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ANALYSIS

Adaptive recreation planning and climate change: a contingent visitation approach

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Abstract

This paper applies a contingent visitation analysis to estimate the effects of changes in climate and resource variables on nature-based recreation demand. A visitor survey at Rocky Mountain National Park 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 climate scenarios and resource variables. A relatively small proportion of respondents indicated that their visitation behavior would change under the hypothetical climate scenarios, and the net effect on visitation is slightly positive. Both direct (weather-related) and indirect (resource-related) climate scenario variables are found to be statistically significant determinants of contingent expected changes in visitation. The results of the contingent visitation analysis are compared with the results of a regression analysis of historic visitation and climate variation for methodological assessment, and we find that they are in close agreement.

Keywords: Climate change; Recreation; Contingent behavior; National parks

1. Introduction

Tourism is one of the world's largest industries, and ecotourism is a substantial part of the tourism industry. Since ecotourism involves resource-based recreation, it can be directly and indirectly affected by climate change. Thus, 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 the recreation planning process to incorporate adaptive strategies to address a changing climate, as well as 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 called contingent visitation

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(an application of contingent behavior methodology). Climate may impact the visitor in two ways. First, the visitor's utility from his or her 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 indirectly affect visitation behavior. Survey methods are needed to gather information about park visitors, their preferences toward recreation activities, and how their visitation behavior might change under hypothetical climate scenarios. Contingent visitation 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. We believe RMNP is representative of a large number of North American national parks such as Glacier, Grand Teton, and Yellowstone in the United States and Waterton, Banff, and Jasper in Canada.

Economists have long recognized that climate affects individual well-being (Cline, 1992). Precipitation, temperature, wind, and sunshine affect location choices for migration (Blomquist et al., 1988). Madison (2003) estimates that slight (+2.5 °C) warming would result in net amenity benefits for high latitude countries. Thus, it is reasonable to expect that climate would affect recreation visitation as well.

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 visitation 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 contingent visitation method demonstrated external validity in his study of hypothetical recreational visits under varying lake quality levels. Chase et al. (1998) used contingent visitation to measure the hypothetical impact on visitation demand of alternative entrance fee levels at three national parks in Costa Rica.

Fankhauser et al. (1999) suggests that any efficient strategy to adapt to a changing climate must reflect the inherent long time horizon and uncertainties about future estimates of climate change. To that end, this paper develops climate scenarios based a 20-year forecast of climate effects, and uses confidence intervals to report the range of visitation estimates between climate scenarios (univariate hypothesis tests).

2. Theoretical model

Consider an individual's utility function, represented by $u(x_j,q_j,z)$, 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, with its price normalized to one. 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 specifies that the quality of recreation is influenced by several variables, including climate conditions. With respect to climate, we posit 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:

$$V_i = f(S^{D}_{1i}, S^{D}_{2i}, \ldots, S^{D}_{ni}, S^{I}_{1i}, S^{I}_{2i}, \ldots, S^{I}_{ni}, A_{1i}, A_{2i}, \ldots, A_{ni}, \mathrm{TC}_i, D_{1i}, D_{2i}, \ldots, D_{ni}) \quad (1)$$

where V_i = number of annual visits to the recreation site; S^{D}_{1i}, S^{D}_{2i}, ..., S^{D}_{ni} = direct climate scenario variables, including temperature, precipitation, number of days with snow-free hiking trails; S^{I}_{1i},S^{I}_{2i},..., S^{I}_{ni} = indirect climate scenario variables, including elk population, ptarmigan population, and the vegetation composition of the Park; A_{1i},A_{2i},...,A_{ni} = activities in which the visitor participated during the visit; TC_i = travel cost per visit; D_{1i},D_{2i},..., 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.

3. 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:

$$H_0\colon \beta_1 = 0 \qquad H_A\colon \beta_1 \neq 0$$

$$H_0\colon \beta_2 = 0 \ldots \quad H_A\colon \beta_2 \neq 0 \ldots \qquad (2)$$

$$H_0\colon \beta_n = 0 \qquad H_A\colon \beta_n \neq 0$$

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:

$$H_0\colon \beta^{D}_{1} = 0 \qquad H_A\colon \beta^{D}_{1} \neq 0$$

$$H_0\colon \beta^{D}_{1} = 0 \ldots \quad H_A\colon \beta^{D}_{2} \neq 0 \ldots$$

$$H_0\colon \beta^{D}_{n} = 0 \qquad H_A\colon \beta^{D}_{n} \neq 0$$

$$H_I\colon \beta^{I}_{1} = 0 \qquad H_A\colon \beta^{I}_{I} \neq 0$$

$$H_0\colon \beta^{I}_{2} = 0 \ldots \quad H_A\colon \beta^{I}_{2} \neq 0 \ldots$$

$$H_0\colon \beta^{I}_{n} = 0 \qquad H_A\colon \beta^{I}_{n} \neq 0$$

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.

4. 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 visitation study.

The visitor survey was designed during the winter of 2001. 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 from the Canadian Climate Center and the Hadley Climate Center (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, consistent with the CCC and Hadley models. These models estimated significant effects on the vegetation composition of the Park, particularly the high alpine tundra, which is vulnerable to warming temperatures. In addition, there were predicted effects to populations of large mammals such as elk, as well as birds such as the white-tailed ptarmigan, which nests in the alpine tundra.

Data from the two global circulation models and their respective resource effects 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. While the two scenarios developed from the CCC and Hadley models are related to climate change forecasts, the other scenarios were developed to decouple climate change from vegetation and wildlife effects so that they would not be highly correlated. 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 1.

Changes in weather and natural resources at other recreation sites were not explicitly mentioned. Thus, this analysis is a partial equilibrium one, and may overstate the effects if respondents assumed there were no changes at other sites.

The survey design was developed using graphical and numeric representations of the climate scenarios. Icons and symbols that proportionally represented

Table 1
RMNP visitor surveys and hypothetical climate scenarios

Climate scenario variables	Baseline scenario	Version A		Version B		Version C		Version D	
		Scenario		Scenario		Scenario		Scenario	
		1^{CCC}	2	1^{Had}	2	1	2^{EH}	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.

Table 2
Contingent visitation 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**?

hypothetical changes were included to give a more descriptive presentation of climate scenarios. An excerpt from Version A of the visitor survey is presented in Appendix A.

The contingent visitation questions asked the respondent to consider if their number of visits and length of stay would have been affected under the hypothetical 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 2.

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 control for their 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 pretested with RMNP visitors before distribution during the survey period.

5. 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 frequently visited areas of RMNP at five specific locations that 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 1378 attempts to distribute surveys during the survey period, and 112 were refused. Thus, a total of 1266 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 3 weeks later to non-respondents along with a cover letter. 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).

6. Data analysis

Respondents were asked to estimate the change in the number/duration of their visits to RMNP under the hypothetical climate regimes. The trip response model in Eq. (1) was applied to estimate coefficients for the independent variables. These coefficients 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 1934.

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 whether the change in visitation is statistically different from zero. Second, ordinary least squares regression is used to estimate the trip response model (change in number of trips) 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.

7. Results

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.

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 below.

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 4 below.

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 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

Table 3
Survey results—CCC climate scenario

CCC scenario results ($n = 442$)	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	

Table 4
Survey results—Hadley climate scenario

Hadley scenario results ($n = 252$)	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	

tourism. Survey results indicated that visitors spend an overall average of US\$665.03, which amounts to US\$52.40 per person, per visitor day during their visit to RMNP; of this, US\$24.78 of which was spent in the gateway community of Estes Park. The calculations are based on survey data which showed an average group size of 4.3 persons and an average length of stay of three days. Average visitor expenditures in Estes Park (by category) are provided in Table 6; these amounts were used in the input–output analysis and form the basis of the regional impact results.

Table 5
Survey results—extreme heat climate scenario

Extreme heat scenario results ($n = 480$)	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)	

Table 6
Average RMNP visitor expenditures in Estes park, Colorado, by category

Visitor spending category	Average expenditure	Average expenditure per person, per visitor day
Gasoline	US\$15.15	US\$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	US\$309.81	US\$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, Colorado) output and employment was calculated using the IMPLAN input–ouput model (MIG, 1997). The results are presented below in Table 7.

7.1. Univariate analysis and hypothesis test results

The construction of confidence intervals allows for tests of the statistical significance between the three climate scenarios as well as the illustration of the range of uncertainty of results. 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. The variance of the product of the two distributions is *not* equal to the product of the two variances. That is,

$$\mathrm{Var}(XY) \neq \mathrm{Var}(X) \times \mathrm{Var}(Y), \tag{4}$$

Table 7
Regional economic impact results—comparison of climate scenarios

Economic impact: Estes Park, Colorado	CCC	Hadley	Extreme heat
Mean change in annual visitor days	1,357,588	1,002,080	(821,187)
	↓	↓	↓
Output impact (US$ millions)	+ US$44 (+ 12.4%)	+ US$32 (+ 9.2%)	− US$26 (− 7.5%)
Employment impact (# jobs)	+ 981 (+ 15.4%)	+ 725 (+ 11.4%)	− 600 (− 9.3%)

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:

$$\mathrm{Var}(X) = E[(X^2) - E(X)]^2 \tag{5}$$

(Mood et al., 1974; Casella and Berger, 1990). The variance of the product of the two distributions is therefore:

$$\begin{aligned}
\mathrm{Var}(XY) &= E(X^2)E(Y^2) - \mu_X^2\mu_Y^2 \\
&= (\mathrm{Var}(X) + \mu_X^2)(\mathrm{Var}(Y) + \mu_Y^2) - \mu_X^2\mu_Y^2 \\
&= \mathrm{Var}(X)(\mathrm{Var}(Y) + (\mathrm{Var}(X)\mu_Y^2) \\
&\quad + (\mathrm{Var}(Y)\mu_X^2) + \mu_X^2\mu_Y^2 - \mu_X^2\mu_Y^2 \\
&= \mathrm{Var}(X)(\mathrm{Var}(Y) + (\mathrm{Var}(X)\mu_Y^2) \\
&\quad + (\mathrm{Var}(Y)\mu_X^2)
\end{aligned} \tag{6}$$

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

$$\begin{aligned}
\mathrm{S.E.} &= \mathrm{S.D.}(XY)/\mathrm{sqrt}(n) \\
&= \mathrm{sqrt}\ \mathrm{Var}(XY)/\mathrm{sqrt}(n) \\
&= \mathrm{sqrt}[\mathrm{Var}(X)(\mathrm{Var}(Y) + (\mathrm{Var}(X)\mu_Y^2) \\
&\quad + (\mathrm{Var}(Y)\mu_X^2)]/\mathrm{sqrt}(n)
\end{aligned} \tag{7}$$

where S.E. = the standard error of the joint distribution, and S.D. = the standard deviation. The standard errors for each of the three climate scenarios were calculated according to Eq. (7), and are presented in Table 8 below.

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

$$(1-\alpha)100\%\ \text{Confidence Interval} = \hat{Y} \pm t_{\alpha/2}\mathrm{S.E.} \tag{8}$$

The 95% confidence intervals for this analysis are calculated using $t = 1.96$; S.E. is the standard error of the distribution. The confidence intervals for the three climate scenarios are presented below in Fig. 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.

7.2. 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

Table 8
Variance and standard error of individual contingent visitation 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

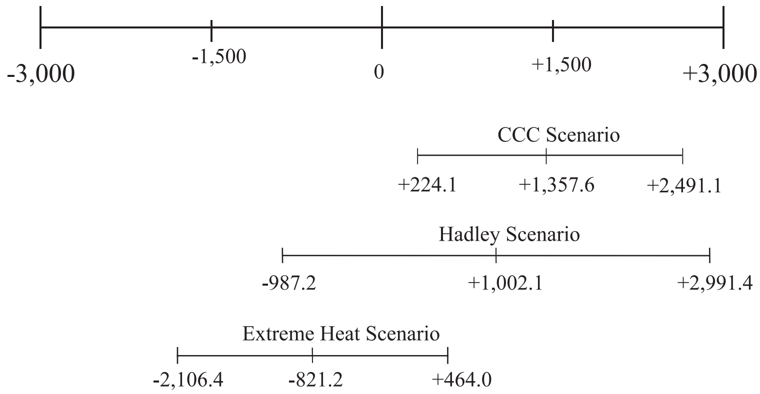

Fig. 1. 95% confidence intervals for change in number of annual visitor days (000s).

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 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 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

Table 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	S.E.	t-Statistic	Prob.
Intercept term	0.1898	0.1394	1.3615	0.1736
Change in number of days with high temperature >80 °F	− 0.0051	0.0021	− 2.3943	0.0168
Change in number of elk in RMNP	− 7.29e − 06	5.16e − 05	− 0.1412	0.8877
Change in percentage of RMNP acres of alpine tundra	− 0.0032	0.0028	− 1.1248	0.2609
Distance traveled (miles)	− 2.14e − 05	7.28e − 05	− 0.2946	0.7684
Distance traveled, squared (miles^2)	5.51e − 09	1.84e − 08	0.2998	0.7644
Gender (1 if female, 0 if male)	0.1794	0.0615	2.9178	0.0036
Age (in years)	− 0.0027	0.0024	− 1.1339	0.2570
R^2	0.0117	Mean-dependent variable		0.0399
Adjusted R^2	0.0073	S.D.-dependent variable		1.2096
S.E. of regression	1.2052	F-statistic		2.6213
Sum of squared residuals	2246.878	Prob(F-statistic)		0.0108
Log likelihood	− 2492.621			

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.

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). Thus, the two subsets of observations were 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 10.

As suggested by a reviewer, with a majority of visitors indicating no change, about 100 visitors indicating they would take more trips, and approximately 100 visitors indicating they would take fewer trips, the structure of the data would appear suited to a two-stage analysis. This would involve the estimation of a probit model of the respondent's decision of whether to change the number of trips taken at all, followed by a linked continuous model of the change in the number of trips only for those indicating they would change their number of visits. The linkage is through including a variable calculated from the probit model in the second-stage regression. This variable is called the inverse mills ratio (Greene, 1999). This ratio reflects the selection effect in the second stage regression by analyzing only the subset of respondents who would change their visitation. If this inverse mills ratio is statistically significant in the second stage regression and there is a significant correlation between the first and second equations, then the two linked equations are a more appropriate statistical model of the visitor decision-making process. We tested such a sample selection model using Limdep econometric software and found the inverse mills ratio to be statistically insignificant and the correlation between the two equations to be near zero (− 0.067 to − 0.147, depending on model specification). This suggests that there is no selectivity bias and that linking the two equations is unnecessary. This conclusion is reinforced by the linked second stage continuous model, which indicated that all of the variables

Table 10
Regression results for positive responses only

Dependent variable: change in number of trips (positive only)				
Method: least squares				
Included observations: 99				
Variable	Coefficient	S.E.	t-Statistic	Prob.
Intercept term	1.0738	1.2962	0.8284	0.4096
Change in number of days with high temperature>80 °F	0.0411	0.0223	1.8427	0.0686
Change in number of elk in RMNP	0.0107	0.0266	0.4022	0.6884
Change in percentage of RMNP acres of alpine tundra	0.0009	0.0005	1.6701	0.0983
Distance traveled (miles)	− 0.0042	0.0020	− 2.1125	0.0374
Distance traveled, squared (miles^2)	2.31e − 06	1.15e − 06	2.0171	0.0466
Gender (1 if male, 0 if female)	0.9937	0.6545	1.5183	0.1324
Age (in years)	0.0054	0.0246	0.2205	0.8260
R^2	0.1144	Mean-dependent variable		2.5758
Adjusted R^2	0.0462	S.D.-dependent variable		3.0875
Std. error of regression	3.0152	F-statistic		1.6788
Sum of squared residuals	827.3387	Prob(F-statistic)		0.1240
Log likelihood	− 245.5681			

Table 11
Regression results for negative responses only

Dependent variable: change in number of trips (negative only)				
Method: least squares				
Included observations: 113				
Variable	Coefficient	S.E.	*t*-Statistic	Prob.
Intercept term	− 2.2416	0.7513	− 2.9836	0.0035
Change in number of days with high temperature>80 °F	0.0062	0.0138	0.4481	0.6550
Change in number of elk in RMNP	0.0114	0.0271	0.4222	0.6738
Change in percentage of RMNP acres of alpine tundra	− 5.90e − 05	0.0003	− 0.2287	0.8196
Distance traveled (miles)	0.0013	0.0006	2.0138	0.0466
Distance traveled, squared (miles^2)	− 2.76e − 07	2.67e − 07	− 1.0337	0.3036
Gender (1 if male, 0 if female)	0.7016	0.3321	2.1128	0.0370
Age (in years)	− 0.0069	0.0130	− 0.5293	0.5977
R^2	0.1257	Mean-dependent variable		− 1.7080
Adjusted R^2	0.0674	S.D.-dependent variable		1.7813
S.E. of regression	1.7202	*F*-statistic		2.1556
Sum of squared residuals	310.7111	Prob(*F*-statistic)		0.0441
Log likelihood	− 217.4884			

were highly insignificant, despite the independent regression estimation indicating that several of the variables were statistically significant. Thus, it appears that imposing the linkage on the second stage is inconsistent with the data, and so we report independent regression and probit estimates in the tables that follow.

When only positive responses are considered, we find that the results (Table 10) 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 model—see Table 9), 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 in Table 11. 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 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

Table 12
Binary probit regression results for contingent visitation analysis

Variable	Coefficient
Change—number of days with high temperature>80 °F	0.0148***
Change—number of days with precipitation>0.25 in.	− 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 at 90% ***significant at 99%

survey respondents would change their visitation behavior under the hypothetical climate scenarios revealed the following results, presented in Table 12. 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 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%.

8. 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 a revealed-preference analysis. In that study, a regression analysis was used to measure the effects of climate change on visitation, using historical visitation, climate, and population data for the period ranging from 1987 to 1999. 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 hypothesis that the coefficient vectors are the same for the two seasons is rejected, and two subsets of observations were created to analyze the relationships for the peak (May–October) and off-peak

Table 13
Visitation regression results

Regression coefficients	Peak (May–October)			Off-peak (November–April)		
	Value	S.E.	*t*-Statistic	Value	S.E.	*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
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	2.4566			2.1986		

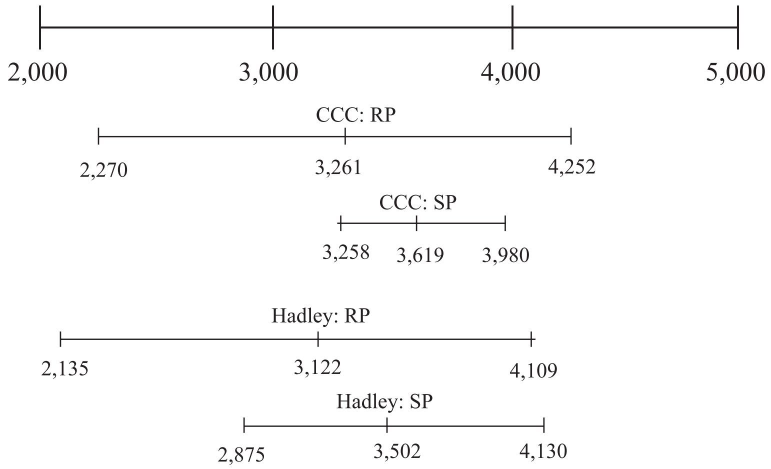

Fig. 2. 95% confidence intervals for 2020 visitation forecasts: methodological comparison (000s of visitors).

(November–April) seasons. The results of the regression analyses for both seasonal subsets are presented in Table 13.

Using 2020 climate forecasts and a baseline year (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- (RP) and stated-preference (SP) methods is useful for methodological comparison. Fig. 2 illustrates the 95% confidence intervals for the visitation forecasts for the CCC and Hadley scenarios under both the revealed- and stated-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.

8.1. Comparison of contingent visitation extreme heat scenario to summer 2002

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 °F, 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 10 preceding years), which offers an opportunity to observe empirically the predicted effects of extreme temperatures on visitation levels. Survey results estimated an 8.75% decrease in visitation under the hypothetical Extreme Heat climate scenario. Table 14 presents actual visitation data for the summer months

Table 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.

of 2002, compared with the same months in the previous year.

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.

9. Conclusions

A contingent visitation 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 visitation 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 and two-thirds 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. 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.

We believe these results are suggestive of the likely magnitude of effects of climate change for other large high-alpine national parks in North America (e.g., Grand Teton, Glacier, Banff, Jasper). More importantly, the contingent visitation methodology presented in this paper may be useful for park and recreation managers worldwide as they attempt to plan for possible effects of climate change on visitation and ecotourism.

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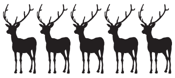
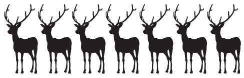
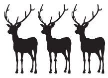
Appendix A. RMNP Visitor survey, version A

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.

A.1. 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 Alpine tundra Open woodland Evergreen	(% acres)  15% 2% 77%	(% acres)  0% 20% 72%	(% acres)  25% 5% 70%

A.2. 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

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