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State park visitations on the North Shore of Minnesota

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Introduction

Ongoing climate change is one of the major environmental challenges of our time, and economists have been actively engaged in trying to project its economic impacts. Economists are in broad consensus that these impacts are potentially quite large, but also that they are likely to vary significantly over different sectors of the economy. Agriculture, for example, is one sector that is likely to be disproportionately affected because of the likely impact of changing climate on the length of growing seasons, precipitation patterns, and so forth[Cline(1992); Mendelsohn, Nordhaus and Shaw(1994)]. The tourism industry is another sector likely to be heavily affected, especially those forms of tourism that are based on outdoor amenities likely to be impacted by climate change. Among these is a sector that has come to be called *nature-based recreation*, a broad category of tourism that includes hunting, fishing, camping, hiking, skiing, and outdoor sightseeing. A large recent scholarly literature has emerged that examines likely impacts of climate change on nature-based recreational activities [See, for example, Richardson and Loomis(2004); Jones and Scott(2006); Scott, Jones, and Konopek(2008); Nyaupane and Chhetri(2009); Albano et al(2013); Maddison(2015); Fisichelli(2015)].

Previous studies of the effects of climate change on nature-based recreation have examined the likely impacts of changes in the levels of climate variables while largely not addressing the important question of increased risks associated with climate change. For example, a common strategy to date has been to investigate the effect of changes in variables such as average temperatures or levels of precipitation on levels of recreational activity in settings such as national parks. However, even though much of the focus of climate studies to date has been on average climate trends such as global average temperatures, there is also a clear acknowledgment that another important consequence of ongoing climate change is the likely increased incidence of extreme events, such as drought, floods, fires or heat waves [see, for example, McKibben and Wilcoxen(2002), Weitzman(2007)]. In terms of affecting recreational tourism, the increased risks associated with extreme events may well be just as important as changes in the levels of climate variables such as temperatures, if not more so. If so, existing studies may be overlooking an important factor in terms of gauging impacts on future economic activities such as tourism.

In this paper, we derive estimates of impacts on tourism activities of the increased incidence of extreme climate events likely to occur under ongoing climate change. These estimates are based upon historical data on state park visitations along the north shore of Lake Superior in northern Minnesota. Unlike existing studies, we estimate the impact of extreme climate events using daily visitation data, which permits estimation of visitation responses to extreme events that are typically masked in existing studies that rely on data that are aggregated over longer periods of time.[1] We then use projections of climate models to assess the magnitude of the impacts of extreme climate events on local tourism. Finally, we attempt to address a potential source of concern regarding our estimates: the extent to which tourists engage in spatial and/or intertemporal substitution to mitigate the impact of extreme events on their tourism behavior.

Theory

Consider a risk-neutral individual's expected utility function, represented by $EU[x_j, EQ_j(CC), z]$, where $EU(\cdot)$ is expected utility, x_j is the annual number of trips to recreation site j,

[1] See, for example, Fisichelli et al(2015). Loomis and Richardson(2006) is one of the few studies that have focused on extreme events by modeling variability, but they use aggregated monthly visitation data.

EQ_j represents the expected quality of site j, and z is a vector of alternative consumption goods. In this model, all of the uncertainty derives from the probabilistic nature of Q, which is a function of the realized state of climate change. The individual will maximize his utility subject to his budget constraint, represented by $I = p_j x_j + z$, where I is individual income, p_j represents the travel cost or implicit price of access to site j, and the price of the alternative goods z is normalized to one. The result of this constrained utility maximization is a system of demand functions $[x(p_j, Q_j, I)]$, with the quantity of trips (x_j) decreasing in price, increasing in quality, and increasing in income.

The quality variable is central to the analysis, since all of the impact of climate change on recreational activity is assumed to occur through it. In the long term, climate change is predicted to cause complex changes in a number of variables that could affect trip quality, especially temperature, humidity, and precipitation. All of these changes could affect recreation activity by altering the quality of the recreation experience. However, the nature of the impact is likely to vary, depending upon the variable, but also depending upon how different variables move together. For example, higher average temperatures may improve the quality of the experience but higher average humidity may lower it, and if the two things occur together, the effect on quality could well be ambiguous. In projecting future impacts of climate change on recreational activity, we will consider what climate models tell us about the likely co-movement of different climate variables.

A central premise of this study is that recreation quality is influenced by the risk of extreme events such as drought, heat waves, flooding, and fires. Existing studies based upon monthly visitation data are unable to capture the effect of extreme events on tourism activity for two reasons. Because they generally use data on tourism activity which is aggregated over entire months, they are unable to capture tourism behavior which often consists of reactions to short-term weather conditions, shorter than a month. In addition, almost all climate measures that are aggregated over an entire month will not reflect extreme weather events, which are typically intense, shorter term events. In this study, we focus on three specific measures of risk associated with climate change: risk from extreme heat events, flood risk, and fire risk, all of which are assumed to affect some measure of tourism activity:

$$\text{Tourism} = f(\text{Heat Risk, Fire Risk, Flood Risk, } Z) \tag{1}$$

In this model, Z is a vector of non-risk control variables including temperature or heat index levels, precipitation levels, and economic variables. Estimating this model would yield daily predictions for tourism activity conditional on each of these variables, including measures of heat, flooding and fire risk.

Study Area

For a number of years, the north shore of Lake Superior in northern Minnesota has been an important destination for recreational tourism in the upper Midwest. The area supports a variety of recreational activities year-round, including hiking, hunting, fishing, birding, boating and canoeing, downhill and cross-country skiing, and snowmobiling. The eight state parks that are the subject of this study are located at various points on the north shore (see Figure 1) and receive between 1.6 and 1.9 million visitors per year. Figure 2 graphs annual visitation data for each of these parks from 1996 through 2013. These data reveal an overall steady, perhaps slightly upward trend of visitors over time, which is subject to short-term fluctuations. They also reveal a hierarchy of visitation traffic among the parks, with Gooseberry Falls State Park, the southernmost and therefore most easily accessible to visitors from the south, receiving by far the most visitors.

Data and Variables

The analysis is based upon daily visitation data during the late-spring to summer months for all eight state parks on the North Shore, from May 2002 through September 2014.[2] This comprises 15,914 total observations, though some observations were discarded because of brief periods of time when various parks were closed for renovation or other reasons, and during early July of 2011, when a government shutdown temporarily closed all of the parks. Omitting these observations leaves us with 14,233 usable observations. Table 1 reports park-level summary statistics for this visitation variable.

The key regressors in our analysis are the climate variables, particularly the ones related to extreme events. In principle, tourism activity will be influenced most strongly by risk signals that are salient, in terms of conveying clear information of heightened risk conditions. Such information could be conveyed, for example, by physically risky events such as actual flooding or fires, or by official warnings of risky conditions. The variables we will use to capture the different kinds of risk will reflect this salience consideration. Flood Risk is a variable that indicates damages from actual flooding that occurred within St. Louis, Lake, or Cook County on a given day, weighted by the inverse of the distance from the reported event to each park. Historical measures of heat risk are based on indexes such as temperature or heat index. In our study, we measure heat risk as a dichotomous variable depending upon whether the maximum heat index for the day exceeds a given threshold. Our measure of fire risk is based upon the National Fire Danger Rating System, under which the risk of wildfire dangers is rated on a five point scale from "Low" to "Extreme". Our fire risk variable is a dichotomous variable that indicates whether the risk of wildfires exceeds a given threshold level on this scale.

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[2] The year 2002 is the earliest year for which daily records are available from the Parks and Trails Division of the Minnesota Department of Natural Resources.

For heat risk and fire risk, various threshold levels are used. Regarding heat risk, the National Weather Service issues health advisories when the heat index begins to exceed certain levels. For heat index values between 80 and 90, the public is warned to exercise *caution*, and for values between 91 and 103, the public is warned to exercise *extreme caution*. For heat risk, our indicator variables HR^{80} and HR^{91} correspond to these two levels of the heat index. For fire risk, we use three related indicator variables, which are defined in terms of whether the risk of wildfires is considered "High" or greater, "Very High" or greater, or "Extreme". The specific variable we use is based on a measure known as the *energy release component*(ERC), which measures the energy content(in BTU's per square foot) in local combustible biomass in a given area. For ERC values between 30 and 35, the risk of fire is considered high; for ERC values between 35 and 42, the risk of fire is considered very high; and for ERC values greater than 42, the risk of fire is considered extreme. Our specific fire risk variables are correspondingly defined as FR^{30}, FR^{35}, and FR^{42}.

Regression results

It will be recognized that ours is a panel data set: a pooled time-series cross-section sample of eight parks over twelve years of daily data, which permits us to exploit both cross-sectional and temporal variation. Here, we report the results of estimation of a fixed-effects model, where the fixed effects represent the various state parks. Omitting the fixed effects in order to simplify notation, the model is:

$$\begin{aligned}&\text{Visitations} = f(HR^{X}, FR^{X}, \text{Flood Risk, Precipitation, Heat Index,}\\&\text{Gasoline price, Per capita income}, D^{Weekend}, D^{May}, D^{June}, D^{July}, D^{Sept})\end{aligned} \tag{2}$$

where *Visitations* is the daily number of visitors at the park. HR^X and FR^X are each one of our heat and fire risk variables defined earlier. *Flood risk* is a variable that measures the occurrence of a flooding event, weighted both by the severity of the event and the inverse of the distance of the event from the state park observation unit. This model also includes various control variables, including daily levels of precipitation and the heat index, where *Precipitation* is the amount of precipitation, in inches, and *Heat Index* is the average heat index for the day, in degrees Fahrenheit. This model also controls for observations that occur on weekends, and the price of gasoline and state per capita income, both adjusted for inflation. The analysis also includes fixed effects for the different months. Table 2 lists variable definitions and key summary statistics for all variables.

The results of a series of least squares regressions with fixed effects are reported in Table 3. Since tests indicated that heteroscedasticity was present in the data, the figures in parentheses are clustered robust standard errors, clustered for the different state parks. The results indicate that heightened heat risk and fire risk both have significant negative impacts on park visitations. Under heat conditions when tourists are advised to exercise caution(HR^{80}), the impact of heat risk is negative and highly significant at standard significance levels. The estimated effect of heat risk is also negative and the point estimate is even larger when tourists are advised to exercise extreme caution(HR^{91}). However, the estimated impact is much less significant. Similarly, fire risk has a significantly negative impact on visitations, particularly under extreme risk conditions(FR^{42}).[3] The evidence strongly suggests that extreme climate events associated with higher temperatures and greater risk of fires are likely to have significantly negative impacts on recreational activity on the North Shore.

[3] The variable FR^{30} was not significant in any of the regressions, suggesting that merely "high" fire risk conditions, as opposed to "very high" or "extreme" conditions, was not considered sufficient risk by recreationists to discourage them from visiting the parks.

On the other hand, the results suggest that flood risk does not negatively impact visitations; indeed, the estimated coefficient on our flood risk variable is even positive, though it is not significant. This may seem like a surprising result, and one might well attribute it to the crudeness of our flood risk variable, which captured separate flood events of varying severities that occurred anywhere in the three counties, often miles away from any of the parks. Consider also the evidence presented in Figure 3, which reports state park visitations during the month of June 2012, during which Duluth and the southern North Shore experienced one of the most intense flooding events in history, on June 19^{th} and 20^{th} [MN Department of Natural Resources]. On those days, only Gooseberry and Split Rock, the two state parks located closest to the area where the most damaging flooding occurred, experienced a significant drop-off in visits on those two days, and then almost immediately recovered. Given all of this evidence, we will confine our attention only to heat risk and fire risk in our subsequent discussion of the impact of projected climate change trends in the future.

Considering the remaining variables, the results reveal a number of other factors that appear to have systematic impacts on state park visitations. The positive and highly significant coefficient on Heat Index suggests that absent extreme heat conditions, warmer temperatures translate into more park visitors. Similarly, precipitation translates into significantly fewer visitors, while absent extreme fire risk conditions, additional dryness has no significant impact on visitations. As expected, park visitations are significantly higher on weekends and as per capita income has increased over time, and they are significantly lower when the real price of gasoline is higher.

Overall, these results strongly suggest that controlling for other factors, tourism activity is affected by risk considerations. Since each of the risks investigated here may well be associated with ongoing climate change, we can conclude that climate riskiness may well have significant impacts on tourism activity. How large these impacts are likely to be is the subject of the next section.

Projections of extreme climate change events on tourism activity

In this model, the coefficients on the various measures of heat risk, fire risk, and flood risk are interpreted as the impact of the various kinds of heightened risk on daily tourism levels. For example, the coefficient HR^{80} is interpreted as the impact of the occurrence of an extreme heat event, defined as a day when the maximum heat index exceeds eighty, on the level of tourism activity. For example, consider model (1) in Table 3. The coefficient of -47.20 on HR80 indicates that every additional day when the heat index exceeds eighty translates into a reduction of 47.2 visitors for each park. Similarly for HR^{91}, and for FR^{35} and FR^{42}. Multiplying a coefficient estimate by the current probability of the occurrence of such an extreme event yields the current expected impact of an extreme heat event on tourism activity, holding other factors constant. Based on climate models, we will calculate probabilities of the occurrence of extreme heat events under various climate change scenarios. The difference in the expected impacts on tourism activity yields the predicted impact of climate change.

To illustrate our method, Table 4 reports historical data for two of our variables – number of days when the heat index exceeded eighty, and number of days when ERC exceeded thirty-five – during the thirty year period 1980 to 2009, broken down by the peak summer months June, July, and August. For comparison purposes, also reported are projections of these variables into the future generated by two commonly-referenced climate change models: RCP 4.5 and RCP 8.5. The main difference between these two models concerns their assumptions regarding the rate of increase over time and ultimate level of greenhouse gas emissions, with RCP 8.5 assuming higher amounts of both. We will call RCP 4.5 the *low-range* scenario and RCP 8.5 the *high-range* scenario, in line with their consensus interpretation among climate scientists. The projections reported here are projected averages for these variables over the thirty-year period 2035 to 2064.

Table 4 reveals that generally speaking, both of our variables – number of days with heat index above 80 and number of days with ERC above 35 – are projected to increase considerably in the future. For example, whereas the number of days in July where the heat index exceeded 80 averaged 4.36 during the historical period, this number is projected to increase to 8.40 under the low-range climate scenario and to 9.19 under the high-range scenario. In percentage terms, the heat index exceeded 80 in roughly 14% of all July days during the historical period, whereas this number is projected to increase to 27% under the low-range scenario and around 30% under the high-range scenario. Similarly, fire risk – as measured by the percentage of days where the ERC exceeds 35 – occurred in 2.3% of days in July during the historical period, whereas it is projected to increase to 5.3% of days under the low-range scenario and 9.1% of days under the high-range scenario.

Let us consider the implied impact on park visitations of increased risk conditions resulting from climate change, as projected to the period 2030 to 2064 under our low-range scenario (model RCP 4.5). This analysis will account for the fact that in addition to heat risk and fire risk, our estimations show that *average* heat index also significantly affects visitations. This latter effect will serve to temper the projected impact of climate change, because of the estimated positive coefficient on *heat index*: visitations increase as average temperatures (and heat indexes) increase. The projected impact on visitations is calculated as follows:

$$\Delta \text{ Visitations} = \beta^{HR}(\text{Days}^{HR}{}_{\text{Proj}} - \text{D}^{HR}{}_{\text{Hist}}) + \beta^{FR}(\text{Days}^{FR}{}_{\text{Proj}} - \text{D}^{FR}{}_{\text{Hist}})$$

$$+ \beta^{HI}(Days^{HI}_{Proj} - D^{HI}_{Hist}) \quad (3)$$

Under the low-range scenario, the point estimate is that there are projected to be 4.04 more days in July where the heat index will exceed 80. This model also projects that there will be 3.0 more days in July where the ERC will exceed 35. Finally, the model projects that the average heat index will increase by 3.79 degrees. Multiplying these implied impacts by the estimated coefficients on HR^{80}, FR^{35}, and heat index and summing yields the point estimate that there will be a decline of about 207 visitors per day in July at each of the parks in the future period. This represents a significant reduction, recalling that over our entire sample, park visitations averaged roughly 1125 visitors per day per park.

Table 4 indicates that the projected effects of climate change will vary from month to month. Compared to July, for example, the number of days of heat risk and fire risk are both lower in June, while the picture is more mixed for August. Furthermore, the climate models project that the average increases in the heat index will also vary across months, with June experiencing the smallest projected increase(2.62 degrees) and August experiencing the largest increase(nearly four degrees) under the low-range scenario. All of this implies, of course, that the projected impact on park visitations will also vary across months.

Applying equation (3), Table 5 reports the projected impact on visitations for each of the main summer months under both the low range and high range climate scenarios, both in number of visitations and as a percentage of the historical average of visitations during each month. For example, whereas the parks each project to experience a reduction of about 207 July visitors (or 14.1% of the average of historical July visitations) under the low-range scenario, this number increases to about 301 (about 20.4%) under the high-range scenario. Overall, the projected impact on park visitations during June is relatively modest, both in absolute and percentage terms, because the projected changes in both heat risk and fire risk are relatively small for that month. The projected impacts for July and August are considerably larger because both climate models project significant increases in both heat risk and fire risk, as measured by our HR and FR variables.

Discussion

In assessing the impact of changing climate on visitation activity, it is relevant to consider how visitors are likely to respond given the availability of alternative activities. The fact that climate-related risk events are short-term and episodic opens up various substitution possibilities. To be concrete, if the North Shore becomes increasingly prone to temporary spells of increased heat and fire risk over time, in principle visitors could go elsewhere, pursue alternative activities on the North Shore, or simply postpone their visits until conditions improve. To the extent that they do these things, there are obvious implications for gauging the impacts of climate change on total tourism activity. For example, when a visitor decides not to cancel a trip to the North Shore but rather, to merely postpone, her visit is not lost forever but is merely observed at some other point in time. Satisfactorily accounting for this and other substitution possibilities is methodologically quite challenging and beyond the scope of this exercise. In this section, however, we report some preliminary results of an analysis of survey data of visitors to the North Shore that speaks to the issue of how tourists are likely to respond to climate change.

The objective of the survey, which was administered in summer of 2015, was to understand better the attitudes of North Shore visitors toward climate change, and to gauge their likely response to changes in climatic conditions. As part of the survey, respondents were presented with climate change scenarios and queried on a number of behavioral and attitudinal factors, as well as personal characteristics. The scenarios presented broadly corresponded to the climate conditions projected in RCP 4.5 and RCP 8.5. In all, 2,450 surveys were administered and 1,398 were completed, for a response rate of 57%. On the whole, the respondents tended to be somewhat older, upper-middle income and well-educated. The most common activities for which they came to the North Shore were: scenic driving, hiking, visiting cultural or historic sites, swimming, picnicking, and viewing wildlife.

Of particular interest here are the results of a set of questions where respondents were presented with the climate change scenarios and then queried about how they were likely to respond. The main question of interest here, along with a summary of responses, are reported in Table 6. In this question, respondents were explicitly asked about what they would do if climate were to change according to the scenario, and they were then presented with a series of possible options, including cancelling their trip, rescheduling their trip, travelling elsewhere, and staying on the North Shore but participating in a different activity. Several messages emerge from the overall pattern of responses. The first is that relatively few were likely to cancel their scheduled visit. This is observed in the average responses to "cancel" and "cancel but reschedule", both of which were quite low, in the range of "not at all likely" to "slightly likely". It is also telling that when asked if they would visit the North Shore less in the future, the average response was again not at all to slightly likely. By and large, many respondents do not see changing climate altering their trip-taking behavior very much.

At the same time, the responses do not indicate no impact at all. When queried explicitly about whether their plans would remain the same, the average response was between "somewhat likely" and "very likely". Indeed, the responses indicate that it was at least slightly likely that they would travel elsewhere to do their intended activity, either on the North Shore or elsewhere.

And on average, it was between slightly likely to somewhat likely that they would stay on the North Shore but do something else.

What do we make of these responses, given our analysis of the historical data presented earlier, which revealed significant negative responses to risky events, in terms of park visitation behavior? One distinct possibility is that there is a marked difference between stated preferences and revealed preferences. When confronted with the reality of an actual climate-related outcome such as extreme heat event or fire risk, the actual behavioral response may well be stronger than when queried about some hypothetical possibility. However, the survey responses do speak to the likelihood of both spatial and temporal flexibility in responding to climate events, which suggests we might want to adopt a more measured interpretation of the earlier results. It is not entirely clear that the aggregate response to extreme climate events, in terms of the overall negative effect on park visitations, is as large as the regression coefficients suggest. The survey results suggest that at least some visitors may well be responding by doing other things, or postponing their visits for better conditions.

Conclusions

This study has attempted to answer what we consider to be a largely unanswered question in the scholarly literature on climate change; namely, the likely behavioral response to increased incidence of risky climate change-related events. That this question has been unanswered is striking given the emphasis placed on extreme climate events in the scientific literature. Existing economic studies that have attempted to characterize this response by examining measures of recreational activity are unable to do so using data aggregated over periods of time as long as month. Such data do not permit observation of the recreational response to intense, shorter-term events. In this study, we have exploited a new data set consisting of daily observations on visitation activity at state parks in northern Minnesota over a period of thirteen years, and the results are clear. Controlling for a number of other factors, increased incidence of heat risk and fire risk have significantly negative effects on the propensity to visit state parks. The overall economic impact on tourism activity will likely be tempered by spatial and intertemporal substitution, but it is unlikely to be eliminated entirely.

Figure 1: Study Area

Figure 2: Annual Visitors, North Shore state parks, 1996-2013

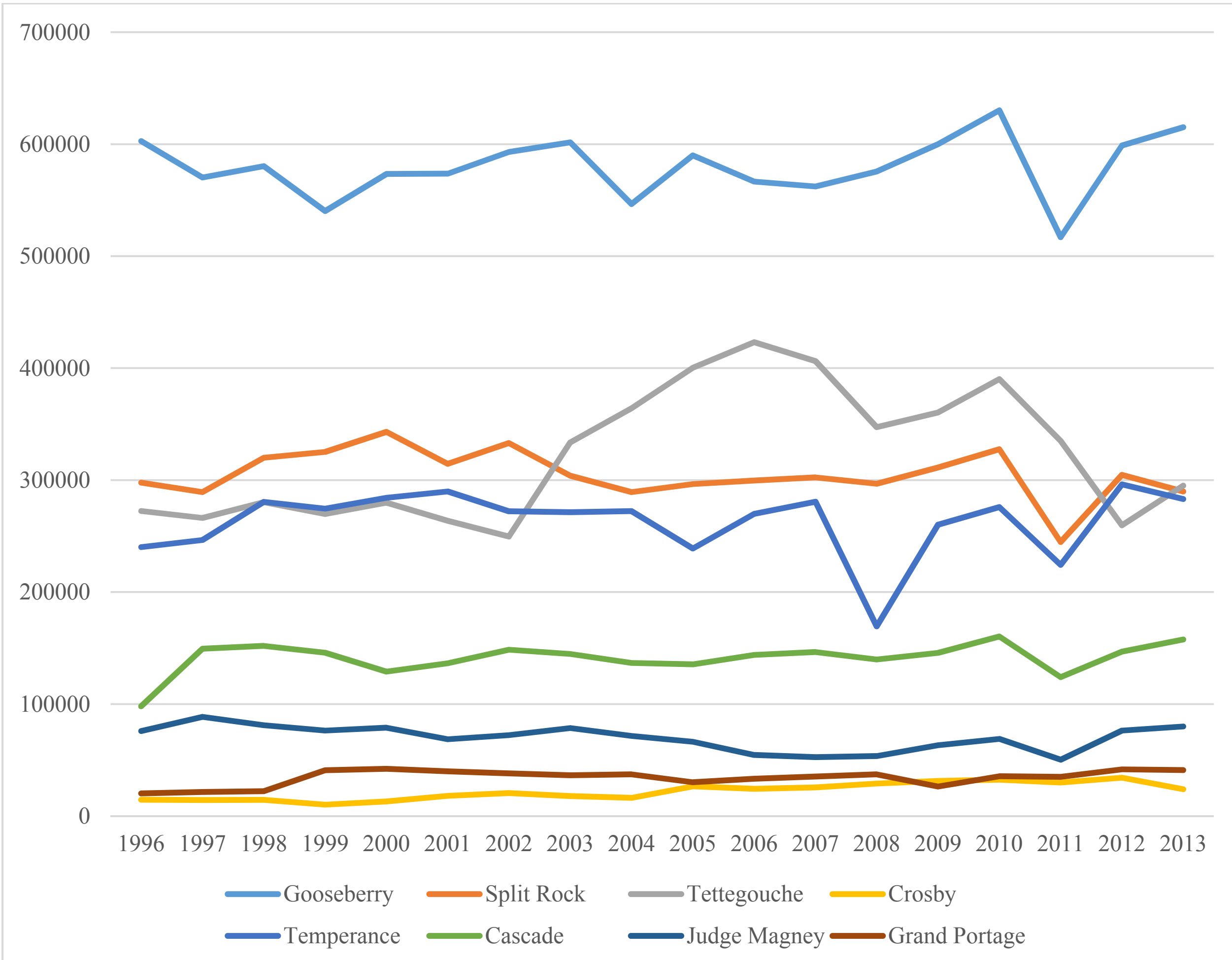

Figure 3: State park visitations, June 2012

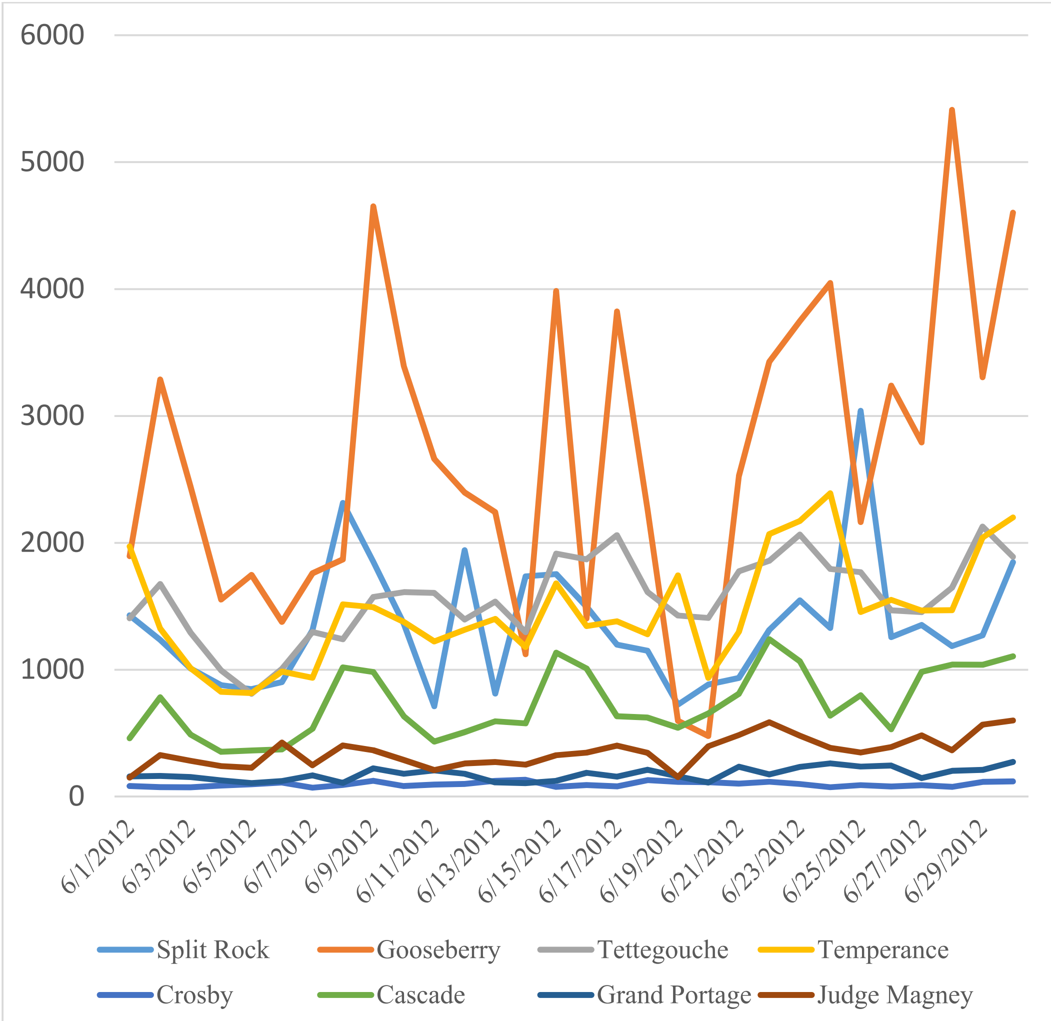

Table 1: Summary statistics on daily visitations, 2002-2014

	Mean	Std. Dev.	Min	Max
Cascade	767.16	376.39	63.00	2,051
Crosby-Manitou	111.08	88.83	3.00	665
Gooseberry Falls	2,895.36	1,471.37	189.00	9,640
Grand Portage	196.39	122.05	9.00	1,665
Judge Magney	377.72	213.37	6.00	1,320
Split Rock	1,516.83	778.22	122.00	5,624
Temperance	1,447.62	658.68	2.00	5,852
Tettegouche	1,676.90	1,022.68	183.00	10,853

Table 2: Definitions and summary statistics

A. Definitions

Visitations:	Number of visitors at a given state park, per day.
HR^X:	= 1 if heat index > X, = 0 if not.
FR^X:	= 1 if ERC > X, = 0 if not.
Flood risk:	Property damages from a flood event (in any of Cook, Lake, or St. Louis counties) times 1/DIST, where DIST is distance from the flood event to the park.
Precipitation:	Number of inches of precipitation, per day.
Heat index:	Average daily heat index.
$D^{Weekend}$:	= 1 if Saturday or Sunday, = 0 if not.
Gasoline price:	Price of gasoline in dollars, adjusted for inflation.
Per capita income:	State income per capita in dollars, adjusted for inflation.

B. Summary statistics

	Mean	Std. Dev.	Minimum	Maximum
Visitations	1125.30	1159.32	2	10853
HR^{80}:	0.18	0.38	0	1
HR^{91}:	0.02	0.13	0	1
FR^{30}:	0.37	0.48	0	1
FR^{35}:	0.16	0.42	0	1
FR^{42}:	0.06	0.23	0	1
Flood risk:	0.00035	0.0115	0	0.9996
Precipitation:	0.11	0.29	0	3.4
Heat index:	69.04	11.94	28.35	101.45
$D^{Weekend}$:	0.29	0.45	0	1
Gasoline price:	3.12	0.73	1.76	4.44
Per capita income:	46790.67	1307.65	44480	49047

Table 3: Determinants of daily visitors, All eight north shore state parks, 2002-2014

	(1)	(2)	(3)	(4)
HR^{80}(Caution)	-47.20***	-47.50***	--	--
	(15.41)	(15.46)		
HR^{91}(Ext Caution)	--	--	-74.34	-75.25
			(46.63)	(46.90)
FR^{35}(Very High)	-15.79**	--	-14.75**	--
	(6.27)		(6.00)	
FR^{42}(Extreme)	--	-41.86***	--	-39.55***
		(11.61)		(11.29)
Flood Risk	279.43	279.16	263.01	262.68
	(181.28)	(181.01)	(169.85)	(169.50)
Heat Index	8.15***	8.11***	7.42***	7.38***
	(2.67)	(2.67)	(2.56)	(2.56)
ERC(dryness)	0.77	0.68	0.71	0.63
	(0.96)	(0.86)	(0.94)	(0.84)
Precipitation	-30.61**	-30.30**	-29.09**	-28.78**
	(14.05)	(13.99)	(13.71)	(13.65)
Per capita income	0.03***	0.03***	0.03***	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)
Real price of gasoline	-46.69***	-46.18***	-46.29***	-45.82***
	(16.88)	(16.68)	(16.85)	(16.67)
Weekend	420.47**	420.60**	418.76**	418.88**
	(172.39)	(172.44)	(172.17)	(172.23)
R^2	0.721	0.721	0.721	0.721

Cluster-robust standard errors in parentheses. Results on constant term; park, month fixed effects omitted. N = 14,233. *** Significant at .01; ** Significant at .05; * Significant at .10.

Table 4: Historical and projected incidence of heat risk and fire risk

	Historical	Projected	
	(1980 – 2009)	Low-range	High-range
A. Heat Risk			
(Number of days HI > 80)			
June	0.91	1.66	2.57
July	4.36	8.40	9.19
August	2.00	5.53	5.95
B. Fire Risk			
(Number of days ERC > 35)			
June	1.80	3.30	1.30
July	2.30	5.30	9.10
August	0.80	11.80	9.60

Table 5: Projected impact of climate change on daily park visitations by summer month, low-range and high-range scenarios

	Low-range scenario	High-range scenario
(a)Number of visitations		
June	-37.7	-78.0
July	-207.2	-301.2
August	-292.1	-288.2
(b)Percentage of historical visitations		
June	-4.0%	-8.2%
July	-14.1%	-20.4%
August	-18.6%	-18.3%

Table 6: Survey question, North Shore survey, and responses

(1)Question: If summer conditions were to change according to the potential future conditions we provided, how like would you:

[Scale of responses: 1: Not at all likely; 2: Slightly likely; 3: Somewhat likely; 4: Very likely; 5: Extremely likely]

(2)Responses	Mean (Std. Dev.)
Cancel but reschedule during the season	1.47(0.82)
Cancel your trip for the full season	1.33(0.74)
Travel elsewhere on the North Shore to participate in your planned activity	2.09(1.13)
Travel outside the North Shore to participate in your planned activity	1.87(1.04)
Stay on the North Shore but do something else	2.36(1.17)
Visit the North Shore less often in the future	1.51(0.85)
Visit the North Shore more often	2.17(1.22)
Keep my plans the same.	3.65(1.08)

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