The Effects of Terrorism Events and Changes in the U.S. Homeland Security Advisory System on National Park Visitation

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Abstract. In this paper, we disentangle the impacts of terrorism events and the subsequent Homeland Security Advisory System (HSAS) on visitation at U.S. National Park Service (NPS) sites. To do this, we estimate a random effects model using a balanced panel of monthly site visitation between 1979 and 2013, spanning the period between two major terrorism events: 9/11 and the Oklahoma City bombing. The estimation results show increased visitation after the 1995 Oklahoma City bombing, but a decrease in visitation after 9/11. Visitation declines diminish the farther the site is from the twin towers and the more time has passed since 9/11. Elevated terrorism threat levels under the HSAS have a negative impact on visitation, but the impact of the warning dies out over time. An interaction effect indicates that large visitation sites close to the Twin Towers may experience more visitation after the HSAS level increases. We suggest the negative HSAS time effect may be due to some potential visitors choosing to stay home, while the positive interaction effect may indicate other people substituting away from other activities toward visiting NPS sites.

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JEL Codes: C23, L83, Q26

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Introduction

The U.S. Department of Homeland Security (DHS) created the Homeland Security Advisory System (HSAS) in March of 2002 and subsequently abandoned it in May of 2011. This system utilized a color-coded threat level which was designed to qualitatively express the likelihood of a terrorism event with five levels ranging from low (green) to severe (red). The initial level was elevated (yellow) and it was never lowered such that the level was either elevated (yellow), high (orange), or severe (red). The chronology of prior threat level changes is posted online (http://www.dhs.gov/homeland-security-advisory-system).

Homeland Security Secretary Janet Napolitano outlined some of the criticisms of the HSAS while introducing its replacement, the National Terrorism Advisory System, in 2011. Warnings under the HSAS tended to be general rather than specific regarding geography and were at times lengthy in their duration. For example, the threat level for all domestic and international flights was raised in August 2006 to high (orange) and remained there until the HSAS was terminated. The DHS website describes that the new system "…will more effectively communicate information about terrorist threats by providing timely, detailed information…" (DHS, 2011). This is consistent with the experimental findings of Granderton et al. (2005). They found that subjects were willing to pay for more geographically detailed threat information, the amounts paid increased with the threat level, and their hypothetical responses were based on the information purchased.

This study seeks to disentangle the effects of terrorism events and the subsequent HSAS on visitation at U.S. National Park System (NPS) sites. The NPS has approximately 350 sites (see Figure 1) for which it records monthly visitation data and makes use of its own site type (e.g., National Historical Sites) and regional designators. Park sites have significant heterogeneity across visitation numbers, geographic location, park type, and acreage to name a few. This heterogeneity allows for testing whether possible effects from the HSAS diminish based on the length of the warning and distance from given locations (for example, relative to major cities or 9/11 terrorist sites). The goal is to provide a more complete understanding of the extent to which NPS visitation was affected by the federal government's terrorism advisory systems.

There are two primary contributions of this paper. First, our study adds to the parks literature regarding the distribution, magnitude, and length of possible terror threat effects to large complex systems. Second, we provide evidence into the behavioral response of government sourced terror threat changes; do park visitors respond in uniform proportion to the threat level indicated by the government or do they create their own dynamic spatial risk assessment? What are the implications for managers of such a system?

Literature Review

Kalist (2010) estimated the terrorism alert effects on major league baseball attendance using daily observations for the 2002 and 2003 seasons. His findings suggest there were statistically significant decreases in attendance. The strongest effects were during the first alert level rise from elevated to high, a two week span that encompassed September 11th (September 10-24th, 2002). The effect was larger for games played in large market metropolitan statistical areas (over 5.6 million). However, within this period the magnitude and statistical power of the overall visitation effect diminished such that it was insignificant the last four days. Subsequent alerts were statistically insignificant in their effect on both overall and large market attendance. This pattern is consistent with Ding's (2006) terror threat response theoretical model and empirical evidence from hurricane warnings (see Wang and Kapucu, 2008). Bonilla and Grimmer (2013) show that while terrorism alerts raise the public's expectation of a terrorist event, they do little to change public's policy preferences. Gaibulloev and Sandler (2019) argue that the macroeconomic impacts of large scale terrorist attacks such as 9/11 have been modest and transitory, although there are likely large short-run impacts to the tourism industry.

McIntosh and Wilmot (2011) used NPS monthly data from 1979 – 2006 to determine park visitation. They included binary variables to capture September 11th, 2001, and periods where the threat level rose above elevated (yellow). Their findings provide evidence of geographically based impacts as parks in the Northeast and North Central NPS regions with large visitation (greater than 1,000,000 annual) experienced statistically significant decreases during these periods. The terrorism threat alert binary variable was significant across the aggregated periods suggesting potentially lingering effects in certain geographic locations. Also relevant to most sites was a significant positive visitation externality between NPS sites. Visitation increased as the number of sites within 100 miles increased

This study extends McIntosh and Wilmot (2011) to a longer sample period and a deeper investigation of how terrorism events (i.e., Oklahoma City bombing and 9/11 twin towers disaster) and the federal terrorism advisory system influence national park visitation over space and time. Such a study is important in the design of future advisory systems to minimize the economic impact and to help U.S. park officials allocate resources efficiently.

Hypotheses

The literature points to several potentially important factors in determining the visitation effects from terror threats. First, as the number and duration of threats increase, there may be a dampened response. Second, large urban areas may be deemed more likely to be targeted and elicit a greater response. Third, geographic locations that directly experienced terror events may have heightened and lingering responses. Fourth, sites that would normally be visited in combination may all be avoided. Finally, Eisenman et al. (2009) found ethnic differences in terrorism related avoidance behaviors. These suggest spatial panel models are likely the most appropriate method for statistically analyzing the data.

Data and Variables

Our dataset is a monthly balanced panel containing 262 National Park sites across the years 1979-2013. Based on the literature, we include variables such as 12-month lagged visitation, monthly dummies, unemployment rate, an exchange rate index, and the gas index. See Table 1 for a more detailed description of the visitation and national economic indicators.

Additional variables related to time and space from terrorism events and the HSAS system were constructed (see Table 2). The temporal variables were constructed to capture the possible decaying effect over time of the terrorism event and changes in the advisory threat level. The Oklahoma City Federal Building was bombed in April 1995. The time decay variable (*OK Time Decay*) is therefore equal to zero prior to the event, equal to one the month of the event, and equal to 1/ (1+ number of months since event month) thereafter. For example, in May 1995 the value of the Oklahoma City time decay variable is equal to 1/(1+1) = 1/2 while in March 1996 the value is 1/(1+11) = 1/12. Therefore, to match the expectation of a decaying negative effect on visitation, the expected sign of the coefficient is negative while the decaying variable value is utilized to provide the decay effect on visitation.[2] A similar variable was constructed for the terrorism events on September 11, 2001 (*9/11 Time Decay*).

Similarly, spatial variables were constructed to capture the potential effect of a distance decay on site visitation. This possibility suggests that sites closer to terrorism events would experience a larger decrease in visitation than those further away (i.e., the closer to the terrorism site, the more people stay home). The distance decay variable (*OK Distance Decay*) is therefore equal to zero prior to the event and equal to 1/(site distance in km to the Oklahoma Federal building) thereafter. To clarify, the variable becomes a fixed effect for each site after the event. For example, a site 0.5 linear km from the Oklahoma City Federal Building would take on the value of zero prior to April 1995 and would equal 2 for all time periods after while a site 1,000 km would take on the value of zero prior to April 1995 and 0.001 after. The idea is to capture a distance-specific effect. Similar variables were constructed for each 9/11 terrorism site; however, to avoid multicollinearity the World Trade Center Twin Towers site was used for distance (*Twin Towers Distance Decay*). Of course, there may be an interactive effect that goes beyond the additively separable effects of the space and time variables above. To address this possibility, interaction terms were created and used, when multicollinearity did not create significant issues.

Variables capturing the HSAS period and HSAS changes were created as well. A dummy variable was constructed to control for the period while the HSAS was in existence (March 2002 – May 2011). Next, in the spirit of the decay variables above, a time decay variable was created where each increase in the HSAS was treated as an event that resets the time decay (*HSAS Time Decay*). The first chronological change to the color-coded HSAS system occurred in September

[2] Other functional forms were tested as well, including 1/(number of months since event)^2 and 1/(number of months since event)$^{0.5}$. Based on AIC as a criterion, the more simple 1/(number of months) was a better fit. This was true for distance variables as well.

2002. Therefore, the variable equals zero for all periods prior to September 2002, it equals one in September 2002, and starts to decay by 1/(number of months since last raised) until May 2002 when the alert level was again raised and the variable reset to equal one. This pattern repeats until the end of the HSAS period, where the variable value is again equal to zero until the end of the sample.[3] It is also possible that distance from the terrorism event sites could have an interactive effect with the HSAS time decay variable. While there are several possibilities, multicollinearity concerns limited the number of interaction terms that could be added to the model.

Econometric Model

The basic panel data model takes the following form:

$$V_{i,t} = \beta_0 + \beta_1 V_{i,t-12} + \boldsymbol{\gamma}'\boldsymbol{X}_{i,t} + \mu_i + \varepsilon_{i,t},$$

where $i = 1, \dots, 262$ and $t = 1, \dots, 35\ yrs \times 12\ months = 420$, $V_{i,t}$ is visitation at the i^{th} site for time period *t*. The vector of covariates, $\boldsymbol{X}_{i,t}$, includes the two types of explanatory variables: national economic variables and terrorism/HSAS variables as described above. We consider several temporal, spatial and interaction decay versions of the latter variables. The term μ_i captures possible fixed effects, while the error term $\varepsilon_{i,t}$ captures possible random effects.

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[3] Several alternatives to this pattern are possible based on when the HSAS alert level was raised and lowered and the number of times this was done. We tested some alternative versions including where the decay would stop (equal zero) the month it was lowered rather than continuing until it was raised again. It is also possible that the decay should be based on the number of times it had been raised rather than the number of months since the change (e.g. count, equal to 1/2 for 2nd time changed until next change when equal to 1/3, etc.; again, a version where the decay was stopped when lowered was considered). We also considered that people might become more concerned as the number of changes increased; we tested variables that had an increasing value based on the count number of the threat change (e.g. equal to 2 for 2nd time changed until next change when equal to 3, etc.; again, a version where the decay was stopped when lowered was considered). Based on AIC criterion, the time decay from one threat level raised to the next threat level raised was a good statistical fit.

Site visitation may be correlated (e.g., during a trip to an area such as Washington D.C. with several national monuments) in ways that are not captured by our set of covariates, $\boldsymbol{X}_{i,t}$. To address this possible issue, we introduce a spatial RE model robustness check for our results. More specifically, the model assumes that the covariance between park sites is determined by the inverse of the distance between them. We provide more details on the spatial RE model and estimation in the Appendix.

Finally, following McIntosh and Wilmot (2011), we allow for structural differences in the coefficients depending on whether average annual site visits were small (visits <100k), medium (100k ≤ visits < 1,000k), or large (visits ≥ 1,000k). Initially, small and large site dummy variables were introduced to the model and were found to be significant. The full sample was then split into three sub-samples, based upon the size of the park (small, medium, large) previously defined.

Estimation Results

The results are presented in Table 3. For brevity, the monthly dummy variable coefficients, which are consistently statistically significant fixed effects, are not shown; however their effects are presented in Figure 2. Consider the macroeconomic and lagged visitation results first. These results are mixed with some of the estimated coefficients matching our intuition and some having unexpected signs. Focusing on the first two random effects (RE) columns, one-year lagged visitation and real disposable income have a positive impact on current visitation. This matches our intuition. There is strong persistence in visitation with an autoregressive coefficient of approximately 90%. Gas prices also have the expected sign such that higher gas prices discourage park visitation, a statistically significant effect. However, we expected the unemployment rate and the exchange rate to have negative impacts. More unemployment and a stronger dollar should, all else equal, discourage park visitation. Multicollinearity with gas prices and disposable income may make it difficult to disentangle the relative impacts of these two variables. Next, we turn to the terrorism and HSAS results.

The Twin Towers distance decay, 9/11 time decay, and interaction variable are the expected signs and there are large differences in the magnitudes of the coefficients between the small, medium, and large sites (last three columns of Table 3). It seems likely that, when significant, the negative effects on visitation are strongest when closer to the Twin Towers and closer to the 9/11 date. Being further from the Twin Towers site and the 9/11 date leads to dampened negative effects. The Oklahoma City distance decay follows this pattern as well. Interestingly, the Oklahoma City time decay is significant and positive, which we are unable to fully explain.

The HSAS time decay variable is negative and significant for all three site size models. These results suggest that, just based on the time effect, the negative effects of an increase in the threat level of the HSAS decrease throughout the ensuing time periods until the next threat level increase. Based on median visitation, the coefficients suggest that during the month of the threat level increase, visitation decreases by 12.4% for small, 3.9% for medium, and 8.6% for large visitation sites. These expected effects decay quickly based on the chosen decay rate, which is equal to 1/(number of months since last raised). Interestingly, the coefficient for the HSAS time and distance decay interaction term (HSAS Time Decay x Twin Tower Distance Decay) is positive, large, and statistically significant.

In trying to better understand the estimation results, we propose that two opposing behavioral effects may exist following terrorism events or advisory system changes. One type of effect is labeled “stay-home”, where potential visitors choose to respond by staying home and, therefore, site visitation decreases. However, an alternative effect may be driving behavior for others and may be responsible for unexpected coefficient signs or insignificant estimated coefficients. We refer to the alternative effect as “substitution”, whereby people avoid highly and densely attended social events (e.g., New York Yankees, Radio City Music Hall, etc.) and, instead, visit less densely populated NPS sites. Substitution would then lead to increases in park site visitation close to a terrorism event or HSAS warning.

To help interpret the coefficients of the site size models, we present representative sites and the effects due to the terrorism and HSAS related variables over time in Figures 3-5. The visitation effect that stands out for the New York sites is the time and distance interaction term for the 9/11 event (see Figure 3). The effect is relatively large and consistent with “stay-home” behavior but it also dissipates quickly over space and time. For example, if we fix time to the month of September 2001, the effect suggests that a large visitation site located ten kilometers from the Twin Towers site, with average September visitation of one hundred thousand, would have experienced a decrease of approximately 42,000 (-42%) visits due to this variable alone (see Figure 4). At a distance of 100 kilometers, the effect is a visitation loss of 4,200 (-4.2%). Any site outside of the 100 kilometer radius would expect little effect from the interaction term from September 2001 and onward. This is confirmed in the plots for the sites relatively close to Oklahoma City in Arkansas, Missouri, and Oklahoma, where both the pure distance and interaction effects are negligible (see Figure 5). Similarly, the Oklahoma distance decay variable has little impact in New York. The spatial RE model reinforces the results; the coefficients for the small, medium, and large models (see Table A.1 in the Appendix) are nearly identical to those in Table 3.

The significant coefficients of the HSAS variables for large sites may indicate evidence of the "stay-home" and "substitution" hypothesis. In New York, the Castle Clinton National Monument has a predicted negative ("stay-home") and decaying time effect from an increase in the HSAS threat level (see Figure 3). Given the same coefficient and variable values, the same is true for the Chickasaw National Recreation Area in Oklahoma. However, the interaction term with distance suggests a positive effect (potentially "substitution"); the effect is large for Castle Clinton and negligible for Chickasaw based on their distances from the Twin Towers.

Conclusion

A population's response to terrorist events, both real and anticipated, is an important topic for policymakers. In this study we add to the discussion by exploring the potential spatial response, magnitude and length of past terrorism events and possible terror threats effects on National Park visitation. The results indicate visitation was not uniformly affected across distance and time by 9/11 or a generalized nation threat level change. The decline in visitation appears localized, as the further away a park is from the event location, the weaker the effect on visitation. This suggests that the concept of more geographically specific terrorism threat warnings may be reasonable. A result that aligns with the shortcomings of the initial advisory system documented by the Homeland Security Secretary.

The negative effect on visitation from the 9/11 event erodes overtime, as expected. Similarly, the observed negative time decay effect for the HSAS system indicates that an increase in the threat level dampens as time passes. These two effects are in contrast to the one observed after the Oklahoma City event, which is puzzling. Two distinct responses behaviors, "stay-home" and "substitution", are proposed as explanation for consumer responses to perceived and announced threat level changes. Unfortunately, the current data do not allow for direct testing of these competing hypotheses. A possible extension would be to survey park visitors regarding how they would react to advisory changes under alternative notification systems. The results suggest that mangers at the NPS can anticipate regional declines in visitation from changes in perceived threat levels.

Table 1. Descriptions, Data Sources, and Descriptive Statistics for the National Park Visitation and Macroeconomic Data

Name	Description and Data Source	Mean	Standard Deviation
V (Dependent Variable)	National Park Visitation (number of monthly visitors) SOURCE: email correspondence with Butch Street Public Use Statistics Office, National Park Service	75,920	184,872
RDI	U.S. Real Disposable Income SOURCE: Federal Reserve Economic Data (St Louis) Billions of Chained 2012 U.S. Dollars [DSPIC96]	7,717	2,311
Unemployment Rate	U.S. Unemployment Rate (in percentages) SOURCE: Federal Reserve Economic Data (St Louis) Unemployment Rate: Full-Time Worker [LNS 14100000]	6.49	1.80
Exchange Rate	U.S. Trade-Weighted Exchange Rate SOURCE: Federal Reserve Economic Data (St Louis) Trade Weighted U.S. Dollar Index: Major Currencies, Goods [TWEXMMTH]	93.61	15.40
Gas Prices	U.S. Gas Price Index (1982-1984=100) SOURCE: Federal Reserve Economic Data (St Louis) Consumer Price Index: Gasoline (All Types) In U.S. City Average, All Urban Consumers [CUSR 0000 SET BO1]	141.40	72.80

Notes. Monthly sample size for national park visitation across all 262 sites = 110,040. Monthly sample size for U.S. macroeconomic data = 420.

Table 2. Terrorism and HSAS Variables and Descriptions

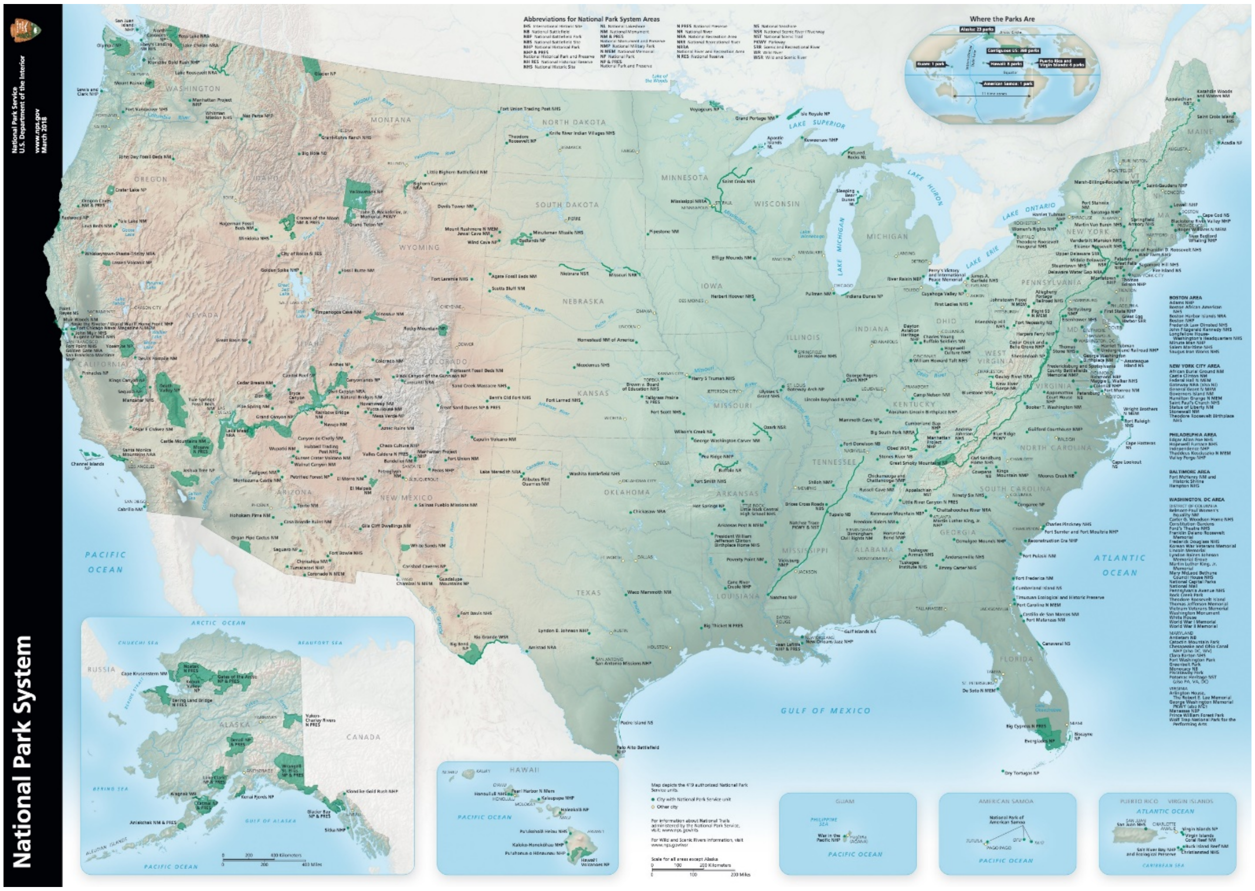
Name	Description	Expected Sign and Interpretation
TT Dist. Decay (Twin Towers Distance Decay)	= 0, before September 2001 = 1/(distance in KM from park site to NY twin towers), for September 2001 and after Site fixed effect post September 2001	Negative sign. The closer the site is to the Twin Towers, the larger the negative effect on and after September 2001; i.e. the negative effect erodes as the distance grows.
9/11 Time Decay	= 0, before September 2001 = 1, for September 2001 = 1/ (1 + number of months since September 2001), after September 2001	Negative sign. The closer in time to September 2001, the larger the negative effect on and after September 2001; i.e. the negative effect erodes as more time passes.
(TT & 9/11 Inter.) Twin Towers & 9/11 Decay Interaction	= (Twin Towers Distance Decay * 9/11 Time Decay)	Negative sign. Interaction of two variables that are both expected to have a negative impact.
OK Dist. Decay	= 0, before April 1995 = 1/(distance in KM from park site to Oklahoma City Federal Building), for April 1995 and after Site fixed effect post April 1995	Negative sign. The closer the site is to the Oklahoma City Federal Building, the larger the negative effect on and after April 1995; i.e. the negative effect erodes as the distance gets larger.
OK Time Decay	= 0, before April 1995 = 1, for April 1995 = 1/ (1 + number of months since April 1995), after April 1995	Negative sign. The closer in time to April 1995, the larger the negative effect on and after April 1995; i.e. the negative effect erodes as more time passes.
HSAS	= 1 while HSAS system operational (March 2002 - May 2011); = 0 otherwise	Unclear. Control variable for entire HSAS period.
HSAS Time Decay	= 0, before September 2002 (HSAS first raised) = 1, on months when raised = 1/ (1 + number of months since last raised), until raised again = 0, after May 2011 (end of HSAS)	Negative sign. The closer in time to a raised threat level the larger the negative effect on and after that change; i.e. the negative effect erodes as more time passes between threat level rises but is reset with each raise.
HSAS TT Inter. (HSAS Twin Towers Interaction)	= (HSAS Time Decay * Twin Tower Distance Decay)	Unclear. It is unclear whether a combined effect will accentuate or diminish the effects from the individual variables.

Table 3. Estimation Results (Dependent Variable is Visitation, $V_{i,t}$; Sample Period 1979:1 – 2013:12)

Variable	Random Effects (n = 262)		Random Effects w/ Size Dummies (n = 262)		Small Sites (n = 70)		Medium Sites (n = 131)		Large Sites (n = 61)	
	Coef	Std Err	Coef	Std Err	Coef	Std Err	Coef	Std Err	Coef	Std Err
MACROECONOMIC AND LAGGED VISITATION VARIABLES										
Constant	9,425***	1,791	5,688***	1,842	1,328***	158.3	6,375***	781.3	42,000***	7,457
$V_{i,t-12}$	0.9136***	0.00118	0.9099***	0.00121	0.8256***	0.00331	0.8773***	0.00209	0.8811***	0.00285
$RDI_{i,t-12}$	0.01351	0.1479	0.2446	0.1478	0.0351***	0.01332	0.2382***	0.06904	0.2349	0.5838
Unemp. Rate	231.4***	74.91	230.2***	74.91	29.01***	6.623	41.18	31.85	784.2**	309.7
Exchange Rate	24.99***	11.10	25.06**	11.10	-1.983**	0.9826	4.285	4.756	110.3**	45.75
Gas Prices	-7.712**	3.676	-7.922**	3.676	-1.917***	0.3252	-7.457***	1.556	-24.88	15.24
SPATIO-TEMPORAL TERRORISM AND ADVISORY SYSTEM VARIABLES										
TT Dist. Decay	-6,667***	2,173	-6,758***	2,169	-131.1	682.9	-612.5	766.0	-19,870**	8,421
9-11 Time Decay	-8,138***	2,017	-8,147***	2,017	-189.3	180.6	-3,268***	848.3	-25,650***	8,435
TT & 9-11 Inter.	-126,600***	15,530	-126,500***	15,530	-11,320**	4,895	-11,380**	5,496	-421,800***	60,050
OK Dist. Decay	-189,300	292,200	-201,400	291,200	-133,600***	23,500	-1,158,000***	204,200	-194,300	844,900
OK Time Decay	4,330**	1,987	4,334**	1,987	427.2**	176.2	1,484*	859.8	17,000**	8,151
HSAS	1,112***	398.5	1,102***	398.5	116.6***	35.27	391.2**	167.9	3,344***	1,655
HSAS Time Decay	-3,034***	886.3	-3,047***	886.4	-353.1***	79.20	-801.5**	372.8	-12,040***	3,703
HSAS TT Inter.	23,070***	6,348	22,950***	6,348	525.8	2,000	-542.1	2246	84,670***	24,550
SITE SIZE DUMMY VARIABLES										
Small Site			-2,581**	1,136						
Large Site			20,990***	1,218						
ERROR VARIANCES										
σ_μ (site only)	8,071		7,435		302		2,005		18,060	
σ_ε (site and time)	37,596		37,597		1,716		11,202		75,296	

Notes. The models include month dummies; see Figure 2 for a plot of the coefficients. (*),(**),(***) significant at the 10, 5, and 1 percent levels.

Figure 1. National Parks across the United States



Source: National Park Service (https://www.nps.gov/index.htm)

Figure 2. Month Visitation Coefficient Estimates (relative to July, the omitted month)

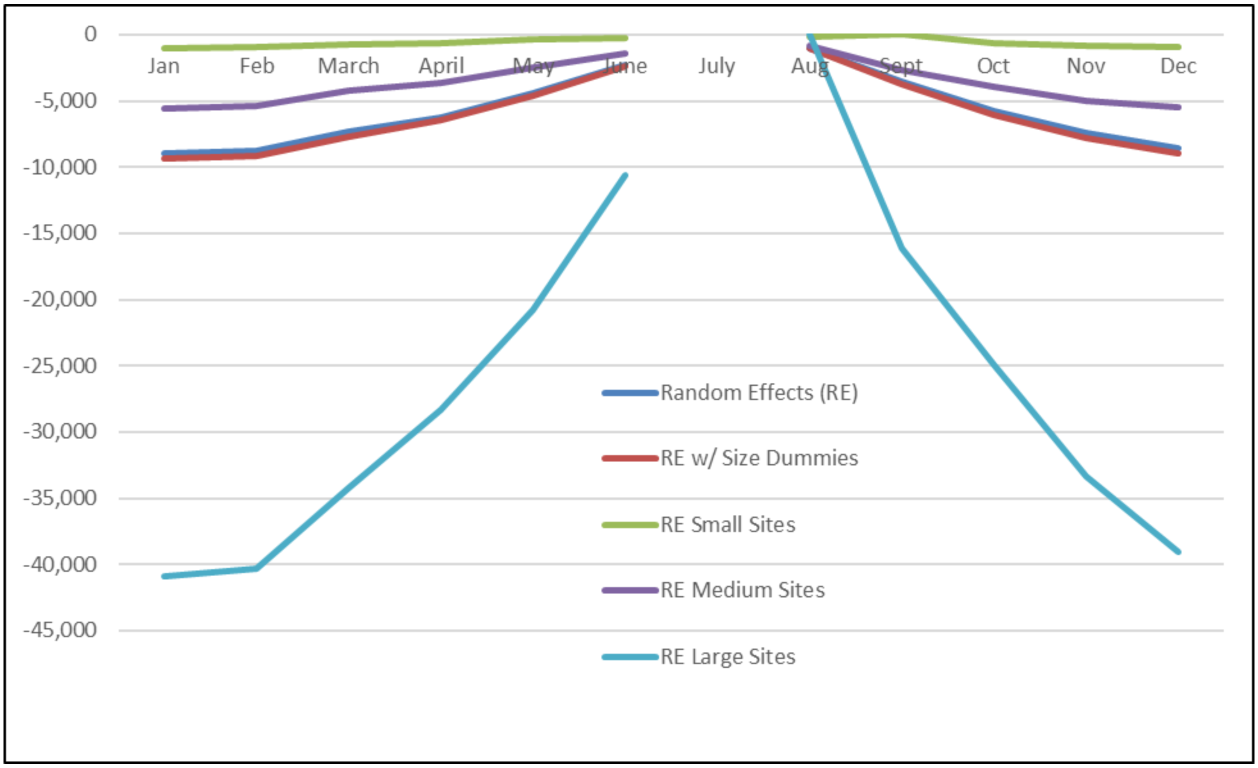
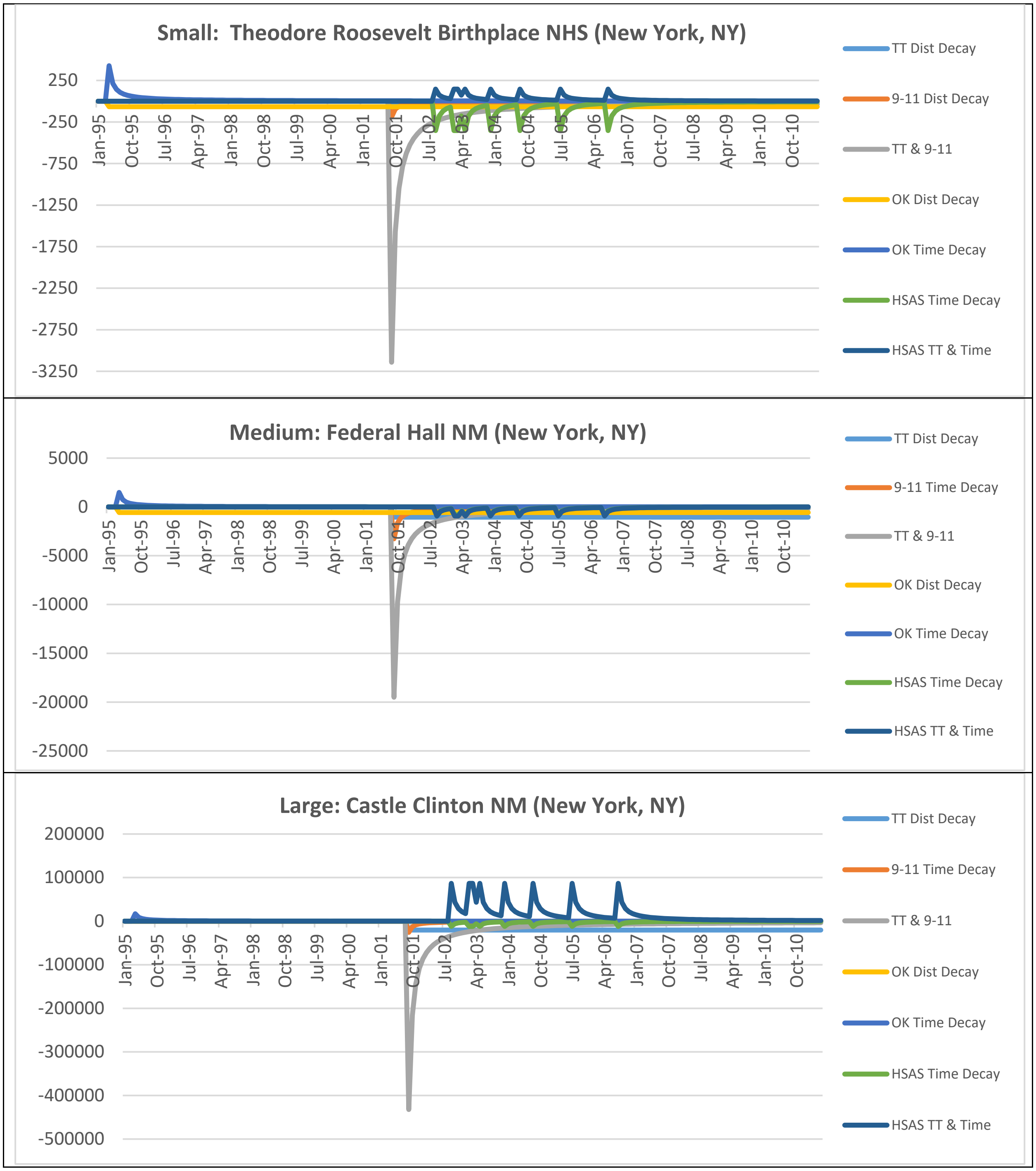
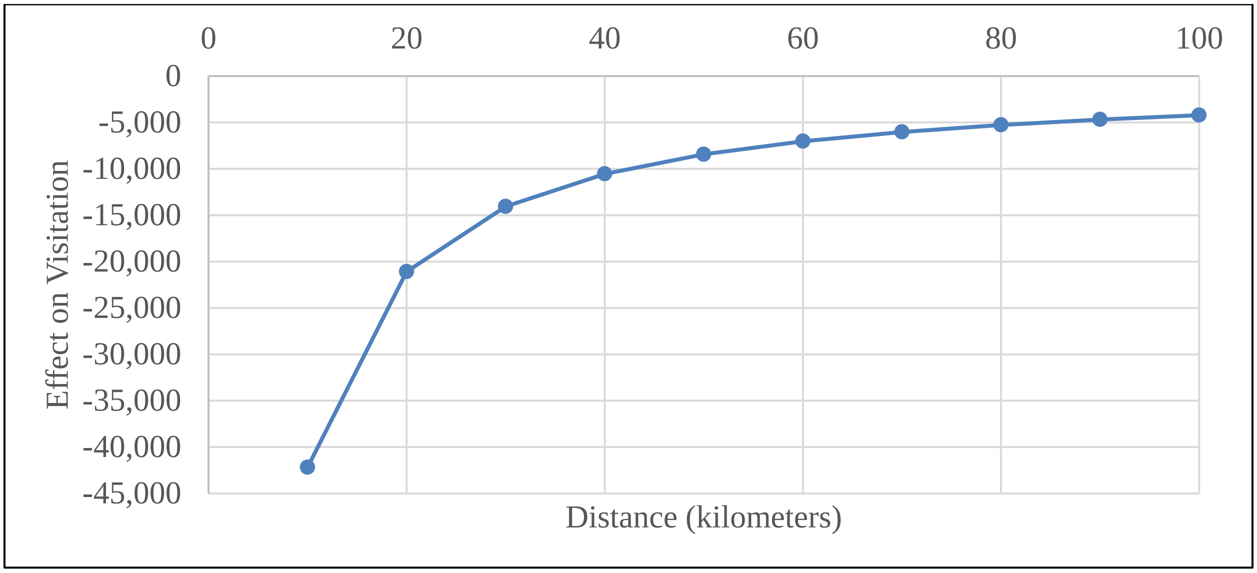


Figure 3. Impacts of HSAS and Terrorist Events for Small, Medium & Large NY Sites



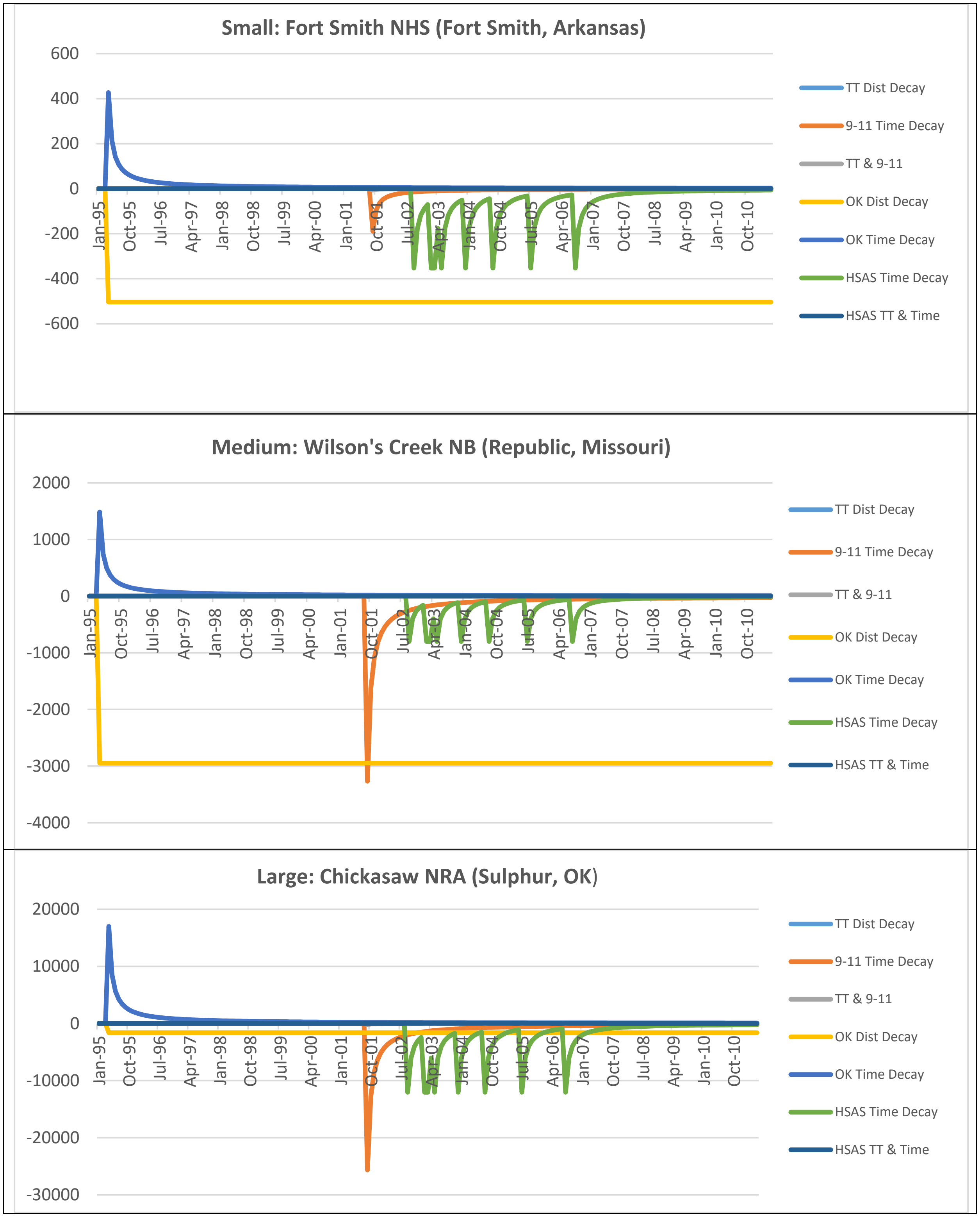
Note: the coefficients used to make the predictions come from the Small, Medium, and Large Sites Random Effects models (not the Random Effects Model with Size Dummies).

Figure 4. Predicted Spatial Decay of the Time-Distance Interaction Effect for a Large Visition Site in September, 2001 (100,000 Monthly Visits).



Note: the coefficients used to make the prediction come from the Large Sites Random Effects model.

Figure 5. Impacts of HSAS and Terrorist Events near Oklahoma City, OK



Note: the coefficients used to make the predictions come from the Small, Medium, and Large Sites Random Effects model (not the Random Effects Model with Size Dummies).

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Appendix. Spatial Random Effects (SRE) Model

The model is

$$V_{i,t} = \beta_0 + \beta_1 V_{i,t-12} + \boldsymbol{\gamma}'\boldsymbol{X}_{i,t} + \mu_i + \varepsilon_{i,t} \tag{1}$$

where $V_{i,t}$ is monthly visitation for park i in month t. The standard RE error assumptions apply. The spatial component is specified by assuming that park visitation is correlated across space. Specifically, we assume that

$$\sigma_{i,j} = cov(\mu_i, \mu_j) = \rho_{i,j} * \sigma_\mu^2,$$

where

$$\rho_{i,j} = corr(\mu_i, \mu_j) = f\left(dist_{i,j}\right) = \theta/dist_{i,j}.$$

Provided $0 \leq \theta < 1$ and $dist_{i,j} > 1$, then $0 \leq \rho_{i,j} < 1$. We calibrate $\theta = 7.15 \times 10^{-4}$ thousand km, which is slightly less than the shortest distance between any two sites in the data. This ensures that $0 \leq \rho_{i,j} < 1$.

The full (partitioned) variance-covariance matrix will be

$$\Omega_{NT\times NT} = \begin{bmatrix} \Sigma_{11} & \cdots & \Sigma_{1N} \\ \vdots & \ddots & \vdots \\ \Sigma_{N1} & \cdots & \Sigma_{NN} \end{bmatrix}$$

where

$$\Sigma_{ii} = \begin{bmatrix} \sigma_\varepsilon^2 + \sigma_\mu^2 & \cdots & \sigma_\mu^2 \\ \vdots & \ddots & \vdots \\ \sigma_\mu^2 & \cdots & \sigma_\varepsilon^2 + \sigma_\mu^2 \end{bmatrix}_{T\times T}$$

for $i = 1, \ldots, N$ and

$$\Sigma_{ij} = \sigma_{i,j}\boldsymbol{i}\boldsymbol{i}' = \begin{bmatrix} \sigma_{i,j} & \cdots & \sigma_{i,j} \\ \vdots & \ddots & \vdots \\ \sigma_{i,j} & \cdots & \sigma_{i,j} \end{bmatrix}_{T\times T}$$

where $i \neq j$ and $\boldsymbol{i}'$ is the unit row vector. If $\theta = 0$, then the model is aspatial and Ω is block diagonal.

Table A.1. Spatial RE Estimation Results (Dependent Variable is Visitation, $V_{i,t}$; Sample Period 1979:1 – 2013:12)

Variable	Random Effects (n = 262)		Random Effects w/ Size Dummies (n = 262)		Small Sites (n = 70)		Medium Sites (n = 131)		Large Sites (n = 61)	
	Coef	Std Err	Coef	Std Err	Coef	Std Err	Coef	Std Err	Coef	Std Err
MACROECONOMIC AND LAGGED VISITATION VARIABLES										
Constant	9,112***	1,808	5,633***	1,848	1,330***	158.6	6,356***	783.7	41,876***	7,484
$V_{i,t-12}$	0.9136***	0.001178	0.9101***	0.001206	0.8258***	0.003309	0.8772***	0.002087	0.8812***	0.002846
$RDI_{i,t-12}$	0.01370	0.1479	0.02296	0.1479	0.03520***	0.01332	0.2380***	0.06906	0.2339	0.5838
Unemp. Rate	232.8***	74.91	230.6***	74.91	28.98***	6.623	41.22	31.85	784.5***	309.7
Exchange Rate	25.02**	11.10	25.03**	11.10	-1.977**	0.9827	4.268	4.756	110.3***	45.75
Gas Prices	-7.561**	3.676	-7.891**	3.676	-1.917***	0.3252	-7.4560***	1.556	-24.85	15.24
SPATIO-TEMPORAL TERRORISM AND ADVISORY SYSTEM VARIABLES										
TT Dist. Decay	-9,554***	2,159	-7,134***	2,161	-129.7	683.6	-610.2	766	-20,060***	8,426
9-11 Time Decay	-8,074***	2,017	-8,138***	2,017	-189.2	180.6	-3,268***	848.3	-25,640***	8,435
TT & 9-11 Inter.	-126,600***	15,530	-126,500***	15,530	-11,320**	4,895	-11,380**	5,496	-421,800***	60,060
OK Dist. Decay	-187,300	292,000	-195,100	291,500	-134,200***	23,520	-1,156,000***	204,300	-193,700	844,900
OK Time Decay	4,325***	1,987	4,325**	1,987	428.3***	176.2	1,482*	859.9	17,000**	8,152
HSAS	1,132***	398.5	1,105***	398.5	116.7***	35.27	390.9***	167.9	3,347**	1,655
HSAS Time Decay	-3,017***	886.3	-3,045***	886.4	-353.1***	79.20	-801.7**	372.8	-12,040***	3,703
HSAS TT Inter.	23,100***	6,348	22,955***	6,348	526.8	2,000	-542.6	2246	84,690***	24,550
SITE SIZE DUMMY VARIABLES										
Small Site			-2,563**	1,134						
Large Site			20,660***	1,086						
ERROR VARIANCES										
σ_μ (site only)†	8,071		7,435		302		2,005		18,060	
σ_ε (site and time)	37,596		37,597		1,716		11,202		75,296	

Notes. The models include month dummies. (*),(**),(***) significant at the 10, 5, and 1 percent levels. †The σ_μ and σ_ε estimates for random effects are the same because they are estimated prior to specifying the spatial correlation structure captured by $\sigma_{i,j}$.