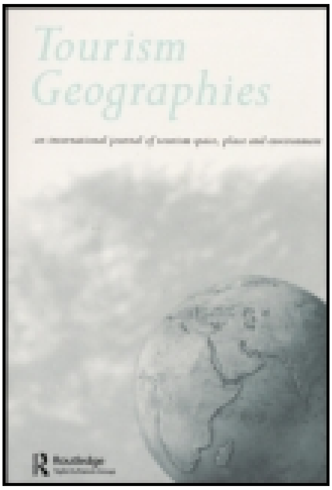

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Hurricane impacts on southeastern United States coastal national park visitation

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As a major contributor to local economies, the tourism industry has been greatly impacted by natural disasters. This study demonstrates the association between tourism economies and impacts of hurricanes in the southeastern United States containing coastal national parks, known for attracting a large number of tourists and having experienced hurricanes. In keeping with two longitudinal data methods (i.e. panel logit model and autoregressive integrated moving average), this study focused on the relationship between the (1) duration, intensity, and damage of hurricanes; (2) existing climate conditions; and (3) tourism demand on park visitation during hurricane and tourism seasons. As a whole, the impacts of hurricanes and climate conditions (precipitation, temperature) were found to have a negative effect on tourism demands (park visitation). With regard to the response of tourism economies to natural disaster damage, parks that experienced stronger natural disasters may be closed for a longer period in order to reconstruct facilities or natural/cultural resources damaged by storms. In an attempt to improve tourism-based regional economies, overcome the challenge of natural disasters on tourism economies, and increase opportunities for establishing disaster management, it is necessary to make an effort to allay unexpected damage to tourism-based areas through proactive plans for disaster mitigation activities.

Keywords: natural disaster; climate change; panel logit model; autoregressive integrated moving average (ARIMA); hurricanes; coastal national parks; southeastern United States; resilience

Introduction

Natural hazards can have overwhelming short- and long-term impacts on the natural and built environment, ultimately affecting local communities and their economies. Between 2000 and 2009, 19 hurricanes struck the southeastern and Gulf coastlines of the United States (National Oceanic and Atmospheric Administration [NOAA], 2012). Examining category 4 and 5 hurricanes for the entire Atlantic Ocean and Northwest Pacific Ocean coastal areas over the past 30 years, Webster, Holland, Curry, and Chang (2005) found that the number of hurricanes in the period 1990–2004 had more than doubled that during the 1975–1989 period. This increasing number of severe weather events have also impacted park visitation and the tourism industry (Intergovernmental Panel on Climate Change [IPCC], 2012; Pezzullo 2009), most notably national seashores and national parks along the US coast, which have faced serious threats from hurricanes and other coastal storms due to their locations (Stone, Grymes, Dingler, & Pepper, 1997). Such locations

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can be considered "natural disaster hotspots" as suggested by Dilley, Chen, Deichmann, Lerner-Lam, and Arnold (2005).

While these violent events can actually be healthy for ecological systems because they flush silted swamps and replenish food chains, some have been truly devastating, affecting not only natural and cultural resources within parks, but also visitor facilities and recreational opportunities (Fritz et al., 2007). For instance, Hurricane Andrew, one of the strongest hurricanes, caused approximately $20 billion in damage, left about 250,000 people homeless, and killed 15 people in southern Florida in 1992 (Davis, 1995). Its track also crossed the Everglades and Biscayne National Parks, carving a wide swath of devastation through both parks.

In recent years, natural disasters resulting from these events have been occurring more frequently and with greater intensity (Schneider et al., 2007), especially in the Atlantic (Emanuel, 2005). A study conducted by NOAA (2009) showed that wind speeds of hurricanes had increased 5%–10% and the combined global land and ocean surface temperature has increased by 0.17°C/decade during the past 25 years period (1979–2004). Moreover, recent studies attributed this increase to climate change and predicted that the change is expected to gradually increase the frequency and severity of these natural hazards in coming years (Baade, Baumann, & Matheson, 2007; Blanco, 2006).

Given severe weather events are increasing in and around national parks, managers are becoming more proactive in including strategies to assess risk and mitigation plans for hurricanes, volcanoes, wildfires, etc., within their strategic management policy (Cioccio & Michael, 2007). However, it is realized that such proactive planning is largely emerging (Jantarasami, Lawler, & Thomas, 2010). While literature does exist on the impacts of severe weather events in and around national parks (e.g. Scott, Jones, & Konopek, 2008), a large focus has been on the impact on the ecosystem (Davis, 1995). Direct or indirect social and economic impacts on parks and adjacent communities have been much less studied (see Zhong, Deng, & Xiang, 2008). In addition, previous research is largely anecdotal with specific cases providing little to no statistical analysis of historical data on a broad regional scale.

The degree to which hurricanes affect the number of national park visitors has rarely, if ever, been thoroughly investigated. The number of visitors is closely related to the capital which tourists inject into an area and this is also connected with sustainability with regard to the surrounding local economies (Eagles, 2002; Mules, 2005). The negative impact of hurricanes on the visitor number may limit not only the extent to which people pursue outdoor recreation opportunities, but also the degree to which financial benefits from both parks and surrounding communities can be realized. In the end, quantitative information on visitation during and after hurricanes can help to better assure emergency management and recovery plans.

Focusing on the southeastern United States, which is known for attracting large numbers of tourists to its coastal national parks each year and an increase in hurricanes, this study has the following three research objectives:

- To address the relationship between park visitation trends and hurricanes affecting coastal national parks in the southeastern United States
- To determine the impact of hurricanes on park visitation in coastal national parks in the southeastern United States
- To investigate the influence of other factors (e.g. park capacity, neighboring community capacity, and US capacity for recreational demands) on the park visitation in coastal national parks in the southeastern United States.

Natural disaster impact and national park visitation in the United States

The national park system in the United States is considered important because of the scenic and biological values of the preserved areas as put forth in the 1916 Organic Act. Since its inception, the US National Park Service (NPS) has been charged with preserving and protecting key lands while providing tourism opportunities for the current and future generations. In the context of tourism economies, the importance of the parks can be measured through job creation, tax revenues and region income increase, and the number of visits (Ioannides & Timothy, 2010). Visiting parks offer individuals opportunities to enjoy scenery, fresh air, and a learning environment, and generate a direct impact on the park revenue and an indirect benefit for the local economy (Chase, Lee, Schulze, & Anderson, 1998; Ioannides, 2006; Loomis, 1999; Mules, 2005; Schwartz & Lin, 2006; Scott & Munson, 1994; Weiler, Loomis, Richardson, & Shwiff, 2003).

Hurricanes and other intense storms cause widespread impacts on both biophysical and human systems (Davis, 1995). Studying various impacts of severe weather events is essential in understanding the disaster process and is therefore effective in facilitating disaster reduction policies. With a clear understanding of impacts, it is possible to develop disaster-specific mitigation and preparation plans which are essential in vulnerable locations such as national parks and seashores that are repeatedly threatened by natural hazards and potential disasters.

Whereas climatologists focus on natural hazards and forecast techniques (Anthes et al., 2006; Zhao, Dabu, & Li, 2004), many social scientists mainly examine hazard impacts on human activity (Bigio, 2003; Easterling et al., 2000; Zhong et al., 2008). In addition, ecologists have been interested in disaster impacts on ecosystems. However, research on severe weather events and their impacts on parks has been limited to focusing on ecosystems, including vegetation, trees, animals, and other environments (Blanco, 2006; Davis, 1995; Easterling et al., 2000; Helmer & Hilhorst, 2006; Swiadek, 1997). For instance, Swiadek (1997) examined the impact of Hurricane Andrew on mangrove forests, while Davis (1995) addressed the influence of the hurricane with an emphasis on geology.

Given the lack of studies concerning natural disaster (e.g. storm) impact on tourism in the form of park visitation, the pertinent literature was reviewed focusing on visitation from various points of view (e.g. introduction to park visitation and economic impact or socio-economic issues of park visitation, tourists' perception of natural disasters and travel risk) (Job, 2008; Park & Reisinger, 2010; Scott & Munson, 1994). In such studies, park visits served as both a dependent and an independent variable. Some research (Chase et al., 1998; Scott & Munson, 1994) has focused on factors impacting park visits at the individual level, especially examining the relationship between socio-demographic characteristics (i.e. age, race, gender, education, and income) and park visits. Others (e.g. Kim, Lee, Klenosky, 2003) have focused on indicators describing the linkage between park visitation and transportation to park or park facilities (i.e. park overdevelopment, cost, and accessibility).

Among socio-demographic variables, income was the single best predictor of perceived constraints to visiting parks (Chase et al., 1998; Scott & Munson, 1994). Low-income respondents (i.e. individuals who made less than $15,000 a year) were significantly more likely than those individuals with the highest income level to report their use of parks was limited due to fear of crime (Chase et al., 1998; Scott & Munson, 1994). Differences between low- and high-income respondents were also more pronounced for parks being too far away or lacking public transportation.

To determine whether or not the additional designations of public lands increase the recreational use in panel data analysis, Loomis (1999) modeled visitor use as the dependent variable, and wilderness acreage, demographic variables (e.g. income, unemployment rate, an age group of 18–44), and a price proxy (i.e. the index price of gasoline) as the independent variables. Adding new acreage resulted in a statistically significant increase in visitor use in all regions (Loomis, 1999).

Demonstrating a method that can provide useful confidence intervals for a deterministic model, Weiler et al. (2003) employed the relative significance of climate change and population growth on the local economy of a Rocky Mountain National Park (RMNP) gateway community through park visitations. Such a study provides important clues about the driving factors influencing park visits. Visitation to an RMNP as a function of demographic variables, measures of climate change (e.g. precipitation, temperature, sea level) of neighboring areas, and entrance fees was modeled (Weiler et al., 2003).

Research design and methods

Analytical framework and hypotheses

As illustrated in Figure 1, an analytical framework is put forth to address the theoretical and empirical approach for two statistical models (i.e. a panel logit model and autoregressive integrated moving average (ARIMA) in estimating the relationship between tourism

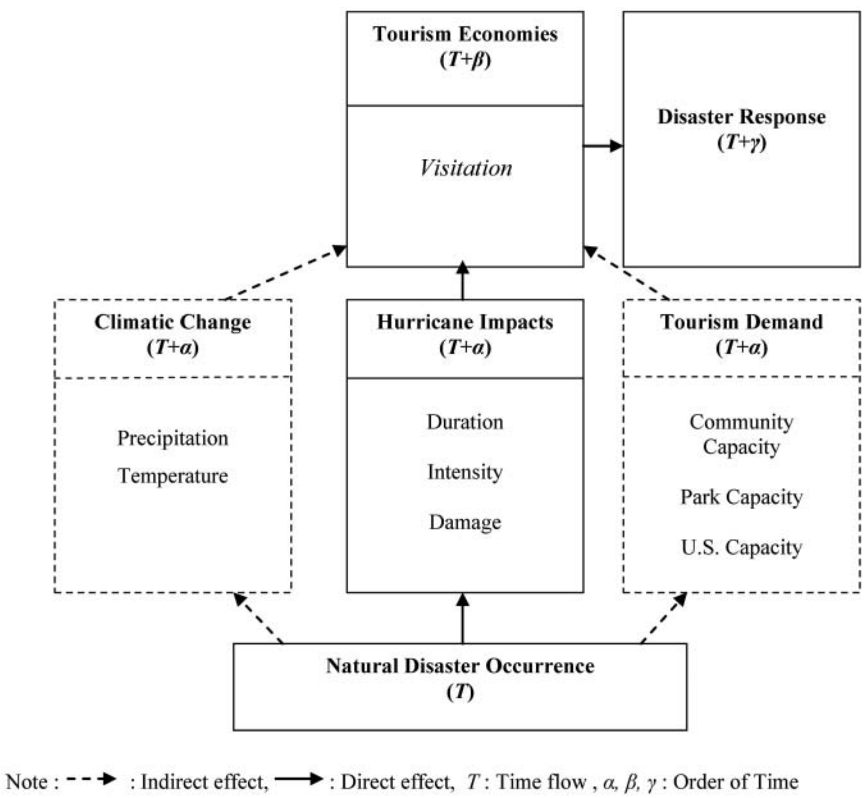

Figure 1. Analytical framework.

economies (e.g. job creation, increasing tax revenue, regional income, park visits as pointed out by Ioannides and Timothy (2010)). In addition, the framework is constructed to examine natural hazards and the interplay between tourism economies and climate change (e.g. sea level, CO_2 emission, precipitation, temperature as indicated by Scott, Jones, & Konopek [2007] and Nyaupane and Chhetri [2009]) and tourism demand. Among indicators (in relation to tourism economies and climate change), the relationship between the climate change factor and tourism economies based on park visits (*time flow T*) has been examined and the degree or variation of climate change risk can be estimated through the precipitation and temperature in an area over time (Bigio, 2003; Brody, 2008; Chase et al., 1998; Schwartz & Lin, 2006; Weiler et al., 2003).

Second, the degree of tourism economies' response to the impact of a severe weather event (e.g., hurricane) relies on the occurrence (i.e., duration), severity (i.e., intensity), and damage (i.e., human and physical damage) of the event (Sadowski & Sutter, 2005). More specifically, the disaster impact (*T*) after a natural hazard, encompasses human damage (i.e., fatalities and injuries) and physical damage (i.e., property and crop damage) (Anbarci, Monica, & Charles, 2005; Brody, Zahran, Maghelal, Grover, & Highfield, 2007; Kellenberg & Mobarak, 2008). Disaster damage contributes to the challenge (i.e. decrease) or opportunity (i.e. increase) of regional social and economic conditions before a severe weather event.

In addition, tourism demand conditions (*T*) before a severe weather event, as a part of the socio-economic situations, contribute to the degree of park visits ($T+\alpha$, α, β, and γ mean the order of time) as a part of tourism economies in the study areas. These tourism demand conditions consist of three capacities in accordance with the spatial level (i.e., park, community, country) or spatial spillover effect (i.e., direct effect, indirect effect). As a direct effect, the park capacity includes the park entrance fee and inflated value based on the consumer price index in 2004 (Chase et al., 1998; Schwartz & Lin, 2006; Weiler et al., 2003). The inflated value in accordance with the 2004 consumer price index was selected to represent the most recent value within the study period. The community and US capacity of tourism demands, as a part of the indirect effect, involves population, employment or unemployment, gas price, and per capita income (Loomis, 1999). In the end, the association between the disaster response ($T+\beta$) and tourism economies ($T+\alpha$) affected by a severe weather event, climate change, and tourism demand is examined through an empirical analysis method (i.e. ARIMA).

Based on the literature review and analytical framework, eight hypotheses were derived from the three main listed below.

Hypothesis 1: *Greater duration, intensity, and damage of a hurricane lower visits to a park*

H1a: *Greater hurricane duration as measured by storm days and hurricane frequency lowers visits.*

H1b: *Greater hurricane intensity such as maximum wind speed and hurricane category lowers visits.*

H1c: *Greater hurricane damage such as fatalities, property damage, and crop damage lowers visits.*

Hypothesis 2: *Better climate condition (i.e. lower climate change) for the southeastern United States as measured by low average precipitation and appropriate temperature results in more visits to a park.*

H2a: *Less precipitation equals higher park visits.*

H2b: *More severe temperature as measured by the maximum temperature and minimum temperature lowers park visits.*

Hypothesis 3: *Better tourism demand results in higher visits*.

H3a: *Better park capacity for visitation such as a low entrance fee and low inflation leads to higher visits.*

H3b: *Better community capacity for visitation such as high population, high employment, and many service industries equals higher visits.*

H3c: *Better US capacity for visitation such as a high population of 15∼44 years old, high per capita income, low gas prices, and low unemployment rates result in higher visits.*

Data collection and study areas

Park visitation data, as the dependent variables, were collected from the NPS Public Use Statistics Office. These data consisted of the total number of visitors entering parks for recreational purposes per month between 1979 and 2004, in particular, during the hurricane/tourism season (June–November) of each year. Hurricane data were obtained from the official NOAA website. More importantly, data on casualties and property damage at the county level were collected from the Spatial Hazard Events and Losses Database for the United States (SHELDUS) at the Hazard Research Lab, University of South Carolina. Therefore, we use the mean damage of counties surrounding the national park. However, it is necessary to note that these damage data are estimates obtained through observation or secondary reports and it may over- or under-estimate true loss.

Both precipitation and temperature, as a part of the climate change variable, are measured as the average precipitation and temperature recorded by weather stations by county in the study area. The data were collected from the National Climatic Data Center (NCDC) website of the US Department of Commerce. With regard to tourism demand (i.e. park, community, and US capacity), data were obtained from the US Census Bureau and contained detailed economic information for counties (i.e. population, employment, per cent of service industry) located in the 10 study areas and for the overall United States (i.e. percent of the population of 15–44 years old, gas price, per capita income, unemployment rate) for the time periods in question. This data collection in relation to the community and US capacity for tourism demand was based on the basic assumption regarding the economic synergistic effect of tourism (Eagles, 2002; Gilg, 2010; Mules, 2005). Economic data pertaining to income, employment, and percentage of related industries were also utilized in the analysis following the work of Cutter, Boruff, & Shirley (2003) and Toya and Skidmore (2007).

Twenty-seven NPS units, including historic sites, parks, seashores, memorials, monuments, and preserves, are located along the Gulf coast and the Atlantic Ocean. Among them, 10 park units were selected for this study, given they have attracted a high number of visitors and have experienced hurricanes during the study period. The parks are: *Padre Island* (Kleberg, Kenedy, and Willacy Counties; Texas), *Gulf Islands* (Jackson and Harrison Counties; Mississippi), *Everglades* (Collier County; Florida), *Dry Tortugas* (Monroe County; Florida), *Biscayne* (Miami-Dade County; Florida), *Canaveral* (Brevard County; Florida), *Cumberland Island* (Camden County; Georgia), *Cape Lookout* (Carteret County;

North Carolina), *Cape Hatteras* (Dare County; North Carolina), and *Assateague* (Worcester County; Maryland).

Data analysis

First, to assess the impact of hurricanes on park visitation, a statistical regression analysis was used to develop a model of the relationship between storm damage and park visits during the hurricane seasons between 1979 and 2004. Panel data analysis, which examines a particular topic within multiple sites periodically observed over a given time span, has become increasingly popular with many researchers in various fields (Yaffee, 2003). The combination of time series with cross-sections or groups can enhance the quality and quantity of data in ways that would be impossible using only one dimension, and the results of the analysis in ways that permit the researchers to investigate the dynamics of change with time-series data and characteristics of groups (Gujarati, 2003).

Panel data analysis endows regression analysis with both a spatial and a temporal dimension. There are several types of panel analytic models: constant coefficients models, fixed effects models, and random effects models. The constant coefficients model assumes that there are neither significant panels nor significant temporal effects. On the other hand, the fixed effects model would have constant slopes but intercepts that differ according to the cross-sectional group or time. In some cases, even though there are no significant temporal effects, there are significant differences between groups (panels). The random effects model is called a regression with a random constant term. While the random effects model depends on both the cross-section and the time series within it, the error components models error term should be uncorrelated with the time series component and the cross-sectional error. For this reason, this study employed panel data analysis with a fixed effect and a random effect model.

Second, to investigate the change in visits within six national parks (i.e. *Dry Tortugas*, *Biscayne*, *Everglades*, *Assateague Island*, *Cape Hatteras*, and *Cape Lookout*) affected by Hurricanes Andrew and Gloria, we estimated a time-series analysis with an ARIMA intervention model. In the case of representing a non-stationary in a time series, the non-stationary can be minimized through proper differencing and in the end can be stationary (Ismail, Suhartono, & Ifend, 2009). In such a model, the ARIMA is useful in employing a non-stationary in a time-series model. Furthermore, an extreme change in the mean of a time series is known as structural change (Ismail et al., 2009). This change is caused by an intervention coming from both external and internal factors (e.g. environmental law or regulation, stock stabilization, oil embargo, the bombing of the World Trade Center, natural disasters) (Worthington & Valadkhani, 2004).

Empirical results

Natural disaster assessment and visitation trends

In general, the 10 chosen national parks have been very important tourism attractions and also have been affected by diverse severe weather events over the years. During the study period, the national parks experienced eight hurricanes such as Allen (1980), Gloria (1982), Diana (1984), Elena (1985), Hugo (1989), Andrew (1992), Emily (1993), and Charley (2004). Although the 10 parks are located in disaster-prone areas, overall the number of park visits continued to increase during the study period. However, we recognize a decline in park visitors in 1990 and 2004, compared to park visitors in the five years between 1985 and 1990. Whereas the average number of park visits in 1985 was 170,621, the average in 1990 fell to 125,402 and in 2004, the average number of visits was 120,722. This period is consistent with the aftermath of hurricane occurrences such as Diana, Elena, and Hugo. Considering the hurricane duration, intensity and damage in the study period, a decline in park visits would be expected. In an attempt to investigate the relationship between hurricane (i.e. Andrew and Gloria) exposure and visitation trends in more detail, we categorized six of the 10 parks into two groups in terms of hurricane-damaged areas.

The first group was comprised of the three parks *Dry Tortugas*, *Biscayne,* and *Everglades* (all between the Gulf of Mexico and the Atlantic Ocean) each having experienced considerable hurricane damage, especially from Hurricane Andrew in 1992. The second group comprised of the parks *Assateague Island*, *Cape Hatteras*, and *Cape Lookout* (all located along the Atlantic Ocean) which had experienced damage from Hurricane Gloria in 1982.

With regard to the first group, Table 1 displays the correlation between the average visitation and hurricane duration, intensity, and damage of pre- and post-Hurricane Andrew during the period 1990–1995 (from June to November). The average number of park visits in the first group in 1990 was 33,480. However, in 1992, this average fell to 20,028 following the hurricane in 1992. In 1995, three years after the hurricane, the average number of visits was slightly higher than before Hurricane Andrew. In addition, comparing changes from 1993, the baseline year (i.e. the year without any hurricane impacts), the change in the rate of visits is 61.3%, similar to the change in 1990. This result indicates a recovery from the natural disaster (Table 2).

With respect to the association between park visits and Hurricane Gloria in 1982, Table 3 represents the variations in average visitation from 1980 to 1985 for the parks in the second group. The number of visits in 1980, three years before Gloria, was 153,923. Unexpectedly, in 1983, one year after the hurricane, the number of visitors rose to 168,013. However, since 1984, two years after Gloria, the average visitation has been somewhat lower than before Hurricane Gloria, compared to the baseline year 1980 (i.e. the year without any storm impacts). This finding shows that besides recovery from the hurricane there are other reasons why visitation in the second group continued to decrease.

Table 1. Hazard exposure[1] and visitation trend.

	Visitation[2]		Hurricane impacts		
Year	Average (persons)	Change from 1993 (%)	Duration (days)	Intensity (category)	Damage (average fatalities)
1990	33,480	63.90	0.17	0.39	0
1991	40,714	52.60	0.33	0.56	0
1992	20,028	−6.90	0.17	1.44	0.63
1993[3]	21,427	0	0	0	0
1994	18,381	−16.60	0.20	0	0.18
1995	34,964	61.30	0.11	0	0

[1]Hurricane Andrew occurred in 1992.
[2]Visitation to *Dry Tortugas*, *Biscayne*, and *Everglades* during the period of June through November of each year to correspond to tourist and hurricane seasons.
[3]Baseline year.

Table 2. Hazard exposure[1] and visitation trend.

Year	Visitation[2]		Hurricane impacts		
	Average (persons)	Change from 1980 (%)	Duration (days)	Intensity (category)	Damage (average fatalities)
1980[3]	153,923	0	0	0	0
1981	159,364	3.50	0.28	0.11	0
1982	168,133	8.40	0.11	0.33	0
1983	168,013	8.30	0.06	0	0
1984	147,017	−4.70	0.39	0.06	0.01
1985	144,798	−6.30	0.61	0.61	0

[1]Hurricane Gloria occurred in 1982.
[2]Visitation to *Assateague Island*, *Cape Hatteras*, and *Cape Lookout* during the period of June through November of each year to correspond to tourist and hurricane seasons.
[3]Baseline year.

Natural disaster impacts on park visitation

To investigate the hurricane impact on park visitation in more detail, we employed the panel logit and time-series models (see Table 3). The first panel indicates that in our sample, the average number of visitors was 124,192. The average visitor variable was measured on a continuous scale, whereas the change in the number of visitors is the dummy – whether the number of park visitors increased or decreased more than the average number of park visitors every year of the study period (1 = increase, 0 = decrease). As expected in *Hypothesis 1*, the average change is less than half. This reflects the influence that the disaster season of six months, from June to November, had on decreasing park visitation.

The second panel provides information on the hurricane duration, intensity, and physical and human damage, which are measured on continuous scales. In particular, the hurricane category variable, representing the disaster intensity, ranges from 0 to 10 in the disaster-prone areas. Through this result, we can estimate how often hurricanes occur in the disaster-prone areas and the intensity of hurricanes during the study periods. In addition to the hurricane category, the hurricane damage variables such as fatalities and property and crop damage show the average amount of damage caused by the hurricanes. According to SHELDUS (2011), the average of fatalities ranges from 0 to 3.75 and that of property and crop damage is 1,033,346 and 436,671, respectively.

The third panel illustrates climate characteristics (i.e. average precipitation and maximum/minimum temperatures) indirectly influencing the number of park visits. In the last panel, with regard to tourism demands, nine variables describe the extent of park, community, capacity, and US capacity, which is measured on continuous scales and dummies. These variables represent socio-economic conditions which contribute to park visitation activities in communities as well as the nation.

More specifically, the entrance fee variable among the park capacity factors was measured as a dummy – whether or not park visitors paid an entrance fee (1 = yes, 0 = no). In accordance with the capacity scope, the remaining variables include inflation for 2004, overall population, employment, service industry, population of 15–44 years old, gas prices, per capita income, and unemployment rate. Through tourism demand, we can estimate the effect of socio-economic factors on the number of park visits.

As a first estimation procedure, the panel logit model was used to predict the change in the number of park visits influenced by hurricanes, climate, and tourism demand. The associations between predictor variables and the probability of visitation are estimated

Table 3. Descriptive statistics of visitation, hurricane and climate change impacts, and tourism demand.

			Mean	SD	Minimum	Maximum
Visitation						
Average visitors[1] (person)			124,192	157,238	670	632,948
Change in the number of visitors (increase: 1, decrease: 0)			0.46	0.50	0	1
Hurricane impacts						
Duration	Days		0.19	0.62	0	6
	Frequency		0.13	0.37	0	3
Intensity	Maximum wind speed (mph)		6.71	20.81	0	130
	Hurricane category[2]		0.19	1.11	0	410
Damage	Average fatalities (person)		0.02	0.19	0	3.75
	Average property ($)		1033,346	1.34e+07	0	4.20e+08
	Average crop ($)		436,671	6368,299	0	1.25e+08
Climate change impacts						
Average precipitation (mm)			524.43	325.63	1.17	2609.48
Average maximum temperature (F*10)			845.31	76.41	537	981
Average minimum temperature (F*10)			678.91	87.96	364.25	790.4
Tourism demand						
Direct effect	Park capacity	Entrance fee (no pay: 0, pay: 1)	0.7	0.46	0	1
		Inflated value (based on the consumer price index of 2004)	23962.6	4892.08	14706	40597.80
	Community capacity	Population (person)	351178.70	594322.00	9320.00	2358714.00
		Employment (person)	17657.72	6914.80	5850.70	40203.40
		Service industry (%)	33.99	8.29	12.85	56.89
Indirect effect	US capacity	Population of 15∼44 years old (%)	46.03	1.59	42.75	47.97
		Gas price (cents per gallon)	97.61	41.35	49.20	286.30
		Per capita income ($)	20697.90	7100.48	9146.00	33090.00
		Unemployment rate (%)	6.23	1.41	4.00	9.70

[1]During the period of June through November of each year to correspond to tourist and hurricane seasons in all study areas.
[2]Hurricane category is based on the Saffir–Simpson scale.

using maximum likelihood techniques. It should be noted that the model estimates the probability of visitation, but does not estimate the extent of visitation.

The three models in Table 4 are statistically significant at the 0.01 or 0.05 level according to Wald χ^2 statistics. The regressors are meant to capture various hurricane damages, climate attributes, and socio-economic conditions associated with the change in the number of park visits. In addition, this estimation reveals a stochastically well behaved conditional expectation function that fits our study purpose to identify the determinants of the number of park visits.

More specifically, Model I focused on hurricane characteristics and climate attributes. The coefficient of hurricane category and average maximum temperature is negative and significant for the dependent variable, change in the number of visitors. As expected, this result indicates that higher hurricane intensity and higher temperature lead to a lower degree of park visits. Furthermore, this result supports *Hypotheses 1b* and *2b* that higher storm intensity and severe temperatures lead to fewer visitations. In addition, Model II, focusing on tourism demand related to direct or neighboring socio-economic conditions, shows that the significant coefficient of population and employment is positive for the change in the number of visitors, supporting *Hypothesis 3b*. This finding shows that greater population and better employment are helpful in creating a demand for visitation and contribute to more park visits. Model III is a fully specified model incorporating important variables from the three panels or other models. Overall, this result supports the research hypotheses as did Models I and II.

Response of tourism economies in relation to natural disaster damage

As a second estimation procedure, we employed a time-series model. This model predicted visitation influenced by hurricane damage and tourism demand (especially estimates of the return time to visitation equilibrium, suggesting a disaster recovery) (see Table 5). We then divided the six parks into two groups (i.e. Models I and II in Table 5) in accordance with park or region hurricane damage.

In Table 5, as expected in *Hypothesis 3c*, the US per capita income positively and significantly affected visitations in all three parks damaged by Hurricane Andrew. This finding is consistent with the result of Model II in Table 4, suggesting that better economic conditions or activities help to create demand for visitation and contribute to more park visits. Consistent with the results of Model I and *Hypothesis 1c*, the average fatality variable is negative and significant regarding park visits in two parks, except for *Dry Tortugas*. This finding shows that fatalities from storm damage have a negative effect on park visitation.

In addition, as expected in *Hypothesis 1*, Table 5 also shows that the coefficient of the hurricane intervention variable in two of the three parks was negative and significant. The estimated coefficients are –4.59 and –0.59, respectively, in *Biscayne* and *Everglades*. This result indicates a change in park visits for the two parks in the post-hurricane period. Overall, the three parks damaged by Hurricane Andrew experienced negative or adverse park visits. On the other hand, in AR (1) of Table 5, we see that the hurricane shock seemed to be most persistent in *Dry Tortugas* with an AR (1) coefficient of 0.93. Since *Dry Tortugas* has a higher coefficient than the other two parks, it can be interpreted that the park took the longest time to return to visitation equilibrium.

In a similar example showing the effect of disaster damage and economic conditions on park visitation, we investigated Hurricane Gloria. Similar to the results from Hurricane Andrew, the US per capita income is positive and significant in two of the parks, *Assateague*

Table 4. Panel logit model estimated disaster losses, economic development and visitation.[1]

			Model I		Model II		Model III	
			Fixed effect	Random effect	Fixed effect	Random effect	Fixed effect	Random effect
Intercept				2.0159^{*}		-13.851^{**}		-34.511^{***}
Hurricane impact								
Duration	Days		−0.0968	−0.1159			−0.0359	
	Frequency							−0.0273
Intensity	Maximum wind speed		0.0055	0.0053				
	Hurricane category		-0.1239^{*}	-0.1205^{*}			-0.1519^{**}	-0.1580^{**}
Damage	Average fatalities		−0.0333	−0.0349			−0.0280	−0.8569
	Average property		6.68e−10	4.58e–09			1.06e–09	−1.73e–09
	Average crop							3.27e–08
Climate change impacts								
Average precipitation			−0.0002	−0.0002			−0.0004	−0.0003
Average maximum temperature			-0.0018^{*}	-0.0048^{*}			−0.0020	0.0018
Average minimum temperature				0.0029			−9.56e-06	−0.0036
Tourism demand								
Direct effect	Park capacity	Entrance fee				−0.3214		−0.1752
		Inflated value			-0.0003^{**}	-0.0003^{***}		−0.00006
Indirect effect	Community capacity	Population			−8.06e–07	−3.54e–07	3.31e–07	1.85e–07
		Employment			0.0009^{***}	0.0008^{***}	0.0004^{***}	0.0004^{***}
		Service industry			−0.0189	−0.0244	−0.0311	-0.0405^{*}
	US capacity	Population of 15∼44 years old			0.3659^{***}	0.3635^{***}	0.6832^{***}	0.6626^{***}
		Gas price					−0.0006	−0.0008
		Per capita income			0.0004^{***}	0.0004^{***}		
		Unemployment rate			−0.0659	−0.0625		0.1017
N			1284		1560		1284	
Log likelihood			−847.68	−878.85	−884.68	−936.06	−695.53	−735.58
Wald χ^2			11.87^{**}	11.21^{**}	310.50^{***}	187.30^{***}	316.20^{***}	176.50^{***}

[1]During the period of June through November in all study areas.
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 5. ARIMA estimated impacts of hurricanes on visitation.[1]

	Model I[2]			Model II[3]		
	Dry Tortugas	*Biscayne*	*Everglades*	*Assateague Island*	*Cape Hatteras*	*Cape Lookout*
Intercept	4.2425***	−0.3739	8.7154***	10.5556***	11.5508***	7.1619***
Hurricane intervention	−0.2844	−4.5934**	−0.5888**	−0.7486	−0.1111	−0.2959
Average fatalities	0.0582	−0.3581***	0.3000***	1.5369	−5.3682	−3.8452
Gas price	0.0004	0.0021	0.0009	0.0003	0.0002	−0.0011
US per capita income	0.0002***	0.0006**	0.0001**	0.0001*	0.00004	0.0002***
AR[4] (1)	0.9030***	0.8646***	−0.2937	0.2765	0.8682***	0.8246***
AR (2)	−0.5587***	–	–	–	−0.6009***	–
MA[4] (1)	−0.2843	0.1196	0.8481***	0.4236*	−0.5212	−0.6111**
Hurricane category	2	4	2	2	2	2
N	66	62	66	72	72	72
Log likelihood	−17.385	−41.878	−9.702	−54.233	−39.129	−11.013
Wald χ^2	66.70***	124.13***	1230.84***	14.99**	74.16***	80.99***

[1]During the period of June through November of each year to correspond to tourist and hurricane seasons in six study areas.
[2]National parks affected by Hurricane Andrew.
[3]National parks affected by Hurricane Gloria.
[4]AR: autoregressive, MA : moving average.
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Island and *Cape Lookout*. This result shows that as a neighborhood or indirect effect, better economic conditions or activities contribute to more park visits as predicted in *Hypothesis 3*. In addition, as not expected, the coefficient of the hurricane intervention variable regarding the three parks was negative but not significant. Therefore, it was difficult to estimate the change in visitations for the three parks in the post-hurricane period. On the other hand, the result of AR (1), given in Table 5, indicates that the hurricane shock appeared to be most persistent on *Cape Hatteras* among the three parks with an AR (1) coefficient of 0.87. Similar to the case of *Dry Tortugas*, this finding shows that in terms of visitation, this park has taken the longest time to return to equilibrium among the three parks.

Conclusion and discussion

This study demonstrated the negative impact of hurricanes on park visitations in a quantitative respect following numerous statistical models. It can be deduced that park visitations are largely affected by hurricanes, consistent with Cioccio and Michael (2007), Faulkner (2001), and Murphy and Brayley (1989). The most significant impact, however, may not be based solely on the frequency of storms, but rather their intensity. Similar to findings of previous studies (Stone et al., 1997), the stronger the storm, the more impact it will have on the number of park visits, in particular, within coastal park areas (i.e. disaster-prone areas). Parks that experienced stronger storms may be closed for a longer period of time in order to reconstruct facilities or natural or cultural resources damaged by storms.

In addition, our model indicates that park visitations might be affected not only by the meteorological characteristics of hurricanes induced by climate change, but also by the actual damage of a storm on the park environment. This result is consistent with Chase et al. (1998), Schwartz and Lin (2006), and Weiler et al. (2003) who suggest that climate change and population growth can greatly impact park visitations. Communities whose main industry is nature-based tourism would be most negatively impacted by a change in park visitations.

Study limitations and future research

These conclusions must be interpreted with some degree of caution due to data-quality concerns, the limitation of results, and basic assumptions. Park visitation data used in this study are not perfectly reliable since they are not 100% counting data, but estimation data based on official national park websites. To minimize this limitation, future research should collect primary data on park visits to enhance the validity of our findings. In addition to this, data pertaining to entrance fees (i.e. exact amount collected per month) at each park site during the study period was extremely difficult to gain access to (i.e. gatekeeping of records or lack of records kept). As a result, entrance fees were dummy-coded. Perhaps in future studies, a smaller window of time may be considered to aid in gathering such information. In addition, during the limited study period, this study focused on 10 US coastal national parks, within the southeast United States. As a result, some limitations in generalizing the findings exist. For this reason, future studies should involve noncoastal parks and parks in other countries impacted by severe weather events over a longer study period.

It should be mentioned that as families are displaced by the impacts of these natural hazards and crews (either operating for profit or as volunteer tourists) descend on the community in efforts to reconstruct neighborhoods, infrastructure, etc., locals and workers potentially inject monies into the economy by spending at restaurants, grocery stores, gas stations, and lodging facilities (Baade et al., 2007). We did not account for such activity in differentiating this form of economic activity on the local economy. As a result, the economic activity post-severe weather events may be slightly inflated. Future studies should take into consideration the degree to which locals are displaced versus those who remain in residences in the local area as well as the contribution contract workers and reconstruction crew members makes to the economy. Additionally, future studies should include detailed interviews with park managers and destination marketing organizations in an effort to understand what steps have been undertaken in encouraging visitors to return.

Finally, in employing empirical analysis, this study assumed that natural disasters like hurricanes represent a multifaceted challenge, not only to the tourism industry, but also to the surrounding local communities from an economic aspect. This assumption is limited in that it does not include other aspects (e.g. environmental quality and tourism demands, local tourist systems, transport systems, surrounding cultural and social conditions in tourism-based areas) (Dubois & Ceron, 2009; Foucat & Martin, 2008). Therefore, future research should be conducted to include a variety of factors influencing tourism economies. Despite its limitation, this study is the most empirical effort to date that addresses the relationships between tourism economies and impacts of severe weather events, especially adjacent to coastal national parks in the southeastern United States.

Policy implications of increasing opportunities in tourism economies affected by severe weather events

Tourism is now a major contributor to the economies of many local communities in accordance with the spillover effect or indirect effect (Hjerpe & Kim, 2007; Milne &

Ateljevic, 2001). However, as described in the findings of this study, there have been challenges or risks in tourism economies caused by both natural and human-induced disasters (Burby & Wagner, 1996; IPCC, 2012; Murphy & Brayley, 1989). To improve tourism-based regional economies, overcome the challenges in tourism economies posed by natural disasters, and increase opportunities for achieving disaster management, it is necessary to make an effort to mitigate natural hazard impacts to tourism-based areas. In general, since tourists are less familiar with local hazards, they are more vulnerable than locals (Burby & Wagner, 1996; Faulkner, 2001). For this reason, one of the more obvious steps that can be taken is to assess the risks a visitor destination is exposed to and develop management plans for coping with disaster situations in advance (Burby & Wagner, 1996; Faulkner, 2001).

To do this, policy-makers, planners, tourism industry agencies, and residents in this area need to develop proactive plans for disaster mitigation activities to prepare for severe weather events and corresponding impacts. As pointed out by Quarentelli (1998), these stakeholders need to collectively draw up organizational disaster plans and integrate them with overall community mass emergency plans. In particular, in an effort to decrease challenges and increase opportunities in tourism economies damaged by natural disasters, planners and managing organizations need to continuously set up effective and specific strategies tied to tourism disaster management (e.g. customer information, customer shelter, secure facilities) before and after severe weather events (Faulkner, 2001). In addition, attractions, eating establishments, lodging facilities, and other businesses dependent on tourism must have current evacuation plans in place and should be regularly updated. Furthermore, a network of communication should be implemented in destinations that link such businesses to local, state, and national authorities for evacuation and search-and-rescue purposes.

In addition to structural hazard mitigation for tourism disaster management (in an effort to increase the social network in the context of non-structural hazard mitigation), it is necessary to have an effective means of communicating information regarding response efforts for residents and tourists with limited access to information when displaced by severe weather events. In order to accomplish this strategy, tourism-dependent communities need to establish the emergency notification system called One-Call which simultaneously sends voice and text messages to all individuals who register with the system. A similar system is widely available to students on college campuses throughout the United States when emergency notifications are sent from administration. This hazard mitigation strategy will be helpful to minimize losses caused by natural hazards and maintain the existing tourism economy – ultimately allowing visitors to return to destinations more quickly following severe weather events.

Findings from this study underscore the dual mission that the US NPS has managed for since its inception – preserve and protect fragile ecosystems and species while providing tourism opportunities for the country's citizens. Questions remain as to whether the NPS should be expeditious in cleaning up following an intense storm or embrace the resulting disaster as being part of nature and therefore part of the park and its history. Instances of the former occurring have been well documented, including the wildfires of 1988 in Yellowstone (Meyer, 2001) and the eruption of Mount St. Helens in 1980 in the state of Washington (Murphy & Brayley, 1989). As Howe, McMahon, and Propst, (1997) point out, communities that are more dependent on tourism (i.e. "gateway communities") may be more instrumental in influencing policy, which would dictate or impact how quickly clean-up should occur within a particular park. Currently with nearly each NPS park unit having a "friends of the park" (or equivalent), such an organization could serve to communicate the needs of local residents as it relates to livelihoods and the economy. Ultimately those communities adjacent to a national park with more diversified economies have a less likelihood of being impacted by decreased park visitations directly following a major natural disaster. Unfortunately, many national park sites in the southeastern United States are adjacent to rural communities and are not afforded such diversification in their economies.

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