be about 2,270 acre-feet. The monthly model based estimate of the change in releases is approximately 30 percent lower than the aggregated irrigation season estimate for the change in releases. For the purposes of this analysis, the better statistical results of the monthly model are judged to be more important than the difference in the adjusted R-Squared value. Therefore, the monthly model results are used to evaluate changes in irrigation releases

According to the U.S. Department of Agriculture (USDA) Risk Management Agency (2017), an average of 65,390 acre-feet of irrigation water was released from Lake Altus over the 1995 to 2010 period and 43,363 acre-feet reached the fields in the Lugert-Altus Irrigation District. This translates into an average efficiency of 66.3 percent. An appraisal level water supply augmentation report for the W.C. Austin Project in Oklahoma (Bureau of Reclamation, 2005) indicated an average of about 41,000 acre-feet of water is delivered from 63,000 acre-feet released from storage, an efficiency of 65%. For the purposes of this analysis it is assumed that efficiencies have increased slightly and that 2/3 of releases are delivered to the field. Therefore, when calculating irrigation related benefits and regional impacts, the change in releases associated with a change in reservoir elevation are multiplied by 2/3. Therefore, it is estimated that a one foot change in reservoir elevation would translate into a change in irrigation deliveries of 1,053 acre-feet (2/3*1,580).

The 2015 Reclamation Altus Dam Safety of Dams, Irrigation Benefits Technical Report (Altus Safety of Dams Report) estimated an average irrigation delivery of 1.59 acre-feet per acre for the Lugert-Altus Irrigation District. Therefore, a 1,053 acre-foot change in water deliveries associated with a 1 foot change in Reservoir elevation would be the equivalent of irrigation water application on about 662 acres. It should be recognized that this represents average conditions for the crop rotation used in the Altus Safety of Dams Report.

Irrigation Water Supply Benefits and Revenues

Irrigation water supply benefits and revenues are estimated in the Altus Safety of Dams Report. The Altus Safety of Dams Report used a farm budget approach to estimate benefits. Farm budgeting is a process of estimating costs, returns and net farm income for a representative farm operation. Irrigation benefits are estimated by comparing net farm income for an operation that includes irrigated acreage with an operation that does not include irrigated production. The difference in net farm income is attributed to the application of irrigation water and is a measure of irrigation water benefits.

The farm budgets must be representative of the types of operations that exist in a study area. Characteristics to be considered in determining whether a budgeted farm is representative of farming operations in the study area include cropping patterns, crop yields, output prices received, variable and fixed input requirements, and input prices. Irrigation water supply benefits estimated using the farm budget approach represent an annual value.

Sources of information used in the Lugert-Altus Irrigation District farm budget analysis included Oklahoma State University extension wheat budgets, University of California Extension cotton budgets, United States Department of Agriculture - Economic Research Service (USDA-ERS) normalized crop prices for Oklahoma, United States Department of Agriculture - National Agricultural Statistics Service (USDA-NASS) average county yield data, and Bureau of Labor Statistics, Occupational Employment Statistics wage data.

Cropping Patterns

Three crops were included in the Lugert-Altus Irrigation District farm budget analysis to represent irrigated production: cotton, wheat, and fallow land. Separate budgets were completed for each crop. Non-irrigated production was represented by fallow land alone. In reality there are many more crops grown in the District, however these three crops represent the range of various crops grown. The variety of crops represented by cotton and wheat are shown in Table 19.

Table 19 – Crops and cropping pattern used for the irrigated farm budgets

Representative Crop	**Crops included**	**Percentage Split**
Cotton	Cotton, soybeans, pecans, peanuts	83.7%
Wheat	Oats, alfalfa hay, other hay, sorghum, wheat, milo, irrigated pasture, silage, dry beans	8.7%
Fallow Land	Fallow, idle, unused, Irrigated but not harvested, Multi-cropped	7.6%

The irrigated farm budgets included 320 acres of irrigated land and 16 acres of waste for cotton and 900 acres of wheat and 45 acres of waste for wheat. Waste acreage accounts for the farmstead, roads, ditches, and other waste acres. The crop used to represent dryland conditions was fallow land, which included 900 acres of fallow land and 45 acres for waste.

Crop Yields and Prices

Crop prices and yields used in the Lugert-Altus Irrigation District farm budget analysis are shown in Table 20. Crop prices used in the farm budget analyses were 2013 USDA-ERS normalized prices for Oklahoma. USDA-ERS calculates normalized prices every year to smooth out the effects of short run seasonal and cyclical variation that occurs for agricultural inputs and outputs. These normalized prices are based on 5-year lagged averages of actual nominal market prices. For example, an average of 2011-15 market prices is used to calculate normalized prices for 2016. State level normalized prices are calculated by multiplying the national-level normalized prices by the average ratios of the State-level market prices to the national market prices.

Table 20 – Yields and prices used to estimate irrigation benefits

Representative Crop	Yield Unit	Yield	Price	Estimated farm income per acre
Wheat	Tons	1.23	$197.67	$243.13
Cotton	Pounds	1,110	$0.73	$810.30
Cotton seed	Tons	0.8	$193.47	$154.78

County average crop yields used in the Lugert-Altus Irrigation District farm budget analysis were obtained from USDA-NASS except for cotton seed. The yield for cotton seed was obtained from the Oklahoma State University extension budgets. The average farm income per acre based on the cropping patterns presented in Table 15 is about $830 per acre.

Farm Expenses

The Lugert-Altus Irrigation District farm budgets included expenses for land, labor, overhead costs, returns to farm management, equity, and other input costs. For representative crops, farm expenses are generally obtained from published Extension Studies that provide production practices, costs, and revenue, as well as overhead costs.

Variable input costs were obtained from published Extension budgets and, when needed, they were indexed to 2013 using the Index of Prices Paid which is published annually by USDA-NASS and is specific to agricultural products. Information from Extension budgets published by Oklahoma State University were used to estimate the costs for fertilizer, agricultural chemicals, and other required inputs. Cultural practices, labor requirements, and machinery complements were based on previously completed enterprise budgets.

Land values for investment and tax assessment purposes were obtained from Oklahoma State University Extension budgets. Table 21 presents the land investment values along with the 5-year average value used in the Lugert-Altus Irrigation District farm budget analysis.

Table 21 - Land Investment Values, 2009-2013

Year	Irrigated Cropland (value per acre)	Pasture (value per acre)
2009	$1,090	$848
2010	$1,181	$881
2011	$1,189	$969
2012	$1,484	$1,012
2013	$1,764	$1,081
AVG	$1,340	$958

Source: Oklahoma State University.

Farm labor includes farm operator, family, and hired labor. The labor rates are provided by the Bureau of Labor Statistics, Occupational Employment Statistics data. A 5-year average rate (2008-2012) was used. The farm operator labor rate is $23.14 per hour. Family labor rates and hired labor rates are $11.13 per hour. In this analysis the farm operator primarily operates the machinery, while other labor is done by both the farm operator and family or hired labor. Family or hired labor may operate machinery when the farm operator has worked more than 240 hours in a given month. Labor hours for operations involving machinery are increased 10 percent to account for the extra labor involved in equipment set up, moving, maintenance, work breaks, and field repair.

The equipment needed to produce the commodities in the representative budgets was obtained from either a 2002 University of California Cotton Crop Extension budget or from an Oklahoma State University budget for wheat. A fallow land budget was created based on a modified dryland wheat budget that has no revenues but includes costs for controlling weeds. Farm machinery data used in the analysis includes purchase price, salvage value, machine use, and fuel and repair costs. If needed, all machine costs were indexed to 2013 using the Index of Prices Paid (USDA-NASS).

Fuel, oil, grease, and repair costs are calculated on a per hour basis for farm equipment and on a per mile basis for vehicles, and then multiplied by the total hours or miles the equipment is used to calculate the total maintenance cost.

Annual investment and repair costs are included for buildings and improvements in the representative farm budgets. These costs include items such as fuel tanks, wells and pumps, shop buildings, and tools, etc. Investment costs and associated annual repair expenses were obtained from the 2002 University of California Extension budget and indexed to 2013 using the Index of Prices Paid. Building and improvement costs for the wheat budget were obtained from an Oklahoma State University budget.

Depreciation was calculated for machinery, vehicles, buildings and improvements using the sinking fund method. Buildings, vehicles, and machinery generally have maximum useful lives of 40 years, 10 years, and 25 years, respectively, although the equipment life in the analysis is usually less than the maximum useful life and varies based on annual use. Salvage value was set at 10 percent of the investment value and the depreciation rate used was 3.375 percent.

Property taxes were computed on the full assessed value of land and on the inventory value of all equipment and improvements included on the representative farm. The taxable value is one-half the market value. Farm equipment is taxed on one-half the inventory value of all equipment on the farm. In addition to land, improvements, and equipment taxes, a social security tax rate of 7.65 percent is computed against all hired labor wages.

Insurance costs include farm liability, hazard, and vehicle insurance and excludes non-farm property such as the home and the household car. Insurance costs used in the Lugert-Altus Irrigation District farm budgets were $2,200 per year for liability and vehicle insurance, $6.67 per $1,000 of buildings and machinery investment for cotton, $7.20 per $1,000 investment for fallow land, and $7.75 per $1,000 investment for wheat.

Utility costs from the 2013 Bureau of Labor statistics Consumer Expenditure Survey were used to estimate telephone and electricity costs. Telephone costs were estimated to be $948 per year. Non-pumping electricity costs used in the budgets were $1,222 per year. An additional 2 percent of the total variable cost was added to each farm budget to cover any miscellaneous costs.

Returns to the Farm Family

The returns to the farm family include a return to labor and management. The returns to the farm family are noncash allowances for the operator’s factors of production and are deducted from the net farm income to determine the payment capacity. The farm operator’s labor was valued at the current wage rate for supervisory farm labor. Labor performed by the farm operator’s family was valued at the same wage rate as hired farm labor. An allowance of 6 percent of variable costs is made for the farm operator’s management ability over and above the supervisory labor rate.

Estimated Irrigation Benefits and Revenues

The estimated benefit of irrigation water in the Lugert-Altus Irrigation District in the Altus Safety of Dams Report was $66.49 per acre-foot in 2013 dollars. Using the Consumer Price Index (CPI) for all urban consumers to index 2013 (CPI value equals 232.957, where 1982 to 1984 equals 100) values to 2016 (CPI value of

240.007), the value of irrigation water would be $68.50 per acre-foot. The Safety of Dams Irrigation Benefits Technical Report also estimated average crop revenue of about $830 per irrigated acre or about $855 per irrigated acre in 2016 dollars.

The Altus Safety of Dams Report estimated a total of 47,841 irrigated acres in the Lugert-Altus Irrigation District and average irrigation water deliveries of 76,197 acre-feet, for an estimated irrigation application of 1.59 acre-feet per acre. The total benefit of irrigation in the Lugert-Altus Irrigation District is estimated to equal 76,197 acre-feet of deliveries multiplied by the average benefit of $68.50 per acre-foot, or $5.22 million annually in 2016 dollars. Total revenues from agricultural sales associated with crop production are estimated to be 47,841 acres multiplied by average estimated revenues of $855 per irrigated acre, or $40.9 million annually in 2016 dollars.

The estimated benefit value of irrigation water of $68.50 per acre-foot multiplied by the estimated change in irrigation deliveries from a one foot change in reservoir elevation of 1,053 acre-feet results in an estimated change in irrigation benefits of $72,100 annually. This represents approximately 1.38% of total irrigation benefits in the Lugert-Altus Irrigation District. The estimated average crop revenue of $855 per irrigated acre multiplied by the change in irrigation acreage from a one foot change in reservoir elevation of 662 acres results in an estimated change in crop revenues of $566,000 annually. This represents approximately 1.38% of total crop revenues in the Lugert-Altus Irrigation District.

Regional Impact Analysis

A regional economic impact analysis is an assessment of the effect of a change in expenditures resulting from a change in recreation visitation, crop production, a change in activities supported by a water supply, building a project, changing operations, implementing a new regulation, or making some other change that would influence economic activity in a regional economy. Any activity, or change in activities, that influences expenditures will have an impact on many sectors in the regional economy. The primary purpose of a regional impact analysis is to evaluate the effect of a project or change in operations on income, employment, and the value of output produced in the region where a change in spending will occur. This analysis evaluates the regional impacts from a change in recreation related spending and agricultural output associated with a change in reservoir levels.

There are three different types of data and information that are needed to estimate the regional economic impacts. The first is the estimated change in recreation visitation and crop production associated with different reservoir elevations. The second is recreation expenditures and gross crop revenues associated with different levels of visitation and crop production. The third is a model which can be used to convert recreation expenditures and gross crop revenues into changes in regional economic activity.

The change in recreation visitation and crop revenues can be estimated using the same visitation and irrigation water delivery models used to estimate benefits. The projected change in visitation and crop production resulting from a change in lake elevation is multiplied by the estimated expenditures per visit or revenues per irrigated acre to estimate the total change in recreation spending and crop revenues due to a change in lake elevation. The regional impacts from changes in recreation spending and crop revenues are estimated using the IMPLAN (impact analysis for planning) model.

The IMPLAN Model uses the U.S. Department of Commerce national input-output model as the basis for evaluating impacts. The national input-output model provides a detailed view of the interrelationships between U.S. producers and consumers which characterizes interactions within the regional economy. These characterizations are then used to estimate the flows of commodities used by industries as well as commodities produced by industries. The IMPLAN model includes two major components: data files that describe exchanges and spending patterns within a region as well as leakages of spending outside the region and a software program that performs the operations necessary to estimate regional impacts.

The IMPLAN model includes 536 different economic sectors which are potentially affected by changes in spending. Not all of these sectors are relevant for all regions and the extent to which expenditures affect the regional economy depends on the types of industries located within the region. Total regional economic impacts are the sum of the impacts for each of the 536 sectors. The large number of potential impact sectors combined with the variation in sectors affected by any one particular category of spending results in a very large matrix of impacts. Therefore, in order to make the regional impact results understandable and relatively easy to follow, the regional impact results are presented in summary tables.

The total regional impacts from changes in the demand for goods and services are the sum of direct, indirect, and induced effects. Direct effects represent impacts on the industry that is immediately affected. For example, if recreation visitation increases as a result of higher lake levels, then the amount of recreation services demanded would increase and more inputs would be needed to meet that demand. The direct effect would be the increase in income and employment needed to satisfy increased demand for recreation services. Indirect effects account for transactions between different sectors. If the recreation service industry expanded in the region to satisfy increased demand, then the recreation service industry will increase demand for locally produced materials and labor to produce recreation services. The result is additional jobs and income created to meet new recreation industry demand. Induced effects measure the effects of the changes in household income resulting from direct and indirect effects on demand for goods and services such as housing, restaurants, and retail sales. Regional impacts are generally measured in terms of employment, income, and the value of output produced.

The regional economic impacts associated with the historic recreation visitation and historic agricultural production are estimated to represent baseline economic activity associated with recreation and crop production in the study area from which the magnitude of impacts resulting from changes in reservoir elevation can be evaluated. The regional impacts associated with a one foot change in reservoir elevation are also estimated so regional impacts can be estimated for a range of potential changes in lake elevation.

Regional economic impacts are generally not equivalent to economic benefits. Economic benefit is a measure of well-being from the perspective of all of society while regional economic impacts are a measure of changes in income and employment from the perspective of a local community or region. Any change that results in increased regional spending will increase economic activity and generate some level of positive regional impact, but will not necessarily generate economic benefits. Therefore, in most cases regional impacts cannot be added to economic benefits as a measure of total benefit.

Regional Impact Area

A regional impact analysis needs to account for the direct impacts of recreation spending and crop production as well as the economic linkages of those sales. For example, if a recreation area is located in a rural county where there are few retail stores and restaurants but an adjacent county contains a large town where people stop before going to the recreation site, then there is an economic linkage between the recreation site and the large town and the area of impact would include both counties. The counties included in the regional impact area for recreation and irrigation analysis are shown in Table 22. The same impact areas were used for both the recreation and agricultural analyses for consistency.

Table 22 – Impact areas used to estimate regional economic impacts

Recreation Area or Irrigation District	Counties Included in Impact Area	Major Cities
Great Plains State Park	Caddo, Comanche, Jackson, Greer, Kiowa	Anadarko, Lawton, Altus
Quartz Mountain Nature Park and Lodge	Caddo, Comanche, Jackson, Greer, Kiowa	Anadarko, Lawton, Altus
Lugert – Altus Irrigation District	Caddo, Comanche, Jackson, Greer, Kiowa	Anadarko, Lawton, Altus

Estimating Crop Production Revenues and Recreation Expenditures by Expense Category

In order to accurately estimate the regional impacts from recreation visits and crop sales, expenditures must be estimated by sector or spending category. For example, one sector associated with recreation spending is eating and drinking establishments and another sector would be gasoline purchases. The regional impacts associated with these two sectors are different because the input requirements to satisfy final demand for these two sectors are different.

These expenditures represent a change in final demand for that spending category. The spending categories become a group of "events" in IMPLAN which specifies how much spending is attributable to each sector. Once the estimated expenditures are input, IMPLAN can then be used to estimate the total impacts of that spending on the regional economy. It is important to include only those expenditures that occur within the region that is being evaluated and to exclude expenditures that are simply a shift in spending by those who live in the impact region. The determination of spending category is much simpler for crop production because the final demand sector is the type of crop grown. Therefore, only two crop production sectors are needed, cotton farming and grain farming. Therefore, the majority of the discussion below refers to the determination of recreation expenditures.

In order to accurately estimate regional impacts, two pieces of information are needed. The first is the source of money spent on an activity and the second is the location of goods or services purchased in connection with the activity. The source of money is important because money that comes from outside the impact region represents an injection of funds to the region while money that originates from within the region is a redistribution of spending between different expenditure categories. The regional impacts associated with a redistribution of spending is likely to be very small compared to expenditures originating from outside the region. The location of goods and services purchased is important because payments made outside the impact region will have little or no effect on income and employment in the region.

It is assumed that all spending on agricultural production originates from outside the region. Therefore, 100 percent of spending on agricultural output is treated as an increase in regional spending. It is much more difficult to estimate the percentage of total recreation spending that represents a flow of expenditures into the study region.

Recreation expenditures generate regional economic impacts as a result of visitors from outside the region buying goods and services related to their recreation trip inside the study region. Spending by visitors that live in the area can create regional impacts to the extent that the shift in sectors of spending generate different income and employment impacts, but those impacts will be very small compared to expenditures by those visiting from outside the region. Therefore, spending by residents and businesses inside the impact area are assumed to be insignificant and only the estimated expenditures from outside the region are included in the regional impact analysis.

Crop Production Revenues that Generate Regional Impacts

Total crop revenues associated with irrigated production during a representative year were estimated using crop yields presented in the Altus Safety of Dams Report for the Lugert-Altus Irrigation District and 2016 crop prices. Cotton lint prices were obtained from a 2017 United States Department of Agriculture, Agricultural Marketing Service (USDA – AMS) report and cotton seed prices were obtained from the National Cotton Council of America (2018). The regional impacts associated with crop revenues from the entire Lugert-Altus Irrigation District provide a basis for evaluating the change in regional impacts due to a change in reservoir elevation. Crop acreage, yields, prices, and revenues associated with irrigated production in the Lugert-Altus Irrigation District are presented in Table 23. Total annual crop revenues associated with irrigated production in the Lugert – Altus Irrigation is estimated to be a little over $38.0 million based on information from the Altus Safety of Dams Report analysis indexed to 2016 prices.

Table 23 – Crop revenues associated with irrigated production in the Lugert-Altus Irrigation District

Crop	Acreage	Yield/acre	2016 Price	Revenue
Cotton	40,026	1,110 pounds	$0.7025/pound	$31,211,300
Cotton seed	40,026	0.8 tons	$195.00/ton ($0.0975/lb)	$6,244,100
Wheat	4,147	1.23 tons	$114.67/ton ($3.44/bu)	$584,900
Fallow	3,668	0	$0	$0

The baseline regional impacts from irrigated agriculture are estimated using a value of final demand for cotton related output of $37,455,400 annually and a value of final demand for wheat of $584,900 annually. These are input into IMPLAN as changes in final demand for these crop outputs.

It was estimated in the Irrigation Releases, Deliveries, and Impact on Irrigated Acreage section above that a 1,053 acre-foot change in water deliveries associated with a 1 foot change in Reservoir elevation would be the equivalent of irrigation water application on about 662 acres. Using the equivalent change in irrigated acreage as the basis for estimating the change in crop production revenues and final demand, the change in crop acreage and revenues from a 1 foot change in reservoir elevation is shown in Table 24.

Table 24 – Estimated crop revenues associated with changes in irrigated production as a result of a 1 foot change in reservoir elevation

Crop	Acreage	Yield/acre	2016 Price	Revenue
Cotton	554	1,110 pounds	$0.7025/pound	$432,000
Cotton seed	554	0.8 tons	$195.00/ton ($0.0975/lb)	$86,400
Wheat	57	1.23 tons	$114.67/ton ($3.44/bu)	$8,000
Fallow	51	0	$0	$0

For the purposes of the regional impact analysis, cotton related revenues used for final demand are $518,400 annually and wheat revenues are $8,000 annually.

Regional Economic Impacts from Crop Sales

Regional impacts are generally measured in terms of value of industry output, employee compensation, and employment. The value of industry output is a measure of the total value of purchases by intermediate and final consumers associated with product demand. Industry output is directly comparable to the Gross Regional Product. Therefore, changes in the value of total industry output for each alternative is a measure of the impact each alternative would have on the value of all goods and service produced in the study region. Employee compensation represents wages and benefits paid to employees and employment is the number of part-time and full-time employees.

In order to estimate the regional impacts from crop sales in the study region, the estimated value of crop sales must be placed into the IMPLAN sectors that best match the crop production categories included in IMPLAN. The IMPLAN sectors used to evaluate regional crop production impacts are shown in Table 25.

Table 25 – IMPLAN sectors used to estimate crop production impacts

Crop Production Category	IMPLAN Sector	IMPLAN sector description
Cotton	3008	Cotton farming
Wheat	3002	Grain farming

The crop sales estimates presented in Table 23 and Table 24 in the previous section are input into the IMPLAN sectors shown in Table 25 to estimate regional crop production impacts. The results are presented in Table 26. The crop production baseline represents the impacts associated with irrigated production at current levels.

Table 26 – Regional impacts from crop sales and changes in crop sales

Type of Impact	Employment	Labor Income	Value Added	Value of Output
Crop Production Baseline				
Direct Effect	257.4	$19,182,300	$23,916,600	$38,040,300
Indirect Effect	108.1	$3,626,200	$5,047,200	$8,552,800
Induced Effect	86.3	$2,797,000	$5,921,800	$10,784,800
Total Effect	451.8	$26,605,500	$34,885,600	$57,377,900
Crop Production (one foot change in elevation)				
Direct Effect	3.6	$265,400	$331,000	$526,400
Indirect Effect	1.5	$50,200	$69,800	$118,400
Induced Effect	1.2	$38,700	$81,900	$149,200
Total Effect	6.3	$354,300	$482,700	$794,000

Recreation Expenditures that Generate Regional Impacts

In order to estimate the regional impacts associated with recreation at Great Plains State Park and Quartz Mountain Nature Park and Lodge, total recreation expenditures and the location of expenditures (within the impact region or outside the region) must be known. The ideal source of recreation expenditure information would be a survey of visitors asking what items had been purchased specifically for the trip, how much had been spent, and where the items were purchased. However, obtaining site specific expenditure data is not possible for this analysis because it would require lengthy and time consuming surveying of visitors on site. Budget and time constraints preclude surveying individual recreational visitors. Therefore, an alternative method for estimating expenditures and locations of expenditures is needed.

The primary source of information used to estimate the percentage of expenditures spent within the region by recreation participants originating outside the region is the U.S. Fish & Wildlife Service 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation for Oklahoma (U.S. Fish & Wildlife Service, 2014). The U.S. Fish & Wildlife Service National Survey is conducted every 5 years and provides the estimated annual expenditures for different categories of goods and services required to participate in fishing, hunting, and wildlife-associated recreational activities. The 2011 survey is the most recent survey available. The types of recreation included in the survey include fishing, hunting, and wildlife viewing.

The primary source of recreation spending is a study of the economic value of sportfishing trips to Oklahoma lakes (Melstrom, et al., 2015). These expenditures are for sportfishing, but the estimates include overnight expenditures and it is assumed that several types of activities would be included in the fishing activity. These expenditures are for Oklahoma residents, so expenditures by out of state participants may be understated. The values presented in Table 27 are the basis for recreation expenditure estimates.

Table 27 - Recreation spending per trip for Oklahoma resident anglers

Spending Category	All Trips		Single Day Trips		Overnight Trips	
	Median	Average	Median	Average	Median	Average
Transportation	$30	$53	$20	$25	$50	$86
Lodging and Food	$10	$62	$0	$14	$50	$113
Fishing costs	$10	$34	$8	$20	$20	$49
Total	$50	$149	$28	$59	$120	$248

Source: Melstrom, et al., 2015.

Expenditure information from Quartz Mountain Nature Park and Quartz Mountain Lodge are used to adjust lodging expenditures for these two sites. Actual lodging expenditures for these two sites are substituted for the values estimated used to estimate lodging expenditures at Great Plains State Park. The average cost of staying at the Quartz Mountain Lodge, based on data from January of 2010 to December of 2016, was $82.17 per night and the average cost per visit at Quartz Mountain Nature Park was $16. The $16 value is for both day use and overnight use. However, in this analysis it is assumed that all visits are over-night visits at Quartz Mountain Nature Park, so the $16 value is used for lodging at the Nature Park. The average cost for overnight camping in Great Plains State Park is $22 per night, which is used to estimate regional impacts.

Not all of the recreation expenditures described above generate regional impacts because some visitors originate from within the study area. The process used to estimate expenditures within the region by recreators who live outside of the region is described in detail in Appendix C. The resulting estimate of expenditures per visit that generate impacts is presented in Table 28.

Table 28 – Estimated recreation expenditures that generate regional impacts

Expenditure category	Great Plains State Park Expenditures		Quartz Mountain Nature Park Expenditures	Quartz Mountain Lodge Expenditures
	Day Use (per visit)	Overnight Use (per visit)	Overnight use (per visit)	Overnight use (per visit)
Food	$10.05	$20.10	$20.13	$22.17
Lodging	$0	$21.05	$15.33	$78.72
Transportation	$11.98	$23.95	$23.95	$41.19
Other	$9.58	$23.47	$23.47	$23.47
Total	**$31.61**	**$88.57**	**$82.88**	**$165.55**

The regional expenditure per visit represents the amount that would be applied to all visitors since it is adjusted to account for the proportion of total visitors that originate from outside of the region and the percentage of spending that would occur outside of the region. The estimated expenditures associated with total annual visitation and with the change in visitation from a one foot change in elevation at each site are shown in Table 29. These expenditures are the basis for estimating the regional impacts from recreation expenditures in the next section.

Table 29 – Estimated annual average recreation expenditures and expenditures associated with a one foot change in elevation

	Great Plains State Park		Quartz Mountain Nature Park		Quartz Mountain Lodge	
Expenditure category	**Annual average expend-itures**	**Change in expend-Itures from a one foot change in elevation**	**Annual average expend-itures**	**Change in expend-Itures from a one foot change in elevation**	**Annual average expend-itures**	**Change in expend-itures from a one foot change in elevation**
Food	$1,334,400	$17,800	$142,300	$2,600	$348,300	$2,300
Lodging	$436,100	$6,100	$108,300	$2,000	$1,236,800	$8,100
Transportation	$1,590,500	$21,200	$169,300	$3,100	$647,200	$4,200
Other	$1,361,300	$18,200	$165,900	$3,000	$368,800	$2,400
Total	**$4,722,300**	**$63,300**	**$585,800**	**$10,700**	**$2,601,100**	**$17,000**

Regional Impacts from Recreation Expenditures

The recreation related expenditures must be placed into IMPLAN sectors that best match spending categories shown in Table 29. The IMPLAN sectors used to evaluate regional recreation impacts are shown in Table 30.

Table 30 – IMPLAN sectors used to estimate regional recreation impacts

Expenditure category	IMPLAN sector	IMPLAN sector description
Food – grocery stores	3400	Retail Services – Food and Beverage Stores
Transportation	3402	Retail Services – Gasoline Stores
Miscellaneous expenses	3496	Other Amusement and Recreation
Lodging	3499	Hotels and Motel Services – including Casino Hotels
Food - restaurants	3501	Full Service Restaurant Services

The estimates of recreation expenditures presented in the previous section are input into the IMPLAN sectors to estimate regional recreation impacts. The regional impacts from recreation expenditures at Great Plains State Park and Quartz Mountain Nature Park and Lodge combined are shown in Table 31 and Table 32. Baseline recreation impacts represent the impacts associated with recreational activity at current levels.

Table 31 – Great Plains State Park Regional Impacts

Type of Impact	Employment	Labor Income	Value Added	Value of Output
Recreation Baseline				
Direct Effect	51.1	$888,100	$1,369,900	$2,822,600
Indirect Effect	4.9	$173,800	$364,900	$699,200
Induced Effect	4.0	$130,000	$275,300	$501,300
Total Effect	60.0	$1,191,900	$2,010,100	$4,023,100
Recreation (one foot change in elevation)				
Direct Effect	0.7	$11,900	$18,400	$37,900
Indirect Effect	0.1	$2,300	$4,900	$9,400
Induced Effect	0.1	$1,800	$3,700	$6,700
Total Effect	0.9	$16,000	$27,000	$54,000

Table 32 – Quartz Mountain Nature Park and Lodge Regional Impacts

Type of Impact	Employment	Labor Income	Value Added	Value of Output
Recreation Baseline				
Direct Effect	35.2	$639,200	$1,115,500	$2,281,700
Indirect Effect	4.4	$161,200	$300,000	$596,100
Induced Effect	3.0	$98,000	$207,500	$377,900
Total Effect	42.6	$898,400	$1,623,000	$3,255,700
Recreation (one foot change in elevation)				
Direct Effect	0.3	$5,600	$9,700	$19,900
Indirect Effect	0.1	$1,400	$2,600	$5,200
Induced Effect	0.0	$900	$1,800	$3,300
Total Effect	0.4	$7,900	$14,100	$28,400

The Impact of Altus Air Force Base on the Regional Economy

A community profile for the Altus region by the Altus Southwest Area Economic Development Corporation (2018) indicates there are two major contributors to economic growth and stability in the region, Altus Air Force Base and the agricultural industry. The impact of agriculture on the regional economy and potential impacts from changes in reservoir elevations have been described in detail above.

Altus Air Force Base has a significant impact on the regional economy as a result of expenditures, employment, and income associated with the Air Force Base. Although this analysis is an evaluation of the economic impacts of water supply conditions on activities in the region and is not an evaluation of the Air Force Base in particular on the regional economy, it is important to recognize the economic impacts of Altus Air Force Base operations on the region and potential impacts of water supply shortages that would threaten the viability of Base operations.

A Fiscal Year 2016 Altus Air Force Base Economic Impact Statement (Altus Air Force Base, 2018) indicated that there was a total of 3,164 military personnel and dependents and 1,507 civilian personnel associated with the Air Base. Total construction and operations expenditures on the Air Base were a little over $60.8 million and total payroll was about $230.6 million. A 2011 report evaluating the economic impact of five Oklahoma military installations, including Altus Air Force Base (Oklahoma Department of Commerce and The State Chamber of Oklahoma, 2011), indicated an annual employment impact of about 7,500 jobs over the 2011 to 2015 time period. A more up to date 2017 report by the Oklahoma Aeronautics Commission, estimated that the Altus Air Force Base directly and indirectly accounts for nearly 8,890 jobs per year in the region.

The estimated employment impact of Altus Air Force Base can be used to estimate the population supported by activities at the Air Force Base. The Federal Reserve Economic Data (FRED) database maintained by the Research division of the Federal Reserve Bank of St. Louis includes national estimates of the employment-population ratio, which can be used to translate the average number of people supported by a wage earner into a total population estimate. The national estimate for 2016 was 59.73% which translates into 1.674 people put employed person. Another approach could be to use household size as the basis for converting employment into population. However, there can be more than one wage earner in a household so this would tend to overstate the number of people supported by an employed person. The 2016 Census estimate for household size ranges from 2.29 people in Greer County to 2.74 people in Caddo County.

In 2017 the total population of the five counties included in the study area was 190,560 people. Assuming an employment-population ratio of 1.674 people per employed person, the Altus Air Force Base accounts for about 14,900 people in the region. Therefore, the population associated with Altus Air Force Base represents approximately 7.8% of the total study area population.

The analysis of recreation impacts estimated that about 4.2% of total recreation visitation at Great Plains State Park and Quartz Mountain Nature Park and Lodge are from the five county study region. Therefore, if the Altus Air Force Base related population was no longer in the region this would represent a 0.33% loss in recreation visitation. Average visitation at all three recreation sites is estimated to be 134,839 annually, so a 0.33% decrease in visitation represents an average reduction of 445 recreation visits per year. This would represent a loss in regional economic activity in addition to the loss of jobs and income described above.

Summary

This analysis has developed models of recreation visitation and irrigation deliveries, estimates of the benefits associated with recreation and agricultural production, and estimates of the regional economic impacts associated with recreational expenditures and agricultural sales. Using these models and estimates, the potential economic and regional impacts associated with the effects of drought as measured by changes in reservoir elevation are discussed.

The models of recreation visitation and irrigation deliveries include reservoir elevation as an explanatory variable so changes in elevation can be translated into changes in visitation or irrigation water supplies. Therefore, the effects of drought on recreation and crop production are conveyed through reservoir elevation. The analysis includes estimates of the impacts from a 1 foot change in reservoir elevation which can be applied to different drought scenarios and resulting changes in reservoir elevation.

This analysis also includes recreation and irrigation water supply benefit estimates from previously completed studies. These per unit benefit estimates are applied to visitation and irrigation delivery modeling results to estimate the change in benefits from a change in reservoir elevation. Finally, expenditures per recreation visit and the value of crop sales per unit sold are estimated and applied to the modeling results to estimate the change in the value of regional economic activities from a change in reservoir elevation.

Winter and recreation season recreation visitation models using historical monthly data were estimated for Great Plains State Park, Quartz Mountain Nature Park, and Quartz Mountain Lodge. Reservoir elevation was not a statistically significant variable in the winter models, so changes in visitation from changes in reservoir elevation were estimated for only the recreation season models. Irrigation season models were estimated for irrigation deliveries to the Lugert-Altus Irrigation District.

The results of the analysis indicate historical average recreation benefits of $4.44 million annually at all three recreation sites, recreation expenditures of $7.91 million annually, recreation related employment of 103 jobs, and the total value of output due to recreation of $7.28 million annually. The benefits associated with crop production from irrigation is estimated to be $2.06 million annually, irrigated crop revenues of $40.9 million annually, crop production related employment of 452 jobs, and the total value of output due to irrigated crop production of $57.38 million annually. The impacts of a one foot change in reservoir elevation at Altus Reservoir and Tom Steed Lake are summarized in Table 33 and Table 34.

Table 33 – Estimated recreation benefits and regional impacts associated with a one foot change in reservoir elevation

	Visitation			Recreation Benefits	Recreation Regional Impacts	
Recreation Area	**Average Annual Visitation (2000-2016)**	**Change in visitation for a one foot change in elevation**	**Percentage change in recreation season visitation for a one foot change in elevation**	**Change in recreation value from a one foot change in elevation**	**Change in Recreation Spending from a one foot change in elevation**	**Change in the value of regional output from a one foot change in elevation**
Great Plains State Park	**112,059**	**1,482**	**1.32%**	**$41,200**	**$63,400**	**$54,000**
Quartz Mountain Nature Park and Lodge	**22,779**	**240**	**1.05%**	**$14,400**	**$27,700**	**$28,400**

Table 34 – Estimated irrigation benefits and regional impacts associated with a one foot change in reservoir elevation

	Irrigation Deliveries			Irrigation benefits	Irrigation Regional Impacts	
Agricultural Area	Average irrigated acreage (acres)	Change in irrigated acreage for a one foot change in elevation (acres)	Percentage change in irrigated acreage for a one foot change in elevation	Change in irrigation benefits from a one foot change in elevation	Change in gross agricultural revenues from a one foot change in elevation	Change in the value of regional output from a one foot change in elevation
Lugert – Altus Irrigation District	**47,841**	**660**	**1.38%**	**$72,100**	**$566,000**	**$794,000**

The impacts presented in Tables 33 and 34 for a one foot change in reservoir elevation is useful for evaluating potential drought impacts as long as the effect of drought can be translated into a change in reservoir elevation. However, the effect of drought on reservoir elevation may not be known.

In order to better understand the potential impact of drought on recreation activity, historical monthly average elevations at Altus Reservoir and Tom Steed Reservoir were compared to monthly average elevations over the 2010 to 2013 period, which was a period of drought. This approach is not likely to be applicable to evaluating the impact of drought on irrigation deliveries and crop production because a decrease in reservoir elevation during drought would likely occur in order to mitigate for drought effects. In other words, reduced elevation may compensate for the effect of drought. However, using the approach to correlate reservoir elevation with deliveries is valid for non-drought years because in this case differences in elevation correspond to differences in storage, which can translate into differences in potential water deliveries.

Reservoir elevation during drought years was compared to reservoir elevation during other years to evaluate the magnitude of impact a drought has on recreation visitation. The difference in elevation was calculated as the difference in weighted monthly elevation, where the weight is based on the percentage of total recreation visitation that occurs each month during the March to October recreation season. The weighted average difference in elevation during the drought years 2010 to 2013 compared to other years is 9.83 feet for Altus Reservoir and 3.02 feet for Tom Steed Reservoir. These differences in elevation are multiplied by the estimated impact per foot of elevation change to estimate the impacts of a drought such as what occurred over the 2010 to 2013 period on recreation benefits and recreation related regional activity. The estimated annual impacts of drought conditions that occurred during the 2010 to 2013 period on recreation benefits and expenditures shown in Table 35.

Table 35 – Impact of drought conditions on recreation benefits and expenditures

Recreation Area	Benefits per foot of elevation	Expenditures per foot of elevation	Difference in elevation	Difference in benefits	Difference in expenditures
Great Plains State Park	$41,280	$63,400	3.02	$124,700	$191,500
Quartz Mountain Park	$9,540	$10,700	9.83	$93,800	$105,200
Quartz Mountain Lodge	$4,860	$17,050	9.83	$47,800	$167,600

The estimated loss of recreation benefits during the 2010 to 2013 drought period are $266,300 annually and recreation related expenditures are reduced $464,300 annually. The reduction in expenditures would translate into annual regional impacts shown below in Table 36.

Table 36 – Regional impacts of drought conditions on recreation related activities

Recreation Area	Annual loss of jobs during 2010 – 2013 drought	Annual loss of labor income during 2010 – 2013 drought	Annual reduction in value added during 2010 – 2013 drought	Annual reduction in the value of output during 2010 – 2013 drought
Great Plains State Park	2.7	$48,300	$81,500	$163,100
Quartz Mountain Park and Lodge combined	3.9	$77,700	$138,600	$279,200

It is estimated that recreation related impacts associated with drought conditions over the 2010 to 2013 period corresponds with a loss of 6.6 jobs, $126,000 in lost labor income and a loss in the value of output of $442,300 annually. These results indicate substantial recreation losses as a result of drought conditions.

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Appendix A - Data Used to Estimate the Great Plains State Park, Quartz Mountain Nature Park, and Quartz Mountain Lodge Visitation Models

Table A-1: Great Plains State Park recreation season visitation model base data

Year	Month	Visitation	Elevation	March	April	May	June	July	August	Wet month	Temperature	Median income	Gas & time index
2000	July	23529	1408.34	0	0	0	0	1	0	0	84.2	45,917	0.5984
2000	August	23529	1407.24	0	0	0	0	0	1	0	88.7	45,917	0.5984
2000	September	12070	1406.4	0	0	0	0	0	0	0	77.4	45.917	0.5984
2000	October	8267	1407.7	0	0	0	0	0	0	1	64	45,917	0.5984
2001	March	9812	1407.83	1	0	0	0	0	0	0	47.1	46,522	0.6029
2001	April	21637	1407.48	0	1	0	0	0	0	0	62.8	46,522	0.6029
2001	May	30798	1411.23	0	0	1	0	0	0	1	69.4	46,522	0.6029
2001	June	24786	1410.42	0	0	0	1	0	0	0	80.6	46,522	0.6029
2001	July	10978	1409.35	0	0	0	0	1	0	0	89.6	46,522	0.6029
2001	August	20790	1408.6	0	0	0	0	0	1	1	82.6	46,522	0.6029
2001	September	13100	1407.94	0	0	0	0	0	0	0	72.5	46,522	0.6029
2001	October	9688	1407.16	0	0	0	0	0	0	0	62.6	46,522	0.6029
2002	March	9478	1405.82	1	0	0	0	0	0	0	46.4	46,018	0.5909
2002	April	18905	1406.51	0	1	0	0	0	0	1	59.9	46,018	0.5909
2002	May	28952	1406.06	0	0	1	0	0	0	0	66.4	46,018	0.5909
2002	June	22997	1405.44	0	0	0	1	0	0	0	79.3	46,018	0.5909
2002	July	11672	1404.93	0	0	0	0	1	0	0	81.5	46,018	0.5909
2002	August	22783	1404.05	0	0	0	0	0	1	0	83.8	46,018	0.5909
2002	September	13812	1403.56	0	0	0	0	0	0	1	75	46,018	0.5909
2002	October	8526	1404.56	0	0	0	0	0	0	1	56.3	46,018	0.5909

2003	March	8718	1403.89	1	0	0	0	0	0	0	49.6	45,671	0.6187
2003	April	14476	1403.56	0	1	0	0	0	0	1	60.6	45,671	0.6187
2003	May	25435	1403.26	0	0	1	0	0	0	0	69.6	45,671	0.6187
2003	June	18312	1406.53	0	0	0	1	0	0	1	75.2	45,671	0.6187
2003	July	8950	1405.64	0	0	0	0	1	0	0	85.6	45,671	0.6187
2003	August	11958	1405.15	0	0	0	0	0	1	1	84.6	45,671	0.6187
2003	September	12468	1404.47	0	0	0	0	0	0	0	71.6	45,671	0.6187
2003	October	7416	1403.95	0	0	0	0	0	0	0	64.4	45,671	0.6187
2004	March	8911	1404.14	1	0	0	0	0	0	1	54.5	45,771	0.6713
2004	April	12275	1403.85	0	1	0	0	0	0	1	59.7	45,771	0.6713
2004	May	22864	1403.44	0	0	1	0	0	0	0	72.9	45,771	0.6713
2004	June	15306	1403.47	0	0	0	1	0	0	1	77.4	45,771	0.6713
2004	July	6477	1403.8	0	0	0	0	1	0	1	81	45,771	0.6713
2004	August	8247	1403.42	0	0	0	0	0	1	0	78.3	45,771	0.6713
2004	September	11876	1402.76	0	0	0	0	0	0	0	76.1	45,771	0.6713
2004	October	7254	1403.94	0	0	0	0	0	0	1	63.1	45,771	0.6713
2005	March	9211	1407.47	1	0	0	0	0	0	0	50.7	44,927	0.7482
2005	April	10787	1407.03	0	1	0	0	0	0	0	59.5	44,927	0.7482
2005	May	23695	1406.74	0	0	1	0	0	0	0	68.9	44,927	0.7482
2005	June	16850	1406.72	0	0	0	1	0	0	0	80.4	44,927	0.7482
2005	July	8358	1406.15	0	0	0	0	1	0	1	81.9	44,927	0.7482
2005	August	8560	1406.94	0	0	0	0	0	1	1	81.1	44,927	0.7482
2005	September	12531	1407.61	0	0	0	0	0	0	1	77	44,927	0.7482
2005	October	9158	1407.32	0	0	0	0	0	0	0	62.8	44,927	0.7482
2006	March	8756	1405.54	1	0	0	0	0	0	1	54.9	45,527	0.8083
2006	April	10103	1404.98	0	1	0	0	0	0	0	66.9	45,527	0.8083

2006	May	21743	1404.69	0	0	1	0	0	0	1	72.9	45,527	0.8083
2006	June	15746	1403.75	0	0	0	1	0	0	0	81	45,527	0.8083
2006	July	7963	1402.89	0	0	0	0	1	0	0	86.5	45,527	0.8083
2006	August	5523	1402.33	0	0	0	0	0	1	0	85.8	45,527	0.8083
2006	September	10468	1401.86	0	0	0	0	0	0	0	70.9	45,527	0.8083
2006	October	8637	1402.12	0	0	0	0	0	0	1	62.4	45,527	0.8083
2007	March	8967	1403.44	1	0	0	0	0	0	0	57.2	47,460	0.8373
2007	April	9865	1405.75	0	1	0	0	0	0	0	54.9	47,460	0.8373
2007	May	22581	1410.03	0	0	1	0	0	0	0	69.3	47,460	0.8373
2007	June	17254	1414.32	0	0	0	1	0	0	1	76.3	47,460	0.8373
2007	July	10428	1413.09	0	0	0	0	1	0	0	80.2	47,460	0.8373
2007	August	26438	1412.69	0	0	0	0	0	1	1	84	47,460	0.8373
2007	September	10685	1411.38	0	0	0	0	0	0	0	76.5	47,460	0.8373
2007	October	8538	1410.86	0	0	0	0	0	0	1	65.7	47,460	0.8373
2008	March	8972	1411.34	1	0	0	0	0	0	1	50.5	47,085	0.9308
2008	April	9320	1411.35	0	1	0	0	0	0	1	57.6	47,085	0.9308
2008	May	20983	1410.87	0	0	1	0	0	0	0	71.4	47,085	0.9308
2008	June	16843	1410.15	0	0	0	1	0	0	0	82	47,085	0.9308
2009	July	10315	1407.1	0	0	0	0	1	0	1	82.9	45,975	0.7575
2009	August	6215	1406.21	0	0	0	0	0	1	0	82.9	45,975	0.7575
2009	September	10538	1406.77	0	0	0	0	0	0	1	72.1	45,975	0.7575
2009	October	7751	1407.22	0	0	0	0	0	0	0	55.6	45,975	0.7575
2010	March	7105	1407.42	1	0	0	0	0	0	0	49.5	45,676	0.8323
2010	April	9153	1407.5	0	1	0	0	0	0	0	60.1	45,676	0.8323
2010	May	20780	1406.95	0	0	1	0	0	0	0	69.8	45,676	0.8323
2010	June	20456	1406.51	0	0	0	1	0	0	0	84.4	45,676	0.8323

2010	July	10526	1410.29	0	0	0	0	1	0	1	83.1	45,676	0.8323
2010	August	4963	1409.52	0	0	0	0	0	1	0	86.7	45,676	0.8323
2010	September	9834	1409.27	0	0	0	0	0	0	0	77.4	45,676	0.8323
2010	October	7936	1409.49	0	0	0	0	0	0	0	64.4	45,676	0.8323
2011	March	7364	1408.34	1	0	0	0	0	0	0	52.2	45,492	0.9615
2011	April	9176	1407.73	0	1	0	0	0	0	0	64.2	45,492	0.9615
2011	May	20693	1407.87	0	0	1	0	0	0	1	71.8	45,492	0.9615
2011	June	19318	1406.78	0	0	0	1	0	0	0	87.6	45,492	0.9615
2011	July	9253	1405.65	0	0	0	0	1	0	0	92.1	45,492	0.9615
2011	August	3115	1404.6	0	0	0	0	0	1	0	91.2	45,492	0.9615
2011	September	9137	1403.77	0	0	0	0	0	0	0	73.4	45,492	0.9615
2011	October	7121	1403.37	0	0	0	0	0	0	1	63.1	45,492	0.9615
2012	March	7128	1403.76	1	0	0	0	0	0	1	58.3	45,690	0.9909
2012	April	9867	1404.67	0	1	0	0	0	0	1	64.4	45,690	0.9909
2012	May	20496	1404.09	0	0	1	0	0	0	0	74.7	45,690	0.9909
2012	June	19053	1403.65	0	0	0	1	0	0	0	81.5	45,690	0.9909
2012	July	9189	1402.6	0	0	0	0	1	0	0	87.6	45,690	0.9909
2012	August	5196	1401.68	0	0	0	0	0	1	0	83.8	45,690	0.9909
2012	September	4213	1401.06	0	0	0	0	0	0	0	76.3	45,690	0.9909
2012	October	7068	1400.47	0	0	0	0	0	0	0	61.3	45,690	0.9909
2013	March	5726	1398.93	1	0	0	0	0	0	0	49.3	46,431	0.9749
2013	April	6897	1398.59	0	1	0	0	0	0	0	54.7	46,431	0.9749
2013	May	16543	1398.92	0	0	1	0	0	0	0	69.4	46,431	0.9749
2013	June	19053	1398.22	0	0	0	1	0	0	0	81.5	46,431	0.9749
2013	July	10384	1397.58	0	0	0	0	1	0	1	82.4	46,431	0.9749
2013	August	5828	1396.82	0	0	0	0	0	1	0	83.3	46,431	0.9749

2013	September	4182	1397.08	0	0	0	0	0	0	0	77.4	46,431	0.9749
2013	October	2366	1398.12	0	0	0	0	0	0	1	62.4	46,431	0.9749
2014	March	5946	1396.88	1	0	0	0	0	0	0	46.8	47,529	0.9698
2014	April	6900	1396.23	0	1	0	0	0	0	0	60.1	47,529	0.9698
2014	May	19650	1396.47	0	0	1	0	0	0	1	70.9	47,529	0.9698
2014	June	18270	1397.9	0	0	0	1	0	0	1	79.2	47,529	0.9698
2014	July	10003	1397.43	0	0	0	0	1	0	1	80.1	47,529	0.9698
2014	August	5582	1396.7	0	0	0	0	0	1	0	83.7	47,529	0.9698
2014	September	4653	1396.08	0	0	0	0	0	0	0	75.6	47,529	0.9698
2014	October	2874	1395.54	0	0	0	0	0	0	0	66.6	47,529	0.9698
2015	March	6515	1394.48	1	0	0	0	0	0	0	51.3	48,568	0.8334
2015	April	7074	1395.4	0	1	0	0	0	0	1	61.3	48,568	0.8334
2015	May	15681	1412.34	0	0	1	0	0	0	1	65.8	48,568	0.8334
2015	June	26491	1413.01	0	0	0	1	0	0	1	79.9	48,568	0.8334
2015	July	12345	1411.2	0	0	0	0	1	0	1	84.4	48,568	0.8334
2015	August	7145	1410.99	0	0	0	0	0	1	0	82.2	48,568	0.8334
2015	September	5875	1410.5	0	0	0	0	0	0	0	79.9	48,568	0.8334
2015	October	3240	1410.28	0	0	0	0	0	0	1	64.9	48,568	0.8334
2016	March	7623	1410.88	1	0	0	0	0	0	0	56.4	49,000	0.7961
2016	April	7300	1413.18	0	1	0	0	0	0	1	61.8	49,000	0.7961
2016	May	16846	1411.33	0	0	1	0	0	0	0	68.3	49,000	0.7961
2016	June	30382	1411.39	0	0	0	1	0	0	1	80	49,000	0.7961
2016	July	13203	1411	0	0	0	0	1	0	1	84.8	49,000	0.7961
2016	August	8216	1410.44	0	0	0	0	0	1	1	82.7	49,000	0.7961
2016	September	6018	1411.78	0	0	0	0	0	0	1	76.5	49,000	0.7961
2016	October	8315	1410.84	0	0	0	0	0	0	0	68.3	49,000	0.7961

Table A-2: Great Plains State Park winter season visitation model base data

Year	Month	Visitation	Elevation	December	January	Wet Month	Temperature	Median income	Gas & Time index
2000	November	8858	1407.44	0	0	0	43	45917	0.5984
2000	December	8858	1407.27	1	0	0	31.3	45917	0.5984
2001	January	1730	1407.6	0	1	1	36.1	46522	0.6029
2001	February	3420	1407.92	0	0	1	40.6	46522	0.6029
2001	November	9780	1406.88	0	0	0	54	46522	0.6029
2001	December	3716	1406.5	1	0	0	41.9	46522	0.6029
2002	January	3411	1406.25	0	1	0	40.6	46018	0.5909
2002	February	3860	1406.11	0	0	0	41.7	46018	0.5909
2002	November	8532	1404.36	0	0	0	47.5	46018	0.5909
2002	December	3802	1404.45	1	0	1	40.6	46018	0.5909
2003	January	3599	1404.24	0	1	0	37.2	45671	0.6187
2003	February	4138	1404.13	0	0	0	38.8	45671	0.6187
2003	November	7832	1403.61	0	0	0	50.2	45671	0.6187
2003	December	3615	1403.27	1	0	0	43	45671	0.6187
2004	January	3378	1403.12	0	1	0	41	45771	0.6713
2004	February	3258	1403	0	0	1	40.5	45771	0.6713
2004	November	4505	1407.75	0	0	1	49.6	45771	0.6713
2004	December	3508	1407.46	1	0	0	43	45771	0.6713
2005	January	3214	1407.65	0	1	1	39.2	44927	0.7482
2005	February	3674	1407.82	0	0	0	45.3	44927	0.7482
2005	November	5078	1406.73	0	0	0	52.2	44927	0.7482
2005	December	3206	1406.4	1	0	0	38.8	44927	0.7482
2006	January	3054	1406.08	0	1	0	47.1	45527	0.8083

2006	February	3256	1405.72	0	0	0	41.5	45527	0.8083
2006	November	4780	1401.68	0	0	0	51.3	45527	0.8083
2006	December	2631	1401.73	1	0	1	41.5	45527	0.8083
2007	January	2784	1401.61	0	1	1	35.8	47460	0.8373
2007	February	2994	1401.45	0	0	0	40.5	47460	0.8373
2007	November	4523	1410.35	0	0	0	51.1	47460	0.8373
2007	December	2347	1410.28	1	0	1	38.1	47460	0.8373
2008	January	2681	1409.96	0	1	0	39.4	47085	0.9308
2008	February	2342	1409.86	0	0	0	42.6	47085	0.9308
2009	November	3487	1406.99	0	0	0	53.1	45975	0.7575
2009	December	1654	1406.87	1	0	0	36	45975	0.7575
2010	January	967	1407.06	0	1	0	36.3	45676	0.8323
2010	February	2154	1407.56	0	0	0	37.2	45676	0.8323
2010	November	2849	1409.48	0	0	1	50.4	45676	0.8323
2010	December	1573	1409.12	1	0	0	41.2	45676	0.8323
2011	January	961	1408.89	0	1	0	36.1	45492	0.9615
2011	February	2094	1408.78	0	0	0	40.8	45492	0.9615
2011	November	2854	1404.52	0	0	1	49.5	45492	0.9615
2011	December	1548	1404.37	1	0	1	40.1	45492	0.9615
2012	January	948	1404.07	0	1	0	43.3	45690	0.9909
2012	February	1684	1403.82	0	0	0	43.9	45690	0.9909
2012	November	3369	1399.99	0	0	0	54.7	45690	0.9909
2012	December	1739	1399.7	1	0	0	41	45690	0.9909
2013	January	1874	1399.47	0	1	0	40.1	46431	0.9749
2013	February	1014	1399.36	0	0	1	41.4	46431	0.9749
2013	November	2729	1397.99	0	0	1	46.6	46431	0.9749

2013	December	1800	1397.82	1	0	0	34.7	46431	0.9749
2014	January	1900	1397.49	0	1	0	37.4	47529	0.9698
2014	February	1692	1397.25	0	0	0	36.1	47529	0.9698
2014	November	3437	1395.54	0	0	1	45.5	47529	0.9698
2014	December	2867	1395.21	1	0	0	42.1	47529	0.9698
2015	January	1425	1395.03	0	1	1	38.7	48568	0.8334
2015	February	1500	1394.73	0	0	0	39.6	48568	0.8334
2015	November	3612	1411.27	0	0	1	51.1	48568	0.8334
2015	December	2800	1411.94	1	0	1	44.6	48568	0.8334
2016	January	1501	1411.1	0	1	0	39.6	49000	0.7961
2016	February	1921	1410.99	0	0	0	49	49000	0.7961
2016	November	3815	1410.86	0	0	1	56.1	49000	0.7961

Table A-3: Quartz Mountain Nature Park recreation season visitation model base data

Year	Month	Sold	Revenue	Revenue in 2016 $'s	Average real revenue	Elevation	March	April	May	June	July	August	Wet month	Temperature	Median income	Cost index
2010	March	2045	135,812	149,484	73.10	1544.56	1	0	0	0	0	0	0	49.6	45,676	0.8323
2010	April	1884	144,674	159,238	84.52	1549.06	0	1	0	0	0	0	1	62.5	45,676	0.8323
2010	May	2181	194,155	213,700	97.98	1552.77	0	0	1	0	0	0	0	70.3	45,676	0.8323
2010	June	2666	146,170	160,884	60.35	1551.62	0	0	0	1	0	0	0	84.6	45,676	0.8323
2010	July	2470	282,487	310,924	125.88	1552.31	0	0	0	0	1	0	1	82.4	45,676	0.8323
2010	August	1780	171,282	188,524	105.91	1541.72	0	0	0	0	0	1	0	86	45,676	0.8323
2010	September	1277	112,228	123,526	96.73	1539.77	0	0	0	0	0	0	0	70	45,676	0.8323
2010	October	1790	123,824	136,289	76.14	1540.26	0	0	0	0	0	0	0	65.1	45,676	0.8323
2011	March	1653	126,951	135,455	81.94	1545.16	1	0	0	0	0	0	0	53.9	45,492	0.9615
2011	April	1458	128,362	136,961	93.94	1545.26	0	1	0	0	0	0	0	63.9	45,492	0.9615
2011	May	1448	145,181	154,906	106.98	1545.15	0	0	1	0	0	0	1	71.7	45,492	0.9615
2011	Jun	2654	179,206	191,210	72.05	1537.35	0	0	0	1	0	0	0	88.3	45,492	0.9615
2011	Jul7	2089	229,410	244,777	117.17	1532.82	0	0	0	0	1	0	0	93.5	45,492	0.9615
2011	August	1030	96,752	103,233	100.23	1531.89	0	0	0	0	0	1	0	92	45,492	0.9615
2011	September	1228	103,110	110,017	89.59	1531.34	0	0	0	0	0	0	0	74.9	45,492	0.9615
2011	October	1827	104,411	111,405	60.98	1531.24	0	0	0	0	0	0	1	64.4	45,492	0.9615
2012	March	1792	129,082	134,936	75.30	1533.72	1	0	0	0	0	0	1	59.9	45,690	0.9909
2012	April	1229	100,943	105,521	85.86	1534.76	0	1	0	0	0	0	1	66.1	45,690	0.9909
2012	May	1504	135,003	141,126	93.83	1535.14	0	0	1	0	0	0	1	75.4	45,690	0.9909
2012	June	2706	158,827	166,030	61.36	1535.24	0	0	0	1	0	0	0	81.3	45,690	0.9909
2012	July	1825	186,347	194,799	106.74	1534.37	0	0	0	0	1	0	0	87.6	45,690	0.9909
2012	August	1333	128,718	134,556	100.94	1533.75	0	0	0	0	0	1	0	84.3	45,690	0.9909
2012	September	1761	142,148	148,595	84.38	1532.99	0	0	0	0	0	0	0	75.8	45,690	0.9909
2012	October	1707	110,472	115,482	67.65	1532.51	0	0	0	0	0	0	0	61.4	45,690	0.9909

2013	March	1345	95,884	98,786	73.45	1532.13	1	0	0	0	0	0	0	50.1	46,431	0.9749
2013	April	1194	96,601	99,524	83.35	1532.2	0	1	0	0	0	0	0	55.2	46,431	0.9749
2013	May	1410	115,677	119,178	84.52	1532.17	0	0	1	0	0	0	0	70.1	46,431	0.9749
2013	June	2355	112,668	116,078	49.29	1531.58	0	0	0	1	0	0	0	82.6	46,431	0.9749
2013	July	1512	159,609	164,439	108.76	1530.71	0	0	0	0	1	0	1	82.9	46,431	0.9749
2013	August	1536	147,999	152,478	99.27	1530.06	0	0	0	0	0	1	0	85	46,431	0.9749
2013	September	1171	106,174	109,387	93.41	1529.65	0	0	0	0	0	0	0	78.7	46,431	0.9749
2013	October	1333	78,714	81,096	60.84	1529.57	0	0	0	0	0	0	0	63.1	46,431	0.9749
2014	March	817	69,837	70,802	86.66	1529.2	1	0	0	0	0	0	0	45.8	47,529	0.9698
2014	April	1051	96,473	97,806	93.06	1528.9	0	1	0	0	0	0	0	62	47,529	0.9698
2014	May	930	88,154	89,372	96.10	1528.62	0	0	1	0	0	0	1	70.2	47,529	0.9698
2014	June	2479	120,436	122,100	49.25	1529.45	0	0	0	1	0	0	0	79.3	47,529	0.9698
2014	July	1547	151,987	154,087	99.60	1529.34	0	0	0	0	1	0	1	80.9	47,529	0.9698
2014	August	1836	171,292	173,659	94.59	1528.6	0	0	0	0	0	1	0	83.9	47,529	0.9698
2014	September	894	83,211	84,361	94.36	1528.2	0	0	0	0	0	0	0	75.9	47,529	0.9698
2014	October	1202	75,422	76,464	63.61	1527.84	0	0	0	0	0	0	0	67.5	47,529	0.9698
2015	March	1033	84,748	85,817	83.08	1527.95	1	0	0	0	0	0	0	50.8	46,235	0.8334
2015	April	847	74,600	75,541	89.19	1534.6	0	1	0	0	0	0	1	62.2	46,235	0.8334
2015	May	797	74,052	74,986	94.09	1559.46	0	0	1	0	0	0	1	65.9	46,235	0.8334
2015	June	2435	122,479	124,024	50.93	1559.12	0	0	0	1	0	0	1	79.5	46,235	0.8334
2015	July	1838	182,963	185,271	100.80	1556.04	0	0	0	0	1	0	1	83.9	46,235	0.8334
2015	August	1408	139,932	141,697	100.64	1550.65	0	0	0	0	0	1	1	81.9	46,235	0.8334
2015	September	965	85,547	86,626	89.77	1549.6	0	0	0	0	0	0	0	79.5	46,235	0.8334
2015	October	1256	69,673	70,552	56.17	1549.59	0	0	0	0	0	0	1	65.1	46,235	0.8334
2016	March	688	70,820	70,820	102.94	1556.6	1	0	0	0	0	0	0	56.4	49,000	0.7961
2016	April	859	79,843	79,843	92.95	1557.66	0	1	0	0	0	0	1	61.2	49,000	0.7961

2016	May	799	84,002	84,002	105.13	1558.55	0	0	1	0	0	0	1	67.8	49,000	0.7961
2016	June	2460	137,841	137,841	56.03	1559.1	0	0	0	1	0	0	1	80.2	49,000	0.7961
2016	July	1822	194,972	194,972	107.01	1553.91	0	0	0	0	1	0	1	85.4	49,000	0.7961
2016	August	890	100,533	100,533	112.96	1546.83	0	0	0	0	0	1	1	82.5	49,000	0.7961
2016	September	1339	133,607	133,607	99.78	1547.87	0	0	0	0	0	0	1	76.4	49,000	0.7961
2016	October	1299	87,616	87,616	67.45	1547.7	0	0	0	0	0	0	0	68.2	49,000	0.7961

Table A-4: Quartz Mountain Nature Park winter season visitation model base data

Year	Month	Sold	Revenue	Revenue in 2016 $'s	Average real revenue	Elevation	December	January	Wet month	Temperature	Median income	Cost index
2010	January	38	641	705.5274	18.56651	1539.64	0	1	1	38.4	45,676	0.8323
2010	February	2	26	28.61734	14.30867	1542.66	0	0	0	41.6	45,676	0.8323
2010	November	157	2513.5	2766.526	17.62118	1541.28	0	0	0	51.6	45,676	0.8323
2010	December	18	563	619.6754	34.42641	1542.21	1	0	0	41.1	45,676	0.8323
2011	January	54	523	558.0342	10.33397	1543.32	0	1	0	37.7	45,492	0.9615
2011	February	52	838	894.1351	17.19491	1544.44	0	0	0	40.8	45,492	0.9615
2011	November	93	3005	3206.296	34.4763	1532.02	0	0	1	50.8	45,492	0.9615
2011	December	8	242	258.2109	32.27636	1532.08	1	0	1	40.3	45,492	0.9615
2012	January	57	591	617.8042	10.83867	1531.9	0	1	0	43.3	45,690	0.9909
2012	February	96	2066.5	2160.224	22.50233	1532.37	0	0	0	43.8	45,690	0.9909
2012	November	159	3245	3392.174	21.33443	1532.17	0	0	0	55.2	45,690	0.9909
2012	December	16	223	233.1139	14.56962	1532.08	1	0	0	42.2	45,690	0.9909
2013	January	27	486	500.7079	18.54474	1532.06	0	1	0	40.2	46,431	0.9749
2013	February	91	1241	1278.557	14.05007	1532.15	0	0	1	42.2	46,431	0.9749
2013	November	224	2796	2880.616	12.85989	1529.54	0	0	1	48.3	46,431	0.9749
2013	December	5	103	106.1171	21.22342	1529.48	1	0	0	34.7	46,431	0.9749
2014	January	48	718	727.9207	15.16501	1529.32	0	1	0	38.2	47,529	0.9698
2014	February	50	920	932.7117	18.65423	1529.29	0	0	0	36.1	47,529	0.9698
2014	November	206	3179	3222.924	15.64526	1527.8	0	0	1	46	47,529	0.9698
2014	December	7	127	128.7548	18.39354	1527.64	1	0	0	42.8	47,529	0.9698
2015	January	111	1787	1809.543	16.30219	1527.64	0	1	0	38.2	46,235	0.8334
2015	February	95	1345	1361.967	14.3365	1527.54	0	0	0	40.1	46,235	0.8334
2015	November	390	5335	5402.302	13.85206	1550.84	0	0	1	51.9	46,235	0.8334
2015	December	125	1840	1863.212	14.90569	1552.76	1	0	1	44	46,235	0.8334

2016	January	184	2410	2410	3.305898	1554.85	0	1	1	38.9	49,000	0.7961
2016	February	176	3146	3146	6.292	1555.87	0	0	0	48.4	49,000	0.7961
2016	November	307	5421.5	5421.5	5.880152	1547.83	0	0	1	56	49,000	0.7961
2016	December	30	328	328	0.602941	1548.24	1	0	0	40.9	49,000	0.7961

Table A-5: Quartz Mountain Lodge recreation season visitation model base data

Year	Month	Sold	Revenue	Revenue in 2016 $'s	Average real revenue	Elevation	March	April	May	June	July	August	Wet month	Temperature	Income	Cost Index
2010	Mar	2045	135812	149483.76	73.097193	1544.56	1	0	0	0	0	0	0	49.6	45,676	0.8323
2010	Apr	1884	144674	159237.87	84.5211618	1549.06	0	1	0	0	0	0	1	62.5	45,676	0.8323
2010	May	2181	194155	213699.96	97.9825597	1552.77	0	0	1	0	0	0	0	70.3	45,676	0.8323
2010	Jun	2666	146170	160884.47	60.3467616	1551.62	0	0	0	1	0	0	0	84.6	45,676	0.8323
2010	Jul	2470	282487	310924.06	125.880187	1552.31	0	0	0	0	1	0	1	82.4	45,676	0.8323
2010	Aug	1780	171282	188524.41	105.91259	1541.72	0	0	0	0	0	1	0	86	45,676	0.8323
2010	Sep	1277	112228	123525.63	96.7311149	1539.77	0	0	0	0	0	0	0	70	45,676	0.8323
2010	Oct	1790	123824	136288.97	76.1390871	1540.26	0	0	0	0	0	0	0	65.1	45,676	0.8323
2011	Mar	1653	126951	135455.07	81.9449927	1545.16	1	0	0	0	0	0	0	53.9	45,492	0.9615
2011	Apr	1458	128362	136960.59	93.9373057	1545.26	0	1	0	0	0	0	0	63.9	45,492	0.9615
2011	May	1448	145181	154906.25	106.979452	1545.15	0	0	1	0	0	0	1	71.7	45,492	0.9615
2011	Jun	2654	179206	191210.48	72.0461497	1537.35	0	0	0	1	0	0	0	88.3	45,492	0.9615
2011	Jul	2089	229410	244777.5	117.174485	1532.82	0	0	0	0	1	0	0	93.5	45,492	0.9615
2011	Aug	1030	96752	103233.13	100.226341	1531.89	0	0	0	0	0	1	0	92	45,492	0.9615
2011	Sep	1228	103110	110017.03	89.5904191	1531.34	0	0	0	0	0	0	0	74.9	45,492	0.9615
2011	Oct	1827	104411	111405.18	60.9771127	1531.24	0	0	0	0	0	0	1	64.4	45,492	0.9615
2012	Mar	1792	129082	134936.38	75.29932	1533.72	1	0	0	0	0	0	1	59.9	45,690	0.9909
2012	Apr	1229	100943	105521.17	85.8593703	1534.76	0	1	0	0	0	0	1	66.1	45,690	0.9909
2012	May	1504	135003	141125.92	93.833725	1535.14	0	0	1	0	0	0	1	75.4	45,690	0.9909
2012	Jun	2706	158827	166030.44	61.3564063	1535.24	0	0	0	1	0	0	0	81.3	45,690	0.9909
2012	Jul	1825	186347	194798.58	106.738946	1534.37	0	0	0	0	1	0	0	87.6	45,690	0.9909
2012	Aug	1333	128718	134555.87	100.94214	1533.75	0	0	0	0	0	1	0	84.3	45,690	0.9909
2012	Sep	1761	142148	148594.98	84.3810202	1532.99	0	0	0	0	0	0	0	75.8	45,690	0.9909
2012	Oct	1707	110472	115482.34	67.6522227	1532.51	0	0	0	0	0	0	0	61.4	45,690	0.9909

2013	Mar	1345	95884	98785.747	73.4466518	1532.13	1	0	0	0	0	0	0	50.1	46,431	0.9749
2013	Apr	1194	96601	99524.445	83.3538068	1532.2	0	1	0	0	0	0	0	55.2	46,431	0.9749
2013	May	1410	115677	119177.74	84.5232228	1532.17	0	0	1	0	0	0	0	70.1	46,431	0.9749
2013	Jun	2355	112668	116077.68	49.2898864	1531.58	0	0	0	1	0	0	0	82.6	46,431	0.9749
2013	Jul	1512	159609	164439.26	108.756126	1530.71	0	0	0	0	1	0	1	82.9	46,431	0.9749
2013	Aug	1536	147999	152477.91	99.2694713	1530.06	0	0	0	0	0	1	0	85	46,431	0.9749
2013	Sep	1171	106174	109387.15	93.4134534	1529.65	0	0	0	0	0	0	0	78.7	46,431	0.9749
2013	Oct	1333	78714	81096.129	60.8373063	1529.57	0	0	0	0	0	0	0	63.1	46,431	0.9749
2014	Mar	817	69837	70801.943	86.6608854	1529.2	1	0	0	0	0	0	0	45.8	47,529	0.9698
2014	Apr	1051	96473	97805.975	93.0599192	1528.9	0	1	0	0	0	0	0	62	47,529	0.9698
2014	May	930	88154	89372.031	96.0989578	1528.62	0	0	1	0	0	0	1	70.2	47,529	0.9698
2014	Jun	2479	120436	122100.07	49.2537611	1529.45	0	0	0	1	0	0	0	79.3	47,529	0.9698
2014	Jul	1547	151987	154087.02	99.6037598	1529.34	0	0	0	0	1	0	1	80.9	47,529	0.9698
2014	Aug	1836	171292	173658.76	94.5853786	1528.6	0	0	0	0	0	1	0	83.9	47,529	0.9698
2014	Sep	894	83211	84360.733	94.363236	1528.2	0	0	0	0	0	0	0	75.9	47,529	0.9698
2014	Oct	1202	75422	76464.112	63.6140697	1527.84	0	0	0	0	0	0	0	67.5	47,529	0.9698
2015	Mar	1033	84748	85817.107	83.0756118	1527.95	1	0	0	0	0	0	0	50.8	46,235	0.8334
2015	Apr	847	74600	75541.089	89.1866454	1534.6	0	1	0	0	0	0	1	62.2	46,235	0.8334
2015	May	797	74052	74986.176	94.0855402	1559.46	0	0	1	0	0	0	1	65.9	46,235	0.8334
2015	Jun	2435	122479	124024.09	50.9339172	1559.12	0	0	0	1	0	0	1	79.5	46,235	0.8334
2015	Jul	1838	182963	185271.1	100.800382	1556.04	0	0	0	0	1	0	1	83.9	46,235	0.8334
2015	Aug	1408	139932	141697.26	100.637259	1550.65	0	0	0	0	0	1	1	81.9	46,235	0.8334
2015	Sep	965	85547	86626.186	89.7680688	1549.6	0	0	0	0	0	0	0	79.5	46,235	0.8334
2015	Oct	1256	69673	70551.934	56.1719219	1549.59	0	0	0	0	0	0	1	65.1	46,235	0.8334
2016	Mar	688	70819.81	70819.81	102.93577	1556.6	1	0	0	0	0	0	0	56.4	49,000	0.7961
2016	Apr	859	79843	79843	92.9487776	1557.66	0	1	0	0	0	0	1	61.2	49,000	0.7961

2016	May	799	84002	84002	105.133917	1558.55	0	0	1	0	0	0	1	67.8	49,000	0.7961
2016	Jun	2460	137841	137841	56.0329268	1559.1	0	0	0	1	0	0	1	80.2	49,000	0.7961
2016	Jul	1822	194972	194972	107.009879	1553.91	0	0	0	0	1	0	1	85.4	49,000	0.7961
2016	Aug	890	100532.5	100532.5	112.957865	1546.83	0	0	0	0	0	1	1	82.5	49,000	0.7961
2016	Sep	1339	133606.8	133606.8	99.7810306	1547.87	0	0	0	0	0	0	1	76.4	49,000	0.7961
2016	Oct	1299	87616	87616	67.4488068	1547.7	0	0	0	0	0	0	0	68.2	49,000	0.7961

Table A-6: Quartz Mountain Lodge winter season visitation model base data

Year	Month	Sold	Revenue	Revenue in 2016 $'s	Average real revenue	Elevation	December	January	Wet month	Temperature	Median income	Cost Index
2010	January	787	44,902	49,422	62.7981458	1539.64	0	1	1	38.4	45,676	0.8323
2010	February	1007	56,587	62,283	61.8504789	1542.66	0	0	0	41.6	45,676	0.8323
2010	November	980	67,318	74,095	75.6068242	1541.28	0	0	0	51.6	45,676	0.8323
2010	December	748	50,667	55,767	74.555461	1542.21	1	0	0	41.1	45,676	0.8323
2011	January	667	41,236	43,998	65.9644348	1543.32	0	1	0	37.7	45,492	0.9615
2011	February	813	50,183	53,545	65.8605303	1544.44	0	0	0	40.8	45,492	0.9615
2011	November	1320	95,483	101,879	77.1811549	1532.02	0	0	1	50.8	45,492	0.9615
2011	December	1004	59,315	63,288	63.0361921	1532.08	1	0	1	40.3	45,492	0.9615
2012	January	872	47,928	50,102	57.4561069	1531.9	0	1	0	43.3	45,690	0.9909
2012	February	1357	80,096	83,729	61.7013057	1532.37	0	0	0	43.8	45,690	0.9909
2012	November	1566	99,930	104,462	66.7064001	1532.17	0	0	0	55.2	45,690	0.9909
2012	December	852	54,965	57,458	67.4388276	1532.08	1	0	0	42.2	45,690	0.9909
2013	January	726	45,895	47,284	65.129373	1532.06	0	1	0	40.2	46,431	0.9749
2013	February	1063	65,635	67,621	63.6136578	1532.15	0	0	1	42.2	46,431	0.9749
2013	November	1292	93,305	96,129	74.4030171	1529.54	0	0	1	48.3	46,431	0.9749
2013	December	625	44,231	45,570	72.9113072	1529.48	1	0	0	34.7	46,431	0.9749
2014	January	405	33,407	33,869	83.6261411	1529.32	0	1	0	38.2	47,529	0.9698
2014	February	686	50,431	51,128	74.530334	1529.29	0	0	0	36.1	47,529	0.9698
2014	November	923	70,238	71,208	77.1489534	1527.8	0	0	1	46	47,529	0.9698
2014	December	519	41,647	42,222	81.3534487	1527.64	1	0	0	42.8	47,529	0.9698
2015	January	211	16,313	16,519	78.2881071	1527.64	0	1	0	38.2	46,235	0.8334
2015	February	601	42,059	42,590	70.8645253	1527.54	0	0	0	40.1	46,235	0.8334
2015	November	806	68,513	69,377	86.076055	1550.84	0	0	1	51.9	46,235	0.8334
2015	December	777	63,431	64,231	82.6656245	1552.76	1	0	1	44	46,235	0.8334

2016	January	729	74,407	74,407	102.067215	1554.85	0	1	1	38.9	49,000	0.7961
2016	February	500	40,940	40,940	81.88	1555.87	0	0	0	48.4	49,000	0.7961
2016	November	922	78,748	78,748	85.4094902	1547.83	0	0	1	56	49,000	0.7961
2016	December	544	34,376	34,376	63.1902574	1548.24	1	0	0	40.9	49,000	0.7961

Appendix B - Addressing Potential Econometric Issues

Serial Correlation

The data used in this analysis is time-series data, which means there are specific potential econometric issues that may need to be addressed to ensure the best statistical results are obtained for the estimated model. One common econometric problem that is frequently found in time-series data is serial correlation, also called autocorrelation, which occurs when errors for individual observations in an estimated regression are correlated with each other. In other words, the error associated with an observation in one time period influences the error associated with an observation in a following time period. Serial correlation does not cause the coefficient estimates of the explanatory variables to be biased, where biased estimates are systematically different than the "true" values of the explanatory variables, but does cause an underestimation of the variation or standard error of the estimate. As a result, serial correlation can result in an estimator appearing to be statistically significant when in actuality it may not be.

The standard test for serial correlation is the Durbin–Watson Test. The Durbin – Watson Test tests for first-order serial correlation, which means the error from one time period is carried over to the next time period and the effect is not lagged over additional time periods. First-order serial correlation would be most likely for this simple recreation model. The Durbin – Watson test for serial correlation indicated there was a potential problem with both models.

One method that can be used to address the serial correlation problem is to adjust the standard errors of the model to account for larger standard errors when serial correlation exists and re-evaluate the statistical significance of the individual coefficients. These increased standard errors are called Newey – West standard errors and the resulting estimates of statistical significance result in more reliable t-tests. The t-statistics corrected for serial correlation are used to evaluate the models.

Heteroskedasticity

Another common econometric problem is heteroscedasticity, which means the error terms in an estimated model are not constant across observations. For example, families with low incomes may spend relatively little on vacations so there would be relatively little variation in vacation spending for those families while some high income families may spend a large amount on vacations while others never take a vacation. The variation in vacation spending by high income families may be very large. Therefore, a data set that combines high and low income families would likely have non-constant variation in vacation spending which would result in heteroskedasticity.

Heteroskedasticity does not cause biased estimates, but it does potentially lead to underestimated standard errors which would lead to artificially high t-statistics. A commonly used remedy for dealing with heteroscedasticity is to estimate robust standard errors, which corrects the artificially high t-statistics. Stata includes options for estimating robust standard errors, which were used to estimate corrected t-statistics. The use of robust standard errors does not change the estimated model coefficients.

Specification Error

Another potential problem that is frequently encountered in a regression model is specification error. Common specification errors include omitted relevant variables and including irrelevant variables. An omitted relevant variable creates bias in the estimated explanatory variables included in the equation because the influence of the omitted variable is absorbed into the error term and the other explanatory variables included in the equation. As a result, estimates of the explanatory variables could be skewed away from their true values.

One formal specification criteria that is frequently used to test the likelihood of an omitted variable is the Ramsey Regression Specification Error Test or Ramsey RESET test. The Ramsey RESET test measures whether the fit of an equation can be significantly improved by the addition of explanatory variables to the model. These additional explanatory variables are equal to the predicted value of the dependent visitation variable raised to the 2nd, 3rd, and 4th power. The intuition behind the test is that the additional explanatory variables act as proxies for potentially missing variables. If these additional variables are not statistically significant, then there is a lower likelihood of a missing relevant variable in the model. A Ramset RESET test was conducted for both models and the test results indicated that omitted variables was not an issue.

Unlike the omitted variable problem, including irrelevant variables does not create bias. However, including irrelevant variables does increase the variance of the estimated coefficients and will decrease the t-statistics used to evaluate significance. One approach that can be used to evaluate the problem of irrelevant variables is to remove an explanatory variable that is not statistically significant or has very little impact on the dependent variable and comparing the modeling results to determine if there is a significant change in the variation in the dependent variable that is explained by the model. A major problem with this approach is the potential for introducing the more serious specification error of omitted variable bias. As a result, theoretically based models are used for the analysis and variables that are not statistically significant based on t-tests are retained in the models to avoid potentially creating biased estimates.

Multicollinearity

Multicollinearity occurs when two or more explanatory variables tend to move together in a linear fashion. Multicollinearity does not create bias in the coefficient estimates, but it does increase the variance and standard errors of the individual coefficient estimates. The primary issue with multicollinearity is that it makes identification of the influence of individual variables very difficult. For example, if education and income are highly correlated and both are included in a regression model of recreation visitation, then it would be difficult to separate out the individual effects of income and education on visitation because they move together and essentially act as one. If the analyst is interested in the specific impact of income on visitation, the income coefficient may not be an accurate indicator of the influence of income on visitation. However, the estimated income and education coefficients considered together may be an accurate indicator of the two influences combined.

Multicollinearity was evaluated using simple correlation coefficients and through the use of variance inflation factors (VIFs). A correlation coefficient (r) is a measure of the strength of correlation between two variables. An $r = 1$ is perfectly positively correlated, an $r = -1$ is perfectly negatively correlated, and an $r = 0$ is completely uncorrelated. The simple correlation coefficients for the Great Plains State Park and Quartz Mountain Nature Park and Lodge data did not indicate significant correlation. The correlation between summer and temperature was expected, however the two variables are intended to measure different influences. The summer variable represents summer breaks from school and traditional vacation time that is planned in advance and would occur regardless of climatic variation. The temperature variable represents an increased likelihood of taking a trip during warmer weather. In this case correcting the problem of multicollinearity by removing or combining variables could lead to the more serious problem of bias from a specification error. The negative correlation of lake elevation and the index for gas and time cost would appear to be a spurious correlation and correcting this could again create a specification error.

One issue with the use of simple correlation coefficients is that they only measure correlation between two individual variables, but do not measure correlation between combinations of variables. VIF's are used to detect multicollinearity by evaluating the extent to which variation in one explanatory variable can be explained by all of the other explanatory variables. The VIF is an index measuring the degree to which multicollinearity has increased the variance of the estimated coefficient. As a rule of thumb, a VIF greater than 5 is an indicator that multicollinearity may be a problem. The estimated VIF's for the two equations were less than 5 so a multicollinearity problem was not indicated by the VIF scores.

Appendix C – Derivation of within region expenditures by outside of region visitors

Trip and Expenditure Data

Information provided in a study of the economic value of sportfishing trips to Oklahoma Lakes (Melstrom, et al., 2015) is used to estimate representative expenditures per recreation trip. Recreation spending estimates are presented in Table C-1.

Table C-1 - Recreation spending per trip for Oklahoma resident anglers

	All Trips		Single Day Trips		Overnight Trips	
Spending Category	Median	Average	Median	Average	Median	Average
Transportation	$30	$53	$20	$25	$50	$86
Lodging and Food	$10	$62	$0	$14	$50	$113
Fishing costs	$10	$34	$8	$20	$20	$49
Total	$50	$149	$28	$59	$120	$248

Source: Melstrom, et al., 2015.

These expenditures are for sportfishing, but overnight expenditures would include camping or other lodging and it is assumed that several types of activities would be included in the fishing activity. These expenditures are for Oklahoma residents, so expenditures by out of state participants may be understated. The values presented in Table C-1 are the basis for recreation expenditure estimates.

Within Region and Outside of Region Expenditures

An additional complication that must be addressed is the location of recreation expenditures. For this analysis it is assumed that impacts only occur as a result of spending within the study area by out of region visitors traveling to the region where the recreation area is located. Recreation spending by those that live in the area represents a redistribution of spending rather than a new source of spending. As an example, a person that is going to recreate at a lake may have decided not to participate in some other type of activity (perhaps they would have spent the money on bowling or some other activity) or may have taken the money spent on recreation from some other unrelated type of spending (perhaps they decided not to buy clothes). Therefore, treating those expenditures as additional regional spending will overstate regional impacts. As a result, the percentage of visitors from outside the region must be estimated.

The estimated percentages of visitors from out of state were based on monthly visitation data obtained from the Oklahoma Tourism and Recreation Department, State Parks Division. The data for fiscal years 2001 through 2006 included information on the number of day use and out of state visitors. The accuracy of the out of state visitation percentages and the methods used to derive these estimates are unknown. Out of state visitation at Great Plains State Park varied by month and year from 5.4 percent to 26.3 percent of all visits over the 2001 to 2006 period. Average out of state visits over the entire period was 15.5 percent. The percentage of recreation visits from out-of-state used in this analysis for

Great Plains State Park and Quartz Mountain Nature Park and Lodge is 15.5 percent. Out of state visitation data are not available for Quartz Mountain Nature Park and Lodge.

In addition to the out-of-state visitors, the percentage of visitors within Oklahoma but outside of the study regions must be estimated. This estimate is simply based on the location of the Oklahoma population. It was assumed that the probability of a person visiting the site is the same for all locations within the state so the percentage of the total population located within the five county impact area represents the percentage of visitors to the site. In fact, the probability of visiting a site is inversely proportional to the distance of the location from the site. However, the form of this distance – visitation probability relationship is not known. Based on 2010 U.S. Bureau of the Census population estimates, approximately 5% of all in-state visitors are located within the five county impact region. Recreation expenditures by the 5% that live within the impact area represent a redistribution of spending between sectors and would generate little or no regional impacts.

Combining the information that 15.5% of visitors to Great Plains State Park and Quartz Mountain Nature Park and Lodge are from out of state and that 5% of in-state visitation originates from within the five county study region, the estimated within region percentage of visitors can be calculated. An estimated 84.5% of visitation originates from within Oklahoma (100% - 15.5%) and 95% of in-state visitation originates from outside of the five county study area (100% - 5%). Therefore, 80.3% of total visitation originating from within Oklahoma is from outside the study area (84.5% * 95%). The percentage of total visitation originating from outside the study area is estimated to be 95.8% (15.5% + 80.3%).

The percentages of visitors from outside the study area are multiplied by the average number of visits/trips to each recreation area to estimate the number of visitors generating regional impacts. The estimated number of visitors are then multiplied by the estimated average expenditure per trip to estimate total recreation based expenditures for each expenditure category. These expenditures are the basis for estimating the baseline regional economic impacts associated with each recreation area. Regional economic impacts associated with a one foot change in elevation are also presented to portray the potential impact of drought that results in a change in lake elevation.

Another expenditure location issue that needs to be resolved before regional impacts can be estimated is determining the proportion of the identified trip expenditures made by those living outside of the study area that is actually spent in the impact region. The general expense categories identified for estimating regional impacts are food, lodging, transportation, and equipment.

Food could be purchased in the home region in a grocery store and prepared in the recreation area, food may be purchased in a grocery store located in the recreation area and prepared in the recreation area, or food may be purchased from restaurants in the region. For this analysis it is assumed that ½ of grocery store expenditures are in the home region and ½ are purchased in the recreation area. It is also assumed that all restaurant expenditures are in the recreation area. Therefore, 75% of total food expenditures are assumed to be in the recreation area.

Lodging expenses apply only to overnight trips and refer not only to cabins or hotel rooms, but to recreational vehicle or tent accommodations as well. Given that the lodging activity occurs only at the destination site, 100% of lodging expenses are assumed to occur in the recreation area.

The major expense associated with transportation costs is gasoline. It is assumed that visitors fill up with gasoline at home before they leave and fill up in recreation region when they leave to come back home. Therefore, transportation expenditures are assumed to be ½ in the recreation area and ½ is assumed to be in the origin site outside of the region.

Finally, it is assumed that most recreation related equipment is purchased in the home region before leaving for the trip. In order to account for potential replacement of equipment that is lost, broken, or forgotten, 10% of equipment expenditures are assumed to be within the region. Any other miscellaneous costs are assumed to be ½ in the recreation region and ½ outside of the region. The resulting percentages of total recreation expenditures within the region by spending category are shown in Table C-2.

Table C-2 – Estimated percentage of total trip related recreation expenditures by out of region visitors that occur the impact region

Recreation Area	Food	Lodging	Transportation	Equipment	Other
Great Plains State Park	71.8%	95.7%	47.9%	9.6%	47.9%
Quartz Mountain Nature Park and Lodge	71.9%	95.8%	47.9%	9.6%	47.9%

Estimated Percentage of Total Expenditures that Generate Regional Impacts

Combining the estimated expenditures per trip, the percentage of visitors from outside the study region, and the percentage of recreation expenditures by out of region visitors that is spent within the region, the expenditures per visit that generate regional impacts can be estimated. The results are presented in Table C-3.

Table C-3 – Estimated recreation expenditures that generate regional impacts

Expenditure category	Great Plains State Park Expenditures		Quartz Mountain Nature Park Expenditures	Quartz Mountain Lodge Expenditures
	Day Use (per visit)	**Overnight Use (per visit)**	**Overnight use (per visit)**	**Overnight use (per visit)**
Food	$10.05	$20.10	$20.13	$22.17
Lodging	$0	$21.05	$15.33	$78.72
Transportation	$11.98	$23.95	$23.95	$41.19
Other	$9.58	$23.47	$23.47	$23.47
Total	**$31.61**	**$88.57**	**$82.88**	**$165.55**