DISSERTATION

ESTIMATING THE ECONOMIC EFFECTS OF CLIMATE CHANGE ON NATURE-BASED TOURISM: A COMPARISON OF REVEALED- AND STATED-PREFERENCE METHODS

Submitted by

Robert B. Richardson

Department of Agricultural and Resource Economics

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WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY ROBERT B. RICHARDSON, ENTITLED ESTIMATING THE ECONOMIC EFFECTS OF CLIMATE CHANGE ON NATURE-BASED TOURISM: A COMPARISON OF REVEALED- AND STATED-PREFERENCE METHODS, BE ACCEPTED AS FULFILLING IN PART THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

Committee on Graduate Work

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Adviser

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Department Chair

ABSTRACT OF DISSERTATION

ESTIMATING THE ECONOMIC EFFECTS OF CLIMATE CHANGE ON NATURE-BASED TOURISM: A COMPARISON OF REVEALED- AND STATED-PREFERENCE METHODS

Exogenous effects of a changing climate may influence visitation for nature-based recreation sites such as national parks, and in turn, may impact the regional economy of a gateway community and the net economic benefits of recreation. The studies herein represent the examination of the economic effects of climatic change on nature-based tourism.

The first paper explores the use of revealed-preference data in the measurement of the relative effects of climate variables on visitation at Rocky Mountain National Park (RMNP) and the economy of its gateway community. Historical data are used to estimate a multiple regression of the past effects of climate variability on park visitation. Temperature was found to have a positive and statistically significant effect on visitation. Visitation effects, along with forecasts of climate variables and regional population, are then used with an input-output model to forecast the impact to the economy of the gateway community of Estes Park, Colorado. The results of the statistical model are used to estimate prediction intervals for the regional effects, including employment and income. Prediction intervals allow for testing the relative effects of climate change and

population growth on future estimates of visitation; from this, population growth was found to be the only significant determinant of future park visitation.

The second paper is an application of a contingent behavior analysis in the measurement of the effects of climate and resource variables on park visitation. A visitor survey at RMNP included descriptions of hypothetical climate scenarios (depicting both weather- and resource-related variables), and questions about how respondents' visitation behavior would change contingent upon the scenarios. Survey responses are used to estimate the impact of climate change on park visitation and to test for the relative significance among scenarios. A relatively small proportion of respondents indicated that their behavior would change under the hypothetical climate scenarios, and the effect on visitation is positive. Both direct (weather-related) and indirect (resource-related) climate scenario variables are found to be statistically significant determinants of contingent behavioral changes. The results of the stated-preference analysis are compared with the revealed-preference results for methodological assessment, and we find that they are in close agreement.

The third paper uses the contingent valuation method (CVM) to estimate the effects of daily weather variables on recreation economic benefits (net willingness to pay) at RMNP. A visitor survey was used to gather responses to a dichotomous-choice CVM question about visitors' willingness to pay for their recreation experience. CVM responses were analyzed with daily weather data to measure the degree to which temperature, precipitation, and cloud cover influence recreation benefits. Both temperature and precipitation had a positive and statistically significant effect on the estimated recreation benefits per trip.

In each analysis, climate variables are found to have statistically significant effects on visitation, local economic measures, and net recreation benefits, but the estimated economic effects of predicted climate change are quite small.

Robert B. Richardson
Department of Agricultural and Resource Economics
Colorado State University
Fort Collins, CO 80523-1172
Fall 2002

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CHAPTER 1: INTRODUCTION

Economics of Natural Resource Changes

Potential changes in the global climate pose challenges for public land managers concerned with future land uses (Loomis and Crespi, 1999). Land managers at national parks in the U.S. are mandated by Congress to "conserve the scenery and the natural and historic objects, the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations" (Everhart, 1983). Changes in climate, resulting from higher levels of greenhouse gas (GHG) concentration, impact the park planning process from both sides of the mandate. Climate affects the wildlife, vegetation, and other resources that the National Park Service is charged with preserving, and it also affects the degree of visitor use of park resources (both directly, through the visitor experience, and indirectly, through changes in park resources). The environmental uncertainty of future climate effects, the resulting economic uncertainty faced by resource-dependent communities, and the social uncertainty of population growth characterize the economic problem: which uncertainties are most significant for moderating the effects of future climate change?

Previous studies of the economic effects of climate change have primarily focused on social welfare impacts of global warming on particular economic sectors, such as agriculture and natural resources. A comprehensive analysis of the impact of climate change on the U.S. economy estimated a 0.2% gain in GDP for U.S. economic market sectors (Mendelsohn and Neumann, 1999). The Intergovernmental Panel on Climate

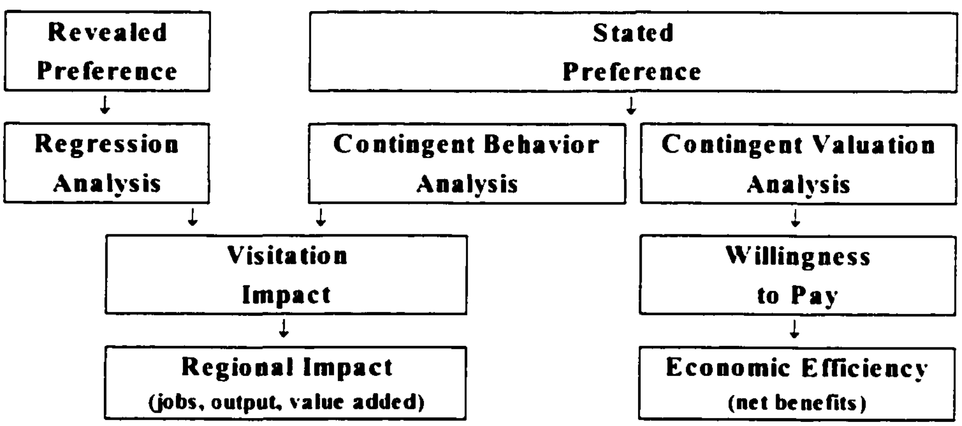
Change (IPCC, 1996) predicted substantial annual damage estimates to agriculture for global warming in the range of 2.5° to 4°C. Adams *et al.* (1999) used simulation models to estimate the effects of increasing temperatures on agricultural production. They predicted decreases in crop yields for most grains and livestock production, and found mixed results for citrus yields and forage production, which varied dramatically across regions. For the case of a 2.5°C increase in temperature and 7% increase in precipitation, they estimate welfare increases of less than three percent over baseline values in 2060. Mendelsohn *et al.* (1999) finds that only for temperature increases of more than 2.5°C does climate variation produce negative agricultural effects. Estimates of the effects of climate variation on timber production are mixed as well. Callaway *et al.* (1994) predicted substantial declines in forest production from warming; the Terrestrial Ecosystem Model used by Joyce (1995) predicted increases in forest production. Sohngen and Mendelsohn (1999) estimated a 4% increase in net present value of net timber surplus from increases in temperature of 1.5° to 2.5°C and a 7% increase in precipitation; the economic effects ranged 6-7% for warming of 5°C. Negative effects were estimated for U.S. energy expenditures (Morrison and Mendelsohn, 1999) and the U.S. commercial fishing industry (Markowski *et al.*, 1999), which varied widely by region.

Climate is expected to affect recreation in three ways (Mendelsohn and Markowski, 1999). First, longer summer seasons and shorter winter seasons affect the availability of recreation opportunities. Second, changes in climate may affect the overall comfort and enjoyment of outdoor activities. Third, global warming may alter the ecological systems of an area, and ultimately the quality of the recreation experience. These authors used a travel cost approach to measure changes in recreation benefits for a

2.5°C increase in temperature and a 7% increase in precipitation. They estimate a welfare increase ranging from 7% (using a linear demand model) to 9% (using a loglinear demand model). Welfare impacts were greater for a 5°C increase in temperature. They estimated substantial benefits to fishing and boating, which offset losses to skiing, camping, and wildlife viewing. Loomis and Crespi (1999) estimate a 3.1% increase in economic value for eight groups of recreation activities based on 1990 use levels and a 1.2% increase based on 2060 use levels (when impacts of effective CO_2 doubling are expected). Substantial losses to downhill and cross-country skiing were offset by gains to reservoir, beach, golf, and stream recreation. They estimate a 2% decline in benefits from forest-based recreation (based on a mid-level estimate of forest cover loss); greater declines are estimated from scenarios depicting larger losses of forest cover.

Changes in natural resources resulting from climate change have measurable economic effects, including the impacts to the demand for outdoor recreation, the regional economy of neighboring communities, and the economic efficiency of public goods provision. Such resource changes may be exogenous (*e.g.*, changes in climate patterns) or endogenous (*e.g.*, changes in management direction). Economics offers several tools with which to measure these effects. Measuring the impact to the regional economy from a change in resources requires the estimation of the induced effect on visitation. This can be done in two ways, using revealed- and stated-preference methods. First, a regression analysis of historical data (revealed-preference) can be used to estimate coefficients on independent variables representing resource changes (as long as resource changes occurred during some historic baseline period) and their influence on visitor use. Prediction intervals can be formed around the visitation forecasts to test for the relative effects of resource changes and population growth on future recreation use. Second, a contingent behavior analysis (stated-preference method) can be performed by using a visitor survey to elicit responses on conditional changes in visitation based on hypothetical resource scenarios. The results of either analysis can be used, in conjunction with an input-output model, to estimate the impact to the regional economy of a gateway community in terms of employment, output, and income. Furthermore, in order to measure the effects to the economic efficiency of the recreation good, the contingent valuation method can be used; hypothetical resource changes can be described in a visitor survey to elicit responses about potential changes in economic benefits (or net willingness to pay). Figure 1.1 illustrates the methods of measurement used in each analysis.

Figure 1.1 Methods of Measurement



This study is a comprehensive analysis of the impacts to visitor demand, regional economic variables, and economic efficiency of exogenous changes in natural resources resulting from potential climate change. The studies described in the following three papers propose to test the null hypothesis that changes in climate (and the resulting changes in resources) have no effect on visitation or the benefits derived from recreation. Rejection of this null hypothesis suggests several policy implications, including the need for a strategy for mitigating, rationing, or accommodating the predicted changes in park visitation. The regional implications for the gateway community suggest the need for a strategy that addresses infrastructure development, transportation, and employment issues to address future changes in regional population and climate change.

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CHAPTER 2: APPLICATION OF REGRESSION RESULTS TO PREDICTION INTERVALS FOR REGIONAL IMPACT ANALYSIS

Introduction

Input-output (IO) models are useful for examining potential changes in the structure of an economy over time. Such policy models incorporate final demand variables to yield a single solution for necessary input variables, and are thus, deterministic. While theoretically useful, such determinism is unrealistic, and furthermore, the policy relevance of this type of finite answer is also limited. Policymakers will want to know with what degree of certainty these IO estimates are made. These predictions have an underlying stochastic element, which can be derived from the underlying statistical model or sample averages used to compute the inputs from which the output is derived. Using the causal statistical model to form confidence intervals around the input estimates allows for the configuration of confidence intervals around the output results. The method is used to test for the relative significance of population versus climate change as a future determinant of local economic activity in Rocky Mountain National Park's gateway community.

When comparing alternative development paths or policies, this methodology presented in this chapter should allow decision makers to ascertain whether there is any statistical difference between alternatives. By exclusively using an IO model, it is impossible to measure a range of likely jobs created or indicate if one alternative is statistically different from another. The construction of prediction intervals around these types of deterministic policy estimates would increase the information content of IO analyses and its contribution toward making optimal resource allocation decisions (English, 2000).

The principal contribution of this chapter is to provide a relatively simple approach to constructing confidence intervals around the change in the estimated total *number of spending units* in a region. This approach thus develops confidence intervals around the second type of estimate necessary to evaluate impact analyses and takes advantage of the fact that such unit estimates are often the result of an econometric model or a simple calculation of means.

Exogenous inputs into IO models are often based on regression results which themselves have explicit stochastic elements. Since one can construct confidence intervals for regression estimates, and these estimates are used in turn as inputs into the IO model, confidence intervals for IO outputs should then also be possible. These confidence intervals (or prediction intervals) can be used in a manner similar to what is described for regression analysis.

By combining statistical and deterministic approaches, this paper details and demonstrates a method that can provide useful confidence intervals for deterministic models. These explicit confidence intervals can then be used to compare a variety of scenarios and results, providing researchers with a tool to assess the relative significance of different economic drivers. The method is applied to test the relative roles of climate change and population growth on the local economic activity of the gateway community of Rocky Mountain National Park through park visitation.

Prediction Intervals

The standard IO system can be written in matrix notation as

$$Y = (I - A)\,X, \tag{2.1}$$

which has a solution structure of

$$X = (I - A)^{-1}\,Y. \tag{2.2}$$

X is the vector of inputs, Y is the vector of final demand variables, and $(I - A)^{-1}$ is the matrix of interdependence coefficients. In the case of a regional employment model, the elements in the $(I - A)^{-1}$ matrix measure the direct and indirect employment levels from each sector of the economy to satisfy given levels of final demand. Using equation (2), we may find the levels of employment from all sectors required to support specified levels of final demand in all sectors. In addition, equations (1) and (2) have dynamic representations of

$$\Delta Y = (I - A)\,\Delta X \qquad \text{and} \qquad \Delta X = (I - A)^{-1}\,\Delta Y \tag{2.3}$$

respectively (Miller and Blair, 1985).

The formula for calculating prediction intervals for final demands $\hat{Y}$ based on econometric results is

$$(1\text{-}\alpha)100\%\ \text{Prediction Interval} = \hat{Y} \pm t_{\alpha/2}\, se[1 + W'(Z'Z)^{-1}\, W]^{0.5} \tag{2.4}$$

A 95% confidence interval for this analysis is calculated using $t = 2$; *se* is the standard error of the regression. The *Z* matrix represents the explanatory exogenous variables, while the *W* matrix represents adjusted or future value of those variables in the generation of each of the forecasts. Thus, the matrix $[W'(Z'Z)^{-1}\, W]$ represents the adjusted variables; in this paper's application, the adjusted variables reflect climate change scenarios and population forecasts. The new standard error for resulting final demand estimates $\hat{Y}$ is therefore represented by $se[1+ W'(Z'Z)^{-1} W]^{0.5}$ (Mendenhall, 1990).

Combining equations (3) and (4) yields the impact calculation formula for the upper and lower bounds of the 95% confidence intervals for the resultant endogenous IO estimates. The upper bound can be written as $[\ \hat{Y} + t_{\alpha/2}\, se[1+W'(Z'Z)^{-1} W]^{0.5}\ ] * (I - A)^{-1}$ and the lower bound is expressed as $[\ \hat{Y} - t_{\alpha/2}\, se[1+W'(Z'Z)^{-1} W]^{0.5}\ ] * (I - A)^{-1}$. The predicted final demand variables, in this case new visitor expenditures through $\hat{Y}$, will result in a range of necessary input variables, such as local retail employment, which will be required to meet this new final demand. Equations (3) and (6) thus provide the link between the econometric model and the IO model that allows for the creation of confidence intervals around deterministic model estimates.

Theoretical Model

The first step requires an estimate of visitation as a function of climate and population variables. Second, a visitor expenditure profile is applied to these visitation estimates in the second step to get changes in final demand.

Total visitation to Rocky Mountain National Park for month i is a function of several climate and demographic variables. The econometric model takes the form

$$V_i = X_i\beta \qquad 2.5$$

where V_i represents total visitation for month i, X_i represents the climate and demographic variables for month i, and β represents the vector of parameters for each independent variable. The specified model takes the form

$$V_i = \beta_0 + \beta_1 S_i + \beta_2 T_i + \beta_3 P_i + \beta_4 Pop_i + \beta_5 SVDV_i + \varepsilon_i \qquad 2.6$$

where S_i represents average snow depth for month i, T_i represents average maximum temperature for month i, P_i represents total precipitation for month i, Pop_i represents average monthly population for 12 counties along Colorado's Front Range, $SVDV_i$ represents a dummy variable for school vacation months (for which $SVDV = 1$ for July and August), and ε_i represents the normally-distributed disturbance term.

Empirical Model

Scientists at the Natural Resources Ecology Laboratory at Colorado State University provided historical climate data for the period 1987-1998 for several regional weather stations. Historical population data and population projections for the Front Range counties of Colorado was gathered from the state demographer's office; counties of the Front Range include Adams, Arapahoe, Boulder, Clear Creek, Denver, Douglas, El Paso, Gilpin, Jefferson, Larimer, Teller, and Weld counties.

Since monthly visitation at RMNP varies significantly throughout the year, reaching its peak during the summer months and dropping to its low during the winter months, the Chow test was performed to determine if the regression coefficients are structurally different in seasonal *subsets* of the data (Chow, 1960). The F statistic for testing the restriction that the coefficients in the two seasonal regressions are the same is 22.32. The critical value is 2.36 for 5% significance, so the hypothesis that the coefficient vectors are the same for the two seasons is rejected (Greene, 1999). Two subsets of observations were thus created to analyze the relationships for the peak (May-October) and off-peak (November-April) seasons.

Consequently, two separate seasonal empirical models of historic visitation data against explanatory climate and demographic variables for the period 1987-99 took the form

Peak: $V_i = \beta_0 + \beta_1 S_i + \beta_2 Tmax_i + \beta_3 P_i + \beta_4 Pop_i + \beta_5 SVDV_i + \varepsilon_i$ 2.7

Off-Peak: $V_i = \beta_0 + \beta_1 S_i + \beta_2 Tmin_i + \beta_3 P_i + \beta_4 Pop_i + \varepsilon_i$ 2.8

where $Tmax_i$ represents average maximum temperature in month i for the peak season regression and $Tmin_i$ represents average minimum temperature in month i for the off-peak season regression. The regression coefficients for the independent variables are provided in Table 2.1.

Table 2.1: Visitation Regression Results

Regression Coefficients	Peak (May-October)			Off-Peak (November-April)		
	Value	Std.Error	t-Statistic	Value	Std.Error	t-Statistic
Intercept	-639,549.7	162,598.1	-3.9333	23,247.2	18,155.8	1.2804
Snow depth	-386.3	71.0	-5.4388	17.5	8.5	2.0513
Maximum temperature	18,457.7	3,330.1	5.5427	n.a.	n.a.	n.a.
Minimum temperature	n.a.	n.a.	n.a.	1,257.2	413.4	3.0410
Precipitation	846.4	302.9	2.7947	-60.4	-1.3	-1.2603
Front Range Population	0.022	0.050	4.3088	0.016	2.5	2.4907
School Vacation DV	200,961.4	27,049.0	7.4295	n.a.	n.a.	n.a.
R^2	0.8840			0.3064		
Adjusted R^2	0.8741			0.2624		
Durbin-Watson Statistic	2.4566			2.1986		

The regression coefficients display the expected signs. The coefficient on the snow depth variable is negative for the peak season regression and positive for the off-peak regression, which is consistent with the recreation activities for each season. The opposite is true for the coefficient on the precipitation variable; more visitors during rainier summer months could be due to park re-entry following seasonal afternoon thunderstorms. The R^2 is 0.88 for the peak season model and 0.31 for the off-peak model. The Durbin-Watson statistics are not significantly above 2.0 for either model, which suggests that the null hypothesis (that there is no significant autocorrelation in the data) be accepted.

Prediction Intervals for IO Models

In order to compare the prediction intervals of the forecasts of future monthly visitation under No Climate Change, CCC, and Hadley scenarios, six forecasts of monthly visitation were generated. The associated standard errors were used to estimate prediction intervals based on the model presented in Section II. The 1996 baseline was compared to the forecasts using the projected population of Front Range counties for the year 2020. These forecasts project peak season visitation under the No Climate Change (but with population growth), CCC, and Hadley scenarios, and off-peak season visitation under the same scenarios. The results are provided in Table 2.2.

Table 2.2: Forecast of Future Park Visitation

Regression Models	Mean Monthly Visitation	Total Season Visitation	Monthly Standard Error	95% Confidence Intervals		
				Minimum	Maximum	Width
Peak Season (May-Oct):						
1996 Baseline	422,717	2,536,303	71,808	1,674,612	3,397,993	1,723,380
2020 Forecast/No Climate Change	814,234	4,885,404	116,155	3,491,545	6,279,263	2,787,718
2020 Forecast/CCC	870,324	5,221,941	117,683	3,809,750	6,634,132	2,824,382
2020 Forecast/Hadley	846,285	5,077,711	116,583	3,678,710	6,476,711	2,798,002
Off-Peak Season (Nov-Apr):						
1996 Baseline	64,096	384,574	9,608	269,278	499,871	230,592
2020 Forecast/No Climate Change	93,730	562,383	15,338	378,332	746,434	368,101
2020 Forecast/CCC	94,261	565,564	15,531	379,189	751,938	372,749
2020 Forecast/Hadley	95,089	570,534	15,478	384,792	756,276	371,484

The estimated peak season visitation *with* climate change under both the CCC and Hadley scenarios is higher than the *no climate change* scenario, demonstrating the effects of reduced snow depth, higher maximum temperatures, and in the case of the Hadley model, more precipitation. Overall, peak season visitation is projected to be higher using the CCC model due to its higher temperature estimates (most evident in May, June, July, and October). The estimated off-peak visitation is generally estimated to be greater than that of the historic period, illustrating the effects of greater snow-depth and higher minimum temperatures. The key question, however, still involves ascertaining the relative significance of population versus climate change effects.

Clearly, for both seasonal regressions, the standard error for the 2020 forecasts are significantly greater than that for the original regression analysis, and in both cases, the related confidence intervals are approximately 1.6 times that of the original regression analysis. The confidence intervals for the 2020 forecasts under the CCC and Hadley climate change scenarios are slightly greater than that for the no climate change forecast, demonstrating the increased variability in the climate variables under climate change scenarios. The CCC scenario appears to have greater variability than the Hadley scenario.

Hypothesis

Forecasting states of the future economy using an IO model requires estimating the exogenous factors that drive the model. Once these variables are estimated the IO model calculates the exact endogenous repercussions of the new exogenous impacts. However, this type of analysis can give a misleading sense of precision, which may actually be a disservice in the policy process. Furthermore, such point estimates provide a poor comparative tool for evaluating competing policies.

Combining statistical models with deterministic models can create effective confidence intervals that are more useful for policy analysis. Econometric results and sample averages are often used to determine the potential exogenous impacts to be inserted into an IO model for policy implications. These statistical parameters have explicit confidence intervals, which can be used as the upper- and lower-bound final demand inputs to an IO analysis. The upper and lower bounds of resultant IO endogenous impacts allow the construction of confidence intervals around the changes predicted by the IO model. It would then be possible to test different hypotheses regarding the relative significance of policy changes affecting the endogenous variables.

The proposed method of using the regression estimates to create confidence intervals around IO impacts will be used to test the hypothesis that the changes in Front Range population create the only statistically significant effect on employment in the Estes Park area. To reject this hypothesis implies that climatic changes as predicted by the CCC and Hadley models also have a statistically significant impact on employment in Estes Park, in addition to the effect of population increase.

Unit of Analysis

This study is motivated by an inquiry into possible effects of climate change on visitation to Rocky Mountain National Park (RMNP) and its gateway community of Estes Park, Colorado. Population growth along the Colorado Front Range is likely to be a major factor in future Park visitation as well, with a more certain impact than climate change. Thus, both future climate and population will influence visitation in the Park, which is the major economic driver of the gateway community. A micro-based dataset was constructed, composed of historical monthly visitation data for RMNP, climate variables, and population data for Front Range counties in Colorado. In order to simulate a useful planning horizon, this effort focused on determining the 2020 climatic and population effects on visitation.

Population in Estes Park and visitor use of RMNP has almost doubled since 1960. Current rates of population growth are 2 to 3% for many areas in the Rocky Mountains with resulting urban sprawl and development in mountain communities (Stohlgren, 1999). Even faster growth is occurring along Colorado's Front Range, the major source of potential RMNP visitors.

The analysis of the climate change driver focuses on the monthly and annual changes in precipitation and temperature due to higher levels of greenhouse gas (GHG) concentrations. These higher levels of GHG have been used to simulate changes in global climate. Results from two global circulation models are used to estimate potential climate changes for the Rocky Mountain Region, including RMNP and the Estes Park area. Both of the scenarios developed by the two models use 1961 to 1990 as the baseline for the assessment. The CCC (Canadian Climate Center) model scenario tends to be more than 4° F warmer than the historical baseline period, and predicts a drier overall climate. The Hadley model scenario is approximately 2° F warmer and tends to estimate more precipitation in the winter season (or off-peak months), and a drier summer season (or peak months).

Data Analysis and Results

The construction of confidence intervals around the visitation estimates, which are the basis for final demand inputs into the IO model, implies that confidence intervals can now be constructed around the resulting IO estimates of endogenous output, employment, and income. Incorporating the upper and lower visitation bounds of the visitation estimates into the IMPLAN (MIG, 1997) model can thus create intervals around estimated job impacts with the same 95% confidence interval as the regression estimates. In other words, the 95% confidence interval present in the estimates of exogenous inputs (visitation and associated spending) allows for the construction of the same size confidence interval around the endogenous output (*e.g.*, jobs).

Peak Months

During the peak months of May through October, the baseline 1996 regression results from Table 2 estimated a mean monthly visitation of 422,717 with a standard error of 71,808; the mean total seasonal visitation was estimated to be 2,536,303. Using the method noted above, the confidence interval formed around this total seasonal visitation estimate was at the minimum 1,674,612 (the lower bound of the confidence interval) and at the maximum 3,397,993 (the upper bound of the confidence interval).

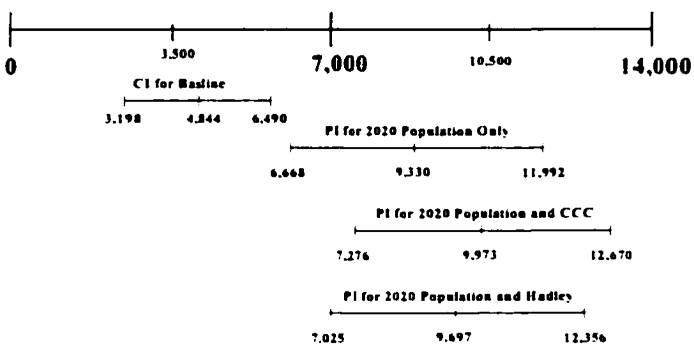
These visitation estimates were used along with postulated visitor spending in the IMPLAN model to determine the regional impact of both climate and population on employment for the 1996 baseline year. The mean total seasonal visitation was used to determine the mean number of jobs (4,844) that would result from the 2,536,303 visitors in the peak season. The upper (3,397,993) and lower (1,674,612) bounds of the visitation confidence interval surrounding the mean were then used to determine that with 95% confidence, 4,844 jobs, plus or minus 1,646, would be created in the baseline peak season as a result of visitation.

The 2020 comparison of population and climate change effects required progressive isolation of the two impacts. The regression coefficients were first used to estimate the impact of population alone on visitation under the No Climate Change scenario. Mean monthly visitation was estimated to be 814,234, with a standard error of 116,155, resulting in a mean total seasonal visitation of 4,855,404. Using the same method as noted above for the baseline example, this information was used to construct a prediction interval around the mean total seasonal visitation results. The maximum or upper bound was estimated to be 6,279,263 and the minimum or lower bound was 3,491,545, or the mean plus or minus 1,393,859. This created a mean job creation of 9,330 plus or minus 2,262.

Similar procedures were used to create prediction intervals around the regression results combining population change with the two climate (CCC and Hadley) models. The CCC model with population growth estimated that mean seasonal visitation would be 5,221,941, plus or minus 1,412,191 in 2020. From this visitation estimate, the mean number of new jobs created in 2020 under the CCC scenario would be 9,973 plus or minus 2,697. The Hadley model with population estimates estimated mean seasonal visitation in 2020 of 5,077,711, plus or minus 1,399,001. This translated into 9,697 new jobs in 2020 plus or minus 2,672.

Figure 2.1 illustrates that confidence intervals for peak-season 1996 baseline jobs and 2020 population jobs do not overlap, signifying that they are statistically different from one another. Therefore, population growth between the two periods is expected to have a significant effect on visitation, as well as economic activity and jobs in Estes Park. Note that population growth proved to be the only significant determinant in the 2020 peak season forecast. The prediction intervals for 2020 population and the CCC and Hadley scenarios do overlap, implying that changes in jobs due to population and both climate scenarios were statistically indistinguishable from those due to population alone. This example underscores the importance of prediction intervals in assessing relative significance of different drivers of future economic activity.

Figure 2.1: 95% Prediction Intervals for Total Peak Season Jobs



The results for the peak model suggest that we accept the hypothesis that only Front Range population growth was significant in determining future peak-season jobs in the region. For planners, this suggests that regional population is the most influential factor in the forecasting peak-season employment in Estes Park. Climate change effects are relatively minor, unless there are some non-linear threshold effects associated with climate-induced visitation.

Off-Peak Months

Due to the structural differences between visitation patterns in peak and off-peak seasons, results for off-peak months could be different. The Estes Park economy is driven mainly by peak season visitation, due to its mountainous climate and the pattern of vacationers. In off-peak winter months, visitation to the Park slows due to difficult winter driving conditions and the narrower interests of winter visitors. In fact, many businesses in Estes Park close down for several months during the off-peak season.

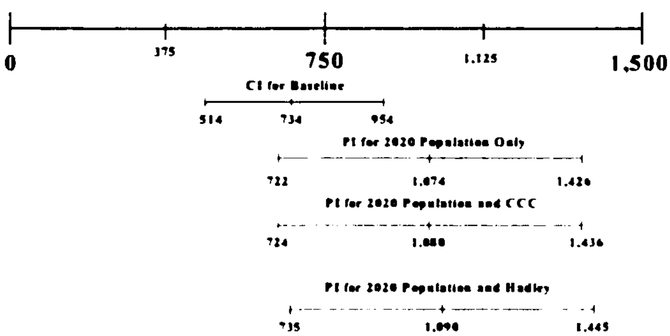
During the off-peak months of November through April, the 1996 baseline regression estimated that mean monthly visitation was 64,096 with a standard error of 9,608; thus, mean seasonal visitation was estimated to be 384,574. The confidence interval formed around this seasonal visitation estimate was at the minimum 269,278 and at the maximum 499,871. The mean and bounds of the visitation estimate were used in the IO model to provide a mean estimate and predicted range of resultant job impacts. The mean seasonal visitation was used to determine the mean number of jobs (734) that would result from the 384,574 visitors in the peak season. The upper (499,871) and lower (269,278) bounds of the confidence interval suggested with 95% confidence that 734 jobs, plus or minus 220, would be created in the baseline off-peak season as a result of visitation.

In order to isolate the population and climate effects from the baseline year regression results, the visitation estimate was calculated using only population estimates for 2020, assuming no climate changes. Mean monthly visitation was estimated to be 93,730, with a standard error of 15,338, and a mean total seasonal visitation of 562,383. Visitation's upper bound was estimated to be 746,434 and the lower bound was 378,332 (or the mean plus or minus 184,019). This implied a mean job creation of 1,074 plus or minus 352.

Similar procedures were used to create prediction intervals around the regression results of population change and the CCC and Hadley models. A CCC climate in combination with population growth resulted in mean total seasonal visitation of 565,564, plus or minus 186,374 in 2020. The mean number of new jobs in 2020 based on this CCC forecast was 1,080 plus or minus 356. When the Hadley model and population estimates were combined, the estimate for mean total seasonal 2020 visitation was 570,534, plus or minus 185,742. This translated into 1,090 new jobs in 2020 plus or minus 355.

For the off-peak months, Front Range population growth and the climate changes predicted by the two models proved to be statistically the same as the baseline, again underlining the utility of this paper's confidence interval approach. Figure 2.2 illustrates that the confidence intervals for 1996 baseline jobs and 2020 population jobs overlap, implying that they are statistically identical to one another. The prediction intervals for 2020 population only and the CCC and Hadley scenarios also overlap, implying that the

Figure 2.2: 95% Prediction Intervals for Total Off-Peak Season Jobs



changes in climate also do not provide a statistically distinguishable effect on jobs. The more local nature of winter visitation and the greater randomness of such flexible visits are likely much of the reason for these results.

Given the results for the off-peak months, we rejected the hypothesis that either population growth or climate change had significant impacts on visitation and local economic activity during the winter season. Again, this analysis allows economic planners another tool in comparing economic policies. Variations in off-peak climate or population are not likely to have substantial impacts on local jobs, and can therefore be lower priorities for contingency planning.

Conclusions

The analysis described in this chapter demonstrates two important uses of prediction intervals in the forecast of future economic impacts generated by natural resource changes. First, the application of stochastic regression results in the construction of confidence intervals around output calculations allows for the assessment of the degree of certainty of impact estimates. Thus, the results from an input-output model are no longer purely deterministic, but instead incorporate the underlying uncertainty upon which input estimates are based. Second, the calculation of prediction intervals around output estimates for various scenarios allows for the testing of relative significance among the drivers of economic activity. In this chapter, we found that between regional population and climate variables, only population was revealed to be a significant determinant of future peak-season economic impact.

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CHAPTER 3: CONTINGENT BEHAVIOR ANALYSIS OF THE EFFECTS OF CLIMATE CHANGE ON NATIONAL PARK VISITATION

Introduction

The impacts of natural resource changes on a visitor's recreation experience may affect decisions about the frequency and duration of future visits to a national park. These changes in visitor behavior will affect local economic activity in the park's gateway community. The purpose of this study is to estimate the role of climate variables and their effects on national park visitation using a stated-preference methodology. Climate may impact the visitor in two ways. First, the visitor's attitude toward his recreation experience may be *directly* affected by the weather. Changing temperature, precipitation, and snow depth may affect the visitor's decisions about the frequency or duration of future visits. Second, changes in climate patterns may affect wildlife populations and the composition of vegetation in the park, and these changes may affect the visitor's behavior *indirectly*. Stated-preference methods are needed to gather information about park visitors, their attitudes about their visit, their preferences toward recreation activities, and how their visitation behavior might change under hypothetical climate scenarios. Contingent behavior (CB) analysis is employed using a visitor survey to test for the significance of direct and indirect climate scenario variables on visitation at Rocky Mountain National Park (RMNP) in Colorado.

Several studies have recorded the effects of climate on recreation. Cato and Gibbs (1973) used a survey of recreational boaters in Florida and estimated that temperature and expected rainfall had a significant effect on the likelihood of taking a boating trip. Loomis and Crespi (1999) estimated that a 2.5°C increase in temperature and a 7%

increase in precipitation were associated with a 3.1% increase in visitor days for eight groups of outdoor recreation activities. Significant decreases in downhill and cross-country skiing days (52%) were offset by increases in reservoir (9%), beach (14%), golf (14%), and stream recreation (3.5%).

Contingent behavior analysis has been applied in several previous recreation studies, but most combined stated-preference visitation data with revealed-preference travel cost data to measure contingent effects on consumer surplus (Whitehead *et al.*, 2000; Loomis *et al.*, 2001; Grijalva *et al.*, 2002). Loomis (1993) found that the CB method demonstrates external validity in his study of hypothetical recreational visits under varying lake quality levels. Chase *et al.* (1998) used CB to measure the hypothetical impact to visitation demand of alternative entrance fee levels at three national parks in Costa Rica.

Theoretical Model

Consider an individual's utility function, represented by $u(x_j, q_j, I)$, where $u(\cdot)$ is utility, x_j is the annual number of trips to recreation site j, q_j represents the quality of site j, and I represents individual income. The individual will maximize his utility subject to his budget constraint, represented by $I = p_jx_j + z$, where p_j represents the travel cost or implicit price of access to site j, and z represents a vector of all other goods. A system of Marshallian demand functions $[x(p_j, q_j, I)]$ emerges, with the quantity of trips (x_j) decreasing in price, increasing in quality, and increasing in income (Whitehead *et al.*, 2000).

The theoretical model for this study suggests that the quality of recreation is influenced by several variables, including climate conditions. It is further suggested that climate influences quality (and thus, the number of annual recreation trips) both directly, through the visitor experience, and indirectly, through the enjoyment of the site's plant and wildlife resources, which are directly affected by climate. The model also considers the influences of the visitor's preference for particular recreation activities, the visitor's travel costs, and the demographic characteristics of the visitor on total demand for recreation at the site.

The theoretical model can therefore be represented as:

$$V_i = f(S^D_{1i}, S^D_{2i}, \ldots, S^D_{ni}, S^I_{1i}, S^I_{2i}, \ldots, S^I_{ni}, A_{1i}, A_{2i}, \ldots, A_{ni}, TC_i, D_{1i}, D_{2i}, \ldots, D_{ni}) \quad 3.1$$

where

$V_i =$	number of annual visits to the recreation site
$S^D_{1i}, S^D_{2i}, \ldots, S^D_{ni} =$	direct climate scenario variables, including temperature, precipitation, number of days with snow-free hiking trails
$S^I_{1i}, S^I_{2i}, \ldots, S^I_{ni} =$	indirect climate scenario variables, including visitor crowding, elk population, ptarmigan population, and the vegetation composition of the Park
$A_{1i}, A_{2i}, \ldots, A_{ni} =$	activities in which the visitor participated during the visit
$TC_i =$	travel cost per visit
$D_{1i}, D_{2i}, \ldots, D_{ni} =$	demographic characteristics of the visitor, including gender, age, level of education, annual income, employment status, and membership in an environmental organization
$i =$	individual respondent to survey

Hypothesis

It is hypothesized that visitation at a recreation site is influenced by expected climate conditions in the area, as well by other variables, including but not limited to a visitor's chosen recreation activities, travel costs, and demographic characteristics. Climate conditions may affect visitation both directly and indirectly. Therefore, we test the null hypothesis that the climate scenario variables ($S^D{}_{1i}$, $S^D{}_{2i}$, …, $S^D{}_{ni}$; $S^I{}_{1i}$, $S^I{}_{2i}$, …, $S^I{}_{ni}$) have no effect on the number of visits to the site per year. If β is the coefficient on the climate scenario variables, then we suppose:

$$
\begin{array}{ll}
H_0:\ \beta_1 = 0 & H_A:\ \beta_1 \neq 0 \\
H_0:\ \beta_2 = 0\ldots & H_A:\ \beta_2 \neq 0\ldots \\
H_0:\ \beta_n = 0 & H_A:\ \beta_n \neq 0
\end{array}
\qquad 3.2
$$

By distinguishing between the direct and indirect climate scenario variables, we can test their relative effects on the visitation decision. Thus, the expanded hypothesis can be restated as:

$$
\begin{array}{ll}
H_0:\ \beta^D{}_1 = 0 & H_A:\ \beta^D{}_1 \neq 0 \\
H_0:\ \beta^D{}_2 = 0\ldots & H_A:\ \beta^D{}_2 \neq 0\ldots \\
H_0:\ \beta^D{}_n = 0 & H_A:\ \beta^D{}_n \neq 0 \\
 & \\
H_0:\ \beta^I{}_1 = 0 & H_A:\ \beta^I{}_1 \neq 0 \\
H_0:\ \beta^I{}_2 = 0\ldots & H_A:\ \beta^I{}_2 \neq 0\ldots \\
H_0:\ \beta^I{}_n = 0 & H_A:\ \beta^I{}_n \neq 0
\end{array}
\qquad 3.3
$$

where the superscripts *D* and *I* represent the coefficients for direct and indirect climate scenario variables, respectively.

In addition to hypothesis tests based on a multivariate model, univariate hypothesis tests on overall visitation are also conducted based on three climate scenarios. The univariate tests involve construction of 95% confidence intervals around the mean estimate for change in visitation to RMNP for each of the three scenarios. For confidence intervals that include zero, we conclude that the estimated change in visitation is not statistically different from zero, given the variability in the survey data.

Empirical Analysis and Survey Design

The recreation site for the empirical analysis is Rocky Mountain National Park, a 266,000-acre alpine preserve in north-central Colorado, in the Front Range of the Rocky Mountains. The Park protects a large wildlife population, alpine meadows, conifer forests, aspen groves, and several high mountain peaks, including Long's Peak, the Park's tallest. RMNP receives over three million visitors annually, with significant seasonal variation (87% of annual visitation occurs between May and October, suggesting an influence of seasonal climate). These characteristics make RMNP an ideal location to conduct the contingent behavior study.

A visitor survey was conducted in the summer of 2001 at RMNP. Scientists at the Natural Resource Ecology Laboratory at Colorado State University provided data for a baseline climate scenario and two hypothetical scenarios as depicted by two global circulation models (known as CCC and Hadley), which specified expected temperature levels, precipitation, and snow depth. Population dynamics models were used to estimate the impact of climate on park resources, including wildlife and vegetation composition. Data from the two climate forecasts and the resource estimates were configured as climate scenarios for the survey; four other hypothetical scenarios were created in order to incorporate a wider range of hypothetical climate variation. In total, four survey versions were developed, each with a "typical day" (baseline) scenario and two hypothetical scenarios. The four survey versions and their respective hypothetical climate scenarios are summarized in Table 3.1.

The survey design was developed using graphical and numeric representations of the climate scenarios. Icons and symbols that proportionally represented hypothetical changes were included to give a more descriptive presentation of climate scenarios. Version A of the visitor survey is presented in Appendix A.

The contingent behavior questions asked the respondent to consider if their *number of visits* and *length of stay* would have been affected under the hypothetical

Table 3.1: RMNP Visitor Surveys and Hypothetical Climate Scenarios

		Version A		Version B		Version C		Version D	
Climate Scenario Variables	Baseline Scenario	Scenario 1^{CCC}	2	Scenario 1^{Had}	2	Scenario 1	2^{EH}	Scenario 1^{CCC}	2^{EH}
Temperature									
# days high > 80°F	3	15	20	13	30	1	50	15	50
# days low < 10°F	83	36	110	46	20	70	30	36	30
Precipitation									
# days > 0.25 in.	18	15	28	15	10	47	36	15	36
Hiking Trail Access									
# summer days trails snow-free	168	184	213	184	246	120	140	184	140
Trail Ridge Road									
# days road open for driving	139	174	123	164	194	95	205	174	205
Visitor Crowding									
Average # daily visitors - July	23,205	24,202	24,600	23,814	27,840	17,000	29,500	24,202	29,500
Average # daily visitors - October	10,551	12,028	10,020	10,900	12,661	9,000	7,000	12,028	7,000
Wildlife population									
# Elk	1,040	1,500	600	2,060	2,800	1,700	800	1,500	800
# Ptarmigan	34	4	60	2	0	52	15	4	15
Vegetation Composition									
% Alpine tundra	15%	0%	25%	2%	7%	35%	12%	0%	12%
% Open/wooded	2%	20%	5%	7%	30%	15%	18%	20%	18%
% Evergreen	77%	72%	70%	84%	53%	50%	60%	72%	60%

CCC = CCC Climate Scenario; Had = Hadley Climate Scenario; EH = Extreme Heat Climate Scenario climate scenarios; and if so, how many more (or fewer) trips or days would they have visited. The contingent behavior questions are provided as an excerpt from the survey instrument in Table 3.2 below.

In addition, a modified Likert scale was used to obtain responses about the relative importance of park resources. Information about travel costs and demographic characteristics was elicited in order to estimate the potential effects. The survey was tested in two focus groups for content, clarity, and length, and the design was shortened and refined according to the focus group suggestions. The final version was pre-tested with RMNP visitors before distribution during the survey period.

Table 3.2: Contingent Behavior Questions

How would these changes in conditions affect your visitation?

Question:	Scenario 1	Scenario 2
If at the beginning of the year, you knew Rocky Mountain National Park weather and conditions would be as described in Scenarios 1 and 2 rather than the current scenario, would you:	__Visit ***more*** often? # of additional yearly trips ____ __Visit ***less*** often? # of fewer yearly trips ____ __ **No change** in # trips	__Visit ***more*** often? # of additional yearly trips ____ __Visit ***less*** often? # of fewer yearly trips ____ __ **No change** in # trips
Would the changes in weather and resources described in Scenarios 1 and 2 affect your ***length of stay*** in Rocky Mountain National Park on a typical trip?	Would you stay ___ **Longer**? ___ days longer ___ **Shorter**?___ days fewer ___ **No change?**	Would you stay ___ **Longer**? ___ days longer ___ **Shorter**? ___ days fewer ___ **No change**?

Data Collection

Members of the survey team were trained in visitor contact and survey introduction procedures at the intended sampling locations at RMNP in advance of the survey period. An intercept script and procedures for handling refusals were discussed thoroughly and were rehearsed with RMNP visitors.

During the survey period (June 21 – September 12, 2001), visitors were selected randomly in heavily-visited areas of RMNP at five specific locations: Bear Lake Parking Lot, Bear Lake Shuttle Bus, Sprague Lake, Alpine Visitor Center, and Long's Peak Trailhead. Sampling sites were selected in order to identify visitors in an array of locations who had been hiking, sightseeing, driving Trail Ridge Road, and other activities. Survey dates were selected in order to obtain samples from weekdays, weekends, and holidays. Each of the five survey sites was sampled on four weekend days and four weekdays, for a total of 40 survey dates.

On selected sampling dates, visitors were approached randomly at the chosen sampling sites, and surveys were distributed to willing respondents, who took the survey with them to be completed and mailed in at a later date. Mail-returned surveys were chosen because of the complexity of the climate scenarios and the amount of time required to complete the questionnaire. There were 1,378 attempts to distribute surveys during the survey period, and 112 were refused. Thus, a total of 1,266 surveys were distributed. Following Dillman's Total Design Method (Bailey, 1994), reminder postcards were mailed to survey recipients one week after the day of distribution, and supplementary copies of the survey were mailed three weeks later to non-respondents along with a cover letter (presented in Appendix B). At the end of the survey collection period, 967 surveys were returned, which amounts to a 70% response rate (or a 76% response rate, net of refusals).

Data Analysis

This analysis incorporates primary data collected in a visitor survey at RMNP during the summer of 2001. The contingent behavior survey described current climate conditions, including temperature, snow depth, precipitation, wildlife populations, and vegetation composition, along with two hypothetical future climate scenarios (in four different survey versions, with varying scenarios). Respondents were then asked to estimate the change in the number/duration of their visits to RMNP under the hypothetical climate regimes. A trip response model will be developed in order to estimate coefficients for the independent variables. These coefficients will allow for the measure of the sensitivity of visitation to possible changes in future climate.

The data analysis process involves the aggregation of survey results for each of the four survey versions. Since each survey included contingent behavior questions for two climate scenarios, responses were restructured in such a way that each survey response represents two responses to climate scenarios, thereby doubling the number of observations in the sample. Therefore, although 967 surveys were returned, the number of contingent behavior observations in the sample is 1,934.

Two statistical analysis techniques are used to test the hypothesis. First, confidence intervals are constructed around the mean estimates for the change in visitor days under the CCC, Hadley, and Extreme Heat climate scenarios to test for statistical significance in the response data. Second, ordinary least squares regression is used to model the contingent behavior responses (change in number of trips, change in length of stay) as a function of climate scenario variables, travel cost, and demographic variables;

t-tests are used to examine the statistical significance of individual variables and of various climate scenarios.

Results

Two of the hypothetical climate scenarios were developed using global circulation models. The CCC scenario was included in Survey Versions A and D, and 8.6% of the 442 respondents to those surveys indicated that their visitation behavior would change under the hypothetical climate scenario. The application of their responses to total RMNP visitation data yields a mean estimate of 1,357,888 additional visitor days, as provided in Table 3.3 below.

Table 3.3: Survey Results – CCC Climate Scenario

RESULTS: CCC SCENARIO (n=442)	CHANGE NUMBER OF TRIPS	CHANGE LENGTH OF STAY
Number of respondents who would change their visitation behavior	38	51
% Respondents who would change their visitation behavior	8.60%	11.54%
Average additional trips per visitor	+0.14 trips per visitor	+0.10 days per trip
Total Visitation – 1999	3,186,323	
Projected New Visitation	3,618,856	
Change in Visitation (%)	13.57%	
Change in Visitation (#)	432,533	
Average length of stay (days)	3.04	
Mean Change in Annual Visitor Days	1,357,588	

The Hadley climate scenario was included in Survey Version B, and 11.1% of the 252 respondents to that survey indicated that their behavior would change under the hypothetical climate scenario. The application of their responses to total visitation data yields a mean estimate of 1,002,080 additional visitor days, as provided in Table 3.4 below.

Table 3.4: Survey Results – Hadley Climate Scenario

RESULTS: HADLEY SCENARIO (n=252)	CHANGE NUMBER OF TRIPS	CHANGE LENGTH OF STAY
Number of respondents who would change their visitation behavior	28	34
% Respondents who would change their visitation behavior	11.11%	13.49%
Average additional trips per visitor	+0.10 trips per visitor	+0.13 days per trip
Total Visitation – 1999	3,186,323	
Projected New Visitation	3,502,426	
Change in visitation (%)	9.92%	
Change in visitation (#)	316,103	
Average length of stay (days)	3.04	
Mean Change in Annual Visitor Days	1,002,080	

Four other climate scenarios were developed in order to incorporate a wider range of climate variation. One example of these scenarios was described as an "Extreme Heat" scenario. It was included in Survey Versions C and D, and 16.25% of the 480 respondents to those surveys indicated that their behavior would change under the hypothetical climate scenario. The application of their responses to total visitation data yielded an estimate of 821,187 fewer visitor days, as provided in Table 3.5 below.

Changes in future visitation levels at RMNP will impact the economy of the gateway community of Estes Park, which is primarily driven by RMNP tourism. Survey results indicated that visitors spend an overall average of $665.03, which amounts to $52.40 per person, per visitor day during their visit to RMNP; of this, $24.78 of which was spent in Estes Park. The calculations are based on an average group size of 4.3 persons and an average length of stay of three days. Average visitor expenditures in Estes

Table 3.5: Survey Results – Extreme Heat Climate Scenario

RESULTS: EXTREME HEAT SCENARIO (n=480)	**CHANGE NUMBER OF TRIPS**	**CHANGE LENGTH OF STAY**
Number of respondents who would change their visitation behavior	78	82
% Respondents who would change their visitation behavior	16.25%	17.08%
Average additional trips per visitor	-0.09 trips per visitor	-0.09 days per trip
Total Visitation – 1999	3,186,323	
Projected New Visitation	2,907,520	
Change in visitation (%)	-8.75%	
Change in visitation (#)	(278,803)	
Average length of stay (days)	3.04	
Mean Change in Annual Visitor Days	(821,187)	

Park (by category) are provided below in Table 3.6; these amounts were used in the input-output analysis and form the basis of the regional impact results.

Table 3.6: Average RMNP Visitor Expenditures in Estes Park, CO, by Category

Visitor Spending Category	**Average Expenditure**	**Average Expenditure Per Person, Per Visitor Day**
Gasoline	15.15	1.21
RMNP Entrance Fee	8.66	0.69
Hotel	162.73	13.01
Camping Outside RMNP	7.56	0.60
Camping Inside RMNP	3.52	0.28
Food: Restaurants	62.11	4.97
Food: Grocery Stores	36.02	2.88
Supplies	6.01	0.48
Guide Fees	8.05	0.64
Total	309.81	24.78

Based on the average changes in annual visitor days outlined above under the three climate scenarios along with visitor spending estimates, the impact to local (Estes Park, CO) output and employment was calculated using the IMPLAN input-ouput model (MIG, 1997). The results are presented below in Table 3.7.

Table 3.7: Regional Economic Impact Results – Comparison of Climate Scenarios

Economic Impact: Estes Park, CO	**CCC**	**Hadley**	**Extreme Heat**
Mean Change in Annual Visitor Days	1,357,588	1,002,080	(821,187)
	↓	↓	↓
Output Impact ($millions)	+ $44 (+ 12.4%)	+ $32 (+9.2%)	+ $26 (-7.5%)
Employment Impact (# jobs)	+ 981 (+ 15.4%)	+ 725 (+ 11.4%)	- 600 jobs (- 9.3%)

Univariate Analysis and Hypothesis Test Results

The construction of confidence intervals allows for tests of the statistical significance between the three climate scenarios. Since the estimate for the mean change in annual visitor days is based on the responses to two contingent behavior questions (regarding the change in the number of trips and the length of stay), the standard error must incorporate the covariance from two distributions. Neither of the two questions' responses is conditional upon the other, and the response data are uncorrelated, so we assume that the two distributions are independent. Although independence allows that the expected value of the product of the two distributions is equal to the product of the expected values of each distribution, the variance of the product of the two distributions is *not* equal to the product of the two variances. That is,

$$Var\,(XY) \neq Var\,(X) \times Var\,(Y), \qquad 3.4$$

where X and Y represent each of two independent distributions, and *Var* represents the sample variance. The variance of a distribution X is defined as:

$$Var\,(X) = E[(X^2) - E(X)]^2 \qquad 3.5$$

(Mood, Graybill and Boes, 1974; Casella and Berger, 1990). Also, it can be shown that:

$$Var\,[f(X)] = E[f(X)^2 - E(f(X))]^2. \qquad 3.6$$

Therefore, the variance of the joint distribution of the two normally-distributed variables is derived as follows:

$$Var\,(XY) = E[((XY) - \mu_X \mu_Y)^2] \qquad 3.7$$
$$= E[(XY)^2 - 2(XY\mu_X \mu_Y) + (\mu_X \mu_Y)^2]$$
$$= E(X^2)\,E(Y^2) - 2E(XY\mu_X \mu_Y) + \mu_X^2 \mu_Y^2$$
$$= E(X^2)\,E(Y^2) - \mu_X^2 \mu_Y^2$$

where μ_X and μ_Y represent the population means of X and Y, respectively. Following equation 3.5 above, the variance of a distribution can be restated as:

$$Var\,(X) = E[X - \mu_X]^2 \qquad 3.8$$
$$= E[X^2 - 2\mu_X X + \mu_X^2]$$
$$= E(X)^2 - 2\mu_X E(X) + \mu_X^2$$
$$= E(X)^2 - 2\mu_X^2 + \mu_X^2$$
$$= E(X)^2 - \mu_X^2$$

Therefore, by rearranging terms, we find that:

$$E(X)^2 = Var\,(X) + \mu_X^2 \qquad 3.9$$

Returning to the calculation of *Var* (XY) in Equation 3.7 above, we substitute Equation 3.9 for $E(X^2)$ and $E(Y^2)$, as follows:

$$Var\,(XY) = E(X^2)\,E(Y^2) - \mu_X^2 \mu_Y^2 \qquad 3.10$$
$$= (Var(X) + \mu_X^2)\,(Var(Y) + \mu_Y^2) - \mu_X^2 \mu_Y^2$$
$$= Var(X)\,(Var(Y) + (Var(X)\,\mu_Y^2) + (Var(Y)\,\mu_X^2) + \mu_X^2 \mu_Y^2 - \mu_X^2 \mu_Y^2$$
$$= Var(X)\,(Var(Y) + (Var(X)\,\mu_Y^2) + (Var(Y)\,\mu_X^2)$$

Substituting this derivation for *Var* (XY), the standard error of the joint distribution is calculated as follows:

$$se = sd\,(XY) / \text{sqrt}\,(n) \qquad 3.11$$

$$= \text{sqrt}\ Var\,(XY) / \text{sqrt}\,(n)$$

$$= \text{sqrt}\,[Var(X)\,(Var(Y) + (Var(X)\,\mu_Y^2) + (Var(Y)\,\mu_X^2)] / \text{sqrt}\,(n)$$

where *se* = the standard error of the joint distribution, and *sd* = the standard deviation. The standard errors for each of the three climate scenarios were calculated according to Equation 3.11, and are presented in Table 3.8 below.

Table 3.8: Variance and Standard Error of Contingent Behavior Responses

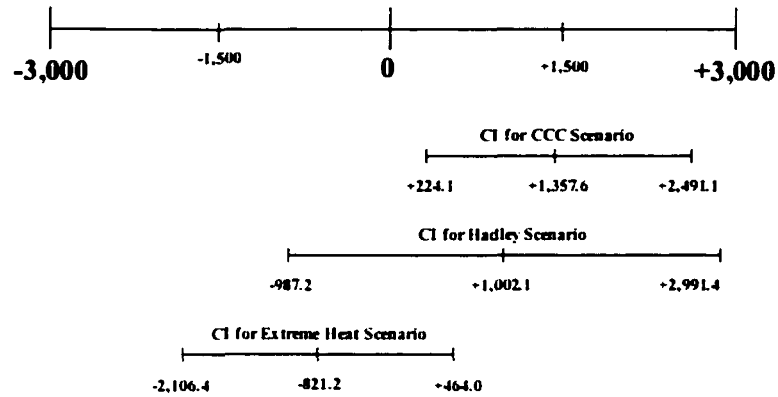
Contingent Behavior Responses	**CCC Scenario**	**Hadley Scenario**	**Extreme Heat Scenario**
Sample size	n=442	n=252	n=280
Variance	1.4511	2.4433	2.0502
Standard deviation	1.2046	1.5631	1.4318
Standard error	0.0578	0.1005	0.0699

Using the standard errors, confidence intervals are calculated according to the following formula (Mendenhall, 1990):

$$(1\text{-}\alpha)\ 100\%\ \text{Confidence Interval} = \hat{Y} \pm t_{\alpha/2}\, se \qquad 3.12$$

The 95% confidence intervals for this analysis are calculated using $t = 1.96$; *se* is the standard error of the distribution. The confidence intervals for the three climate scenarios are presented below in Figure 3.1. The results for the change in visitor days for the CCC scenario indicate that the impact is statistically different from zero; the entire range of the confidence interval is positive, implying an increase in visitation contingent upon that climate scenario. The ranges of the confidence intervals for the Hadley and Extreme Heat scenarios indicate that the impacts are not statistically different from zero.

Figure 3.1: 95% Confidence Intervals for Change in Number of Annual Visitor Days (000s)



Multivariate Analysis and Hypothesis Test Results

Approximately 13% of all survey respondents indicated that they would change their behavior under the hypothetical climate scenarios. Approximately 6.1% of respondents indicated that they would visit RMNP *more* often (positive responses); approximately 7.0% of respondents indicated that they would visit RMNP *less* often (negative responses). An ordinary least squares regression (OLS) analysis on the full sample (positive, negative, and zero responses) yielded the following results, provided in Table 3.9. The dependent variable is the change in the number of trips to RMNP, and represents the respondents' answers to the contingent behavior questions in number of additional or fewer (or zero) trips. The direct and indirect climate scenario variables were chosen based on their expected influence on the regression model and low correlation with other variables. Among the climate scenario variables for the full sample analysis, only the term representing the change in the number of hot summer days is significant at the 95% level; the coefficient is negative, implying that an increase in the number of hot

Table 3.9: Regression Results for Entire Survey Sample

Dependent Variable: Change in number of trips (positive, negative, or zero)
Method: Least Squares
Included observations: 1555

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept term	0.189849	0.139442	1.361492	0.1736
Change in number of days with high temperature > 80°F	-0.005117	0.002137	-2.394283	0.0168
Change in number of elk in RMNP	-7.29E-06	5.16E-05	-0.141212	0.8877
Change in percentage of RMNP acres of alpine tundra	-0.003184	0.002831	-1.124781	0.2609
Distance traveled (miles)	-2.14E-05	7.28E-05	-0.294566	0.7684
Distance traveled, squared (miles^2)	5.51E-09	1.84E-08	0.299802	0.7644
Gender (1 if female, 0 if male)	0.179404	0.061486	2.917809	0.0036
Age (in years)	-0.002697	0.002378	-1.133932	0.2570

R-squared	0.011722	Mean - dependent variable	0.039871
Adjusted R-squared	0.007250	S.D. - dependent variable	1.209552
Std. error of regression	1.205160	F-statistic	2.621298
Sum of squared residuals	2246.878	Prob(F-statistic)	0.010807
Log likelihood	-2492.621		

summer days is associated with a decrease in visitation. For this direct climate scenario variable, we reject the null hypothesis that climate has no effect on visitation at RMNP. For the indirect climate scenario variables (*i.e.*, elk and alpine tundra variables), we do not reject the null hypothesis of no effect. It is also worth noting that the variable representing the gender of the respondent is significant at 95%; the coefficient is positive, implying that female respondents were more likely to change their visitation behavior under the climate scenarios than male respondents.

Since only about 13% of respondents indicated that their visitation behavior would change under the hypothetical scenarios, most of the responses to the contingent behavior questions were zero. Therefore, an OLS analysis on only the responses where a behavior change was indicated (positive and negative responses) was performed, and it yielded the following results, provided in Table 3.10.

Table 3.10: Regression Results for Positive and Negative Responses

Dependent Variable: Change in number of trips (positive and negative only)
Method: Least Squares
Included observations: 212

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept term	0.991258	0.932047	1.063527	0.2888
Change in number of days with high temperature > 80°F	-0.040975	0.015543	-2.636278	0.0090
Change in number of elk in RMNP	-0.032750	0.023986	-1.365374	0.1736
Change in percentage of RMNP acres of alpine tundra	-0.000164	0.000324	-0.506794	0.6128
Distance traveled (miles)	-0.000230	0.000946	-0.242677	0.8085
Distance traveled, squared ($miles^2$)	1.83E-07	4.41E-07	0.415146	0.6785
Gender (1 if female, 0 if male)	1.151719	0.453639	2.538843	0.0119
Age (in years)	-0.008212	0.017328	-0.473911	0.6361
R-squared	0.080261	Mean - dependent variable		0.292453
Adjusted R-squared	0.048701	S.D. - dependent variable		3.271207
Std. error of regression	3.190557	F-statistic		2.543155
Sum of squared residuals	2076.649	Prob(F-statistic)		0.015708
Log likelihood	-542.6990			

This model incorporates the contingent behavior responses only for respondents who indicated that their behavior would change under the hypothetical scenarios (either positively or negatively). The results are consistent with the full sample model (above); that is, among the climate scenario variables, only the variable representing the change in the number of hot summer days is significant at the 95% level; the coefficient is negative, implying that an increase in the number of hot summer days is associated with a decrease in visitation. For this direct climate scenario variable, we again reject the null hypothesis of no effect of climate on visitation levels. For the indirect climate scenario variables (*i.e.*, elk and alpine tundra variables), we do not reject the null hypothesis of no effect. Again, the gender variable is significant at 95%, and the coefficient is positive.

In order to determine if regression coefficients are structurally different between the subset containing positive and that containing negative responses, the Chow test was used (Chow, 1960). The *F* statistic for testing the restriction that the coefficients in the two behavioral subset regressions are the same is 20.2. The critical value is 2.36 for 5% significance, so the hypothesis that the coefficient vectors are the same for the two subsets is rejected (Greene, 1999). The two subsets of observations were thus analyzed separately in order to estimate the climate effects for the positive and negative responses. The OLS regression results for the positive response subset are provided below in Table 3.11.

Table 3.11: Regression Results for Positive Responses Only

Dependent Variable: Change in number of trips (positive only)
Method: Least Squares
Included observations: 99

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept term	1.073837	1.296250	0.828418	0.4096
Change in number of days with high temperature > 80°F	0.041144	0.022328	1.842700	0.0686
Change in number of elk in RMNP	0.010703	0.026609	0.402243	0.6884
Change in percentage of RMNP acres of alpine tundra	0.000860	0.000515	1.670108	0.0983
Distance traveled (miles)	-0.004189	0.001983	-2.112513	0.0374
Distance traveled, squared (miles^2)	2.31E-06	1.15E-06	2.017149	0.0466
Gender (1 if male, 0 if female)	0.993743	0.654498	1.518328	0.1324
Age (in years)	0.005433	0.024644	0.220463	0.8260

R-squared	0.114371	Mean - dependent variable	2.575758
Adjusted R-squared	0.046245	S.D. - dependent variable	3.087469
Std. error of regression	3.015234	F-statistic	1.678829
Sum of squared residuals	827.3387	Prob(F-statistic)	0.124036
Log likelihood	-245.5681		

When only positive responses are considered, we find that the results are slightly different than the model that considered pooled responses. In this case, both the direct climate scenario variable (representing the change in the number of hot summer days) and the indirect climate scenario variable (representing alpine tundra) are significant at the 90% level. Here, the coefficients on both variables are positive, implying that an increase in the number of hot summer days and/or an increase in alpine tundra would be associated with an increase in visitation. For these variables, we reject the null hypothesis of no effect of climate variables on park visitation. The coefficient on the elk population variable is not significant, and therefore we do not reject the null hypothesis of no indirect climate effect. It is also worth noting that in this case, the coefficients on the variables representing distance traveled and the square of distance traveled are both significant at the 95% level. The coefficient estimate on the distance variable displays a negative sign (as in the previous two models—see Table 3.9 and 3.10), which is consistent with the expectation that visitors who travel greater distances are less likely to be influenced by climate in their visitation behavior.

The OLS regression results for the negative response subset are provided below in Table 3.12. When only negative responses are considered, we find that neither the direct nor the indirect climate scenario variables are significant; thus, we do not reject the null hypothesis that climate has no effect on visitation. However, the variables representing distance traveled and the gender of the respondent are both significant at the 95% level. The coefficient on the distance variable is positive, implying that among those who would visit less often under the climate scenarios, those who traveled further are more likely to take even fewer trips than those who traveled shorter distances. The gender

Table 3.12: Regression Results for Negative Responses Only

Dependent Variable: Change in number of trips (negative only)
Method: Least Squares
Included observations: 113

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept term	-2.241601	0.751311	-2.983586	0.0035
Change in number of days with high temperature > 80°F	0.006183	0.013798	0.448101	0.6550
Change in number of elk in RMNP	0.011422	0.027055	0.422175	0.6738
Change in percentage of RMNP acres of alpine tundra	-5.90E-05	0.000258	-0.228679	0.8196
Distance traveled (miles)	0.001284	0.000638	2.013846	0.0466
Distance traveled, squared ($miles^2$)	-2.76E-07	2.67E-07	-1.033727	0.3036
Gender (1 if male, 0 if female)	0.701636	0.332081	2.112848	0.0370
Age (in years)	-0.006868	0.012976	-0.529299	0.5977

R-squared	0.125651	Mean dependent variable	-1.707965
Adjusted R-squared	0.067361	S.D. dependent variable	1.781259
Std. error of regression	1.720219	F-statistic	2.155621
Sum of squared residuals	310.7111	Prob(F-statistic)	0.044064
Log likelihood	-217.4884		

coefficient is positive as well, implying that among negative respondents, females are more likely to take fewer trips under the hypothetical scenarios than males.

An alternative multivariate test involves a qualitative response model that simply distinguishes visitors who would change their behavior (contingent upon the climate scenarios) and those who would not. A binary probit regression analysis on whether or not survey respondents would change their visitation behavior under the hypothetical climate scenarios revealed the following results, presented in Table 3.13. The dependent variable in the binary probit regression is the binary outcome of the contingent behavior question regarding changes to the respondent's visitation behavior. The binary variable is equal to 1 if the respondent indicated that he/she would visit RMNP "more often" or "less often" or if he/she would stay "longer" or shorter" (contingent upon the two climate

Table 3.13: Binary Probit Regression Results for CB Analysis

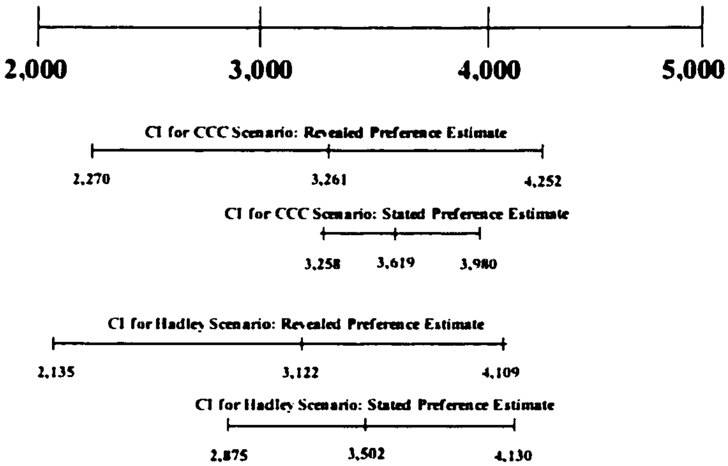
Variable	Coefficient
Change – number of days with high temperature > 80°F	0.0148 ***
Change – number of days with precipitation > 0.25 inches	- 0.0190 ***
Change – number of elk	0.0001 *
Change – percentage of RMNP acres of alpine tundra	0.0254 ***
Distance traveled (in miles)	- 0.0004 ***
Gender (1 if male, 0 if female)	0.1446 *
Age (in years)	- 0.0128 ***
Retired (1=yes, 0=no)	0.2355 *
Member of environmental organization (1=yes, 0=no)	0.1229
Education (in years)	- 0.0219
McFadden $R^2 = 0.08$	* - significant @ 90% ***- significant @ 99%

scenarios) and equal to 0 if the respondent indicated "no change" in the number of trips or in the length of stay. The probit results indicate that the variables representing changes in temperature, precipitation, and the composition of vegetation represented by alpine tundra were significant determinants of the probability of a behavioral change at a level of 99%; the variable representing changes in the elk population was significant at a level of 90%.

Methodological Comparison of Stated Preference and Revealed Preference Results

The results of the contingent behavior analysis indicate that visitation would increase by about 13.6% under the climate scenario depicted by the CCC circulation model and by about 9.9% under the scenario depicted by the Hadley model. These results do approximate the results found in the revealed-preference study (presented in Chapter 2). In that chapter, a regression analysis was used to measure the effects of climate change on visitation, using historical visitation, climate, and population data. Using 2020 climate forecasts and a baseline (1996) regional population level, we are able to isolate the effects of changing climate variables in the forecast of future visitation. Under the revealed-preference approach, visitation was estimated to increase 11.6% under the CCC scenario and 6.8% under the Hadley scenario. The close association of the results between the revealed- and stated-preference methods is useful for methodological comparison. Figure 3.2 below illustrates the 95% confidence intervals for the visitation forecasts for the CCC and Hadley scenarios under both the revealed- and stated-

Figure 3.2: 95% Confidence Intervals for 2020 Visitation Forecasts: Methodological Comparison (000s of Visitors)



preference analytical methods. Note that all four confidence intervals overlap, implying that the estimates generated by the two methods are not statistically different from one another. Confidence in the visitation estimates is strengthened by the agreement found under the two analytical approaches.

Conclusions

A contingent behavior analysis was used to measure the effects of changes in direct and indirect climate scenario variables on visitation to RMNP. A visitor survey was used to ask park visitors how their visitation behavior would change under hypothetical climate scenarios. The results indicate that the effects of changes in certain climate variables would have a positive impact on visitation levels. Temperature was found to be a positive and significant determinant of visitation behavior. A 13.6% increase in visitation was estimated under the CCC scenario, and a 9.9% increase was estimated for the Hadley scenario. These estimates are comparable to those found in previous studies. Loomis and Crespi (1999) estimated visitation increases from warming for reservoir (9.2%), beach (14.1%), and golf (13.6%) recreation activities. They did find negative effects to forest-based recreation (2.0%) due to estimated loss of forest cover (the population dynamics models used in the RMNP analysis predicted modest gains to forest cover under both the CCC and Hadley scenarios).

A comparison of the results of the contingent behavior analysis with that of the revealed-preference analysis indicate that the two approaches produce statistically identical estimates of future visitation. In both the revealed- and stated-preference approaches, climate effects were statistically significant from zero. While the overall net effect to visitation due to climate change is small under both methods, the survey data revealed that most visitors planned their trips well in advance (68 days, on average) and over 66% of respondents indicated that their most recent trip to RMNP was either the "sole destination" or "primary purpose" of the trip. More than 70% of respondents indicated that the activities of viewing conifer forests, viewing wildflowers, and driving over Trail Ridge Road were either "important" or "very important" to their decisions to visit RMNP. The average distance traveled was 643 miles, the average length of stay was more than three days, and over 60% of respondents were from outside of Colorado. These results suggest that summer vacations and the opportunity to view the alpine scenery of RMNP were the main factors in the visitation decision, and that visitors are less sensitive to slight changes in climate.

A hypothetical climate scenario described as "Extreme Heat" was included in two survey versions, and the analysis of the results of that scenario indicate that visitation would decline due to the effects of such a weather regime. Interestingly, the summer of 2002 in the RMNP area could be described as unusually hot and shared several characteristics with this hypothetical Extreme Heat scenario. In the survey, the scenario was described as having 50 summer days in which the high temperature exceeded 80° Fahrenheit, as compared with three such days in the baseline (Typical Day) scenario. In the summer of 2002, there were 33 days for which the high temperature exceeded this level (more than any of the ten preceding years), which offers an opportunity to observe empirically the predicted effects of extreme temperatures on visitation levels. Survey results estimated a 8.75% decrease in visitation under the hypothetical Extreme Heat climate scenario. Table 3.14 presents actual visitation data for the summer months of 2002, compared with the same months in the previous year.

Table 3.14: Monthly RMNP Visitation for Summers 2002 and 2001

Monthly Visitation	**Number of Extreme Heat Days**	**2002**	**2001**	**% Change**
June	10	507,745	521,862	-2.7%
July	19	671,180	789,781	-15.0%
August	4	617,330	644,716	-4.3%
Summer Total	33	1,796,255	1,956,359	-8.8%

Source: National Park Service: Rocky Mountain National Park

Actual levels of visitation in the summer months of 2002 were 8.8% lower than in the previous year, which support the visitation effects of extreme heat estimated by the contingent behavior analysis. While other factors such as wildfires and drought conditions may have influenced visitation levels in 2002, unusually high temperatures are expected to have been a contributing factor in the decline.

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CHAPTER 4: A CONTINGENT VALUATION ANALYSIS OF THE IMPACT OF CLIMATE ON RECREATION BENEFITS

Introduction

The recreation benefits to a consumer are a measure of the utility the consumer obtains from the recreation experience (Loomis and Walsh, 1997). The level of particular weather variables may influence the benefit or utility derived from the recreation experience. The effect of weather on the visitor's experience may affect the economic efficiency of the recreation consumption decision. The purpose of this paper is to measure the influence of weather conditions on the visitor's net willingness to pay (WTP) for the recreation good. The effect of weather conditions on recreation benefits is associated with the overall benefits and costs of climate change policy. The results of this analysis could be used in the measurement of the economic value of weather forecasts for recreation, in order to maximize value (utility) to visitors.

Only a few studies have considered the effects of climate on recreation benefits. In quantifying the WTP for beach use, McConnell (1977) and Silberman and Klock (1988) found temperature to have a positive and statistically significant effect on net benefits. Loomis and Crespi (1999) estimated a welfare gain of over 3% from the impact of climate change on eight groups of recreation activities, based on 1990 use levels. Mendelsohn and Markowski (1999) estimated that a 2.5°C increase in temperature and a 7% increase in precipitation would generate a 7-9% increase in recreation benefits. This chapter contributes to this sparse literature, and the empirical analysis focuses on a resource that has not been studied previously in this context, a national park.

This analysis requires both primary and secondary data. A survey of visitors to Rocky Mountain National Park (RMNP) was used to gather primary information about visitors' recreation experience and their willingness to pay for visits. Since weather conditions vary from day to day, secondary climate data was collected from the National Park Service for the survey period are used to relate economic benefits to daily weather.

The contingent valuation method (CVM) has been used extensively to measure changes in recreation benefits under varying levels of particular amenities. CVM is an accepted method of valuing recreation benefits as well as other benefits for which no market exists (Cummings *et al.*, 1986; Loomis, 1987). The U.S. Department of Interior (1986), which oversees the National Park Service, has approved CVM for valuing natural resource damages. CVM is one of two preferred approaches for valuing outdoor recreation in Federal benefit-cost analyses (U.S. Water Resources Council, 1983).

The premise of CVM is based on a hypothetical market for the use or preservation of a natural resource for which there is no market for the exchange of a good. This hypothetical market includes the description of a good (*e.g.*, recreation experience), a payment vehicle (*e.g.*, travel costs), and a procedure for the elicitation of value (*e.g.*, dichotomous-choice approach). In this study of the climate change effects on the recreation benefits of visiting RMNP, the good to be valued is the most recent recreation trip to RMNP. The payment vehicle used in this analysis is a hypothetical increase in travel costs. The dichotomous-choice approach asked the respondent to answer yes or no to a randomly assigned bid amount. This approach was utilized in this study because it was suitable for a mail survey and it corresponds to the manner in which consumers make choices in a true market (*i.e.*, based on price, they decide to buy or not).

Theoretical Model

The theoretical representation follows Hanemann (1984). We assume that an individual's utility is a function of her recreation experience at RMNP (represented by R) and the consumption of all other goods (represented by income I). The utility function can therefore be represented as:

$$U = f(R, I) \qquad 4.1$$

Consumption of the recreation good may depend on an individual's income as well as her personal preferences (known only to the individual), and thus, the utility function is not observable. Therefore, some components of each individual's utility function are treated as stochastic, resulting in an indirect utility function and a stochastic element, as follows:

$$U = f(R, I) = v(R, I) + e \qquad 4.2$$

where e represents an independent identically-distributed error term with a zero mean.

Under the dichotomous-choice approach, survey respondents are asked whether or not they would still take their most recent trip to RMNP if travel costs were $\$X$ higher. The respondent will answer yes if her utility from the recreation experience (with the associated loss of $\$X$ in income) is greater than or equal to her original utility level without having taken the trip. The "YES" respondent would hypothetically take the trip (R=1) at the higher travel cost, and the "NO" respondent would choose not to take the trip (R=0). Therefore, the probability of a YES response is represented as follows:

$$P(\text{YES}|\$X) = P[f(R=1, I-\$X) \geq f(R=0, I)] \qquad 4.3$$

Since the individual's utility function is not observable to the researcher, it is common to assume that the utility function has a stochastic element, which results in the following transformation of the probability function:

$$P(\text{YES}|\$X) = P[v(R=1, I-\$X) + e_1 \geq v(R=0, I) + e_2] \quad 4.4$$

where e_1 and e_2 are error terms with means of zero (Loomis, 1987). The distribution of the difference in the error terms is assumed to be a standard logistic function (Hanemann, 1984; Loomis, 1987). The responses to the dichotomous-choice question are analyzed using a binary logit model in order to estimate WTP.

The theoretical model for this investigation suggests that recreation benefits (measured as net willingness-to-pay) are influenced by weather conditions on the day of the recreation visit. The theoretical model is represented as:

$$WTP_{it} = f(T_t, P_t, W_t, C_t, A_{1i}, A_{2i}, \ldots, A_{ni}, TC_i, D_{1i}, D_{2i}, \ldots, D_{ni}) \quad 4.5$$

where

WTP_i =	net benefits (willingness to pay) from recreation experience
T_t =	daily temperature (maximum, minimum)
P_t =	daily precipitation
W_t =	daily average wind speed
C_t =	daily average cloud-cover
$A_{1i}, A_{2i}, \ldots, A_{ni}$ =	activities in which the visitor participated during the visit
TC_i =	travel cost per visit
$D_{1i}, D_{2i}, \ldots, D_{ni}$ =	demographic characteristics of the visitor, including gender, age, level of education, annual income, employment status, and membership in an environmental organization
i =	individual respondent to survey
t =	date

Econometric Specification

Primary data collected in a visitor survey at RMNP will be used along with weather data to estimate the effects of daily weather on economic benefits of recreation. In the survey, visitors responded to a dichotomous-choice question regarding willingness to pay a single bid amount. The probability that a respondent would pay a given amount can be statistically estimated using a qualitative choice model such as a logit equation (Hanemann, 1984). The econometric model to be estimated is therefore:

$$\text{Probability (YES)} = 1 - \{1 + \exp[\beta_0 - \beta_1(\$X) + \beta_T(T) - \beta_P(P) - \beta_W(W) - \beta_C(C) + \beta_A(A) + \beta_{TC}(TC) + \beta_D(D)]\}^{-1} \quad 4.6$$

where

β_0 = the intercept plus the product of additional coefficients multiplied by the means of their respective variables,

β_1 = the coefficient on the WTP variable (estimated using the binary logit technique),

$\$X$ = the given bid amount,

β_T = the coefficient on the temperature variables (T^{max}, T^{min}),

β_P = the coefficient on the precipitation variable (P),

β_{WS} = the coefficient on the wind speed variable (WS),

β_C = the coefficient on the cloud cover variable (C),

β_A = the coefficient on the activity variables (A_n),

β_{TC} = the coefficient on the travel cost variable (TC), and

β_D = the coefficient on the demographic variables (D_n).

An empirical model is estimated to measure the coefficients on the weather variables of concern:

$$[\log(\text{YES})/(1-\text{YES})] = \beta_0 - \beta_1 (\$X) + \beta_T (T) - \beta_P (P) - \beta_{WS} (WS) - \beta_C (C) + \beta_A (A) + \beta_{TC} (TC) + \beta_D (D) \quad 4.7$$

Finally, this model is converted to a WTP equation by dividing each slope coefficient (except β_1, the coefficient on the bid amount) by β_1, according to Cameron's (1988) reparameterization:

$$\text{WTP} = \beta_0/\beta_1 + \beta_T/\beta_1 (T) - \beta_P/\beta_1 (P) - \beta_{WS}/\beta_1 (WS) - \beta_C/\beta_1 (C) + \beta_A/\beta_1 (A) + \beta_{TC}/\beta_1 (TC) + \beta_D/\beta_1 (D). \quad 4.8$$

This specification allows for the interpretation of the problem of interest: the coefficients on the climate variables (β_T, β_P, β_{WS}, and β_C) represent the impact of daily weather on a visitor's willingness to pay.

Hypothesis

Using the model presented above, we use t-tests to examine the null hypothesis that daily weather variables (representing temperature, precipitation, wind speed, and cloud cover) have no effect on the respondent's recreation benefits. Thus, from Equation 4.6, we test:

$$H_0: \beta_T = 0 \qquad H_A: \beta_T \neq 0 \quad 4.9$$
$$H_0: \beta_P = 0 \qquad H_A: \beta_P \neq 0$$
$$H_0: \beta_{WS} = 0 \qquad H_A: \beta_{WS} \neq 0$$
$$H_0: \beta_C = 0 \qquad H_A: \beta_C \neq 0$$

To reject this hypothesis implies that weather variables do influence the visitor's utility from a recreation experience. Changes in future climate patterns will therefore affect the economic efficiency of the consumption of recreation goods, which suggests policy implications for the management of public recreation sites and ecological preserves.

Empirical Analysis

The study site for the empirical analysis is Rocky Mountain National Park (RMNP) in north-central Colorado. RMNP's diverse wildlife population, scenic alpine meadows, conifer forests, aspen groves, and high mountain peaks attract over three million visitors per year from throughout the U.S. and the world.

A visitor survey was conducted in the summer of 2001 at RMNP. Respondents were asked if they would have made their trip if travel costs had been higher. Bid payment amounts were randomly chosen, and respondents were asked the following dichotomous-choice contingent valuation question:

> *As you know, some of the costs of travel such as gasoline have been increasing. If the travel cost of this most recent visit to Rocky Mountain National Park had been $___ higher, would you have made this visit?*
> *Circle one: YES NO*

Bid amounts in the survey ranged from $1 to $495, and this range was chosen based on other recent surveys of willingness to pay for recreation. Surveys were tested with focus groups for content, clarity, and length, and the design was modified according to the focus group comments. The final survey version was pre-tested with visitors before distribution during the sampling period.

Data Collection

The contingent valuation analysis requires data on willingness to pay (for the recreation experience) and on weather for the survey date (explanatory variables). Data for willingness to pay (WTP) were collected through visitor surveys at RMNP for the survey period of June – September, 2001. Daily weather data were provided by the National Park Service for the sampling period.

During the sampling period, visitors were selected randomly in heavily-visited areas of RMNP at five specific locations. Sampling sites were selected in order to identify visitors in an array of locations who had been hiking, sightseeing, driving Trail Ridge Road, and other activities. Survey dates were selected in order to obtain samples from weekdays, weekends, and holidays. Each of the five survey sites was sampled on four weekend days and four weekdays, for a total of 40 survey dates.

On selected sampling dates, visitors were approached randomly at the chosen sampling sites, and surveys were distributed to willing respondents, who took the survey with them to be completed and mailed in at a later date. Mail-returned surveys were chosen because the CVM question referred to the visitor's "most recent trip," which was still in progress when the questionnaires were distributed; this approach allowed the respondent to complete the survey at the end of her visit and mail it in at her convenience. There were 1,378 attempts to distribute surveys during the sampling period, and 112 were refused. Thus, a total of 1,266 surveys were distributed. At the end of the survey collection period, 967 surveys were returned, which amounts to a 70% response rate (or a 76% response rate, net of refusals).

Daily weather data were provided by the National Park Service's Weather Information Management System and included daily observations of the following variables for the entire sample period, provided below in Table 4.1. The variable *SOW* is a representation of the daily "state of weather," which is recorded at 1:00pm and coded as 0-9, according to Table 4.2 below.

For the sampling period, there were no observations for the *SOW* variable codes 4, 5, 7, or 8, so these variables were dropped. Dummy variables were created for each of

Table 4.1: Daily Weather Data for RMNP (June - September, 2001)

Variable Name	Definition	Mean Value	Minimum	Maximum
SOW	State of Weather (see Table 4.2)	n.a.	0	7
TEMP	Temperature (°F) (at 1:00pm)	74.2	39.0	88.0
RH	Relative Humidity (%) (at 1:00pm)	29.9	7.0	84.0
WDIR	Wind Direction (at 1:00pm)	4.0	0.0	8.0
WS	Wind Speed (mph) (at 1:00pm)	5.2	0.0	12.0
TMPMAX	Daily Maximum Temperature	80.0	51.0	90.0
TMPMIN	Daily Minimum Temperature	48.7	33.0	65.0
RHMAX	Daily Maximum Relative Humidity	71.2	34.0	96.0
RHMIN	Daily Minimum Relative Humidity	17.6	0.0	41.0
PPTDUR	Daily Precipitation Duration (hours)	0.8	0.0	6.0
PPTAMT	Daily Precipitation Amount (inches)	0.0	0.0	0.4

Table 4.2: Definitions of State of Weather (SOW) Variables

Variable	Explanation
0	Clear (<10% clouds)
1	Scattered Clouds (10-50% clouds)
2	Broken (60-90% clouds)
3	Overcast (>90% clouds)
4	Foggy
5	Drizzle or misty
6	Raining
7	Snowing or Sleet
8	Showers/Isolated or Scattered Precipitation (in sight or at station)
9	Thunderstorm in progress (lightning seen or heard)

the observations coded 3, 6, and 9 (*OVERCAST*, *RAIN*, and *TSTORM* respectively) for purposes of the statistical analysis. The value of each of these dummy variables is equal to 1 when its respective *SOW* code was recorded as an observation, and equal to 0 when any other code was recorded.

In addition to the CVM question, the visitor survey also included questions about the activities in which the visitor participated during her most recent visit, which allows for the test of how much particular recreation activities may affect a respondent's willingness to pay. These activities include picnic (*PICNIC*) and driving over Trail Ridge Road (*DTRROAD*), among several others (*e.g.*, hiking, camping, backpacking, and sightseeing). Each variable has a value equal to 1 if the visitor participated in that activity, and 0 if they did not. The visitor survey also included questions about the respondent's distance traveled and demographic characteristics (*e.g.*, age, income).

Data Analysis

This analysis incorporates primary data collected through visitor surveys at RMNP, as well as daily weather data for the respective sampling period. The data analysis involves four steps. First, the survey and daily weather data were merged and aligned in order to coordinate a comprehensive dataset that included comparable variables. Second, a binary logit statistical analysis is used to estimate the coefficient on the bid amount (β_1), and weather variables (β_T, β_P, β_{WS}, and β_C) (see Equation 4.6). Third, an empirical model is specified to include all significant weather, attitude, and demographic variables. Finally, a WTP equation is estimated by transforming the coefficients (Cameron, 1988); the reparameterized coefficients (see Equation 4.8) are used to draw conclusions about the incremental WTP associated with changes in the weather variables.

Results

Results of a binary logit analysis of the dichotomous choice responses to the CVM question of willingness to pay are provided in Table 4.3. Note that the dependent

Table 4.3: Binary Logit Regression Results for CVM Analysis

Dependent Variable: YPAY
Method: ML - Binary Logit (Quadratic hill climbing)
Included observations: 625

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Intercept term	-1.624653	1.774713	-0.915446	0.3600
BIDAMT ($)	-0.006504	0.001052	-6.181391	0.0000
TEMP (°F)	0.017302	0.021362	0.809923	0.4180
PPTAMT (inches)	4.250329	2.054937	2.068350	0.0386
WS (miles per hour)	-0.033265	0.046309	-0.718338	0.4725
OVERCAST (=1 if present)	0.169035	0.494938	0.341528	0.7327
RAIN (=1 if present)	-0.774746	0.790055	-0.980623	0.3268
TSTORM (=1 if present)	-0.043346	0.289278	-0.149841	0.8809
PICNIC (=1 if participated)	0.430598	0.212661	2.024810	0.0429
DTRROAD (=1 if participated)	0.368087	0.225571	1.631803	0.1027
Distance traveled (miles)	0.001978	0.000305	6.486172	0.0000
Distance traveled, squared (miles^2)	-2.72E-07	6.11E-08	-4.459387	0.0000
Income	8.78E-06	2.39E-06	3.678854	0.0002

S.E. of regression	0.389150	Mean - dependent variable	0.739200
Sum squared residuals	92.67980	S.D. - dependent variable	0.439423
Log likelihood	-285.8121	LR statistic (12 df)	145.7409
Restr. log likelihood	-358.6825	Probability(LR stat)	0.000000
McFadden R-squared	0.203161	Total obs	625
Obs with YPAY=0	163	Obs with YPAY=1	462

variable in this case is *YPAY*, which is equal to 1 if the respondent indicated that they would pay the bid amount (YES) and 0 if they indicated they would not pay (NO). One of the slope coefficients on the weather variables, *PPTAMT*, is significant above the 95% level; the sign on *PPTAMT* is positive (suggesting greater probability of responding YES to the CVM question with more precipitation). Contrary to expectations, *PPTAMT* is not correlated with the *RAIN* and *TSTORM* dummy variables (correlation coefficients are 0.18 and 0.10, respectively). Each of the slope coefficients on the variables *BIDAMT* (bid amount), *PICNIC* (participated in picnic activities during the most recent RMNP visit), *DIST* (one-way travel distance to RMNP), *DISTSQ* (square of DIST variable), and *INC* (household income) is significant at the 95% level and display the expected signs.

We repeated the regression analysis, but eliminated insignificant variables in order to estimate at a logit equation with statistically significant variables that could be meaningfully reparameterized into a WTP function. Table 4.4 presents the specified logit

Table 4.4: Specified Binary Logit Model

Dependent Variable: YPAY
Method: ML - Binary Logit (Quadratic hill climbing)
Included observations: 625

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Intercept term	-2.679648	1.366754	-1.960593	0.0499
BIDAMT ($)	-0.006505	0.001036	-6.281274	0.0000
TEMP (°F)	0.028407	0.016824	1.688469	0.0913
PPTAMT (inches)	4.446690	1.846271	2.408470	0.0160
PICNIC (=1 if participated)	0.410945	0.210787	1.949570	0.0512
DTRROAD (=1 if participated)	0.370858	0.220514	1.681791	0.0926
Distance traveled (miles)	0.001935	0.000301	6.438810	0.0000
Distance traveled, squared (miles^2)	-2.62E-07	5.97E-08	-4.390011	0.0000
Income	9.04E-06	2.37E-06	3.817378	0.0001

S.E. of regression	0.388229	Mean - dependent variable	0.739200
Sum squared residuals	92.84441	S.D. - dependent variable	0.439423
Log likelihood	-286.6003	LR statistic (12 df)	144.1643
Restr. log likelihood	-358.6825	Probability(LR stat)	0.000000
McFadden R-squared	0.200964	Total obs	625
Obs with YPAY=0	163	Obs with YPAY=1	462

equation, re-estimated after eliminating insignificant variables. This logit equation permits the acceptance of the hypotheses that the coefficients on some of the weather variables (i.e., wind speed, cloud cover) are equal to zero. However, we reject the hypothesis that the coefficients on temperature (*TEMP*) and precipitation (*PPTAMT*) are zero, along with that for the coefficient on certain recreation activities (*PICNIC*, *DTRROAD*), travel cost (represented here as *DIST* and *DISTSQ*), and demographic (*INCOME*) variables. The coefficient estimates on all of the independent variables are significant above the 90% level.

According to Cameron's (1988) approach, it is possible to calculate an equation that relates willingness to pay to weather, activity, and demographic variables. The slope coefficients in Equation 4.11 are reparameterized by dividing the intercept and all coefficients (other than that on the bid amount) by the coefficient on the absolute value of the bid amount. This conversion for the logit function generates the following equation:

$$WTP = -411.95 + 4.37TEMP + 683.60PPTAMT + 63.18PICNIC + 57.01DTRROAD + 0.30DIST - 4.03\text{E-}05DISTSQ + 0.0014INC \quad 4.12$$

The specification in Equation 4.12 allows that parameters be interpreted in the same manner as ordinary least squares results; a one-degree increase in temperature is associated with a increase in willingness to pay of $4.37. Individuals driving over Trail Ridge Road are willing to pay $57.01 more than those that did not. An increase in a visitor's income of $1,000 can be associated with an increase in WTP of $1.40. We expect that the reason for the high coefficient estimate on precipitation is related to the coincidence of the late-summer monsoon season (which brings greater levels of rain to the region) and school-vacation summer months (which were found to be a highly significant determinant of visitation levels in Chapter 2).

Mean WTP is calculated using the mean values for each of the explanatory variables and is estimated to be $314.95 per trip. Based on survey results that indicated an average group size of 4.3 persons and an average length of stay of three days, we estimate the net WTP per person, per day to be $24.47.

In order to estimate the effect of climate change on mean WTP, the 2020 temperature and precipitation forecasts from the CCC and Hadley circulation models are substituted for mean temperature and precipitation amounts. The substitutions indicate that mean WTP would increase 6.7% to $336.05 per trip under the temperature and precipitation forecast presented by the CCC model; mean WTP would increase 4.9% to $330.38 per trip under the climate forecast presented by the Hadley model. Although we find that certain climate variables are statistically significant determinants of net willingness to pay for recreation, the effects of predicted changes in regional climate are small. Findings in this study are of the same relative magnitude as previous estimates of economic effects of climate change (Mendelsohn and Markowski, 1999; Loomis and Crespi, 1999).

Conclusions

In the contingent valuation analysis presented in this chapter, we used the results of a dichotomous-choice CVM question from a RMNP visitor survey in a regression analysis of daily weather data at RMNP in order to measure possible effects of weather variables on a visitor's net recreation benefits. Weather variables representing daily temperature and precipitation amount were found to be statistically significant determinants of willingness to pay, but when climate forecasts for 2020 were applied to the coefficient estimates from the regression analysis, we find that the effects of predicted climate change on recreation benefits to be small but of the same relative magnitude as the effects estimated in previous studies. The impact of a changing climate on net willingness to pay could be more significant for greater changes in weather variables.

This analysis has implications for the value of weather forecasts for recreation planners, resource managers, and climate change policymakers. Measurable effects of weather on recreation benefits are relevant for economic efficiency analysis in terms of maximizing recreation value (or utility) to visitors. Improved weather forecasts would enhance the efficiency of the recreation visitation decision by minimizing uncertainty and transactions costs.

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CHAPTER 5: CONCLUSIONS

The analyses presented in the preceding chapters are concerned with the estimation of possible economic effects of exogenous climate change on nature-based tourism. First, possible impacts to national park visitation and the regional economy of nearby gateway communities can be estimated using both revealed- and stated-preference methods. We used historic monthly visitation data for Rocky Mountain National Park (RMNP) in Colorado, USA, along with historic climate and regional population data to perform a regression analysis in the measurement of possible climate effects. Climate effects were found to be statistically different from zero, but in the formation of prediction intervals, it was determined that only regional population was a significant determinant of future park visitation. Contingent behavior analysis was used in a visitor survey at RMNP as a tool for considering possible effects of direct and indirect climate scenario variables on the visitation behavior of survey respondents. Survey results indicated that the visitation effects of climate change were positive and statistically different from zero, and that their relative magnitudes (10-13%) were consistent with the findings of previous studies. A comparison of the survey results with the regression results indicated that the two methods yielded similar results and that their estimates of future visitation were not statistically different from one another. Finally, responses to a dichotomous-choice contingent valuation question in the visitor survey were analyzed along with daily weather data for RMNP to estimate possible effects of climate on visitor recreation benefits. Consistent with the findings in the other studies, climate effects were found to be statistically significant determinants of willingness to pay, but the impact of predicted climate change on recreation benefits was found to be small (5-7%) and relatively close to estimates found in previous studies.

These results have implications for planners and policymakers concerned with the possible economic effects of a changing climate. The estimates presented in these chapters can be used to measure the impact of climatic variation to park visitation levels, to the local economy for visitor rationing or infrastructure planning purposes, or to the economic efficiency of the provision of the recreation good. The results of these analyses are associated with the overall benefits and costs of climate change policy regarding nature-based tourism.

APPENDIX A: RMNP VISITOR SURVEY, VERSION A

YOUR VISIT TO ROCKY MOUNTAIN NATIONAL PARK

WHAT DO YOU THINK?

Thank you for agreeing to complete this survey. Before we start, we wish to provide you with a description of the key natural resources in Rocky Mountain National Park (RMNP) on which we will be focusing.

Resource Descriptions


Elk: a mammal whose average size ranges from 500 pounds for cows to 700 pounds for bulls. They mate in autumn, and calves are born in early summer. There are currently about 1,040 elk in RMNP.


White-tailed Ptarmigan: a bird that is a close relative of the prairie grouse and lives in alpine tundra. Ptarmigan nest on the ground soon after the snow melts and hatch eggs in late June. There are currently about 34 ptarmigan in the Trail Ridge Road area.


Open woodland: areas of grass and shrubs with a few large trees.


Evergreen trees: refers to conifer or needleleaf trees such as pines, spruce, fir, and cedar trees in Rocky Mountain National Park.


Alpine tundra: treeless plain at high altitudes (above treeline), often with shrubs or wildflowers.

I. Importance of different natural resources for Rocky Mountain National Park

Please tell us how important the following activities and natural resources are in terms of your decision to ***visit*** Rocky Mountain National Park during the year.

Please circle one number for each item	**Importance for your visit to RMNP**			
	Not Important	Somewhat Important	Important	Very Important
Viewing elk	1	2	3	4
Viewing ptarmigan	1	2	3	4
Fishing for catchable trout	1	2	3	4
Viewing aspen groves	1	2	3	4
Viewing conifers/evergreens	1	2	3	4
Viewing alpine tundra/flowers	1	2	3	4
Snow-free hiking trails	1	2	3	4
Driving over Trail Ridge Road	1	2	3	4
Solitude or lack of crowds	1	2	3	4
Expected high temperature for the day	1	2	3	4
Expected precipitation	1	2	3	4
Adequate snow for skiing or snowshoeing	1	2	3	4

II. Tell us about your most recent trip to Rocky Mountain National Park.

1. Please check the primary activities you participated in during this most recent trip to Rocky Mountain National Park (**check all that apply**):

___ Hiking/walking
___ Bicycling
___ Fishing
___ Picnicking
___ Driving for pleasure
___ Driving Trail Ridge Road
___ Sightseeing/photography
___ Birdwatching
___ Aspen viewing
___ Elk viewing/bugling
___ Other wildlife viewing
___ Alpine tundra/flower view
___ Camping
___ Backpacking
___ Mountain/rock climbing
___ Other, please describe____

2. Was your most recent visit from home to Rocky Mountain National Park (**check only one**):
   2a. ___ the sole destination (you went directly to the Park and then back home)?
   2b. ___ the primary purpose (but not sole purpose of your trip from home)?
   2c. ___ one of many equally important reasons or destinations for your trip from home?
   2d. ___ just an incidental or spur of the moment stop on a trip taken for other purposes or to other destinations?
   →If you checked either 2c or 2d, did the trip from home to Rocky Mountain National Park also involve visiting family or friends? ___Yes ___No

3. Did you plan this visit to Rocky Mountain National Park (**check only one**):
___ 6 or more months in advance of the trip?
___ 1-6 months in advance of the trip?
___ 1-4 weeks in advance of the trip?
___ less than one week in advance of the trip?

4. What was the amount of time you spent in Rocky Mountain National Park on this most recent trip? _________# of hours or ________ # of days

5. What was the one-way **travel time** of your trip from home to Rocky Mountain National Park? __________ # minutes __________ # hours

6. What was your one-way **travel distance** from home to Rocky Mountain National Park? ___________# one-way miles

7. What is the distance from your home to the next best recreation area you would go to if you could not go to Rocky Mountain National Park ? _______________ # one way miles

8. Including yourself, what was the number of people in your group that traveled on this most recent trip? __________# of persons in your group

9. How many trips did you take to Rocky Mountain National Park in the last 12 months (including this trip)? _____ # Trips

III. How would your visitation change with the weather?

The weather varies from year to year, with some hot-dry summers and some cool-wet summers. Weather affects wildlife, vegetation, as well as access to various roads and trails. Please **compare the following scenarios** of changes in weather, wildlife, and vegetation in Section A, and **respond to the questions** in Section B on the bottom of the facing page. These questions ask about how your trips to Rocky Mountain National Park would be affected, given these different weather scenarios.

Section A: Background Information

	Typical Day	**Scenario 1**	**Scenario 2**
Temperature Number of days with summer high temperature greater than 80°F	3 days	15 days	20 days
Number of days with winter low temperature less than 10°F	83 days	36 days	110 days
Precipitation Number of summer days with precipitation above 0.25 inches	18 days	15 days	28 days
Hiking Trail Access Trails snow-free	July 1–December 15	June 15–December 15	June 1 – December 30
Trail Ridge Road Trail Ridge Road open for driving	May 30 – October 15	May 10 – October 30	June 10 – October 10
Visitor Crowding Average daily visitors (July)	23,205	24,202 (4% increase)	24,600 (6% increase)
Average daily visitors (October)	10,551	12,028 (14% increase)	10,020 (5% decrease)

	Typical Day	Scenario 1	Scenario 2
Elk Each elk symbol represents about 200 elk	1,040 elk	1,500 elk	600 elk
Ptarmigan Each ptarmigan symbol represents about 4 birds in the Trail Ridge Road area	34 birds	4 birds	60 birds
Vegetation Composition	(% acres)	(% acres)	(% acres)
Alpine tundra	15%	0%	25%
Open woodland	2%	20%	5%
Evergreen	77%	72%	70%

Section B: Questions--How would these changes in conditions affect your visitation?

Question:	Scenario 1	Scenario 2
1. If you knew Rocky Mountain National Park weather and conditions would be as described in Scenarios 1 and 2, would you have changed the number of trips you took in the last 12 months?	__Visit ***more*** often? # of additional yearly trips ____ __Visit ***less*** often? # of fewer yearly trips ____ __ **No change** in # trips	__Visit ***more*** often? # of additional yearly trips ____ __Visit ***less*** often? # of fewer yearly trips ____ __ **No change** in # trips
2. Would the changes in weather and resources described in Scenarios 1 and 2 have affected your ***length of stay*** in Rocky Mountain National Park on a typical trip?	Would you stay ___ **Longer**? ____ days longer ___ **Shorter**?____ days fewer ___ **No change**?	Would you stay ___ **Longer**? ____ days longer ___ **Shorter**? ____ days fewer ___ **No change**?
3. Would the changes affect ***when*** you would visit?	Would you visit __ **Earlier** in the year? __ **Later** in the year? __ **No change** in time of year	Would you visit __ **Earlier** in the year? __ **Later** in the year? __ **No change** in time of year

IV. Trip Expenditures

Please record the dollar amount **you personally** spent to visit Rocky Mountain National Park (RMNP) on this most recent trip for:

Trip Expense	**Amount Purchased in Estes Park**	**Total Amount Spent**
Gasoline/related automobile costs	$	$
Park entrance fees	$	$
Hotel/motel	$	$
Camping outside RMNP	$	$
Camping inside RMNP	$	$
Food/drink: restaurants	$	$
Food/drink: grocery stores	$	$
Supplies/equipment rental	$	$
Guide/horseback riding fees	$	$
Airline ticket	$ Not Applicable	$
Rental car	$ Not Applicable	$

2. As you know, some of the costs of travel such as gasoline have been increasing. If the **travel cost** of this most recent visit to Rocky Mountain National Park had been $______ higher, would you have made this visit?

   Circle one: YES NO

3. If you visited Rocky Mountain National Park in the last 12 months **prior to this most recent visit**, please check the primary activities you participated in (**check all that apply**):

___Hiking/Walking
___ Bicycling
___ Fishing
___ Picnicking
___ Driving for pleasure
___ Driving Trail Ridge Road
___ Sightseeing/photography
___ Birdwatching
___ Aspen viewing
___ Elk viewing/bugling
___ Other wildlife viewing
___ Alpine tundra/flower view
___ Camping
___ Backpacking
___ Mountain/rock climbing
___ Cross-country skiing
___ Snowshoeing
___ Other, please describe____

V. Please tell us something about yourself.

These last few questions will help us in evaluating how well our sample represents visitors. YOUR ANSWERS WILL BE KEPT STRICTLY CONFIDENTIAL AND WILL ONLY BE USED FOR THE ANALYSIS OF THIS STUDY. YOU WILL NOT BE IDENTIFIED IN ANY WAY.

1. Are you? _____ Male _____ Female

2. Age _____ years

3. Are you retired? _____ Yes _____ No

4. What is your zip code? ________________________________

5. Are you a member of a conservation or environmental organization? ____ Yes ____ No

6. Your highest level of formal education? (Please circle one)

1 2 3 4 5 6	7 8 9	10 11 12	13 14 15 16 17	18 19 20
(elementary)	(jr. high)	(high school)	(college or technical school)	(graduate or prof. school)

7. Do you work outside the home? _____ Yes _____ No

8. When you recreate, do you almost always go on weekends, holidays, vacations, or other non-work days?
   _____ Yes _____ No

9. How many weeks of paid vacation do you receive each year? _____ weeks

10. How many members are in your household? _____ persons

11. How many of these contribute to paying the household expenses? _____ people

12. Including these people, what was your approximate household income from all sources (before taxes) last year?

_____ less than $10,000
_____ $10,000-$19,999
_____ $20,000-$29,999
_____ $30,000-$39,999
_____ $40,000-$49,999
_____ $50,000-$59,999
_____ $60,000-$69,999
_____ $70,000-$79,999
_____ $80,000-$89,999
_____ $90,000-$99,999
_____ $100,000-149,999
_____ over $150,000

Thank you for completing the survey!

If you have any additional comments on the resources or management of Rocky Mountain National Park, please feel free to write them on the back cover of this survey. When you are finished, please place the survey in the stamped return envelope and mail it back to us.

COMMENTS?

Please feel free to write any comments you have about your most recent trip to Rocky Mountain National Park.

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please fold here for mailing

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please fold here for mailing

Colorado State University

Fort Collins, CO 80523-1172

APPENDIX B: COVER LETTER FOR RMNP VISITOR SURVEY

Rocky Mountain National Park Visitor Survey

Dear Visitor:

How we manage Rocky Mountain National Park affects all of us in many ways. These ways include the condition of the hiking trails, the number of wildlife you see and the quality of the water you drink in the Park. You were given this survey because you have visited the Park and we want your opinion of this most recent visit.

Specifically, Colorado State University and the town of Estes Park are interested in finding out about your most recent trip and how that trip might have changed if the weather had been different this summer. This information will aid in better anticipating the number of visitors that may come to the Park each year. This type of information can be used for everything from planning the number of shuttle buses used in the park to scheduling to avoid conflicting events in Estes Park when a large number of visitors are passing through town to get to Rocky Mountain National Park.

You are one of a small number visitors being asked to give their opinion on this important issue. In order that the results of the study truly represent the thoughts of people visiting Rocky Mountain National Park. it is important that each questionnaire be completed and returned. The survey booklet contains all the information you need to complete the survey. There are no right or wrong answers! It is important to hear from each and every person, whether this is your first visit to Rocky Mountain National Park or you are a regular visitor.

A stamped return envelope has been provided to make it easy to mail your survey back to us. Your responses are completely confidential. You will not be individually identified in our results.

If you have any questions, please call me at (970) 491-2485 or email me at: jloomis@agsci.colostate.edu. I will be happy to answer any questions you have.

We look forward to receiving your survey in the days ahead.

Thanks,

Dr. John Loomis
Project Leader