

## Research Article

## Recreation and disarray: Analysis of disorder in U.S. national parks

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## ABSTRACT

One of the best examples of balancing conservation with recreation-based tourism is the United States National Park System. With millions of visits per year in many parks, incidents of disorder are inevitable. Despite the limited amount of past literature examining more formal crime within national parks, to date, no studies have examined incidents of disorder or how these might affect recreation in these public spaces. This study examines over 74,000 incidents of disorder from 2000 to 2023 across four national parks using citation data from the *Central Violations Bureau*. These incidents were categorized and analyzed descriptively and longitudinally using autoregressive integrated moving average (ARIMA) models. The study finds that disorder is infrequent relative to visitation, with traffic-related citations comprising approximately 66 % of all incidents. In contrast, only about 5 % of citations were directly related to conservation or natural resources. These findings provide an empirical foundation for informing low-cost, prevention-oriented park management strategies.

*Management implications:*

- Long-term monitoring and categorization of disorder incidents in national parks can help managers anticipate trends and adapt strategies to reduce routine infractions.
- Analysis of longitudinal trends using ARIMA models can help identify temporal and spatial hotspots for disorder, enabling park managers to allocate resources more effectively to these areas.
- Educating park visitors about the consequences of disorder and their role in preserving natural environments can foster a culture of stewardship, enhancing both conservation and recreation experiences.
- The study's insights can guide preparedness plans for future crises (e.g., surges in visitation, environmental stressors), ensuring park management remains resilient and effective in balancing recreation and conservation.

## 1. Introduction

While research on U.S. national parks has traditionally centered on tourism management, natural resource conservation, and the impacts of climate change, relatively little attention has been paid to the role of disorder – minor violations, visitor misbehavior, and regulatory infractions – within these protected areas. Yet, the intersection of human activity, legal enforcement, and park management presents a valuable opportunity for empirical inquiry. This study builds on that intersection, combining insights from environmental management and criminology to explore how disorder manifests in national parks and how it may affect visitor experiences, resource degradation, and management

outcomes.

In criminology, it is a well-established that disorder tends to breed crime (Brantingham & Brantingham, 2013; Newton & Felson, 2015), particularly in densely populated urban areas characterized by social disorganization, economic distress, and weak collective efficacy (Gracia, 2024; Sampson & Raudenbush, 2001, pp. 1–6; Skogen, 1992). These studies demonstrate that visible signs of disorder such as vandalism, litter, and public intoxication can signal a lack of social control and invite more serious criminal behavior. Disorder is defined as the presence of social or physical incivilities which can create conditions conducive to more serious offenses that are often considered traditional or stereotypical crimes. In national parks, while violent or property

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crimes can occur, they are likely rare events. Far more common, though, are forms of disorder such as illegal parking, fee evasion, or camping violations. These seemingly minor infractions can still generate significant strain on park resources, enforcement personnel, and visitor perceptions of safety and order. As tourism to national parks grows, driven in part by social media and greater access to natural areas, understanding and managing such disorder becomes increasingly critical (Wichman, 2024).

This study asks: How can disorder in national parks be effectively classified, monitored, and addressed to support conservation efforts and improve visitor experience? We examine whether a measurable trend toward increased disorder exists and how it intersects with broader park management challenges. To answer this, we draw on the framework of conservation criminology, which merges theories from criminology, natural resource management, and risk analysis to better understand environmental harm and its prevention (Gibbs et al., 2010; Gore, 2017; Gore & Bennett, 2022; Moreto & Elligson, 2025). This field has gained increasing relevance in the context of anthropogenic climate change, which intensifies pressures on ecosystems and public spaces, driving higher incidences of environmental crime and illegal activities that threaten natural resources and outdoor tourism and recreation opportunities (White, 2025).

Although conservation criminology has often focused on issues such as wildlife trafficking (Kurland & Pires, 2017), illegal logging (Pires & Marteache, 2023), or elements of illegal, unreported, and unregulated fishing (Petrossian et al., 2024), its emphasis on situational crime prevention and risk-focused management makes it equally applicable to disorder-related challenges in recreational settings. In this study, we emphasize that the goal is not to equate civil infractions with crime, but to apply crime science principles to better understand where and when disorder occurs and how it may be mitigated. Much like how strategic placement of trash receptacles and effective communication can reduce littering (Miller et al., 2020), environmental and temporal analyses of citations issued in national parks may offer useful insights into how to prevent undesirable behavior.

Disorder, as outlined in broken windows theory (Welsh et al., 2015), includes both *social incivilities* (e.g., loitering, public drinking) and *physical incivilities* (e.g., litter, damage to infrastructure). These forms of disorder contribute to fear among community members, creating a negative feedback loop that leads to increased transience, social disorganization or unwillingness to intervene, and a heightened criminal presence. While national parks and other public spaces may not meet all the criteria of the environments typically associated with this definition, lacking permanent residents and relying on rangers and land managers for stewardship, we argue that a similar conceptualization of disorder is relevant. In this context, disorder can still provoke anxiety, foster distrust, and generate a perceived lack of safety among park visitors. This is particularly concerning for outdoor recreation spaces open to the public which thrive on tourism. Additionally, we believe that studying the trends of disorder will help address the current gap in understanding the intersection of crime, visitation, and conservation efforts.

To address these concerns, this study uses 23 years of citation data from four U.S. national parks to analyze spatial and temporal patterns of disorder. Our findings aim to inform park management strategies, improve classification and reporting practices, and ultimately support the preservation of park integrity in the face of growing visitation and evolving threats to public space stewardship.

## 2. Literature review

Academic research has yet to comprehensively investigate the nuances that connect criminal activity to national parks and other shared, rural settings within the United States. While some studies have examined the connections between crime and community or urban parks, highlighting how crime patterns are influenced by surrounding neighborhoods and land-use characteristics (Boessen & Hipp, 2018; Spencer &

Schnell, 2025), there remains a significant gap in understanding the prevalence and nature of crime within national parks. Moreover, little is known about how such crime may affect visitation, tourism, or other key dynamics, particularly given the National Park System's historical and cultural significance in the United States.

### 2.1. Public spaces

There has been some work into crime in public spaces that is worth discussion. Prior research has often investigated individual roles of certain factors on crime (Brisman and Rau, 2008; Grinols et al., 2011) or how individual national parks experience crime or perceive it (Gilbert, 2000; Wing & Tynon, 2006, 2008). Additionally, while visitation and tourism are often linked to an increase in crime when examining county-level data in countries with higher tourism rates like Spain (Montolio & Planells-Struse, 2016) and Croatia (Recher & Rubil, 2020), this appears to be different when examining specific rural locations. Grinols et al. (2011) investigated how visitation affected crime rates using county level and location specific-data at national sites such as battlefields, memorials, and national parks, finding that there is no significant relationship with violent or property crimes and the rate of visitation when examining specific, often rural, locations. Additionally, Gilbert (2000) found that within Gettysburg National Military Park, rangers' perception of crime and actual crime rates are similar and that minor offenses were the only increasing trend, highlighting the importance of proactive law enforcement and the need for observation and cooperation between law enforcement, visitors, and volunteers to keep disorder from becoming more legitimate crime.

In addition to formal law enforcement, national park management routinely addressed disorder through non-criminal strategies embedded in day-to-day operations. Rangers and park staff play a frontline role in enforcing rules, maintaining infrastructure, providing emergency medical services, educating visitors, and resolving low-level infractions to protect visitors and the ecosystem (Adventure Travel Trade Association, n.d.; U.S. Department of the Interior, n.d.). These practices, which can include signage, patrols, trail monitoring, and outreach, reflect a broader management orientation that emphasizes prevention and stewardship (Nolan, 2025). While not typically framed in criminological terms, these efforts constitute a parallel system of order maintenance that complements formal enforcement.

### 2.2. National and state forests

Forests, including national and state forests, have received increasing scholarly attention in relation to crime and disorder. Wing and Tynon (2006, 2008) analyzed hotspots of crime, or small geographical areas where there is a higher concentration of criminal incidents, within in Oregon and Washington state parks. Analyzing over 45,000 spatially referenced incidents, including felonies, misdemeanors, and infractions, they found that crime in forested areas is non-randomly distributed. Hotspots frequently emerged near population centers, transportation corridors, and recreation facilities, underscoring the influence of human presence and accessibility on environmental crime patterns.

In addition to spatial analyses, research has expanded to include crimes directly targeting natural resources. Gilbert (2000) explored the rise of archaeological theft, while Bourgon (2022) documented the complex and often community-entangled issue of redwood tree poaching and illegal logging, arguing for collaborative approaches between law enforcement and local stakeholders. These studies reflect a growing recognition that natural areas are not immune to crime, and that environmental harm often intersects with social and institutional dynamics.

### 2.3. National resources and biodiversity

It should be noted that the interest of disorder in national parks

extends well beyond the focus on interpersonal crime and criminality. That is, beyond interpersonal conflicts, which can occur anywhere, disorder in national parks can pose a significant risk to the biodiversity and preservation of natural resources in national parks as well as tourism and visitation. Clark (2024) discussed how U.S. environmental crime enforcement routinely face challenges regarding funding, capability, and inconsistency, arguing that the challenge posed by environment protection and enforcement agencies are stupendous and the lapse and difficulties they face lead to habitat degradation, water contamination, and illegal hunting that can become normative, making these challenges even more difficult to confront. This issue with normalization continues further. Spencer (2020) highlighted the issue of wildlife poaching that occurred exclusively in national parks and how the line between hunter and poacher can become remarkably thin, so too can tourists and nature goers quickly become a contributor to disorder when certain circumstances align, indicating the importance of structural and management-oriented programs (see also Spencer et al., 2021). Beyond the United States, international studies have discussed how environmental crimes within or near forested and protected park boundaries reflect institutional failures and economic inequalities (Alshible et al., 2023; White, 2017) undermine conservation goals and management structures. Similarly, Pires and Marteache (2023) investigated illegal redwood logging in California's Humboldt State Park, finding logging hotspots are more likely in areas with closer proximity to roads, close to parking spots or trails, in areas with old growth redwoods, and further from camping sites. Their findings indicate the importance of a crime science framework that prioritizes opportunity and structural solutions that contribute to environmental and wildlife crime, also emphasized in additional pieces (Pires & Moreto, 2017; Pires & Solans, 2023).

#### 2.4. Crime science and the lack of crime focused research

Building from this, multiple studies have found that state forests have higher rates of disorder, such as vehicle incidents, trespassing, drug related crimes, and much lower rates of violent crime or interpersonal crimes (see Ekblad, 2013; Stauber, 2017). Additionally, studies have found that these incidents are not random and are instead in contracted hotspots (Pandit et al., 2016; Stauber, 2017), with population centers, transportation routes and parking areas, and campsites and water resources as all being significant. Utilizing a survey distributed through the online tool MTurk, Snyder and Freng (2023) assessed national park visitor's perception and experience with victimization, behavioral change, and fear as it relates to national parks. They found that verbal assaults and theft are the most common themes of crime and disorder, occurring with a majority of individuals failing to report what had occurred to them. The role of fear of crime in parks was highlighted, as well as a few associated factors associated with increased risk of victimization, highlighting that victimization may decrease likelihood of return and even overall perception of nature, findings echoed in previous studies (Brisman & Rau, 2009; Brunt et al., 2000; George, 2010). If perceived lack of safety from individuals can decrease visitation or even approval of national parks and nature, ensuring perceived safety and increasing security measures, both enforcement and preventative in nature, should be a priority amongst both law enforcement and conservation efforts. Though it was recently found via an MTurk survey of recent national park visitors that most were unaware of national park rules regarding firearms<sup>1</sup> (Freng & Snyder, 2025), studies such as Brisman and Rau (2008) and Mack (2017) described the need special consideration in the role of firearms in national parks to protect visitors

and their perception of safety. These studies emphasize the importance of protecting visitors' perceived safety if visitors are to retain their connection to the park system. These studies highlight that disorder and perceived safety, rather than crime or more serious interpersonal violence, are the more endemic issue for policymakers and law enforcement to tackle with the assistance and information provided by empirical studies.

Even with these few important and poignant studies, additional literature regarding the impact of crime and disorder in national parks is largely absent due to a variety of reasons including difficulties obtaining data, issues with underreporting, and the vast geographies of protected nature areas that cause many crimes to simply go unnoticed. Stadler et al. (2023) recently called for increased research and study into crime and law enforcement in the US National Park System, citing increased visitation following the COVID-19 pandemic, as well as workforce pressures and operational issues that hamstring law enforcement efforts to monitor and protect such massive areas (see Tynon et al., 2010). This echoed previous writings that detailed shifts in ranger perception and a misalignment between prioritizing leisure benefits and that of enforcement (Pendleton, 2000). With compounding stresses and a severe shortage in understanding the problems related to disorder in national parks and its effect on visitation or conservation, it should be a central priority among researchers and practitioners to continue researching these related topics.

#### 2.5. Crime science framework

This research is informed by a crime science approach to understand disorder in four national parks selected for study. Crime science is the application-based framework that uses opportunity-based and contextually-driven theories to investigate the causal factors and empirically driven responses to crime (Brantingham & Brantingham, 1981; Sidebottom & Wortley, 2015). That is, crime science draws from a body of practice-driven research and empirically tested theories to understand the drivers of crime and disorder. These theories include rational choice theory, which examines crime as a cost-benefit decision made by a likely offender (Cornish & Clarke, 1986); crime pattern theory, which examines the intersection of targets and offenders at a meeting of targets and offenders at a specific time and setting (Brantingham & Brantingham, 2013; Clarke, 2010, pp. 271–283; Kuang et al., 2017); and routine activities theory, which considers crime as a convergence of a likely offender and a suitable offender when there is a lack of a suitable guardian (Cohen & Felson, 1979). Using these opportunity-based theories, crime science argues that criminal behavior, and by extension disorder, is influenced by the immediate environment in which crime occurs, that crime is not randomly located in time and space, and to understand crime patterns prove most effectively to control and prevent crime (Danner et al., 2017). Though disorder is not inherently criminal activity, we believe that informing this study with the likes of the crime science framework will be beneficial to the study's purpose.

In recent years, crime science has grown in possible utility and has become a predominant framework for exploring conservation-related, criminological research. Chiang et al. (2024) utilized several years of U.S. Coast Guard data to find the prevalence, routes, and growing presence of fishing vessels used for cocaine trafficking into the United States from Central and South America, developing further understanding of a unique convergence between IUU fishing, environmental impacts, and drug trafficking. Similarly, Petrossian et al. (2024) utilized a crime science framework to investigate the role of ports as facilitators for international illegal transshipment. Crime science has been utilized further in the cases of crime and conservation efforts in national parks at the international level, such as the investigation of the travel patterns of fishing poachers in the Great Barrier Reef Marine Park off the coast of Australia by Weekers et al. (2019). This study found that offender target selection was highly localized, that target locations were heavily

<sup>1</sup> While the US national park service does not designate carrying firearms as illegal, they adhere to federal, state, and local firearm laws. Additionally, there are a few specific legalities surrounding illegal use and possession. See the attached link for further information: <https://www.nps.gov/articles/firearms-in-national-parks.htm>

dependent on the nearby boat ramps to their targets, among other findings that could lend to policy implications for conservation. Further studies show the utility of crime science in crime and conservation efforts by analyzing the crime scripts of poaching in Vietnam (Violaz et al., 2021), or to investigate how foot patrols, tourism, and local park communities can affect illegal bushmeat snaring in Olifants West Game Reserve (Sosnowski, 2023). Given the previous literature that portrays the line between criminal action and public use of space and resources as fuzzy (Spencer, 2020), we believe understanding the context of criminal action, through the lens of crime science, is beneficial. This study further extends crime science as a tool for conservation efforts against crime and disorder by looking at the temporal trend and comparative nature of disorder in the national parks studied.

### 2.6. Current study

This study contributes to the growing literature on disorder in protected areas by examining how such issues manifest through civil infractions, specifically tickets and citations issued within national parks. We use citation data from four parks: Badlands, Everglades, Shenandoah, and Yosemite, to analyze longitudinal trends to better understand the spatial and temporal characteristics of disorder in these diverse park settings.

Although, these parks were selected non-randomly due to data availability, they represent a wide range of ecological, geographical, and operational characteristics found across the U.S. national park system. They vary significantly in size, climate, flora and fauna, levels of visitation, and primary visitor activities. While this sampling approach may limit generalizability, it provides a meaningful starting point for identifying patterns and differences in how disorder presents in distinct park contexts.

Our goal is to offer a comprehensive overview of disorder within these four parks and to highlight the value of integrating such analysis into broader park management and conservation strategies. This study also seeks to encourage greater scholarly and operational attention to disorder in national parks, a topic that has received limited empirical treatment despite its practical relevance.

This research is guided by the following questions:

1. How does disorder manifest in U.S. national parks?
2. What are the differences in the types and frequencies of disorder across the four parks studied?
3. How have trends in disorder changed over time within these parks?

## 3. Data and methods

### 3.1. Sample

Data on disorder-related incidents for the four national parks examined in this study were extracted from the *Central Violations Bureau (CVB)*, covering the period from January 1, 2000 to December 31, 2023. The CVB is a national entity responsible for processing federal citations and associated fees (Central Violations Bureau, n.d.). The dataset includes all citations listed as Class B (Pirius, 2022), along with other unclassified misdemeanors issued on federal property, including our selected national parks.

The citations in this dataset reflect incidents that we conceptualize as disorder, as they generally fall below the threshold of traditional violent of property crimes tracked by national systems such as the National Incident-Based Reporting System (NIBRS) or the Uniform Crime Report (UCR) (FBI, 2020). In most cases, these citations represent civil infractions or minor regulatory violations rather than criminal offenses. More serious incidents, such as those resulting in physical harm or significant property damaged are typically addressed through other legal mechanisms and are not captured in this dataset.

The extracted data was not uniformly coded across the four parks nor

within each park. Therefore, a categorization schema was created where eight categories were used to code the data (see Table 1). These categories broadly represent distinct frequencies observed within the dataset’s prior descriptions of the incidents. Additionally, categories such as “natural resources” were created to further analyze incidents of disorder unique to their park settings. Across the four park’s data the incidents of disorder were double coded by the paper’s authors using the eight categories and interrater reliability was ~90 %, which suggests extreme consistency among coders (Cohen’s Kappa = 0.90,  $p < 0.000$ ). Across the four parks and from 2000 to 2023 a total of  $N = 74,169$  incidents of disorder were identified.

### 3.2. Analytic strategy

This study employed a primarily descriptive approach to examine incidents of disorder by category type, as well as time-series analysis to examine the trends amid the near quarter century of data. Time-series analysis is a common methodology used in longitudinal crime studies allowing for control of serial dependence, seasonality, and random error among other sources of noise (Burbridge, 1999). To do so, we used autoregressive integrated moving average (ARIMA) models to analyze and describe trends among categories of disorder type for each national park. ARIMA models are statistical models used for time series analysis and predicting future values using the combination of previous values (Newbold, 1983; Shumway & Stoffer, 2017) While a visitation variable data was recorded for this study, it was only analyzed in relation to incidents of disorder. That is, no independent variables were used to regress our dependent variable and make predictions about future disorder. The predictions modeled are short-term, derived solely from the time-series ARIMA analysis using 23 years of disorder data in the form of citations. However, these predictions are highly limited and lack utility without additional context. The primary goal of this study was not to make predictions but to systematically and descriptively examine incidents of disorder in a manner that has not been previously undertaken. All models were estimated in R (R Core Team, 2024) using a variety of statistical packages tailored for ARIMA modeling.

Using the coded disorder data for each park, we implemented systematic modeling strategies mimicked for each national park. Initially, we assessed the stationarity of the data using the Augmented Dickey-Fuller test. Following this, we differenced the data and conducted a second stationarity test to confirm the results. For each park, the results of both stationary tests confirmed that the disorder data are stationary ( $p < 0.001$ ). Since the data are stationary, it was appropriate to continue

**Table 1**  
Coding schema for categories of incidents of disorder.

Category	Classification Information
Alcohol & Drug	Any incident regarding alcohol and/or drug use (including operating a vehicle while under the influence - DUI/DWI), open containers, drug or alcohol related paraphernalia.
Camping	Activities related to illegal or prohibited camping outside of designated areas, illegal fires.
Drone/ Fireworks	Any incidents of aerial related prohibited activity such as fireworks usage or flying of drones.
Miscellaneous	All incidents falling outside the scope of previous categories, including off-leash pets, use of sound producing devices, riding of skateboards in prohibited areas, etc.
Natural Resources	Incidents related to the improper handling or possession of flora, fauna, or related resources, illegal hunting or fishing, destruction of natural resources, and any incident involving archaeological resources.
Payment	Failure to pay park entrance fee, unregistered entrance or use of park property and resources.
Traditional	Activities typically referred to as traditional crime ranging from fraud, theft, assault, disobeying law enforcement instructions, illegal discharge of a firearm, etc.
Traffic	Traffic related incidents such as seatbelt violations, driving without insurance, speeding.

**Table 2**  
Counts and frequencies of disorder by category, 2000–2023

	Alcohol & Drugs	Camping	Drone & Fireworks	Misc.	Natural Resources	Payment	Traditional	Traffic	TOTAL
Badlands	107 (5.43 %)	12 (0.61 %)	12 (0.61 %)	35 (1.78 %)	110 (5.59 %)	192 (9.75 %)	44 (2.23 %)	1457 (74.00 %)	1969 (2.65 %)
Everglades	680 (4.82 %)	222 (1.57 %)	18 (0.13 %)	770 (5.46 %)	3095 (21.95 %)	670 (4.75 %)	387 (2.74 %)	8258 (58.57 %)	14,100 (19.01 %)
Shenandoah	1396 (9.72 %)	1015 (7.07 %)	26 (0.18 %)	358 (2.49 %)	327 (2.28 %)	588 (4.09 %)	212 (1.48 %)	10,441 (72.68 %)	14,363 (19.37 %)
Yosemite	4717 (10.79 %)	4894 (11.19 %)	41 (0.09 %)	1059 (2.42 %)	584 (1.34 %)	2338 (5.35 %)	1459 (3.34 %)	28,645 (65.48 %)	43,737 (58.97 %)
TOTAL	6900 (9.30 %)	6143 (8.28 %)	97 (0.13 %)	3089 (4.16 %)	4116 (5.55 %)	2921 (3.94 %)	2102 (2.83 %)	48,801 (65.81 %)	74,169 (100 %)

**Table 3**  
Descriptive statistics for disorder & visitation by national park from 2000 to 2023.

	Disorder			Visitation		
	Mean	SD	N	Mean	SD	N
Badlands	82	96	1969	954,144	90,823	22,899,465
Everglades	588	334	14,100	988,489	150,979	23,723,734
Shenandoah	598	385	14,363	1,311,047	175,676	31,465,137
Yosemite	1822	1059	43,737	3,681,630	530,597	88,359,116

modeling using the ARIMA model. Next, we performed the autocorrelation function (ACF) and the partial autocorrelation function (PACF) for each series to determine the most appropriate parameter estimates  $p$ ,  $d$ , and  $q$ . Where  $p$  is the number of lag observations included in the model,  $d$  is the number of times that the raw observations are differenced to achieve stationarity, and  $q$  is the size of the moving average window. The model specification results are contained within [Tables 4 and 5](#) and do differ between each national park.

#### 4. Results and analysis

##### 4.1. Descriptives

Between 2000 and 2023, a total of 74,169 incidents of disorder (in the manner of citations) were recorded across all four parks by law enforcement, correlating with approximately 166.4 million visitors during the same period. This results in an incident rate of about 0.00045 incidents per visitor, indicating that less than 1 % of visitors were issued a citation. Due to data limitations, it was not possible to analyze whether multiple citations were issued to the same individual. It is possible though that a few individuals (less than the provided statistic) were responsible for the majority of the disorder in the parks. A description of disorder counts and frequencies by category for each park is presented in

**Table 4**  
Full ARIMA model results by national park.

	Model Specification	Coefficients			Model Fit Statistics			
			Estimate	SE	$\sigma^2$	Log Likelihood	AIC	BIC
Badlands	ARIMA (1,0,0)	AR (1)	0.609	0.058	430	-814	1634	1643
		Mean	17.568	3.873				
Everglades	ARIMA (1,1,1) (0,0,2) [12]	AR (1)	0.295	0.093	2869	-1452	2913	2931
		MA (1)	-0.823	0.060				
		SMA (1)	0.199	0.062				
		SMA (2)	0.223	0.062				
Shenandoah	ARIMA (2,1,1) (0,1,1) [12]	AR (1)	0.349	0.066	3279	-1391	2793	2810
		AR (2)	0.205	0.065				
		MA (1)	-0.958	0.023				
		SMA (1)	-0.678	0.059				
Yosemite	ARIMA (2,0,2) (0,1,1) [12]	AR (1)	1.435	-0.450	16,190	-1729	3470	3492
		AR (2)	0.100	0.093				
		MA (1)	-0.589	0.098				
		MA (2)	-0.295	0.073				
		SMA (1)	-0.543	0.058				

[Table 2](#). Also presented in [Fig. 1](#) are the correlations between visitation and crime using a lagged visitation. That is, the images in [Fig. 1](#) indicate whether previous years' visitation influences the next year's disorder. For the Everglades and Yosemite, the correlation is extremely small indicating little to no influence. The influence for the Badlands and Shenandoah is negative and strong at  $\sim -0.49$ . These latter relationships may be an indication that prior visitation levels influence the following years prevention strategies, staffing levels, etc.

There is much variation of citations (total count and by category) between each park provided from the official data. Yosemite issued the most citations (43,737) and Badlands the least (1,969). Across all parks, traffic-related disorder comprised between 58 % and 74 % of all citations. The fewest incidents of disorder were for camping and drone/firework related citations. Of particular non-similarity were the number of incidents for natural resources in the Everglades ( $n = 3095$ ; 21.95 % of disorder in the park). To further contextualize the information presented in [Table 2](#), descriptive statistics for disorder and official visitation are presented in [Table 3](#). Additionally, visualization of visitation data for each park are presented as a line graph in [Fig. 2](#). Visitation data was obtained directly from the NPS ([NPS Stats, n.d.](#)). In terms of total visitation, Badlands and the Everglades were similar across the time period at  $\sim 23$  million total visitors. Shenandoah had slightly more visitors at  $\sim 31$  million and Yosemite had the most at  $\sim 88$  million visitors. With the

**Table 5**  
Filtered ARIMA model results by national park.

	Model Specification	Coefficients			Model Fit Statistics				
			Estimate	SE	$\sigma^2$	Log Likelihood	AIC	BIC	
Badlands	ARIMA (1,1,1)	AR (1)	0.429	0.097	295	-503	1012	1020	
		MA (1)	-0.965	0.042					
Everglades	ARIMA (1,1,1) (0,0,2) [12]	AR (1)	0.200	0.090	2328	-1317	2645	2662	
		MA (1)	-0.811	0.057					
		SMA (1)	0.176	0.064					
		SMA (2)	0.181	0.062					
Shenandoah	ARIMA (5,0,2)	AR (1)	1.921	0.077	2209	-1272	2562	2593	
		AR (2)	-0.934	0.153					
		AR (3)	-0.266	0.151					
		AR (4)	0.049	0.146					
		AR (5)	0.189	0.068					
		MA (1)	-1.642	0.051					
		MA (2)	0.804	0.050					
		Mean	61.355	11.233					
Yosemite	ARIMA (2,1,1) (0,1,1) [12]	AR (1)	0.721	0.068	10,680	-1600	3210	3228	
		AR (2)	-0.208	0.063					
		MA (1)	-0.941	0.030					
		SMA (1)	-0.555	0.058					

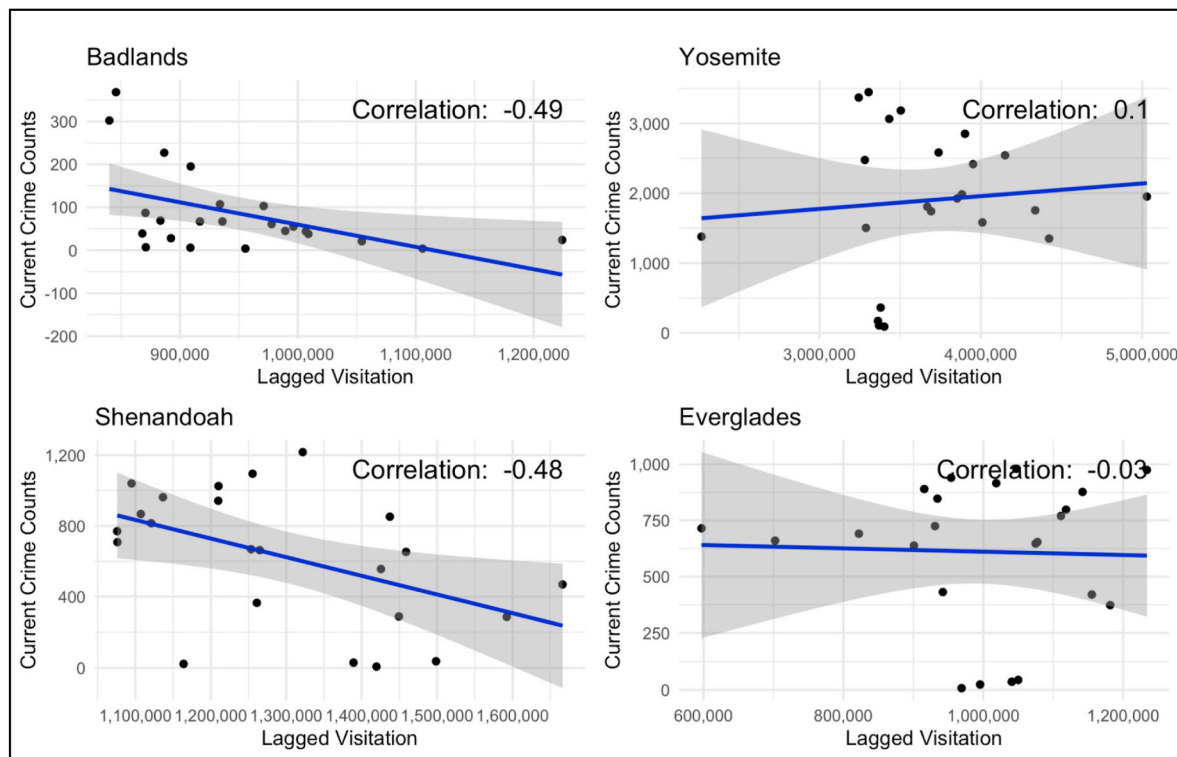


Fig. 1. Relationship between lagged visitation and disorder.

exception of declines during the COVID-19 pandemic, visitation for all four parks has steadily increased from 2000 to 2023.

4.2. ARIMA model

Full ARIMA models were estimated for each national park using all incidents of disorder, and the results are presented in Table 4. There is much variability in model specifications between the parks. Notably, the models for the Everglades, Shenandoah, and Yosemite indicate underlying trends and seasonality, which may impact model performance. The Yosemite model, in particular, features a complex structure with additional moving average components, reflecting its nuanced data dynamics. In all models, past values significantly influence future values, as evidenced by positive autoregressive coefficients. However, the

negative moving average (MA) terms in the Everglades and Shenandoah models suggest that past errors exert a dampening effect on future observations. While the Badlands model exhibits robust and parsimonious fit, the other models, especially that for Yosemite, show signs of poor fit. This may be attributed to the complexity of the data or underlying trends that were not adequately captured by the models. Overall, these results suggest that further model refinement is necessary.

To address the concerns described above, models were estimated by category (without traffic) due to the extreme skew present in the data. Approximately 58%–74% of all disorder incidents were traffic related. However, because the remaining observations of disorder for all other categories was so small they could not be kept disaggregated and instead were combined for modeling. The filtered models (without traffic) provide more stationarity and use for longitudinal understanding of

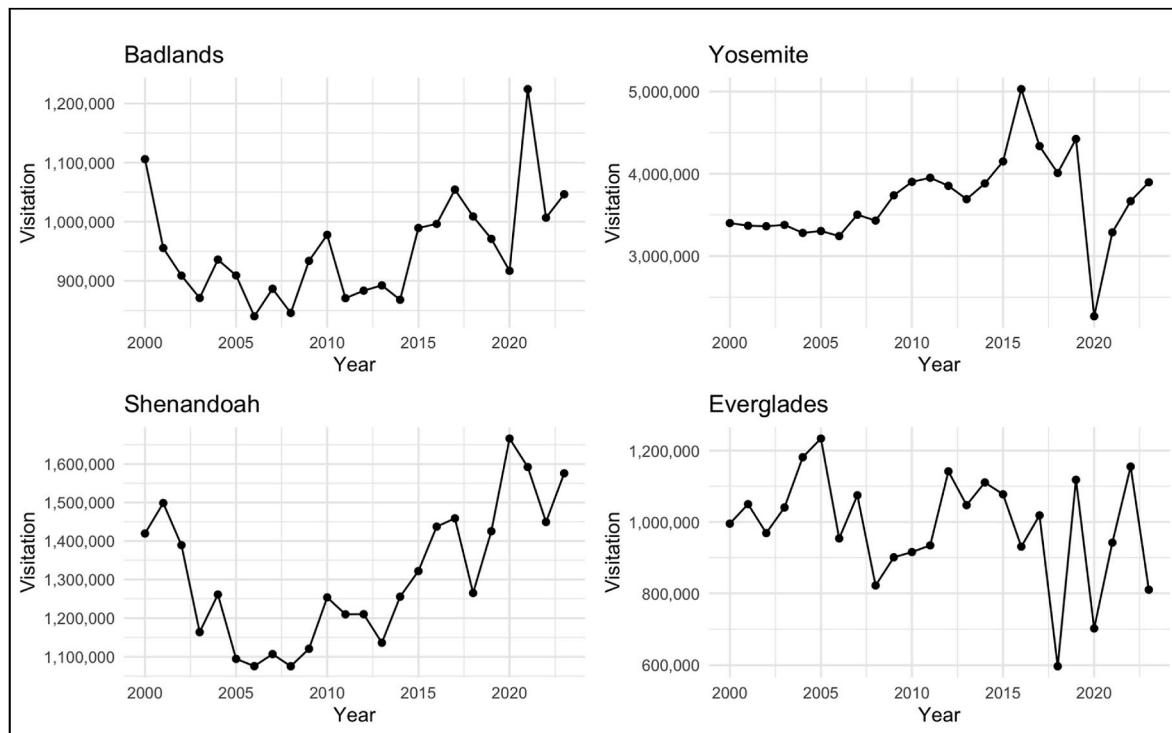


Fig. 2. Visitation trends by national park, 2000–2023

disorder in national parks compared to the full models. The filtered model results are presented in Table 5. Compared to the full models, the filtered ARIMA models generally performed better for Badlands, Everglades, and Shenandoah. Lower AIC values were observed for each park’s models. However, the root mean square error and mean absolute errors (not shown) for the Yosemite model increased compared to the full models indicating poorer performance. To further investigate the most appropriate model for Yosemite, a seasonal model (Seasonal SARIMAX) was estimated (not provided). This model did not improve fit nor provide more robust estimates. Therefore, only the models described in Tables 4 and 5 are discussed further.

5. Discussion and conclusion

This study examined how disorder manifests in U.S. national parks, how it varies across four selected parks, and how these patterns change over time. Using citation data obtained from the Central Violations Bureau, categorized infractions into eight types, with traffic-related citations comprising the vast majority across all parks. Notably, Everglades National Park exhibited a higher volume of natural resource-related citations – particularly violations tied to fishing activities such as illegal fishing, overfishing, or improper equipment use. These findings highlight how local park characteristics shape the types of disorder observed, underscoring the need for site-specific rather than system-wide intervention strategies.

Our temporal analysis using ARIMA models revealed relatively stable year-over-year trends in citation frequency, with no strong evidence of systematic increases or decreases, except for clear disruptions during the COVID-19 pandemic. Interestingly, changes in park visitation were not significantly associated with changes in citation rates. This suggests that enforcement patterns, visitor behavior, or both may be relatively consistent over time, regardless of fluctuations in visitation numbers.

Importantly, our findings show that incidents of disorder are relatively rare in proportion to overall visitation, aligning with broader criminological research indicating that a small minority of individuals are often responsible for a disproportionate share of infraction (Caspi

et al., 2016; Falk et al., 2014; Hein et al., 2017). While disorder is present, the data suggest that national parks remain overwhelmingly safe and well-managed public spaces for the majority of visitors.

The predominance of traffic-related citations, even in remote and less developed areas are analogous to more urban settings. This is illustrations of how behaviors commonly associated with urban environments extend into protected public lands. Other forms of disorder such as camping violations or resource infractions occurred at much lower rates and often sporadically. These trends may reflect both enforcement focus and data collection limitations. Some more serious issues such as poaching or cultural resource theft, may be treated as criminal offenses outside the scope of citation data, highlighting a gap that future research should explore.

From a park management perspective, early signs of disorder, particularly those occurring in high-traffic areas like parking lots, campgrounds, and trailheads should be prioritized for intervention. Targeted situational crime prevention strategies, informed by principles of opportunity, can help reduce these low-level infractions before they escalate or affect visitor experience. These interventions may include environmental design changes, educational signage, increased ranger presence, and strategic placement of amenities such as waste receptacles or informational kiosks. Such strategies not only contribute to a safer and more orderly visitor environment but may also prevent more serious offenses, support staff capacity, and enhance the long-term sustainability of tourism in protected areas. Managing disorder proactively can promote positive park experiences, encourage responsible use, and protect valuable natural and cultural resources.

This study highlights the importance of understanding disorder in national parks through both spatial and temporal lenses. The observed patterns, especially the seasonal fluctuations identified in Everglades and Shenandoah, can inform more responsive and adaptive management approaches. Longitudinal insights into how disorder evolves over time also offer critical guidance for resource allocation, staff scheduling, and visitor engagement. As visitation continues to grow, future research should incorporate additional variables such as staffing levels, weather, and infrastructure improvements to enhance predictability and

planning. Further refinement of citation classification systems and data-sharing between parks could also help national-level agencies identify trends, assess intervention effectiveness, and strengthen the empirical foundation for conservation-oriented park management. Some of these proposed changes are discussed in detail in the following section.

### 5.1. Policy implications

The findings of this study offer several actionable insights for improving national park management, particularly through cost-effective, prevention-oriented policies grounded in crime science. These recommendations aim to reduce low-level disorder and support long-term conservation and visitor safety without relying heavily on law enforcement resources.

#### 5.1.1. Improve data collection and accessibility

A key limitation identified in this study is the lack of standardized and accessible data on park-related infractions. We recommend the development of a centralized reporting system, modeled after the National Incident-Based Reporting System (NIBRS), to improve internal tracking and support empirical research. Such a system would allow NPS staff, volunteers, and even visitors to report observed signs of disorder in real time. Enhanced data quality would support early intervention, reduce the buildup of disorder, and help prevent escalation to more serious concerns, such as visitor fear and endangerment.

#### 5.1.2. Applying situational crime prevention strategies

Drawing on the situational crime prevention framework (Clarke, 1983, 1987), national parks can implement structural and behavioral interventions to reduce opportunities for disorder. These strategies are designed to be practical, scalable, and non-law enforcement dependent, making them ideal for park settings. As Braga et al. (2015) have shown, environmental interventions targeting social and psychological cues can significantly reduce disorder and crime. Examples from conservation criminology further support this approach, including the work of Spencer (2020), Lemieux (2014), and Lemieux et al. (2022) on wildlife crime prevention. These studies demonstrate how small, targeted design and policy changes can lead to meaningful improvements in compliance and resource protection.

#### 5.1.3. Rethink traffic enforcement through design

Traffic-related citations made up the bulk of disorder incidents in our study. Rather than increasing enforcement capacity, which would be cost-prohibitive, we recommend applying design-based solutions to influence visitor driving behavior. Research by Charlton et al. (2010) and Theeuwes et al. (2024) shows that lane markings, road width, speed bumps, and road surface texture all influence speed selection. Minor infrastructure adjustments such as removing centerlines or narrowing lanes could passively reduce speeding without the need for increased patrols or radar enforcement.

#### 5.1.4. Address natural resource violations through community engagement

Natural resource violations, particularly in Everglades National Park, require park-specific solutions due to the diversity of infractions (e.g., illegal fishing, overharvesting). In addition to administrative oversight, community-based strategies should be employed. This includes: establishing tip hotlines for anonymous reporting, partnering with local organizations and guides to educate the public on conservation and species protection, and creating outreach campaigns to highlight the long-term ecological and economic impacts of resource depletion.

While not a guaranteed deterrent, public awareness and education have proven effective in reducing illegal behaviors across multiple environmental contexts, from illegal fishing (Blank & Gavin, 2009; Keane et al., 2011; Kurland et al., 2017) to bird poaching (Fairbrass et al., 2016). Informal enforcement by engaged communities can complement formal enforcement mechanisms and help foster a

conservation-oriented culture.

### 5.2. Limitations and future research

Despite using data from the *Central Violations Bureau*, this study was limited to longitudinal analysis for examining incidents of disorder. Our data was mostly non-contextual and did contain location information preventing opportunities for spatial analysis. Additionally, our data only includes incidents reported by the *Central Violations Bureau*. Not included are incidents not considered disorder or where citations were not issued. Also, not included are incidents unknown to law enforcement. While much is known about how little crime is officially reported by law enforcement, little is known about the reporting rates for disorder. With only 20,000 employees in the National Park Service (National Park Service) and over 80,000 square miles under the jurisdiction of the NPS (Melroy, 2022), the number of unreported incidents is undoubtedly significant. Estimates of crime that fall within this undocumented number range from 40 % to nearly 60 %, or even higher depending on context and circumstance and leading to numerous ineffective outcomes (Gramlich, 2024; Skogan, 1977; Thompson & Tapp, 2023) therefore, we are likely only providing a snapshot of the disorder that occurs in these four parks. Additionally, as our research is exploratory, the data categories we used are not based on a priori research. While we strived to create categories that best contextualized our data, more research is needed to better understand the complexities of disorder-related data. Additional research should also seek to increase the robustness of disorder data with the inclusion of geographic information. With more robust data, additional types of statistical analyses can be conducted and a more nuanced understanding of disorder may be explained.

### CRedit authorship contribution statement

**Noah D. Cohen:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization, Investigation, Validation. **M. Dylan Spencer:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing.

### Availability of data and materials

Data available upon request.

### Declaration of generative AI

The authors declare that there was no use of any AI programming throughout the work on this paper.

### Funding

No outside funding was used to support this work.

### Declaration of competing interest

The authors declare that we have no personal, financial, or professional interests that could be perceived as a conflict of interest regarding the subject matter of this research project. This includes no current or recent consulting relationships, stock ownership, or funding sources that could influence the results or interpretation of this study.

### Data availability

The authors do not have permission to share data.

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